Texas Aquatic Science

From Molecules to Ecosystems and Headwaters to Ocean

TEACHER GUIDE TO
AQUATIC SCIENCE AND ECOSYSTEMS CURRICULUM
FOR MIDDLE SCHOOL AND HIGH SCHOOL

Texas A&M University Corpus Christi | Harte Research Institute for Gulf of Mexico Studies

Texas Parks & Wildlife
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The Meadows Center for Water and the Environment
Texas State University

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PWD BK K0700-1808 (5/15)

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Texas Aquatic Science
Teacher Guide

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A Joint Project of

Texas Parks and Wildlife Department

The Meadows Center for Water and the Environment at Texas State University

The Hart Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi

Funding Support by

The Ewing Halsell Foundation, San Antonio

Sport Fish Restoration Program, U.S. Department of the Interior

Special Acknowledgement

The Missouri Department of Conservation produced an aquatic science guide for students and teachers that served as a model for our work in Texas. We wish to thank them for their willingness to allow us to use and adapt materials from their student and teacher guide for *Conserving Missouri's Aquatic Ecosystems.*

A Comprehensive Aquatic Science Curriculum

Texas Aquatic Science is a curriculum consisting of a teacher guide, student reading text and guide, specially produced videos, and ancillary materials.

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Acknowledgments

Texas Parks and Wildlife Department

Nancy Herron, Outreach and Education Director at Texas Parks and Wildlife Department provided leadership direction on educational content and review of the text, along with staff members Caleb Harris, Karen Marks, Susan Loomis, Cappy Smith, Kiki Corry, Lee Smith, and Chase Fountain.

Missouri Department of Conservation

We wish to acknowledge the generous partnership of the Missouri Department of Conservation (MDC), most specifically Mike Huffman, Regina Knauer, Jack Woodhead, Elaine Callaway, Melanie Carden-Jessen, and Mary Scott for their contribution, support for the project, and permission to use and adapt MDC materials in the production of Texas Aquatic Science and the Teacher Guide.

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Timothy Birdsong, David Bradsby, Lisa Brown, Valerie Bugh (larvalbug.com), Ron Coley, Corpus Christi Caller Times, Kiki Corry, Shannon Davies, Kelly Drinnen, Ducks Unlimited Canada, Ducks Unlimited, Inc., Carolyn Chipman Evans, Chase Fountain, Stephan Magnelia, Dakus Geeslin, Mary Gomillion, Denise Gordon, Sharla Gutierrez, Caleb Harris, Jennifer Idol (the Underwater Designer), The In-Fisherman, Ron Kabele, Susan Loomis, Allison Knight, Gordon Linam, Cindy Loeffler, Stephan Magnelia, Jennifer Mandel Buratti, Karen Marks, Sam Massey, Randall Maxwell, Kevin Mayes, Captain Mike McBride, Larry McKinney, Heather Millar, Meredith Miller, Warren Pullich, Steve Quinn, Shelly Rosen, Margaret Russell, Olivia Sanchez, Andrew Sansom, Lindsay Sansom, Donna Shaver, Kris Shipman, Patt Sims, Cappy Smith, Lee Smith, Jessica Snyder, Greg Southard, Gail Sutton, Brenda Templeton, Travis Tidwell, Jace Tunnell, Wes Tunnell, Emily Warren, Terry Wendland, Donna Work, Scott Yaich, and Brian Van Zee

Editing, Graphics, Technical Review, and Design

A special thanks goes to Dr. Rudolph Rosen for editing, design work, graphics, and production of Texas Aquatic Science Teacher Guide, information and technical review, and invaluable help on this project.

Cover Photo

Texas Parks and Wildlife

About the Author

Sandra Johnson, Ph.D.

Dr. Sandra Johnson specializes in writing science curriculum aligned with state curriculum standards and conducting professional development for teachers. Dr. Johnson is a former teacher with experience with kindergarten, elementary, secondary, and gifted and talented students. She served as Science Consultant for Region XIII Education Service Center serving 59 school districts training teachers in kindergarten, elementary, and secondary classrooms. In addition, she has taught at both the University of Texas in Austin and Texas A&M–Corpus Christi. She is an educational consultant providing curriculum writing for a number of non-profit educational and conservation organization and conducts professional development for teachers all over Texas.

About the Partners

Texas Parks and Wildlife Department

Texas Parks and Wildlife is the state agency charged with the management of the state's fish, wildlife and parks, and the habitats upon which they rely. In a state whose population is 86% urban and land is 95% privately owned, TPWD relies on the understanding and cooperation of Texans for conservation of natural resources. Studies have shown that most Texans don't know where their drinking water comes from and struggle to navigate environmental issues. With the long-term challenges our state faces, such as how to provide water for people and the environment, TPWD believes building science-based knowledge and outdoor experiences are essential to developing the critical skills Texans will need to make informed decisions about the future of our natural resources. TPWD was a leader in forging a public-private partnership to develop the Texas Children in Nature strategic plan and network of regional efforts, and in the development of the companion Texas Natural Resource/Environmental Literacy Plan. TPWD was inspired by the work of the Missouri Department of Conservation's aquatic ecosystem curriculum for schools and obtained permission to adapt their guide for Texas. TPWD engaged two of Texas' most trusted leaders in water issues as partners for this project.

The Meadows Center for Water and the Environment, Texas State University

Located at the San Marcos Springs, on the Texas State University campus, The Meadows Center for Water and the Environment's core mission is to develop and promote programs and techniques for ensuring sustainable water resources for human needs, ecosystem health, and economic development. The Meadows Center engages in a holistic approach to the management of natural systems where key principles of sustainability and equitable use guide sound water policy. Work includes the following:

- Advancing scientific and technical knowledge through research on aquatic resources
- Identifying and analyzing socio-economic and political issues affecting water use
- Guiding the development of environmentally sustainable public water policy in Texas
- Cultivating public awareness and education about water resource issues

At Texas State, The Meadows Center serves as an integrating mechanism for the university's multidisciplinary expertise in aquatic resources. The Meadows Center's projects create new opportunities to disseminate this significant repository of knowledge and information to the community at large.

Hart Research Institute for Gulf of Mexico Studies, Texas A&M University - Corpus Christi

The Harte Research Institute for Gulf of Mexico Studies (HRI) is an endowed research component of Texas A&M University-Corpus Christi dedicated to advancing the long-term sustainable use and conservation of the Gulf of Mexico. It is the goal of HRI to be a research center of excellence providing international leadership in generating and disseminating knowledge about the Gulf of Mexico ecosystem and its critical role in the economies of the North American region. It is our further goal, to actively engage in efforts to both realize our vision and further our mission.

Among objectives, HRI establishes partnerships and alliances with educational, governmental, nongovernmental, and private sector organizations interested in long-term sustainable use and conservation of the Gulf of Mexico; develops and supports outreach and education activities that promote the development of critical thinking skills, and; advances conservation biology and biodiversity of the Gulf of Mexico.

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10.1 What Is a Wetland

6.2 C; 6.12 E;
7.2 C; 7.10 A;
8.2 C; 8.11 A, B;

Aquatic Science: 2 J; 10 B;
Environmental Science: 2 K;

10.2 Reading and Research

6.2 C; 6.12 E;
7.2 C; 7.11 B;
8.2 C; 8.11B;
Aquatic Science: 2 J; 10 B;
Environmental Science: 2 K;

10.3 Wetland Food Webs

6.2 C; 6.12 E;
7.2 C; 7.5 C; 7.10 A; 7.11 A, B;
8.2 C; 8.11 A;
Aquatic Science: 2 J; 5 C; 10 B; 11 A;
Environmental Science: 2 K; 4 B; 6 E;

10.4 Migration Stations

6.3 B, C; 6.12 E;
7.3 B, C; 7.11 B; 7.12 A; 7.13 A, B;
8.3 B, C; 8.8 C; 8.11 C;
Aquatic Science: 2 H, J; 3 B; 12 A, D;
Environmental Science: 2 I, K; 4 A; 9 E;

10.5 Field Trip to a Wetland

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E;
7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.5 A, B; 7.8 C; 7.10 A; 7.11 A; 7.13 A, B;
8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C;
Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 C D; 7 C; 9 C; 10 A, B; 11 A, B; 12 A, B, D;
Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 B, E; 4 A, B, E; 5 B; 6 E; 7 D;

Chapter 11: Bays and Estuaries

11.1 What Do We Know about Bays and Estuaries?

6.2 C; 6.12 E;
7.2 C;
8.2 C;
Aquatic Science: 2 J; 9 A;
Environmental Science: 2 K;

11.2 Reading and Research

6.2 C; 2.12 E;
7.2 C; 7.11 B;
8.2 C; 8.7 C; 8.11 C;
Aquatic Science: 2 J; 4 A; 9 A; 10 B; 12 A, C;
Environmental Science: 2 K; 5 B; 8 A; 9 A, E;

11.3 Salinity

6.1 A, B; 6.2 C, D, E; 6.4 A; 6.12 E;
7.1 A, B; 7.2 C, D, E; 7.10 A; 13 A;
8.1 A, B; 8.2 C, D, E; 8.4 A, B; 8.11 B, C;
Aquatic Science: 1 A, B; 2 F, G, H, J; 4 A; 9 A; 10 B, C;
Environmental Science: 1 A, B; 2F, G, K; 4 B, D;

11.4 The Ups and Downs in an Estuary

6.2 E; 6.3 C; 6.12 E;
7.2 E; 7.3 C; 7.5 A; 7.8 A; 7.13 A;
8.2 E; 8.3 C; 8.11 A, B, C;
Aquatic Science: 2 F, H, J; 11 B; 12 B, C, D;
Environmental Science: 2 F, I, K; 3 G; 5 A; 8 A, 9 E;

11.5 Ecosystem Services

6.2 C; 6.12 E;
7.2 C; 7.10 B;
8.2 C; 8.11 B, C, D;
Aquatic Science: 2 J; 3 B; 12 A, B, D;
Environmental Science: 2 K; 3 B; 8 B; 9 A, D;

Chapter 12: Oceans–The Gulf of Mexico

12.1 ABC's of the Gulf

6.2 C; 6.12 E;
7.2 C; 7.10 A;
8.2 C; 8.11 A;
Aquatic Science: 2 J; 10 B;
Environmental Science: 2 K;

12.2 Reading and Research

6.2 C, D; 12 E;
7.2 C, D; 7.5 C; 7.10 A;
8.2 C, D; 8.11 A;
Aquatic Science: 2 J; 11 A; 12 B;
Environmental Science: 2 K; 9 E;

12.3 Ocean Currents

6.1 A, B; 6.2 A, C, E; 6.3 B, C; 6.4 A, B; 6.9 A, B;
7.1 A, B; 7.2 A, C, E; 7.3 B. C; 7.4 A, B;
8.1 A, B; 8.2 A, C, E; 8.3 B, C; 8.4 A, B; 8.10 A;
Aquatic Science: 1 A, B; 2 E, F, G, H, J; 6 B; 8 A;
Environmental Science: 1 A, B; 2 E, G, H, I, K; 6 C; 8 B;

12.4 Wind and Waves

6.1 A, B; 6.2 C, D, E; 6.3 B, C; 6.4 A, B;
7.1 A, B; 7.2 C, D, E; 7.3 B, C; 7.4 A, B;
8.1 A, B; 8.2 C, D, E; 8.3 B, C; 8.4 A, B;
Aquatic Science: 1 A, B; 2 G, H, J;

Environmental Science: 1 A, B; 2 E, F, G, H, I, K;

12.5 Researching Ocean Organisms and Food Webs

6.12 C, D, E, F;
7.11 A, B; 7.12 A; 7.13 A;
8.10 A;
Aquatic Science: 3 B; 5 C; 10 B; 11 A;
Environmental Science: 3 B; 4 B; 6 E;

12.6 Field Trip to the Gulf of Mexico

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E;
7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.5 A, B; 7.8 C; 7.10 A; 7.11 A; 7.13 A, B;
8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C;
Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 C D; 7 C; 9 C; 10 A, B; 11 A, B; 12 A, B, D;
Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 B, E; 4 A, B, E; 5 B; 6 E; 7 D;

Chapter 13: Fishing for Conservation

13.1 Gone Fishing?

6.1 A; 6.2 C; 6.8 B; C, D;
7.1 A; 7.2 C; 7.7 C;
8.1 A; 8.2 C; 8.6 A, C;
Aquatic Science: 2 J;
Environmental Science: 2 K;

13.2 Which Fish Am I?

6.1 A; 6.2 C; 6.4 A, B; 6.12 D;
7.1 A; 7.2 C; 7.4 A, B; 7.11 A, B; 7.12 A, C;
8.1 A; 8.2C; 8.4 A, B; 8.11 A;
Aquatic Science: 1 A; 2 G, J; 10 A, B;
Environmental Science: 1 A; 2 F, G, K; 4 A, B;

13.3 Reading and Research

6.2 C; 6.12 E;
7.2 C; 7.10 A; 7.13 A;
8.2 C; 8.11 A, B, C;
Aquatic Science: 2 J; 10 A; 12 C, D;
Environmental Science: 2 K; 9 A, E, G;

13.4 Fishing Line Experiment

6.1 A, B; 6.2 B, C, D, E; 6.4 A, B; 6.12 E;
7.1 A, B; 7.2 B, C, D, E; 7.4 A, B; 7.10 A, B; 7.11 A, B; 7.12 A; 7.13 A;
8.1 A, B; 8.2 B, C, D, E; 8.4 A, B; 8.11 A, B;
Aquatic Science: 1 A, B; 2 E, F, G J; 3 B, C, E; 5 C, D; 10 B; 11 A, B;
Environmental Science: 1 A, B; 2 E, F, G, H, K; 3B, C, E; 4 B; 6 E; 9 G;

13.5 Fish Sampling and Ecosystem Assessment

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E;
7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.10 A; 7.11 A; 7.13 A;
8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C;
Aquatic Science: 1 A, B; 2 E, F, G, H, J; 5 A, B, C, D; 7 C; 10 A, B; 11 A, B; 12 A, B, C, D;
Environmental Science: 1 A, B; 2 E, F, G, H, I, K; 4 A, B, E; 5 A, B, C; 7 A, C, D; 8 A; 9 A, B, C, E

Chapter 14: Water for People and the Environment

14.1 Who Owns the Water?

6.2 C;
7.2 C;
8.2 C;
Aquatic Science: 2 J;
Environmental Science: 2 K;

14.2 Reading and Research

6.2 C; 6.12 E;
7.2 C;
8.2 C; 8.11 C;
Aquatic Science: 2 J; 12 A, B, D, E;
Environmental Science: 2 K; 9 A, E, F, J, K;

14.3 What's the Pollution?

6.2 C; 6.3 B, C; 6.12 E;
7.2 C; 7.3 B, C; 7.8 C;
8.2 C; 8.3 B, C; 8.11 C;
Aquatic Science: 2 H, J; 7 A, B; 12 A, B, E;
Environmental Science: 2 I, K; 5 B, C; 9 A, E, F, J, K;

14.4 Water Conservation

6.2 C; 6.3 B;
7.2 C; 7.3 B;
8.2 C; 8.3 B;
Aquatic Science: 2 H, J; 12 B;
Environmental Science: 2 I, K; 5 B;

Teacher Guide
Texas Aquatic Science

Aquatic Ecosystems and Science Guide for Texas Middle and High School Students.

Introduction

Purpose

Texas Aquatic Science was developed to help teachers make students aware of the importance of water to life and their part in conserving this valuable resource. This *Teacher Guide* is linked to short videos, which provide an overview of the main ideas in each chapter and to *Texas Aquatic Science* text for students that provides clear concise scientific information in an interesting way with illustrations of important concepts. Videos and student text can be found at http://texasaquaticscience.org/

The *Texas Aquatic Science* curriculum looks at water from the molecular level to the level of aquatic ecosystems. The *Teacher Guide* includes activities to guide students through the understanding that the characteristics of the water molecule make it unique in its value to all of life, and conservation of water is a priority for all of us. Student are also introduced to the wide variety of aquatic ecosystems through science investigations, games, models, Internet projects, reading the student guides, short videos, and field based assessments of water quality and environmental conditions in a variety of field trips. Students use multiple intelligences to learn and to demonstrate their new knowledge in creative products and performances.

Standards

The activities are aligned with the state curriculum standards, the *Texas Essential Knowledge and Skills* for sixth through eighth grade and for *Aquatic Science* and *Environmental Science* courses for high school.

Educational Perspective

Lessons in each chapter begin with an activity to allow the teacher to assess what students know about the concepts to be studied. Lessons embed higher order thinking skills, provide depth and complexity of learning, and provide a wide variety of hands-on activities that engage students in many contexts and methods. Each lesson includes an opportunity for students to apply what they have learned by synthesizing the information and demonstrating their learning by developing creative products or performances.

Howard Gardner's *Multiple Intelligences* are integrated throughout the lessons to help meet the needs of all students by providing opportunities for students to learn and demonstrate new knowledge in ways that best fit their learning strengths. Activities are designed to be inexpensive and to use the materials that are already in most classrooms. Teachers will find the activities easy to implement and fun for students. Teaching materials for some lessons such as aquatic organism game cards, posters, and videos are linked to the curriculum guide and easy for teachers to download and print or view. I hope that you find the *Teacher Guide* and *Texas Aquatic Science* useful and your students enjoy the activities and come to understand the importance of water and the need for conservation of our aquatic ecosystems.

The Importance of Outdoor Learning

Whether turning to the research proof on the effectiveness of learning outdoors, or turning to the faces of happy and engaged students, teachers see the benefits of using the outdoors as a rich, experiential learning environment. The outdoors awakens curiosity and discovery. It sharpens focus and concentration. Outdoor projects bring real-world experiences and relevancy to learning. Students of all ages and abilities find connections to the natural world, and most easily engage in inquiry-based explorations. Learning outdoors works.

But don't just take our word for it. The Texas Natural Resource/Environmental Literacy Plan, launched in 2013 by experts in formal and informal education, encourages learning in outdoor settings. Environmental literacy is the knowledge, skills and ability to understand, analyze and address major natural resource opportunities and challenges. The plan states, "As Texans have fewer direct experiences in the natural world, it becomes increasingly important to educate all citizens about our natural resources through accessible, safe, and enjoyable outdoor experiences. The environment provides an excellent context for this learning."

This curriculum teacher guide includes opportunities to take learning outdoors into the aquatic environments of Texas, or bring elements of the outdoors into the classroom. The partners' experience in the outdoors extends throughout the state. Opportunities available through the *Texas Aquatic Science* partners for experiential learning about aquatic ecosystems include natural habitats, wildlife management areas, state parks, glassbottom boat and kayak tours of Hill Country springs, coastal islands and paddling trails through the estuary, and discovery voyages into the Gulf. In addition to the tips within this guide, there are many wonderful training workshops that will help teachers overcome the barriers to teaching outdoors, including lesson plans, ideas for class management, and safety.

Components of the Lessons

Lessons have a variety of components. Students use science journals, participate in co-operative learning activities, take part in a number of different modes for assessment, and collect data on a variety of field investigations.

Science Journals

Science journals provide opportunities for students to record their discoveries, questions, experiments, observations, reflections, labeled drawings or diagrams, data tables, and graphs. Systematic records of their work help students develop awareness and understanding of their experiences. Writing down what they see and do helps them to put learning into words, and having the written record helps them review and think about their learning.

Science journals help teachers to be aware of student progress in science process skills as well as science concepts. The journal then becomes a tool for helping parents understand the student's development over time.

To help students get started journaling, provide specific guidelines. Each entry should include the date, time, weather, and location. This allows comparison of data over a period of time and forms the basis for observations. Using complete sentences for all notes helps to make the meaning clear when student read them later. All drawings and diagrams should be labeled so that they will mean something to the student when they are reviewed at a later date.

Cooperative Learning Activities

A variety of cooperative learning activities are included in the lessons. Some things are as simple as designing and conducting investigations in small groups, where students each have a part in making the work go smoothly. Other activities include a variety of ways for students to help each other by breaking down tasks and each concept apart and teaching it to the rest of the group. Some of these include:

ABC Brainstorming

Students use the alphabet to trigger ideas as they brainstorm on a topic or concept.

Carousel Brainstorming

Student groups are assigned to a poster with a concept or question. Posters are hung around the room. Each group is assigned a different color marker to write ideas, questions, or quotes on the posters. Then groups rotate around the room commenting on each poster's concept or question or making responses to what other groups have written. To conclude, the class reviews the information on each poster and contributes other ideas.

Jigsaw

Students work in small groups. Each group is assigned some portion of material to learn and then teach to the other students. These "expert" groups decide how to teach their material to the rest of the class. Then one person from each group meets with individuals from all the other groups and they teach one another what they have learned. In the end all students will have learned all of the information.

Numbered Heads

Divide students into small groups give each student in every group a number that corresponds to a question in the student chapter. Students look for the answer to their questions in the student text. As each number is called and the question is read, each student with that number gives an answer to the question.

Round Robin Brainstorming

Assign each small group a question or problem and give them time to discuss and think about answers. Designate one student as a recorder to take down other group members' responses. Another student is assigned as a reporter to share the group's responses with the class.

Team-Pair-Solo

Have students work on a problem or an idea in small groups, then in pairs, and then work on it individually.

Think-Pair-Share

Assign a question or problem to the class. Allow everyone to think about it individually, then have student pair-up and exchange their ideas. Have the pairs share their responses with the class.

Three-Minute Review

Stop any time during a lesson and give students 3 minutes to work in small groups to review what has been said, ask clarifying questions, or answer assigned questions.

Assessments

Each chapter provides multiple opportunities for assessment. The first lesson in each chapter provides a formative assessment to help teachers plan for appropriate student learning and to help students focus on what is to come. In addition, every lesson has a component to allow students the opportunity to synthesize what they have learned and apply it in creative products and presentations. The student reading also includes questions at the beginning of the chapter, which help students know what to focus on in the reading. These questions help scaffold the reading level for younger students and provide another type of assessment for the teacher to consider. Student science journals are also useful for formative and summative assessments. At the end of each chapter there are a multiple choice and open-ended questions for students along with an answer key. The open-ended questions have many possible answers. The answer key provides only an example of what teachers might expect to find in an answer, but do not exhaust all possibilities. Teachers should also feel free to add to or substitute their own questions for these assessments. Finally, each field trip provides opportunities for performance assessment.

Field Investigations

The curriculum includes eight field investigations. The field trips vary in purpose and destination. Teachers may choose to do one or all of the field trips depending on your time, transportation, and financial constraints. In addition, teachers of aquatic science courses in Texas high schools are required in the TEKS to conduct long-term studies of a local aquatic site with their classes. Those teachers may wish to substitute their local long-term study site as the destination for their field trips. The following information will give you an idea of the types of field investigations included.

Chapter 1 introduces students to a local creek or pond to use water chemistry testing they have practiced in the classroom.

Chapter 3 asks students to take a field trip on the school grounds through a scavenger hunt looking for places where water flows, infiltrates, or accumulates and how land use influences the quality of water in their watershed.

Chapter 4 includes a field trip to a local pond or stream to collect organisms for a native aquarium for observation in the classroom.

Chapter 6 uses a field trip to a local pond or stream to practice mark and recapture techniques for estimating the population of an aquatic invertebrate.

Chapter 8 has students conduct a field investigation to use multiple methods of assessing water quality in a local stream or river.

Chapter 10 includes a field trip to a local wetland such as a playa lake or wetland to look at the unique characteristics of these aquatic ecosystems from soil, to plants, to wildlife species.

Chapter 12 has a longer field trip to investigate saltwater ecosystems of bays, estuaries, and the Gulf of Mexico.

Chapter 13 helps students learn fishing techniques and provides opportunities for students to practice fishing while they examine multiple criteria for evaluating a local aquatic ecosystem.

Making the Most of Field Trips

To get the most from field trips, prepare students in advance with skills they will be using and with concepts they may encounter. After the field trip, follow up with projects or reports where students can demonstrate what they have learned. Be sure students are aware of behavior expectations and safety precautions.

Planning

Field trips require careful planning. If you are lucky enough to have a pond on your school grounds or in a nearby park, using those will help students feel more responsible for taking care of the site. A nearby stream can also provide opportunities for doing a variety of field activities. If you have to travel farther from your school, logistics become more complicated, but can be well worth the effort for the first hand experience that students will have. If you are using a public site, make arrangements well ahead of time and learn about any rules or limitations that you might encounter. Be sure you have permission before you go on private property.

Managing Student Behavior During Field Work

Students know the rules and expectations for indoor behavior and have established routines for focusing attention and are bounded by the limited space available. Outdoors, these well established rules, routines and expectations are quickly “forgotten” among the many distractions.

Your task when teaching outdoors is to work with students’ increased enthusiasm and energy while maintaining focus so that learning occurs and student safety is maintained. Here are some ways to maximize control in the outdoor environment.

Set ground rules about outdoor behavior before leaving the classroom. Make a list of the behaviors, which you believe to be essential such as staying on the path, bringing litter back to the classroom, maintaining personal space, etc. Reinforce this behavior when students are gathered outside, before beginning any activities. Ask you class to help you plan ahead for handling any disruptive behavior. Students should come up with appropriate consequences such as having offenders sit out of activities that they are disrupting. Remind students that safety and learning are the priorities.

Set physical boundaries beyond which students cannot wander. Use clear landmarks such as a specific patch of trees or a path as your boundary markers. Designate a “home base”—usually your debriefing area. If students are scattering to do an activity, set a clear signal such as a sports whistle or a bell to indicate that the activity is over and students should return to home base. Students should always be in sight of the teacher.

Use the buddy system. Students should be paired with a buddy in their group all day. Teachers can assign partners so that compatible students are together. Sometimes a particular student can be partnered with a teacher or other adult. Students should notify their teacher or other adult when they are going to the restroom, and they should take their buddy with them.

Have all students, parents and teachers wear nametags with group number, or class and grade on the nametags. Color- coding each small group’s tag may be helpful in knowing where students should be working.

Gather students in a circle, preferably seated, when debriefing an activity, so that you have everybody’s attention and everyone can participate. Debrief away from competing noises. Ask for eye contact. Avoid speaking to a group with your back to the sun or an interesting distraction. Use your voice levels to set the tone for the type of learning that you want to happen.

Be aware of weather conditions and physical fitness levels of students. Many students will complain about being cold, hot or about the long distance that they have to walk. You need to read when these complaints are serious and need to be heeded or when the student just requires some positive but firm encouragement. Make adjustments for students with physical problems. Students with asthma or other physical problems will need to walk more slowly.

If you are walking for a distance, make sure that one adult leads the group and one adult brings up the rear, encouraging the slower walkers and making sure that no stragglers get left behind. Be vigilant. Be aware of students’ whereabouts and watch behavior.

Safety

The main concern for any field trip is safety. Become familiar with Texas Education Agency Texas Safety Standards (PDF, 20MB). Have plenty of volunteers to help supervise students. Ideally you would have one adult for every 5-10 students, depending on the age of your students. Provide volunteers with a list of students with whom they will be working and with their responsibilities. These responsibilities may include monitoring student behavior, supervising a specific task, or assisting with fishing or other equipment. Maintain all safety procedures for using chemical tests or other equipment including wearing goggles.

Planning for Emergencies

Planning for emergencies is important. Be sure the principal knows where students are going, and ask the school nurse to accompany you, if possible. Take a first aid kit including a buffered eyewash solution, life preservers, a reach pole, and a cell phone. Be sure the bus and driver remain at the site. In case of severe weather, do not seek shelter around water or under trees; return to the bus to take refuge. Help students learn to recognize poisonous plants, venomous snakes, and various biting invertebrates and what they should do if they encounter these.

Other Considerations

Be sure to send home permissions slip forms at least a month in advance and a reminder two weeks prior to the event. Be sure to make arrangements for students with special needs.

Make sure that other teachers know that students will be out on the field trip. They may have a way that students can utilize their field experiences in their other classes.

Water is Life

Water has properties that make it essential to life, and while water recycles and cleans itself, there are limited quantities which must be conserved.

Chapter 1

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Discuss their ideas about water and its uses.
2. Know the difference between elements and compounds.
3. Recognize water as an abiotic part of the ecosystem.
4. Know that matter has physical and chemical properties.
5. Recognize that chemical formulas are used to identify substances and subscripts allow us to determine the number of atoms of each element.
6. Make a model of water distribution on Earth and the amount of water useable by humans.
7. Describe abiotic parts of an ecosystem and how organisms depend on abiotic factors such as water.
8. Describe interactions of biotic and abiotic parts of the ecosystem.
9. Use models to help them understand abstract ideas.
10. Explain, on the molecular level, what makes water a polar molecule and how that affects water's properties.
11. Plan and carry out a comparative investigation of the surface tension of various liquids.
12. Discuss surface tension in the aquatic environment.
13. Investigate their own use of water and devise ways to cut usage to conserve our water supply.
14. Identify the constants, and the dependent and independent variables in the water conservation experiment.
15. Read Chapter 1: Water Is Life to reinforce concepts and vocabulary and find new information.
16. Go online to various websites and search for water quality information.
17. Use technology and methods for testing water for pollution and determining water quality including water chemistry test kits and equipment.

18. Identify sources of water samples in their water quality tests.
19. Use safe practices and conservation of resources in the lab.
20. Collect data and record information in tables.
21. Draw conclusions based on data.
22. Make connections between testing of water quality and careers.
23. Identify ways human activity can affect aquatic environments.
24. Identify sources of water samples in their water quality tests.
25. Use safe practices and conservation of resources in the lab.
26. Collect data and record information in tables.
27. Draw conclusions based on data.
28. Make connections between testing of water quality and careers.
29. Identify ways human activity can affect aquatic environments.
30. Demonstrate the use of course apparatus, equipment, techniques, and procedures.
31. Collect baseline quantitative data, including pH, salinity, temperature, mineral content, nitrogen compounds, phosphates and turbidity from an aquatic environment.
32. Identify water quantity and quality in a local watershed.
33. Identify how human activities impact aquatic environments.
34. Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic ecosystem.
35. Analyze the cumulative impact of human population growth on an aquatic system.
36. Identify the impact of various laws and policies such as the Clean Water Act on aquatic systems.
37. Compare and describe how adaptations allow an organism to exist within an aquatic environment.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, B, C, D, E; 6.3 A, B, C; 6.4 A, B; 6.5 A, C; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A, B, C; 7.4 A, B; 7.6 A; 7.11 B; 7.12 A; 7.13 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 A, B, C; 8.4 A, B; 8.5 D; 8.11 B; 8.14 A

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 B; 7 C; 12 A, B, E; 10 B; 12 C

Environmental Science: 1 A, B; 2 E, F, G, K; 3 E; 4 D, E; 5 B; 9 A, B, C, E, K

Materials

For every activity students will need their science journals.

Lesson 1.1

Chart paper and markers

Lesson 1.2

Inflatable globe

For Each Group

5-gallon aquarium or bucket filled with water

2-cup measure

Clear bowl

½ cup measure

Eyedropper

1 lb box of salt

Ice cubes

Food coloring

Clear jar

Microscope slide

Paper towels

Lesson 1.3

For each pair of students:

Six 2½-inch blue circles and twelve 1-inch gray circles

Wax paper

Eyedroppers

Toothpicks

1 vial of blue food colored water

For each group of 4 students:

Glass of colored water

Celery, white carnations, white daisies, or other white flower

2 glass microscope slides

Petri dish

Tape

Lesson 1.4

For each pair of students:

Plastic 200 ml graduated cylinder

Bowls of water

Clear containers in several shapes

3-5 ice cubes

6 large blue circles and 12 small grey circles from the last activity

For the Class:

Teakettle

Hot plate

Clear plastic container with a lid for the teacher to catch steam

Safety goggles

Lesson 1.5

For each pair of students

Vials of various liquids such as alcohol, vinegar, oil, soapy water

Water

Eyedroppers

Pennies

Paper towels

Beaker

25 milliliters of distilled water

Pipette

New pennies

Old pennies

1 quarter

Tiny amount of dish soap

Cup of water

Regular paper clip

Large paper clip

Optional:

Native aquarium (10 gallon aquarium or a smaller aquarium for each group, nets, seines, plastic gallon jugs, collected organisms)

Lesson 1.6

For each pair of students:

Safety goggles

Clear plastic cups

Graduated cylinders

Scale

Water

Salt

Blue and gray circles from previous lesson

Small green circles and large white circles to make models of salt molecules

Blue and yellow food coloring

Corn syrup

Bottle of warm club soda

Bottle of cold club soda

Paper towels

Old newspapers

Lesson 1.7

1 *Water Use Record* sheet for each student

1 *Bar Graph Template* sheet for each student

Pens or pencils

Colored pencils

Lesson 1.8

Student Guide, Chapter 1

Science journals

Pens and pencils

Lesson 1.9

Safety goggles—one per student

At least three water samples for each group pre-labeled A, B, C. Sample sources may be tap water, rainwater, pond water, creek water, etc.

Water quality test kits, meters or other equipment which may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, phosphate kit, etc.

Water Chemistry Investigation sheet for each student

Secchi disc, stop watch, tennis ball or piece of wood, macro-invertebrate identification chart such as the *Bug Picking* chart on the Texas Parks and Wildlife website.

Safety Precautions

Students and teachers wear safety goggles.

Use caution when handling glass.

Only the teacher should handle the teapot and collect steam.

Go over safety guidelines for field investigations.

Vocabulary

- Abiotic
- Adhesion
- Aquatic organisms
- Aquatic resource
- Biotic
- Charge
- Clean Water Act
- Cohesion
- Compound
- Conductivity
- Decompose
- Dissolve/dissolving
- Dissolved oxygen
- Element
- Gaseous
- Hydrosphere
- Ion
- Inorganic
- Liquid
- Molecule
- Molecular
- Natural resource
- Nitrates
- Organic
- pH
- Polar
- Polarity
- Reservoirs
- Solid
- Solubility
- Solute
- Solvent
- States
- Surface tension
- TPWD–Texas Parks and Wildlife Department

- TCEQ–Texas Commission on Environmental Quality
- NRCS–Natural Resource Conservation Service

Teacher Resources

American Chemical Society teacher resources and lesson plans

http://www.middleschoolchemistry.com/

Other websites

http://www.tpwd.state.tx.us/landwater/water/conservation/fwresources/biotic.phtml

http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_lf_k0700_1117a.pdf

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_lf_k0700_1118a.pdf

http://www.tceq.gov

http://www.nrcs.gov

Enrichments

Project WET

- Adventures in Density
- Choices and Preferences, Water Index
- Common Water
- Drop in the Bucket
- Every Drop Counts
- H_2Olympics
- Hangin' Together
- Is There Water on Zork?
- Water Meter
- What's the Solution?

Project WILD Aquatic

- How Wet Is Our Planet?
- Something's Fishy Here!
- What's in the Water?

Guest Speakers:

- Water resource professional to talk about careers and clean water issues
- Texas Stream Team volunteer water quality monitor

Lesson 1.1: What Do I Know About Water?

Objectives

1. Students will discuss their ideas about water and its uses.

TEKS

6.3 A; 7.3 A; 8.3 A

Aquatic Science: 3 A

Environmental Science: 3 A

Estimated Time

1 Class period

Materials Needed

Chart paper and markers

Special Instructions

Write questions on the board.

Procedure

Eliciting Students' Knowledge About Water

Have each group of 4 students work together to write the answers to the questions on chart paper and discuss their ideas about water. Allow 10 to 15 minutes for groups to discuss and record their answers.

Ask each group to share and discuss their ideas with the class.

Questions:

- **How much of the Earth do you think is covered with water?**
- **Why is water important?**
- **How do you use water?**
- **How much water do you use each day?**
- **How do you know if water is good quality?**
- **Would you drink water from a local farm pond or creek? Why or Why not?**
- **Would you drink water from a local river? Why or Why not?**
- **Would you drink water from the ocean? Why or why not?**

Explain to the class that this chapter will help them understand the value, importance, and properties of water as well as some ways to determine whether water is clean or not.

Lesson 1.2: Water Distribution and Scarcity

Essential Concept

While nearly ¾ of the Earth is covered with water, only a very small amount of that water is available for human use.

Objectives

1. Students will make notes of water distribution on Earth and the amount of water useable by humans.
2. Students can describe abiotic parts of an ecosystem and how organisms depend on abiotic factors such as water.
3. Students will describe interactions of biotic and abiotic parts of the ecosystem.

TEKS

6.3 B; 6.12 E; 7.3 B; 8.3 B; 8.11 B

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 class period

Materials Needed

Inflatable globe

<u>For Each Group</u>

5-gallon aquarium or bucket filled with water

2-cup measure

Clear bowl

½ cup measure

Eyedropper

1 lb box of salt

Ice cubes

Food coloring

Clear jar

Microscope slide

Paper towels

Procedure

1. Surface Water

Ask students to use an inflatable globe to look at the percent of water versus land on the Earth. Toss the globe from person to person and notice where each person's index finger touches when they catch the globe. Tally the number of times the person's index finger touches water and how many times it touches land. The teacher should record the tally. Have students use the tally to find the percent of time fingers touch water. In a typical class, after many catches, it easily averages to 7 out of 10 fingers on average touch on water. This mirrors the percent of surface water on Earth. Seventy percent of the Earth's surface is covered with water. While Earth has a large percent of water on the surface, much of that water is saltwater and not useable for drinking.

2. Distribution of Water on Earth

This model can be carried out by small groups of students so that students have the opportunity to be physically involved.

Ask students to make a model to demonstrate water distribution. Fill a five-gallon aquarium with water. In the model the water in the aquarium represents all the water on Earth.

Remove 2 cups of water and put it in a clear bowl. Explain that this represents all the freshwater on Earth. (About 3% of the total amount of water on Earth) The rest (97%) is saltwater. Pour salt into the aquarium and place the salt container in front of it.

Remove ½ cup of water from the 2 cups. Explain that the 1½ cups remaining represents water frozen in polar ice caps and glaciers. Pour out the 1½ cups of water and replace with ice cubes. Pour the ½ cup of water into a jar and explain that this represents the unfrozen fresh water found on the Earth's surface, (about .05% of all the freshwater on Earth).

Fill the dropper from the ½ cup and place a drop on a microscope slide.

Ask students what they think this dropper full of water represents. (The portion of all the water on Earth that is available fresh water for human use (about 0.0025%). Explain that the rest of the ½ cup is too polluted, inaccessible, or too costly to transport. Place a few drops of food coloring in the ½ cup of water to indicate it is not available for human use.

3. Assessing What We Learned: Uses of Water

- **What are some ways people use water?** (Drinking, cleaning, laundry, irrigation, industries such as production of electricity, etc.)
- **How do animals and plants use water?** (Drinking, habitat, photosynthesis, etc.)
- **What does the word "biotic" mean?** (Living)
- **What are some biotic parts of the ecosystem?** (Plants, animals, fungi, bacteria, etc.)

- **What does the word “abiotic” mean?** (“A” means “without”, “biotic” means living so “abiotic” means “without life”.)
- **What are the abiotic parts of the ecosystem?** (Sunlight, air, soil, rocks, water)
- **How do the biotic and abiotic parts of an ecosystem interact?** (Living (biotic) things depend on other living things and non-living (abiotic) parts of the ecosystem to survive.)

Have students give some examples: (Plants depend on soil, air, water and the sun to provide nutrients and light to conduct photosynthesis. Some plants depend on animals to pollinate their flowers and/or spread their seeds. Animals depend on water, air, soil, rocks, and the sun to help provide water, shelter, food, and space for their habitat. Animals depend on plants and/or other animals for food.)

4. Explain that every living cell contains water.

- **What does this fact tell us about the importance of water?**
- **Could life exists without access to water in some manner?**

Vocabulary

- Abiotic
- Biotic

A Model of Distribution of Water

1. Fill a five-gallon aquarium with water. In the model the water in the aquarium represents all the water on Earth.
2. Remove 2 cups of water and put it in a clear bowl.

   This represents all the freshwater on Earth. (About 3% of the total amount of water on Earth) The rest (97%) is saltwater.
3. Pour salt into the aquarium and place the salt container in front of it.
4. Remove ½ cup of water from the 2 cups.

   The 1½ cups remaining represents water frozen in polar ice caps and glaciers. Pour out the 1½ cups of water and replace with ice cubes.
5. Pour the ½ cup of water into a jar.

   This represents the unfrozen fresh water found on the Earth's surface, (about .05% of all the freshwater on Earth).
6. Fill the dropper from the ½ cup and place a drop of water on a microscope slide.
   - **What do you think this dropper full of water represents?**
7. Place a few drops of food coloring in the ½ cup of water to indicate it is not available for human use because it is polluted.
   - **What are some ways people use water?**
   - **How do animals and plants use water?**
   - **What does the word "biotic" mean?**
   - **What are some biotic parts of the ecosystem?**
   - **What does the word "abiotic" mean?**
   - **What are the abiotic parts of the ecosystem?**
   - **How do the biotic and abiotic parts of an ecosystem interact?** Give some examples of these interactions.

   Every living cell contains water.
   - **What does this fact tell us about the importance of water?**
   - **Could life exists without access to water in some manner?**

Lesson 1.3: Properties of Water
Polarity, Cohesion, Adhesion

Essential Concept

Water has properties that make it important to life on Earth.

Objectives

1. Students know the difference between elements and compounds.
2. Students know that matter has physical and chemical properties.
3. Students recognize that chemical formulas are used to identify substances and students can determine the number of atoms of each element in chemical formulas containing subscripts.
4. Students use models to help them understand abstract ideas.
5. Students identify water as an important necessity for life on Earth.

TEKS

6.1 A, B; 6.2 C; 6.3 A, B, C; 6.4 A; 6.5 A, C; 7.1 A, B; 7.2 C; 7.3 A, B, C; 7.4 A; 8.1 A, B; 8.2 C; 8.3 A, B, C; 8.4 A; 8.5 D

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 Class period

Materials

Science journals

For each pair of students:

Six 2½ inch blue circles and twelve 1 inch gray circles

Wax paper

Eyedroppers

Toothpicks

1 vial of blue food colored water

For each group of 4 students:

Glass of colored water

Celery, white carnations, white daisies, or other white flower

2 glass microscope slides

Petri dish

Special Instructions

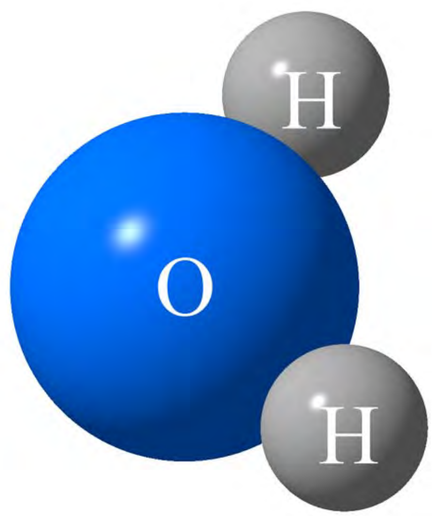
Die cut large and small circles, collect materials.

Procedure

1. Elements and Compounds

Write **H_2O** on the board. Have students review **elements** and **compounds** by asking them to explain what the symbol means. (Students should be able to explain that the H represents an **atom** of the element hydrogen and the O represents an atom of the element oxygen. Together these atoms form the **molecule** H_2O, which contains 2 hydrogen atoms and 1 oxygen atom and represents the **compound** water.

- **What does the subscript 2 mean?** (It indicates the number of atoms of hydrogen in the compound.)



Provide each student with one 2½ inch blue circle and two 1 inch gray circles to represent oxygen and hydrogen atoms. Tell students that you will use these circles to make a molecular model of the compound water. Have students put the circles together so that it looks like Mickey Mouse. This is the position that the hydrogen atoms take when they connect with the oxygen atom. This position is important because it gives the water molecule a slight positive charge on the hydrogen side and a slight negative charge to the oxygen side of the molecule. This slight charge causes water molecules to be attracted to each other and to many other forms of matter. When a neutral molecule has a positive area at one end and a negative area at the other, it is called a **polar molecule**. Water molecules cling to one another based on the attraction between the positive end of 1 water molecule and the negative end of another.

2. It Sticks Together.

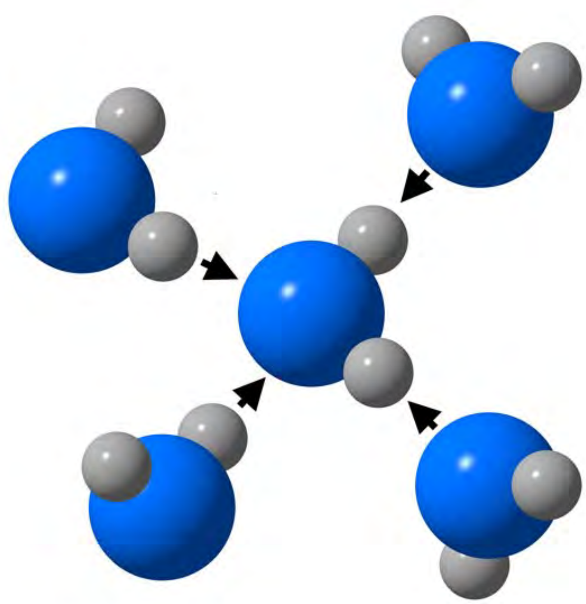
To help students see how this happens give each pair of students a piece of wax paper, a small vial of blue colored water, and 2 toothpicks. Explain that the food coloring is added to the water to make it easier to see. Ask students to use the eyedropper to drop 8 -10 drops of water randomly on their piece of wax paper. Notice how each drop looks. Write a description in your journal.

Next take turns with your partner using a toothpick to drag the water around on your wax paper.

- **What happens?** Describe it in your journal**.**
- **Can you and your partner get all the water droplets to join together? How is this happening?** (Water clings to the toothpick and slides across the slick wax paper. When it touches another drop of water they join to form a bigger drop. This continues until the drop gets too heavy to hold together and be moved.)

3. Making a Molecular Model

To illustrate this with a molecular model give each pair of students the other 5 large blue circles and 10 small gray circles. Ask students to make more water molecules on their desk. Students should think how these molecules might join together given that one side of each molecule is positively charged and the other side is negatively charged. (They should come up with the idea that opposite charges attract and arrange molecules where a hydrogen atom of one molecule is near an oxygen atom of another molecule until all the molecules are close together.) **Note:** Because water is a liquid and fluid, the arrangement of the molecules will change as the water flows. Therefore the model does not actually show the molecules touching. Have students think about how this model is different from the real water molecules and the real drops of water. (The model is 2 dimensional, larger than real molecules, atoms are not actually joined together, actual water molecules of hydrogen and oxygen are not visible to the human eye, etc.)



4. Cohesion and Adhesion.

The property of water clinging to itself is called **cohesion**. When water clings to another form of matter it is called **adhesion**. In our activity we saw both of these properties illustrated. Explain where we saw cohesion (water droplets joining together on the wax paper). Explain where we saw adhesion (water droplets clinging to the toothpicks as we moved it around on the wax paper).

Provide colored water in a glass for each group of 4 students. Have students pour a small amount of the colored water into a Petri dish and set it aside for use later. Give each group a stalk of celery. (You may also want to have each group use a different plant such as white carnation, daisy, or other white flower to see the flow of water in a different context.) Students should make a fresh cut at the bottom of the celery or flower stem and set them in the glass of colored water.

Have students write in their journals to describe the celery or flowers and the way their experiment is set up. The celery or flowers should sit in the colored water over night. Meanwhile, have each group tape 2 microscope slides together, and set them upright in the Petri dish, which contains some of the colored water from the glass. Have students describe what they have done in their journals. Set these aside to observe what happens.

Recheck these plants and the slides tomorrow and discuss any changes students observe and have them write descriptions of what happened in their journals. (The colored water will move up the plant stem and be visible in the veins of the plant. The colored water will also move up between the 2 microscope slides.)

5. Assessing Our Learning

- **Why do you think cohesion and adhesion are important properties of water? (**Cohesion and adhesion are properties of water that are very important to life on Earth because they allow water to climb up plant stems and enable blood to flow through our bodies.)
- **What would happen to plants if water did not have these properties?** (No water means no photosynthesis, which means green plants could not exist.)
- **Without green plants what would happen to animals and people?** (No plants means no food. Even if there were other food, animals could not exist without the fluids moving through their bodies. Because of its properties water is a necessity for life on Earth.)

Vocabulary

- Adhesion
- Charge
- Cohesion
- Compound
- Element
- Molecule
- Polar

Lesson 1.4: Properties of Water
Three States: Solid, Liquid, Gas

Essential Concept
Water has properties that make it important to life on Earth.

Objectives
1. Students know the difference between elements and compounds.
2. Students recognize water as an abiotic part of the ecosystem.
3. Students know that matter has physical and chemical properties.
4. Students recognize that chemical formulas are used to identify substances and can determine the number of atoms of each element in chemical formulas containing subscripts.
5. Students use models to help them understand abstract ideas.

TEKS
6.1 A, B; 6.2 C, D, E; 6.3 A, B; 6.4 A; 6.5 A; 6.12 E; 7.1 A, B; 7.2 C, D, E; 7.3 A, B; 7.4 A; 8.1 C, D, E; 8.2 C, D, E; 8.3 A, B; 8.4 A; 8.5 D

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time
1 Class period

Safety Precautions
Only the teacher should handle the steam. Teacher should wear safety goggles and use potholder.

Materials Needed
<u>For each pair of students:</u>

Plastic 200 ml graduated cylinder

Bowls of water

Clear containers in several shapes (rectangle, cylinder, oval, etc.)

3-5 ice cubes

6 large blue circles and 12 small grey circles from the last activity

<u>For the Class:</u>

Teakettle

Hot plate

Clear plastic container with a lid for the teacher to catch steam

Procedure

1. Water in Three States.

Have each group of four students place 50 ml of water into a plastic 100 ml graduated cylinder and place it in the freezer over night. Have student record the amount of water in their graduated cylinder in their journals.

The next day, students should observe that the level of ice in the graduated cylinder is higher than the level of water you started with. Explain to students that as water freezes, it expands and takes up more space than it did as liquid water.

2. Observing and Describing Three States of Water

Give students clear bowls of water, ice cubes, various shapes of containers. Have students explore with the materials and make a data table for characteristics of **solid, liquid, and gaseous** states of water in their journals.

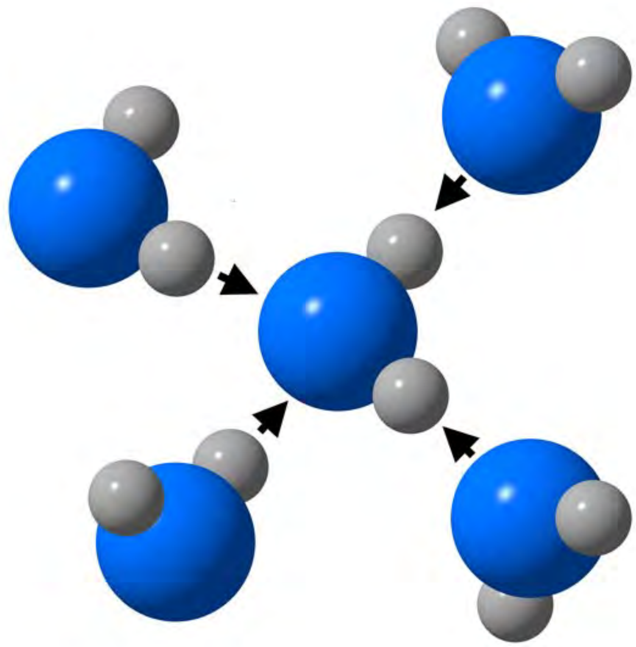
- **What characteristics does water show in the solid state?** (Students should come up with several characteristics such as: The solid maintains its shape [as long as it is not melting] in all of the containers and on its own, it doesn’t pour or spread out, it will float in water.)
- **What characteristics does water show in the liquid state?** (The liquid water takes the shape of the container, pours, can be spilled and spreads out over a surface.)

Meanwhile bring a teapot of water to a boil on a hotplate. When steam comes out of the spout ask students:

- **What characteristics does water show in a gaseous state?** (It spreads out through the air, looks like tiny particles similar to smoke, and when a small amount is caught in a container by the teacher, it cools and returns to the liquid state when it condenses on the sides of the container).

3. Molecular Model.

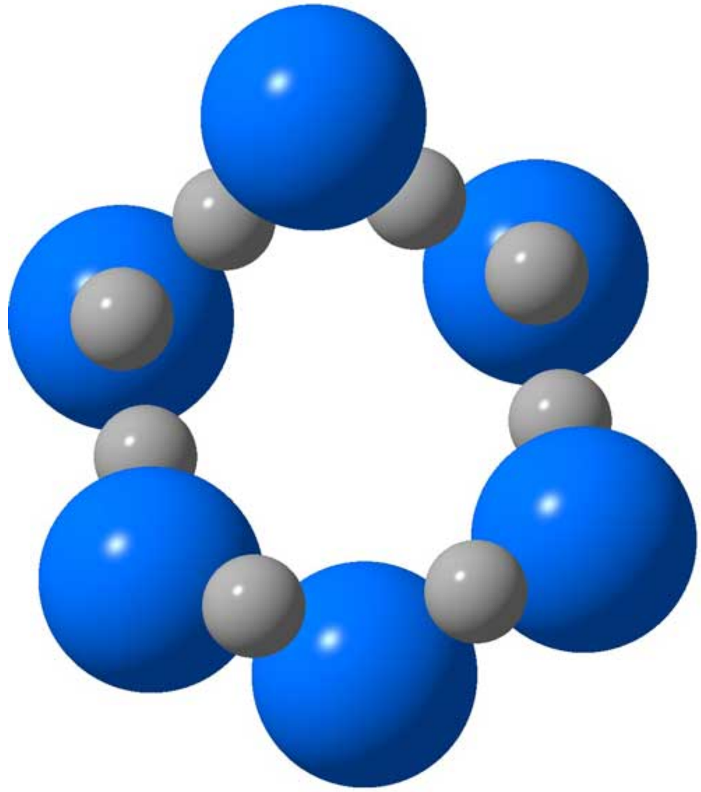
For each pair of students use the 5 large blue circles to represent oxygen and the 10 small gray circles to represent hydrogen to make a molecular model of water in each state. Remember the distinctive shape of the water molecule and the polar nature of the molecule with a positive charge on the hydrogen side and the negative charge on the oxygen side**.**



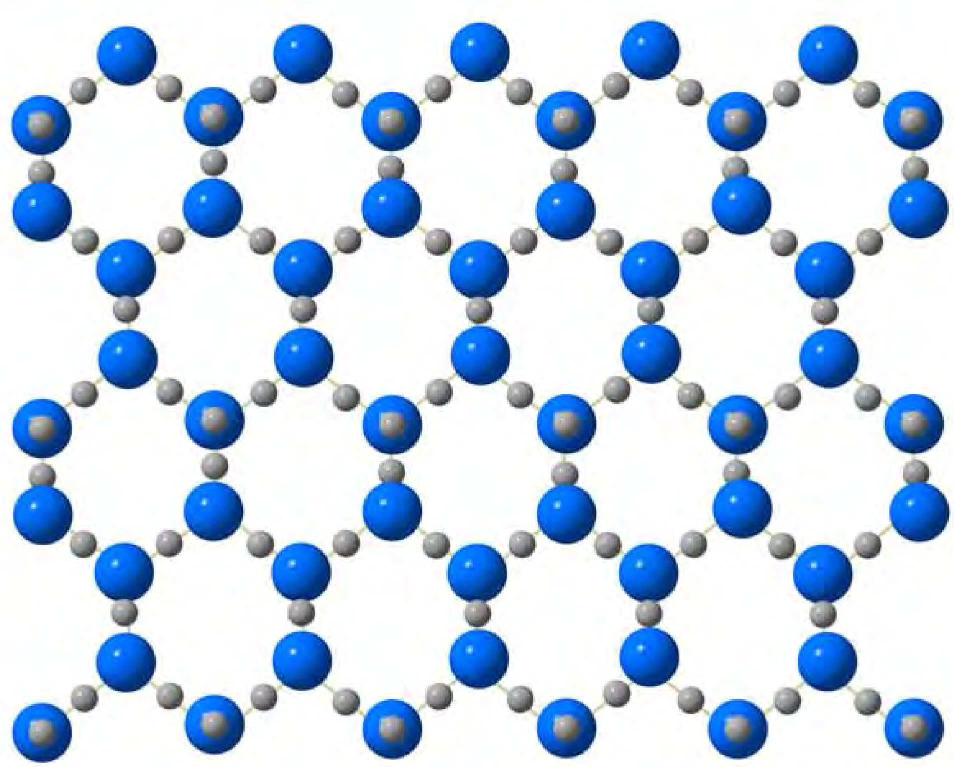
- **What would the water molecules do in a gaseous state?** (Students should demonstrate water molecules spread out on the desk so that they are fairly far apart.)
- **What would the molecules do in a liquid state?** (Students should place the molecules closer together but not quite touching with hydrogen atoms between each oxygen atom as in the previous lesson.)
- **What would the water molecules do in a solid state?** (Students should demonstrate how the molecules would be connected to each other forming a solid structure.)
- **How could we connect all of the molecules without losing any of the atoms and use the positive and negative charges to help develop the solid structure?** (Students should come up with the idea of putting the molecules in a circle connecting at one hydrogen atom in each molecule. This will leave an open space in the middle with hydrogen atoms around the outside of the circle. If students have a hard time coming up with this, give them a start by asking them to place the oxygen atoms in a circle with some space between them and add the hydrogen atoms to make the Mickey Mouse ears while connecting each adjoining water molecule.)

Ask students to describe the molecular structure of solid water (ice).

- **Why do you think the space in the middle in the middle of the structure might be important?** (The space causes the solid form of water to take up more space than the same number of molecules of liquid water. Remember the water frozen in the graduated cylinders.)



- **What would happen to the hydrogen atoms on the outside of the circle if we had more water molecules?** (Those hydrogen atoms would be attracted to other oxygen atoms and eventually create a lattice like matrix.)



4. Assessing our Learning: Water Molecule Game

If you have a group that needs to get up and move around, you can make this into a game, which can be done outside or in the classroom. Number students off from 1 to 3. All the 1s and 2s are hydrogen atoms and all the 3s are oxygen atoms.

Ask the oxygen atoms to find two hydrogen atoms to attach themselves to. They can put a hand on the shoulder of each hydrogen atom. This threesome represents a molecule of water.

Ask students to come up with ways to show each of the three states that water can take when you call out each state.

Call out, "Form Water Vapor!" (Students should move apart and spread the molecules around in the space.)

Call out, "Form Liquid Water!" (Students should move closer together with hydrogen atoms from one molecule near, but not touching, the oxygen atom of another molecule where molecules are attracted to each other, but move over and around each other as a fluid.)

Call out, "Form Solid Ice!" If students have a problem, give them hints such as, "Six water molecules make a circle." (Students should form up with one hydrogen atom of each molecule touching one oxygen atom of another molecule on the shoulder. The second hydrogen atom of each molecule will be on the outside of the circle to form ice or snow.

- **Can you see the shape of a snowflake?**
- **How is this structure different from the water vapor and liquid states?** (The structure is more stable.)

When students have the molecules put together to form the solid ice, ask them:

- **What makes this molecular structure a solid?** (The molecules are closer together and in a more organized structure.)
- **Does it take up more space in the solid form or the liquid form?** (It takes up more space as a solid. If students don't come up with the idea, relate your observations to the water that they froze in the graduated cylinder.

The solid ice molecule is put together in a lattice type structure that holds it shape better than liquid water or gaseous water. This structure leaves an open space in the middle, which takes up more space.

5. Applying What We Learned

If no one has tried putting the ice in water to see what would happen, do so at this time.

- **Why do you think the ice floats in water?** It's the same substance, just in a different state. (Students may come up with various ideas.)
- **How could the molecular structure make ice less dense than liquid water so that it would float?** (The open space in the middle makes the solid lighter than the liquid form.)
- **Why is it important for living things that ice floats?** (Without this property,

lakes would freeze solid in winter, killing fish and other aquatic life.)

- **Would a molecule have to be moving fast or moving slowly to be able to join to other molecules?** (Moving slowly)
- **In which state do you think the water molecules are moving fastest?** (The gaseous state–The molecules are moving fast and pushing on each other and other molecules in the air, which causes them to move farther apart.)

Extension

Behavior of other Substances

Ask students to think about the following question.

- **What other substance can you think of that exists in all three states of matter under normal temperature and pressure on Earth?**

There are few substances that are able to exist at normal temperatures and pressures in our world commonly in solid, liquid, and gaseous states. Ask students to brainstorm, and make a chart listing substances and the states in which they have seen that substance. Students may think of a variety of substances such a liquid steel and solid steel, liquid nitrogen and gaseous nitrogen, etc. that demonstrate some different states, but these are possible only under extreme temperature or pressure. However, they will not be able to think of a substance other than water that normally is found in all three states under normal temperature and pressure conditions. Students may say that Coca Cola and other sodas will evaporate and freeze and are liquid. Point out to students that an important ingredient of Coca Cola and other sodas is water.

- **Would other solid substances float in their liquid form?**

To try an experiment to answer this question, freeze ice cube trays of an oil. (Olive oil, palm oil, lamp oil or citronella oil) Ask students to put the solidified oil in liquid of the same oil.

- **Does the solid oil float in the liquid? (**The solidified oil will sink.)
- **Why do you think the solid oil won’t float?** (Its molecular structure does not provide the open space that ice (solid water) has in its molecular structure, which allows ice to float. The solid oil is more dense than the liquid oil.)

Vocabulary

- Gaseous
- Liquid
- Molecular
- Polar
- Solid

Lesson 1.5: Properties of Water
Surface Tension

Essential Concept
Surface tension is a property of water to which some animals are specially adapted.

Objectives
1. Students will implement a comparative study of the surface tension of various liquids.
2. Students will relate the molecular structure of water including its polar nature to its surface tension.
3. Students will discuss the importance of surface tension in the aquatic environment.
4. Students will define heredity as the passing of genetic instructions from one generation to the next generation.
5. Students compare and describe how adaptations allow an organism to exist within an aquatic environment.

TEKS
6.1 A, B; 6.2 A, C, D, E; 6.3 A; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A; 7.4 A, B; 7.5 A; 7.11 B; 8.1 A, B; 8.2 A, C, D, E; 8.3 A; 8.4 A, B; 8.14 A

Aquatic Science: 10 B

Estimated Time
3 class periods including a possibility of fieldwork

Materials
<u>For each pair of students</u>

Vials of various liquids such as alcohol, vinegar, oil, soapy water

Water

Eyedroppers

Pennies

Paper towels

Beaker

25 milliliters of distilled water

Pipette

New pennies

Old pennies

1 quarter

Tiny amount of dish soap

Cup of water

Regular paper clip

Water striders or photos of water strider

Native aquarium:

- 10-gallon aquarium or small aquariums for each group
- seines and nets
- gallon jugs for creek/pond water, collected plants and other aquatic organisms

Special Instructions

Prior to class, rub a tiny amount of dish soap over both sides of the quarters and let dry.

Safety Precautions

Students and teachers should wear safety goggles.

Be sure to stress safety in the field if you go out to collect for a native aquarium.

Procedure

1. Surface Tension of Water

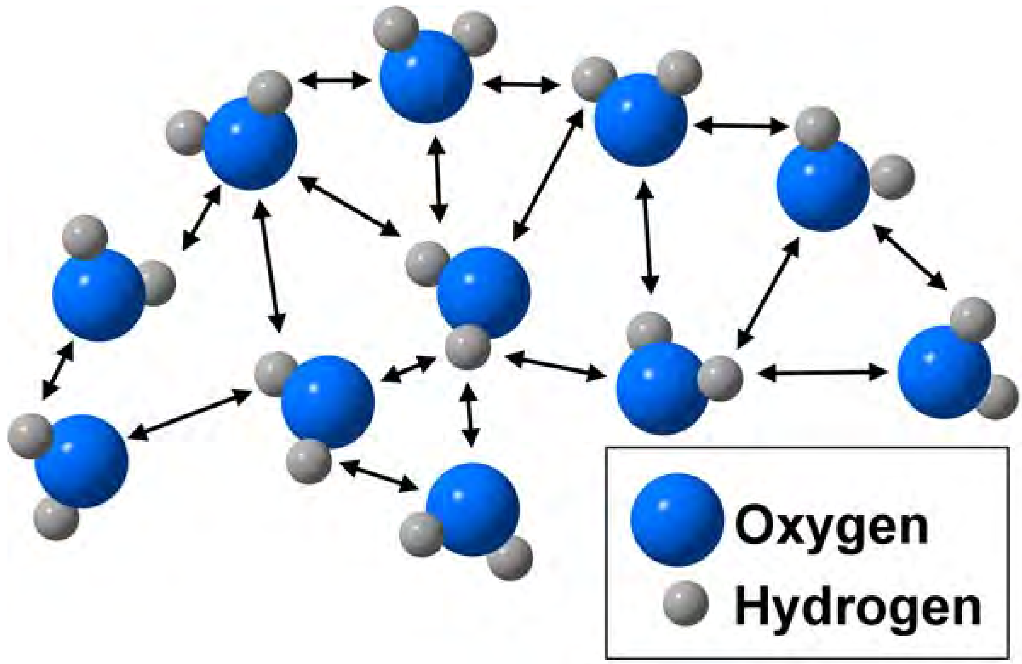
Have students predict how many drops of water they think can fit on a penny and note their predictions in their notebooks.

Try dropping water gently on the penny. Count the drops your penny holds. Have students describe what they see as the water accumulates on the face of the penny and compare the description of the water with the descriptions of the other liquids. Add your data for water to your table.

- **How are the various liquids alike or different from the water? Did the penny hold more or fewer drops of water than other liquids?** (Students should notice that the water piles up higher and rounder on the penny than any of the other liquids and should count more drops before the penny overflows.) Refer back to the students' predictions.

This property of water is called surface tension.

- **What do you think causes this to happen?** (Water's strong surface tension is caused by the attraction of water molecules to each other. The water molecules beneath the surface are pulled in all directions by this attraction, while the molecules at the surface are pulled together and in. This creates a tighter arrangement of molecules at the surface than beneath the surface and causes the round shape of a drop of water.)



- **What property of water molecules causes this to happen?** (Polarity)

2. Surface Tension of Various Liquids

Have students work in pairs. Place the penny on a paper towel. Experiment by dropping various liquids such as alcohol, vinegar, oil, soapy water, or other liquids one at a time gently on the top of a penny. Have students count the number of drops of each liquid that they can put on the penny before it runs off the edges of the penny. Students should make a table in their journals to record their results for each liquid.

Be sure to flush the eyedropper and rinse and dry the penny after each liquid is tested to be sure there is no contamination.

Describe what each liquid looks like as it accumulates on the penny. Add this data to your table. Be sure to flush the eyedropper and wash and dry the penny after each liquid is tested to be sure there is no contamination.

Extension

Prior to class, rub a tiny amount of dish soap over both sides of the quarter and let it dry.

- **How many drops of water do you think will fit on a quarter?**

(These quarters have been pretreated with a tiny amount of dish soap and allowed to dry, but students are not told about its treatment.)

Ask students to add water drops. (The water will immediately slide off the quarter.)

Encourage discussion of why the water is not piling up on the quarter. Students should realize that there is something different about the quarter.

Ask students to plan an investigation to find out what caused the water to slide off of the quarter. Provide materials to facilitate student investigations. When students discover the cause of the behavior of the water, discuss the problem of pollution in water.

- **How would pollution affect animal and plant life in the water?** (Too many phosphates from dish soap and laundry, or fertilizer in water can cause excess plant growth and eutrophication depleting the oxygen supply in water.)

3. Learning More About Surface Tension

Give each pair of students a cup that is about ¾ full of water. Have students very carefully place a regular paper clip on the surface of the water. This has to be done very carefully so it may take a few tries. The paperclip should sit on top of the water. You may see indentions at the ends where it bends the surface tension, but does not break it.

- **If the paperclip is put on the surface on end or on the edge, what happens?** (It will sink to the bottom of the cup.)
- **Why do you think the regular paper clip can stay on the surface of water?** (Students should realize that the paper clip is more dense than water and if dropped into the water will sink. It stays on top of the water because the water molecules are creating surface tension just as they did when they piled up on the penny.)

4. Observations in Nature

- **Have you ever seen anything like this in nature?** (Some students may remember seeing water striders or spiders move across the water without sinking.)

If there is a pond or creek nearby, take students to observe water striders, spiders, or other invertebrates that seem to skim across the water. Have students observe these animals closely. If you do not have a pond or creek nearby, try to capture and bring some water striders to class for close observation or use a photo. You may wish to set up a native aquarium to use for observations in this activity and future activities.

Setting Up a Native Aquarium. To set up a native aquarium, use a 10-gallon aquarium or several smaller aquariums. (One aquarium for each student group would be nice, but is not imperative.) Collect pond/creek water, aquatic plants, minnows, aquatic insects including water striders, a few rocks, or whatever is in your local pond or creek. If you have plenty of plants, you will not need a bubbler to aerate the water. If you don't have enough plants to keep oxygen replenished in your aquarium, you can use a bubbler or you can collect several gallons of extra pond water and add new pond water every day. **<u>Do not add tap water.</u>** It has too much chlorine and will kill the animals in your aquarium. Also, if you collect predators, (such as crayfish) be sure to keep them in a separate aquarium or they will eat everything.

Describe the water strider's adaptations in your journal. (Long legs spread the weight of the water strider over a large surface area. The unique arrangement of their legs and the surface tension of water give water striders the ability to glide across the surface of the water. Narrow pointed ends of the legs do not penetrate the surface. Close observation shows evidence of water's surface tension where the water strider's legs dent or bend the water’s surface, but do not break through.)

Photo courtesy of Valerie Bugh, larvalbug.com

You might have students do some library or Internet research to learn more about adaptations of the water striders legs.

These adaptations are characteristic of invertebrates that live in aquatic environments.

- **Do you think these would be genetic characteristics or learned behaviors? How would you know?** (It is genetic [an inherited trait] and is passed on to the young. You can see this by making many observations of these types of invertebrates in different places over a long period of time.)
- **Why would these be important characteristics to pass on to the next generation?** (The water striders legs give them many advantages in finding and catching prey in aquatic environments such as speed, and the ability to travel around and among plants and debris.)

Vocabulary

- Polar
- Surface tension

Lesson 1.6: Properties of Water
Ability to Dissolve Other Substances

Essential Concept

Water is called the “universal solvent” because many other solid, liquid and gaseous substances dissolve in water.

Objectives

1. Students know the difference between elements and compounds.
2. Students recognize water as an abiotic part of the ecosystem.
3. Students know that matter has physical and chemical properties.
4. Students recognize that chemical formulas are used to identify substances and can determine the number of atoms of each element in chemical formulas containing subscripts.
5. Students use models to help them understand abstract ideas.
6. Students will be able to explain, on the molecular level, what makes water a polar molecule. Students will also be able to show in a drawing that the polar nature of water can explain some of water’s properties.
7. Students will plan and carry out a comparative investigation.

TEKS

6.1 A, B; 6.2 A, B, C, D, E; 6.3 A, B; 6.4 A; 6.5 A; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A, B; 7.4 A; 7.12 A; 7.13 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 A, B; 8.4 A; 8.5 D

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 Class period

Safety Procedures

Wear safety goggles

Materials Needed

<u>For each pair of students:</u>

Safety goggles

Clear plastic cups

Graduated cylinders

Scale

Water

Salt

Blue and gray circles from previous lesson

Small green circles and large white circles to make models of salt molecules

Blue and yellow food coloring

Corn syrup

Bottle of warm club soda

Bottle of cold club soda

Paper towels

Old newspapers

http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/thermochem/solutionSalt.html (animation of water dissolving salt) Be aware that websites come and go. Please check before assigning for student research.

Procedure

1. Will water dissolve solids?

Give each pair of students a graduated cylinder, a clear cup, and a container of water, a scale and about 7 teaspoons of salt. Have students measure out 150 ml of water into the clear cup. Students should also weigh out 40 grams of salt on a piece of notebook paper and pour it into another cup. Have student begin adding salt to the water. Students will describe what they see in their journals. Have students stir the salt and water.

- **What happens?** (The salt will begin to dissolve and will disappear.) Have students write a description in their journals.

The amount of a substance that can **dissolve** in a liquid (at a particular temperature) is called the **solubility** of the substance. The substance being dissolved is called the **solute**, (in this case, salt) and the substance doing the dissolving is called the **solvent** (in this case, water). Water is often called "the universal solvent" because it can dissolve so many other substances.

- **How do you know when a solute** (like salt) **has dissolved in a solvent** (like water)? (When the solute is completely incorporated into the solvent).

Extension

- **Is there a limit to how much solute will dissolve in a solvent?** (Yes) **How do you know?** Students should give examples such as: (We have seen this happen when you add too much sugar to your tea and some settles to the bottom.)
- **How could we find out if more salt would dissolve in the water?** (We could add more salt to our solution and see if it dissolves or settles to the cup's bottom.)
- **Will water dissolve all solids? How could we find out?** (We could try a variety of other solids such as sugar, sand, baking soda, etc.)

2. Making a Molecular Model.

Give each pair of students the blue and gray circles to make models of water molecules and small green circles and large white circles to make salt molecules. The green circles represent sodium and the white circles represent chlorine. Together the sodium and chlorine are ionically bonded to make the molecule NaCl, which is sodium chloride or salt. This molecule is made up of a positively charged sodium **ion** and a negatively charged chloride ion. An **ion** is an atom or molecule, which has gained or lost one or more of its valence electrons, giving it a net positive or negative electrical charge. The **polarity** of water molecules enables water to dissolve many ionically bonded substances.

Water can dissolve salt because the positive part of water molecules (hydrogen) attracts the negative chloride ions, and the negative part of water molecules (oxygen) attracts the positive sodium ions. The attraction between the water molecules and the salt ions begins to overcome the attraction the ions of sodium and chloride have for each other and the water pulls away the ions of the salt one by one dissolving the salt. Use your paper circles to show how this could happen.

If you have time, you might want to show this video to illustrate how the water molecules disconnect the sodium and chloride. (Be aware that websites come and go and you may need to find another site if this one is taken off of the Internet.)

http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/thermochem/solutionSalt.html

3. Will water dissolve liquids?

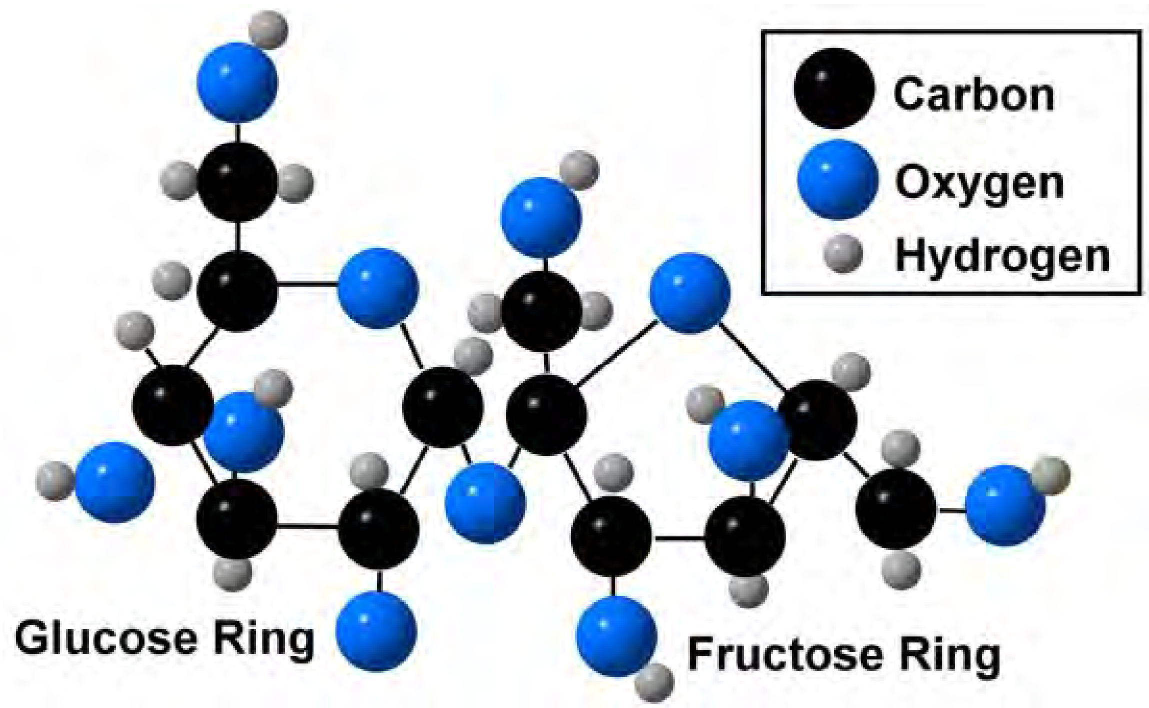
Provide pairs of students with clear cups of blue colored water (about ¾ of a cup and ¼ cup of yellow colored corn syrup. Corn syrup is mostly glucose, but also contains another sugar, fructose. Add the corn syrup to the water and see what happens. (The yellow corn syrup flows through the water and settles on the bottom of the cup. Some places you can see small spots of green where water dissolves the corn syrup. After a few minutes you may see a thin layer of green between the blue and the yellow.)

Stir the corn syrup into the water and describe what you see. (The liquid will turn green.)

- **Is the corn syrup dissolved in the water? How do you know?** (The two colors of liquid are completely mixed, changing the color, and nothing has settled to the bottom.)

Show students the diagram of sucrose molecules. Ask students to look at the different atoms in sucrose. Sucrose is a large molecule made up of carbon, oxygen, and hydrogen. Sucrose has many O–H bonds which are polar. These polar areas exhibit a positive charge near the hydrogen atom and a negative charge near the oxygen atom.

- **How do you think the glucose dissolves in the water?** (The polar glucose molecules attract the opposite charges on water's polar molecules.)



Extension

Will water dissolve all liquids? How could we find out? (We could experiment with dissolving other liquids such as mineral oil, vinegar, or alcohol and see what happens.)

4. Will gases dissolve in water?

We have seen the solids and liquids can dissolve in water.

- **Do you think that gases will dissolve in water? Why or Why not?** Let students discuss their ideas. Some students may not have thought of gases being dissolved in water, but other students may think of bubbly soft drinks.)

Provide each group of 5 students with a bottle of plain water labeled “1” and a bottle of warm club soda labeled “2” (both should have labels removed) paper towels, and enough newspapers to cover the desk and soak up spills. Have students make a data table and write their observations of the two bottles of liquid in their journals. **Are there any signs of gas in either bottle?** Open bottle number one very slowly. Write down any observations. (There will be a cracking sound as they break the plastic lid, but the water will not change.) Open bottle number two very slowly. Have students write down any observations in their tables. (The same cracking sound of the plastic lid will happen, but then there may also be a hiss and many bubbles will appear and rise to the surface and pop. Tighten the top of the cap back and fewer bubbles will continue to form.

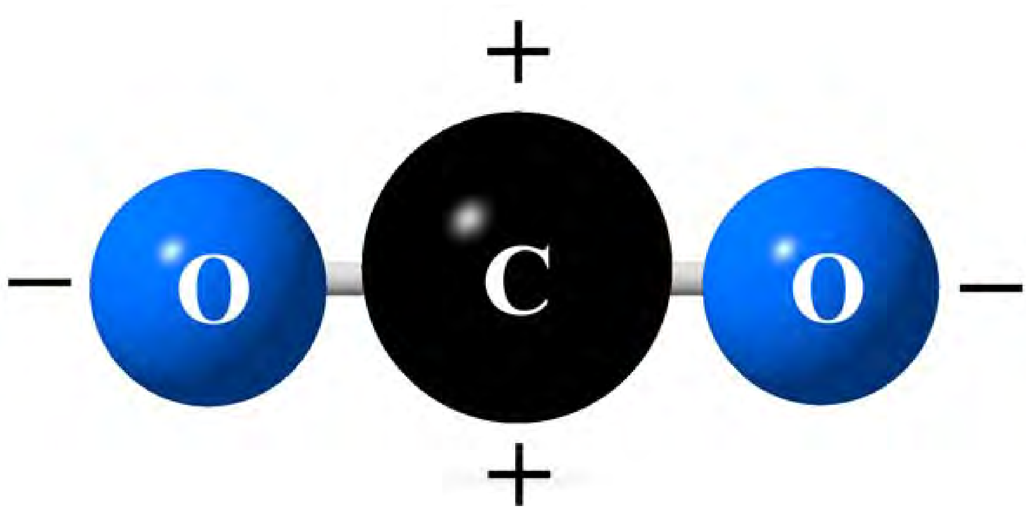
- **What do you think caused the hissing sound and the bubbles in bottle number two?** (A gas escaping)
- **What happened when the bottle cap was put back on the bottle?** (Fewer bubbles formed.)

- **What do you think is in each of the bottles?** (Plain water in bottle number one, and some kind of carbonated water in bottle number 2)
- **What is the gas that makes these bubbles?** Some students may know that the bubbles are carbon dioxide. (CO_2)
- **Could you see the CO_2 before the bottle was opened? Why not? Where was the CO_2?** (No, you could not see it, because it was dissolved in the water and when the pressure was released by opening the cap, the bubbles escaped.)

Explain to students that when club soda is manufactured, carbon dioxide gas is added to cold water under high pressure. This forces more gas to dissolve than ordinarily would. So when room temperature club soda is opened, some of the carbon dioxide escapes the solution.

5. Molecular Model.

Give students a large black circle to represent carbon and 2 large blue circles to represent oxygen. The two oxygen atoms attached on either side of the carbon atom. This creates a slight positive charge on the free (unattached) sides of the carbon atom and a slight negative charge on the free (unattached) sides of the oxygen atoms. This makes carbon dioxide a polar molecule and makes it soluble in water because the water molecules are attracted to these polar areas. The bond between carbon and oxygen is not as polar as the bond between hydrogen and oxygen in water, but is polar enough that carbon dioxide can dissolve in water. In carbonated water, molecules of carbon dioxide are thoroughly mixed and dissolved in water. Each molecule of CO_2 is surrounded by water molecules. The CO_2 molecules are not as strongly attracted by the water molecules as salt. This weaker attraction allows CO_2 to come out of solution easily.



- **Where do the CO_2 molecules go when they come out of solution?** (They go into the air. That is why if you leave the lid off of the club soda for long, it will lose its fizz).

6. Do you think carbon dioxide will stay dissolved better in hot or cold water? (Students will make a hypothesis.)

- **How could we find out?** (Students will plan and implement a comparative investigation. We have data for warm club soda. We could make observations of cold club soda and compare our data. Then we could heat a sample from the cold club soda bottle while keeping another sample cool to see what happens.)
- **What criteria will we use to decide if more carbon dioxide is escaping from the solution?** (More bubbles will come out of solution and go to the surface and pop.)
- **If more carbon dioxide stays dissolved in the solution what do you think we will see?** (Fewer bubbles come out of solution and go to the surface and pop.)

Give students the cold bottle of club soda and ask them to label it as bottle number three.

Have students open the cold club soda slowly and make observations and record them in their table.

- **How did the cold club soda compare to the warm club soda?** (Fewer bubbles) Use this information to change or keep the hypothesis you made earlier.

7. Gather more data.

Give students 4 cups, 1 cup should be 1/3 full of hot tap water, 1 cup should have ice and water. Have students fill each of the other 2 cups with 100 ml of club soda from the cold club soda bottle. Have student place one of the club soda filled cups in the hot water bath and one in the cold water bath. Watch the surface of the club soda in both cups.

- **Which cup has the most bubbles coming to the surface and popping?** (The cup in the hot water bath)
- **Does the carbon dioxide stay dissolved better in hot water or cold water?** (Carbon dioxide stays dissolved better in cold water.)
- **How do you know?** (Fewer gas bubbles escape from the club soda in the cold bath.)
- **Why do you think carbon dioxide gas escapes faster from hot water than cold water?** (Because the carbon dioxide is only slightly attracted to the polar water molecules so that even at room temperature it will slowly escape from solution. Warming the club soda increases the escape of carbon dioxide because it causes the molecules in the solution to move faster and this movement breaks the loose attachment and allows the carbon dioxide to escape faster.)

Extension

At the beginning of class, fill glasses with tap water from a faucet with an aerator screen (which almost all faucets have). Set the glasses out, by the end of class bubbles will form all around as the oxygen and air dissolved by the agitation of the screen will come out of solution. If you have some faucets in your classroom with and without screens, the smooth laminar flow of a non-screen faucet will not produce water that out-gasses air later in the glass. Have students compare water from the two types of faucets. (**Note:** Often you can twist the aerator off of a faucet, if you don't have both types of faucets.)

- **How does water dissolve oxygen in nature?** (The agitation of waves and wind helps to aerate the water in lakes, and other surface water.)

8. Applying What We Learned

- **Based on this experiment, why do you think people store left over soda in the refrigerator?** (Less carbon dioxide escapes when the soda is colder and the molecules are moving more slowly so that the soda won't lose its fizz.)
- **Why do you think it is important in the natural environment that water can dissolve gases?** (Aquatic animals need oxygen just as land animals do. Oxygen is dissolved in the water that these animals live in. Fish and other aquatic animals are adapted to use their gills to get oxygen from the water in order to stay alive.)
- **Based on what we learned today, do you think it would be easier for aquatic animals to get oxygen in cold water or warm water?** (Cold water–More oxygen can be dissolved in cold water, when the temperature of the water gets too warm less oxygen is available for aquatic animals.)

In the summer some fish species such as gar may come to the surface of a pond to gulp air. **Why do you think this happens?** (They are responding to the external stimuli in the environment [amount of dissolved oxygen in the water]. When there is not enough oxygen dissolved in the water, fish must find another [though less efficient] way of getting oxygen. Some species, such as gar, are able to absorb oxygen through their swim bladder, which they can fill with air by gulping air from the surface.)

Vocabulary

- Dissolve
- Ion
- Solubility
- Solute
- Solvent

Lesson 1.7: Investigating Water Consumption

Essential Concept

Water is a renewable natural resource, but access to clean water is finite and conservation is important.

Objectives

1. Students will investigate their own use of water and devise ways to cut usage to conserve our water supply
2. Students will identify the constants and the dependent and independent variables in the water conservation experiment.
3. Students will make changes in the amount of water they use and will record and graph results.

TEKS

6.1 A, B; 6.2 A, B, C, D, E; 6.4 A; 7.1 A, B; 7.2 A, B, D, E; 7.4 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.4 A; 8.11 B

Aquatic Science: 2 E, F, H, J

Environmental Science: 2 E, F, I, K

Estimated Time

3 Class periods

Materials

1 *Water Use Record* sheet for each student

1 *Bar Graph Template* sheet for each student

Pens or pencils; blue and red pencils

Procedure

Day One

1. Water as a Renewable Resource

We've talked about water as an important abiotic part of the environment.

- **What are some of the reasons water is important in the environment?** (All living things require water to transport nutrients; some living things must take in oxygen, which is dissolved in water in the aquatic environment. Water provides important habitat in many biomes on Earth, etc.)

- **What properties of water are important in the environment?** (The **polarity** of the molecule allows water to have **cohesion** [stick to itself] and **adhesion** [stick to many other things]. It also causes **surface tension**, which allows dew to form [for some animals to drink] and provides a way for some animals to catch prey. It has the property of **dissolving** other materials which allows oxygen to be dissolved in the water for aquatic animals to obtain through gills or other mechanisms. The solid **state** of water is less dense than the liquid state and therefore floats allowing life to continue in the water under ice in winter and cold climates, the **3 states** allow water to be cleaned, recirculate, and be reused.)

Water has been recirculating over and over during the whole history of the Earth.

- When we have something in the environment that is so important and is reusable, what do we call this? (A renewable natural resource)
- **If water is renewable, does that mean that we can use it any way we want to and as much as we want to? Why?** (No. Water may recycle, but we have a finite amount available and it can be costly to find, clean, desalinate, and remove water from difficult places if it is not part of the small percent of clean water to which we already have access. We cannot take water for granted.)

2. Cast Beyond Tomorrow

Ask students to research the answers to the following questions as homework.

- **What is the source of your drinking water?**
- **Are there any water quality or water quantity issues about your water source?**
- **What will affect your water source in the future?**
- **Who makes decisions that affect your water source?**

How much water do we use every day and what do we use it for? (Allow students an opportunity to discuss and think through their use of water.)

To help us find out how much water we use and how we use it every day, we will keep data about our water use. Distribute a Water Use Record sheet to each student.

Instruct students to use the sheet to record their water use for the next 24 hours and bring the completed page to class the next day.

Day Two

3. Our Water Use

Have students work in groups of 4 to tabulate their group's water use. Then have each group put the amount of water used on the board and calculate a class water use total. Lead class discussion of water use findings.

- **Are students surprised by how much water the class uses each day?**
- **Why would it be important to reduce our water use?**

- **How could we reduce our daily water use?**
- **Where did we use the most water?**

4. Experimenting with Water Use

Ask students to agree upon one thing they will all change about their daily water use to conserve water (for example, take a shorter shower). Alternatively, each group could choose a different water use to change.

Using the *Water Use Record* sheet, instruct the students to record their water use for the next 24 hours (Day 2), <u>changing the amount of water used for agreed-upon activity</u>, and bring the completed page to class the next day.

Day Three

5. Experimental Variables and Constants

Ask students to identify the constants and the dependent and independent variables in their water conservation experiment. (**Independent variables** are the water use habits they changed; **dependent variable**s are the things that change depending on the action they have taken, such as the amount of water they used; **constants** include the person using the water and recording water use, facilities used, and the water use habits they did not change.)

6. Reporting Results of our Experiment

Have each group report their water use findings and tabulate results for their group and write their results on the board. Calculate a class water use total.

7. Graphing Our Results

Using their *Personal Water Use* information, instruct the students to create a bar graph on the template provided to show their results. Be sure that they provide the following:

- An appropriate title
- A label for each axis with appropriate units
- An appropriate number scale, and category labels
- Correctly plotted data

Have students add the *Water Use Record* sheets and graphs to their science notebooks.

- **Based on our data, what conclusions can we draw about ways to conserve water in our every day life?**
- **Where did we use the most water?**
- **Was the class able to cut their water use?**
- **If each group made a different water use change, compare water use and conservation results between groups. Which change made the biggest difference in the class total water use?**

Lead a class discussion about water conservation and challenge students to make their water use changes permanent and incorporate other water use changes.

Vocabulary

- Adhesion
- Cohesion
- Dissolving
- Polarity
- Renewable natural resource
- States
- Surface tension

WATER USE RECORD

Objective

Record and present personal water usage data.

Directions

1. Using the charts, make a tick mark in the appropriate box each time you use water, or per minute, for showers.

2. Multiply the number of "Times" (or minutes, for showers) by the "Gallons per time" and place that number in the column "Total gallons per activity."

3. Add the "Total gallons per activity" column and enter the total in the last box.

4. Using your Personal Water Use information, create a bar graph on the template provided to show your results. Be sure to provide the following:
   - Use a red pencil for your original data and a blue pencil for your data from the second day
   - An appropriate title
   - An appropriate number scale, and category labels
   - A label for each axis with appropriate units
   - Correctly plotted data

Student Page

Name: ____

Date: _____________

Personal Water Use—Day 1

Activity	Times	Gallons per time	Total gallons per activity
Flush a toilet		4	
Brush teeth with water running		3	
Take a shower (count minutes)		5 per minute	
Take a bath		20	
Eat one meal		2.5	
Total Gallons Daily Water Use			

Personal Water Use—Day 2

Name:_______________________________________

Date: _______________

Activity	Times	Gallons per time	Total gallons per activity
Flush a toilet		4	
Brush teeth with water running		3	
Take a shower (count minutes)		5 per minute	
Take a bath		20	
Eat one meal		2.5	
Total Gallons of Daily Water Use			

BAR GRAPH TEMPLATE

Name: ____
Date: _________________

Lesson 1.8: Reading and Research

Essential Concept

Water is important, is diversely distributed, and useable water is scarce. Water has many uses, and specific properties, but is sometimes polluted. Water quality can be determined with various tests.

Objectives

1. Students will read *Chapter 1: Water Is Life* to reinforce concepts and vocabulary and find new information.
2. Students will look at various websites and search for water quality information and write a paragraph about the quality of water in Texas.
3. Students will make a table showing water properties and their importance.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

Varies. Reading and research may be done in class or as homework. Allow at least 20 minutes for in class discussion and questions.

Materials

Student Guide, Chapter 1

Science journal

Pens and pencils

Computer and Internet

Procedure

1. Student Reading

Have students read *Chapter 1: Water Is Life*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) Why is water important? What is the hydrosphere?

Water is essential to life. The hydrosphere is all the water on Earth.

2) What are natural resources? What are aquatic resources?

Natural resources are anything found on Earth that can't be made by humans. Aquatic resources are water and all things that live in or around water.

3) How do we use water?

Uses of water may include drinking, cooking, washing, growing crops, generating power, manufacturing, transportation, etc.)

4) How much water is available for human use?

The amount of water available for human use may be described as less than 0.003%, a tiny fraction of all water or about 2 million gallons per person.

5) What is conservation? Why is it important?

Conservation is careful use. Conservation is important because water and other resources are essential and in limited supply.

6) What are the special properties of water? Why are they important?

Answers may include:

Water Property	Importance
Can take three forms: liquid, solid and vapor	Permits self-purifying (water) recycling
Solid form (ice) is not as dense as liquid form	Ice floats and lakes do not freeze solid so organisms can survive in winter Ice can break rocks by freezing and thawing
Dissolves many different things	Aquatic animals and plants can obtain oxygen from water Animals and plants can draw nutrition from water

Molecules attract one another, creating surface tension	Things can float on or move across the surface of water Water forms drops
Molecules cling to other things	Water can climb up plant roots and stems Blood can flow through tiny blood vessels
Has a high boiling point and a low freezing point; Can absorb a lot of heat before it begins to get hot	Provides living things a fairly constant environment
Transparent to light	Plants can live under water

7) How can we tell if water is polluted or clean?

We tell if water is polluted or clean by determining its quality using physical, chemical and biological tests.

8) How does water pollution affect aquatic life?

Some ways water pollution affects aquatic life include:

- Cloudy water blocks light and slows plant growth.
- Too much fertilizer causes overgrowth of algae.
- Toxic chemicals are poisonous to living things.

9) How does water's temperature affect the amount of oxygen in it?

Cold water holds more oxygen.

10) What is water quality?

Water quality is water's fitness for a particular use.

11) How do humans affect water quality?

Humans affect water quality by polluting or conserving water. Answers may include specific examples.

2. Internet Research

Have students do some Internet research on water quality in Texas. Have students use the information they find in their research to write a paragraph in their science journals about water quality in Texas.

You may want to have students Google “Texas Parks and Wildlife Water Quality”, or “Texas Commission on Environmental Quality” or “Natural Resource Conservation Service Water Quality”, or “United States Geological Service and Water Quality or assign some specific websites such as:

http://www.tpwd.state.tx.us/landwater/water/conservation/fwresources/biotic.phtml

http://www.tpwd.state.tx.us/landwater/water/environconcerns/water_quality/sigsegs/

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_lf_k0700_1117a.pdf

http://www.tceq.state.tx.us/

http://www.tceq.texas.gov/waterquality

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/quality/

http://water.usgs.gov/owq/

http://ga.water.usgs.gov/edu/waterquality.html

http://www.indeed.com/q-Water-Quality-jobs.html

Be aware that websites come and go. Please check websites before assigning to students.

Vocabulary

- Aquatic organisms
- Aquatic resource
- Clean Water Act
- Decompose
- Dissolved oxygen
- Hydrosphere
- Inorganic
- Natural resource
- NRCS–Natural Resource Conservation Service
- Organic
- Reservoirs
- TCEQ–Texas Commission on Environmental Quality
- TPWD–Texas Parks and Wildlife Department
- Water pollution

Lesson 1.9: Student Investigation
Water Quality

Essential Concept

Water quality can be assessed with various technology and methods.

Objectives

1. Students use technology and methods for testing water for pollution and determining water quality.
2. Students become familiar with the use of water chemistry test kits and equipment.
3. Students identify sources of water samples
4. Students use safe practices and conservation of resources in the lab.
5. Students collect data and record information in tables.
6. Students draw conclusions based on data.
7. Students make connections between testing of water quality and careers.
8. Students identify ways human activity can affect aquatic environments.
9. Students demonstrate the use of course apparatuses, equipment, techniques, and procedures.
10. Students collect baseline quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, phosphates, nitrogen compounds, and turbidity.
11. Students identify water quality in a local watershed.
12. Students predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
13. Students analyze the cumulative impact of human population growth on an aquatic system.
14. Students identify the impact of various laws and policies such as the Clean Water Act on aquatic systems.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 8.1 A, B; 8.2 A, C, D, E; 8.4 A, B

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 B; 7 C; 12 A, B, C, E

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 E; 4 D, E; 5 B; 9 A, B, C, E, K

Estimated Time

2 Classes periods with a possibility of fieldwork

Materials

Safety goggles—one per student

At least 3 water samples for each group pre-labeled A, B, C. Sample sources may be tap water, rainwater, pond water, creek water, bay water, etc. depending on local resources

Water quality test check sheets, kits, probes, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, etc.

Water Chemistry Investigation sheet for each student

Physical Water Quality Indicators check sheet

Invertebrates & Vertebrates as Water Quality Indicators information sheet

Bug Picking Data Sheet

High school students should also have secchi disc, stop watch, tennis ball or piece of wood, salinity test

Special Instructions

Water samples and test kits and equipment must be prepared in advance.

The included *Water Chemistry Investigation* sheet may require modification depending on number of water samples and water quality test kits, meters, or other equipment used.

Safety Precautions

Students and instructors must wear safety goggles when using chemical tests.

Use extra care when handling glass.

Stress field safety for classes conducting field investigations.

Procedure

Day One

1. Water Chemistry

We've talked about how important water is and how limited our access is to water that is useable by humans and other living things.

- **What kinds of things limit the water that living things can use?** (Sediment, chemical pollutants such as fertilizers and herbicides, heat, amount of dissolved oxygen, organic wastes and decay, salts, etc.)

Today we will learn some ways to identify pollutants in water.

Use a cooperative learning activity. Divide the class into four groups. Each group will lead a class discussion of different components of water chemistry. Give each group one of the definitions. (See *Definition* sheet at the end of the lesson.)

Ask the groups to read and discuss the definitions and answer the questions.

Have students consider what it means for one water sample to have a higher or lower pH, conductivity, dissolved oxygen level or nitrate content than another.

Groups will share their ideas and information with the class.

Have students take notes in their science notebooks describing the meaning of each characteristic.

Definitions

- **pH** is a measure of acidity. Pure water has a pH of 7, which is considered neutral. In the United States, most rainwater is moderately acidic (5.5) due to contamination from acid-forming gases in the air. These gases include carbon dioxide, sulfur dioxide and nitrogen oxides. They come from the burning of fossil fuels. Acidity can cause toxic heavy metals to dissolve into the water. **What could this acid rain mean for local water supplies? Is it better to have high, low, or neutral pH levels?**
- **Conductivity** measures how easily electricity flows through the water. Salts dissolved in water allow it to conduct more electricity. Other substances that may not be dissolved, but are suspended in the water, also cause it to conduct electricity more easily. These may also cause the water to appear cloudy or dark. Some common causes of higher conductivity include wastes from animals or humans and eroded soils that have washed into the water. Water in estuaries varies in salinity. Ocean water is called saltwater and is about 35 parts per thousand salt, or 3.5%. Texas' Laguna Madre has even higher salinities, due to little rainfall, evaporation, and minimal exchange of water between the ocean and Laguna Madre waters. **Why would differences in salinity be important to local ecosystems?**
- **Dissolved oxygen** is important to support aquatic life. In general, higher dissolved oxygen is better for fish and other aquatic life. Air is 21% oxygen or 210,000 parts per million. Most of Texas' waters are 0.0005-0.0015% oxygen or between 5 and 15 parts per million**. In hot summers oxygen levels may be lower. What would this mean for local aquatic life?**
- **Nitrates** can come in many forms. Fertilizer and animal and human waste are common sources of nitrates in Texas' waters. Golf centers use a lot of fertilizer to keep their golf courses green. Nitrates may stimulate plant growth. **What sources of fertilizer might be found in your area? What would this mean for local aquatic life?**
- **Phosphates** can come from fertilizers and from household detergents. Phosphates stimulate plant growth. What sources of phosphates might be found in your area? How do they affect the life in water?

2. Testing Water Samples

Prepare in advance by setting up the room. If there are enough water samples and water quality test kits, distribute a set to each group. If there is only one set of equipment for each test, provide water samples to each group and set up stations around the room where groups take turns using the equipment at each station to test their water samples.

Distribute a *Water Chemistry Investigation Sheet* to each student.

Divide students into groups. Give each group a set of water samples. Tell students the sources of the water samples (e.g., tap water, rain water, pond water, etc.), but do not tell students which sample is which. Explain that they must figure out which is which by testing the samples.

First have students use the check sheet for *Physical Indicators of Pollution* to record observations about color and odor for each water sample.

Demonstrate the use of each kit, meter, or other equipment according to the directions accompanying it.

Have students test each sample and record their results.

Have students place the completed data sheets in their science notebooks.

Have students clean up and prepare kits, meters, or equipment for use by the next group or class.

Day Two

Finish any testing that was not completed on Day One.

3. Assessing What We Learned: Drawing Conclusions Based on Data

Have each group report the results for one of the water chemistry tests that they conducted yesterday, and their hypotheses about the source of one of the water samples. (Tap water, rainwater, pond/creek water, etc.)

- **What data do you base your hypothesis on?**
- **Which water sample would you drink? Why?**

Reveal the source of each of the water samples (e.g., A is tap water, B is rain water, C is pond water, etc.) and discuss the **data** on which your conclusions are based.

Be sure to address any misconceptions students may have about each water characteristic.

Discuss application of these testing skills during field trips to aquatic environments.

- **How would each of these tests help us to understand what is happening in a local aquatic ecosystem?**

Extension 1

Follow up the Internet research done in the last lesson (1.8) by discussing careers found when researching water quality.

- **What jobs help to monitor water quality and plan ways to alleviate environmental conditions that impact water?** (Soil and water scientists at various governmental agencies (such as TPWD, TCEQ, NRCS), university researchers, etc.)

- **What kind of education is necessary to have one of these jobs?** (At least a bachelors degree in hydrology, aquatic studies, biology, ecology or other science degree)

You may want to invite one of the scientists from one of these agencies (TPWD, TCEQ, NRCS) to visit your class and answer questions about their job and how they were trained.

Extension 2

Have students do some Internet research to learn about the **Clean Water Act** and identify the impact of this law on aquatic systems.

Be sure to check websites to be sure that they are still active.

Clean Water Act Websites:

http://www.epa.gov/regulations/laws/cwa.html

http://www.epa.gov/lawsregs/laws/cwahistory.html

- **How does this law fit into the jobs that are concerned with water quality?**

Extension 3

Take a field trip to evaluate a nearby creek or pond using the tests you have practiced and the check sheets at the end of the lesson. You may also want to collect samples for a native aquarium.

Students may start a long-term study of a local aquatic site by visiting a nearby pond or creek and collecting baseline water quality data and making observations of human activity along the banks of the creek or pond. If you have an aquatic site on the school grounds, the water quality data can be done on a regular basis along with weather data (See Lesson 2.2). (Daily, weekly, monthly, depending on your lesson plans)

Students should predict how human activities impact physical, chemical, and thermal changes in the water, which will affect the living and nonliving components of the aquatic ecosystem.

Students should look at the *Weather Data, Physical Indicators of Pollution* check sheet, water temperature, turbidity, pH, salinity, nitrates, phosphates, dissolved oxygen, *Invertebrate and Vertebrate Water Quality Indicators* information sheet, and macro-invertebrate identification sheets such as the *Bug Picking* sheet from Texas Parks and Wildlife Department.

- **Where does the water come from to this aquatic ecosystem?**

Have students analyze the cumulative impact of human population growth on this aquatic ecosystem.

- **How might this impact change over the coming years?**

Vocabulary

- Conductivity

- Dissolved oxygen
- Nitrates
- Phosphates

Definitions

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- **Nitrates** can come in many forms. Fertilizer and animal and human waste are common sources of nitrates in Texas' waters. Golf centers use a lot of fertilizer to keep their golf courses green. Nitrates may stimulate plant growth. **What sources of fertilizer might be found in your area? What would this mean for local aquatic life?**

- **Phosphates** can come from fertilizers and from household detergents. Phosphates stimulate plant growth. What sources of phosphates might be found in your area? How do they affect the life in water?

WATER CHEMISTRY INVESTIGATION

Objective

1. Record your group's observations about the color and odor of each water sample in the table below.
2. Following the directions for each meter, test kit or other equipment to test each water sample and record data in the table below.

Group: ____ (names)
Date: ______________________

Physical and Chemical Characteristics of Unknown Water Samples

Water sample	Temperature (°C)	Color	Odor	Foam	pH	Conductivity ______ (units)	Dissolved oxygen ______ (units)	Nitrates And/or phosphates ______ (units)	Water sample source

WEATHER OBSERVATIONS AND MEASUREMENTS

Objective

Obtain, record, and present weather data.

Name: ____

Date: ______________________

Location: ____

Weather factor	Observation or measurement
High temperature	
Low temperature	
Wind speed	
Wind direction	
Atmospheric pressure	
Relative humidity	
Precipitation	
Cloud cover	

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A ***musky*** smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A ***chlorine*** smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Invertebrates and Vertebrates as Water Quality Indicators

Invertebrates

A stream with:

- A great variety of insects, with few of each kind, indicates clean water.
- Less variety of insects, with greater abundance of each kind, indicates that there is too much organic matter in the water.
- Finding only one or two kinds of insects in great abundance indicates severe organic pollution caused from excessive human or livestock waste or high algae populations.
- If no insects are found, but the stream appears clean there may be some type of toxic pollution, which includes chemical pollutants such as chlorine, acids, metals, pesticides, and oil.
- Excessive sediment may be caused by erosion or discharge from a pipe and may reduce the amount of water in the stream causing extreme temperatures, and causing a loss of oxygen, which may smother insects resulting in a reduction of the number of animals in the area.

Note about Invertebrates

The types of **invertebrates** found can help students know about the quality of the water. Print out the Texas Parks and Wildlife *Bug Picking Data Sheet* at **the end of this lesson** to help identify invertebrates found in creeks and indicate which invertebrates are associated with clean water and which predominate in polluted water.

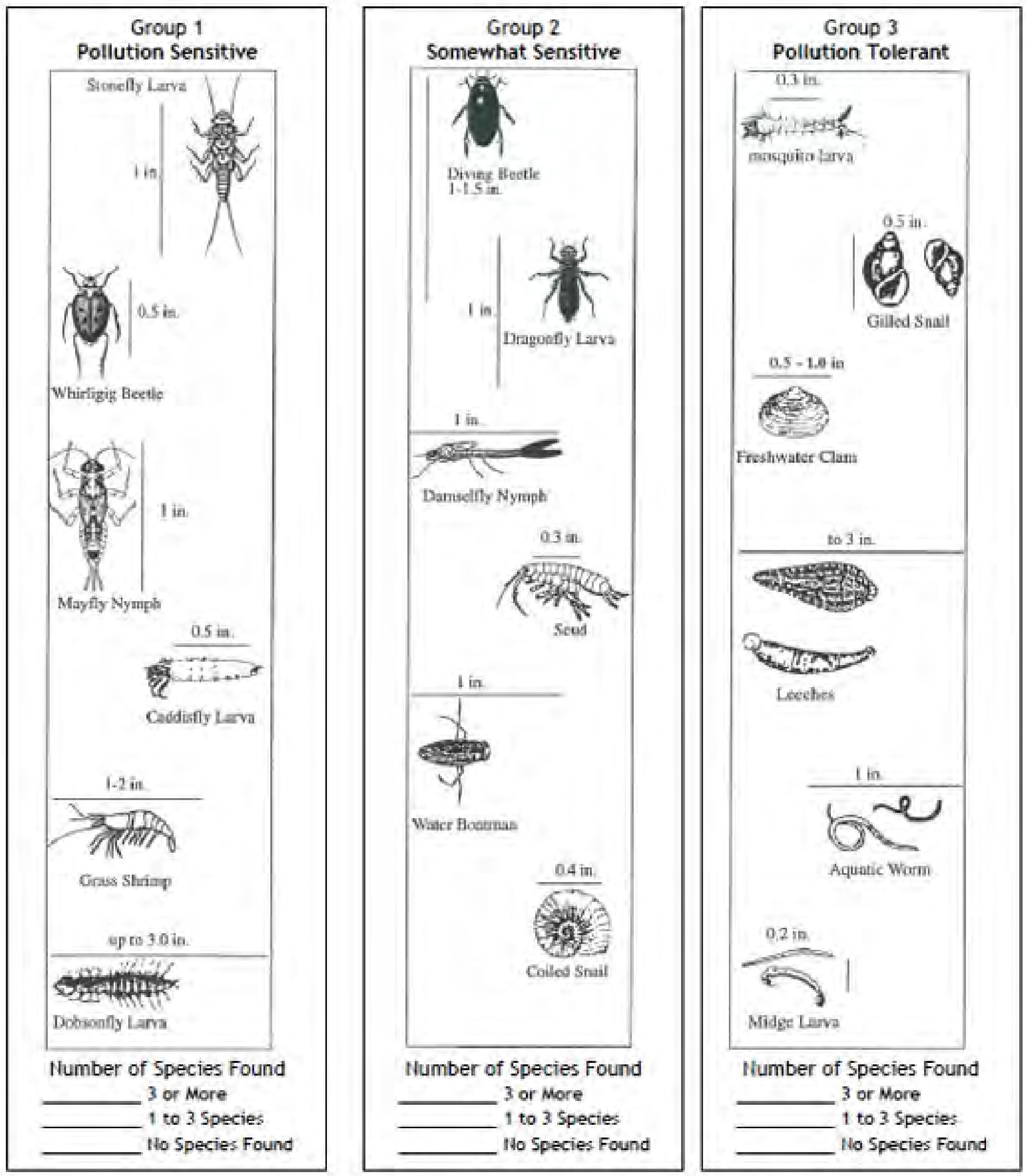
Vertebrates

- If fish are exhibiting some odd behavior such as jumping out of the water or being non-responsive, it may indicate toxins in the creeks. A chemical analysis is needed to find the source of the toxin. Contact the TCEQ.
- If there are no fish or other vertebrates in the creek, it may indicate that the creek is stressed from urban runoff, sewage, or toxins entering the stream. Chemical analysis is needed to the find the source of the problem. Contact the TCEQ.

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department

Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: (Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: **Not Polluted** **OK** **Polluted**

Chapter 1 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **What proportion of the water on the Earth is fresh water?**

   A 3%

   B 25%

   C 75%

   D 97%

2. **What is water quality?**

   A Water running off hot pavement

   B Water's fitness for a particular use

   C Water used mainly for agriculture

   D All of the above

3. **Water is a unique substance. It can be found on Earth in all three states—solid, liquid, and gas. Which of the following are other properties of water?**

   A Exhibits surface tension

   B Acts as a solvent

   C Is transparent

   D All of the above

4. **In the experiment in which you recorded your daily water use, what was a constant?**

   A The person using the water

   B The amount of water used

   C The ways in which water was used

   D The temperature of the water

5. **How does water pollution affect aquatic life?**
   A Cloudy water blocks light and slows plant growth
   B Too much fertilizer causes overgrowth of algae
   C Toxic chemicals are poisonous to living things
   D All of the above

6. **How do humans affect water quality?**
   A By taking biological surveys
   B By creating surface tension
   C By boiling and freezing water
   D By polluting or conserving water

7. **What is the hydrosphere?**
   A All the freshwater on Earth
   B All the water on Earth
   C Two hydrogen atoms and one oxygen atom bonded together
   D None of the above

8. **What are natural resources?**
   A Any recyclable substance
   B Anything made in a factory
   C Anything found in the hydrosphere
   D Anything found on Earth that can't be made by humans

9. **What is conservation?**
   A Careful use
   B Thinking very hard
   C Taking anything we want
   D Taking water for granted

10. How does water's temperature affect the amount of oxygen in it?

- **A** Cold water floats
- **B** Liquid water turns to gas
- **C** Cold water holds more oxygen
- **D** Oxygen is vital for life

11. Earth's land areas, oceans, and atmosphere maintain fairly constant average temperatures. What is the best explanation for these constant average temperatures?

- **A** Earth's Northern Hemisphere and Southern Hemisphere have opposite seasons
- **B** Earth is tilted and rotates daily on its axis
- **C** The continuous motion of air and water distributes the sun's energy
- **D** Global weather systems generally move from west to east

12. A frog lives in a pond containing duckweed.

Facts About Duckweed
• Duckweed is a small plant that grows in water. • Many water birds depend on duckweed for food. • Duckweed can reproduce rapidly in water that is rich in the nutrients used in agriculture

Which of these human activities would most likely cause an overgrowth of duckweed in a pond environment?

- **A** Gradually introducing geese into the pond
- **B** Fishing in the pond as recreation
- **C** Planting trees in nearby forests
- **D** Heavily fertilizing nearby farm fields

Chapter 1 Assessment

Write your own answer for each of the following questions.

1. How much freshwater is available for living organisms—including humans—to use? Compare this to the amount of saltwater on Earth and to the total amount of all water on Earth. Explain why water is a natural resource that must be conserved.

2. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as farm irrigation, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Texas.

3. Create a chart to describe three special properties of water and to justify why these are essential to life on Earth.

Chapter 1 Assessment Answer Key

Multiple-choice questions

1. What proportion of the water on the Earth is fresh water?

A. 3%

2. What is water quality?

B. Water's fitness for a particular use

3. Water is a unique substance. It can be found on Earth in all three states—solid, liquid, and gas. Which of the following are other properties of water?

D. All of the above

4. In the experiment in which you recorded your daily water use, what was a constant?

A. The person using the water

5. How does water pollution affect aquatic life?

D. All of the above

6. How do humans affect water quality?

D. By polluting or conserving water

7. What is the hydrosphere?

B. All the water on Earth

8. What are natural resources?

D. Anything found on Earth that can't be made by humans

9. What is conservation?

A. Careful use

10. How does water's temperature affect the amount of oxygen in it?

C. Cold water holds more oxygen

11. Earth's land areas, oceans, and atmosphere maintain fairly constant average temperatures. What is the best explanation for these constant average temperatures?

C. The continuous motion of air and water distributes the sun's energy.

12. Which of these human activities would most likely cause an overgrowth of duckweed in a pond environment?

D. Heavily fertilizing nearby farm fields

Write-in questions

1. How much freshwater is available for living organisms—including humans—to use? Compare this to the amount of saltwater on Earth and to the total amount of all water on Earth. Explain why water is a natural resource that must be conserved.

   Answers should include:

   - Amount of freshwater available for living organisms:

     Less than 0.003%, or a tiny fraction of all water on Earth, or about 2 million gallons per person
   - **97% of all the Earth's water is salt water**
   - Reasons for conserving water:

     Water is essential to all life
   - **No new water can be made**

2. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as farm irrigation, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Texas.

   Answers may include:

Activity/technological solution	Potential benefit	Potential drawback
Paved roads/parking lots	Improve surface transportation	Water running off surface carries heat and pollutants
Farm irrigation	Improves food production	Irrigation uses a lot of water
Use of fertilizers	Increases plant growth	Cause overgrowth of algae
Use of herbicides	Kills problem weeds	Are toxic to other plants and animals
Sewer systems	Carry away waste	Can contaminate waters

3. Create a chart to describe 3 special properties of water and to justify why these are essential to life on Earth.

Answers may include:

Property	Importance
Water can take three forms: liquid, solid and vapor	Water permits self-purifying and recycling.
The solid form of water (ice) is not as dense as the liquid form.	Ice floats and lakes do not freeze solid so aquatic organisms can survive in winter. Ice can break rocks by freezing and thawing.
Water dissolves many different substances.	Aquatic animals and plants can live and grow under water. Animals and plants can draw nutrition from water
Water molecules attract one another, creating surface tension.	Things can float on or move across the surface of water. Water forms drops.
Water molecules cling to other things	Water can climb up plant roots and stems. Blood can flow through tiny blood vessels.
Water has a high boiling point and a low freezing point and can absorb a lot of heat before it begins to get hot.	Water provides living things a fairly constant environment.
Water is transparent to light.	Plants can live under water.

The Ultimate Recyclable

All water on Earth, including the water that flows from our taps and the water we flush down the drain, is part of a natural cycle. You are drinking the same water that dinosaurs drank millions of years ago.

Chapter 2

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will be able to:

1. Diagram and describe the path of water through the hydrosphere, geosphere and atmosphere (the water cycle).
2. Identify the sun's energy as the driver of the water cycle fueling evaporation and transpiration, which puts water into the atmosphere to form clouds.
3. Identify ways that the water cycle impacts the aquatic environment.
4. Identify ways that humans and other living things impact the water cycle.
5. Generate ideas for finding reliable weather information.
6. Use appropriate instruments and charts to measure and record weather at their school in preparation for measuring weather at an aquatic site.
7. Define and differentiate between weather and climate
8. Make a model of runoff and infiltration of rainwater in an aquatic environment.
9. Model how pollution gets into aquatic environments and generate a list of 5 ways people can help keep water clean.
10. Present information about runoff and pollution in aquatic systems with an illustrated song, a rap, or a children's story.
11. Identify the source of home and school tap water.
12. Identify how wastewater from home and school is treated.
13. Diagram water from the source to their home, through their drains, to wastewater treatment, and back into the environment.
14. Play a computer game to test their appropriate use of water in their homes.
15. Make a drawing with labels to show what they have learned about water in their homes and the environment.

16. Make a drawing with labels to show what they have learned about water in their homes and the environment.
17. Using a specific example, explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences to aquatic resources in Texas.
18. Explain how the availability of freshwater for humans and other living organisms is dependent upon the water cycle
19. Read *Chapter 2: The Ultimate Recyclable* to reinforce concepts and vocabulary and find new information.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 C, D; 6.3 B, C; 6.4 A; 6.12 E; 7.1 A, B; 7.2 C, D; 7.3 B, C; 7.4 A; 7.8 B, C; 7.13 A; 8.1 A, B; 8.2 C, D; 8.3 B, C; 8.4 A; 8.10 A, B

Aquatic Science: 2 G, J; 4 A; 6 A; 7 A

Environmental Science: 2 H, I, K; 4 C; 5 B; 6 A;

Materials

For every activity students will need their science journals.

Lesson 2.1

Long strips of butcher paper

Crayons, markers, chalk, water colors

Copies of *Student Instructions* and *Rubric* for Water Cycle Story

Lesson 2.2

Student water cycle diagrams and answers to questions from yesterday

Copy of *Weather Terms and Measurements Table* for each student

Copy of *Wind Speeds and Descriptions Chart* for each student

Copy of *Weather Observations and Measurements* sheet for each student

Pens or pencils

Weather instruments

Computers and Internet access

Lesson 2.3

<u>For Each Group of 3 Students</u>

Runoff and Infiltration Activity:

3 large foil roasting pans

Pump sprayer containing water

Food coloring

Soil (use topsoil or freshly dug yard/garden soil—commercial potting soil is too light)
1-foot square of sod (grass with soil attached—available at lawn and garden supply store)
Paper towels for spills
Wooden blocks to prop up the ends of the pans
Science journals
Pencils/pens

Lesson 2.4
For Each Group of 4 Students
Building an Aquifer Activity:
6” X 8” clear plastic container such as a lettuce box
1 lb oil based modeling clay (not Playdough)
5 cups sand
6 cups small rocks (aquarium rocks)
Straw
Spray bottle
3” x 5” piece of green felt
¼ cup cocoa
Pipette
Bucket of water
Cup
Roll scotch tape
Bottle red food coloring

Lesson 2.5
Student Guide, Chapter 2
Notebook paper for notes
Student journals
Computer and Internet

Lesson 2.6
Chart paper
Pencils
Markers
Student journals
Crayons or colored pencils

Safety Precautions

Use lab equipment safely.

Vocabulary

- Abiotic
- Acid Rain
- Aquifer
- Atmosphere
- Biosphere
- Climate
- Condensation
- Evaporation
- Geosphere
- Groundwater
- Hydrosphere
- Infiltration
- NOAA (National Oceanic and Atmospheric Administration)
- Precipitation
- Recharge
- Runoff
- Saturated zone
- Surface water
- Transpiration
- Wastewater
- Water treatment
- Weather
- Wetlands

Enrichments

Project WET:

- Dust Bowls and Failed Levees
- Get the Ground Water Picture
- Incredible Journey
- Piece It Together
- Poetic Precipitation

- Poisoned Pump
- Sparkling Water
- Thirsty Plants
- Water Models
- Wet Vacation
- Where Are the Frogs?

Project WILD Aquatic:

- Alice in Waterland
- Water Wings
- What's in the Air?
- Where Does Water Run?

Guest speakers:

- Local drinking water treatment plant worker
- Local wastewater treatment plant worker
- Local weather reporter

Service learning:

- Storm drain stenciling
- Litter pickup

Additional Enrichments:

- School weather station
- Field trip: Wastewater treatment plant tour

(**Note: Check with your local water treatment plant for availability of tours.)**

Lesson 2.1: How Does Water Cycle?

Essential Concept

The water cycle encompasses water movement from the clouds in the atmosphere to Earth, the geosphere, and into streams, aquifers, lakes, rivers, and oceans, the hydrosphere.

Objectives

1. Students will demonstrate their understanding of the water cycle with labeled diagrams and descriptions.
2. Students will identify the sun's energy as the driver of the water cycle fueling evaporation and transpiration, which puts water into the atmosphere.
3. Students will indicate that water in the atmosphere condenses to form clouds and falls to Earth to either be absorbed into the soil as groundwater to fill aquifers, or to run off and accumulate in streams, or other bodies of water.
4. Students identify precipitation as the rainfall that brings liquid water back to Earth.
5. Students will identify ways that the water cycle impacts the aquatic environment.
6. Students will identify ways that humans and other living things impact the water cycle.
7. Students will apply what they learned to write a story about the water cycle.

TEKS

8.10 A

Aquatic Science: 4 A; 6 A

Environmental Science: 4 C; 6 A

Estimated Time

2 class periods and homework to finish story

Materials

Large pieces of butcher paper

Crayons, markers, chalk, water colors

Pencils/pens

Science journals

Procedure

1. Diagramming the Water Cycle

Provide large pieces of butcher paper, crayons, markers, colored pencils, or chalk for each group.

Ask students to work together in groups of 4 to create a mural showing how water cycles in our environment. Encourage students to think of places water might go in its cycle that others might not think about, such as water drunk from a pond by a raccoon and returned to the soil in urine to evaporate back into the atmosphere. Students will present their group diagrams to the class.

Allow students to add to their diagrams as they see and hear other groups presentations. At the end of the presentations, all groups should have included the following in their diagrams:

- evaporation
- condensation
- precipitation
- interception (plants catch and slow precipitation)
- infiltration or recharge (water soaking into the ground)
- transpiration (plants releasing water through photosynthesis)
- runoff of surface water or stream flow
- groundwater
- accumulation (water storage in ocean, atmosphere, icepack, groundwater or fresh surface waters)

Students should work in their groups to answer the following questions in their journals:

- **Where does water come from?**
- **Where does water go when it rains?**
- **Are clouds water?**
- **Where do clouds go, if it doesn't rain?**
- **Where does the energy to drive the water cycle come from?**
- **What does water have to do with weather?**
- **Do living things in the biosphere contribute in any way to the water cycle?**
- **What can happen to water in various parts of the water cycle that will change water for better or worse? (making it cleaner or dirtier)**

Application questions for higher order thinking:

- **Does polluted water stay polluted forever or can dirty water get clean again?**
- **What role does the water cycle have in an aquatic environment?**
- **Where does water go when we flush it down the drain?**

2. Reviewing Our Water Cycle Diagrams

Students will review the water cycle by presenting their diagrams from yesterday and share their ideas about answers for their questions. Teachers may wish to assign specific questions to each group for discussion to avoid duplication.

Students may add information to their diagrams as different groups present their diagrams. So that in the end all diagrams should have complete information.

3. Using What We Learned: Writing a Story

The water cycle is typically presented as a simple cycle of evaporation, condensation, precipitation, surface runoff, and accumulation. In reality a water molecule can follow many different possible paths and does not necessarily go through those steps in a particular order. Ask students to work in groups of three to write one of the following two stories and present it to the class to show the process of the water cycle. Be aware that water may stay in some places like glaciers and the ocean for long periods of time. All member of the group will participate in creating the story, illustrations, and presentation.

1) A single water molecule that passes through various parts of the water cycle. There should be at least 20 steps. The steps should be varied and should not all repeat the exact same pattern.

Or

2) Two or more water molecules that start out together, but become separated by following different paths in the water cycle and rejoin later There should be at least 20 varied steps altogether.

The story can be told in any of the following formats:

- written story with at least 3 illustrations
- poem with at least 3 illustrations
- song or rap with at least 3 illustrations
- comic strip or graphic novel with at least 3 panels

Be sure to use the proper terms.

Some possibilities to consider:

- Since it is a cycle, you can start at any point in the cycle.
- Evaporation can occur from rivers, lakes, oceans, plants, animals, cloud droplets, dew, fog, puddles, etc.
- Condensation or deposition can make clouds (liquid droplets or ice particles), fog, dew, frost, snow, etc.
- Not all water vapor condenses at the same time. Wind can move water vapor and clouds to different locations.
- Precipitation can be rain, snow, sleet, freezing rain, or hail. Have a particular season in mind.
- Not all clouds produce precipitation – cloud droplets can evaporate back into the atmosphere.
- Surface runoff can include flows of water across the surface or underground, water caught on or dripping from plants or other objects, puddles, streams, lakes, oceans, glaciers, etc.

- Plants and animals can take in and give off water.

Example :

Molly the water molecule had been in the ocean so long she didn't remember anything about the rest of the world. She loved the ocean and would have happily stayed there, but one day, the sun evaporated her into the atmosphere, she was caught up with many other water molecules as lost and confused as she was. They were all in a huge hurricane. For a few days the hurricane cloud got more and more crowded till at one point some of the molecules started to precipitate out of the cloud. The cloud blew on until it was above the San Antonio, Texas, area and Molly got pushed, shoved, and precipitated onto the zoo grounds. She soaked into the soil and was there for about a day when she… etc.

Vocabulary:

- Atmosphere
- Biosphere
- Condensation
- Evaporation
- Geosphere
- Hydrosphere
- Precipitation
- Transpiration

Water Cycle Story

Due Date:______________________

The water cycle is typically presented as a simple cycle of evaporation, condensation, precipitation, surface runoff, and accumulation. In reality a water molecule can follow many different possible paths and does not necessarily go through those steps in a particular order. Ask students to work in groups of three to write one of the following two stories and present it to the class to show the process of the water cycle. Be aware that water may stay in some places like glaciers and the ocean for long periods of time. All member of the group will participate in creating the story, illustrations, and presentation.

1) A single water molecule that passes through various parts of the water cycle. There should be at least 20 steps. The steps should be varied and should not all repeat the exact same pattern.

Or

2) Two or more water molecules that start out together, but become separated by following different paths in the water cycle and rejoin later There should be at least 20 varied steps altogether.

The story can be told in any of the following formats:

- written story with at least 3 illustrations
- poem with at least 3 illustrations
- song or rap with at least 3 illustrations
- comic strip or graphic novel with at least 3 panels

Be sure to use the proper terms.

Some possibilities to consider:

- Since it is a cycle, you can start at any point in the cycle.
- Evaporation can occur from rivers, lakes, oceans, plants, animals, cloud droplets, dew, fog, puddles, etc.
- Condensation or deposition can make clouds (liquid droplets or ice particles), fog, dew, frost, snow, etc.
- Not all water vapor condenses at the same time. Wind can move water vapor and clouds to different locations.
- Precipitation can be rain, snow, sleet, freezing rain, or hail. Have a particular season in mind.
- Not all clouds produce precipitation – cloud droplets can evaporate back into the atmosphere.
- Surface runoff can include flows of water across the surface or underground, water caught on or dripping from plants or other objects, puddles, streams, lakes, oceans, glaciers, etc.
- Plants and animals can take in and give off water.

Rubric for Stories

I. Story, Song, or Rap **20 points**

1. The beginning gets the reader/listener's attention.
2. The story is appropriate for young children.
3. The story is clear, detailed, and gives ways to improve the environment.
4. All members of the group participate in presenting the project.

II. Illustrations **20 points**

1. The pictures are neat and clean.
2. The pictures are colorful.
3. The illustrations help move the story along.
4. The illustrations help to show the components of the lesson (soil, plants, hard surfaces, precipitation, runoff, pollution, and human activities that harm and those that protect the environment).

III. Organization **15 points**

1. The title is interesting or catchy.
2. Information is clear and concise.
3. The story has a beginning, middle, and end.
4. The illustrations make the story easy to understand.

IV. Accuracy **15 points**

1. The story gives accurate information about all of the components in the lesson.

V. Grammar and Punctuation **10 points**

1. Stories, songs, or raps should be neatly written.
2. Uses complete sentences.
3. Uses appropriate punctuation.
4. Uses correct spelling.

VI. Cooperative Groups **20 points**

1. All students worked together well.
2. All students participated in the presentation.
3. All students made illustrations.
4. All students worked on the writing of the song, rap, or story.

Lesson 2.2: The Water Cycle
Weather and Climate

Essential Concept

Weather is movement of water through the water cycle and varies with the seasons and the location. Weather refers to short-term atmospheric and hydrologic conditions, while climate refers to long-term weather patterns.

Objectives

1. Students generate ideas for finding reliable weather information.
2. Students will use appropriate instruments and charts to measure and record weather at their school in preparation for measuring weather at an aquatic site.
3. Students use the Internet to investigate climatic information in their area.
4. Students explain how precipitation and evaporation are related to climate.
5. Students explain how evaporation and precipitation affect aquatic environments.
6. Students watch a video on the Internet, and make a diagram of how wind and water currents affect weather.

TEKS

6.1 A, B; 6.2 C, D; 6.4 A; 7.1 A, B; 7.2 C, D; 8.1 A, B; 8.2 C, D; 8.4 A; 8.10 A, B

Aquatic Science: 2 G

Environmental Science: 2 H

Estimated Time

Two class periods.

Safety Precautions

Use lab equipment safely.

Materials

Copy of *Weather Terms and Measurements Table* for each student

Copy of *Wind Speeds and Descriptions Chart* for each student

Copy of *Weather Observations and Measurements* sheet for each student

Pens or pencils

Weather instruments

Computers and Internet access

Science journals

Procedure

1. Finding Weather Information

Students brainstorm as a class to generate ideas for finding reliable weather information. Be sure that students include newspapers, Internet weather sites, television or radio stations and taking their own data. Have students discuss how weather affects their daily lives. Ask students to describe some ways weather affects the availability of fresh water in their area or water in bays and estuaries.

Distribute a *Weather Terms and Measurements Table and Wind Speed and Descriptions Chart* to each student.

Lead class discussion of the weather terms and measurements and wind speeds described in the tables.

Distribute a *Weather Observations and Measurements* sheet to each student.

Ask students to use the sheet to record the day's weather data from one of the sources generated above and bring the completed page to class the next day

2. Measuring and Monitoring Weather Conditions

Take measurements at the school of weather data with instruments that you have available. Include as many of the following as possible temperature, precipitation, cloud cover, wind speed and direction, barometric pressure, and relative humidity.

Have students make a data table in their journals for their information. Make a graph of each component that you can continue for a sustained period. (a week, month, semester)

Discuss the need to take weather data on field trips to your aquatic site. If you have an aquatic site on campus assign students to take the measurements every day, or every week (or as often as you go to your aquatic site) on a rotating basis. Use your data to make monthly line graphs of each of the weather measurements (temperature, precipitation, cloud cover, etc.) at your school or at your aquatic site. Point out that line graphs are used for continuous data such as weather data. Use your graphs at the end of each semester to compare various weather changes and to find any correlations between various weather measurements or between weather elements and aquatic conditions.

- **Why would weather measurements be important in an aquatic ecosystem?**
- **Do we see a dominant wind direction in our area? Why might we see that trend?**
- **How might the aquatic environment be shaping the weather in different areas of the country?**

3. Climate

Weather is what is happening today in the hydrologic cycle. Climate is the long-term weather patterns of an area. Look at the historical weather data of your nearest city including precipitation by going to the Internet, and, on Google, look for NOAA and the monthly annual precipitation of your city. For instance I put in "NOAA precipitation data

for Austin, TX for 20 years" and it took me to:
http://www.srh.noaa.gov/images/ewx/aus/ausmonrain.pdf.

This site gave me Monthly Annual Rainfall charts from 1942 to 2012 for Austin Bergstrom Airport including averages of the year. You can use any of these years to make graphs. In addition to this chart, there is another chart on this same page that breaks down the data into 30-year groups giving the normal precipitation for each month over 30 years and the average for the 30-year period.

Make graphs with whatever years that you choose and analyze these graphs for:

- time period covered
- range of precipitation
- average annual precipitation
- percent of time that precipitation exceeded average
- percent of time that precipitation was below average.
  - **What does the data tell you about the climate in your area?**

4. Precipitation and Evaporation Patterns

Often precipitation and evaporation rates vary from region to region. Look at another Internet site http://www.twdb.state.tx.us/publications/state_water_plan/2012/04.pdf

Scroll down the page and you will find two maps side by side. One is a map of precipitation in various parts of the state from the Texas Water Board. The other is a map of lake evaporation from Texas Parks and Wildlife Department.

Note: As with all websites, check to be sure it is still active before assigning the students this activity.

Divide the class into groups and assign each group a region of the state and find the precipitation and evaporation for that area.

- **Does your assigned region have more precipitation or evaporation? Explain.**
- **What affect would this have on the aquatic ecosystems in your assigned region?**

Have students make a data table to record the Region, Precipitation, and Evaporation. Have each group report the data for their assigned region to the class to be recorded on their tables.

5. Assessing Our Learning

Have groups work together to answer the following questions in their science journals. Students should write at least one paragraph to answer each question.

- **How are precipitation and evaporation related to climate?**
- **How do the precipitation and evaporation affect aquatic ecosystems?**

Extension

To learn more about influences on the weather, look at an animation of wind and water currents in the tropics on the Internet at:

http://earth.rice.edu/mtpe/hydro/hydrosphere/topics/Ocean_Atm_Circ_ElNino.mov

Check website to be sure it is active before assigning activities to students.

Make a diagram in your journal of how wind and water currents affect weather.

Vocabulary:

- Climate
- Evaporation
- NOAA (National Oceanic and Atmospheric Administration)
- Precipitation
- Weather

Weather Terms and Measurements Table

Term	Description or definition	Instrument of measurement	Units of measurement	Abbreviation
Air temperature (High = highest temperature of the day; Low = lowest temperature of the day	Hotness or coldness of surrounding atmosphere	Thermometer	Celsius or Fahrenheit degrees	^oC or ^oF
Wind speed	Velocity of air movement	Anemometer	Miles or kilometers per hour	mph, mi/hr or km/hr, kph
Wind direction	Compass bearing from which wind is moving	Vane or windsock	None	N, S, E, W, NE, SE, NW, SW
Beufort Scale	Description of wind conditions and speed	Chart	Description With a number and miles per hour	Calm, light air, slight breeze, etc. to hurricane 0-12 mph
Atmospheric or barometric pressure	Weight of the atmosphere over a unit area of Earth's surface	Barometer	Inches of mercury or millibars	Inches of Hg or mb
Relative humidity	Amount of moisture in the air as a percentage of the maximum possible	Hygrometer	Percentage	%
Precipitation	Amount of rain, snow, sleet or hail that reaches the ground	Rain gauge	Inches, feet or millimeters	in., ft. or mm
Cloud cover	Fraction of sky obscured by clouds	Direct observation	Description	Clear, scattered clouds, partly cloudy, mostly cloudy, overcast

Student Page

Wind Speed and Descriptions Scale

Adapted from the Beaufort Scale

Use this chart to help you describe wind conditions.

Smoke rises straight up. **CALM** Less than 1 MPH -- 0	Whole Trees are in motion; walking against the wind is difficult. **MODERATE GALE** 32-38 MPH -- 7
Smoke drifts, weather vanes still. **LIGHT AIR** 1-3 MPH -- 1	Twigs break off the trees. **FRESH GALE** 39-46 MPH -- 8
Leaves rustle and weather vanes move. **SLIGHT BREEZE** 4-7 MPH -- 2	Slight building damage **STRONG GALE** 47-54 MPH -- 9
Light flag extended, leaves & small twigs in constant motion **GENTLE BREEZE** 8-12 MPH -- 3	Trees uprooted; seldom happens inland. **WHOLE GALE** 55-63 MPH -- 10
Dust, dry leaves, loose papers raised & Small branches move **MODERATE BREEZE** 13-18 MPH -- 4	Very rare; much general damage **STORM** 64-72 MPH -- 11
Small Trees in leaf start to sway; crested wavelets form on inland waters **FRESH BREEZE** 19-24 MPH -- 5	Anything over 73 MPH **HURRICANE** 73+ MPH -- 12
Large Branches are in motion, telephone wires whistle **STRONG BREEZE** 25-31 MPH -- 6	

WEATHER OBSERVATIONS AND MEASUREMENTS

Objective

Obtain, record, and present weather data.

Directions

1. Find a reliable source of daily information about the weather in your area.
2. Record today's weather data for your area. Be sure you report the source of each piece of data, the date and location for which it was reported.

Name: ____

Date: ______________________

Location: ____

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Lesson 2.3: Water Runoff and Infiltration

Essential Concept

Snow and ice-melt, and rain either run off of hard surfaces to accumulate in streams, rivers, and oceans or sink into the soil (infiltrate). The streams, rivers and oceans form our surface water, and the water that infiltrates provides water that may be used by plants or seep deeper underground to form aquifers where it is held as groundwater.

Objectives

1. Students will make a model of runoff of rainwater and infiltration in an aquatic environment.
2. Students will model how pollution gets into aquatic environments.
3. Students will present information about runoff and pollution in aquatic systems in the form of a news story.

TEKS

6.1 A, B; 6.2 C, D; 6.3 B, C; 6.4 A; 7.1 A, B; 7.2 C, D; 7.3 B, C; 7.4 A; 7.8 B, C; 8.1 A, B; 8.2 C, D; 8.3 B, C; 8.4 A

Aquatic Science: 2 H; 7 A

Environmental Science: 2 I; 5 B

Estimated Time

1 class period for building and using the model

Writing a news story can be done as homework or in another class period

Materials

<u>For Each Group of 3-4 Students</u>

Runoff and Infiltration Activity:

3 large foil roasting pans

Pump sprayer containing water

Food coloring

Soil (use topsoil or freshly dug yard/garden soil—commercial potting soil is too light)

1-foot square of sod (grass with soil attached—available at lawn and garden supply store)

Paper towels for spills

Wooden blocks to prop up the ends of the pans

Science journals

Pencils/pens

Special Instructions

If you have multiple classes using the runoff/infiltration materials, have students clean up their stations before they leave. They can dump all the soil in one container, stack the sod, and refill the water sprayers before they leave.

Procedure

1. Investigating Runoff and Infiltration

Today we will make a model to look at what happens when it rains. You will use pans to represent three different hills: one with plants growing on it, one with bare ground and one with pavement. The hills slope to streams, lakes, or wetlands, which are represented by clear spaces at the bottom of the hills.

Ask each group of 3-4 students to fill one foil pan with soil so that it comes half way up the side on one end and gently slopes to the bottom of the pan, stopping about 2 inches from the opposite end of the pan. Gently pack the soil. If the soil is very dry, you might want to spray it lightly with water so that it stays in place. Prop the pan up on wooden blocks or several textbooks to create a slope. Leave 2 inches clear to represent a small pool at the bottom of the hill.

Ask students to make a similar hill in the second pan, but put soil only about 1/3 of the way up and place the sod on top of the soil. Trim the sod to fit if necessary, leaving about 2 inches open at one end of the pan. Gently press the sod down. Raise the sod end of the pan on blocks. The bottom 2 inches represent a small pool at the bottom of the hill.

Leave the third pan empty to represent a parking lot and raise one end of the pan. The bottom 2 inches will represent a small pool at the bottom of the hill.

Have students use the pump sprayer to spray water onto the sod, the bare soil, and the paved surface. Have students count the number of times they squeeze the trigger before water runs off into the pool at the bottom of the hill. Students should keep a record of their number of squeezes for each soil condition.

- **What happens in each case?** (The water takes longer to run out of the sod-covered hill than the bare-soil hill, and runs off faster down the pavement than the soil. Also, more soil will flow into the small pool at the bottom from the bare-soil hill than from the sod-covered hill.)

Have students discuss with their groups what caused the differences in the results of their rain on each of the soil, sod, and pavement hills. Students should describe some situations in which soil might be washed into aquatic resources. (house or road construction, farming row crops, dirt from roads, sparsely grassed lawns, and parking lots etc.) Students should base their explanations on the data they collected during their experiment.

2. Pollution in Runoff

When rainwater runs off of surfaces it carries along with it any impurities that it picks up or dissolves along the way. Tell the class to imagine that a man has spilled used motor oil on the ground while changing the oil in his car.

Write in your journals a prediction of what will happen if oil were spilled on each of the three hills.

Place a few drops of food coloring on each hill. (Food coloring runs quickly off the bare surface, but is absorbed by the soil and the sod.)

- **What happens on each of the different soil conditions?**

Ask the class to write a prediction in their journals of what will happen when it rains on each hill. Use the pump sprayer to spray water onto the sod, the bare soil and the paved surface. (Colored water runs quickly off the bare surface, less quickly off the soil, and slowly from the sod.)

Have students discuss the results observed and their implications for local aquatic resources.

- **What is erosion? What causes it?** (Erosion is the washing away of soil. It is caused by water running over unprotected soil.)
- **What is sediment? Where does it come from?** (Sediment is soil that has washed into a body of water. It comes from places where erosion is happening or from other places where dirt collects such as parking lots.)
- **How does human activity affect erosion and sedimentation?** (Humans walk across places creating pathways of bare soil through plant material. They have farms where soil is plowed and left bare during a season of no growth. They bring dirt on their cars onto parking lots. They construct buildings where soil is cleared of plant material during construction, etc.)
- **What is the impact of erosion and sedimentation on aquatic resources?** (Erosion often takes fertile topsoil from places it is needed leaving less fertile soil exposed and causing sedimentation in streams, rivers, ponds, etc. This sedimentation makes water muddy and prevents sunlight from reaching plants, which normally put oxygen into the water. These plants may die, decay, and cause oxygen depletion, which in turn causes other aquatic organisms to become stressed or die.
- **What is pollution?** (Litter, heat, sediments, or chemicals that are deposited or come off the land.)
- **What would happen to the pond if every house in your community had someone spilling motor oil on the soil?**
- **What are the limitations of our models?** (The models are a much smaller size and cannot show the scale of problems represented, and materials for different types of pollution are more limited than what we would find in the real world.)

3. Runoff at the Gulf of Mexico

Look on line at satellite images of a river delta such as the Rio Grande, Neches, or Trinity Rivers to see how water flow moves materials to the ocean just as our water sent material to the pond.

Websites might include NASA
http://eol.jsc.nasa.gov/sseop/EFS/printinfo.pl?PHOTO=STS060-83-50

Where you will find Photo #: STS060-83-50 Date: Feb. 1994

STS060-083-050 Rio Grande Delta,

From Google Maps you can click on satellite images of Houston at

http://wwp.greenwichmeantime.com/time-zone/usa/texas/houston/map-houston/

to see the Trinity River. Or you can go near Port Arthur to see where the Neches River enters Sabine Lake.

You may wish to move down the coast on the satellite image and see if you can find other rivers emptying into bays or the Gulf of Mexico.

- **What do you notice about each of the rivers?** (The rivers all bring sediments to the Gulf, which change the color of the water and leave soil all around the mouth of the river.)

3. Assessing What We Learned

Ask students to write a news story to tell about pollution, such as sediment, chemicals, or organic matter flowing into groundwater such as aquifers, or flowing into the surface water in ponds, bays, or the Gulf of Mexico. Be sure to include in your storyline ways that humans can prevent this from happening. (Planting trees, grass, or gardens to hold soil, limiting use of herbicides and pesticides, picking up our dog poop, cleaning up litter, cleaning wastewater before it reenters the environment, etc.)

Include ideas about surface water, runoff, infiltration, groundwater, human activity, and pollution.

Illustrations can be on posters or included with the text of the story.

Students should use the Rubric at the end of the lesson to guide them.

Vocabulary

- Aquifer
- Erosion
- Groundwater
- Infiltration
- Sedimentation

Rubric for Stories

I. News Story **25 points**

1. The beginning gets the reader/listener's attention.
2. The story is appropriate for a newspaper, or radio, or TV news broadcast.
3. The story is clear, detailed, and gives ways to improve the environment.

II. Organization **25 points**

1. The title is interesting or catchy.
2. Information is clear and concise.
3. The story has a beginning, middle, and end.
4. The illustrations make the story easy to understand.

III. Accuracy **25 points**

1. The story gives accurate information about all of the components in the lesson.

IV. Grammar and Punctuation **25 points**

1. Story is neatly written.
2. Story uses complete sentences.
3. Story uses appropriate punctuation.
4. Story uses correct spelling.

Total **100 points**

Lesson 2.4: Infiltration and Aquifers

Essential Concept

Rain either runs off of hard surfaces to accumulate in streams, rivers and the ocean to form surface water, or sinks (infiltrates) into the soil where it may be used by plants, or seeps deeper underground to form aquifers and to be held as groundwater.

Objectives

1. Students will model infiltration and pollution of aquifers
2. Students will generate a list of 5 ways people can help keep water clean.

TEKS

6.1 A, B; 6.2 C, D; 6.3 B, C; 6.4 A; 7.1 A, B; 7.2 C, D; 7.3 B, C; 7.4 A; 7.8 C; 8.1 A, B; 8.2 C, D; 8.3 B, C; 8.4 A

Aquatic Science: 2 H

Environmental Science: 2 I

Estimated Time

1 class period

Materials

<u>For Each Group of 4 Students</u>

Building an Aquifer Activity:

6" X 8" or larger clear plastic container such as a lettuce box

1 lb oil based modeling clay (not Playdough)

5 cups sand

6 cups small rocks (aquarium rocks)

Drinking straw

Spray bottle

3” x 5” piece of green felt

¼ cup cocoa

Pipette

Bucket of water

Cup

Roll scotch tape

Bottle red food coloring

Special Instructions

If you have multiple classes using these materials, have students clean up their stations before they leave. Ask students to remove and discard the felt, straw, sand, and rocks. They can ball the clay up for reuse, and fill water bottles.

Procedure

1. Aquifers

We looked at what happens when pollution gets into runoff, but what happens if the pollution goes underground?

- **What is groundwater?** (Groundwater is water that seeps into the ground and stays underground such as water in aquifers. Aquifers are like underground reservoirs of water. We drill wells into them and pump water from them, which we use in many ways, such as for drinking, for our farms, and in our cities.)
- **What happens to water as it moves through soil and rocks?** (Some of the pollutants are filtered out.)

If all the pollutants aren't filtered out in the soil and rocks, people set up water treatment plants to clean our drinking water by settling, filtering, or adding chemicals to kill bacteria or remove contaminants.

2. Building an Aquifer

Have students work in groups of 4 to build a model to look at how an aquifer fills, and how a well in an aquifer works.

Along the longest side of the clear plastic container toward one end, tape the drinking straw vertically to the inside of the container so it is 1/8" above the bottom. This will represent your well.

Pour a layer of sand about 1" deep so that it covers the entire bottom of the container, including part of your straw.

Pour water into the sand, wetting it completely but with no standing water on top of the sand. Notice how the water is absorbed by the sand, remaining around the sand particles as it is stored as groundwater in the aquifer.

Flatten the modeling clay like a pancake and <u>cover half of the sand with the clay</u>, gently pressing the clay along three sides of the container, <u>making sure it surrounds your well</u>. This represents the confining layer of rock that keeps water from passing through.

Pour a small amount of water over the clay and see how it remains on top.

Place rocks over the sand and clay, <u>covering the entire container</u>. Arrange the rocks so that on the straw end of the container there is a hill, with a valley on the other end of the container. Do not expose the layers below.

Pour water into the aquifer until the water in the valley is about 1" from the top of the hill. Notice how the water surrounds the rocks and is stored there. Your container now has both groundwater and surface water, which can be your drinking water.

Place the piece of green felt on top of the hill. This will be your lawn or your farm. You may need to use a little clay to fasten it to three sides of your container.

Remove the top of the spray bottle and insert its stem into the straw, depressing the trigger will pull water up from your well.

- **How does your well water look?** (Some well water is clean enough to drink without treatment.)

3. Pollution in the Aquifer

Sprinkle some of the cocoa on top of the green felt. This represents fertilizers and other chemicals used on your farm or on your lawn.

Using your pipette squirt some of the red food coloring close to the felt, and on the surface water (This represents other pollution, perhaps from an industrial source or from septic tanks.) Watch as the pollution spreads around the surface water and into the aquifer.

Fill the spray bottle with water and make it rain on your lawn or crop, watch the water run off the hill and into the surface water, carrying the excess fertilizers and chemicals. It is also seeping through your lawn and down into the ground water.

Remove the top of the spray bottle and insert its stem into the straw, depressing the trigger will pull water up from your well.

- **Now how does your well water look? Would this water be safe to drink?** (The water should look discolored from the fertilizer and pollution. It is not safe to drink with fertilizer and industrial pollution in it.)
- **What measures are taken to try to keep the water in our aquifers clean?** (Strict regulations with high fines regulate septic tanks and industry in aquifer recharge zones.)

4. Assessing What We Learned about Runoff and Aquifers

Work with your group to generate a list of <u>5 things</u> that you can do to help keep runoff and aquifers clean. Write your list in your science journal.

Vocabulary

- Aquifer
- Groundwater
- Infiltration
- Surface Water

Lesson 2.5: Reading and Research

Essential Concept

Water is cleaned as it evaporates and leaves behind pollutants as part of the water cycle, then it is reused over and over providing water for our homes and the environment. This cycle happens continuously.

Objectives

1. Students will read *Chapter 2: The Ultimate Recyclable* to reinforce concepts and vocabulary and find new information.
2. Students will find out where the water for their homes comes from and how their home wastewater is processed.
3. Students will draw a diagram and label the parts showing the source of water for their home and its path through the house and back into the environment.

TEKS

6.2 C, 7.2 C, 8.2 C;

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

Varies. Reading and research may be done in class or as homework. Allow at least 20 minutes for in class discussion and questions.

Materials

Student Guide, Chapter 2

Journals

Pens and pencils

Computer and Internet

Procedure

1. Student Reading

Have students read *Chapter 2: The Ultimate Recyclable*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is the water cycle?

The water cycle is the movement of water through the atmosphere, geosphere, and biosphere.

2) Where does it start and where does it end?

The water cycle can start anywhere water exists in any form. Because it is a cycle, it has no beginning or end.

3) Where does water spend most of its time?

Water spends most of its time in the oceans.

4) What is weather?

Weather is the movement of water through the water cycle, or the observed atmospheric conditions in a given time and place.

5) What is climate?

Climate is the average atmospheric conditions in an area over many years.

6) How do water and climate affect the quality and quantity of our water?

Weather and climate affect the quality and quantity of our water in many ways, including:

- The water cycle is the natural process that purifies Earth's water.
- How much water there will be in a certain region in a given part of the water cycle depends on the amount of rainfall, the effect of temperature on evaporation, and the uptake of water by plants.
- Even small changes in the global cycle can cause droughts or floods locally.

7) What kind of climate does Texas have? *Answers may include:*

- Texas climate is very varied, with the wettest areas in the east and driest in the west.
- Texas is strongly influenced by the onshore flow of tropical air from the Gulf of Mexico. Coastal areas may receive abundant rain from hurricanes, especially in late summer and early fall, and may even experience flooding.
- Many areas of Texas, such as South and West Texas may receive little rain year-round and experience drought.
- While the Panhandle and North Texas may experience regular periods of below-freezing temperatures each winter, most of Texas has mild winters with only occasional periods of cold.

8) What is surface water?

Surface water is water that flows over the land.

9) What is groundwater?

Groundwater is water that soaks into and is present in the ground.

10) What happens to water after we've used it? Where does it go when we flush or it goes down the sink drain?

Wastewater goes to a water treatment plant or into septic systems.

11) How many systems can you identify in this chapter?

Water cycle, drinking water treatment, water distribution, weather, wastewater treatment, home plumbing, weather, etc.

3. Challenge Question

Ask students to discuss the following question to apply what they've learned:

- **If water is so recyclable, how can we use that characteristic to our long term advantage in creating a sustainable water future in Texas?**

4. Let's Find Out

Ask students to research and write the answer to one of the following questions in their journals.

- **Where does your water come from at home?** (a private well, municipal water system from a lake/river or aquifer/groundwater, or a rural water system from a lake/river, or groundwater, etc.)
- **Where does the wastewater from your home go to be processed?** (septic tank, water treatment plant, etc.)
- **Are there any aquifer recharge zones near the area where you live?**
- **If you are in a recharge zone, are there special regulations about septic tanks, or water treatment?**

Students may check with their parents, call the water utility office, or look on the utility website on the Internet for this information.

Use the information you found to draw a simple diagram in your journal showing the movement of water from your source through your house and back into the environment. Label the parts of your diagram.

Vocabulary:

- Acid Rain
- Aquifers

- Atmosphere
- Biosphere
- Evaporation
- Geosphere
- Groundwater
- Hydrologic cycle
- Precipitation
- Runoff
- Saturated zone
- Surface water
- Transpiration
- Wetlands

Lesson 2.6: Tap Water and Wastewater

Essential Concept

Water journeys not only through the water cycle, but also from a surface or groundwater source to our homes and schools, and down our drains and out of the building to be cleaned and returned to the environment.

Objectives

1. Students will identify the source of school tap water.
2. Students will identify how wastewater from school is treated.
3. Students will diagram water from the source to their school, through their drains, to wastewater treatment, and back into the environment.
4. Students will play a computer game to test their appropriate use of water in their homes.
5. Students will make a drawing with labels to show what they have learned about water in their home, school, and the environment.

TEKS

6.12 E; 7.13 A

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

1 period

Materials

Chart paper

Pencils

Markers

Journals

Crayons or colored pencils

Special Instructions

The teacher should conduct an investigation to determine where the school's tap water comes from, how the school's tap water is treated, where the school's wastewater goes, and how the school's wastewater is treated.

Procedure

1. Where Do We Get Our Water?

Using the information students learned from the "Let's Find Out" section of the last lesson, have students work together as a class to generate ideas about where they think their school tap water comes from. List ideas on the board or on an overhead or chart paper. Discuss each idea and then ask questions to fill in other information.

- **Do we all have the same water source? Do you think water we get at school is from the same source as the water you get at home?**
- **Do you get water at your home from untreated groundwater such as wells** (This may be the source for some students, especially in rural areas.)
- **Does anyone use treated groundwater?** (Some cities and rural water systems have wells into an aquifer where they get water for their water systems, and they treat this water.)
- **Does anyone use treated water from a surface water source?** (This would be like a municipal or rural water system using lake water.)

  Have students work in groups to talk through the steps water must take to get from a source to the tap.
- **What steps does water go through to get from this source to your faucet at your school or house?** (In some cases water is pumped from the source to the treatment plant and then to homes and schools. In other cases it may be pumped directly from wells to the house.)

  Have each group draw a diagram on chart paper of how they think this works for their home. (Ask students to leave room on their chart so that they can add more steps to their diagrams.)
- **Where do you think your school and home wastewater goes?** (Some possible ways that wastewater may travel include from the drain to septic systems or sewage lagoons of individual domestic systems in suburban and rural areas, small-scale treatment systems in domestic systems in suburbs, and large-scale treatment plants and wastewater wetlands in municipal systems.)

  Have students add the flow of wastewater from drains in their school to the water treatment facility to their diagrams.
- **What are the steps wastewater must go through to get from toilets back into the environment?** (Wastewater moves from drains to septic systems where organic material is broken down by bacteria, then the water slowly seeps back into the ground. It also can move from drains to sewers to water treatment plants where water is filtered, suspended material is allowed to settle, and chemicals are added to kill bacteria and other organisms. Then clean water is sent back to surface waters such as lakes and rivers, where it is reused by people and the environment.)

  Have students add the steps in treatment and water's return to the environment to their diagrams.

- **Where does water go when it runs off of a street? (**Stormwater runoff usually goes through storm drains or ditches, then directly into streams, lakes and wetlands without being cleaned or processed. Anything that is on the ground, streets or parking lots such as litter, grass clippings, fertilizer, pesticides, motor oil, or other chemicals goes directly into streams, lakes, and wetlands.)

  Have students add this runoff to their diagrams.

2. What Do You Think Goes Down the Drains in Your Home?

Have students go to the following site to play a game called *Down the Drain* to see if the things they have going down the drain at their homes are appropriate for their plumbing, and find out if they are conserving water. **Note: Websites come and go. Be sure you check to see if it is still active, before giving the web address to students.**

www.miwaterstewardship.org/youthstewards/onlinewatergames/downthedrainyougo

In this game students can choose an urban or rural home. They will see all the drains in the house and choose ways that they use their drains. They will get feedback on their use of water and the condition of their drains.

3. Assessing What We Learned: Water's Journey

Have students draw a picture and label the parts in their journals and write the story of water's journey.

Indicate the source of their water, the way it gets to their homes or school and out of the tap, down the drain, to the wastewater treatment system and back into the environment.

Water is an abiotic part of the ecosystem to which organisms react. Indicate in your drawing how organisms use water, and interact in water, and how organisms react to pollutants in the water.

Explain how something that seems beneficial, like plowing farmland, fertilizing your lawn or garden, changing the oil in your car, or paving roads can have unintended consequences for aquatic environments. (These activities add sediments, and chemical and thermal pollutants to our water.)

Vocabulary:

- Abiotic
- Groundwater
- Surface Water
- Wastewater
- Water treatment

Chapter 2 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. How does the water cycle purify water?

- **A** Water flows through underground aquifers.
- **B** Every time water evaporates it becomes pure again.
- **C** Water vapor condenses to form raindrops.
- **D** All of the above.

2. Where does the water cycle start?

- **A** Anywhere water exists in any form
- **B** Water vapor condenses in clouds
- **C** When precipitation falls to the ground
- **D** In the oceans

3. What is weather?

- **A** Hot, damp summers and cold, dry winters
- **B** The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
- **C** Average atmospheric conditions in an area over many years
- **D** The movement of water through the water cycle

4. What is climate?

- **A** Hot, damp summers and cold, dry winters
- **B** The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
- **C** Average atmospheric conditions in an area over many years
- **D** All of the above

5. What is surface water?

- **A** Water absorbed by plants and released slowly into waterways
- **B** Water that soaks into the ground
- **C** Water that flows over the land
- **D** Water frozen in glaciers, snowpacks, and polar ice caps

6. What is groundwater?

A Water absorbed by plants and released slowly into waterways

B Water that soaks into the ground

C Water that flows over the land

D Water frozen in glaciers, snowpacks, and polar ice caps

7. Where does water go when it runs off a street?

A To wastewater treatment plants for processing before being returned to the environment

B To drinking water treatment plants, then through pipes to our taps

C To pick up air pollution, forming acid rain

D Through storm drains or ditches, then directly into streams, lakes, wetlands, bays and estuaries without being cleaned or processed

8. Where does water go when it goes down the drain?

A To a wastewater treatment plant, septic system or lagoon for processing before being returned to the environment

B To drinking water treatment plants, then through pipes to our taps

C To pick up air pollution, forming acid rain

D Through storm drains or ditches, then directly into streams, lakes and wetlands without being cleaned or processed

Chapter 2 Assessment

Directions

Write your own answer for each of the following questions.

1. Define weather and climate and differentiate between the two. How are they related?
2. Describe Texas' climate.
3. Justify the following statement: The availability of water for humans and other living organisms is dependent upon the water cycle.
4. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as groundwater wells, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Texas' fresh and marine waters.

Chapter 2 Assessment Answer Key

Multiple-choice questions

1. How does the water cycle purify water?

   B. Every time water evaporates it becomes pure again.

2. Where does the water cycle start?

   A. Anywhere water exists in any form

3. What is weather?

   D. The movement of water through the water cycle

4. What is climate?

   C. Average atmospheric conditions in an area over many years

5. What is surface water?

   C. Water that flows over the land

6. What is groundwater?

   B. Water that soaks into the ground

7. Where does water go when it runs off a street?

   D. Through storm drains and ditches, then directly into streams, lakes, wetlands, bays, and estuaries without being cleaned or processed

8. Where does water go when it goes down the drain?

   A. To a wastewater treatment plant, septic system or lagoon for processing before being returned to the environment

Write-in questions

Write the answers to the following questions in your own words

1. Define weather and climate and differentiate between the two. How are they related? Describe Texas' climate.

Definitions:

- **Weather is the movement of water through the water cycle, or the observed atmospheric conditions in a given time and place.**
- **Climate is the average weather conditions over longer periods of time.**

Difference:

- **Weather is the actual observed atmospheric condition at a given time and place.**
- **Climate is the atmospheric conditions one would expect to observe, based on a long-term average, at a given time and place.**

Relationship:

- **Climate is determined and understood by observing and recording weather over many years. It includes seasonal variations in weather.**

2. Texas's climate:

Answers may include:

- **Texas climate is very varied, with the wettest areas in the east and driest in the west.**
- **Texas climate is strongly influenced by the onshore flow of tropical air from the Gulf of Mexico.**
- **Coastal areas may receive abundant rain from hurricanes, especially in late summer and early fall, and may even experience flooding.**
- **Many areas of Texas may receive little rain year-round and experience drought.**

3. Justify the following statement: The availability of fresh water for humans and other living organisms is dependent upon the water cycle.

Answers may include:

Availability of water depends on rain to replenish surface and groundwater. How much water there will be in a certain region in a given part of the water cycle depends on the amount of rainfall, the effect of temperature on evaporation, and the uptake of water by plants during the growing season. Even small changes in the global cycle can cause droughts or floods at the local level.

4. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as groundwater wells, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Texas.

(See chart.)

Answers may include:

Activity/technological solution	Potential benefit	Potential drawback
Groundwater wells	Provide water for various uses: drinking, cleaning, irrigation, etc.	Aquifers can take thousands of years to recharge; pumping out water may cause ground subsidence (sinking or caving in)
Paved roads/parking lots	Improve surface transportation	Water running off surface carries heat and pollutants
Storm systems	Carry away runoff and waste	Can contaminate water bodies
Use of fertilizers	Increases plant growth	Results in overgrowth of algae
Use of herbicides	Kills problem weeds	Toxic to other plants and animals

Watersheds and the Land

Everyone lives in a watershed. Everything that happens on the land in a watershed affects the water

Chapter 3

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

1. Students will work together to generate a definition of watersheds.
2. Students will identify their watershed address.
3. Students will look at changes to water, an abiotic part of the environment on which all living things depend, and how those changes affect living things.
4. Students will discuss changes in water in a watershed caused by erosion.
5. Students will discuss changes in water in a watershed caused by various human uses of the land.
6. Students will explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences, and support the explanation using a specific example of aquatic resources in Texas.
7. Students will use a topographic map to find the height of a geographic feature.
8. Students will use a topographic map to help them create a model of a watershed. Students will look at problems on the school grounds that might affect the watershed.
9. Students will predict where water will flow off of the model watershed.
10. Students will predict where water will accumulate in the model watershed.
11. Students will identify factors that contribute to how water flows in a watershed.
12. Students will decide where to build a house in the watershed model based on the places where water will flow and where it will accumulate.
13. Students will look at the effects of pollution in different places in a model watershed.
14. Students will define point-source and non-point source pollution.

15. Students will take part in a scavenger hunt to look at land use and pollution where water flows from the school grounds into the watershed.
16. Students will describe the impact of erosion and sedimentation on aquatic resources in Texas.
17. Students make a map of the school grounds showing erosion and pollution problem areas and will show on the map ways they think the class could help alleviate problems.
18. Students will identity Texas' natural physiographic regions and explain how land type may affect Texas' aquatic resources, wildlife and recreation in and around water.
19. Students will analyze data on maps to formulate reasonable explanations related to interrelationships among geology and hydrology of regions of Texas.
20. Students will describe biotic and abiotic parts of an aquatic ecosystem.
21. Students will explain the relationship between the watershed and the water body into which it drains.
22. Students will draw conclusions about the relationships among the characteristics of physiographic regions, watershed, and aquatic environments.
23. Students will read background information on watersheds.
24. Students will answer questions about watersheds
25. Students will draw a poster to inform and motivate the public to take action to control effects of erosion and various pollutants on organisms that live in water.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 C, E; 6.3 B, C; 6.4 A; 6.12 C, E; 7.1 A, B; 7.2 C, E; 7.3 B, C; 7.4 A; 7.8 B, C; 8.1 A, B; 8.2 C, E; 8.3 B, C; 8.4 A; 8.9 C; 8.11 B, C

Aquatic Science: 2 H, J; 3 B; 4 A; 7 B; 12 A, B, D

Environmental Science: 2 I, K; 3 B; 5 A, B; 9 A

Materials Needed

Lesson 3.1

Science journals

Pencils/pens

Chart paper

Markers

Lesson 3.2

For Each Group of 6 Students

Oil based clay

Scissors

Plastic knife

Topographic Map of Buffalo Hill

Topographic Map of Green Hill Point

Disposable aluminum cookie sheet or rectangular cake pan

Wax paper

2 spray bottles with water

2 two-inch dowels cut in one-foot lengths or other roller to flatten clay

Paper clips for each student

Construction paper

Paper towels

Newspapers

Food coloring (red and green)

Blue, red, yellow, and green colored pencils

For high school: http://www.topoquest.com/ (Source for topographic maps)

Lesson 3.3

Copies of the *What's in Our Watershed?* scavenger hunt and clipboards for each student. If you don't have clipboards, you can use heavy cardboard and a clamp for a clipboard.

Pencils

Science journals

Lesson 3.4

Map 3.1: *Texas River Basins* (watersheds) map

Map 3.2: *Texas River Basins and Major Bays* (watersheds) map labeled

Map 3.3: *Texas Natural Regions* Map

Map 3.4: *Texas Natural Regions and River Basins* (watersheds) map

Map 3.5: *Texas Notable Features*

Download maps here:
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/maps.pdf

For High School

River Basin Map of Texas and *Physiographic Map of Texas* from the Bureau of Economic Geology. The website is http://www.beg.utexas.edu/pubs/pubs-teachers.php

Science journals

Pencil/Pens

Computer and projector or Smart Board (optional)

Lesson 3.5

- Student Guide
- Science journal
- Pens or pencils
- Posterboard
- Various art materials of the student’s choice

Safety Precautions

Make sure students understand field trip behavior guidelines

Vocabulary

- Accumulation
- Bays
- Coastal basins
- Drains
- Erosion
- Estuaries
- Eutrophication
- Headwaters
- Hydrological
- Hydrologist
- Impermeable surface
- Intermittent or ephemeral streams
- Land use
- Litter
- Natural physiographic regions
- Non-point source pollution
- Photosynthesis
- Point source pollution
- Pollution
- River basin
- Runoff
- Sediment
- Topographic map
- Topography
- Watershed

Enrichments

Project WET:

- Branching Out!
- Just Passing Through
- Rainy-Day Hike
- Sum of the Parts

Project WILD Aquatic:

- Watershed
- Where Does Water Run?

Teacher Resources

Bureau of Economic Geology

River Basin Map of Texas, Physiographic Map of Texas, Ecoregions of Texas, Geology of Texas, Aquifers of Texas, General Soil Map of Texas, Tectonic Map of Texas, Vegetation/Cover Types of Texas, Industrial Minerals of Texas, and Land-Resource Map of Texas. The website is http://www.beg.utexas.edu/pubs/pubs-teachers.php

Or e-mail at: pubsale@beg.utexas.edu

Texas Parks and Wildlife website for information on the Natural Regions of Texas is http://www.tpwd.state.tx.us/

Guest Speakers:

- Stream Team volunteer to talk about volunteer opportunities and watershed issues.

Service learning:

- Storm drain stenciling
- Litter pickup

Lesson 3.1: What Is a Watershed?

Essential Concept

We all live in a watershed.

Objectives

1. Students will work together to generate a definition of watersheds.
2. Students will identify their watershed address.
3. Students will look at changes to water, an abiotic part of the environment on which all living things depend and how those changes affect living things.
4. Students will discuss changes in water in a watershed caused by erosion.
5. Students will discuss changes in water in a watershed caused by various human uses of the land.
6. Students will explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences, and support the explanation using a specific example of aquatic resources in Texas.

TEKS

6.12 E, 7.8 B; 8.11 B

Aquatic Science: 12 A, B, D

Environmental Science: 5 A, B; 9 A

Estimated Time

1- 2 class period

Materials

Science journals

Pencils/pens

Chart paper

Markers

Procedure

1. Do You Live in a Watershed?

Ask the class this question. Have students raise hands to indicate if they live in a watershed. Some students may not know if they live in a watershed or not. Write the word *watershed* on the board.

2. Analyzing Words

Let's look at what the word *watershed* means. Take the word apart. We know that watersheds have something to do with water, because *water* is part of the word.

What could the word *shed* mean? Students may suggest ideas that are far from the topic such as *a small storage building* or *a lean-to,* but probably someone will come up with *something that comes off* as in "The raincoat *sheds* water." Or "The cat *sheds* hair."

So if we know what *water* is and we know that *shed* means *to come off.* Then what would a *watershed* be. (A place where water comes off and flows to other places–it is all the water that drains (comes off) from an area into a body of surface water.)

Therefore, we all live in a watershed. Where would the water in our watershed go? (Runs off into lakes, rivers, ponds, etc. and either eventually reaches the Gulf of Mexico or sinks into the ground and becomes part of the groundwater.)

- **How do you know which watershed you live in?** (Your watershed is the land from which water collects in the nearest stream, river, or lake.)
- **When it rains at your home, what stream, or river does the water travel to?**

Ask students to use a map of Texas to trace the nearest river and find their watershed address.

Example:

My watershed address begins with my yard in Austin, and includes Little Walnut Creek, Big Walnut Creek, Lady Bird Lake, the Colorado River, Matagorda Bay, and the Gulf of Mexico.

Ask students to determine their "watershed addresses". This can be done **with a map** that has streams and rivers or river basins marked or can be done **on the Internet** using the following website: http://cfpub.epa.gov/surf/locate/index.cfm

Students put in their zip code, and the website will take them to the nearest watershed(s). If they click on the watershed, it will take them to a site with a labeled drawing and information about their watershed. Write down the name of the watershed. If they scroll down to "Other Watersheds Downstream" and click on the watershed listed it will tell you the next part of your watershed address. Write this information down. Continue to that site, click on the next "Other Watersheds Downstream" and it will take you to the next part of your address. Continue in this way until you get to a bay, which feeds into the Gulf of Mexico. This list of watersheds will be the watershed address.

Alternate Internet Method:

Students may also go to Google Maps, type in the home address. Students must find the nearest creek or river, you might have to alternate between map and satellite views to find the nearest creek. The creek will be the first part of the watershed address. Ask students to zoom out and follow this creek to where it joins a river, record each river/lake that you find, continue to follow the river to the next watershed until it takes you all the way to the Gulf of Mexico. When all watersheds are listed the student will have the watershed address.

3. Erosion, Non-Point Source Pollution and Point Source Pollution

Watersheds collect the water, an abiotic part of our ecosystem, that makes it possible for humans, plants, animals, and other organisms to live and survive, but water often travels a long way in Texas and a lot can happen to the water before it reaches the Gulf of Mexico.

Make a Chart

Ask students to predict how chemical, organic, physical, and thermal changes in this abiotic part of the environment affect the living things that depend on the water in your watershed. (Write ideas on chart paper and come back to check them at the end of the lesson.)

Have students take notes in their journals as you discuss the following questions.

- **How does what happens on land in the watershed in our area affect the water in [name your local lake, stream, wetland, or estuary]?** (Water draining off of the land in our area may become muddy, or pick up pollutants.)
- **What makes water muddy?** (Soil eroding away and washing into bodies of water)
- **Is muddy water bad?** (Muddy water has sediments. If there are too many sediments in pond or stream water, plants cannot get enough light to grow and will die causing decay and oxygen depletion, killing off other living things.)
- **What other things could happen to the water in your watershed?** (Anything that happens on the land can cause changes in water in our watershed to make it unusable by humans and other organisms in the environment. For example:

All of the following cause non-point source pollution.

1) Loss of plants from overgrazing or drought causing erosion
2) Feces from animals, which adds nitrogen to the water
3) Phosphates from detergents from washing machines
4) Acid rain caused by older unregulated coal fired electrical generating plants
5) Automobile exhaust
6) Oil, gasoline, and tire dust runoff from roads

Both of the following can cause point source pollution.

1) Chemical spills from a factory
2) Water used for cooling at power plants which can release thermal pollution

- **What land uses have you seen along your stream, or river, lake or bay, or along the Gulf of Mexico?** (Ranches, chemical plants, oil refineries, farm fields, feedlots, factories, highways, parks, etc.)
- **How would the ways humans use the land affect the watershed? (**Everything that happens to the land goes into the watershed during rain, runoff, and infiltration. All of the above land uses create changes in the water in our watershed. Even parks contribute litter, runoff and erosion to the environment.)

Go back to read the chart of predictions that students made at the beginning of the lesson. Are there things that students would like to add or change in their ideas of how chemical, organic, physical, and thermal changes in water can affect the living things that depend on this essential abiotic part of the environment?

4. Thinking of the Future of our Watershed

Ask students to write a paragraph analyzing and discussing the following questions. Students should use the information on the class chart to help them think about the questions.

- How do you think that more people living on and using the land would affect the water flowing through a watershed?
- How do human activities such as fishing, transportation, dams, and recreation influence aquatic environments?
- How can a technological solution to a problem have both benefits and drawbacks such as risks or unintended consequences? What might be a specific example of consequences for aquatic resources in Texas.

Vocabulary:

- Drains
- Erosion
- Non-point source pollution
- Point source pollution
- Runoff
- Sediment
- Watershed

Lesson 3.2: Topography and Watersheds

Essential Concept

The topography of the area forms the watershed providing places for water to collect.

Objectives

1. Students will use a topographic map to find the height of a geographic feature.
2. Students will use a topographic map to help them create a model of a watershed.
3. Students will predict where water will flow off of the model watershed.
4. Students will predict where water will pool in the model watershed.
5. Students will identify factors that contribute to how water flows in a watershed.
6. Students will decide where to build a house in the watershed model based on the places where water will flow and where it will pool.
7. Students will look at the affects of pollution in different places in a model watershed.
8. Students will define point-source and non-point pollution.

TEKS

6.1 A, B; 6.3 B, C; 7.1 A, B; 7.3 B, C; 7.8 C; 8.1 A, B; 8.3 B, C; 8.9 C;

Aquatic Science: 2 H; 4 A; 7 B

Environmental Science: 5 A, B

Estimated Time

1 class period

Materials

<u>For Each Group of 6 Students</u>

Oil based clay

Scissors

Plastic knife

Topographic Map of Buffalo Hill

Topographic Map of Green Hill Point

Disposable aluminum cookie sheet or rectangular cake pan

Wax paper

2 Spray bottles with water

2 two-inch dowels cut in one-foot lengths or other roller to flatten clay

Paper clips for each student

Construction paper

Paper towels

Newspapers

Food coloring (green and red)

Blue, red, yellow, and green pens or colored pencils

For high school: http://www.topoquest.com/ (Source for topographic maps)

Special Instructions

Copy topographic maps, collect materials

Safety Precautions

Students should use caution with scissors and plastic knives.

Procedure

1. What Is Topography?

A watershed is all the land that drains water into a particular water body such as a wetland, stream, river, lake, bay, or ocean. Topography is what we call the contours of the land like hills, cliffs and valleys. Notice the parts of the word ("top" like the **surface** of the land and "ography" which means to study or to map). A topographic map shows the contours of landforms and elevations in a watershed. There are 2 simplified maps at the end of the chapter to help students learn to use a topographic map and to understand how it creates a 3 dimensional representation of the land.

Note: For older students, you may want to get professional topographic maps online. One source is http://www.topoquest.com/. You can request a map of your area.

Divide students into groups of 6. Give each group the 2 topographic maps. Have students decide the highest elevation of each landform represented and write the height in their journals.

Each line on the map is called a contour line and is an interval representing a certain amount of rise in elevation. On our simplified maps each interval represents 25 feet.

- **What do these maps tell us about the land?** (Students may notice that some lines are closer together than others. These represent steeper sides of the hill. They may notice that where contour lines are farther apart, there are some flat places on the hill. They may notice that some places are more carved out, which may indicate a softer rock or more exposed soil which is eroding faster than surrounding rock.)
- **What does the map tell us about where water will run off in this watershed?** (Water will flow off of the hills and down into the lower levels to the pan, which represents a valley. Students may notice places where water might accumulate in puddles on the way down the hill, or places where they think water may run off faster than other places.)

2. Building a Model

Each group of 6 students will construct a three-dimensional model of the two hills in a disposable aluminum cookie sheet. Three students from each group of six will use one of the topographic maps to make a model of a high point in the watershed. The two hills will sit in the same pan representing two drainage areas both feeding into the valley (pan). Place one hill at each end of the pan.

Students will use the topographic maps as patterns for their models. Have students cut around the largest contour line on their map with scissors. They will roll out the layers of clay to about ¼ inch thick. **Note:** Put the clay on wax paper to keep it from sticking to the desk, lay the largest layer of the landform (represented by the largest contour line) on the clay and cut around it with a plastic knife then place this layer in the aluminum pan.

Students will roll another piece of clay flat. Cut around the next largest contour line with scissors, lay this on the clay and cut around it with the plastic knife. Stack this layer on top of the first layer of clay.

Students will continue to cut away one contour line at a time from the paper map, use it as a pattern, and cut the clay for the next layer until all of the contour lines have been cut from clay and stacked as they were represented on the map. The clay will then represent the hills and valleys in this watershed.

- **Did your model look like what you expected from looking at the topographic map?**

3. Predicting Runoff in a Watershed

After the clay models are complete, have each group work together to predict how they think water will flow off of the hills and into the valley. Students should write their predictions in their journals.

- **How will water move through your watershed?**

(**Note:** Depending on how carefully students match the orientation and position of each interval, the watershed models may be slightly different in position, height, and slope as well as differences in the relationship between the two hills. Therefore, students may see varying patterns of runoff and accumulation of water between groups.)

Give out the appropriate topographic map to each student for the hill that they helped construct.

- **Where do you predict the most water will run off?** Mark these places on your map with a yellow pencil.
- **Where do you predict water will collect in your watershed?** Mark these places with a blue pencil.

Based on their predictions, where do students think would be the best places to build houses.

Have each student cut a house shape from construction paper and write their name on the back of the house. Using a paperclip, have each student place his/her house in the place on the model where they think they would like to live. Ask students to note with a red pencil on their maps where their houses are located.

4. Modeling Runoff and Accumulation

Have students take turns with the spray bottles squirting water to simulate rain on the hills. Be sure that the rain falls on all parts of the hills.

Have students carefully observe the behavior of the water. Ask them to describe where the water went as it fell on their model watershed. (The water will run down from the high points through the crevices in streams until it reaches the low areas in the watershed, where it will accumulate.)

Have students indicate with a black pencil on their maps where they see water actually running off. Is it in the places that you thought runoff would occur? Then note if their house is in a place where water accumulates or if it is in an area that gets a lot of runoff.

- **Did the water flow where you thought it would?**
- **What factors affected the places where water flows?**
- **Were there some surprises in how water moved or accumulated? What caused these unexpected results?**
- **Did the house they built survive? Was it in a place that might flood or have water run through it?**
- **Were their predictions of where water runoff would occur and where water would collect correct? If not, what was the variable that influenced the runoff and collection that they might not have considered?**
- **Did all of the water run off in the same place? What happened? Why?**

5. Where Does Pollution Go?

Ask students to place 1 or 2 drops of green food coloring to represent pollution at the top of the hills and in 4 other places in their watershed. Simulate rain again. Have students use a green pencil to mark their topographic maps with the locations where they put the pollution and draw lines where the pollution ran off and accumulated.

The colored runoff represents non-point source pollution—water pollution that comes from a broad area or a number of sources.

- **What happened to the pollution when it rained?** (No matter where the pollution is located on the hill, it will accumulate in the water at the bottom of the hill.)

If we had pollution in just one place, perhaps from a factory on the side of a hill, that would represent point source pollution. Add 5 drops of red food coloring to one location in the watershed to represent point source pollution. Provide another rainstorm on the watershed.

- **What happens to the pollution when it rains on the top of the hill?**
- **How do we know if the pollution gets into the water at the bottom of the hill?** (The water will change color from green or red to brown when the two types of pollution mix.)

Emphasize that any pollutant on the land of a watershed will be carried by runoff into the main water body of the watershed.

- **If there is pollution in one part of the watershed, how will other parts be affected?**
- **What do we mean by point-source and non-point source pollution? Compare and contrast them and support the answer using a specific example of each that is relevant to aquatic resources in Texas.**
- **If it only rains in one part of the watershed, are other areas affected in any way?**
- **What are the parts of a watershed system?** (Various levels or elevations of landforms, including hills, valleys, various types of soils, wetlands, streams, springs, rivers, lakes, oceans)
- **How does the watershed affect the water body into which it drains?**
- **How do human activities affect the quality and quantity of water in a watershed?**
- **Why do we need a model to understand watersheds?** (Watersheds cover large areas, which can be observed all at one time. A model makes observation easy.)
- **How is this model like a real watershed?**
- **What are the limitations of the model?** (Clay does not allow any water to soak into the ground to show groundwater accumulation. In addition, clay doesn't erode. The size and variety of landforms is limited, squirt bottles cannot represent a hard rainstorm very well, etc.)
- **What other things would be found in a watershed that were not used in our model**? (Potential sources of pollution may include dumps or landfills, farms or animal-feeding operations, golf courses, farms, lawns, and other places that may use fertilizer, sewage treatment plants and other known point sources. In addition, non-point sources of pollution might include highways and mall parking lots, mines and other areas of land disturbance such as construction sites. Also note features that may have positive impacts, such as forested areas, grasslands, or other less-developed areas.)
- **How would roads affect runoff in a watershed**?
- **How would cities affect runoff in a watershed**?
- **What do we mean when we talk about impermeable surfaces?** (These are hard surfaces where water cannot soak in or get through such as parking lots, buildings, roads, or any paved area.)
- **How would grasses, trees, and other plants affect runoff in a watershed**? (Ask students to talk about any examples they have given and how they could positively or negatively affect the watershed.)

Note Preparation for the Next Class: Have students clean up water, ball up clay for use by other classes, and dispose of used materials properly.

Vocabulary

- Accumulation
- Impermeable surface
- Non-point source pollution

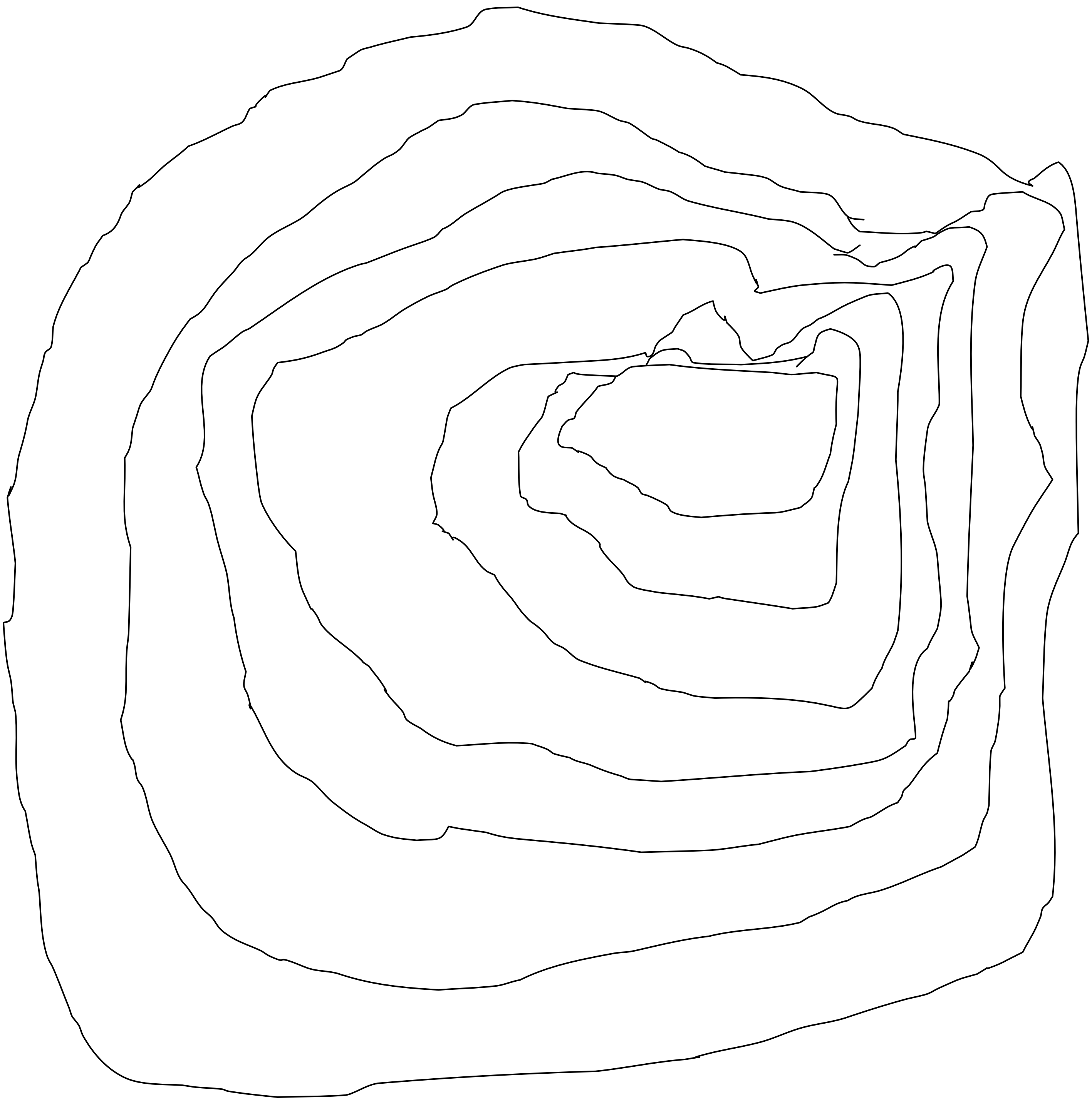
- Point-source pollution
- Runoff
- Topographic map
- Topography
- Watershed

Topographic Map of Buffalo Hill

Each interval = 25 feet

Beginning elevation 100 feet. **North** ↑

How tall is Buffalo Hill?

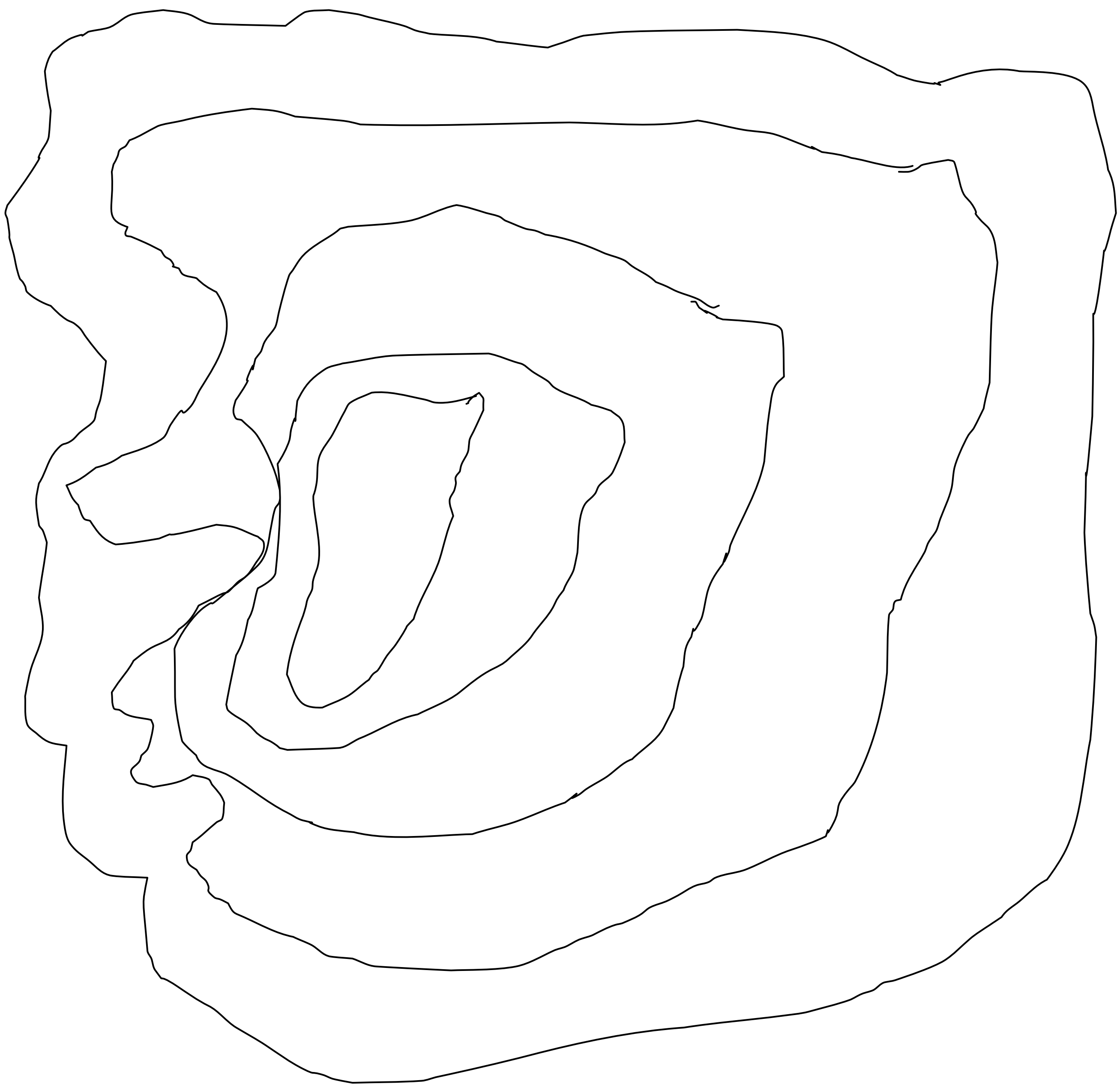


Topographic Map of Green Hill Point

Each interval = 25 feet

Beginning elevation 100 feet. **North** ↑

How tall is Green Hill Point?



Lesson 3.3: Land Use in our Watershed

Essential Concept

School grounds are part of our watershed and we need to maintain the grounds in order to reduce erosion and pollution.

Objectives

1. Students will take part in a scavenger hunt to look at land use and pollution where water flows from the school grounds into the watershed.
2. Students will look at problems on the school grounds that might affect the watershed.
3. Students will define erosion and sedimentation and analyze how human activity affects erosion and sedimentation.
4. Students will describe the impact of erosion and sedimentation on aquatic resources in Texas.
5. Students will define water quality and support their ideas using a specific example of how humans affect water quality in the local Texas watershed.
6. Students make a map of the school grounds showing erosion and pollution problem areas and will indicate on the map ways they think the class could help alleviate problems.

TEKS

6.1 A, B; 6.2 C; 6.12 C; 7.1 A, B; 7.2 C; 7.8 C; 8.1 A, B; 8.2 C; 8.11 B, C;

Aquatic Science: 2 J; 4 A; 7 B; 12 A

Environmental Science: 2 K; 5 A, B; 9 A

Estimated Time

1 Class period and homework

Materials

Copies of the *What's in Our Watershed?* scavenger hunt and clipboards for each student. If you don't have clipboards, you can use heavy cardboard and a clamp for a clipboard.

Pencils

Science journals

Special Instructions

Copy scavenger hunt for students.

Safety Precautions

Make sure students understand field trip behavior guidelines

Procedure

1. What's In Our Watershed?

Note: This is a good activity to do on a day when you have had a recent rain so that students can see where water is accumulating and running off.

Today we are going to conduct a scavenger hunt looking for places on the school grounds where water flows, infiltrates, or accumulates. We are also going to look at land use and places where something could change the quality of water in our watershed. Think about how these changes might affect organisms that live in our watershed.

Pass out student scavenger hunt sheets.

Take the class outside on the school grounds for a hike and scavenger hunt. Remind students that they are standing in a watershed and that everything around them is part of a watershed, because rainwater falls on everything in a watershed.

Teacher Information for the Scavenger Hunt

1) **What land use do you see on the school grounds? (**Land use in your watershed may include land used for buildings, parking lots, athletic fields, lawns, homes, streets, ranches, gardens, forested areas, etc. In short, anything that is on the school grounds or across the road will be in the watershed.)

2) **Where is water collecting or accumulating on the school grounds?** (There may be low places or puddles near gutters or flowerbeds or in open areas where water accumulates. At some schools there may be a stream or pond nearby where water runs off after a rain.)

3) **Do you see signs of runoff?** (Students may see areas that are washed away or where water has flowed out of flowerbeds or gutters, or perhaps where oil and gasoline or trash and litter washed off of parking lots. Have students point out that when rain falls, water flows over all of the surfaces, picking up whatever contaminants or litter may be present as it moves downhill. This is non-point pollution.)

4) **Where is there a place on the school grounds where soil is eroding? Why is this happening?** (If there is an area where students have walked and left a pathway in the soil where no plants are growing, it may have caused some erosion. There may also be places where gutters have allowed water to run, or where there is no grass or other plants, and soil may have washed away, etc.)

5) **What factors influence water flow through the school grounds?** (Elevation, land contours, erosion, impermeable surfaces, etc.)

6) **What are some potential sources of pollution on the school grounds?** (Parking lots, roads, bare places, places that might have been fertilized such as flowerbeds, eroded areas, trash dumpsters, etc.)

7) **What land uses or features may help reduce or contain pollution?** (Grassy areas, berms, or other planted areas between potential pollution sources and any drainage areas, etc.)

8) **How does non-point pollution get in the watershed?** (All runoff flows into ditches and storm sewers, and directly into streams, ponds, rivers or other bodies of water.)

9) **What short or long term changes may happen to the watershed from the runoff from the school grounds?** (Leaf accumulation, fertilizer in flower beds, insecticide spray, drought causing grass to die and wear away, etc.)

10) **How might these changes affect organisms living in the watershed that depend on water for survival?** (Even seemingly innocent changes such as a build up of leaves on the ground in the fall can result in these being washed into streams, around the school grounds. This can add organic matter to streams, causing eutrophication, which can result in an over growth of plants, cutting off light, causing death of plants, using up oxygen in decay and removing oxygen from the water, leaving other organisms short of oxygen and causing stress or death.)

11) **List chemical, organic, physical and thermal changes to the watershed caused by human land use.** (Fertilizer, pesticide, herbicide, dead leaves, erosion, heat from roads and parking lots, etc.)

12) **What effects on living and nonliving components of the ecosystem might we expect from these changes in our watershed?** (Dead leaves decaying and heat from roads and parking lots can cause a depletion of oxygen, suffocating some organisms. Fertilizer can cause aquatic plants to grow and cut off light to the bottom, resulting in dead and decaying plants, and depletion of oxygen. Pesticides and herbicides can kill organisms in streams. Erosion can cause too much sediment to be suspended in water cutting off light for photosynthesis to plants. The loss of plant life could affect the whole food chain, starving many organisms.)

2. Applying What We've Learned

What's the Problem and How Could We Solve It?

Return to the classroom and have students work in groups of 4 for 10 minutes to compare their findings on the scavenger hunt. Then have each group report to the class on one, or two of the questions. Record results on an overhead or on the board. As each group reports, have the class add new information that has not yet been reported.

- **What are the problem areas on the school grounds?** (Have students look at the data collected on their hikes and find places where there are problems that might affect the watershed.)
- **What are erosion and sedimentation**?
- **How does human activity affects erosion and sedimentation.**
- **What is the impact of erosion and sedimentation on aquatic resources in Texas?**
- **How could we prevent erosion and pollution or reduce their effects on our school grounds?**
- **What is good water quality and what is an example of how humans affect water quality in the local Texas watershed?**

Ask students to **draw a map** of the school grounds indicating problem areas. Have students note on their maps ideas that they have for preventing erosion and pollution such as placement of trash cans in litter prone areas, planting gardens in eroded areas to hold soil in place, putting in small gravel pathways or trails where students tend to walk and wear away plants, etc.

Student's ideas may be something that you can submit to the PTA for projects they can help students work on or that they can help fund, or there may be projects that your classes can work on together on a few weekends or even during class.

Have students add their idea maps to their science journals and staple or tape their scavenger hunt pages in their journals.

Vocabulary

- Accumulation
- Erosion
- Eutrophication
- Impermeable
- Land use
- Litter
- Non-point source pollution
- Photosynthesis
- Pollution
- Runoff
- Watershed
- Watershed

Student Page

What's in Our Watershed?
Scavenger Hunt

1. **What land use do you see on the school grounds?**

2. **Where is water collecting on the school grounds?**

3. **Do you see signs of runoff?**

4. **Is there a place on the school grounds where soil is eroding? Why is this happening?**

5. **What factors influence water flow through the school grounds?**

6. **What are some potential sources of pollution on the school grounds?**

7. What land uses or features may help reduce or contain pollution?

8. How does non-point pollution get into the watershed?

9. What short or long term changes may happen to the watershed from the runoff from the school grounds?

10. How might these changes affect organisms living in the watershed that depend on water for survival?

11. List chemical, organic, physical, and thermal changes to the watershed caused by human use.

12. What effects on living and nonliving components of the ecosystem from these changes might we expect in our watershed?

Lesson 3.4: Texas Watersheds, Ecoregions and Physiographic Regions

Essential Concept

The physiographic characteristics of an area affect its aquatic resources.

Objectives

1. Students will analyze data on maps to formulate reasonable explanations related to interrelationships among geology and hydrology of regions of Texas.
2. Students will describe biotic and abiotic parts of an aquatic ecosystem.
3. Students will draw conclusions about the relationships among the characteristics of physiographic regions, watershed, and aquatic environments.
4. Students will explain the relationship between the watershed and the water body into which it drains.
5. Students will identity Texas' ecoregions or physiographic regions and explain how land type may affect Texas' aquatic resources, wildlife, and recreation in and around water.

TEKS

6.2 E 6.4 A; 6.12 E; 7.2 E; 7.4 A; 8.2 E; 8.4 A; 8.11 B

Aquatic Science: 2 J; 3 B; 4 A; 7 B

Environmental Science: 2 K; 3 B; 5 B

Estimated Time

1 class period

Materials

Map 3.1: *Texas River Basins* (watersheds) map

Map 3.2: *Texas River Basins and Major Bays* (watersheds) map labeled

Map 3.3: *Texas Natural Regions* Map

Map 3.4: *Texas Natural Regions and River Basins* (watersheds) map

Map 3.5: *Texas Notable Features*

Download maps here:
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/maps.pdf

Science journals

Pencil/Pens

Computer and projector or Smart Board (optional)

The Keep Texas Wild series explores the last wild places in Texas and how we can preserve them. More at http://www.tpwd.state.tx.us/ (optional)

Special Instructions

Maps on the *Texas Aquatic Ecosystems* website can be expanded or contracted as needed. The teacher can then use these as a part of the class discussion, in a PowerPoint, or on the smart board, PowerPoint, and/or print copies for student use.

Note: Physiographic regions and ecoregions are similar. Physiographic regions tend to have more emphasis on the geography, morphology (history of landforms), and climate. Ecoregions tend to have more emphasis on the environmental conditions, including environmental conditions such as geology, soil, and climate, and geographically distinct assemblage of species, natural communities.

Note: For high school students: You might like to get some maps from the Bureau of Economic Geology. They are detailed and have lots of information on the back. These are 8 ½ inches by 11 inches full color maps and the cost is only 25 cents each. So teachers can afford to get several copies of the maps they want to use and laminate copies for each of their small groups. The maps can then be reused for a number of years. The following are some of the maps available: *River Basin Map of Texas, Physiographic Map of Texas, Geology of Texas, Aquifers of Texas, General Soil Map of Texas, Tectonic Map of Texas, Vegetation/Cover Types of Texas, Industrial Minerals of Texas, and Land-Resource Map of Texas.* The website is http://www.beg.utexas.edu/pubs/pubs-teachers.php

Or e-mail at: pubsale@beg.utexas.edu

Procedure

Pass out copies of maps to students to discuss with their groups.

1. Looking at Watersheds in Texas

Display Map 3.1, the *Texas Watersheds* Map, as students work together to answer the following questions:

Point out that the blue lines on the map are the boundaries of watersheds. Have students notice that there are multiple watersheds in Texas.

- **What part of the state has the least water?** (West Texas)
- **What part has the most water?** (East Texas)
- **In what general direction does the water travel?** (to the southeast)

The counties of Texas are shown in the background on the watershed map from TPWD.

- **Do you see some watershed boundaries that cut through some counties? What would that mean?** (Explain that watershed boundaries do not correspond to political boundaries. In other cases the river of a particular watershed may form a boundary for example the Red River is the boundary between Texas and Oklahoma and the Rio Grande is the boundary between Texas and Mexico. Therefore the watershed boundaries for those rivers cross state or national lines.)

- **Do you see some counties where watershed borders go through counties so that parts of the county are included in one watershed and parts of the same county are included in another watershed?**
- **What does that tell you about the land in that county?** (There are higher elevations in the area of the boundary line and a divide is formed so that water runs off into two different watersheds.)
- **Does this map show streams and rivers in a watershed for a particular river basin?** (No, but we know the streams in our area feed into the river near us so those streams and rivers are all part of the watershed.) Explain that there are multiple smaller watersheds within every large watershed.

2. Locating our Watershed

Look at Map 3.2: *Texas River Basins and Major Bays* (watersheds) map labeled. This map has a color key.

Ask students to look at the key and work together in a small group to label the major river basins/watersheds.

There are also coastal basins in the color key. We will look at those a little later.

- **Can you find the county where you live? Mark it with a small X on your map. (Note:** The print is too small to read so if students can't find their county, provide Texas road maps where they can find their town and then locate the county it is in. Have students mark their county on the Texas River Basin Map.
- **In what river basin/watershed are you located? Use your county mark and the color key to help you find out.**

Now look at the coastal basins. Notice that each forms a bump on the map along the coastline.

- **What do you think those bumps indicate?** (This is where deltas have been built up by the rivers flowing into the bays and estuaries.)

For High School Students

Use the *River Basins Map of Texas* from the Bureau of Economic Geology. Have students look at the map and explain how it is set up and what the blue, black, and red lines mean. (blue is for rivers, black is for river basins, and red lines indicate annual rainfall areas)

Study the rainfall patterns shown on the map.

- **What is the trend in rainfall across the state?** (Less rainfall in the west and more rainfall in the east)
- **How would that trend affect the various river basins?** (More river basins in the east)

- **Given the direction of the flow of the rivers, what can you conclude about elevations in different parts of the state?** (Rivers running to the southeast indicated elevation is higher in the west and northwest and lower in the southeast.)

Look in the blue table at the bottom of the map. Compare the Rio Grande River Basin in the west with the Neches River Basin in the east. (The Rio Grande Basin is l,250 miles long and has an area of 48,259 square miles with 3 reservoirs that can hold 3,772,000 acre feet of water (78 acre feet of water storage per square mile). The Neches River Basin is 416 miles long and has an area of 10,011 square miles with 4 reservoirs that can hold 3,455,500 acre feet of water (345 acre feet of water storage per square mile). This means that The Neches Basin, while $^{1}/_{3}$ the length of the Rio Grande Basin, and ¼ the area, has 1 more reservoir, but a similar amount of conservation storage, but 5 times the acre feet of water storage per square mile reflecting the greater rainfall in that part of Texas.)

Note to the Teacher: Any subset of data in the table can be used for this high school question, or each group might use a different subset of data.

High School: Going Deeper

Have students read the back of the River Basin Map of Texas from the Bureau of Economic Geology and take notes. Each student should come up with at least 3 facts that tell us something of interest about the river basins and their impact on aquatic environments. If you would like to do this in class, you could assign a paragraph or two to each pair of students and have them report back to the class on the important points in their paragraph(s). Give students 10 minutes to read and discuss their paragraph(s). Then follow with reports to the class. Have students take notes in their science journals. Have students use the information to make generalizations about the river basins of Texas.

3. Texas Ecoregions

Give students Map 3.3: *Texas Natural Regions* map. These are the ecoregions used by biologists and are classified by the interacting geology, hydrology, and biology of each area. Assign each group of 2-3 students to go online and research information for one of the eleven natural regions of Texas.

Students should answer the following questions in their report to the class on their assigned natural region. http://texastreeid.tamu.edu/content/texasEcoRegions/

- **How are the geological characteristics of each region related to the hydrological characteristics found there?**
- **How are the hydrological characteristics of each region related to the aquatic environments of the area?**
- **How do the aquatic environments available determine the organisims that are able to live in the area?**

Have each group answer the questions as they share the characteristics of their region with the class. Ask the class to take notes in their journals on each region.

Based on your notes of the reports to the class, answer the following question in your journals.

- **What are Texas' ecoregions and how might land type affect Texas' aquatic resources, wildlife, and recreation in and around water?**

<u>For High School: Connecting the Ideas</u>

Use the *Physiographic Map of Texas* from the Bureau of Economic Geology. Look at the table at the bottom of the map as you examine the map.

- **What generalizations can you make about the geological, hydrological and biological history of the state?** (The Gulf once covered a good part of the state leaving behind sandy soils and muds, chalks, limestone and dolomites. A long fault line divides the state nearly in half with the uplift to the north away from the Gulf. There are mountains to the west and plateaus to the north. At some point the central part of the state was uplifted and eroded away leaving evidence of many faults, volcanic activity and metamorphism. The northern part of the state is high, flat mesas and plains. This geological history has important influences on stream flow directions and patterns, river valley formations, and soil types. All of this, along with the rainfall data we looked at in the *River Basin Map of Texas*, would influence plants that grow in each area, which in turn influences the types of other organisms that would be able to survive.)

Read the back of the *Physiographic Map of Texas* to get more detailed information and to check your ideas. Make additions to your paragraph when you find data to support other ideas. (This can be done in small groups in class with each group taking one physiographic region, or as a homework assignment.)

- **How might a river change as it flows from one physiographic region to another?**
- **How might a river that flows over many physiographic regions be different as it meets the ocean than one that flows through just one or two physiographic regions?**

If students seem interested, other maps from the Bureau of Economic Geology can provide a source of more information that can provide a rich background for understanding Texas' diverse aquatic ecosystems.

4. Comparing Ecoregions with Watersheds.

If we put the watersheds (river basins) map over the top of the ecoregion map, we would have a map that looked like Map 3.4: *Texas Natural Regions and River Basins* (watersheds) map.

Draw the students' attention to your school's county. Discuss the following questions as a class. Ask students to take notes to use in writing a paragraph in their journals.

- **In which watershed is the school located?**
- **What natural region is the county in?**

- **What influence do these two factors have on aquatic environments?**
- **How do the geological, hydrological, and biological systems relate to the aquatic environments in our county?**

5. Writing About Relationships Between Ecoregions and Watersheds

Have students use the answers to these questions to write a paragraph in their journals summing up what they have learned about the relationship of watershed and eoregions on aquatic environments found in their county.

Extension

Compare Map 3.5, *Texas Notable Features* (which shows geological features in relief) with Map 3.1: *Texas River Basins* (watersheds) map.

- **How are some of the notable features related to river basins?**

Vocabulary

- Hydrological
- Physiographic regions
- River basins
- Watershed

Lesson 3.5: Reading and Research

Essential Concept

Everything that happens to the land affects the watershed and the body of water into which it drains.

Objectives

1. Students will read background information on watersheds.
2. Students will answer questions about watersheds
3. Students will draw a poster to inform and motivate the public to take action to control effects of erosion and various pollutants on organisms that live in water.

TEKS

6.12 E, 7.8 B; 8.11 B;

Aquatic Science 7 B; 12 A

Environmental Science; 5 B; 9 A

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Poster can be done at home as homework.

Materials

Student Guide

Science journal

Pens or pencils

Posterboard

Various art materials of the student's choice

Procedure

1. Student Reading

Have students read *Chapter 3: Watersheds and the Land*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is a watershed? Which watershed do you live in?

A watershed is all the land that drains water into a particular body of water. Students should know their watershed by the time they do this lesson.

2) How does the watershed affect the water body into which it drains? How do human activities affect the quality of water in a watershed?

What you do to the land, you do to the water. Everything that happens on the land in a watershed affects the water body into which it drains. A stream, pond, or wetland can only be as healthy as its watershed. How we use the land affects the health of our aquatic resources. As water runs downhill, it picks up whatever is on the ground. When it flows through cities or across fields and pastures, water picks up sediment, pollutants and heat. These contaminants flow into a stream, wetland or lake you use to swim in, fish from, or from which your drinking water comes.

3) What is point-source pollution? What is non-point pollution?

Point-source pollution is contamination that can be traced to a single source. Non-point pollution is water pollution that comes from a broad area or a number of sources.

4) What is erosion? What causes it?

Erosion is the wearing away and movement of solid material such as rock, soil, or mud. It is a natural process caused by the forces of wind, water, ice, gravity, and/or living things.

5) What is sediment? Where does it come from?

Sediment is any bit of rock or soil that is suspended or carried in water. It comes from eroding rock, soil, or mud.

6) How does human activity affect erosion and sedimentation?

Human use of land changes it and may lead to erosion, which causes sedimentation.

7) What is the impact of erosion and sedimentation on aquatic resources?

Erosion impacts soil fertility and water quality. Erosion allows sediments to run into aquatic habitats causing deposits in streams and filling reservoirs and can make it difficult for aquatic organisms to get enough light and oxygen to survive.

Erosion can be accelerated by cutting down too many trees, poor grazing practices, or disturbing land for construction. Planting trees and placing erosion controls along streams and rivers are two ways to slow the effects of erosion. Many Texas farmers and ranchers have worked to improve farming and grazing practices and reduce the amount of soil and other sediment in Texas streams.

3. Challenge Question

Ask students to think about the following questions and write a paragraph in their journals to discuss these ideas.

- **How does your location within a watershed affect the quality of water where you live, and how can you influence the quality of water where others live in your watershed**

4. Using What We've Learned: Making a Poster

Ask students to use posterboard and art material of their choice (markers, crayons, water colors, tempera, colláge, etc.) to make a poster depicting the plight of organisms in water where the watershed has brought in too much sediment, pollution, or heat.

Students should show where the contaminant is coming from and how it affects life in an aquatic ecosystem.

The poster should motivate people to help keep water clean and indicate specific actions to take to protect our water.

Note at least 3 sources of information on the back of the poster.

Give students the Rubric for Posters before they start their work so that they know what is expected of them.

Note: If you wish to make this competitive you might have a prize. For example, posters might be displayed in the hallway for a vote on "Student Favorite Pollution Poster" with the winner receiving an "Earth Day" T-shirt or some other prize. Be aware that some students feel threatened by competition. Research shows that girls, in particular, are often uncomfortable in competition. Make the decision on whether to have a competition based on your knowledge of your students.

Vocabulary

- Bays
- Coastal basins
- Estuaries
- Headwaters
- Hydrologist
- Intermittent or ephemeral streams
- Natural physiographic regions
- Non-point source pollution
- Point source pollution
- River basin
- Sediment
- Watershed

Rubric for Poster

I. Organization **Total 20 points**

1. Title
2. Clear concise information
3. Organized in a logical way
4. Doesn't need explanation

II. Appearance **Total 30 points**

1. Neat, clean, attractive
2. Easy to read and colorful
3. Information easy to understand
4. Motivates action in keeping the environment clean

III. Accuracy **Total 30 points**

1. Includes at least 1 organism
2. Shows the source of the erosion or pollution
3. Shows the affect of the pollution on the organism
4. Indicates how humans cause the problem

IV. Critical Thinking **Total 20 points**

1. Conclusions are based on logical inferences and generalizations
2. At least three sources of information are noted on the back of the poster
3. Actions people can take to keep water clean are clear

Possible Grand Total 100 points

Chapter 3 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **What is non-point pollution?**
   - **A** A stream that empties into a particular body of water
   - **B** Water pollution that comes from a broad area or a number of sources
   - **C** The movement of solid material such as rock, soil or mud
   - **D** Contamination that can be traced to a single source

2. **What is erosion?**
   - **A** Any bit of rock or soil that is suspended or carried in water
   - **B** Water pollution that comes from a broad area or a number of sources
   - **C** The movement of solid material such as rock, soil or mud
   - **D** All of the above

3. **What is a watershed?**
   - **A** A stream that empties into a particular body of water
   - **B** The area where precipitation first collects in tiny trickles too small to create a permanent channel
   - **C** A stream that flows all year long
   - **D** All the land that drains water into a particular body of water

4. **What is point-source pollution?**
   - **A** A stream that empties into a particular body of water
   - **B** Water pollution that comes from a broad area or a number of sources
   - **C** The movement of solid material such as rock, soil or mud
   - **D** Contamination that can be traced to a single source

5. **What is sediment?**
   - **A** Any bit of rock or soil that is suspended or carried in water
   - **B** Water pollution that comes from a broad area or a number of sources
   - **C** The movement of solid material such as rock, soil or mud
   - **D** None of the above

Chapter 3 Assessment

Directions

Write your own answer for each of the following questions.

1. What is the watershed address of your school?
2. Identify and describe the natural physiographic region in which your school is located.
3. How does human activity affect erosion and sedimentation? Justify your answer using an example relevant to Texas' aquatic resources.
4. Describe the relationship between what happens in a watershed and the water body into which it drains. Support your answer with an example of something that is happening in Texas' aquatic resources.
5. Describe how geological, hydrological and biological parts of an aquatic ecosystem interact.

Chapter 3 Assessment Answer Key

Multiple-choice questions

1. What is non-point pollution?

B. Water pollution that comes from a broad area or a number of sources

2. What is erosion?

C. The movement of solid material such as rock, soil, or mud

3. What is a watershed?

D. All the land that drains water into a particular body of water

4. What is point-source pollution?

D. Contamination that can be traced to a single source

5. What is sediment?

A. Any bit of rock or soil that is suspended or carried in water

Write-in questions

1. What is the watershed address of your school?

Assess locally.

2. Identify and describe the physiographic region in which your school is located.

Assess locally. Refer to Activity 3.4.

3. How does human activity affect erosion and sedimentation and what impact does this have on aquatic ecosystems? Justify your answer using an example you may have read about or seen that is relevant to Texas' aquatic resources.

Answers should include at least one effect of human activity and what impact it has on aquatic ecosystems, and one example of something happening in Texas.

Some possibilities include the following:

Human Activity and Its Effects:

- Deforestation, poor grazing or construction speeds up the natural process of erosion.
- Planting trees and placing erosion controls are two ways to slow erosion.
- Planting trees and other vegetation slows moving water down, and plant roots hold soil and rock in place.

Impacts:

- Sediment can clog streams with gravel and fill reservoirs with sediment.
- Excess sediment blocks out light, killing aquatic plants or preventing their growth.

- Sediment covers up the nooks and crannies aquatic animals live in.
- Sediment smothers fish by clogging their gills and reducing the amount of oxygen in water.

Examples from Texas:

- Texas farmers and ranchers have worked to improve farming and grazing practices to reduce the amount of soil and other sediment in Texas streams.
- Texas developers use silt fences, buffer zones and other erosion controls to reduce the amount of erosion and sedimentation in Texas streams.

4. **Describe the relationship between what happens in a watershed and the water body into which it drains. Support your answer with an example of something that is happening to Texas' aquatic resources.**

Answers may include:

Relationship between what happens in a watershed and the water body into which it drains:

- What you do to the land, you do to the water.
- Everything that happens on the land in a watershed affects the water into which it drains.
- A stream, pond or wetland can only be as healthy as its watershed.
- How we use the land affects the health of our aquatic resources.
- As water runs downhill, it picks up whatever is on the ground.

Examples:

- When it flows through cities or across fields and pastures, water picks up sediment, pollutants and heat. These contaminants flow into a stream, wetland, or lake, affecting the water in which you swim or fish, and you use for drinking.
- When you flush your toilet, do the laundry, fertilize your lawn or dump used oil on the ground, you are affecting water quality in your watershed.

5. **Describe how geological, hydrological and biological parts of an aquatic ecosystem interact.**

Answers may include:

Amount of rainfall and the geology of a particular place including:

- Topography
- Rock hardness
- Soil types
- Erosional patterns
- Permeability

Influence the water characteristics of a place including:

- The type of water bodies in the area (ponds, creeks, rivers, ground water such as aquifers).
- Properties of the water such as clarity, and chemistry,.

- Circulation such as the patterns of flow (still to swift).

the water then influences

- What plants can live in that aquatic environment which in turn influences.
- What other organisms can live there.

The geology, soil types, and rainfall amounts also influence:

- What plants can grow on the land along streams and other water bodies, and this influences.
- What other organisms can survive in the land areas along aquatic environments.

In turn, biological organisms influence:

- The erosion of soil and the water in which they live changing the water chemistry and light factors, and the water changes the geology, moving sediments, carving canyons and shaping valleys.

Living in the Water

All aquatic species, including fish and other aquatic animals, are uniquely adapted to life in or around water.

Chapter 4

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

1. Take part in a game to demonstrate their understanding of aquatic adaptations of animals.
2. Define adaptation, identify specific adaptations of aquatic species found in Texas, and explain the role of adaptation in the organism's ability to survive and fill a niche (such as predator, prey, producer, consumer, parasite, or host) in the aquatic community.
3. Define inheritance as the passage of genetic instructions from one generation to the next.
4. Identify the importance of inheritance in aquatic adaptations.
5. Discuss the difference between genetic adaptations and learned behaviors.
6. Examine Texas fish species and record observations.
7. Make accurate labeled drawings of their group's specimen.
8. Identify basic characteristics of organisms that help classify them and use a dichotomous key to identify a fish.
9. Investigate and explain how internal structures may be adaptations that have specific functions.
10. Discuss predator/prey, parasite/host, and producer/consumer relationships.
11. Complete a *Comparison Matrix for Texas Fish* studied.
12. Define species and give a Texas-specific example of an aquatic species.
13. Take part in a field trip to collect aquatic organisms.
14. Examine Texas aquatic organisms and record observations.
15. Compare and describe adaptations that allow a variety of organisms to exist in aquatic environments.
16. Observe and describe how different aquatic environments support different varieties of organisms.
17. Make accurate labeled drawings of their group's aquatic specimen.

18. Complete the *Comparison Matrix* to compare adaptations of various aquatic organisms.
19. Explore short and long term environmental changes that affect organisms and traits in subsequent populations.
20. Diagram the levels of organization in a freshwater ecosystem including organisms, population, community, and ecosystem.
21. Represent energy transfer through the ecosystem in a role playing activity.
22. Differentiate between inherited traits and learned behavior.
23. Synthesize what they have learned to role play the various parts and interactions among members of a freshwater aquatic ecosystem.

Texas Essential Knowledge and Skills

6.1 A, B; 6.2 A, B, C, D, E; 6.3 A; 6.4 A, B; 6.12 D; 7.1 A, B; 7.2 A, B, C, D, E: 7.3 A; 7.4 A, B; 7.5 A, C; 7.10 A; 7.11 A; 7.12 A, C; 7.14 A, B; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 A; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 B, E, F, G, H, J; 3 A, B, E; 10 A, B; 11 A

Environmental Science: 1 A, B; 2 B, E, F, G, H, I, K; 3 A, B, E; 4 A, B, E; 6 C, E

Materials

Activity 4.1

At least 1 print photo per student of an aquatic organisms–these may be photos from *Texas Parks and Wildlife Magazine*, other publications, or from the Internet

Tape or pins

Science journals

Activity 4.2

Student Guide

Science journal

Pencils or pens

Activity 4.3

Dead fish for each group

Field Guides

Copies of *Fish Comparison Matrix* for each student

Magnifiers or microscopes

Access to the *Texas Parks and Wildlife Department Aquatic Species Online Resource Library* at http://tpwd.state.tx.us/huntwild/wild/spices or copies of species *Fact Sheets*

Pens or pencils

Science journals

Computer with Internet connectivity

Activity 4.4

Native aquarium

10 or more gallon jugs

For Each Group

Field Guides

Buckets and other containers

Dip nets

Seines

10-gallon aquarium for the class or smaller aquariums for each group

Note: It is sometimes easier to set up and maintain one large aquarium for the class, but students enjoy making observations of small group aquariums and like to take care of their group's aquarium. The choice should be based on your students and your classroom space.

Activity 4.5

Aquatic organisms from field trip collection

Field Guides

Copies of *Comparison Matrix* for each student

Magnifiers or microscopes

Access to the TPWD Aquatic Species Online Resource Library or copies of specific species *Fact Sheets* at http://tpwd.state.tx.us/huntwild/wild/spices

Pens or pencils

Science journals

Computer with Internet connectivity

Activity 4.6

KWHL Chart

Field Guides

Hand lenses

Microscopes

Metric rulers

Petri dishes

Trays

Probes or plastic spoons

Safety Precautions and Concerns

Students should be careful with lab tools and be aware that some fish have spiny fins that can cause painful stabs. Some organisms can bite or sting.

Review Field Safety Rules

Vocabulary

- Adaptation
- Barbels
- Community
- Ecosystem
- Fins
- Genetic
- Gill covers
- Gills
- Inherited
- Interaction
- Lateral line
- Niche
- Organism
- Population
- Protective coloration
- Salinity
- Scales
- Slime
- Swim bladder

Resource Material for Teachers

http://www.tpwd.state.tx.us/huntwild/wild/species/

http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/

http://www.tpwd.state.tx.us/learning/resources/

http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/

Freshwater Fishes of Texas (TPWD publication)

Salt Water Fishes of Texas (TPWD publication)

Enrichments

Project WET

- Water Address

Project WILD Aquatic

- Fashion a Fish
- Fishy Who's Who

Guest speakers

- Fisheries biologist. Talk about fish adaptations and reproduction.
- Hatchery worker. Talk about fish adaptations and hatchery spawning.

Lesson 4.1: Apt Adaptation

Essential Concept

Aquatic animals have a variety of adaptations, which are acquired over many generations through genetic changes, and inherited by new generations.

Objectives

1. Students will take part in a game to demonstrate their understanding of aquatic adaptations of animals.
2. Students will identify the role of adaptation in the organism’s ability to survive and fill a niche in a specific habitat in the aquatic community (such as predator or prey, producer, consumer, parasite, or host).
3. Students will define inheritance as the passage of genetic instructions from one generation to the next.
4. Students will identify the importance of inheritance in aquatic adaptations.
5. Students will discuss the difference between genetic adaptations and learned behavior.
6. Students will explore short and long term environmental changes that affect organisms and traits in subsequent populations.

TEKS

6.12 D; 7.12 A; 7.14 A; 8.11 A, B;

Aquatic Science: 10 B

Environmental Science: 4 B

Estimated Time

1 class period

Materials

At least 1 print photo per student of an aquatic organisms–these may be photos from *Texas Parks and Wildlife Magazine,* other publications or from the Internet

Tape or pins

Colored pencils, markers, or crayons

Science journals

Special Instructions

Teacher will collect or print out at least one photo of an aquatic animal for each student.

Procedure

1. Apt Adaptations Game

Students may play this game as a class, in small groups, or as pairs. The object of the game is to decide what animal you "are" based on its adaptations. One student is "It". The teacher pins or tapes a photo of an aquatic animal on the student's back. "It" has to guess what animal they are, based on their adaptations. Other students can give clues to "It" when asked one of three questions. Questions must begin with "**How do I** ———?" or "**Do I have**———? such as "How do I move?" Or "How do I feed?" etc. Or "Do I have a beak?" **Am I a_____________?** Such as "Am I a predator?"

All students will record the questions and answers, and what animal was guessed in their journals for later discussion.

2. Class Discussion

Ask students to break into groups of 4. Students should look in their journals at the adaptations of the animals that each of them had in the game. Student should discuss the following questions in their small groups and answer the questions in their journals:

- **Why are the adaptations important in the environment where each of the animals live and how do they help the animal survive?**
- **Are the adaptations internal or external structures?**
- **Why would the animal develop this adaptation? What environmental factor could have caused a need for this adaptation?**
- **Is the adaptation inherited by the offspring of this organism?**
- **Is the adaptation genetic or is it a learned behavior? How do we know?**

Research Questions

Ask students to do library or Internet research on the organism that they had in the game to answer the following questions.

- **How are adaptations passed on in genetic instructions? What is a gene?**
- **What type of reproduction does the organism exhibit?**

After discussing all of the questions in small groups, students will share their group's answers in a class discussion. Assign each group one of the questions to report to the class. Other groups will then contribute any additional information they may have thought about when each question was discussed by their group.

Vocabulary

- Adaptation
- Gene
- Genetic
- Inherited
- Reproduction

Lesson 4.2: Reading and Research

Essential Concept

Aquatic species have specific adaptations for living and surviving in water and in particular parts of an aquatic ecosystem.

Objectives

1. Students will read about adaptations of Texas fish as background information for the fish lab in the next activity.
2. Students will make a data table showing fish adaptations and survival advantages.
3. Students will use the chart *Adaptations to the Aquatic Environment from Headwaters to the Ocean* to explore the wide variety of aquatic adaptations.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J; 3 E

Environmental science: 2 K; 3 E

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Materials

Student Guide

Science journal

Pencils or pens

Procedure

1. Student Reading

Have students read *Chapter 10: Fishing for Answers*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is a species?

A species is a group of related individuals sharing common characteristics or qualities that interbreed and produce fertile offspring having the same common characteristics and qualities as the parents.

2) What is an adaptation?

An adaptation is a behavior or physical trait that increases a species' chance of survival in a specific environment.

3) How are fish adapted to aquatic environments? List at least 5 adaptations.

Answers may include:

All fish are ectotherms. Their body temperature varies with the surrounding water temperature. This means they need less oxygen and energy to live than animals that keep a more constant body temperature.

All fish have gills to get oxygen from the water.

Fish use fins to move around.

Swim bladders allow fish to adjust their depth in the water.

Many species of fish are covered with protective scales.

Fish are coated with slime, which helps reduce friction as they swim through the water.

Many fish species are dark-colored across the back and light on the belly. This helps them blend in to the dark bottom when seen from above, and with the bright surface when seen from below.

Fish have a line along their sides, called a lateral line, which has tiny organs that enable them to sense vibrations in the water.

4) How do fish swim? Why don't fish sink to the bottom or float on top of the water?

When a bass wants to move forward, it begins a side-to-side wiggle that starts at its front and moves to its back. As this wiggle goes backward, the bass goes forward. Swim bladders keep fish from sinking. The more air it contains, the higher a fish will suspend or float in the water.

5) How do fish see, smell, hear, taste and feel? Do fish have other senses that we do not have?

The placement and shape of the eyes of many species of fish allow them to see almost all the way around their bodies. Many fish can see colors, but those that feed at night or live on the bottom rely heavily on their excellent sense of smell. Some fish, like catfish, have taste buds all over their bodies. They can taste food even before taking it into their mouths. A fish's ears are located beneath the skin on either side of the head. Fish also have a sense organ along their sides, called a lateral line, which contains tiny organs that allow them to sense water vibrations. Lateral lines are visible as faint lines like racing stripes. These run lengthwise along each side from the gill covers to the base of the tail.

6 What are some adaptations of different species of fish in Texas?

Answers may include:

Darters have protective coloring that makes them hard to see against the stream bottoms where they live.

Channel catfish have long, round bodies that are flattened on the bottom, skin without scales, taste buds all over their bodies, a good sense of smell, and barbels or "whiskers" with many taste buds.

Largemouth bass have large mouths, broad fins, and strong, heavy bodies with wide, sweeping tails.

Red drum can live in freshwater as well as saltwater in Texas' estuaries, bays and the Gulf of Mexico.

7) How do specific adaptations provide survival advantages to particular species? Make a table to show your data.

Answers may include:

Species	**Adaptation and advantage**	**Adaptation and advantage**	**Adaptation and advantage**
Darter	Protective coloring Hide from their enemies	Live on the bottoms of streams Not washed away in floods	Small (one inch long) Allows them to hide among the rocks at the bottom of streams
Channel catfish	Skin color Camouflages them against the bottom	Taste buds all over bodies Have barbels or "whiskers" with taste buds to guide them to food	Long body, flat on bottom Can scavenge along the bottom
Largemouth bass	Colored blotches Hide them in weeds	Large mouths allow them to catch prey such as frogs, fish or crayfish	Broad fins and strong, heavy bodies Allow them to go in any direction (even backwards

8) Using the information in the chapter make a list of the wide variety of aquatic species' adaptations and the environment for which that adaptation is appropriate:

Answers may include:

Species	Adaptation and Environment
Texas blind salamander	No eyes, no pigmentation in skin–living underground in aquifers and springs
Orangethroat darter	Small, protective coloration–living on the bottom of streams among the rocks
Blue catfish	Flat-bottomed body, barbels, taste buds in skin–living near the bottom of dark or muddy waters
River cooter	Basking, large webbed feet–maintaining body temperature and swimming in currents of cold, swift moving waters
Largemouth bass	Large mouth, strong bodies and broad fins–strong swimming predator
Red drum	Favoring shallow, plant-filled water and tolerating changes in salinity–living in bays and estuaries
Eastern oyster	Attaching to surfaces, building a shell–maintaining position and protection from predators in ocean currents and tides
Kemp's ridely sea turtle	Flippers, laying eggs on the beach–swimming and reproducing in Gulf of Mexico or ocean environments
Black legged stilt	Long legs, long beak–finding food in shallow water
Bottlenose dolphin	Traveling in small groups for safety, using echolocation–swimming and finding food over large areas in the ocean
American alligator	Large powerful tails, ability to submerge while eyes and snout remain above water–predatory adaptations in water
Mayfly nymph	Larva stages in water, breathing tubes, holes, bubbles–safety from predators, finding food in streams or ponds
Duckweed	No stems or roots–floating in ponds, streams, or oceans
Water lily	Floating near the water's surface to photosynthesize–plants of aquatic environments
Plankton	Microscopic, large numbers of organisms–floating and carried on the current in water

3. Cast Beyond Tomorrow Question

Ask students to discuss the following questions to apply ideas about adaptations to specific environments.

What unique characteristics of Texas' waters, both freshwater and saltwater, drive adaptations in Texas' aquatic species? How might Texas' aquatic species differ from species in other states, for example in Oregon, Michigan, or New York?

4. Using What We Learned: Create Your Own Aquatic Creature

Scenario:

Students have been scuba diving and unexpectedly found a new organism. Ask students to work in pairs documenting the characteristics of the new aquatic organism they discovered, to make a colored sketch in their science journals of the new species, and write a paragraph describing the organism and answering the questions below.

- **How does your aquatic creature move through the water? What are the advantages and disadvantages of this method of movement?**
- **How and what does your organism eat? What are the advantages and disadvantages of this method of getting food?**
- **What internal organs does this new organism have that are specialized? What is the purpose of these organs? How do these organs help the organism survive?**
- **What external structures does this new organism have that are specialized? What is the function of these structures? How do these external structures help the organism survive?**
- **Doe this organism tolerate pollution or does it require a pollutant free environment? What characteristics are important in making the organism sensitive to or tolerant of environmental pollutants?**
- **What type of reproduction does this organism exhibit? What are it's life stages? At which stages in its life is it most vulnerable and why?**
- **What is the name of your organism?**

Vocabulary

- Adaptation
- Barbels
- Basking
- Fins
- Flippers
- Gills
- Lateral line
- Protective coloration
- Salinity
- Swim bladder
- Webbed feet

Create Your Own Aquatic Creature

You have been scuba diving and unexpectedly found a new organism.

Work in pairs and use the following questions to guide you in documenting the characteristics of the new aquatic organisms.

1. Describe the organism in a paragraph to answer the questions.
2. Make a colored sketch of the new species.
3. How does your aquatic creature move through the water? What are the advantages and disadvantages of this method of movement?
4. How and what does your organism eat? What are the advantages and disadvantages of this method of getting food?
5. What internal organs does this new organism have that are specialized? What is the purpose of these organs? How do these organs help the organism survive?
6. What external structures does this new organism have that are specialized? What is the function of these structures? How do these external structures help the organism survive?
7. Doe this organism tolerate pollution or does it require a pollutant free environment? What characteristics are important in making the organism sensitive to or tolerant of environmental pollutants?
8. What type of reproduction does this organism exhibit? What are it's life stages? At which stages in its life is it most vulnerable and why?
9. What is the name of your organism?

Lesson 4.3: Fish Lab and Comparison Matrix

Essential Concept

Fish have specific characteristics and adaptations that help them survive in their aquatic environment.

Objectives

1. Students will examine Texas fish and record observations.
2. Students will make accurate labeled drawings of their group's specimen.
3. Students will use a dichotomous key to identify their fish.
4. Students will investigate and explain how internal structures may be adaptations that have specific functions.
5. Students will discuss predator/prey relationships.
6. Students will complete a *Comparison Matrix for Texas Fish* studied.

TEKS

6.1 A, B; 6.2 A, C, E; 6.4 A, B; 7.1 A, B; 7.2 A, C, E; 7.4 A, B; 7.12 A; 8.1 A, B; 8.2 A, C, E; 8.4 A, B; 8.11 A

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 B, E; 10 A, B

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 B, E, 4 A, B

Estimated Time

1 class period for examination of specimen and completing the *Fish Matrix*

Allow at least 20 minutes for in-class questions and discussion.

Materials

Dead fish for each group

Field Guides

Copies of *Fish Comparison Matrix* for each student

Magnifiers or microscopes

Access to the *Texas Parks and Wildlife Department Aquatic Species Online Resource Library* at

http://www.tpwd.state.tx.us/huntwild/wild/species/

http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/

or copies of species *Fact Sheets*

Pens or pencils

Science journals

Computer with Internet connectivity (optional)

Special Instructions

Fish Lab: If possible, obtain a native fish specimen for each group of 4 students. You might want to catch your own or have a friendly fisherman donate a few fish. If possible, try to get at least 3 different species of Texas fish. It is also possible to buy fresh fish at a seafood store or buy specimens through science catalogs.

Note: The seafood store **can not** legally leave all organs in place, but they may leave swim bladders, gills, and scales, if you request it. Swim bladders may be deflated or torn, but students will be able to see the placement.

Check to be sure you can access the TPWD Aquatic Species Online Resource Library at *http://www.tpwd.state.tx.us/huntwild/wild/species/*

You will find fact sheets for fish and other native Texas wildlife.

Safety Precautions

Students should be careful with lab tools and be aware that some fish have spiny fins that can cause painful stabs.

Procedure

1. Using a Dichotomous Key

Students should work in groups of 4 to examine their fish very carefully. First students should try to identify their fish.

If you have field guides to identify Texas fish, use those to key out the species.

If you do not have field guides, you may wish to use the Texas Parks and Wildlife fish books, which have excellent pictures. They are ***Freshwater Fishes of Texas,*** and another for ***Salt Water Fishes of Texas.***

Note: Dead fish quickly lose all color, so students should not try to identify fish species by color shown in the identification guides.

Note to the Teacher

For younger students:

Introduction to Dichotomous Keys

If your students do not know how to use a dichotomous key, here is a quick and easy way to get them started. You can vary the characteristics to fit your group. Just start with some more common characteristics and get more and more specific until there is only one person standing. That will be the species that you are keying out and will be described by the final category and all the preceding categories.

Example:

Ask all the students to stand up. This represents the whole set of students.

To key out a student you will need to pick characteristics that they may have or may not have such as:

If you are a student with brown eyes, remain standing. If you do not have brown eyes, sit down.

If you are a student with brown eyes and have on earrings, remain standing. If you do not have earrings sit down.

If you are a student with brown eyes and have earrings and black shoes, remain standing. If you do not have black shoes sit down.

If you are a student with brown eyes and have earrings and black shoes and wear glasses, remain standing. If you do not wear glasses, sit down.

If you are a student with brown eyes and have earrings and black shoes and wear glasses and have on a red shirt, remain standing. If you do not have on a red shirt, sit down.

When there is only one person standing, then that person should be the species that is described by the characteristics: a student, brown eyes, ear rings, black shoes, glasses, and red shirt. You might want to give it a species name such as:

The red shirted, brown eyed, black footed, glassy eyed, earring wearer.

Another Easy Introduction to Dichotomous Keys

You can also give out a variety of plastic fish or photos of fish. (You can find plastic fish in museum shops or sometimes at stores such as Toys-R-Us or Michael's)

Provide chart paper and markers. Have students make a circle around all of the fish to show the set of all fish. Then have them choose a characteristic and divide the set by that characteristic. (Example: dorsal fins with 2 parts or not 2 part fins) Circle each of these sets. Then divide the 2-part dorsal fin set by another characteristic. (Example: oval body shape or not oval body shape.) Circle each of these sets. Then divide the 2-part dorsal fin, oval body shape set by another characteristic. (Example: reddish body color or not reddish color. This may leave you with only one type of fish in a set and give you the species of that fish. (such as longear sunfish, which has 2 part dorsal fins, an oval body shape, and males are reddish).

2. Fish Lab

After identifying the fish that they are observing, have students pick the fish up and see if they can tell what part of the environment that the fish inhabits (bottom, weedy area, open water).

- **What body characteristics might help you decide where this fish lives?**
- **How do you think the fish moves? What direction is the force that it uses to move it through the water forward? How does it change its direction?**
- **Is its shape made for speed or for fitting in a nook to hide, or for lying on the bottom?**

- **Is it built to be a fast or slow swimmer?**
- **Is it colored to hide or to swim in the open?**
- **Can you tell where it produces the most force with its body to move it through the water or cling to the bottom?**

Have students make a drawing of their fish as they discuss the various external structures that help the fish survive in an aquatic environment. Students should label each part as they examine it. (Drawings should include: lateral line, gill covers, eyes, nostrils, ears, mouth, tongue, teeth, fins, scales, slime, coloration, any unusual parts (such as barbels or whiskers on catfish.)

Hand lenses or microscopes help students see interesting details on scales. Many species of fish can be aged by counting rings on their scales.

If you are using fresh caught or lab specimen fish, you may want to look at the internal structures. If you are looking at fish from a seafood store, you may be able to at least see the swim bladder, and gills. Have students make a second drawing indicating placement of internal organs if possible.

Have students check the reading and make sure that they have found all of the parts discussed.

Save fish for reuse in the next activity. (below)

3. Fish Matrix

If you have at least 3 fish species for the fish lab, you may have students complete the fish matrix for those fish species. Ask students to fill in the matrix with their observations.

If students wish to enter more fish in the matrix, then they may go to the TPWD Aquatic Species Online Resource Library, or other in-class library resources to choose other fish.

If you do not have at least 3 species of fish for the fish lab, then students may choose three (or more) Texas fish species to investigate using the *TPWD Aquatic Species Online Resource Library*, or other in-class library resources. Class time may be provided or research may be assigned as homework.

Have students record their findings by completing rows of the comparison matrix. Have students add the matrix to their notebooks. A similar matrix will be used in later activities.

4. Applying What We've Learned

If you have a native aquarium from a previous field trip, you may wish to key out any fish you have in your aquarium and include their data in the *Fish Matrix.* If you have not yet set up a native aquarium, use the *Fish Matrix* in conjunction with *Activity 4.4.*

Vocabulary

- Adaptation

- Barbels
- Fins
- Gill covers
- Gills
- Lateral line
- Protective coloration
- Scales
- Slime

Fish included in Texas Parks and Wildlife Department Aquatic Species Online Resource Library

Fish are scaled, ectothermic vertebrates found in water environments. They fall into three main groups: agnatha or jawless fish including lampreys and hagfish, chondrichthyes or cartilaginous fish including sharks, skates, and rays, and osteichthyes or bony fish including all other fish. Most fish lay eggs, though a few species give birth to live young.

Alligator Gar *(Atractosteus spatula)*

American Eel *(Anguilla rostrata)*

Atlantic Croaker *(Micropogonias undulatus)*

Atlantic Cutlassfish *(Trichiurus lepturus)*

Big Bend Gambusia *(Gambusia gaigei)*

Bigmouth Buffalo *(Ictiobus cyprinellus)*

Black Buffalo *(Ictiobus niger)*

Black Bullhead *(Ameiurus melas)*

Black Crappie *(Pomoxis nigromaculatus)*

Black Drum *(Pogonias cromis)*

Blacktail Shiner *(Cyprinella venusta)*

Blue Catfish *(Ictalurus furcatus)*

Bluegill *(Lepomis macrochirus)*

Bowfin *(Amia calva)*

Chain Pickerel *(Esox niger)*

Channel Catfish *(Ictalurus punctatus)*

Clear Creek Gambusia *(Gambusia heterochir)*

Cobia *(Rachycentron canadum)*

Comanche Springs Pupfish *(Cyprinodon elegans)*

Common Carp *(Cyprinus carpio)*

Common Snook *(Centropomus undecimalis)*

Crevalle Jack *(Caranx hippos)*

Fathead Minnow *(Pimephales promelas)*

Flathead Catfish *(Pylodictis olivaris)*

Flier *(Centrarchus macropterus)*

Florida Pompano *(Trachinotus carolinus)*

Fountain Darter *(Etheostoma fonticola)*

Freshwater Drum *(Aplodinotus grunniens)*

Gafftopsail Catfish *(Bagre marinus)*

Gizzard Shad *(Dorosoma cepedianum)*

Golden Shiner *(Notemigonus crysoleucas)*

Grass Carp *(Ctenopharyngodon idella)*

Greater Amberjack *(Seriola dumerili)*

Green Sunfish *(Lepomis cyanellus)*

Guadalupe Bass *(Micropterus treculii)*

Hardhead Catfish *(Arius felis)*

Lane Snapper *(Lutjanus synagris)*

Largemouth Bass *(Micropterus salmoides)*

Leon Springs Pupfish *(Cyprinodon bovinus)*

Longear Sunfish *(Lepomis megalotis)*

Longnose Gar *(Lepisosteus osseus)*

Paddlefish *(Polyodon spathula)*

Pecos Gambusia *(Gambusia nobilis)*

Pigfish *(Orthopristis chrysoptera)*

Pinfish *(Lagodon rhomboides)*

Rainbow Trout *(Oncorhynchus mykiss)*

Red Drum *(Sciaenops ocellatus)*

Red Shiner *(Cyprinella lutrensis)*

Red Snapper *(Lutjanus campechanus)*

Redbreast Sunfish *(Lepomis auritus)*

Redear Sunfish *(Lepomis microlophus)*

Redfin Shiner *(Lythrurus umbratilis)*

Rio Grande Cichlid *(Cichlasoma cyanoguttatum)*

San Marcos Gambusia *(Gambusia georgei)*

Sheepshead *(Archosargus probatocephalus)*

Sheepshead Minnow *(Cyprinodon variegatus)*

Shortnose Gar *(Lepisosteus platostomus)*

Smallmouth Bass *(Micropterus dolomieu)*

Smallmouth Buffalo *(Ictiobus bubalus)*

Southern Flounder *(Paralichthys lethostigma)*

Spotted Bass *(Micropterus punctulatus)*

Spotted Gar *(Lepisosteus oculatus)*

Spotted Seatrout *(Cynoscion nebulosus)*

Striped Bass *(Morone saxatilis)*

Striped Mullet *(Mugil cephalus)*

Tarpon *(Megalops atlanticus)*
Texas Shiner *(Notropis amabilis)*
Threadfin Shad *(Dorosoma petenense)*
Tripletail *(Lobotes surinamensis)*
Vermilion Snapper *(Rhomboplites aurorubens)*
Walleye *(Sander vitreum)*
Warmouth *(Lepomis gulosus)*
White Bass *(Morone chrysops)*
White Crappie *(Pomoxis annularis)*
Yellow Bass *(Morone mississippiensis)*
Yellow Bullhead *(Ameiurus natalis)*

Texas Fish and Their Characteristics
Comparison Matrix

Species	**Average Size** Weight Length	**Body** Adaptation Advantage	**Coloration** Adaptation Advantage	**Adaptation** Advantage	**Adaptation** Advantage

Lesson 4.4: Field Trip
Collecting for Native Aquarium

Essential Concept

Aquatic species have specific characteristics and adaptations that help them survive in their aquatic environment.

Objectives

1. Students will take part in a field trip to collect aquatic organisms.
2. Students will classify aquatic organisms using a dichotomous key.
3. Students will compare and describe how adaptations allow organisms to exist in aquatic environments.
4. Students will describe producer/consumer, parasite/host, predator/prey relationships in a freshwater aquatic ecosystem.
5. Students will identify basic characteristics of organisms that help classify them.

TEKS

6.1 A, B; 6.2 A, C, E; 6.4 A, B; 6.12 D; 7.1 A, B; 7.2 A, C, E; 7.4 A, B; 7.11 A; 7.12 A, C; 7.14 B; 8.1 A, B; 8.2 A, C, E; 8.4 A, B; 8.11 A

Aquatic Science 1 A, B; 2 E, F, G, J; 5 A, B, C, D; 10 A, B

Environmental Science: 1 A, B; 2 E, F, G, H, K; 4 A, B, E

Estimated Time

Varies depending on distance to travel for a field trip

Materials

Science journals

<u>Native aquarium</u>

10 or more plastic gallon jugs

<u>For Each Group</u>

Field Guides

Buckets and other containers

Dip nets

Seines

10 gallon aquarium for the class or smaller aquariums for each group for short term observations

Note: It is sometimes easier to set up and maintain one large aquarium for the class, but students enjoy making observations of small group aquariums and like to take care of their group's aquarium. The choice should be based on your students and your classroom space.

Note: If it is not possible to collect organisms for your native aquarium, several Regional Education Service Centers in Texas have science centers that will supply live specimens like danios, elodea, or tetras free to classrooms in their regions.

Special Instructions

Native aquarium: Be sure to have student field trip permission and do a pre-visit to the site to check on safety and access. Obtain permission to visit private property.

For Aquatic Science Course: Make copies of data pages used at the end of the lesson to use for field activity.

Safety Precautions

Review Field Safety Rules

Note for Aquatic Science Course: If possible, make this the second field trip to your long-term aquatic study site. Conduct the same tests for water quality as in Chapter 1.9, in addition to collecting for a native aquarium. Don't forget to take weather readings also. In addition, students should note interrelationships among producers, consumers, and decomposers and identify the way organisms are interdependent.

Procedure

1. Field Trip to Collect for a Native Aquarium

If you have not already set up a native aquarium, now would be a good time to do so. If possible, take students to a nearby pond or stream. Depending on the size and number of the aquariums you will set up, you will need to take 10 or more gallon jugs to collect water. You will need enough water to fill the aquarium(s) and several gallons of water to replenish your supply of water. (Tap water has too much chlorine to use in your aquarium. You could also buy de-chlorinator at pet stores.)

Other containers such as buckets will be needed to hold organisms as they are collected. Allow each student to have an opportunity to collect something.

Collect enough aquatic plants to maintain oxygen levels in the aquarium(s). You will also need rocks and pebbles for the bottom dwellers to hide in.

Students should collect samples of aquatic plants, aquatic insects, fish, snails, tadpoles, and whatever macro-invertebrates you find. Be sure you keep predators such as dragonfly nymphs, crawdads, turtles, frogs, or toads in a separate aquarium(s) and feed them daily.

Have students make note in their journals of observations about the field trip site noting <u>plant cover</u>, any <u>erosion</u> they see, and <u>land use</u> and <u>water quality</u> around the pond or along the stream.

Have students work in groups of 4 to collect in various parts of the pond or stream, and with various types of equipment.

Have students set up aquarium(s) when you return to class.

2. Setting Up a Native Aquarium

1) If you bring pond or stream water back from your field trip in plastic jugs, this step is not necessary. Otherwise BEFORE you get the fish or other live specimens, put gravel and water into the aquarium, set up a filter and begin cycling water. Let water cycle for a few days to let the chlorine dissipate from the water.

Discuss with the class how this aquarium is like or different from a natural aquatic ecosystem.

- **What are the similarities and differences?**
- **What could we add to make it more like the natural environment?**
- **What is the basis of all ecosystems?** (Producers)

2) If you are collecting on the field trip bring plants, such as algae covered rocks, to put in the aquarium. If you are not taking the field trip, add elodea or other aquatic plants to the aquarium, add a light or put the aquarium near sunlight.

Does the plant need anything else? (Yes, nutrients from the soil.)

3) When you are collecting ask students to bring a few rocks, sediment, and gravel from your field trip site. If you are not taking the field trip, bring these ingredients from any nearby stream and add them to the aquarium.

If you are using a filter, explain to students that it can be considered a home for helpful bacteria that break down organic material back into basic nutrients. It also moves the water so it is constantly gets more oxygen from the air. Those two functions are much more important than “filtering” out dirt. The natural world doesn’t have a “filter” it recycles the nutrients. The rocks, gravel, and soil from a nearby stream provide our much needed microorganisms.

4) Add the other organisms you collected from the stream. If you did not take the field trip, add 2 fish for every 10 gallons. Danios are hardy fish to use.

- **What might happen if we put in too many fish and other organisms in the aquarium? (**Fish eat the yummy protein we feed them, and excrete ammonia, which can build up in the aquarium and could kill them.)
- **How can we overcome the ammonia problem? (**The bacteria housed in the filter will convert the ammonia to nitrogen providing nutrients that fertilize the plants and will be used to help plants grow.) You can also take out about 1/3 of the water and replace it with new pond water or de-chlorinated water.
- **What will happen if there are no plants?** (The nutrients will just build up in the tank, no one will use them, and the fish will die.)
- **What will happen if the filter stops running?** (Oxygen levels go down, waste doesn’t get decomposed, and fish die)
- **What else might we add to make the aquarium more natural?** (Other organisms we collected on the field trip such as snails, insects, tadpoles, etc.)

5) Monitor the aquarium in class at least every week, preferably on the same day of the week, or even every day with test strips for ammonia, and nitrogen.

If the aquarium is functioning as the stream does in nature, ammonia should be quickly converted to nitrogen, and plants will use that to grow. There should not be a build-up of any chemicals.

- **Why might we see spikes in one of the nutrients?** (Perhaps we have too many fish, not enough fish, not enough plants, or not enough bacteria to convert the amount of ammonia produced to nitrogen.)

Here are some of the reactions that might occur.

Ammonia too high? (Too many fish, not enough bacteria, filter was just changed destroying bacteria colony)

Nitrite too high? (Bacteria colony is not well established.)

Nitrate too high? (Bacteria are doing their job, but not enough plant growth is happening or perhaps there are not enough plants, or plants can't grow because of other limiting factors such as too little sun.)

Algae is growing a lot on the tank? (Bacteria are doing their job providing lots of good nitrates, which the algae likes. Either add more plants to take up more of the nitrates, add more snails to eat the algae, or take out some fish to cut down on the ammonia being put in the tank.)

As in all things in the natural world, maintaining a natural aquarium is a balancing act. It is a great way for students to learn to be problem solvers, working on a small scale. These problem solving skills can be applied later to the larger natural world.

Vocabulary

- Adaptation
- Appendages
- Barbels
- Fins
- Gill covers
- Gills
- Lateral line
- Protective coloration
- Salinity
- Scales
- Slime
- Swim bladder
- Webbed feet
- Other words as needed on the field trip

WATER CHEMISTRY INVESTIGATION

Objective

1. Record your group's observations about the color and odor of each water sample in the table below.

2. Following the directions for each meter, test kit or other equipment to test each water sample and record data in the table below.

Group: ____ (names)
Date: ____________________

Physical and Chemical Characteristics of Unknown Water Samples

Water sample	Temperature (^oC)	Color	Odor	Foam	pH	Conductivity ______ (units)	Dissolved oxygen ______ (units)	Nitrates And/or phosphates ______ (units)	Water sample source

WEATHER OBSERVATIONS AND MEASUREMENTS

Objective

Obtain, record, and present weather data.

Directions

1. Find a reliable source of daily information about the weather in your area.
2. Record today's weather data for your area. Be sure you report the source of each piece of data, the date and location for which it was reported.

Name: ____

Date: ______________________

Location: ____

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Student Page

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A musky smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A *chlorine* smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Invertebrates and Vertebrates as Water Quality Indicators

Invertebrates

A stream with:

- A great variety of insects, with few of each kind, indicates clean water.
- Less variety of insects, with greater abundance of each kind, indicates that there is too much organic matter in the water.
- Finding only one or two kinds of insects in great abundance indicates severe organic pollution caused from excessive human or livestock waste or high algae populations.
- If no insects are found, but the stream appears clean there may be some type of toxic pollution, which includes chemical pollutants such as chlorine, acids, metals, pesticides, and oil.
- Excessive sediment may be caused by erosion or discharge from a pipe and may reduce the amount of water in the stream causing extreme temperatures, and causing a loss of oxygen, which may smother insects resulting in a reduction of the number of animals in the area.

Note about Invertebrates

The types of **invertebrates** found can help students know about the quality of the water. Print out the Texas Parks and Wildlife *Bug Picking Data Sheet* at **the end of this lesson** to help identify invertebrates found in creeks and indicate which invertebrates are associated with clean water and which predominate in polluted water.

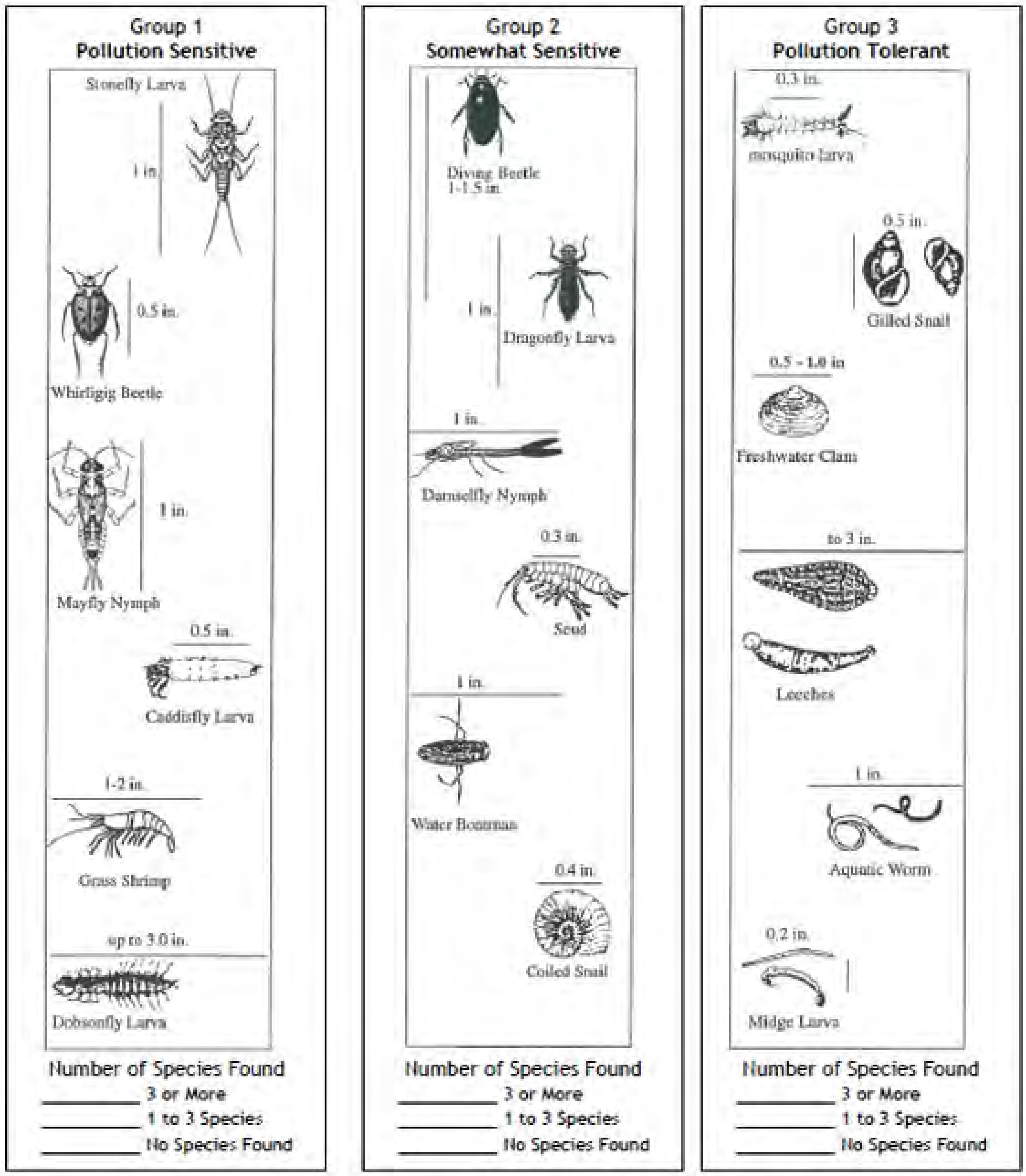
Vertebrates

- If fish are exhibiting some odd behavior such as jumping out of the water or being non-responsive, it may indicate toxins in the creeks. A chemical analysis is needed to find the source of the toxin. Contact the TCEQ.
- If there are no fish or other vertebrates in the creek, it may indicate that the creek is stressed from urban runoff, sewage, or toxins entering the stream. Chemical analysis is needed to the find the source of the problem. Contact the TCEQ.

Student Page

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department
Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: **(Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)**

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: **Not Polluted** **OK** **Polluted**

Lesson 4.5: Aquatic Organisms
Comparison Matrix

Essential Concept

Aquatic organisms have specific characteristics and adaptations that help them survive in their aquatic environment.

Objectives

1. Students will choose at least three aquatic organisms observed on the field trip or in the native aquarium, and identify adaptations that help them survive in an aquatic environment.
2. Student will describe producer/consumer, parasite/host, predator/prey relationships in a freshwater aquatic ecosystem.
3. Students will observe and describe how different aquatic environments support different varieties of organisms.
4. Students will examine Texas aquatic organisms and record observations.
5. Students will make accurate labeled drawings of their group's organisms.
6. Students will use a dichotomous key to identify their aquatic organisms.
7. Students will fill in the *Comparison Matrix* to compare adaptations of aquatic organisms.

TEKS

6.1 A, B; 6.2 A, C, E; 6.4 A, B; 7.1 A, B; 7.2 A, C, E; 7.4 A, B; 7.10 A; 7.11 A; 7.12 A; 8.1 A, B; 8.2 A, C, E; 8.4 A, B; 8.11 A, B

Aquatic Science: 1 A, B; 2 E, F, G, J; 10 A, B

Environmental Science: 1 A, B; 2 E, F, G, H, K; 4 A, B

Estimated Time

1 class period for examination of aquatic organisms, using a key, and completing the *Aquatic Organisms Comparison Matrix*

The written assignment can be done as homework or done in class.

Materials

Aquatic organisms from field trip collection

Field guides

Copies of *Comparison Matrix* for each student

Magnifiers or microscopes

Access to the *TPWD Aquatic Species Online Resource Library* or copies of specific species *Fact Sheets* at http://tpwd.state.tx.us/huntwild/wild/spices

Pens or pencils

Science journals

Computer with Internet connectivity

Rubric for written work

Science journals

Safety Precautions

Students should be careful with lab tools and be aware that some organisms can bite.

Procedure

1. Using a Key

Fish

If you did not key out any species from your aquarium and include their data in the *Fish Matrix* when doing *Activity 4.3*, do so at this time. See *Activity 4.3* for ideas on introducing dichotomous keys.

Other Aquarium Organisms

Look at organisms other than fish that you caught on your field trip. Ask each group to key out a different species from your collection. Use a field guide to help you key out those organisms and see all the different types of animals you have in your native aquarium(s).

Each group can report to the class on the species they chose to key out. A list of organisms collected can be generated and displayed as groups report to the class. If there are more organisms in your aquarium, you may wish to have students add those to the list. Have students record the list in their journals.

2. Aquatic Organisms Lab

Ask students to choose organisms from the class native aquarium collection. Students will examine their organism to look for adaptations to aquatic life. The organisms that students choose will vary depending on the location of your field trip site and the quality of the water. Students often collect a variety of aquatic insect nymphs, such as dragonflies, mayflies, mosquito larva, stoneflies, etc. There may also be bloodworms, snails, water striders, diving beetles, leeches, etc. In addition, depending on the season, students may find tadpoles, toads, salamanders, frogs, or turtles. Some students may choose to examine aquatic plant material brought back from the field trip such duck weed, water lilys, algae, etc.

Students should make a drawing of their organism and label the parts.

- **What adaptations does the organism have to help it survive in an aquatic environment?**

- **How do its adaptations help it live in a specific microhabitat in an aquatic environment?**
- **How do its adaptations help it compete with other species in this habitat?**

3. Aquatic Organism Comparison Matrix

Ask students to choose three or more non-fish aquatic species found on the field trip or they may use one organism that they saw on the field trip, but which was not collected such as spoonbills, snapping turtles, or alligators. They may use the organism they have been examining as one of their 3 if they wish. Students will learn more about their 3 organisms using the *TPWD Aquatic Species Online Resource Library,* field guides, or other in-class or library resources. Class time may be provided or research may be assigned as homework.

Have students record their findings by completing rows of the comparison matrix. Have students add the matrix to their journals.

4. Interview With an Aquatic Organism

Have students choose one of the species they studied and report their findings in the form of a 3-paragraph interview, biography or first-person narrative from the point of view of the plant or animal. Give students the rubric for written work before they start this assignment so that they know exactly what is expected of them.

Vocabulary

- Adaptation
- Gills
- Protective coloration
- Scales
- Slime

Texas Parks and Wildlife Department (TPWD)
Aquatic Species Online Resource Library

Information is provided on the following organisms:

Amphibians typically are vertebrates, which change from an aquatic, water-breathing, limbless larva (or tadpole) to a terrestrial or partially terrestrial, air breathing, four-legged adult. This group includes: frogs and toads, salamanders and newts, and caecilians (limbless amphibians). Learn more about amphibians.

Barred Tiger Salamander *(Ambystoma tigrinum mavortium)*

Barton Springs Salamander *(Eurycea sosorum)*

Blanco Blind Salamander *(Eurycea robusta)*

Bronze Frog *(Rana clamitans clamitans)*

Houston Toad *(Bufo houstonensis)*

Marbled Salamander *(Ambystoma opacum)*

San Marcos Salamander *(Eurycea nana)*

Southern Leopard Frog *(Rana sphenocephala)*

Texas Blind Salamander *(Eurycea rathbuni)*

Birds are air-breathing vertebrates. Their body is covered with feathers. Birds have beaks, wings and scale-covered legs. All birds lay eggs that are covered with a calcium carbonate shell.

American Avocet *(Recurvirostra americana)*

American Kestrel *(Falco sparverius)*

American Oystercatcher *(Haematopus palliatus)*

Black-crowned Night-heron *(Nycticorax nycticorax)*

Black-necked Stilt *(Himantopus mexicanus)*

Bufflehead *(Bucephala albeola)*

Burrowing Owl *(Athene cunicularia)*

Eastern Brown Pelican *(Pelecanus occidentalis)*

Eskimo Curlew *(Numenius borealis)*

Interior Least Tern *(Sterna antillarum athalassos)*

Long-billed Curlew *(Numenius americanus)*

Muscovy Duck *(Cairina moschata)*

Pied-billed Grebe *(Podilymbus podiceps)*

Piping Plover *(Charadrius melodus)*

Reddish Egret *(Egretta rufescens)*

Roseate Spoonbill *(Platalea ajaja)*

White-faced Ibis *(Plegadis chihi)*

Whooping Crane *(Grus americana)*

Invertebrates are animals with no backbone. They may live on land or in water, and may be covered by a shell or exoskeleton.

Blue Crab *(Callinectes sapidus)*

Eastern Oyster *(Crassostrea virginica)*

Fiddler Crab *(Uca rapax)*

Gulf Stone Crab *(Menippe adina)*

Lightning Whelk *(Busycon perversum pulleyi)*

Mammals are air-breathing vertebrates. Their body is covered with hair. All mammals feed their young milk. Most mammals give birth to miniature versions of themselves. For more information and additional species, see *The Mammals of Texas*.

Bottlenose Dolphin *(Tursiops truncatus)*

River Otter *(Lutra canadensis)*

Plants are multicellular nonmobile, photosynthesizing organisms adapted to live on land. They consist of leaves and/or stems that capture the sun's energy and an underground root system. This group includes: moss and liverworts, ferns, conifers, and flowering plants.

Bald Cypress *(Taxodium distichum)*

Little Aguja Pondweed *(Potamogeton clystocarpus)*

Lloyd's Mariposa Cactus *(Sclerocactus mariposensis)*

Texas Wild-rice *(Zizania texana)*

Reptiles are air-breathing vertebrates. A tough leathery skin that has embedded scales covers their body. Most reptiles lay eggs, though some give birth to fully-formed young. This group includes crocodiles, alligators, turtles, snakes, and lizards.

American Alligator *(Alligator mississippiensis)*

Concho Water Snake *(Nerodia paucimaculata)*

Green Sea Turtle *(Chelonia mydas)*

Gulf Salt Marsh Snake *(Nerodia clarkii)*

Hawksbill Sea Turtle *(Eretmochelys imbricata)*

Kemp's Ridley Sea Turtle *(Lepidochelys kempii)*

Leatherback Sea Turtle *(Dermochelys coriacea)*

Loggerhead Sea Turtle *(Caretta caretta)*

Red-eared Slider *(Trachemys scripta elegans)*

Western Cottonmouth *(Agkistrodon piscivorus leucostoma)*

Yellow Mud Turtle *(Kinosternon flavescens flavescens)*

Texas Aquatic Organisms and Their Characteristics Comparison Matrix

Species	Body Shape Adaptation & Advantage	Coloration Adaptation & Advantage	Appendages Adaptation & Advantage	Other Feature Adaptation & Advantage

Rubric for Written Work

I. Organization **65 points**

1. Each paragraph:
   - Contains an introductory sentence that clearly states your purpose
   - Contains at least two supporting sentences that use relevant details
   - Contains a concluding sentence
   - Provides clear information
   - Contains a main idea
   - Progresses in a logical order
2. The story:
   - Has a beginning, middle, and end
   - Stays on topic

II. Accuracy **20 points**

1. Includes at least 3 important accurate ideas about the organism's life and 3 descriptions of aquatic adaptations

III. Mechanics **15 points**

1. Uses correct grammar, spelling, and punctuation

TOTAL POINTS: 100

Lesson 4.6: Native Aquarium Investigations

Essential Concept

Aquatic organisms have specific characteristics and behavioral adaptations that help them to survive and function in the community of their aquatic ecosystem.

Objectives

1. Students will compare and describe how adaptations allow organisms to exist in aquatic environments.
2. Student will describe producer/consumer, parasite/host, and predator/prey relationships in a freshwater aquatic ecosystem.
3. Students will observe and describe how different parts of aquatic environments support different varieties of organisms.
4. Students will identify basic characteristics of organisms that help us classify them.
5. Students will diagram the levels of organization in a freshwater ecosystem including organisms, population, community, and ecosystem.
6. Students will represent energy transfer through the ecosystem in a role-playing activity.
7. Students will differentiate between inherited traits and learned behavior.
8. Students will synthesize what they have learned to role-play the various parts and interactions among members of a freshwater aquatic ecosystem.

TEKS

6.1 A, B; 6.2 A, B, C, D, E; 6.4 A, B; 6.12 D; 7.1 A, B; 7.2 A, B, C, D, E; 7.4 A, B; 7.5 A, C; 7.11 A; 7.12 A, C; 7.14 B; 8.1 A, B; 8.2 A, B, C, D, E; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 B, E, F, G, H, J; 5 C, D; 10 A, B; 11 A, B

Environmental Science: 1 A, B; 2 B, E, F, G, H, I, K; 4 A, B, H; 6 C, E

Estimated Time

<u>KWHL Chart and small group work</u>

1 class period

<u>Lab Time</u>

Varies depending on what questions are chosen for students to investigate.

<u>Role Play</u>

Varies–class time or homework can be used to plan and build puppets or costumes for role-playing parts of an aquatic ecosystem.

1 class period for presentations

Materials

Science journals

KWHL Chart

Field guides

Hand lenses

Microscopes

Metric rulers

Petri dishes

Trays

Probes or plastic spoons

Art materials such as construction paper, tissue paper, paper plates, paper bags, markers, socks, google eyes, pipe cleaners, empty boxes, feathers, felt, (or whatever craft supplies you or students may have)

Other materials as needed

Special Instructions

When deciding on investigations, be aware that some questions that students generate may take longer than one class period to investigate. The choices among the questions that students generate to investigate may be made by the teacher, if necessary.

Safety Precautions

Use lab equipment safely.

Procedure

1. KWHL Chart

Ask students to work together as a class to develop some questions that they would like to investigate about the organisms in their native aquarium using a KWHL Chart. (See KWHL Chart at the end of the lesson.)

A KWHL Chart is a way to help the teacher understand what students **Know,** (prior knowledge and misconceptions), what they **Want to find out,** (developing questions), **How they can find out,** (developing procedures), and what they **Learned**, (conclusions drawn based on data).

Students may come up with a variety of questions in the KWHL process. You may wish to choose only a few (one for each group) or you may wish to investigate only one question by the whole class. You may even decide to look at all the questions over a period of time.

Some questions students might generate with the KWHL Chart for investigating their native aquarium(s) might include things such as:

- **How much food will __________________(a toad, salamander, dragonfly nymph, etc.) eat per day?**
- **What are the microhabitats in our native aquarium?**
- **Which microhabitat in our aquarium is occupied by _______________ (insert the name of one of the organisms in your native aquarium)?**
- **What are the parts of the freshwater community represented in our native aquarium (organisms, populations, community, and ecosystem)?**

You may have students diagram the community in your native aquarium.

- **What niches are filled by the organisms in our aquarium?** (predator/prey/decomposer/scavenger/producer/consumer/parasite/host).
- **What food chain, web, or trophic pyramid is represented by our native aquarium?**
- **Is it possible to teach ______________ (insert name of organism) to come for food?**
- **How does the population of various organisms in our community vary over time?**
- **What factors affect population cycles?**

Discuss the questions generated and choose questions that you will be able to investigate. (control variables, time needed, etc.) Whatever questions are generated by students using the KWHL Chart, ask students **how** they could find the answers to their questions, how much time would be needed to answer the question, and what equipment they would need to carry out their investigations.

Have students divide into groups of 4 and **choose a question**, **write their procedures** (how they will answer their question), **develop data tables** to record information, and **carry out the investigation**. Have students refer to the class work on the KWHL Chart as they work on their investigation. (Or the teacher may choose one question for the whole class to investigate and point out that by having all groups investigate the same question, their data is more reliable, because it is like repeating the experiment a number of times.)

Depending on the questions investigated, it may take from one period to a week, or even a semester to finish the investigations.

When the investigations are finished, have students **draw conclusions based on their data**. These conclusions can be added to the KWHL Chart under **What we Learned.**

2. Using What We Learned:

Role Playing Interactions in Aquatic Ecosystems

After serious science investigations, sometimes it’s nice to have a really fun way to apply what we learned. You may wish to video tape these activities. You can use a rubric to evaluate the student products. Be sure to give the rubric to students before they begin developing their role-play.

Students will work in small groups to develop puppets or costumes for a role-play of interactions in a native aquarium to show how the aquatic ecosystem functions.

Each student in a group should role-play a different organism. (Students may select any plant or animal in the native aquarium or any organism that they saw on the field trip including birds, insects or insect larvae or nymphs, other invertebrates such as snails, crawdads or worms, amphibians, fish, reptiles, mammals, or plants.)

Each organism must either have a costume or a puppet representing its adaptations. Costumes or puppets can be made with construction paper, tissue paper, paper plates, paper bags, markers, socks, google eyes, pipe cleaners, empty boxes, feathers, felt (or whatever craft supplies you or students may have).

Students will work together in their group to plan how to role-play their organisms living and interacting in an aquatic ecosystem.

Writing a Paragraph

Each student will write one paragraph about their organism's adaptations, niche and interactions with other organisms in the ecosystem.

Vocabulary

Adaptation

Community

Ecosystem

Interaction

Niche

Organism

Population

KWHL			
What I **Know**	What I **Want** to Know	**How** can I find out	What I **Learned**

Rubric for Role Play

I. Puppet Show or Role Play Presentations **20 points**

1. The beginning gets attention.
2. The purpose of the story is clear, showing **<u>interactions in the aquatic community</u>**.
3. Students speak clearly and distinctly.

II. Costumes/Puppets **10 points**

1. The costumes/puppets are neat, clean, and colorful
2. The costumes/puppets help to show the **<u>adaptations</u>** of the organism.

III. Organization of the Presentation **15 points**

1. Information is clear, detailed, and shows the **<u>niche</u>** occupied by the organism.
2. The story has a beginning, middle, and end.

IV. Accuracy **15 points**

1. The story includes at least **<u>3 important aspects</u>** of the organisms life.

V. Written Component **20 points**

1. The written paragraph gives detailed information about the organism, its **<u>adaptations and niche</u>** in the ecosystem **<u>and how it interacts with other organisms in the community</u>**.
2. Students use correct grammar, spelling, and punctuation.

6. Student Cooperation **20 points**

1. Students work together cooperatively to problem solve.
2. Students follow directions from the teacher.
3. Students all participate equally in the role-play presentation.
4. Students conserve materials.

TOTAL POINTS: 100

Chapter 4 Assessment

Multiple Choice Questions

Directions

Select the best answer for each of the following multiple-choice questions.

1. **How can some fish change their depth in the water column?**
   - **A** Water's surface tension.
   - **B** By using their fins.
   - **C** The more air a fish's swim bladder contains, the higher the fish will suspend or float in the water.
   - **D** B and C

2. **Which of the following statements about adaptations is true?**
   - **A** Creatures can choose adaptations that will provide them with survival advantages.
   - **B** Species adaptations provide them with survival advantages in a particular environment.
   - **C** All aquatic species have the same adaptations.
   - **D** Both B and C

3. **What is a species?**
   - **A** A group of related individuals sharing common characteristics that interbreed and produce fertile offspring having the same common characteristics as the parents.
   - **B** Animals with a backbone, which are adapted to live in aquatic environments
   - **C** A group of individuals that live together and need each other to survive
   - **D** Both B and C

4. **What is the function of a fish's lateral line organ?**
   - **A** To taste food even before taking it into their mouths
   - **B** To help them hide from their enemies
   - **C** To reduce friction as fish swim through the water
   - **D** To sense vibrations in the water

5. **Why are fish coated with slime?**

A To absorb up to 85 percent of the oxygen available in the water

B To help them blend in to the dark bottom when seen from above, and with the bright surface when seen from below

C To reduce friction as fish swim through the water and to protect them from disease

D None of the above

Open-ended Questions

Directions

Write your own answer for each of the following questions.

1. **Draw a Venn Diagram on a separate sheet of paper and use it to sort some adaptations of the three species of fish you studied.**

Be sure to label each part of the diagram with the name of the fish species it represents.

2. **Design an Aquatic Animal**

Design a non-fish aquatic animal, make a drawing of your animal, describe its adaptations, and explain how the adaptations help it survive. Adaptations should provide it with the following advantages:

It can see nearly all the way around itself.

It can walk on mud easily and swim.

It can stay warm.

It has special sensory parts.

3. **Assess the survival advantage of the 3 fish using the adaptations in your diagram:**

One adaptation, which is shared by all 3 fish

One adaptation, which is shared by 2 fish but not by the third fish

One adaptation, which is displayed by only 1 of the 3 fish

Chapter 4 Assessment Answer Key

Multiple-choice questions

1. How can fish change where they are in the water column?

C The more air a fish's swim bladder contains, the higher the fish will suspend or float in the water.

2. Which of the following statements about adaptations is true?

B Species adaptations provide them with survival advantages in a particular environment**.**

3. What is a species?

A A group of related individuals sharing common characteristics or qualities that interbreed and produce fertile offspring having the same common characteristics and qualities as the parents.

4. What is the function of a fish's lateral line organ?

D To sense vibrations in the water

5. Why are fish coated with slime?

C To reduce friction as fish swim through the water and to protect them from disease

Open Ended Questions

1. Draw a Venn Diagram of adaptations of the 3 fish you studied.

Answers will vary depending on the fish used by each group.

All fish have gills so that should be in all 3 circles.

If a catfish was one of the specimens, then 2 fish will have scales, and 1 will have smooth skin.

Body shape, mouth shapes, eye placement, coloration, etc. may differ among some species.

Catfish have barbels.

Other answers may vary depending on the fish used in the diagram.

2. Survival advantages of the 3 fish.

All fish have gills -- necessary for survival.

Some fish have scales and some do not -- can be protective and aid in survival.

Only the catfish have barbels -- helpful in finding food in dark and muddy waters.

Each fish species is adapted to survive in its particular habitat.

3. Design an Aquatic Animal

Students should generate a drawing with labels and explanatory descriptions that depict an imaginary non-fish aquatic animal that has the following adaptations:

Answers may include:

Eyes on the sides of its head, on stalks, or bulging out from the head allow the aquatic animal to avoid predators because it can see nearly all the way around itself.

Webbed feet or flippers allowing the aquatic animal to walk on mud easily, also make it a powerful swimmer.

Water-repellant fur or feathers, or fat insulating the aquatic animal, helps it stay warm even in cold water.

Special feelers, antennae, whiskers, or mouthparts or senses on unusual places on the body such as smelling with its feet, help it to sense when food is near making it a good predator.

From Sun to Sunfish

Aquatic habitats are communities in which complex interactions take place among populations and individual organisms as they compete for limited resources in an interdependent web of relationships.

Chapter 5

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

1. Examine the importance of interactions in a community.
2. Relate the interactions of their family in their community with interactions of aquatic organisms in the aquatic community.
3. Take part in a simulation of pond life including adaptation, competition, and limiting factors that reduce carrying capacity in an aquatic habitat.
4. Make a data table with results of changes in the habitat.
5. Synthesize information from the simulation to write a news story.
6. Predict the possible effects of changes in the numbers and types of organisms in an aquatic community on the populations of other organisms within the community.
7. Explain how populations of organisms and individuals within a community compete with one another for resources.
8. Recognize factors that affect the number and types of organisms an environment can support.
9. Explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences.
10. Read the student materials and answer the questions.
11. Research at least two fish and add their information to the *Comparison Matrix*.
12. Play a card game to learn about the niches of various organisms in an aquatic ecosystem.
13. Choose 5 organisms that interact in an aquatic system. Students will draw and label a diagram showing the organisms, their niches, and will use arrows to show how the organisms interact in an aquatic ecosystem.
14. Describe a specific example from an aquatic community in Texas of each of the following: producers, consumers, and decomposers. Explain the role each serves in the community.
15. Set up a system for observing and mapping organism behaviors in a native aquarium.

16. Make generalizations about organisms' behavior based on their data from observations and mapping.
17. Make hypotheses about causes of organisms' behavior during observations and mapping.
18. Compare data from observations and mapping with other groups.
19. Plan investigations to test their hypotheses.
20. Evaluate plans for investigations.
21. Conduct their investigations about aquatic organisms behavior and draw conclusions based on their data.
22. Diagram and describe the transfer of energy in an aquatic food web (or the trophic levels in a energy pyramid) in Texas, including producers, consumers, decomposers, scavengers, and predator/prey relationships. Be sure to include the source of energy for the aquatic ecosystem.
23. Students will investigate and explain the effects of energy transformation within an ecosystem in terms of the laws of thermodynamics.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, B, C, D, E; 6.3 A, B, C; 6.4 A; 6.12 D, E; 7.1 A, B; 7.2 A, B, C, D, E; 7.3 A, B, C; 7.4 A; 7.5 A, B, C; 7.8 A, B, C; 7.10 A; 7.11 A; 7.13 A, B; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 A, B, C; 8.4 A; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 B, E, F, G, H, J; 3 A, D; 4 B; 5 C, D; 10 B; 11 A, B; 12 A, C

Environmental Science: 1 A, B; 2 B, E, F, G, I, K; 3 A, D; 4 A, B, F; 6 D, E; 7 A, D; 8 A; 9 A

Materials Needed

Activity 5.2

Poker chips: two red, two white and two blue chips for each student or (3 × 3 inch squares of colored poster board may substitute)

Sufficient space for students to stand arm's distance apart from one another

Small plastic bag for each student

Chart paper and markers to record results of changes

Science journals

Pencils/pens

Activity 5.3

Student Guide

Science journals

Pens or pencils

Internet and computer

Activity 5.4

For each group of 4 students

Copies of Information Cards from the *Aquatic Community Food Web Scramble* activity

Pictures from magazines or the Internet (optional)

Science journals

Pencils

Colored pencils/pens/markers (optional)

Activity 5.5

Native Aquarium(s) with at least 4 kinds of aquatic organisms

Clear overhead transparencies or cellophane

Tape

A variety of colors of Vis-à-Vis pens (4 colors for each group)

Science journals

Pencils

Timer/clock

Transparent tape

Activity 5.6

Aquatic Community Food Web Scramble information card for each species

Aquatic Community Food Web Scramble nametag for each species

Three 6-foot-long strands of yarn or cord per student

Science journals

Pens/pencils

Butcher paper in 6-foot length for each group, with a few extra in case of accidents

Tempera paint, watercolors, markers, or other art materials

Copies of *Energy Pyramid* chart

For High School

Science journal

Energy Pyramid Game Board

Aquatic Community Food Web Scramble information cards

Safety Precautions

Be sure that students understand that, while they are playing a competitive game, there should be no rough housing.

Vocabulary

- Abiotic
- Adapted
- Autotroph
- Biotic
- Carnivore
- Carrying capacity
- Community
- Compete
- Consumer
- Decomposer
- Energy pyramid
- Erosion
- Eutrophication
- Food chain
- Food web
- Habitat
- Herbivore
- Heterotroph
- Host
- Interact
- Invasive species
- Limiting factors
- Natural selection
- Niche
- Omnivore
- Overpopulation
- Parasite
- Plankton
- Population
- Predator
- Prey

- Producer
- Scavenger
- Sedimentation
- Trophic level

Enrichments

- Visit to an Aquarium

Project WET

- Water Address

Project WILD Aquatic

- Aquatic Times
- Designing a Habitat
- Migration Headache

Project WILD

- Oh, Deer! (Change deer to an aquatic species.)

Guest speakers:

- Aquatic biologist, to talk about energy transformation in an aquatic environment.
- Fisheries biologist, to talk about fisheries management and aquatic communities.
- Hatchery worker, to talk about hatchery spawning and aquatic communities.

Lesson 5.1: Interactions of Living Things

Essential Concept

All living things have needs that must be met in order to survive, and living things must interact with other living things in the community in order to meet their needs.

Objectives

1. Students will examine the importance of interactions in a community.
2. Students will relate the interactions of their family in their community with interactions of aquatic organisms in the aquatic community.

TEKS

6.12 E; 7.13 A; 8.11 A, B

Aquatic Science: 11 A

Environmental Science: 6 E

Estimated Time

20 minutes

Materials

None

Procedure

1. Survival

All living things have certain things they need in order to survive.

- **What do <u>you</u> need to survive?** (Students may come up with a variety of things that they think they need such as a place to live, food, water, clothing, sleep, cars and gasoline for transportation, friends, family, various "indispensable" technological tools.)
- **Which needs are most urgent?** (Examples are food, water, shelter, and oxygen.) You may want to also include space to get the things we need.
- **How do you get those needs met in your daily lives?** (Oxygen is in the air in the space all around us, and requires healthy lungs to extract it. Parents, and sometimes students, work in the community to make money to provide food, water, and shelter.)
- **In the process of work what do you and your parents have to do in the community?** (Interact with other members of the community such as co-workers, bosses, etc.)

- **How is your family like a group of organisms in the aquatic community?** (Organisms in an aquatic community also have needs for survival including food, water, shelter, and oxygen. These aquatic organisms must also interact with other members of the aquatic community to obtain their survival needs.)
- **Can you think of some ways aquatic organisms interact?** (Producer/consumer, predator/prey, parasite/host, food chains and webs are interactions in which organisms depend on each other and may compete.)
- **What would happen if one or more of the things you need were in much shorter supply?** (For humans, when things are in short supply, they get more expensive. When things are expensive fewer people can afford to buy them. We compete more to make more money so we can afford the things we need to survive. Or we find other ways to get what we need such as growing a garden or raising chickens.)
- **How is this like an aquatic community?** (When things are in short supply, in nature, fewer aquatic organisms can get what they need. Organisms must compete more to get what they need. When this happens some animals leave the area, are eaten, use up all their energy seeking to get what they need, or die because their needs can no longer be met. This competition for a limited supply of food, water, shelter, and oxygen is what limits the numbers and types of aquatic organisms that can live in a particular aquatic ecosystem.)

Explain to the class that this chapter will help them understand how fish and other aquatic species interact to get the things they need to survive.

2. Using What We Learned

Ask students to write 1-3 sentences in their science journals about how organisms interact in an aquatic environment.

Vocabulary

- Community
- Compete
- Competition
- Interact

Lesson 5.2: Competition within Frio Pond Community

Essential Concept

Competition for basic survival needs is a basic part of living in an aquatic habitat.

Objectives

1. Students will take part in a simulation of pond life including adaptation, competition, and limiting factors that reduce carrying capacity in an aquatic habitat.
2. Students make a data table with results of changes in the habitat.
3. Students will synthesize information from the simulation to write a news story.
4. Students will explain how populations and individual organisms within a community compete with one another for resources, providing specific examples from an aquatic community of Texas.
5. Students will recognize factors that affect the number and types of organisms an environment can support.
6. Students will explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences.

TEKS

6.3 B, C; 6.12 E; 7.3 B, C; 8.3 B, C; 8.11 B

Aquatic Science: 2 H, J; 5 C, D; 11 B; 12 A, C

Environmental Science: 2 I, K; 4 F; 7 A; 8 A; 9 A

Estimated Time

1 class period

Materials

Poker chips: two red, two white and two blue chips for each student or (3 × 3 inch squares of colored poster board may substitute.)

Sufficient space for students to stand arm's distance apart from one another

Small plastic bag for each student

Chart paper and markers to record results of changes

Science journals

Pencils/pens

Special Instructions

If you laminate the poster board pieces, you can reuse them. Note: It usually works better to cut the squares before you laminate so that there are no uncovered edges, which can absorb moisture.

Safety Precautions

Be sure that students understand that, while this is a competitive game, there should be no rough housing.

Procedure

1. **Every Fish for Itself**

Tell students a story about Frio Pond. Frio Pond is a cool, clear pond surrounded by trees, grasses, and other plants. Today we will play a game where you will be a fish living in Frio Pond. You are searching your habitat for some of the things you need to survive.

- **What things will you need?** (Food, water, oxygen are the components of the game shelter and space are not being considered.)

The object of the game is to gather as many poker chips as possible. Each poker chip represents something fish need to survive. Red represents food, blue represents clean water, white represents oxygen. These are all survival needs that can change and limit the number of organisms and populations that can survive in the community. We call them limiting factors. Limiting factors affect the carrying capacity of the community and limit the population of specific species that can survive in the ecosystem.

Have the students stand arm’s distance apart from one another. Give each student a small plastic bag.

Designate 1 student as a recorder and give them a marker and a data table on chart paper. (See data table at the end of this lesson

Rules:

- <u>One foot must remain in place at all times</u>. This represents the fact that fish have certain living conditions that they require and generally must remain in habitats with those living conditions.
- Students are not allowed to slide their foot across the ground and may not take a chip from another “fish” if they already have it in their “fin.”
- Students may <u>gather only one chip at a time</u>. They must put that chip in their baggie before they can gather another chip. They may start gathering only when told to start and must stop when told to stop.
- Students will have <u>30 seconds</u> to gather their survival needs.
- All fish start over with each trial

Scatter the poker chips on the ground around the students so the chips are about 1-2 feet apart.

Say, “Go!”

After 30 seconds, tell the students to stop. Have students sort and count their chips.

Each fish must have at least two chips of each color in order to survive.

- **How many of their survival needs did each fish get?**
- **Do any fish lack a particular requirement?**
- **What might happen to a real fish that lacked one of its requirements for survival?**

Have the student recorder write the survival rate for “Initial Conditions” on the data table.

2. Fish Adaptations

Point out that not all fish have the same requirements. Some might be adapted to survive in water that is warmer or has less oxygen or is clouded with silt.

Gather the chips both from the ground and from the students.

Randomly designate 1 out of every 4 students as catfish.

Explain that catfish are adapted to survive in water that is warmer or has less oxygen or is clouded with silt. Therefore catfish need to gather only one white chip and one blue chip to survive. They will still need 2 red chips. (Refer students to Chapter 4 for information on catfish.)

Scatter chips and start a new round of the game.

- **How many catfish survived this round?**
- **How many other types of fish survived?**

Compare the survival rate between catfish and other fish. Have the recorder write the survival rates for “Catfish and Other Fish” on the data table

- **How did the populations change?**

3. Overpopulated Aquatic Ecosystem

Gather the chips both from the ground and from the students.

Have them stand together in groups of 3 to 5 with one foot touching the other students’ feet.

This represents a water body that is crowded or that lacks adequate living conditions, and is therefore past its carrying capacity.

- **What do we call the place where organisms find all the things they need to survive?** (habitat)

Scatter chips and start another round.

- **How many catfish and other fish survived?**

Record the survival rates for “Crowded/Poor Habitat” on the data table.

Compare the results of this round to those of the previous rounds. In most cases, students will notice that each fish gathered fewer of their survival needs.

- **How did the populations change?**
- **What can we conclude about a pond that is overcrowded with fish or has poor habitat?**

4. Eutrophication

Excess nutrients (nitrogen) from cattle manure runoff have caused an increase in plant growth in the water.

- **What do you predict will happen?** Ask students to write their predictions in their journals. (Algae will grow out of control, use up the nutrients, die and decay. The decay will use up much of the dissolved oxygen in the water. Refer students to Chapters 1–3.)

Gather the chips both from the ground and from the students and once again have them stand arm’s distance apart from one another.

Take out half of the white chips, representing oxygen and redistribute the chips to begin another round.

Record the survival rates for aquatic ecosystem with eutrophication and resulting algae overgrowth on the chart.

- **How did the populations change?**

5. Erosion and Sedimentation Due to Construction

Careless construction in the watershed has caused rapid erosion.

- **What do you predict the effect will be on fish survival?** Ask students to record their predictions in their journals. (Sediment entering the water will clog gills of fish and reduce survival. Refer students to Chapters 1–3.)

Gather the chips both from the ground and from the students.

Take out half of the blue clean water chips.

Redistribute the remaining chips and start another round.

Record the survival rates for “Erosion and Sedimentation” on the chart.

- **How did the populations change?**

6. Invasive Species

A new predator species has appeared that eats the same food as native fish.

- What do we call these non-native species? (Invasive species)
- **What do you predict the effect will be on fish survival?** Ask students to write their predictions in their journals. (More predators in the ecosystem means less food available for native fish species.)

Gather the chips both from the ground and from the students.

Reduce the number of red food chips.

Redistribute remaining chips and start another round.

Record the survival rates for fish for “Invasive Species” on the chart.

- **How did the populations change?**

Gather the chips both from the ground and from the students.

Have students make a data table in their science journals and record the results for the game from the information recorded on chart paper.

7. Drawing Conclusion

- **What were the limiting factors in Frio Pond?** (Availability of oxygen, clean water, and food)
- **What helped some species survive when others could not?** (Adaptations)
- **What conditions changed to decrease carrying capacity?** (Overpopulation, eutrophication, invasive species, erosion, and sedimentation)
- **What was the resulting change in population due to each change in condition?**
- **How was the carrying capacity for Frio Pond affected by changes in the habitat?**
- **How was our game/simulation a model of what happens in a real pond?** (Conditions continually change in a real pond. We looked at various changes that might happen in the ecosystem and how these changes might affected the population of fish.)
- **How was the model limited?** (Size, number of variables affecting population in each round, number of species represented, etc.)
- **How could we improve our model to make it more like the real world?**

8. Using What We Learned: Writing a Newspaper Story

Have students write a newspaper article for the *Morning Fish Gazette* in their science journals telling the story of continuing disasters at Frio Pond. Students can have fun with the story, but must include all the pertinent information and causes and results of the disasters.

Students should include how populations of organisms within a community and individuals within a population compete for resources, and factors that affect the numbers and types of organisms that the ecosystem can support.

Give students the *Rubric for Newspaper Story about Frio Pond* before they start writing..

Vocabulary

- Adapted
- Carrying capacity
- Community
- Erosion
- Eutrophication

- Habitat
- Invasive species
- Limiting factors
- Model
- Overpopulation
- Population
- Sedimentation

Student Page

Continuing Disasters at Frio Pond
Rubric for Newspaper Story

I. Organization **Total 25 points**

1. Interesting beginning
2. Clear concise information
3. Organized in a logical way
4. Includes data table

II. Appearance **Total 20 points**

1. Neat, clean, attractive
2. Easy to read
3. Information easy to understand

III. Accuracy **Total 25 points**

1. Information is correct and communicated appropriately.
2. Correct grammar, punctuation, and spelling.
3. Include factors that limit numbers and types of organisms that the pond ecosystem can support.
4. Include information on how individuals within populations and populations within communities compete for resources.

IV. Critical Thinking **Total 30 points**

1. Conclusions are based on logical inferences and generalizations related to data collected.
2. Reasons for conclusions are stated.
3. Possible causes of changes in carrying capacity are discussed.
4. Results of habitat changes are discussed, specifically as they relate to survival rates of particular species
5. Ways to maintain healthy habitat are suggested.

Possible Grand Total` **100 points**

Every Fish for Itself Data Table

Change in the Environment	Beginning Population	Population After Change
Trial 1: Control/Baseline	All Fish	All Fish
Trial 2: Adaptations	Catfish Other Fish	Catfish Other Fish
Trial 3: Overpopulation	Catfish Other Fish	Catfish Other Fish
Trial 4: Eutrophication	Catfish Other Fish	Catfish Other Fish
Trial 5: Erosion/Sedimentation	Catfish Other Fish	Catfish Other Fish
Trial 6: Invasive Species	Catfish Other Fish	Catfish Other Fish

Lesson 5.3: Student Reading and Research

Essential Concept

Organisms in an aquatic community fill a niche as they interact with other organisms and compete for survival in their habitat.

Objectives

1. Students will read the student materials.
2. Students will answer the questions.
3. Students will research at least two fish and add their information to the *Comparison Matrix*.
4. Students will use what they have learned about interrelationships of organisms in various niches in an ecosystem to take part in critical thinking about differences in food webs in various aquatic ecosystems (i.e., pond, estuary, Gulf of Mexico).

TEKS

6.12 D; 7.11 A; 8.11 A

Aquatic Ecosystems: 10 B

Environmental Systems: 4 A

Estimated Time

Varies—class time may be provided for reading and research or it may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

The Cast Beyond Tomorrow Question will take 30 minutes

Materials

Student Guide

Science journals

Pens or pencils

Internet and computer

Copies of Comparison Matrix

Procedure

1. Student Reading

Have students read *Chapter 10: Fishing for Answers*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What are some of the basic survival needs of all living things?

Most living things require food, water, oxygen, space, and shelter, or protection from the elements and from enemies to survive and grow. Plants make their own food (carbohydrates), but they need sunlight, carbon dioxide, water, and minerals to do so. Most vertebrates need periodic sleep or rest. Some bacteria don't need oxygen.

2) What is a population? What is a community?

A group of one kind of organism living in the same place at the same time is a population of that species. Different populations living in the same place interact with one another. A group of populations of different species living in the same place is called a community.

3) What is habitat? Why is it important? Why must organisms compete for resources? What is carrying capacity?

The physical environment that a species needs to survive is its habitat. Habitat is more than a place. Habitat provides the shelter a species uses to escape predators and the elements, as well as the space it needs for reproducing and for hunting, gathering or producing food. Habitat is important because it includes all the conditions a species needs to survive. Many aquatic plants and animals have very specific needs. They either can't move or can't live in another habitat. When resources in an environment are in short supply, individuals and populations must compete for them. Carrying capacity is the maximum number of individuals in a particular population that an environment can support. The limited biotic (living) and abiotic (non-living) resources in a habitat determine the environment's carrying capacity.

4) What is a niche? Why is it important? What are invasive species? Why are they a problem?

A species' niche includes its way of getting food, the habitat it needs, and the role it performs in the community. Within a community every species has a particular niche. Different species may have similar or even overlapping habitats, but no two species can occupy exactly the same niche in the same community for long.

Example of species, which inhabit specific niches. One species of fish eats insects from the surface. Another fish species eats insects from the bottom. Therefore, the niche is important so that organisms don't compete directly for food. If a new species of fish comes into the habitat and begins to also eat insects from the surface, it will directly compete with the first species of fish for food. Species can also compete for other habitat components such as shelter, space, oxygen, or water.

A species is called invasive if it has been brought (usually by human action) to a place where it did not live naturally, and has survived and expanded its population. When a non-native species can breed and sustain itself in the new habitat, then it may be a problem because it competes with native species for habitat or food. This competition could make it harder for the native species to survive. Over time, this invasion can unbalance the community. As a result, native species could become endangered.

5) ***What is the source of energy for aquatic communities? How does energy circulate among organisms in an aquatic community?***

Aquatic communities run on sunlight. Energy circulates among organisms through feeding relationships (they eat one another).

6) ***What is a food chain? What is a food web? What is an energy pyramid? What is a trophic level?***

A food chain shows how energy moves from producers to primary consumers to secondary consumers, and so on. Food webs show how different food chains are interconnected. An energy pyramid is another way to look at feeding relationships. If you divide a pyramid into levels, you can see that the widest level is at the base and the narrowest one is at the top. The pyramid shape not only shows what eats what, but how much energy is available at each consumer level. Consumer levels are also known as trophic levels. The word "trophic" comes from a word that means "nourishment". So each trophic level shows a change in the type of nourishment used by the organisms. Producers use sunlight to help them create carbohydrates for nourishment. Primary consumers eat plants. Secondary consumers eat animals (and sometimes both plants and animals). Tertiary consumers (and levels above on the pyramid) are animals that may be top predators that usually don't have anything that hunts them for food once they have grown large. Humans are at the top of Earth's energy pyramid. Decomposers may eat dead plant or animal material or both and recycle nutrients back into the soil for plant use.

7) ***How do predator and prey species keep one another in balance in aquatic communities? What is natural selection?***

Both predator and prey are competing against one another for survival; the predator is seeking food, and the prey is trying to keep from being eaten. Predators play an important role by keeping populations of prey species within the habitat's carrying capacity. At the same time, the amount of prey available in a predator's habitat can limit the number of predators that can live there. Natural selection is the process by which some individuals in a population live to reproduce and some do not, based on their ability to survive and reproduce in their environment. In general, natural selection ensures that only the best-adapted individuals survive to pass on their genetic material.

3. Researching Aquatic Species for the Comparison Matrix

Ask students to look in the reading and find the information on Gizzard Shad and Flathead Catfish. Have students put information in their fish Comparison Matrix. For more information, have them go on the Internet to fill in what they need. They should add 2 other fish that they find interesting.

4. Cast Beyond Tomorrow Question

Students will discuss the question in small groups and then share their ideas with the class.

- **In what ways might food webs, food chains, and predator/prey relationships be different in a pond, an estuary, and the Gulf of Mexico?**

Ask students to write the question from their student guides in their notebooks and discuss their ideas in small groups for 5-10 minutes. Students should write in their journals at least one idea about food webs, food chains, and predator/prey relationships for each of the three ecosystems (pond, estuary, and Gulf of Mexico). If students don't know about estuaries, you may want to spend a few minutes discussing what an estuary is. (This is the area where fresh and saltwater mix and many types of animals have nurseries here. They are the source for fish, shrimp, crabs, etc.)

Ask each group to share their ideas with the class and record their ideas on the white board or an overhead. All students should make a table to record the information for each aquatic ecosystem.

- **What generalization can you make about the food webs in these aquatic ecosystems?** (The pond ecosystem is small and can support few types of organisms, the estuary is rich in habitats and nutrients and can support more types of organisms, the Gulf of Mexico is large and has many types of habitats, and therefore can support many, many types of organisms. Therefore the food webs of these aquatic habitats get increasingly complex (with many more different food chains and many types of predator/prey relationships) as the size, richness of habitat, and numbers of types of organisms increases.)

Vocabulary

- Carrying capacity
- Community
- Energy pyramid
- Food chain
- Food web
- Habitat
- Natural selection
- Niche
- Population
- Predator
- Prey
- Trophic level

Comparison Matrix

Species	Average Size Weight Length Advantages & Disadvantages	Body Shape Adaptation Advantages & Disadvantages	Coloration Adaptation Advantages & Disadvantages	Mouth position and teeth Adaptation Advantages & Disadvantages	Method of movement Adaptation Advantages & Disadvantages	Other Adaptation Adaptation Advantages & Disadvantages

Lesson 5.4: What’s My Niche?

Essential Concept

All organisms in an aquatic environment fill a particular niche. The niche is their role in the community.

Objectives

1. Students will play card games to learn about the niches of various organisms in an aquatic ecosystem.
2. Students will choose 5 organisms that interact in an aquatic ecosystem, then draw and label a diagram showing the organisms, and their niches, and will use arrows to show how the organisms interact in the aquatic ecosystem.
3. Students will describe a specific example from an aquatic community in Texas including each of the following: producer, consumer and decomposer and explain the role each serves in the community.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.5 C; 8.2 C; 8.11 A

Aquatic Science: 2 J; 5 C, D; 11 A

Environmental Science: 2 K; 4 B

Estimated Time

1 class period

Materials

<u>For each group of 4 students</u>

Copies of Information Cards from the Food Web activity

Pictures from magazines or the Internet (optional)

Science journals

Pencils

Colored pencils/pens/markers (optional)

Special Instructions

You might ask students who would like, to help color the cards to make them more attractive. Then make color copies on cardstock, cut them apart and laminate them to make playing cards.

You will need one set of cards per group of 4 students for ***What’s My Niche***.

For ***Aquatic Food Chains*** and ***Aquatic Connections*** use the same cards – with added cards for Nutrients, and Decomposers.

Teachers or students can make the new cards with drawings, words, or photos from magazines.

Make two copies of all of the information/game cards, except the Human card.

Make 5 copies of the Human card.

Make 10 copies of the nutrient cards and decomposer cards.

Laminating the cards will help protect them and make it possible to use them repeated times.

Procedure

1. **What's my Niche?**

Ask students to get in groups of 4. Give out one set of the information cards from the *Food Webs Scramble* in Activity 5.6 to each group.

This game can be played by 4 players or 2 teams and a moderator.

<u>Rules for 4 players:</u>

1) One player deals out all the cards, then the cards are put in a stacks face down.
2) Play moves to the right.
3) Players take turns turning over a picture of an organism to the other players.
4) The other players slap the card and the first one to slap gets a chance to get points.
5) The winner of the slap keeps his hand on the card to show the picture, but covers the information.
6) The winner of the slap gets 1 point for each of the following:
    - The name of the organism
    - Where the organism gets its energy (it's food)
    - Who eats the organism
    - The job the animal performs in the ecosystem (producer, consumer, decomposer, scavenger, parasite, host, prey, predator)
    - The location of the aquatic habitat it lives in (bottom, open water, near plants, etc.)

The original player then reads the card information to the group.

The answering player receives 1 point for each part of the niche of the organism that they can tell. There is a total possibility of 5 points per play. Students may not know a lot of the information at first, but will learn more as they play the game.

This game can be used at other times when students are waiting to do their aquarium observations or have finished their work.

Team Play

For more experienced players you can have 2 teams play, the moderator (teacher) shows the pictures to the teams and keeps score. If the pictures on the cards are too small, the teacher may need to use pictures from magazines or the Internet so students will be able to see them.

- The teams line up on each side of the room and take turns answering.
- The person who is playing can have 2 helpers who help them answer the questions (the 2 nearest neighbors).
- When their turn is over, the person goes to the end of the line and the next person moves up.
- The moderator shows a picture to the other team and again the player can have 2 helpers.
- Points are awarded as in the 2-player game. The Moderator keeps score on the board.

2. Aquatic Food Chains Game

Using the same cards – with added cards for Nutrients, and Decomposers.

Teachers or students can make the new cards with drawings or photos from magazines.

Make two copies of all of the information/game cards, except the Human card.

Make 5 copies of the Human card.

Make 10 copies of the nutrient cards and decomposer cards.

This game is for 3-6 players.

Basic rules:

1) Goal is to collect the most cards through completing food chains.
2) There will be cards in your HAND and cards in food chains on the table.
3) Once a card is played in a food chain it cannot be taken out of the chain.
4) Points:
    - All cards in food chains are worth 1 point.
    - All cards still in your hand at the end subtract 1 point.
    - A chain harvested by humans (meaning it ends with a human) is worth no points.
5) The game ends when no one can play anymore.
6) ***A "complete" food chain includes at least Nutrients, Producers, Consumers, and a Decomposer to end the chain (or a human card)*. *Complete food chains can be said to "loop" also.***

To play the game, follow these steps in order.

<u>Set up</u>

1) 7 cards are dealt to each player
2) In this game players do not maintain 7 cards at all times. The number of cards in each hand changes.
3) Set remaining cards in the center of the table, face down as the draw pile.
4) With the 7 cards, each player lays down any food chain links they can make with their own cards.
5) Place cards on top of each other, the lowest thing on the food chain is played down first with the animal or plant that utilizes or eats it on top of it so that both card names can be seen. (Example: **nutrients cards** would be covered by **a producer card,** the producer card could be covered by an **insect that eats it,** etc.)
6) If you made a "complete" food chain. Set it aside upside down. It is done. No one can change this food chain.

<u>Playing – After the game is set up</u>

After everyone uses the cards they are dealt to make any food chains that they can. Then the turns start, each turn consist of 3 things in this order:

1) Draw one card and add it to your hand.
2) Add cards to the top or bottom of your own food chain ***or to another's food chain,*** **o**r make new chains (2 or more cards are needed to start a new chain)
    - Adding a card to another player's food chain allows you to steal their *whole chain*. Move it in front of you.
    - "Complete" chains cannot be stolen or played on once they are turned over.
    - Cards can only be added to one end of the chain at a time, not both ends in one turn.
    - There are no limits to how many cards can be played in a turn.
    - If playing a card allows a player to put two chains together, they can do that also.
3) After you have built as many food chains as you can, pick a predator (any secondary consumer) from your hand and demand food from the other players.

If you do not have a predator, draw till you get one.

Other players must give up one card that is eaten by this predator *if they have one*.

These cards are not placed on food chains in this turn, but are kept in your hand until the next turn.

Example: After playing, I hold up my bass card and say to one of my neighbors, "If you have a blue gill or crayfish feed me." I add the card to my hand for my next turn.

<u>Your turn is over.</u> If you completed a food chain, turn it upside down and set it aside for scoring later.

<u>The next person's turn starts.</u>

<u>Human cards</u> – these either can take cards away from the game (no points to anybody) or double points.

A **Human** card removes a food chain from play and no points are received for that food chain. Obviously you wouldn't want to do this to you OWN chains, but you might want to use it to nullify your neighbor's food chain.

If you add a human to someone's food chain, it doubles the points for that food chain, but those points go to you.

<u>Ending the game</u>

The game is over when all the cards are used or those left are unusable.

A player receives 1 point for every card in a food chain that is on the table, and 2 additional points for any completed food chains (nutrient to decomposer with at least 3 cards).

Cards still in a player's hand are minus 1 point each.

The winner is the player with the most points.

3. Aquatic Connections Game

This is a game for 2-3 players.

The goal of the game is to run out of cards in your hand first. Then cards in other people's hands give you points.

It takes several rounds to win this game.

A total score of 15 wins the game.

<u>Set up</u>

Deal 5 cards to each player, then place all remaining cards in a central pile face down.

Turn the top card of the draw pile and put it face up next to the draw pile for the first playing stack.

<u>Playing</u>

1) The first player draws a card from the face down deck of cards. If it directly interacts with the starter card (prey or predator side of the food chain), the card is placed on top of the starter card.
2) The player may play any number of cards from their hand after drawing one card from the deck
3) If a Nutrient card is drawn it is placed on the table to start another playing stack.

4) If the card has no direct interaction with any playing stack the player puts that card in their hand.
5) The next player draws a card and can play on any pile and can play any number of cards from their hand as well.

Special cards

- A Decomposer card does not end a chain as it did in the last game. It can be covered by a nutrients card and the cycle continues.
- When a Human card is played on a stack, players can no longer add to the stack. Turn that stack upside down.

Ending the game

When a player clears their hand, play stops and they receive a point for each card left in the other players' hands.

If the winning score isn't reached when the deck runs out, reshuffle the cards and play another round.

4. Applying What We Learned: An Aquatic Community Diagram

Ask students to draw a diagram in their journals showing at least ten organisms from a Texas aquatic community, whose niche they learned about in the games. They should label each organism and its niche and use arrows to show how the organisms interact in an aquatic community. Be sure to include the Sun, producers, consumers, and decomposers. **Examples:** Sun (source of energy), algae (producer), water boatman (herbivore), snails (herbivore), springtail (decomposer), mussel (scavenger) backswimmer (predator/carnivore), turtle (predator/carnivore), fish (predator/carnivore), leech (parasite on fish and turtles), human (omnivore)

Arrows should point from the source of the energy to the user of the energy (what is eaten to the eater).

Vocabulary

- Carnivore
- Community
- Consumer
- Decomposer
- Herbivore
- Host
- Niche
- Omnivore
- Parasite

- Predator
- Prey
- Producer
- Scavenger

Student Page

What's My Niche?

This game can be played by 4 players.

Rules for 4 players

1. One player deals out all the cards. Then the cards are put in a stacks face down.
2. Play moves to the right.
3. Players take turns turning over a picture of an organism to the other players.
4. The other players slap the card and the first one to slap gets a chance to get points.
5. The winner of the slap keeps his hand on the card to show the picture, but covers the information.
6. The winner of the slap gets 1 point for knowing each of the following.
   - The name of the organism
   - Where the organism gets its energy (it's food)
   - Who eats the organism
   - The job the animal performs in the ecosystem (producer, consumer, decomposer, scavenger, parasite, host, prey, predator)
   - The location of the aquatic habitat it lives in (bottom, open water, near plants, etc.)

The original player then reads the card information to the group.

The answering player receives 1 point for each part of the niche of the organism that they can tell. There is a total possibility of 5 points per play.

Aquatic Food Chains

Use the same cards as for *What's My Niche* – with added cards for Nutrients, and Decomposers.

This game is for 3-6 players.

Basic rules:

1. Goal is to collect the most cards through completing food chains.
2. There will be cards in your HAND and cards in chains on the table.
3. Once a card is played in a food chain it cannot be taken out of the chain.
4. Points:
   - All cards in food chains are worth 1 point.
   - All cards still in your hand at the end of the game subtract 1 point.
   - A chain harvested by humans (meaning it ends with a human) is worth no points.
5. The game ends when no one can play anymore.
6. ***A "complete" food chain includes Nutrients, Producers, Consumers, and a Decomposer to end the chain (or a human card). Complete food chains can be said to "loop" also.***

<u>**Set up**</u>

1. 7 cards are dealt to each player
2. In this game players do not maintain 7 cards at all times. The number of cards in each hand changes.
3. Set remaining cards in the center of the table, face down as the draw pile.
4. With the 7 cards, each player lays down any food chain links they can make with their own cards.
5. Place cards on top of each other, the lowest thing on the food chain is played down first with the animal or plant that utilizes or eats it on top of it so that both card names can be seen. (Example: **nutrients cards** would be covered by **a producer card,** the producer card could be covered by an **insect that eats it,** etc.)
6. If you made a "complete" food chain, set it aside upside down, it is done. No one can change this food chain.

Playing – After the game is set up

After everyone uses the cards they are dealt to make any food chains that they can. Then the turns start, each turn consist of 3 things in this order:

- Draw one card and add it to your hand.
- Add cards to the top or bottom of your own food chain ***or to another's food chain,* o**r make new chains (2 or more cards are needed to start a new chain)
- Adding a card to another player's food chain allows you to steal their *whole chain*. Move it in front of you.
- "Complete" chains cannot be stolen or played on once they are turned over.
- Cards can only be added to one end of the chain at a time, not both in one turn.
- There are no limits to how many cards can be played in a turn.
- If playing a card allows a player to put two chains together, they can do that also.
- After you have built as many food chains as you can, pick a predator (any secondary consumer) from your hand and demand food from the other players.

If you do not have a predator, draw till you get one.

Other players must give up one card that is eaten by this predator *if they have one*.

These cards are not placed on food chains in this turn, but are kept in your hand until the next turn.

Example: After playing, I hold up my bass card and say to one of my neighbors, "If you have a bluegill or crayfish feed me." I add the card to my hand for my next turn.

Your turn is over. If you completed a food chain, turn it upside down and set it aside for scoring later.

Human cards – these either can take cards away from the game (no points to the player who made the food chain) or double points (to the player who puts the human on the food chain).

A **Human** card removes a food chain from play, and no points are received for that food chain by the player who built it. Obviously you wouldn't want to do this to you OWN chain, but you might want to nullify your neighbor's food chain.

If you add a human to someone's food chain, it also doubles the points for that food chain, and those points go to you.

Ending the game

The game is over when all the cards are used or those left are unusable.

A player receives 1 point for every card in a food chain that is on the table, and 2 additional points for any completed food chains (nutrient to decomposer with at least 3 animals).

Cards still in a player's hand are minus 1 point each.

The winner is the player with the most points.

Aquatic Connections

This is a game for 2-3 players.

The goal of the game is to run out of cards in your hand first. Then cards in other people's hands give you points.

It takes several rounds to win this game.

A total score of 15 wins the game.

Set up

Deal 5 cards to each player, then place all remaining cards in a central pile face down.

Turn the top card of the draw pile and put it face up next to the draw pile for the first playing stack.

Playing

1. The first player draws a card from the face down deck of cards. If it directly interacts with the starter card (prey or predator side of the food chain), the card is placed on top of the starter card.
2. The player may play any number of cards on to stacks from their hand after drawing one card from the deck
3. If a **Nutrient** card is drawn it is placed on the table to start another playing stack.
4. If the card has no direct interaction with any playing stack the player puts that card in their hand.
5. The next player draws a card and can play on any pile and can play any number of cards from their hand as well.

Special cards

- A **Decomposer** card does not end a chain like in the last game. It can be covered by a nutrients card and the cycle continues.
- When a **Human** card is played on a stack, players can no longer add to the stack. Turn that stack upside down.

Ending the game

When a player clears their hand, play stops and they receive a point for each card left in the other players' hands.

If the winning score isn't reached when the deck runs out, reshuffle the cards and play another round.

Lesson 5.5: Native Aquarium Observation

Essential Concept

Each native species has a specific habitat within aquatic ecosystems where it can best meet its needs for survival.

Objectives

1. Students will set up a system for observing and mapping organism behaviors in a native aquarium.
2. Students will make generalizations based on their data.
3. Students will make hypotheses about causes of organisms' behavior.
4. Students will plan investigations to test their hypotheses.
5. Students will compare data with other groups.
6. Students will plan an investigation.
7. Students will evaluate plans for investigations.
8. Students will carry out their investigations and draw conclusions based on their data.
9. If time and cost allow, visit a nearby aquarium such as the Texas State Aquarium in Corpus Christi, Dallas Aquarium, etc.

TEKS

6.1 A, B; 6.2 A, B, C, D, E; 6.4 A; 6.12 E; 7.1 A, B; 7.2 A, B, C, D, E; 7.4 A; 7.10 A; 7.13 A, B; 8.1 A, B; 8.2 A, B, C, D, E; 8.4 A; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 B, E, F, G; 4 B; 5 C; 11 A

Environmental Systems: 1 A, B; 2 B, E, F, G, K; 6 E

Estimated Time

Varies. This activity can be repeated, if you wish to gather more data.

Materials

Native Aquarium(s) with at least 4 kinds of aquatic organisms

Clear overhead transparencies

A variety of colors of Vis-à-Vis pens (4 colors for each group)

Science journals

Pencils

Timer/clock

Transparent tape

Special Instructions

Clear laminating film can be run through the laminator with nothing inside, if you don't have other clear film to use on the side of the aquarium.

If you will be collecting, check the following website to see if any permits are needed. http://www.tpwd.state.tx.us/business/permits/land/wildlife/educational/

Procedure

1. **Mapping Behavior**

We can learn information about the niche an organism occupies by studying the behavior of organisms and recording movements systematically.

Provide each group of 5 students with a sheet of cellophane, transparencies, or laminating film to cover one side of the aquarium. This will be taped to the side of the aquarium as a clear sheet so students can mark the locations of each organism using a different color Vis-à-Vis.

Have each group choose 4 organisms to observe. Ask students to make a key to show the color they are assigning to each organism. (Example: Blue/Bluegill, Red/Gambusia, Orange/Crawdad, and Green/Snail.) **Note:** This is a good combination of organisms so that none are eaten by any of the others, but whatever variety you have will be interesting to observe. Try to keep predators in separate aquariums from their prey.)

Instructions:

One group member will tape the clear sheet on the aquarium and use a grease pencil to label it with the group name or number and trace an outline of the aquarium and its immobile features such as rocks, plants, and surface of the water.

At the same time each day, one team at a time will have a turn to map the locations of the 4 organisms that they have chosen to observe. One member of the group will be the timekeeper each day and the other members will be assigned one of the types of organisms and will find those individuals and mark their location on the clear sheet with the Vis-à-Vis assigned to that organism**.** You may wish to have students rotate jobs in the group so that everyone has a turn to do timekeeping and everyone gets to mark locations of different organisms.

When the team has finished their observations, they will remove their clear sheet with locations marked and use it to make a diagram in their journals of locations marked, and label where each type of organism is located. Wipe the clear sheet clean with a damp paper towl before the next observation.

In addition to the clear sheet, each student will have an aquatic organism observation page in their journals where they make a data table with the date, type of organism, and description of the actions of that organism. These descriptions should include behaviors that won't show up on the maps, which only show location. It might be something such as darting away from the glass when the student approaches, feeding, various types of movements, injuries, or other behaviors.

Each team will have 10 minutes to do their mapping and observations. Two minutes to put up their clear sheet and allow the organisms to settle back down. Five minutes to map organisms' movements, and 3 minutes to write observations of their organism.

It is helpful if the groups are assigned an order to do their observations. **Example:** Group 1 will do their observations for the first 10 minutes of class. Group 2 will do their observations for the second 10 minutes of class, etc. Other groups can be doing other activities from other lessons while the observations are going on. **Example:** Students could play one of the card games from the last activity, or read student materials and answer questions.

Guide the first group through the first observation as a class demonstration. It requires students to work together cooperatively, and be well organized in order to be able to observe all of the organisms at the same time, which may reveal interactions among the organisms.

Or you may wish to have smaller aquariums for each group to observe.

Procedure for mapping:

- Assign one team member of the group to each type of organism.
- One group member will trace around the objects in the aquarium (be sure the student has the center of the aquarium at eye level.
- One team member will watch the clock and call "time" every 30 seconds for 5 minutes.
- The mapping team members will put a number on each of their organisms each time the timekeeper calls, "Time." So there will be 10 numbers for each organism at the end of 5 minutes.
- All team members will fill in their data tables for each organism as they spend the next 3 minutes observing. Students may each observe different organisms and trade information with other students so they work cooperatively to get observations of all 4 types of organisms.

2. Making Generalizations

After all groups have done observations, have each group look at its native aquarium data.

- **Are there any patterns in the locations of each type of organism?**
- **Are the locations of the organisms related to any particular object or stimulus?** (plants, rocks, bubbler, observer, etc.)
- **If there is more than one of each species of organism, do the same species tend to stay together or do they move away from each other?**
- **Were any of the movements related to the students movements?**
- **Were any of the movements related to other observations made by the group?**

Write down any relationships you can see in the data you collected. (**Example:** Dragonfly nymphs tended to stay near plants, bluegill fish tended to stay in open water, snails tended to stay on the bottom, on plants, or on algae growing on the side of the aquarium, and water boatman tend to stay near the surface diving from time to time.)

3. Making Hypotheses

- **Why do you think this is happening? What do you think causes the organism to behave in a particular way?** (Dragonfly nymphs were possibly hiding from fish, bluegills were possibly looking for food, snails were eating, water boatman were looking for food.)
- How could you test your hypotheses? Plan an investigation to test one of your hypotheses.

Have groups share their data and explanations from the observations and mapping. If the class is using one large aquarium for their observations, overlay the maps for each group on the last day.

- **Is the data showing the same patterns throughout the day?**
- **What explanations were generated in each group based on the data?**
- **What investigations were planned by each group?**

4. Evaluating Investigation Plans

Have the class work together to evaluate the plans of each group for investigations and add or change procedure as needed.

5. Conducting Investigations

Have each group conduct its investigation and report back to the class. Topics will vary, but may include short-term changes to the environment, isolation of organisms from other organisms, from plants, or rocks, introduction of food, light, movement, or other changes to external stimuli.

Have each group keep data tables and procedures in their journals. Each group should draw conclusions based on their data.

Alternatives to Making a Native Aquarium

You might take a class to a local aquarium or zoo or even a pet store to do this assignment as a field trip. Call ahead of time to see if there are group discounts and such for student groups at the zoo or aquarium, or to get permission from an aquarium/pet store to bring your class. The cities of Lake Jackson, Houston, Kemah, Galveston, San Antonio, Abilene, Ft. Worth, Dallas, Corpus Christi, and Athens all have aquariums or zoos with aquariums. Check your local area for facilities close to you.

Vocabulary

- Conclusions
- Data
- Generalizations
- Hypotheses

- Mapping
- Niche
- Systematic observations

Lesson 5.6: Aquatic Food Web Scramble

Essential Concept

Aquatic food webs are complex and varied.

Objectives

1. Students will take part in a simulation to model food webs in an aquatic community.
2. Students will look at responses of organisms to changing conditions in an aquatic community.
3. Students will synthesize what they learn, and depict the changing conditions of an aquatic ecosystem using before and after murals.
4. Students will diagram and describe transfer of energy in an aquatic food web and/or energy pyramid.
5. Students will investigate and explain the effects of energy transformation within an ecosystem in terms of the laws of thermodynamics.

TEKS

6.2 C; 6.3 A, B, C; 12 D; 7.2 C; 7.3 A, B, C; 7.5 A, B, C; 7.8 A, B, C; 7.13 A; 8.2 C; 8.3 A, B, C; 8.11 A, B, C

Aquatic Science: 2 H, J; 3 A, D; 5 C, D; 11A,B; 12 A, C

Environmental Science: 2 I, K; 3 A, D; 4 B; 6 D; 7 D; 9 A

Estimated Time

1 class period for the simulation and class discussion

1 class period for the mural

1 class period for the pyramid diagram, or this may be started in class and finished as homework

1 class period to play the game

Materials

Aquatic community *Food Web Scramble* information card for each species

Aquatic community *Food Web Scramble* nametag for each species

Three 6-foot-long strands of yarn or cord per student

Science journals

Pens/pencils

Butcher paper in 6-foot lengths for each group, with a few extra in case of accidents

Tempera paint, watercolors, markers, or other art materials

Copies of the *Energy Pyramid Chart*

For High School

Copies of the *Energy Pyramid Game* board – these might need to be drawn by the students on large pieces of butcher paper to fit the card sizes. See example game board at end the lesson.

Special Instructions

This activity uses the same cards as *What's My Niche?*, *Aquatic Food Chains*, and *Aquatic Connections* card games in Activity 5.4.

Species nametags will need to be copied on to cardstock, laminated, and then cut on the dotted lines to make tags. Also make a nametag for the sun. This could be a sun cut from construction paper and laminated or just the word "Sun".

Punch a hole in the upper corners of each tag. Tie the ends of a 3-foot strand of yarn or cord to each hole. Students may hang these around their necks during the game.

String or yarn will need to be cut in 6-foot lengths (3 lengths per student). Tie the ends of yarn or string or singe the ends of nylon cords to prevent unraveling. Brightly colored braided nylon string or Mason's chalk line, available at most hardware stores, works well.

For High School

- Make 15 copies of the algae and diatoms cards
- Make 4 copies of all the other producer cards
- Make 2 copies of all the other information cards except the following cards, which you will leave out of the game to simplify it. (Muskrat, Beaver, Canada Goose, Horsehair Worms, Mayfly Adult, Mallard Duck)

Divide the cards into the following groups and Label them with their group number in the top right corner of each card.

1) **Producers:** (42 cards) – label each card with a big **P** in the right hand corner

   Algae, Pondweeds, Diatoms, Cattails, Duckweed

2) **Primary Consumers:** (38 cards) - label each card with a big **C1**

   Water Boatman, Rotifers, Mosquito (male) Isopods (pill bugs), Copepods, Water flea, Scuds, Mosquito Larva, Seed Shrimp, Snails, Mussels, Tadpoles, Mayfly Larva, Bloodworms, Springtail, Stonefly Nymph

3) **Secondary Consumers:** (24 cards) – label these with a big **C2**

   Flatworms, Whirligig Beetle, Damselfly Adult, Caddisfly Larva, Horsefly Larva, Diving Beetle, Water mites, Damselfly Nymph, Dragonfly Adult, Backswimmer, Dragonfly Nymph, Water Strider, Red Winged Blackbird.

4) **Tertiary consumers:** (16 cards)– label all these cards with a big **C3**

   Fishing Spider, Leech, Giant Water Bug, Water Scorpion, Leopard Frog, Tiger Salamander, Crayfish, Bluegill

5) **Quaternary Consumers:** (20 cards) –label these cards with a big **C4**

Bullfrogs, Largemouth Bass, Water Snake, Channel Catfish, Snapping Turtle, Kingfisher, Heron, Raccoon, Mink, Ribbon snake

6) **Quinary Consumers**: Humans – label these 2 cards with a big **C5**

On the backs of ALL the cards write – “Nutrients/Detritus”

Make/draw the playing board on big pieces of paper –chart paper, butcher paper, or posterboard.

Procedure

DAY ONE

1. Building an Aquatic Community

Students will take part in a simulation game to help them understand the complexity of aquatic food webs.

This game is designed for groups of 15 to 30 students.

Spread the plant and animal nametags on a table.

Mix the information cards and give each student one card at random, keeping the extra cards.

Assign 1 student to be the sun.

Have each student carefully read his/her entire card to himself/herself, and then pick up the corresponding nametag and three strings.

Check to be sure each student understands the information about the plant or animal he/she is playing. Explain terms and concepts as needed. Be sure each student recognizes his/her plant or animal.

Rules

Tell students that the objective of the game is to develop a self-sustaining community beginning with random populations of plant and animal species.

After the community is established, various factors will be changed to illustrate the interdependency of the community.

Each type of animal or plant listed represents a population of unknown size.

Playing the Food Web Scramble Game

Divide the students according to the information on the cards into the following groups:

- Plants—producers
- Animals that eat only plants—primary consumers or herbivores
- Animals that eat both plants and animals—secondary consumers or omnivores
- Animals that eat only other animals—secondary consumers, carnivores or parasites

The person that represents the sun will be in the center. Have the plants (producers) surround the sun in the center of the playing space.

Primary consumers surround plants and give one end of a string (food line) to each type of plant they eat.

Have students sit on the ground or floor.

Animals that eat both plants and animals (secondary consumers or omnivores), and animal eaters (secondary consumers, carnivores or parasites) surround plant eaters, giving a food line to each major food they eat. Students may receive more than one string if they are eaten by more than one organism.

Check to be sure all students have an adequate food supply for their survival needs and call the group's attention to any inadequacies. **Any student with an inadequate food supply steps to the sidelines (dies) for the moment.**

The group of adequately fed students comprises the community.

2. Evaluating the Viability of the Community

Discuss the community that has been formed, noting presence or absence of major food sources or plant types, the proportion of plant eaters to animal eaters, etc. Have the class decide whether the community could survive.

Make selective substitutions from the extra cards, using students from the sidelines or the community as necessary to produce a well-established community that includes all students.

Have students change nametags as well as cards when making substitutions.

Have students raise the food lines over their heads and note the complexity and web-like appearance.

3. Changing Environmental Conditions in the Community

Explain that each change in the conditions in an area will cause corresponding changes among the community members.

When conditions change, those students who are eliminated must step to the sidelines, taking their food lines with them.

They may then be assigned a new role to reestablish the community with the new conditions.

Discuss each change as it occurs. Students may think of other changes you can make, if you have time.

The following changes are suggested, but many others are possible.

1) Seasonal Changes

Most groups will assume summer conditions when beginning.

Explain that changing to winter causes great differences due to migration, hibernation, plant dormancy, etc.

Photosynthesis continues to occur in aquatic communities even when the water is covered by ice as long as sunlight can penetrate the ice layer. It stops if ice is snow-covered, preventing sunlight from reaching plankton.

<u>Take out half of the plants.</u>

What happens to the community and its populations? (plant eaters will die off (be sidelined) and animals that ate the plant eaters will die off (be sidelined)

Point out the temporary and cyclical nature of these natural changes.

- **What are some examples of how species have adapted to these temporary cyclical changes in conditions?** (When plants die off, plant eating populations decline or consumers adapt. Some ectothermic organisms become less active in colder weather, and therefore require less food. Some become dormant, hibernate, or, if they can, migrate [Example: birds].)
- **What happens in spring?** (Plants regrow and animal populations increase.)

Restore the habitat and its community to warm weather conditions. (Restore all the students who had been sidelined.)

2) Drought Conditions

Explain that low water conditions cause crowding and greater competition for food, less shoreline area, and increased access for terrestrial predators.

Extreme drought conditions (i.e., drying up of ponds) could eliminate some organisms.

Some microscopic species can live in small puddles, and some can even survive in dried up mud, where they wait for water to refill the pond or stream when they become active again.

Air breathers would travel to other areas or die.

<u>Make appropriate changes to the community</u>.

- Do you think that these changes would be temporary and cyclical or permanent? (It depends on how long the drought lasts.)

Point out the distinction between the death of an individual and the elimination of a population.

Restore the habitat and its community to normal conditions.

3) Building Development in the Watershed

Tell the class that the surrounding grassland or woodland is being converted to a housing development without proper erosion control methods used during construction or adequate control of runoff from the home sites.

- **What do you predict the results of this new construction will be?** Ask students to write their predictions in their journals. (Sediment entering the water, possible fertilizer and pesticide pollution from lawns or increased runoff velocities and habitat destruction will alter the community and reduce survival. Refer students to Chapters 1–3.)

<u>Make appropriate changes to the community.</u>

- **What happened?** (sediments may cloud the water cutting off sunlight and clogging gills of animals, herbicides may kill off plants, pesticides may kill off animals.)

- **Do you think that these changes would be temporary and cyclical or permanent?** (It depends on whether the people in the new development value the aquatic habitat. They may make an effort to restore the water quality with appropriate erosion control and be more careful in their use of herbicide and fertilizer. Then the aquatic community could come back.)

Restore clean water conditions bringing back sidelined students.

4) Cattle in Watershed

Tell the class that the surrounding grassland or woodland is being converted to a livestock operation without fencing along the stream or waste management.

- What do you predict the results of this new livestock operation will be? Ask students to record their predictions in their science journals.

(Increased pollution from cattle wastes may cause algae overgrowth and fish kills. Sediment entering the water from cattle trampling the banks and stirring up the mud bottom increases turbidity and reduces photosynthesis. There are few if any shoreline plants. All these will alter the community and reduce survival. Refer students to Chapters 1–3.)

<u>Make appropriate changes to the community adding more plants.</u>

- **What happened?** (Too many plants may block light, or increased sediments may kill off plants causing plant die off, then decay, and depletion of oxygen suffocating some animals.)
- **Do you think that these changes would be temporary and cyclical or permanent?** (If the cattle rancher understands what is happening or has an expert's help, he may apply appropriate controls such as reseeding of plants along the shore to restore erosion control, water tanks, and fencing to keep cattle out of the stream.)

Restore normal conditions and bring back sidelined (dead) players.

5) Herbicide use

Tell the class that herbicide is being used to control weeds in the watershed.

- What do you predict will happen? Ask students to write their predictions in their journals. (Depending on the type of herbicide, aquatic plants could be destroyed, which could completely disrupt the food chain. Refer students to Chapters 1–3.)

<u>Make appropriate changes to the community.</u>

This is one way to end the game.

- **What kinds of changes to the aquatic ecosystem did we see in our simulation/model?** (Abiotic changes such as temperature, nitrogen and other chemicals, sediments and biotic changes to the number and types of organisms that could survive in the aquatic ecosystem)

- What are the external stimuli to which organisms were responding in our model? List these external stimuli in your journal add other external stimuli that might affect organisms in an aquatic community. (seasonal changes [temperature], weather changes [drought], erosion and sedimentation, herbicides [pollution from human causes]. Other external stimuli might include amount of light, temperature, amount of water, speed of current in water, salinity, acidity, and other chemical changes in water, etc.)

When these types of changes happen they change the carrying capacity of the ecosystem.

- **How does the model represent the real world?**
- **What are the limitations of the model?**

DAY TWO

4. Assessing What We Learned: Making a Mural

Give each group of four students a long piece of butcher paper and markers, paint, pencils and erasers.

Assign each group of 4 students <u>one of the changes in the aquatic community</u> that the students experienced in the simulation.

Have students draw a mural depicting their changing environment.

Their mural should show the community <u>before the change</u> and the results that they predict might happen in <u>response to the change</u>.

You should have 5 before and after murals, which can be linked together to show various changes occurring in the aquatic ecosystem.

DAY THREE

5. Making an Energy Pyramid

Give each group of 4 students a set of cards. Ask students to use the cards to help them draw an energy pyramid including trophic levels. ("Trophic" comes from a word that means "nutrition".)

Ask students to answer the following questions from this and the next section of the lesson in their journals.

- **What is an autotroph?** (Students should break the word down. " Troph" means nutrition and "auto" means self. So if an organism is an autotroph, it makes its own nutrition. Therefore plants are one kind of autotroph. There are other autotrophs that use chemicals rather than sunlight to make their food. Autotrophs are the producers of energy used by other organisms.
- **What is a heterotroph?** (Students should, again, break the word down. "Troph" means nutrition and "hetero" means other. So heterotrophs get their nutrition from some other organism. All animals are heterotrophs. Heterotrophs make up the consumer levels of the energy pyramid.)

Each trophic level of the pyramid gets its nutrition from different sources. Producers are autotrophs that make their nutrition from sunlight or chemicals. They are at the base of the pyramid. All other life depends on them.

Primary consumers (herbivores) get their nutrition from plants and are at the second trophic level of the pyramid. All consumers are heterotrophs.

Secondary consumers eat other consumers and sometimes both plants and animals and are at the third trophic level of the energy pyramid.

Tertiary consumers and higher levels are the top predators. They have no predators that eat them once they reach a large size such as dolphins, sharks, turtles, etc. Humans are at the highest level of the pyramid.

6. Energy Pyramid Game

Set up: See *Special Instructions* at the beginning of the lesson.

Playing the game

General Rules

1) Win by accumulating the most points by the time the habitat is full
2) The habitat is full when it can support 2 human cards.
3) Three cards must be played at each turn, cards are played in their trophic level on the board **– P**'s in the **Producer** level, etc.

If the cards you play cannot be "supported" by the correct number of previous trophic level organisms in the habitat, it dies. It doesn't matter if the card doesn't specifically say it eats the thing below it in the trophic level, as long as there are **2 P's, 1 C1 can survive in the game. As along as there are 2 C4's a human can survive. But a second human can't survive until all 4 C4's are in place.**

4) When a card dies it is turned over and is added to the nutrient/detritus bottom layer.

For Example: The first player of the game will play three random cards, they will all three die and become nutrient, because they could not live in a habitat with no food there for them. This will probably happen to the second player too, unless they have a producer card that can be sustained by the nutrients now in the habitat due to the dead previous cards.

5) When a trophic level is full, no more cards can be played on it (except if the card says it can eat something else in that same level.

For example: Giant water bugs can eat small frogs, so if a leopard frog was already in **C3**'s level, supported by enough **C2**'s, someone could go ahead and replace the leopard frog if they had a Giant water bug.

6) When the nutrient/detritus level is full just add newly dead cards to a discard pile that will be used to recycle cards to players.

Points

Players receive points at each turn, but not all plays earn the same amount of points. Here are the point levels:

- **Each card that dies and becomes nutrients/detritus: 1point**
- **A producer card is played and can live: 2pts**
- **A C1 card is played and can live: 3 pts**
- **A C2 card is played and can live: 4 pts**
- **A C3 card is played and can live: 5 pts**
- **A C4 card is played and can live: 6 pts**
- **A C5 human card is played and can live 7pts.**

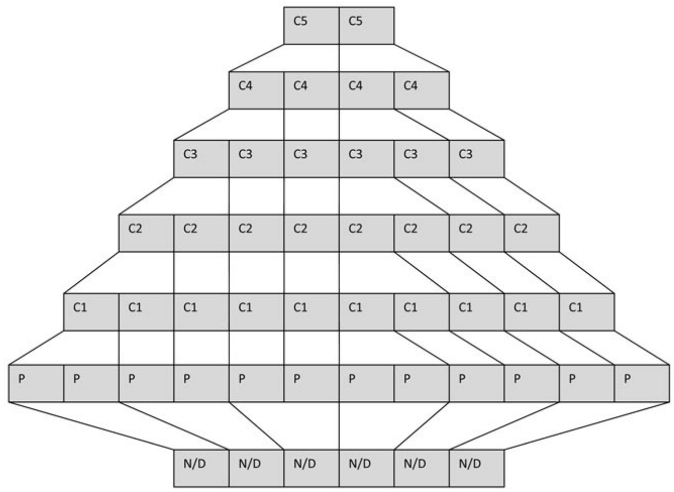
How to begin and play:

1) Stack all cards face down in the middle of the board, each player draws one card, highest trophic level goes first. Put those cards back at the bottom of the stack
2) Each player draws 5 cards.
3) First player plays 3 cards (They will all die–3 points)
4) First player draws 3 more cards to maintain 5 cards
5) Second player plays 3 and draws three, etc, etc, placing cards where they can live, or they die.
6) When the draw pile is empty replenish it with the excess nutrient/detritus stack.
7) Game ends when 2 humans are supported. Student with the most points wins.

Example of Energy Pyramid

<u>Game Board</u>

(An enlarged version is provided on the following page)



This will need to be drawn on a large piece of butcher paper or easel paper to play the game, the lines guide the player to how many previous spots must be full for the card to be supported in the environment as long as cards are played from left to right on each trophic level. For example, three two living P cards are needed to keep the first C1 card alive, but only one more P card allows one more C1 to live. Alternatively it could be used as a guide to how to place the cards and not actually a game board.

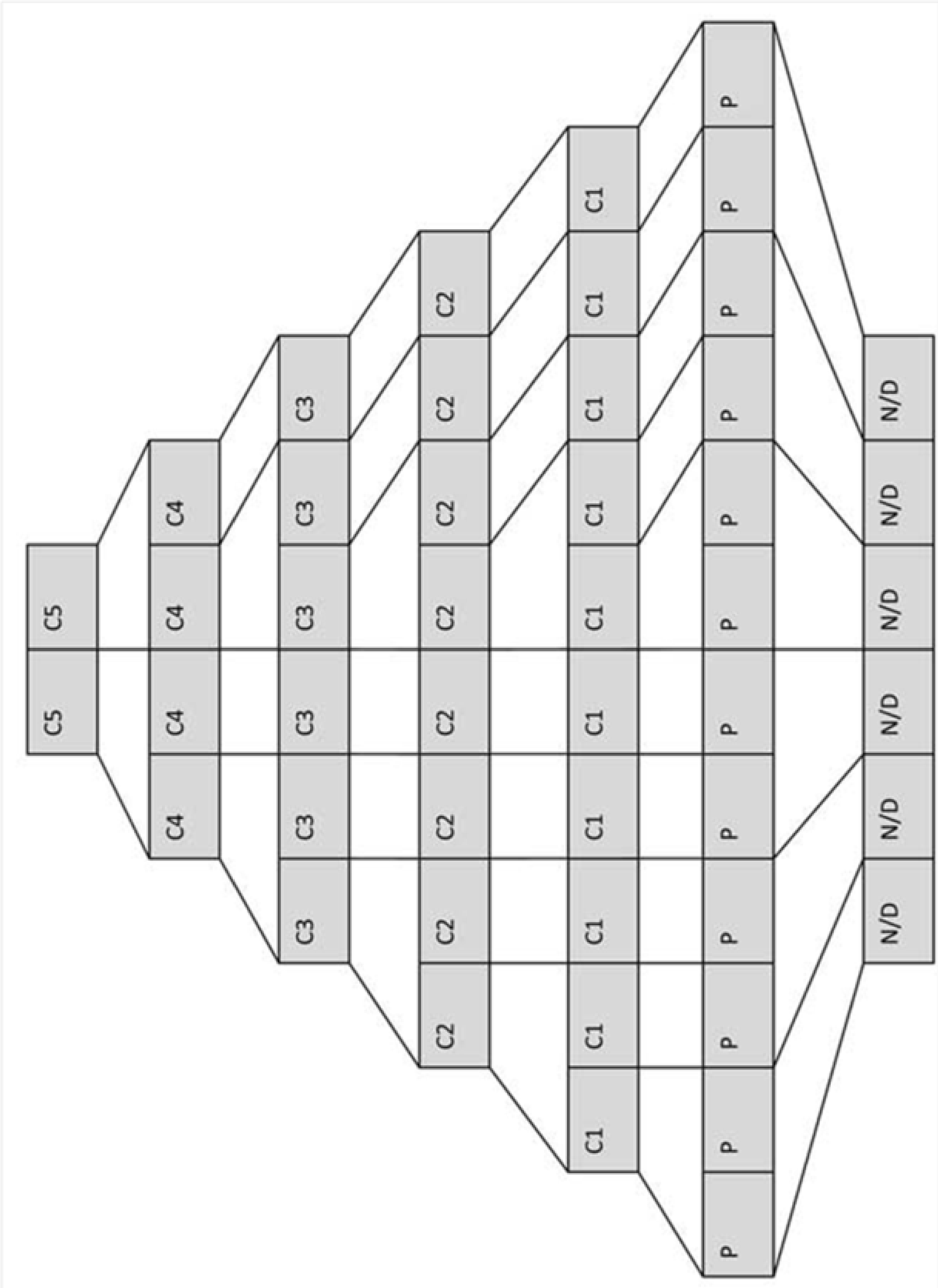
Description: **Nutrient/Detritus** level has 6 places for cards, **P** level has 12, **C1** level has 10 places for cards, **C2** has 8, **C3** has 6, **C4** has 4 and **C5** has 2.

It takes **1 nutrient card to sustain 2 P card**. (This represents how the producer can increase the amount of energy in its level above what is available from the energy of the sun.)

Play cards from the left to the right on each level and follow the lines on the Game Pyramid for help.

The winner is the student who accumulates the most points.

Energy Pyramid Game Board



7. Understanding the Energy Pyramid

Ask students to answer the following questions in their Science Journals.

- **Why are there fewer individuals in each trophic level?** (Energy is lost every time it is transferred to the next level.)
- **Does this game accurately demonstrate the loss of energy in the natural environment**? (No, in the real world nearly 90% is lost at each level.)
- **When all the game pieces are on the board, if 6 of the producer cards are taken out of the system. How many organisms will die because of the lack of support at the producer level?** (**6 P** cards support, **5 C1s**, which support **4 C2's** and on up the pyramid etc. So if **6 P cards** are gone, **15 cards** will be taken out of the pyramid.)
- I**f you wanted to increase the population of C4 animals in the environment, what would you have to make sure you increase as well?** (There would have to be a large increase in all lower levels also to support that growth)
- **Why are their more P cards than nutrient cards?** (Producers are the only ones that can create more organic material from inorganic material by using the power of photosynthesis.)

8. Critical Thinking

- **How does the scientific explanation represented by the energy pyramid help us understand aquatic ecosystems better?**

It shows how energy comes directly from the sun, is transformed by plants, the producers in the first trophic level of the energy pyramid, from solar energy to chemical energy, and used for growth, metabolism, and reproduction for survival of the species.

What is left of the chemical energy is stored and passed on to the primary consumers, in the second trophic level of the energy pyramid, when plants are eaten. Primary consumers use some of that energy for growth, metabolism, and reproduction for the survival of the species. When they are eaten by secondary consumers the rest is passed on to the organisms that eat them.

Secondary consumers [on the third trophic level of the energy pyramid] take what is left of the energy and use it for growth, metabolism, and reproduction for the survival of the species.

Any energy that is left, is either passed on to a higher level, or recycled by decomposers back into the chemicals needed by plants to transform solar energy to chemical energy.

- **Do you think that decomposers are represented accurately by the energy pyramid?**
- **How might decomposers' role in the energy pyramid be represented?** Some people put them with primary or secondary consumers depending on what they eat. Others put them in a third consumer category after carnivores. Let the class decide how they think decomposers should be represented in the energy pyramid.

9. Thought Question

- **Does anyone have an idea for a clearer way to represent the transformation of energy through an ecosystem?**

Ask students to think about this and any ideas that they generate should be recorded in their student journals. You might want to give extra points to anyone who comes up with an interesting idea of another way of representing energy transformation and transfer in an ecosystem.

10. For High School: The Laws of Thermodynamics

<u>First Law of Thermodynamics</u>: During any biological, physical, or chemical process, energy cannot be created or destroyed. It only changes form.

<u>The Second Law of Thermodynamics:</u> Energy quality becomes less reusable or produces less work with every use.

- **How are the laws of thermodynamics demonstrated in the energy pyramid?**

In the energy pyramid we can see that much energy is used at each trophic level for metabolic heat.

We study organisms as part of the energy pyramid because it helps us picture the continual exchange of energy between organisms, both as consumed mass, and as the flow of metabolic heat. This explains why endotherms, animal that are able to maintain a constant body temperature despite changes in the temperature of the environment, expend more energy (maintaining body temperature) than ectotherms, animals whose body temperature is close to that of the environment. All animals other than birds and mammals are ectotherms.

We can also see this law when we study locomotion as organisms use food-derived energy to support movement, in addition to homeostatic thermoregulation.

This constant change of energy at each trophic level from chemical energy to heat energy through metabolism or to mechanical energy through movement, is among the reasons why more organisms can be supported in the environment at the lower trophic levels of the energy pyramid than at the top of the energy pyramid.)

Vocabulary

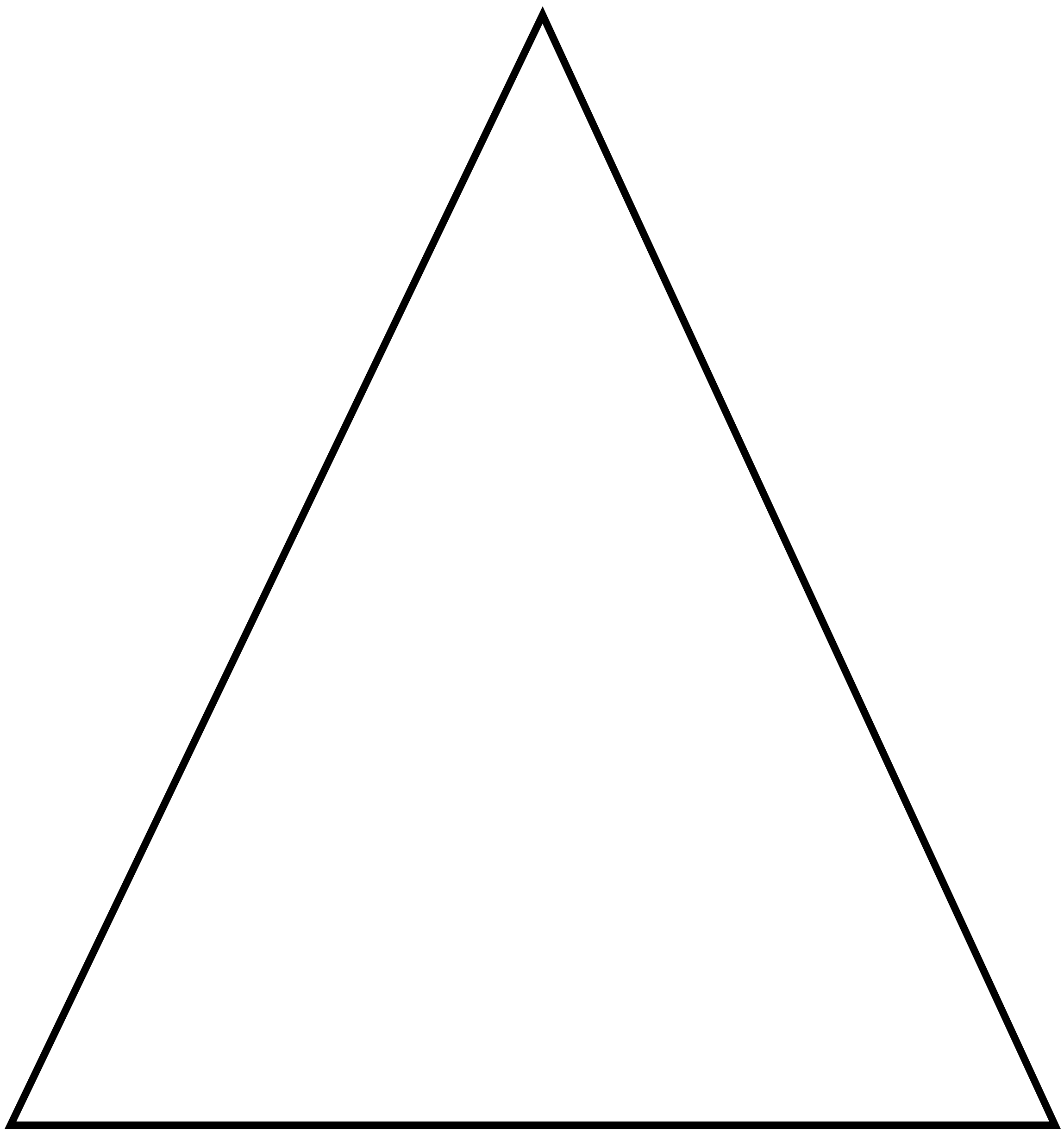
- Autotroph
- Carrying capacity
- Community
- Decomposer
- Drought
- Energy pyramid
- Food chain
- Food web
- Habitat
- Heterotroph

- Invasive species
- Natural selection
- Niche
- Parasite
- Population
- Predator
- Prey
- Primary consumer
- Producer
- Quaternary consumers
- Quinary consumers
- Secondary consumer
- Survival needs
- Tertiary consumer
- Trophic level

Student Page

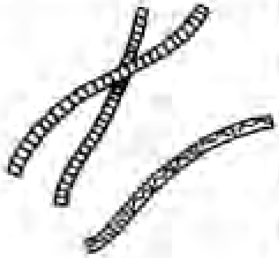
Energy Pyramid

Divide the pyramid into four levels. Fill in organisms that would go at each trophic level and label the trophic levels.



Game Cards

ALGAE
Producer: Many varieties found in ponds
Predators: Grazers that eat aquatic plants
Habitat: Along shoreline and in open water; must have sunlight to produce food. Along with other plants, algae are the first link in the food chain.

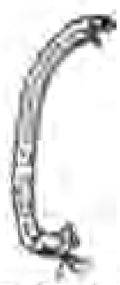


BELTED KINGFISHER
Foods: Mostly fish, some insects, frogs, lizards
Predators: Raccoons, snakes. Skunks prey on young and eggs.
Habitat: Nests in banks near pond; flies over water or sits on branches overhanging the water.

BEAVER
Foods: Bark and twigs of shoreline trees. Summer Foods include water lilies, pondweeds and cattails.
Predators: Coyotes, bobcat, otters, minks and—most importantly—humans (for fur)
Habitat: Streams, rivers, marshes, small lakes; not normally found in ponds unless the pond is near a larger water

BLUEGILL
Foods: Mayflies and other insects, crustaceans, small fish, crayfish, snails and algae when animal foods are scarce
Predators: Bass and other fish, snapping turtles, herons, osprey; adults prized by humans who fish for them
Habitat: Open water or along shoreline where food is abundant

BLOODWORMS
Foods: Plankton, detritus
Predators: Large and small fish
Habitat: Bottom sediments of pond; not really a worm but the larva of a fly



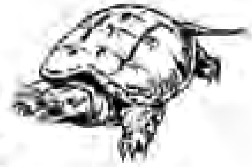
BULLFROG
Foods: Any small animal it can catch and swallow whole, including insects, crayfish, small snakes, minnows and frogs
Predators: Any meat eater that can catch and eat it, such as snakes, herons, fish, raccoons, and humans
Habitat: Shores of lakes, ponds, streams

BACKSWIMMER
Foods: This fierce predator eats other insects, invertebrates, and sometimes small fish.
Predators: Fish, frogs, birds
Habitat: Hanging from surface of the water; on or among the plants; occasionally free-swimming

CANADA GOOSE
Foods: Wetland grasses, grains, sedges, roots of water plants
Predators: Fox, raccoons, coyotes, bobcat, and humans; most eat the eggs or young
Habitat: Marshes, rivers, lakes; nests on ground; defends nest vigorously

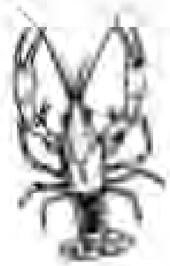
CHANNEL CATFISH
Foods: Fish, insects, crayfish, mollusks, plants
Predators: Young are eaten by other fish; Adults are prized by anglers.
Habitat: Open water or bottom of ponds where they have been stocked.

COMMON SNAPPING TURTLE
Foods: Insects, crayfish, fish, snails, earthworms, amphibians, snakes, small mammals;
Predators: Few. Humans catch adult turtles for their meat; fish eat young; snakes or mammals eat their eggs;
Habitat: Prefer ponds with muddy bottoms, logs and snags

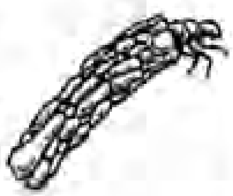


CRANEFLY
Foods: Larvae can be either predacious on worms or insects, or herbivorous, depending on species. Some adults feed on nectar, but many do not eat at all.
Predators: Birds. If near water, fish eat adults. Fish and crustaceans eat larva.
Habitat: Wet moss and other plants along shoreline

CRAYFISH
Foods: Both plants and animals. Sometimes crayfish are predators, and sometimes they act as scavengers.
Predators: Raccoons, otters, fish, wading birds, frogs, turtles. Some people consider crayfish a delicacy.
Habitat: Ponds and streams; sometimes in burrows or under logs or plants



CADDISFLY LARVA
Foods: Small crustaceans, insects, worms, diatoms, algae; Some species are predacious.
Predators: Fish, diving beetles, giant water bugs;
Habitat: Submerged stems of plants in shallow water; stream bottoms in riffles. They construct a tube-like shell from bits of plants or sand particles.



COPEPODS
Foods: Microscopic animals, algae, detritus
Predators: Nearly everything that eats plankton
Habitat: Open water and shallow water of ponds

CATTAILS
Producer: Tall, erect plants with long leaves and usually a green or brown head
Predators: Aphids, caterpillars, moths, beetles, birds, small mammals
Habitat: Rooted along shoreline

DAMSELFLY NYMPH
Foods: Insect larvae, worms, small crustaceans; occasionally small fish and tadpoles
Predators: Fish, larger insects, crustaceans
Habitat: Hides among algae and other plants along the shoreline

DIVING BEETLE
Foods: Caddisfly, mayfly, and stonefly nymphs, or any other small animal they can capture. Diving beetles are ferocious predators with large jaws they use to eat other insects.
Predators: Reptiles, amphibians, fish, wading birds, raccoons, skunks
Habitat: Usually in weedy shallows along shoreline.

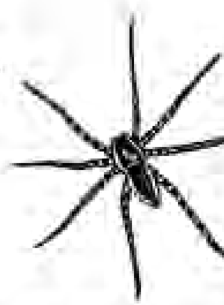
DRAGONFLY ADULT
Foods: Mosquitoes, flies, other insects
Predators: Birds, fish
Habitat: Plants that grow up and stick out from the water; open air over pond

DRAGONFLY NYMPH
Foods: Insect larvae, worms, small crustaceans; occasionally small fish and tadpoles predators: Fish, larger insects, crustaceans
Habitat: Hides among algae and other plants along the shoreline

DUCKWEED
Producer: Small, single-leafed floating plant; rootlets dangle in water
Predators: Flatworms, insect larvae, ducks, geese
Habitat: Free-floating on pond surface

DAMSELFLY ADULT
Foods: Mosquitoes, flies, other insects
Predators: Fish, birds
Habitat: Plants that grow up and stick out from the water; open air over pond

FISHING SPIDER
Foods: Mostly insects; occasionally small fish and tadpoles
Predators: Snakes, frogs, some birds
Habitat: Surface of pond in dense aquatic plants



DIATOMS
Producer: Microscopic algae
Predators: Insects, fish, microscopic animals. Diatoms are a major part of the plant-like plankton, which is the basic food source for all consumers.
Habitat: Free-floating or suspended in open water

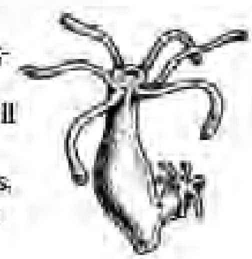
GIANT WATER BUG
Foods: Fiercely predacious, attacking insects, crustaceans and even tadpoles, frogs and fish several times their size
Predators: Fish, frogs, shorebirds
Habitat: Hanging from surface of the water; on or among the plants; occasionally free-swimming

HORSEFLY LARVA
Foods: Worms, snails, other small insects in the water
Predators: Fish, birds
Habitat: Among plants and along bottom at edge of pond

HORSEHAIR WORMS
Foods: Immature are parasites on various crustaceans, mollusks, or insects. Adults do not eat.
Predators: Fish, giant water bugs
Habitat: Quiet water

HUMANS
Foods: Bass, bluegill, channel catfish, bullfrogs, green frogs, crayfish, snapping turtles
Predators: None
Habitat: Designs structures and alters environment to provide suitable places to live

HYDRA
Foods: Tiny (microscopic) animals are trapped in its stinging tentacles. Also captures small crustaceans, insects, small clams and fish, water fleas
Predators: Carnivorous insects, water beetles, recently hatched fish
Habitat: Attached to twigs or plants at the bottom of ponds

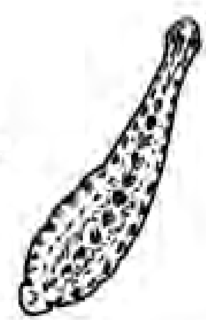


FLATWORM (Planaria)
Foods: Small animals; living or dead protozoans or nematodes
Predators: Worms, insects, crustaceans
Habitat: Under stones and submerged leaves in dark areas

ISOPODS (Sowbugs, Pillbugs)
Foods: Detritus; decaying plants on the bottom
Predators: They have few and are seldom eaten by fish. Some are hosts for nematodes of fish, birds and amphibians.
Habitat: Bottom dwellers able to stand acidic water. Some species prefer clear, cold water; all hide beneath rock and debris.

GREAT BLUE HERON
Foods: Mostly small fish, limited numbers of frogs, crayfish, insects and mice
Predators: Fox, coyotes, bobcat; too large for most predators
Habitat: Marsh, river, lakes; nest in colonies in tops of large, streamside trees

LEECH
Foods: Parasite that feeds on the blood of animals. Most attach to fish, turtles, frogs, snails, insect larvae and worms.
Predators: Fish
Habitat: Bottom dwellers



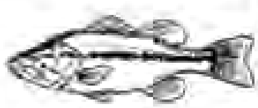
MALLARD DUCK
Foods: Smartweed, corn, acorns, seeds of many water plants, some aquatic invertebrates
Predators: Fox, coyotes, bobcat, mink, humans, raccoon, skunk
Habitat: Marsh, lakes, rivers; nests on ground

MAYFLY ADULT
Foods: Adults do not eat at all. The adult form lives long enough to reproduce, which may only be a few hours.
Predators: Important food source for fish, dragonflies, and birds
Habitat: Air over pond

MAYFLY LARVA
Foods: Small plants, animals, organic debris, diatoms
Predators: Important food source for fish and other insect-eaters such as dragonfly larva and beetles
Habitat: Various species burrow, live on the bottom or are free-swimming among aquatic plants.

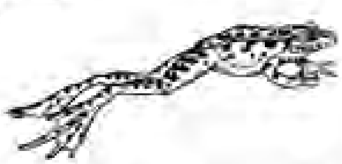
MINK
Foods: Rabbits, muskrats, other small mammals, birds, fish, crayfish, frogs, crustaceans, insects
Predators: Humans, dogs, foxes, owls, coyotes, bobcats
Habitat: These excellent swimmers live in or near wetland habitat including ponds.

LARGEMOUTH BASS
Foods: Adults feed on fish, crayfish, frogs and large insects. Young feed on daphnia and other small crustaceans.
Predators: Snapping turtles, herons. Small fish are eaten by larger fish. Anglers prize them;.
Habitat: Open water or along edge where food supply is abundant.



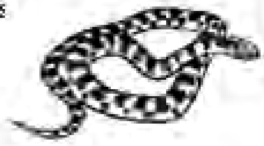
MOSQUITO ADULT
Foods: Females suck mammal blood; males feed on plant juices, if they eat at all.
Predators: Dragonflies, damselflies, other insects, birds, frogs, fish, bats
Habitat: Air over water and surrounding areas

LEOPARD FROG
Foods: Insects, spiders, other invertebrates
Predators: Raccoons, snakes
Habitat: Sits near water's edge but jumps into water if threatened.



MUSKRAT
Food: Roots, bulbs and foliage of cattails, pondweeds, rushes and wild rice; will eat fish, frogs and insects if plants are not available
Predators: Minks, humans, large hawks, owls, snakes, snapping turtles
Habitat: Marshes, sloughs, streams, rivers, ponds and lakes

WATER SNAKE
Foods: Crayfish, frogs, tadpoles small fish, worms, insects
Predators: Hawks, owls; large game fish eat young snakes
Habitat: Under rocks or debris near shore of ponds, lakes, streams and rivers

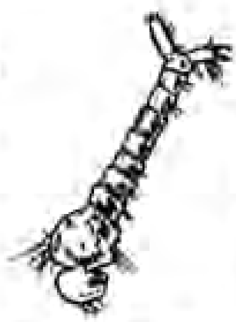


PONDWEEDS
Producers: Aquatic seed plants
Predators: Birds, muskrats, beaver, deer
Habitat: Rooted near shoreline

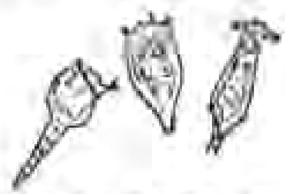
RACCOON
Foods: Wide variety of small animals, insects, fruits, seeds, garbage, crayfish, frogs, some fish predators: Few as adults. Humans and large meat-eaters take some young.
Habitat: Forest and forest edge; night time visitor to ponds and streams

RED-WINGED BLACKBIRD
Foods: Insects, seeds
Predators: Few. Raccoons and snakes will eat eggs.
Habitat: Nest in cattails; migrate in winter

MOSQUITO LARVA
Foods: Tiny plants and animals suspended in the water
Predators: Fish, other insects
Habitat: Mostly on the water's surface, but dive and hide if threatened



ROTIFERS
Foods: Microscopic plants and animals
Predators: Worms, crustaceans
Habitat: Near shoreline and around aquatic plants; some occur in open water



MUSSELS
Foods: Small bits of organic matter suspended in the water. They are considered scavengers
Predators: Fish, muskrats, mink, otters, raccoons; turtles that are able to open the shells or eat the smaller mussels
Habitat: On the bottom of ponds and streams

SEED SHRIMP (Ostracods)
Foods: Bacteria, mold, algae
Predators: Important food source of small fishes
Habitat: On and just above the bottom of ponds; they look like microscopic clams

SPRINGTAIL
Foods: Decaying plant and animal material; occasionally some living plant material
Predators: Fish, spiders, frogs, other animals that eat insects
Habitat: Surface of the pond in quiet backwaters. They hibernate but are among first signs of animal life in the spring.

STONEFLY NYMPH
Foods: Dead plant material; detritus, algae, bacteria and fungi living on detritus. They become predators of other invertebrates.
Predators: Fish, other predaceous invertebrates, amphibians
Habitat: Only found in cool, well-oxygenated flowing waters (very sensitive to pollution);

TADPOLES
Foods: Submerged oozes and scums containing small plants and animals; algae, diatoms, desmids, decaying plants
Predators: Fish, snakes, giant water bugs. Some predacious insects eat the small tadpoles.
Habitat: In shallow areas near the water's edge

TIGER SALAMANDER
Foods: Earthworms, insects, spiders, slugs, snails
Predators: Fishes, snakes, snapping turtles, some birds and mammals
Habitat: In burrows under logs and rocks near water; active only at night

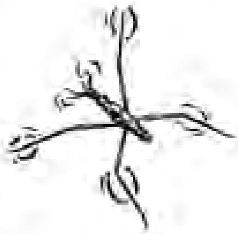
SCUDS
Foods: Scavengers on plant and animal debris
Predators: Birds, fish, insects, amphibians
Habitat: Clear, unpolluted water; on and among plants; near bottom of pond where they can avoid light

WATER BOATMAN
Foods: Algae and decaying plants; sometimes dive to feed on decaying animal material on the bottom; sometimes eat mosquito larvae
Predators: Fish
Habitat: Surface of pond, sometimes diving to find food; must cling to something to stay under water surface

SNAILS
Foods: Algae, other plants, dead plant and animal material
Predators: Many kinds of fish, turtles, some birds
Habitat: Pond bottom, or on plants and dead material in ponds

WATER MITES
Foods: Insects, worms. Some are parasitic.
Predators: Hydras, insect, fish
Habitat: Creep on bottom and on plants

WATER STRIDER
Foods: Prey on insects and small crustaceans near the surface
Predators: Some fish and birds
Habitat: Surface of water; often seen "skating" over the surface in search of food

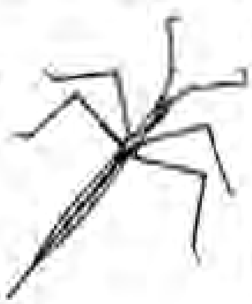


WESTERN RIBBON SNAKE
Foods: Worms, fish, tadpoles, frogs, toads, salamanders, mice, sometimes other small snakes
Predators: Hawks, owls, snapping turtles, herons. Some fish eat small snakes.
Habitat: Near water, ponds, swamps, marshes, sloughs, streams and rivers

WHIRLIGIG BEETLE
Foods: Whirl in circles collecting insects and organic debris at the surface
Predators: Fish, birds, frogs, snakes, and other animals
Habitat: On the surface, often among plants; eyes are divided and can see above and below water at same time

WATER FLEA (Daphnia)
Foods: Filter plankton from the water; algae; organic debris
Predators: Hydras, insects, fish, some rotifers
Habitat: Weedy margins of ponds, abundant in all types of water except fast streams and polluted water

WATER SCORPION
Foods: Small insects; seize prey with powerful forelegs similar to preying mantis
Predators: Animals that eat insects
Habitat: Ponds and weedy sections of lakes and streams; hides just under the surface among plants; long breathing tube at rear



ALGAE	BELTED KINGFISHER
BEAVER	BLUEGILL
BLOODWORMS	BULLFROG
BACKSWIMMER	CANADA GOOSE

CHANNEL CATFISH	COMMON SNAPPING TURTLE
CRANEFLY	CRAYFISH
CADDISFLY LARVA	COPEPODS
CATTAILS	DAMSELFLY NYMPH

DIVING BEETLE

DRAGONFLY ADULT

DRAGONFLY NYMPH

DUCKWEED

DAMSELFLY ADULT

FISHING SPIDER

DIATOMS

GIANT WATER BUG

HORSEFLY LARVA

HORSEHAIR WORMS

HUMANS

HYDRA

FLATWORM (Planaria)

ISOPODS (Sowbugs, Pill bugs)

GREAT BLUE HERON

LEECH

MALLARD DUCK	MAYFLY ADULT
MAYFLY LARVA	MINK
LARGEMOUTH BASS	MOSQUITO ADULT
LEOPARD FROG	MUSKRAT

WATER SNAKE

PONDWEEDS

RACCOON

RED-WINGED BLACKBIRD

MOSQUITO LARVA

ROTIFERS

MUSSELS

SEED SHRIMP (Ostracods)

SPRINGTAIL	STONEFLY NYMPH
TADPOLES	TIGER SALAMANDER
SCUDS	WATER BOATMAN
SNAILS	WATER MITES

WATER STRIDER

Western Ribbon Snake

WHIRLIGIG BEETLE

Water Flea (Daphnia)

Water Scorpion

Chapter 5 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **Complete this analogy: Individual is to population as**
   A Water is to surface tension.
   B Fish is to gills.
   C Niche is to habitat.
   D Population is to community.

2. **Which of these is correct about a community in the environment?**
   A Multiple communities make up a population
   B A community inhabits a specific niche
   C Multiple populations of species make up a community.
   D Each species inhabit multiple niches

3. **Which of the following statements about competition is true?**
   A Individuals within a population may compete with other individuals of the same species.
   B Individuals within a population may compete with individuals of different species.
   C A population within a community may compete with other populations within the community.
   D All of the above

4. **Carrying capacity is the result of which of the following:**
   A Different populations living in the same place interact with one another.
   B Within a community every species has a particular niche.
   C While living organisms have the capacity to produce populations of infinite size, environments and resources are limited.
   D Most energy pyramids can continue for only four or five trophic levels and can support only a few top-level consumers.

5. **Which of the following statements about invasive species is true?**
   - **A** The invasive species may compete with native species for habitat or food.
   - **B** Invasive species are not subject to natural selection.
   - **C** Invasive species play an important role by keeping populations of prey species below their carrying capacity.
   - **D** None of the above

6. **What is the biggest threat to aquatic communities?**
   - **A** Predator/prey relationships
   - **B** Natural selection
   - **C** Human-caused habitat destruction
   - **D** All of the above

7. **Complete this analogy: Competition is to ________ as ________ is to food webs.**
   - **A** Competitor; decomposer
   - **B** Natural selection; sunlight
   - **C** Prey; consumer
   - **D** None of the above

8. **Why can most energy pyramids continue for only four or five trophic levels and support only a few top-level consumers?**
   - **A** Most of the available food energy is changed to heat energy or kinetic energy moving up each trophic level.
   - **B** Animals use energy doing tasks such as hunting and keeping their bodies warm.
   - **C** Only a little of the original energy from the sun passes from one trophic level to the next.
   - **D** All of the above

9. **In a stream, a predator that eats insects only from the gravel bottom is said to fill that specific ____ of the habitat.**
   - **A** Population
   - **B** Trophic level
   - **C** Niche
   - **D** Community

Chapter 5 Assessment

Directions

Write your own answer for each of the following questions.

1. **Create an imaginary aquatic community capable of existing in Texas with populations of at least two examples of each of the following:**
    - Producers, consumers, and decomposers/scavengers
    - Specify producers by placing them in rectangles, consumers in circles, and scavengers/decomposers in triangles
    - Draw (or diagram) and describe the transfer of energy within the community. Use the back of this page.

2. **Create a graphic organizer to specify which populations of organisms within your community (above) compete with one another, and for what resources.**

3. **Predict the outcome in the community if one of the populations (you choose which) were completely removed from the community.**

Chapter 5 Assessment Answer Key

Multiple-choice questions

1. Complete this analogy: Individual is to population as

D Population is to community.

2. Which of these is correct about a community in the environment?

C Multiple populations of species make up a community.

3. Which of the following statements about competition is true?

D All of the above

4. Carrying capacity is the result of the fact that:

C While living organisms have the capacity to produce populations of infinite size, environments and resources are limited.

5. Which of the following statements about invasive species is true?

A The invasive species may compete with native species for habitat or food.

6. What is the biggest threat to aquatic communities?

C Human-caused habitat destruction

7. Complete this analogy: Competition is to ________ as ________ is to food webs.

B Natural selection; sunlight

8. Why can most energy pyramids continue for only four or five trophic levels and support only a few top-level consumers?

D All of the above

9. In a stream, a predator that eats insects only from the gravel bottom is said to fill that specific ____ of the habitat.

C Niche

Write-in questions

1. Create an imaginary aquatic community capable of existing in Texas with populations of at least two examples of each of the following: producers, consumers and decomposers/scavengers. Specify producers by placing them in rectangles, consumers in circles and scavengers/decomposers in triangles. Draw (or diagram) and describe the transfer of energy within the community. Use the back of this page.

Many answers are possible.

Instructors may wish to refer FIG. 5.3 in the Student Guide for an example.

2. Create a table to specify which populations of organisms within your community (above) compete with one another, and for what resources.
Many answers are possible, but may resemble the following example:

Population	Competitors	Resources Competed For
Algae	Duckweed	Sunlight, water, nutrients
Caddisfly larva	Largemouth bass, Crayfish	Food (to not be eaten)
Largemouth bass	Crayfish	Food (eats crayfish) survival
Crayfish	Largemouth bass	Food, Survival (to not be eaten)
Snails	Scuds	Dead plant and animal material

3. Predict the outcome in the community if one of the populations (you choose which) were completely removed from the community.
Many answers are possible.

Taking out any link in a food chain may upset the balance of the whole food web.

Texas' Many Aquatic Ecosystems

Ecosystems are complex interdependent webs of relationships between living and nonliving things. Texas has six kinds of aquatic ecosystem supporting significant biodiversity.

Chapter 6

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Discuss their experiences in various Texas aquatic ecosystems.
2. Generate a list of all the Texas aquatic ecosystems.
3. Identify how all of the Texas aquatic ecosystems are related.
4. Define ecosystem and identify the factors that make up an ecosystem
5. Explain how the parts of an ecosystem interact with one another.
6. Identify Texas’ aquatic ecosystems and explain how the characteristics of the land affect the nature of the water.
7. Compare and contrast Texas’ aquatic ecosystem types.
8. Define biodiversity and assess its importance.
9. Predict the impact of a natural or human-caused environmental change on the organisms in an ecosystem.
10. Describe possible solutions to potentially harmful environmental changes within an ecosystem.
11. Read the student materials and answer the questions.
12. Make a picture and label the parts indicating the relationships among Texas aquatic ecosystems.
13. Identify good water quality as a requirement for a healthy aquatic ecosystem.
14. Identify environmental changes that impact water quality.
15. Generate ideas about how scientists can count populations of organisms.
16. Determine the species composition of plant life on school grounds using line transect sampling, one method used by wildlife biologists to estimate population size.
17. Determine how sampling size effects accuracy and standard error of estimates.

18. Practice the mark and recapture method to estimate the number of beans in a jar.
19. Use the mark and recapture method to estimate a population in a nearby creek or pond.
20. Review natural and manmade causes of environmental change
21. Generate ideas for conserving aquatic ecosystems.
22. 23 Generate a list of things that can be done to conserve aquatic ecosystems.
23. Choose one project from the list for the class to actively help conserve aquatic ecosystems.
24. Choose one thing that they will do individually to actively help conserve aquatic ecosystems.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E, F; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.8 A, B; 7.10 A, B; 7.11 A, B; 7.14 C; 8.1 A, B; 8.2 A, B, C, D, E; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, J, K; 3 E; 4 A, B; 5 A; 7 A; 9 A; 10 A; 11 B; 12 A, B, D

Environmental Science: 1 A, B; 2 E, F, G, H, J, K; 3 C, E; 4 A, B, D, E; 5 B, C, E, F; 8 A; 9 A, B, D, E, K

Materials Needed

Activity 6.1

Science Journals

Pencils or pens

Activity 6.2

Student Guide

Science journals

Pens or pencils

Colored pencils or markers

Activity 6.3

Science journals

Pencils/pens

1 copy of *Plant Sampling—Line Transect Survey Investigation Student Instruction Sheet* and Data Table for each student (optional-students can make their own data table in their journals)

<u>For each group</u>

Set of transect lines
Mallet or hammer for driving wooden transect stakes
Set of plant identification field guides

Activity 6.4

Each pair of students needs these materials:
1-600 ml. beaker, which represents the habitat to be sampled
1-small (50 ml.) beaker (sampling beaker)
White beans
A marker or black beans
Note: You can mark each bean with a marker or you can replace each white bean with a black bean to save on beans.

Activity 6.5

Science journals
Chart paper and markers
White board or chalk board

Safety Precautions

Identify and stay clear of poison ivy and other poisonous plants. Wear long pants and closed-toed shoes. Review field safety guidelines.

Vocabulary

- Abiotic
- Aquifer
- Assumptions
- Bay
- Biodiversity
- Biotic
- Conservation
- Damming
- Draining
- Ecosystem
- Emigration
- Erosion
- Estuary

- Gulf of Mexico
- Healthy ecosystem
- Human impact
- Immigration
- Lake
- Line transect
- Mark and recapture
- Ocean
- Pond
- Population studies
- River
- Sampling
- Spring
- Stream
- Water quality

Enrichments

Project WILD Aquatic

- Aquatic Roots
- Edge of Home
- Watered-Down History

Guest Speaker

- Fisheries biologist may talk about fisheries management and aquatic ecosystems.
- Botanist or wildlife biologist may talk about population studies

Lesson 6.1: It’s All Part of a System
Texas Waters

Essential Concept

While Texas has many types of aquatic ecosystems, they are all part of a system of watersheds that feed into one large system: the Gulf of Mexico.

Objectives

1. Students will discuss their experiences in various Texas aquatic ecosystems.
2. Students will generate a list of all the Texas aquatic ecosystems.
3. Students will identify how all of the Texas aquatic ecosystems are related.
4. Students will identify the source of water for their home.
5. Students identify the different organisms that live in different aquatic ecosystems.
6. Students will describe organisms from at least two aquatic ecosystems.

TEKS

7.10 A, B; 8.11 A

Aquatic Science: 9 A

Environmental Science: 5 B

Estimated Time

30 minutes

Materials

Science Journals

Pencils or pens

Procedure

1. My Water Experiences

We’ve been talking about and investigating aquatic ecosystems.

- **What are some aquatic ecosystems that you have visited?**

Allow students time to share any aquatic ecosystems with which they have had experiences. They may name ponds, streams, or rivers that they have visited as a class or they may think of other places that they have been with their families, near their homes, or on vacation. Try to get students to name as many types of aquatic ecosystems as they can. (A pond at a park where they caught tadpoles, a creek near their house where they went fishing, a lake where their families had a picnic, a vacation at the beach at the Gulf of Mexico, a river where they went tubing, fishing in a bay, etc.) When everyone has had a turn that would like to share, ask students to write down in their journals one memory from an experience in or around water.

2. Texas' Aquatic Ecosystems

Ask students to work in groups of four to think about all the water ecosystems that they might like to visit or that they have heard about. Ask students to think about how these aquatic ecosystems might be related.

Have each group write down three things that they know about aquatic ecosystems in Texas. (Various ideas may be suggested such as: Texas has many types of aquatic ecosystems; aquatic ecosystems are places we enjoy visiting; aquatic ecosystems are habitat for all kinds of wildlife; aquatic ecosystems help make Texas beautiful; much of the water in Texas' aquatic ecosystems eventually flows to the Gulf of Mexico, etc.)

3. Putting Our Ideas Together

Work as a class to answer the following questions. Record students' ideas on chart paper. Have students record the information in their journals at the end of the class discussion.

- **What are some of the aquatic ecosystem you have thought of that are found in Texas?** (Aquifers, springs, streams, rivers, lakes, ponds, wetlands, bays, estuaries and oceans).
- **How are all of these aquatic ecosystems related?** (They are all part of a system of watersheds that feed into one large system: the Gulf of Mexico.)
- **Which of the aquatic ecosystems is salt water or brackish, and which are freshwater ecosystems?** (Some wetlands are brackish water, a mixture of fresh and saltwater, such as estuaries. Bays, and oceans are also saltwater. Aquifers, springs, streams, rivers, lakes, ponds, and some wetlands are freshwater.)
- **How many have you visited? What aquatic ecosystems are close to our school?**

Students may think of swimming in a spring-fed pool such as Balmorhea State Park or Barton Springs pool in Austin. This would be a good time to bring up groundwater and its importance as a source of water in Texas. Talk about the importance of aquifers.

Ask students to write the answers to the following questions in their journals.

- **What is the source of water at your home?**
- **How are the different ecosystems different or similar in the aquatic organisms they support?**
- **Describe some typical organisms from at least 2 aquatic ecosystems, one saltwater ecosystem and one freshwater ecosystem.**

Vocabulary

- Aquifer

- Bay
- Estuary
- Gulf of Mexico
- Lake
- Ocean
- Pond
- River
- Spring
- Stream

Lesson 6.2: Reading and Research

Essential Concept

Texas has a wide variety of aquatic ecosystems that are constantly changing naturally and being changed by human activity.

Objectives

1. Students will read the student materials.
2. Students will answer the questions.
3. Students will make a picture and label the parts indicating how Texas' aquatic ecosystems are related.

TEKS

6.2 C; 7.2 C; 7.10 B; 8.2 C; 8.11 C

Aquatic Science: 2 J; 12 A

Environmental Science: 2 K; 9 E

Estimated Time

Varies, questions can be assigned as homework or done in class.

At least 30 minutes should be provided for class discussion and drawing the diagram.

Materials

Student Guide

Science journals

Pens or pencils

Colored pencils or markers

Procedure

1. Student Reading

Have students read *Chapter 6: Texas Aquatic Ecosystems*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is an ecosystem? What are some of the parts of an ecosystem?

An ecosystem is a complex web of relationships between living and non-living things. The biotic (living) parts of the ecosystem are the communities of plant and animal populations, including humans. The abiotic (non-living) parts include sunlight, air, water, temperatures, soil, and minerals.

2) How do the parts of an ecosystem interact with one another?

Each part of an ecosystem is connected to and depends on all the others. It takes all the parts interacting to make the system work. All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem. Conversely, a healthy, balanced ecosystem provides for all the needs of the communities that live in it.

3) What kinds of aquatic ecosystems do we have in Texas? How are they alike or different from one another?

Texas has six kinds of aquatic ecosystems: aquifers and springs, rivers and streams, lakes and ponds, wetlands, bays and estuaries, and the ocean/Gulf of Mexico.

These ecosystems are alike in that they are all aquatic homes for a variety of organisms. They are different in size, whether they are surface or groundwater, whether they are flowing or standing water, whether they are saltwater or freshwater, and whether they are inland or coastal. These characteristics help determine the organisms that can make each ecosystem its home.

4) What is biodiversity? Why is it important?

Biodiversity refers to the variety and number of different organisms and populations in a community, and the way they live together. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is. Biodiversity is very important to the stability of an ecosystem. If many different species are present, then the loss of one or two species will probably not have a great effect. But if species diversity is low, the loss of one or two species could have a major impact.

5) How do humans impact aquatic ecosystems?

A human activity such as straightening a stream speeds up erosion and cuts out curves that shelter fish and other aquatic life. Changes may destroy habitat for some species and create it for others. Some human activities that can reduce aquatic biodiversity are draining a swamp, damming a river or pumping out water. These activities destroy habitat, which is the main cause of species decline.

6) How can we help conserve aquatic ecosystems?

Protecting and restoring a wide variety of habitat helps keep species from becoming endangered or extinct helping to maintain biodiversity for healthy ecosystems.

3. Getting the Big Picture

Ask students to draw a picture in their journals showing all the types of aquatic ecosystems in Texas and how they are related. Students should label each aquatic ecosystem.

4. Challenge Question

Ask students to brainstorm answers to the following question. Write students' ideas on the board and have students add the list to their science journals.

- **How is the diversity of species in Texas' aquatic ecosystems connected to the economic well being of Texas' citizens?**

Vocabulary

- Abiotic
- Aquifer
- Bay
- Biodiversity
- Biotic
- Damming
- Draining
- Ecosystem
- Erosion
- Estuary
- Human impact
- Lake
- Ocean
- Pond
- River
- Spring
- Stream

Lesson 6.3: The Hunt for Biodiversity

Essential Concept

Biodiversity is important to the health of an ecosystem. Scientists use special methods to survey organisms to find the biodiversity of an ecosystem.

Objectives

1. Students will identify good water quality as a requirement for a healthy aquatic ecosystem.
2. Students will identify environmental changes that impact water quality.
3. Students will generate ideas about how scientists can count populations of organisms.
4. Students will determine the species composition of plant life on school grounds using line transect sampling.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 7.1 A, B; 2 A, C, D, E; 7.11 A, B; 8.1 A, B; 2.2 A, C, D, E; 8.11 C

Aquatic Science: 1 A, B; 2 E, F, J; 3 E; 12 B

Environmental Science: 1 A; 2 E, F, G; 3 E; 4 A, B; 9 E

Estimated Time

1 ½ class periods

Materials

Science journals

Pencils/pens

1 copy of *Plant Sampling—Line Transect Survey Investigation* instruction sheet and and data table for each student (optional-students can make their own data table in their journals)

<u>For each group</u>

Set of transect lines

Mallet or hammer for driving wooden transect stakes

Set of plant identification field guides

Special Instructions

<u>Make a set of transect lines—one for each group in class.</u>

- Tie heavy twine or nylon rope to a tent peg or small wooden stake.
- Measure out 10 meters of line and fasten the other end to another peg or stake.
- Set up transect lines by driving one peg or stake into the ground, stretching the line tight and driving the other into the ground. (Alternatively, class time may be used having students make and set their own transect lines.)

If possible, choose transect line placements that show changes of plant species along the line. For example, moving from a tree-covered area to an open field, from a mowed area to an unmowed area or down a slope.

Safety Precautions

Identify and stay clear of poison ivy and other poisonous plants. Wear long pants and closed-toed shoes for outdoor activities.

Procedure

1. Review of Water Quality Indicators

In lesson 1.9 and again in Lesson 4.4 we visited an aquatic site and looked at water quality. Ask students to work in small groups using their journals to review your data from the field trips checking water quality. (Students should include physical and chemical water testing, observation of watershed land uses and conditions, observations of populations, and community interactions.)

- **What is water quality? (**Water quality is really a check of the health of an aquatic ecosystem. It looks at water chemistry including the amount of oxygen in the water available for use by all the organisms that live there. It looks at other water chemistry [acidity, salinity, nitrates, phosphates, temperature, conductivity, color and odor], all of which impact the living things in the water, and it looks at the variety and number of living things present in the ecosystem. Few different types of organisms, and few numbers of organisms of each type indicate that the water is not providing a healthy ecosystem for the living things there.)
- **What kinds of things affect water quality? (**Runoff, erosion, land use, numbers of cattle, and other domestic animals, amount of rainfall, etc., all affect water quality.)

Have the small groups report back to the class their explanations of water quality and causes of problems with water quality. Each group should be able to give one test or observation that they have recorded in their journals that indicates the quality of water and health of an ecosystem. Each group should also provide one idea about what affects water quality.

2. Scientific Analysis of the Health of an Aquatic Ecosystem

Scientists also check the health of aquatic ecosystems by making observations of populations, and community interactions. Counting populations help us determine biodiversity in the ecosystem. A diverse ecosystem indicates a healthy ecosystem.

Class discussion. Ask students to imagine that they have just been given the task of finding out how many dandelions are on the school grounds.

- **How would you go about finding out how many dandelions are on the school grounds? (**The class may generate a number of ideas for finding this information including counting them all, or looking at various parts of the school grounds and generalizing to the whole area.)
- **Why would we need to know the number and types of land plants in an aquatic ecosystem? (**Few plants mean that more erosion will take place, less variety of plants limits the kinds of animals that can live in the environment.

Explain that counting specific plants such as dandelions is similar to the problems scientists face all the time counting populations.

- **What scientific careers might need to count plant populations?** (Ecologists, biologists, botanists, any of which might work for county or state conservation programs might want to assess plant populations. Before developing a site, builders need to know what kinds of plants and their relative abundance in order to comply with the law.)

Scientists might solve the problem by getting down on their hands and knees and counting every plant and every dandelion on the school grounds and figuring out the percentage of plants on the school grounds that are dandelions. This might take a very long time, but if done carefully it would give a precise answer.

It is often unrealistic for a scientist to count every organism in her/his research area. What scientists often do is to work with a sample, a small section or plot of their research area. From their sample the scientist can then <u>estimate</u> many things about their research area without having spent all the time to count each organism.

Scientists do not base their calculations on just one sample. Instead they use data from many samples.

- **Why do scientists use many samples?** (Scientists use many samples to get the most accurate analysis of the data collected. Multiple samples help take into account areas where there are many organisms and areas where there are fewer organisms.)

Explain that the precise technique or sampling method used depends on what kind of organism you are sampling.

3. Plant Sampling

Provide each student with a copy of *Plant Sampling—Line Transect Survey Investigation* data sheet and student instructions. Or have students make their own data sheet in their science journals.

Guide the class as needed through the procedure to count plants using a line transect. (See student instruction sheet at the end of this lesson.)Ask students to put their line transects in different areas such as mowed lawns, landscaped areas, fence lines, unmowed (natural) areas such as a vacant lot.

Ask students to count the plants that are touching the line or within 5 cm. on either side of the transect line.

Day Two

4. Sharing Our Data

Invite students to share drawings, rubbings, samples or descriptions of plants they could not identify. Have the class identify as many plants as possible using the class field guides.

Have the **recorder** for each group report their plant sampling findings.

Briefly summarize findings from the class's multiple samplings on the board.

Ask students what generalization or conclusions they would draw from their plant sampling findings.

5. Drawing Conclusions

- **What locations on the school grounds do you think might have more diverse plant life?** Natural areas like fence lines and areas with less foot traffic are more diverse than areas with more human control such as lawns or flowerbeds.
- **How diverse is the plant life on the school grounds?** Lawns will have little diversity; more natural areas will have more diversity. Finding a few species, even those with many individual plants of the same species, indicates little diversity. Finding a number of species with several individuals of each species indicates more diversity.

Compare the diversity in front of the school with the diversity in back of the school or along the fence lines.

- **What type of plant is most common in the mowed areas? The fence lines? The unmowed areas?**
- **What does this plant count tell us about the affect of humans on diversity? (**Human activity often causes less diversity either because of overuse, removal of plants, or planting of monocultures, etc.)
- **How might someone do this in an aquatic environment with either stationary (rooted) plants or even plankton? What about where the water is deep? How could you count other species like fish or coral?** (The aquatic environment poses many special difficulties. Transects are still often used. Nets are used to collect phytoplankton or fish along the transects. In the ocean the transects can be very long and the nets used at various depths. Scuba is often employed along short transects for closer counts of fish and coral on reefs for example.)

Vocabulary

- Biodiversity
- Diversity
- Estimate

- Healthy ecosystem
- Line transect
- Population
- Sampling
- Water quality

PLANT SAMPLING— LINE TRANSECT INVESTIGATION

Directions

1. Work with your partners following your teacher's instructions to conduct a valid sampling.
2. One student should act as **recorder** for your group's observations. Other students should work together to count and identify plants.
3. Use <u>plant identification guides</u> to help you identify and list each species that touches the line. If you cannot identify a species, describe or draw it as well as you can. With your teacher's permission, you may make a leaf rubbing or take a sample to identify later. Even if you can't find a plant's name, keep track of it by your own name. "We counted 5 of the thin long leaf plants with white flowers, and 10 of the short leaf plants with no flowers." is sufficient if you can't identify the plant. Scientists may not know all the species they encounter, but they take detailed descriptions so they can find out later.
4. Make a tick mark under the "Individuals" column for each individual of a species that touches the line, but only count each individual once (This may be hard to determine for grasses and some other plants!).
5. Count live plants only—you want your data to reflect current conditions, not the past.
6. Imagine that the line is a plane that extends into the sky. If the vertical plane would touch a plant above the ground, count it. Examine each vertical layer of plants separately: upper (e.g., trees), middle (e.g., shrubs), lower (ground-level, e.g., forbes and grasses).
7. Add up the tick marks in each row and enter the result in the right-hand column under "Total" for that row.
8. Then add up the total number of species and enter that result at the bottom of the second column ("Total number of species").
9. Finally, add up all the numbers in the "Total" column and enter the result at the bottom of the column ("Total individuals").
10. Calculate species percent abundance. (Number of individuals of one species divided by total number of individual plants, x100.)
11. Have the **recorder** for your group report your information to the class.

PLANT SAMPLING—LINE TRANSECT INVESTIGATION

Group: ____ (names)

Date: ____________________

Location:____

Plant Species Occurrence and Percent Abundance

Layer (Upper, Middle, Ground)	Name or Description	Tally of Individuals	Total
	Total species	**Total Individuals**	
	Number of individuals of one species divided by Total number of individuals	**Percent Abundance**	

Lesson 6.4: Measuring Populations

Essential Concept

Estimating populations is important in finding the biodiversity of an ecosystem.

Objectives

1. Students will use the mark and recapture method of estimating population used by biologists.
2. Students will learn how sampling size effects accuracy and standard error of estimates.
3. Students will practice the mark and recapture method to estimate the number of beans in a jar.
4. Students will use the mark and recapture method to estimate a population in a nearby creek or pond.
5. Students will make graphs.
6. Students will draw conclusions based on their data.
7. Students will draw a diagram of a food chain.
8. Students will draw a diagram of levels of organization in an aquatic ecosystem.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E, F; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.11 A; 7.14 C; 8.1 A, B; 8.2 A, B, C, D, A; 8.4 A, B; 8.11 B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, I, J; 4 A, B; 5 A; 7 A; 10 A; 11 B; 12 A, D

Environmental Science: 1 A, B; 2 E, F, G, H, J, K; 3 C; 4 A, B, D, E; 9 A, B, E

Estimated Time

1 day in the classroom

1 day in the field

1 class period figuring formulas from fieldwork, answering questions, and making diagram

Materials

For each pair of students:

1-600 ml. beaker, which represents the habitat to be sampled

1-small (50 ml.) beaker (sampling beaker)

White beans

A marker or black beans

Note: You can mark each bean with a marker or you can replace the captured white bean

with black beans to save on beans.

For the class

Seines or nets

Containers

Silver, brown or tan fingernail polish

Water chemistry kits

Thermometers

Copies of data charts

Science journals

Special Instructions

The 600-ml. beakers should all contain the same number of beans, but the number should only be known by the teacher. This will help with checking math results when figuring total population, standard error and 95% certainty rate.

Safety Precautions

Review field safety measures.

Procedure

1. Population Studies and Biodiversity

Biodiversity of an area is an indicator of the health of an ecosystem. If there are many different kinds of species and a number of individuals of each species, the area is healthier than an area with only one or two species, even if there are many individuals in the area. Biodiversity is the variety of life forms in a given area. The major threats to biodiversity include: human population growth, habitat destruction, overexploitation, invasive species, and global climate change.

2. Estimating Populations

It is important to measure changes in populations in order to understand how different physical or biological factors influence the distribution or abundance of species. However, it usually is not possible to count every individual in a natural population of animals or plants. Instead, ecologists generally make an estimate of population. A variety of methods may be used depending on such factors as the type of organism, the habitat in which the population occurs, and the time and equipment available. These methods vary from counting individuals to quick methods that give crude/imprecise estimates of abundance.

For example some ways to make quick counts include:

- Counting all hummingbirds sighted that come to your hummingbird feeder
- Counting the number of salmon passing a point during migration
- Scanning aerial photographs of white-tailed deer on a ranch in South Texas.
- Counting animal tracks along a trail

Techniques for individually counting animals include:

- Compiling a catalog of photographs or drawings that show unique markings of individuals such as fin shape and markings on whales or spot patterns on African wild dogs or facial expressions in primates
- Tagging individuals with markers visible from a distance or in the hand (e.g., numbered metal leg bands on birds, or streamer tags on red drum

A variety of methods for estimating population size fall between these two extremes. The most popular way to measure the size of a population is called the *Mark and Recapture Technique*. This technique is commonly used by fish and wildlife managers to estimate population sizes before fishing or hunting seasons. These methods involve capturing a sample, marking the sample and releasing the marked individuals back into the population. Soon thereafter scientists sample the population again, recapturing some of the individuals previously marked. This forms the basis for estimating the size of the population at the time of marking and release. This procedure was first used by C. J. G. Petersen in studies of marine fishes and F. C. Lincoln in studies of waterfowl populations, and is often referred to as the Lincoln Index or the Petersen Index.

This concept may be difficult for the students to fully grasp, especially if it is presented only as a mathematical formula. Teachers should create many examples of how proportions are used to estimate the total of a larger sample. For example if I go see 10 classes and see that they all are 60% female, I might assume that the entire school is 60% female. This might not be true, but it will probably be a close estimate of the population of females in the school unless there is something special about the classes observed.

The mark and release method is based on the principle that if a proportion of the population was marked and returned to the original population and, the next time the population is sampled, the proportion of marked individuals in the second sample would be the same as the proportion marked initially to the total population.

Mathematically it looks like this

$$\frac{R}{T} = \frac{M}{N}$$

Where:

R = Marked recapture

M = Marked initially

T = Total in second capture

N = Total population size

For example, suppose you catch 200 bluegills out of a pond having an unknown number of bluegills. You notch the pectoral fins of the bluegills you caught (mark them) and then return them to the pond. You then let them mix thoroughly with all the bluegills in the pond. Later you catch 250 bluegills from the pond and find 50 of them to have notches in their pectoral fins. Then $M = 200$, $T = 250$, $R = 50$, and the unknown total number of bluegills (N) could be estimated as:

$$\frac{R}{T} = \frac{M}{N} \qquad \frac{50}{250} = \frac{200}{N}$$

$$(M * T)/R = N$$

$$(200 * 250)/50 = 1{,}000\ Bluegills$$

Assumptions

The accuracy of this mark and recapture method rests on a number of assumptions being met.

Assumption 1.

During the interval between the preliminary marking period and the subsequent recapture period, nothing has happened to upset the proportions of marked to unmarked animals.

That is, no new individuals were born or immigrated into the population, and none died or emigrated.

Another way to state this assumption is that <u>the population is assumed to be "closed".</u>

You should also be aware that the length of the sampling period is very important. A shorter time interval between marking and recapturing individuals reduces the likelihood that this assumption will be violated. The longer the time interval, the greater the chance that some individuals will die, emigrate, immigrate or even be born, and in which case, it will become an "open" population. However, there must be enough time for the marked individuals to mix back into the population.

Assumption 2.

The chances for each individual in the population to be caught are equal and constant for both the initial marking period and the recapture period.

That is, marked individuals must not become either easier or more difficult to catch.

In addition, marking an individual does not make them more or less likely to be recaptured relative to unmarked individuals. Also, there cannot be something unique about those animals that were initially marked that makes them more conspicuous. For example, if the first time bluegills were sampled mostly females are caught because males are busy watching the nest, then if the second sampling takes place after males are finished guarding nests, males will be more likely to be captured the second time fish are sampled than the first time.

Assumption 3.

Sufficient time must be allowed between the initial marking period and the recapture period for all marked individuals to become randomly dispersed throughout the population (so that assumption 2 above holds).

However, the time period must not be so long that Assumption 1 breaks down.

If marked animals fail to disperse from the sampling area, or if they tend to aggregate in groups, there is a higher probability that they will be recaptured relative to unmarked individuals (or not be captured at all, depending on where they aggregate).

Assumption 4.

Animals do not lose their marks. This is an important factor for animals that shed or molt as they grow.

3. Practicing Mark and Recapture Methods

In this activity your goal is to estimate a population size using the mark and recapture method. You will use an unknown amount of beans as your model population.

Each pair of students needs these materials:

- 1-600 ml beaker, which represents the habitat to be sampled
- 1-small beaker (sampling beaker)
- White beans
- Black beans or black marker

First Capture

1) Obtain a population of white beans, a large habitat beaker, and one small beaker. The white beans will represent the population to be sampled.
2) *Marking*: Using the small beaker as a "trap", push through the white bean population once, filling the trap with beans to the 10 ml line. Count the number of white beans caught, mark each, and record that number in your journal as: *Number marked = M.* (e.g., if you "trapped" 23 white beans with your sampling beaker you would mark and return those beans to the original population). **Note: You can mark each bean with a marker or you can replace the white bean with black beans to save on beans.**
3) Thoroughly mix the marked and unmarked bean population.
    - Which assumption does this fulfill?
4) *Recapturing*: Now sweep through the mixed bean population with the trap once, again filling the trap to the 10 ml line. If you recovered at least one marked or colored bean with this sweep, record the number of marked beans (*recaptures*) as *R*. Record

the total number of beans caught as *T*, (i.e. *marked* + *unmarked*).

5) Now calculate the bean population size using the formula $N = (M*T)/R$

Second Capture:

Repeat steps 2, 3, 4, and 5, but this time fill the trap to the 20 ml line at step 2 and step 4. You will be doubling your sample.

Third Capture:

Repeat steps 2, 3, 4, and 5, but this time fill the trap to the 30 ml line at step 2 and step 4. Again, you are increasing your sample size.

- **Based on the formula, what is the estimate of the total population?**
- **Find the mean of the class capture for each of the 3 sampling captures.**

4. Results

Make a graph of the entire class's mean estimates for population size for each of the three sampling captures.

- **Which sample came closest to the actual number of beans?** (The teacher should know the actual number of beans, and reveal it at this time.)
- **Assuming cost is an issue, which of the three sample sizes would be the most practical?**

In the sampling of actual wildlife, cost usually is an issue. It can be expensive and time-consuming and labor intensive to sample wild populations. Getting accurate results without consuming too many resources (time, money, possible harassment of animal populations) is an important goal.

5. Drawing Conclusions

Look at each assumption. Evaluate how well you were able to satisfy each of the assumptions of the mark and recapture technique. Write your evaluations in your science journals.

- **If migration occurred in a natural population being studied, how would this affect the reliability of your estimate of population size determined using the mark and recapture technique?**
- **Would your population estimate be too high or too low, or would you not be able to predict how your estimate would be biased?** (Remember: migration consists of both immigration and emigration.)

Discuss the kind of bias you would expect to be generated in the estimate of population size if each of the remaining assumptions (2, 3, and 4) were violated.

- **If Assumption 2 is not met, and it is easier to catch marked individuals would it cause the size of the population to be overestimated? Underestimated? Or** have no effect?**

- **If Assumption 3 is not met, and captured and marked individuals are not thoroughly mixed in the population, would it cause the size of the population to be overestimated? Underestimated? Or have no effect?**
- **If Assumption 4 is not met and the marker rubs off and you can't tell marked from unmarked individuals, would it cause the size of the population to be overestimated? Underestimated? Or have no effect?**

Note that it is possible that violating several different individual assumptions may have the same effects.

There are a number of other models (designs and equations) used to estimate population size. Each has its own set of assumptions.

For High School

This mark and recapture formula has been found to sometimes overestimate the true size of the population. By doing repeated estimates and using the following unbiased formula we get a more accurate estimate:

N = [(M-marked capture)(T-total second capture + 1)/(R-marked recaptures +1)] – 1

Which is: $N = [(M)(T+1)/(R+1)]–1$

As in all estimates, it is helpful to have some information about the uncertainty of the estimates (as measured by the standard error, and/or by 95% confidence intervals).

The standard error gives an idea of what the sample mean is likely to be if the experiment were conducted repeatedly. The standard error can be found by using the following formula:

SE-standard error = square root of {[M-first marked capture + 1)(T-total second capture + 1)(M-first marked capture – R-marked recapture)(T-total second capture – R-marked recapture)]/(R- marked recapture + 1)^2(R-marked recapture + 2)}

Which is: SE = square root of $\{[M+1)(T+1)(M–R)(T–R)]/(R+1)^2(R+2)\}$

From the standard error we can calculate the 95% confidence limits of the estimate (which defines the range of values within which the true population size is likely to lie with 95% certainty), using the following formula:

95% confidence interval = N + (1.96)(SE)

There are other formulas for estimating the 95% confidence interval and for estimating N, but these are the formulas we will use.

6. Using What We've Learned: Sampling Aquatic Insect Nymphs

Take a field trip to your nearby stream or pond. Using seines or nets capture aquatic insect nymphs (mayfly nymphs, dragonfly nymphs, stonefly nymphs, etc.) **Note: Be sure to record all invertebrates you captured to add to the records about this aquatic ecosystem.** <u>In your journal, record all organisms that you catch and how many you caught of each. You will use the data later</u>. Choose the most abundant species for a mark and recapture or assign a different nymph to each group to mark and recapture. You can use a dot of silver, brown or tan fingernail polish to mark the thorax of each nymph. (You may want to use a different color of nail polish for each class period.) Return the nymphs to their original spot in the aquatic environment. Give the nymphs time to remix in the population.

Note: It's best to do this in a pond or backwater/quiet water area in a stream, because when you release them back into flowing water they are likely to be swept downstream.

However, these nymphs are a lot harder to capture in a pond.

Collecting Field Data

During the time when the nymphs are reentering the population, have students take weather readings and retest water samples for temperature, pH, dissolved oxygen, turbidity, conductivity, nitrates, speed of flow, or other tests you have been conducting.

In the afternoon, conduct another invertebrate capture and see if you recapture any insect nymphs that you have previously marked. Record your results and return your capture to the aquatic environment.

Note: If going to an aquatic setting is not possible, the class can simulate the same activity with grasshoppers, June bugs, and isopods on the school grounds.

7. Using Our Data

Give each student a *Using Field Data* student page. Have students use their field data to answer the following questions and draw the diagrams required.

- **What producers, consumers, predators, and prey did you capture?**

<u>Draw a diagram of the food chain</u> that you can document from your data.

<u>Diagram the levels of organization</u> within the ecosystem, including organism, population, community, and ecosystem based on your data.

When you return to school use the formula to estimate the population of your chosen insect nymph. (High school students can also find the standard error.)

- **What factors in the aquatic environment do you think may have affected the aquatic insect nymph population?**
- **What short or long-term environmental changes may have affected the individuals or populations in this aquatic environment?**
- **What land uses are present? Have any of these changed since your last visit?**
- **Does your data give you information about the water quality that can help you understand the aquatic insect nymph population?**
- **What are the biotic and abiotic parts of the ecosystem with which organisms interact? Could you see evidence of competition for any of these biotic or abiotic factors such as light, range of temperature, food source?**
- **Can you see any effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic environment?**

- **Were any of the following human activities having any influence on the aquatic insect nymph population? (Fishing, transportation, dams, and recreation)**
- **How does the watershed influence the water quality? What is the source of the water?**
- **Has the amount of rainfall had an impact on the quality of the surface water?**
- **Can you identify any point source pollution in the area?**
- **Is there evidence of non-point source pollution in your data?**
- **Did you find any genetic abnormalities in the organisms you collected?**
- **Has there been any human intervention to improve the habitat?**
- **Do you see evidence of other human impact such as all terrain vehicles, or small personal watercraft? Evaluate the effect of human activities, including habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, and ecotourism, on the environment.**
- **Compare data from this visit with previous visits. How has the water quality changed since the last class field trip to the site?**
- **What is the overall quality of the aquatic environmental system based on your data?**
- **Do you think this is a biologically diverse aquatic ecosystem based on the numbers and types of organisms that you found in the environment?**

Vocabulary

- Assumptions
- Biodiversity
- Emigration
- Estimate
- Immigration
- Mark and recapture
- Population studies

WATER CHEMISTRY INVESTIGATION

Objective

1. Record your group's observations about the color and odor of each water sample in the table below.

2. Following the directions for each meter, test kit or other equipment to test each water sample and record data in the table below.

Group: ____ (names)
Date: ______________________

Physical and Chemical Characteristics of Unknown Water Samples

Water sample	Temperature (^{o}C)	Color	Odor	Foam	pH	Conductivity ______ (units)	Dissolved oxygen ______ (units)	Nitrates And/or phosphates ______ (units)	Water sample source

WEATHER OBSERVATIONS AND MEASUREMENTS

Objective

Obtain, record, and present weather data.

Directions

1. Find a reliable source of daily information about the weather in your area.
2. Record today's weather data for your area. Be sure you report the source of each piece of data, the date and location for which it was reported.

Name: ____

Date: ______________________

Location: ____

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A musky smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A *chlorine* smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Invertebrates and Vertebrates as Water Quality Indicators

Invertebrates

A stream with:

- A great variety of insects, with few of each kind, indicates clean water.
- Less variety of insects, with greater abundance of each kind, indicates that there is too much organic matter in the water.
- Finding only one or two kinds of insects in great abundance indicates severe organic pollution caused from excessive human or livestock waste or high algae populations.
- If no insects are found, but the stream appears clean there may be some type of toxic pollution, which includes chemical pollutants such as chlorine, acids, metals, pesticides, and oil.
- Excessive sediment may be caused by erosion or discharge from a pipe and may reduce the amount of water in the stream causing extreme temperatures, and causing a loss of oxygen, which may smother insects resulting in a reduction of the number of animals in the area.

Note about Invertebrates

The types of **invertebrates** found can help students know about the quality of the water. Print out the Texas Parks and Wildlife *Bug Picking Data Sheet* at **the end of this lesson** to help identify invertebrates found in creeks and indicate which invertebrates are associated with clean water and which predominate in polluted water.

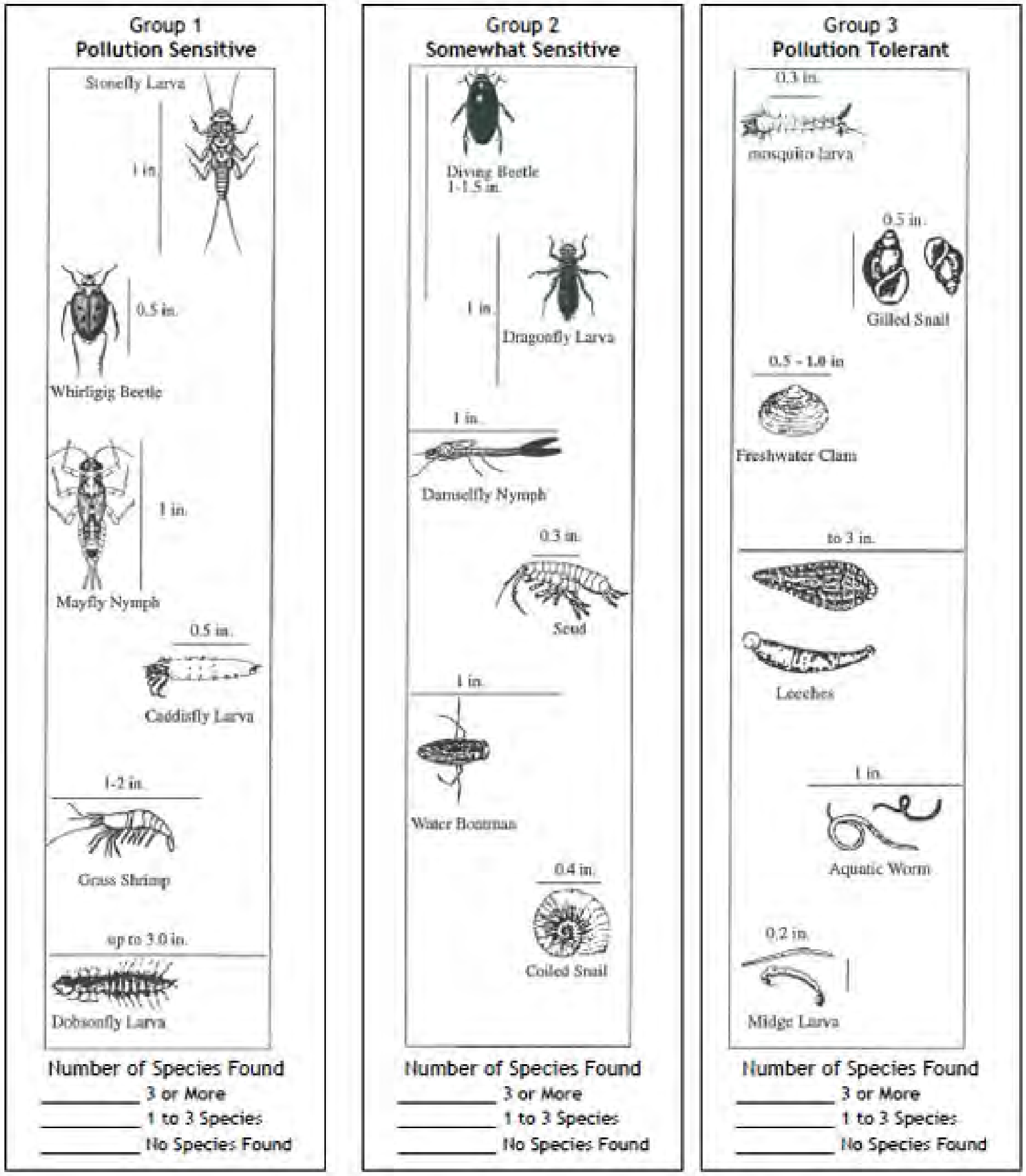
Vertebrates

- If fish are exhibiting some odd behavior such as jumping out of the water or being non-responsive, it may indicate toxins in the creeks. A chemical analysis is needed to find the source of the toxin. Contact the TCEQ.
- If there are no fish or other vertebrates in the creek, it may indicate that the creek is stressed from urban runoff, sewage, or toxins entering the stream. Chemical analysis is needed to the find the source of the problem. Contact the TCEQ.

Student Page

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department
Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: **(Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)**

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: **Not Polluted** **OK** **Polluted**

Student Page

Using Field Data

Use your data from the field trip to answer the following questions and make the diagrams required.

1. What producers, consumers, predators, and prey did you capture?
   - <u>Draw a diagram of the food chain</u> that you can document from your data.
   - <u>Diagram the levels of organization</u> within the ecosystem, including organism, population, community, and ecosystem based on your data.
   - When you return to school use the formula to find the estimate of the population of your insect nymph. (High school students can also find the standard error.)
2. What factors in the aquatic environment do you think may have affected the aquatic insect nymph population?
3. What short or long term environmental changes may have affected the individuals or populations in this aquatic environment?
4. What land uses are present? Have any of these changed since your last visit?
5. Does your data give you information about the water quality that can help you understand the aquatic insect nymph population?
6. What are the biotic and abiotic parts of the ecosystem with which organisms interact? Could you see evidence of competition for any of these biotic or abiotic factors such as light, range of temperature, food source?
7. Can you see any effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic environment?
8. Were any of the following human activities having any influence on the aquatic insect nymph population? (Fishing, transportation, dams, and recreation)
9. How does the watershed influence the water quality? What is the source of the water?
10. Has the amount of rainfall had an impact on the quality of the surface water?
11. Can you identify any point source pollution in the area?
12. Is there evidence of non-point source pollution in your data?
13. Did you find any genetic abnormalities in the organisms you collected?
14. Has there been any human intervention to improve the habitat?
15. Do you see evidence of other human impact such as all terrain vehicles, or small personal watercraft? Evaluate the effect of human activities, including habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, or ecotourism on the environment.
16. Compare data from this visit with previous visits. How has the water quality changed since the last class field trip to the site?
17. What is the overall quality of the aquatic environmental system based on your data?
18. Do you think this is a biologically diverse aquatic ecosystem based on the numbers and types of organisms that you found in the environment?

Lesson 6.5: Conserving Aquatic Ecosystems

Essential Concept

Humans can damage aquatic ecosystems, but they can also improve and conserve aquatic ecosystems.

Objectives

1. Students will review natural and human causes of environmental change
2. Individual students will generate 3 ideas for conserving aquatic ecosystems.
3. Groups will build on individual ideas for conserving aquatic ecosystems.
4. The class will generate a list of things that can be done to conserve aquatic ecosystems.
5. The class will choose one project from the list to actively help conserve aquatic ecosystems.
6. Each student will choose one thing that they will do to actively help conserve aquatic ecosystems.

TEKS

6.12 E; 7.8 A, B; 8.11 C D, E

Aquatic Science: 12 A, B, C, D, E

Environmental Science: 5 B, C, E, F; 8 A; 9 A, D, E, K

Estimated Time

1 class period to generate the list of projects and choose one project in which the class can participate

Time needed to do the project will vary depending on the complexity of the project that the class chooses.

Materials

Science journals

Chart paper and markers

White board and markers

Procedure

1. Class Discussion

Have students review and discuss natural and manmade causes of environmental changes to aquatic ecosystems.

- **What have they seen that indicates a need for conservation of aquatic ecosystems?**

Have students identify the source, use, quality, management, and conservation of water in the watershed they have visited.

Have the class analyze and evaluate the economic significance and interdependence of resources within the environmental system.

Example: What is the economic significance of water in the area?

- **What is the economic significance of petroleum products in the area?**

How do these two resources interact? Water is recyclable, but water quality is often not good due to runoff from streets and roads putting oil residue into water sources. Petroleum products are not renewable, are expensive, and can pollute the water around us, but are significant to our economy.

- **How could we conserve oil and gasoline, reduce runoff, and save money while we protect water?**
- **How are humans dependent on ocean systems?**

Ask the class to evaluate the impact of waste management methods such as reduction, reuse, recycling, and composting on resource availability.

- **How does reduction, reuse, recycling, and composting impact water quality?**

Reducing packaging cuts down costs of manufacturing and reduces litter in streams and rivers, reusing glass bottles or recycling paper and aluminum helps keep litter out of water as well as cutting down manufacturing costs and use of resources. Composting increases soil fertility naturally and so helps keep chemical fertilizers from running off into streams, ponds and lakes.

2. Brainstorming

Use Round Robin Brainstorming to have students review natural and manmade causes of environmental change to aquatic ecosystems and brainstorm some ways humans can help conserve aquatic ecosystems.

Have individual students answer the questions above in their journals and generate three ideas for conserving aquatic ecosystems.

Individuals will share their ideas with their group. The group will take the ideas from individuals and embellish them or generate more ideas. The **recorder** should keep a record on chart paper of all ideas generated by the group.

The group **reporter** then shares the group's ideas with the class to generate a class list of ideas for conserving aquatic ecosystems.

The class will look at all the ideas and see what would be needed to carry out the conservation measures.

- **What problems do you find in aquatic ecosystems due to natural or human causes?**
- **What needs to be done to alleviate those problems?**

Extension

Ask each student group to research one of the following:

- The Clean Air Act
- The Soil and Water Resources Act
- The Endangered Species Act
- The National Park Service Act

Ask student to report their research to the class. Have all students take notes on the reports.

3. Making Conservation a Reality

Is there a way that the class can take on one of the problems discussed as a project?

Students may wish to raise money for a specific conservation organization, volunteer at a non-profit organization, work with a nature center, report on water quality as part of the Texas Stream Team, help the Natural Resource Conservation Service or other conservation group to set up a conservation program and help make it a reality. They might want to lobby the U. S. Congress on some conservation legislation by writing letters or sending e-mails to their congressman. They may want to set up a school recycling program. They may wish to set up and maintain an aquatic ecosystem such as a pond on the school grounds.

4. I Can Make a Difference

Have individual students write a science journal entry exploring something they would like to do themselves to help conserve Texas' aquatic ecosystems.

- **How could you make a difference?**

Ask students to set up a page in their science journals to document their efforts weekly. Have students document their use and conservation of both renewable and non-renewable resources that would affect an aquatic ecosystem.

- **How do they pertain to sustainability?** (Changes in water use, driving habits, recycling, reusing, and disposal of materials)

Vocabulary

- Conservation
- The Clean Water Act
- The Endangered Species Act
- The National Park Service Act
- The Soil and Water Resources Conservation Act

Chapter 6 Assessment

Multiple Choice Questions

Directions

Select the best answer for each of the following multiple-choice questions.

1. Why do scientists use sampling?

A To create new habitat

B Because each part of an ecosystem is connected to and depends on all the others

C Because ecosystems may change in response to natural or human-caused events

D To estimate populations without having to count each organism

2. What kinds of aquatic ecosystems do we have in Texas?

A Aquifers, springs, rivers, and streams

B Lakes, ponds, and wetlands

C Bays, estuaries, and oceans

D All of the above

3. What is biodiversity?

A A complex web of relationships between living and non-living things

B The variety and number of different organisms and populations, and the way they live together

C The kinds of aquatic ecosystems found in Texas

D None of the above

4. Some human activities that reduce aquatic biodiversity include:

A Draining a wetland

B Damming a river

C Pumping water out of an aquifer

D All of the above

5. A balanced ecosystem

A Is always changing

B Doesn't change

C Changes in response to natural and human caused events

D A and C

Open-Ended Questions

Directions

Write your own answer for each of the following questions.

1. What are the biotic and abiotic factors that make up an ecosystem?

2. Describe a beneficial or harmful activity of humans, and explain how these activities affect organisms within an aquatic ecosystem in Texas. Use one of the following activities as the basis for your example: water pollution, restoration of natural environments, introduction of an invasive species, picking up trash.

3. Predict the impact (beneficial or harmful) on the organisms in an aquatic ecosystem in Texas that might be caused by each of the following natural environmental changes: a forest fire in the watershed, a flood, a drought.

4. Suggest a possible solution to one of the potentially harmful environmental changes within an ecosystem that you used as an example in question 2 or 3.

5. Draw a diagram showing Texas aquatic ecosystems from the headwaters to the ocean.

Chapter 6 Assessment Answer Key

Multiple-choice questions

1. Why do scientists use sampling?

   D To estimate populations without having to count each organism

2. What kinds of aquatic ecosystems do we have in Texas?

   D All of the above

3. What is biodiversity?

   B The variety and number of different organisms and populations, and the way they live together

4. Some human activities that reduce aquatic biodiversity include:

   D All of the above

5. A balanced ecosystem

   D A and C

Write-in questions

1. What are the biotic and abiotic factors that make up an ecosystem?

The biotic (living) parts of the ecosystem are the communities of plant and animal populations, including humans. The abiotic (non-living) parts include sunlight, air, water, temperatures, soil and minerals.

2. Describe a beneficial or harmful activity of humans, and explain how these activities affect organisms within an aquatic ecosystem in Texas. Use one of the following activities as the basis for your example: water pollution, restoration of natural environments, introduction of an invasive species, picking up trash.

Many answers are possible, but should resemble one of the following examples:

Human Activity	Specific Example of Effect on Organisms
Water pollution	Runoff polluted with insecticides could kill all the insect larvae living in a stream. This could cause the food web to collapse and most fish species to die.
Restoration of natural environments	Removing a river levee could allow natural oxbow lakes and wetlands to reform. This would restore habitat for fish species that need shallow, slow moving water.
Introduction of an invasive species	Dumping a bait bucket full of crayfish that are not native to a stream could introduce a species that competes with the native crayfish. This could cause the native species to become endangered.
Picking up trash	Fish, birds, and other wildlife die or get injured from swallowing or being tangled in plastic trash. Removing plastic bags, used fishing line and other plastics could reduce the number that die or get injured.

3. Predict the impact (beneficial or harmful) on the organisms in an aquatic ecosystem in Texas of each of the following natural environmental changes: a forest fire in the watershed, a flood, and a drought.

Many answers are possible, but should resemble one of the following examples:

Natural Environmental Change	Specific Example of Effects on Organisms
Forest fire in the watershed	Loss of plants in the watershed could result in increased erosion and sediment entering a water body. These changes may destroy habitat for some species and create it for others. When plants grow back, the ecosystem will return to normal.
Flood	A flood could wash some fish, plants, or other aquatic life away, but would not necessarily cause long-term damage to the ecosystem. It could even have benefits, such as restoring wetland areas and bringing fresh nutrients.
Drought	A drought could result in increased evaporation and no new inflow of water causing loss of aquatic plants and animals and growth of land plants. In brackish water it can increase salinity, which changes the organisms that can survive in the habitat.

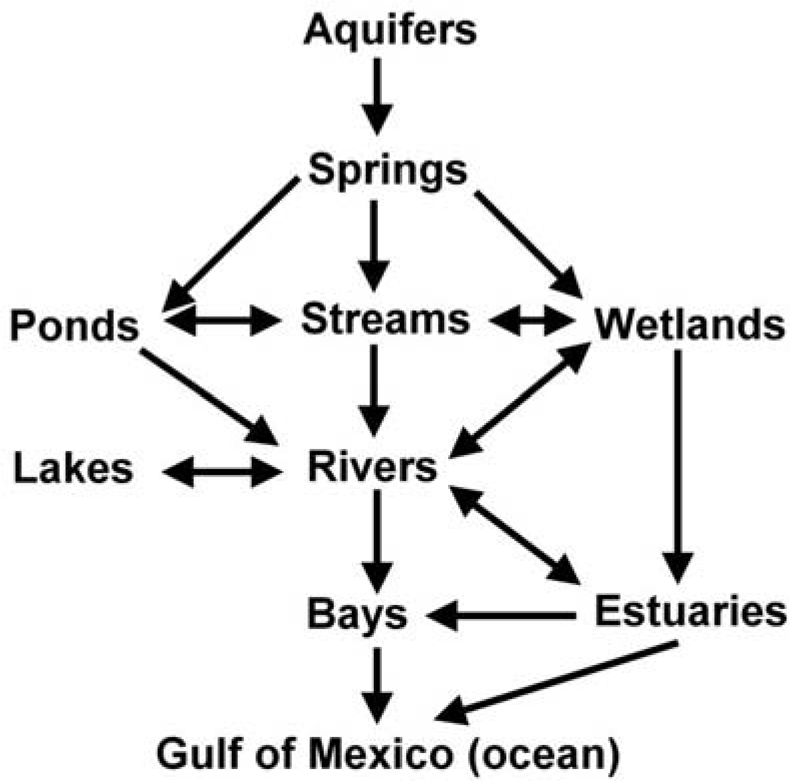
4. Suggest a possible solution to one of the potentially harmful environmental changes within an ecosystem that you used as an example in question 2 or 3.

Many answers are possible, but should resemble one of the following examples:

Potentially harmful environmental change	Specific example of affect on organisms	Possible solutions
Water pollution	Runoff polluted with insecticides could kill all the insect larvae living in a stream. This could cause the food web to collapse and most fish species to die.	Prevent water pollution through regulating insecticide use and by educating people about the potential for harm. Protect and restore habitat for the native species and consider hatchery spawning to support wild populations.
Introduction of an invasive species	Dumping a bait bucket full of crayfish that are not native to a stream could introduce a species that competes with the native crayfish. This could cause the native species to become endangered.	Prevent introduction of the invasive crayfish species by educating people about the potential for harm. Protect and restore habitat for native crayfish species and consider hatchery spawning to support wild populations.
Natural environmental changes	Generally do not have long-term harmful effects to the ecosystem.	Solutions to potentially negative temporary effects should emphasize protecting and restoring a wide variety of habitat, maintaining biodiversity and allowing nature to take its course.

5. Draw a diagram showing Texas aquatic ecosystems from the headwaters to the ocean.

Answers will vary, but should include springs, streams, ponds, lakes, rivers, bays, estuaries, and the Gulf of Mexico.



Aquifers and Springs

Springs have attracted humans to settle nearby where water is abundant, but careful use is necessary to balance the recharge of aquifers with the use by people. Aquifers and springs also provide aquatic habitats where unique species live on the brink of extinction.

Chapter 7

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Work in small groups to make mind maps about aquifers and springs.
2. Collaborate to make a class mind map about aquifers and springs.
3. Read the chapter and answer the questions.
4. Make a drawing with labels of an organism that would be adapted for living in an underground aquifer or a spring.
5. Answer questions about the interrelationship of their organism and its habitat.
6. Identify ways that humans might affect the environment where these organism might live.
7. Identify how increasing human populations in their organism’s habitat could change the carrying capacity.
8. Take part in a simulation demonstrating how water moves through various types of rocks and soil.
9. Compare movement of water through various types of rocks and soil.
10. Identify types of permeable rocks and soils.
11. Identify impermeable natural materials such as clay and granite.
12. Explain how water moves through aquifers.
13. Draw a diagram showing movement of water through at least three kinds of natural materials.
14. Make a diagram of aquifers and a spring.
15. Build a model of aquifers and a spring.
16. Identify the parts of different types of aquifers.
17. Use their aquifer model to see how species may be affected by changes caused by humans in springs and aquifers.
18. Take part in a simulation to see how habitat changes influence species viability.

19. Use the library and Internet to research an endangered species that lives in Texas' aquifers and streams.
20. Write a report of at least six paragraphs on their organism.
21. Include information on the specialized habitat needs of organisms that live in aquifers and springs.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, C, D, E; 6.3 A, B, C; 6.4 A; 6.12 D, E, F; 7.1 A, B; 7.2 C, D, E; 7.3 A, B, C; 7.4 A, C; 7.8 B; 7.10 A; 7.11 A; 7.12 A; 7.13 A; 7.14 A, C; 8.1 A, B; 8.2 C, D, E; 8.3 A, B, C; 8.4 A; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 F, H, J; 3 A; 4 A; 7 A, B, C; 10 B; 11 A, B; 12 A, B, C, D

Environmental Science: 1 A, B; 2 F, I, K; 3 A, B; 4 A, B, D, F, G, H; 7 A, C; 9 A, B, E, J

Materials Needed

Activity 7.1

Chart paper

Markers

Science journals

Activity 7.2

Chart paper

Markers

Science journals

Activity 7.3

<u>For each group of 4</u>

Plastic jars or beakers

225 ml. gravel

225 ml. sand

225 ml. clay

225 ml. water for each soil and rock sample

Porous limestone (optional)

<u>For the Class</u>

Science journals

Pencils/pens

2 rolls of blue crepe paper streamers

Activity 7.4

Science journals

<u>For each Pair of Students</u>

Oil based clay (not Playdough)

Sand

Gravel

Plastic rectangular lettuce keeper or other container

Water in a spray/squirt bottle

Plastic people, plants and animals (optional)

Activity 7.5

Science journals.

Pencils/pens

Aquifer and spring models built in Activity 7.4

Food coloring

20 dice per group of four students

Copies of the Rules for the Extinction Game

Data Sheets (optional–Students may make their own data tables in their journals.)

Graphs (optional–Students may make their own graphs in their science journals.)

Blue, green, and red pens for the graph

Activity 7.6

Library

Internet

Computer

Science journal

Pencils/pens

Endangered and Threatened Animals of Texas by Linda Campbell from Texas Parks and Wildlife Department

Safety Precautions

Remind students that while they will be close together in some of the activities, they should be careful to keep each other safe.

Vocabulary

Adaptation

Alien

Aquifer
Competition
Confined
Contaminants
Ecologist
Ecology
Endangered
External stimuli
Extinction
Groundwater
Habitat
Headwater
Herpetologist
Impermeable
Invasion
Karst
Nonrenewable
Permeable
Recharge
Recharge zone
Recovery
Runoff
Spring
Status
Structures
Taxonomy
Threatened
Unconfined

Enrichments

Videos

Texas the State Springs

Teacher Resources

Endangered and Threatened Animals of Texas by Linda Campbell, Texas Parks and Wildlife Department

Lesson 7.1: What Springs to Mind?

Essential Concept

Springs and aquifers are important sources of water for Texas.

Objectives

1. Students will work in small groups to make mind maps about aquifers and springs.
2. Students will collaborate to make a class mind map about aquifers and springs.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

30 minutes

Materials

Chart paper

Markers

Science journals

Special Instructions

Prepare chart paper for groups by drawing 2 circles. In one circle put aquifers and in the other circle put springs. Connect the 2 circles with a line.

Procedure

1. Mind Mapping Aquifers and Springs

Most of Texas land surface lies above aquifers and aquifers supply about 60% of the water we use in Texas. Springs are the places where water from aquifers comes to the surface. Ask students to work in groups of 4 and draw a mind map of what they know about springs and aquifers.

Provide chart paper with “aquifers” and “springs” circles for each group. Ask students to attach any words they think of that pertain to aquifers or springs around each circle. Give students about 10 minutes to produce their mind map. Then have each group share their ideas with the class. Have group one start a class mind map by putting one of the words from their mind map on the board. Ask each group to add a new word to the mind map as they report their group’s work to the class. Continue from group to group until all the words from the mind maps are on the board.

Students may generate a wide variety of ideas such as underground, caves, rocks, drinking water, swimming, cool water, pristine, endangered species, groundwater, pollution, recharge zone, sinkhole, headwaters, limestone, reservoir, saturated, surface water, stream, wetland, etc. If students don’t know a lot about aquifers and springs, that is all right. The purpose of the activity is to find out what students know so that the teacher has a place to start providing new information.

2. Gaining Understanding

Have students discuss each of the ideas from the class mind map to be sure that students understand how each word is related to aquifers and springs. Have students copy the class mind map in their science journals.

3. Looking Forward

Tell students that you will be learning more about different kinds of aquifers and some of Texas’ best known springs, as well as unique ecosystems that exist in these aquatic habitats.

Vocabulary

Aquifer

Groundwater

Headwater

Recharge zone

Spring

Lesson 7.2: Reading and Research

Essential Concept

Aquifers and springs are complex systems with delicate communities of aquatic organisms.

Objectives

1. Students will read the chapter and answer the questions.
2. Students will make a drawing with labels of an organism that would be adapted for living in an underground aquifer or spring.
3. Students will answer questions about the interrelationship of their organism and its habitat.
4. Students will identify ways that humans might affect the environment where their organism might live.
5. Students will identify how increasing human populations in their organism's habitat could change the carrying capacity.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 A; 7.11 A; 7.12 A; 7.13 A; 8.2 C; 8.11 C

Aquatic Science: 2 J; 10 B; 11 B

Environmental Science: 2 K; 4 H; 7 A; 9 A, B, E

Estimated Time

Varies. Time may be allowed in class to read and answer questions as cooperative groups or it may be done as homework.

1 period for discussion and drawing a picture

Materials

Student Chapter

Science journals

Pencils

Markers and paper

Procedure

1. Student Reading

Have students read *Chapter 7: Aquifers and Springs*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is an aquifer? What is groundwater?

An aquifer is an underground reservoir. Water in an aquifer is called groundwater.

2) What are the kinds of aquifers and how do they differ?

There are three types of aquifers. Unconfined aquifers are directly connected to the surface and have water levels dependent on relatively constant recharge. Confined aquifers are saturated layers of permeable rock materials bounded above and below by largely impermeable rocks, which can squeeze the aquifer and cause it to be under pressure, which is called an artesian aquifer. Artesian flow feeds many of Texas' famous springs. Karst aquifers are contained in limestone and marble rocks that are filled with many small channels and, in some cases large underground caverns and streams.

3) How do aquifers recharge?

Water from rainfall seeps into the aquifer through the ground.

4) What kinds of aquatic ecosystems exist in groundwater? What adaptations enable aquatic life to exist underground?

Aquifers are dark, nutrient poor, anaerobic ecosystems where microorganisms such as bacteria, protozoans, and other unicellular life may live.

Karst aquifers' caves, caverns, and underground rivers can support entire ecosystems that include invertebrates, fish, and amphibians. There is no light so there are no plants. The animals that live there are small and there are few of any one species. These animals are adapted to living in the dark and have no eyes, but they have other sensory adaptations such as antennae, chemreceptors, and touch receptors to help them find food. They also have a very low metabolism allowing them to use the food available efficiently in an environment with a constant temperature and predictable environment.

5) What is a spring? What are headwaters?

Springs are where aquifers emerge naturally on the land's surface forming a pool or stream. Headwaters are the places where rivers start and are sometimes formed by springs discharging large amounts of water.

6) How have springs influenced Texas' history?

Many springs were sites of Native American and later pioneer settlements. They are where cities later developed. Springs have played a large role in the economic development of Texas.

7) How can we help conserve groundwater?

We must limit the amount of water we take from aquifers so that they are able to recharge and maintain necessary water levels. We must also be careful with what we do to the land so that oil, gasoline, fertilizers, chemicals and other hazardous substances do not contaminate and lower the quality of our water.

3. Underground Ecosystems

Have you ever been in a cave? Discuss what it is like underground (dark, stable temperature, no plants). In addition, if it were an aquifer, there would be water. Ask students to think about descriptions in the reading and use the information to help them think about adaptations of organisms.

What kinds of organisms could live in this underground environment?

Have students imagine an animal that could live in this environment and draw a picture of the organism and label its structures showing how it would be adapted for life underground. Some students may wish to make a model instead of a drawing, or they may wish to write a story about the organism. Since students learn in different ways, these ideas provide a way to meet the needs of different students. The main criteria should be that the students provide information on structures and functions and how those structures help the organism survive in an aquifer or spring.

Are there internal structures that help your organism survive?

How does your organism respond to external stimuli?

How does the ecosystem support your organism?

If the environment changes and your organism adapts to the new changes, how might this affect subsequent populations?

What factors in the spring affect the population of your organism?

What chemical, organic, physical, and thermal changes caused by humans might affect your organism in its spring?

How would human population growth affect the aquifer or spring where your animal lives?

Do human recreational activities affect your organism in the spring?

What might change in the ecosystem if the adaptations for your organism help increase diversity? How might this affect the carrying capacity of the ecosystem?

Vocabulary

Adaptation

Aquifer

Artesian aquifers

Confined

Contaminants

External stimuli
Groundwater
Karst
Nonrenewable
Recharge
Runoff
Spring
Structures
Unconfined

Lesson 7.3: A Moving Experience

Essential Concept

Water moves into and through permeable rock in aquifers to recharge the system and keep springs flowing.

Objectives

1. Students will take part in a simulation demonstrating how water moves through various types of rocks and soil.
2. Students will compare movement of water through various types of rocks and soil.
3. Students will identify types of permeable rocks and soils.
4. Students will identify impermeable natural materials such as clay and granite.
5. Students will explain how water moves through aquifers.
6. Students will draw a diagram showing movement of water through at least three kinds of natural materials.

TEKS

6.3 A, B, C; 7.3 A, B, C; 7.8; 8.3 A, B, C

Aquatic Science: 2 H, J; 3 A; 7 B

Environmental Science: 2 I, K; 3 A

Estimated Time

1 class period

Materials

<u>For each group of 4</u>

Plastic jars or beakers

225 ml. gravel

225 ml. sand

225 ml. clay soil

225 ml. water for each soil and rock sample

Porous limestone

Note: Gravel and sand are easily obtained at local gardening/outdoor stores. Clay soil may have to be dug up from a nearby source such as road cuts or backyards.

Hint about clay: If you put clay soil in the container about 2 weeks prior to the activity, soak it with water for a few days, and then let it dry out, it will settle into a "cake" that will be almost impermeable, but will absorb water very slowly over time. If your clay soil has other soils mixed in it, the clay will be more permeable than a sample that is all clay, but it will still be less permeable than the other samples.

For the Class

Science journals

Pencils/pens

2 rolls of blue crepe paper streamers (optional)

Safety Precautions

Remind students that while they will be close together in some of the activities, they should be careful to keep each other safe.

Procedure

1. Observation of Permeability of Soils and Rocks

Have 3 clear beakers or plastic jars: 1 with gravel, 1 with sand, and 1 with clay for each group. Ask each group to pour 225 ml. of water very slowly into each container one at a time. Students should observe the way water flows through the materials and write a description in their science journals of what happens in each container.

In which container did the water flow through fastest?

In which container did the water move slowly or pool on top of the soil or rocks?

If possible use porous limestone or marble, put a slab or chunk of the rock in a container and repeat the experiment.

- **What happens to the water in the limestone?** (Some of the water will run off and some will sink into the limestone filling pores and channels with water. You will see the limestone becomes a darker color as water is absorbed in tiny pores.)

Leave the limestone or marble sitting in water overnight and measure to see how much water is left in the beaker in the morning.

- **How much water did the limestone absorb?**

When water is able to make its way through a material, we say that the material is “permeable”. Permeable materials have pores (small spaces) where water can collect.

2. Water Moves

In this simulation students will experience how water moves through various soils and rocks including gravel, sand, and clay. You will need an open space for the students to work. The simulation can be done outside or you can move the desks to the side of the room.

Note to the Teacher: Students who are playing the part of soil and rocks should not resist when the water molecules try to move past them.

If you would like to allow students to see the path of the water, you can have the water molecules unroll blue crepe paper streamers as they move through the soil and rocks. Have a student playing a particle of soil or rock hold the end of the crepe paper at the beginning of the water's journey.

Round 1

Appoint two students to be water molecules. The rest of the students will be gravel. Have the gravel students stand with their arms outstretched at shoulder level. They should be far apart so that they can turn completely around without touching another gravel particle. Have the water molecules flow through the gravel students to the other side of the group.

Was it easy or difficult to move through the gravel? (Easy)

Round 2

Ask two more students to be water molecules. The rest of the students will represent sand. The sand students should stand with their elbows bent and sticking out from their sides with fingers touching their hips. Their elbows should be almost touching. Ask the water molecules to move through the sand to the other side of the group.

- **Was it easy or difficult to move through the sand? (**It was a little more difficult, but water was still able to move through the sand.)

When water can move through soil and rocks we say that the soil or rocks are permeable.

Round 3

Again, ask two students to be water molecules. The rest of the students will be clay particles in this round. The students who are clay particles should stand very close together with their arms at their sides. This will make it much more difficult or even impossible for the water molecules to move through the clay. Ask the water molecules to try to move to the other side of the group.

Was it easy or difficult to move through the clay? (Very difficult or impossible–The water may pool up around the clay.)

We call soil and rocks that won't let water through "impermeable". Clay and granite are two impermeable natural materials that can help to contain confined aquifers.

If you have used a piece of porous limestone to test permeability, you may wish to model that interaction of rock and water also. Ask 2 more students to be water molecules. Have the rest of the students stand with arms to their side but in irregular clumps with pores and channels through the group. Ask the water molecules to move through the limestone to the other side of the group.

- **Was it easy or difficult to move through the limestone?** (It was harder than gravel or sand, but water can still move through pores and channels.)
- **Which soil or rock was the hardest to move through?** (Clay)
- **Which soil or rock was the easiest to move through?** (Gravel)

- **Which soil and rock might we find in an aquifer where water is stored and moves?** (Gravel, sand and limestone or marble)
- **Where might we find clay?** (Clay is impermeable and may form the boundaries of a confined aquifer, keeping water in a confined space within permeable rock and soils and producing pressure, which allows springs to form at the surface when the aquifer is exposed.)

3. Karst Aquifers

Karst aquifers are made of limestone or marble, and may be found in caves or porous limestone formations. Sometimes they have sinkholes, or underground streams.

We are going to see how karst forms. Give students a piece of limestone or marble, an eyedropper and some vinegar. Ask students to use a hand lens to see what happens to the limestone or marble when vinegar is dropped on it. (It will fizz as the vinegar dissolves the rock.) This is what happens when it rains on limestone, marble, and dolomite (rocks made up of calcium carbonate). Rainwater dissolves carbon dioxide from the air and forms a weak acid (carbonic acid). As this slightly acidic rain falls on limestone and other calcium carbonate rocks, the acid slowly dissolves the calcium carbonate leaving holes and channels. After a long period of time, pores, channels, caverns, sinkholes, and fissures form in the limestone making paths for water to flow through, and causing more weathering and dissolution.

- **How would this form a karst aquifer?** (Water slowly accumulates and moves through the various pores, channels, caverns, sinkholes, and fissures until a substantial amount of water is available underground.)
- **How does water move through a karst aquifer?** It may move slowly and in small amounts through pores in the limestone, or quickly and in large amounts through large caverns or even in underground rivers.

4. Using What We Learned

Ask students to use what they have observed and logical reasoning to analyze how water moves through an aquifer. Students should use their ideas to write a paragraph in their science journals (at least three sentences). They should include a diagram showing water movement through at least three kinds of natural materials.

5. Challenge Questions

Ask students to work in small group to discuss the following questions.

- **How are our lives connected to aquifers?**
- **Which aquifer provides groundwater where you live?**
- **How is your groundwater being used?**
- **Is your groundwater being conserved or is it being depleted?**

Research Question:

- **Are their any laws or regulations about what humans can do to the land above these underground water supplies? Why or why not?**

Vocabulary

Aquifer

Impermeable

Karst

Permeable

Spring

Lesson 7.4: Building a Model

Essential Concept

Springs are the places where groundwater in confined aquifers comes to the surface.

Objectives

1. Students will make a diagram of aquifers and a spring and label the parts.
2. Students will build a model of aquifers and a spring.
3. Students will identify the parts of different types of aquifers.
4. Students will explain how water gets from an underground aquifer to a spring.

TEKS

6.1 A, B; 6.2 A, C, D; 6.3 B, C; 6.4 A; 7.1 A, B; 7.2 C, D; 7.3 B, C; 7.4 A; 7.8 B; 8.1 A, B; 8.2 C, D; 8.3 B, C; 8.4 A

Aquatic Science: 1 A, B; 2 H, J; 7 A, B, C

Environmental Science: 1 A, B; 2 I, K

Estimated Time

1 class period for planning and building the model

1 class period for writing an explanation of the model and answering questions

Materials

<u>For each Pair of Students</u>

Oil based clay (not Playdough)

Sand

Gravel

Plastic rectangular lettuce keeper or other container

Water in a spray/squirt bottle

Plastic people, plants and animals (optional)

Special Instructions

Be sure there are no holes in the container for water to leak out.

Save the aquifer and spring models for use in the next activity.

Procedure

1. Planning a Model of Aquifers and a Spring

Distribute materials to pairs of students. Ask students to think about what they have read about how springs are formed.

Have each pair of students draw a diagram in their journals and label the parts showing how they think they could make a model of a spring. (Students should have layers of sand and gravel with a layer of clay both under and over a part of the sand and gravel layers to make both a confined and unconfined aquifer.) Walk around and look at the diagrams. Ask questions about their ideas to help clarify their thinking.

- **Where is the aquifer recharge zone?**
- **Would the recharge zone need to be higher or lower than the spring?**
- **What is confining the water in the aquifer?**
- **Is there an unconfined aquifer?**
- **What did we learn about permeable and impermeable materials?**
- **How can that information help you plan your model?**
- **Where will the spring emerge? Etc.**

Provide pictures when you can of aquifers from textbooks or the Internet to help struggling students.

2. Building the Model

When students are satisfied with their diagram, allow them to build their model.

Students should come up with a base of clay covered with sand and gravel. Sand and gravel should make a small hump at one end of the container. The sand and gravel should have another clay layer on top of it, but the clay layer should not go all the way across the container, but instead, it should leave an area of sand and gravel unconfined for recharge. The clay should be covered by a larger mound of sand covered with gravel making a big hill at one end of the container. At the bottom of the hill students may want to have mainly sand so that they can see when the water emerges from their spring.

When students are finished building their model, ask them to use the squirt bottle to make a rainstorm in their container. (Students should be sure to get their rain in the recharge zone, the area that was not covered by clay.) Watch the movement of the water.

Is it going to reach the spring?

If not, ask students to continue raining. Both the confined and unconfined aquifers should eventually have water. The spring should emerge on the opposite end of the container from the hill.

3. Explaining the Model

Ask students to explain in their journals how water gets to their spring and answer the following questions.

What are the parts of a confined aquifer? An unconfined aquifer?

What is the role of the recharge zone?

What is the role of the permeable soil and rocks?

What is the role of the impermeable material?

What type of aquifer is not represented by our model? (Karst aquifer)

What are the limitations of our model?

Can you think of a way to improve your design?

Vocabulary

Confined aquifer

Impermeable

Permeable

Recharge zone

Spring

Unconfined aquifer

Lesson 7.5: What Endangers Species?

Essential Concept

Species with very specific habitat needs often become endangered when their habitat changes or is lost.

Objectives

1. Students will use their aquifer model to see how species may be affected by changes in springs and aquifers caused by humans.
2. Students will take part in a simulation to see how habitat changes influence species viability.
3. Students will graph data on salamander populations from the simulation.
4. Students will explain what happened to the habitat to endanger the salamanders.

TEKS

6.2 D, E; 6.3 B; 6.12 E; 7.2 D, E; 7.3 B; 7.8 C; 7.13 A; 7.14 A, C; 8.2 D, E; 8.3 B; 8.11 B, C

Aquatic Science: 2 F, H, J; 4 A; 11 B; 12 A, B, C

Environmental Science: 2 F, I, K; 4 D, F, G; 7 A, C; 9 E, J

Estimated Time

1 class period

Materials

Science journals.

Pencils/pens

Aquifer and spring models built in the last lesson

Food coloring

20 dice per group of four students

Copies of the Rules for the Extinction Game

Data Sheets (optional–Students may make their own data tables in their journals.)

Graphs (optional–Students may make their own graphs in their science journals.)

Blue, green, and red pens for the graph

Special Instructions

You may wish to have more experienced students make their own data table and graphs in their journals.

Procedure

1. The Plight of Threatened and Endangered Species

Like most species that live in aquifers and springs, the Barton Springs salamander has a limited habitat occurring only at the spring outflows of Barton Springs. They are often found hiding among aquatic plants or under rocks and gravel or in water from a few inches up to 15 feet deep. They require the continuous flow of clear, clean spring water. While the Barton Springs salamander can live underground, it also inhabits the surface environment of the springs. They eat amphipods and other tiny crustaceans, and worms. Changes to the temperature, chemistry, sedimentation, bacteria, or flow rate of the springs can have devastating effects on these endangered species.

Biologists, ecologists, herpetologists, and other scientists study these and other endangered and threatened species to learn how to protect them and how to help them recover. They research the status of the organism (how rare the species is), the taxonomy or relationship between species, its life history (such as reproduction and food habits), and the ecology or habitat needs and interactions in order to find out what threatens the organism.

2. Where Does It Go?

Using the models of aquifers and springs built by the students in Activity 7.4, tell students that the people who live at the top of the hill used herbicides to kill off some weeds in their yard. Have each pair of students predict if they think human caused pollution on the hill in their model will make it all the way to the springs.

Then have students put 5 drops of food coloring at the top of the hill and use their squirt bottle to simulate rain. Watch for the color to appear in the aquifer and then in the spring. Students may need to simulate rain several times to get the water moving through their aquifer.

Have students answer the questions below in their journals.

- **Where is the color the strongest?** (Near the top of the hill)
- **Does the color reach the springs?** (If enough rain comes down, it should reach the springs.)
- **Even if only a little color reaches the springs, what would that mean for the sensitive organisms that live there?** (Depending on what the pollutant is, it could kill the animal outright, it could kill the plants used for shelter, it could kill the organisms used for food, and it could make the endangered species sick.)

3. Sensitive Species

Today we will take part in a simulation to look at the effects of changing conditions in the habitat of sensitive endangered species. We saw how pollution can make its way into an aquifer and spring, but there are also other changes that can occur and threaten sensitive plants and animals in an aquifer and spring. In this game we will look at the affects of changes in the aquifer or spring on the populations of sensitive organisms that live there.

Ask students to work in groups of 4 to play the game.

Round 1

In the first simulation we will change only one thing about the springs in which our endangered species lives. We will say that <u>loss of water in the spring kills off some of the plants in the habitat</u>.

Round 2

In the second simulation we will <u>add an invasive species to the spring</u> and find out what happens.

Round 3

In the third simulation we will <u>add a chemical pollutant</u> to the springs.

Read the rules and follow the directions. Record your results on the data table. Each line represents one month in the life of a salamander. **(See rules and data and graph sheets at the end of this activity.)**

4. Graphing Our Data

Graph your data. Use a <u>blue pen</u> for round one of the simulation, a <u>green pen</u> for round two of the simulation, and a <u>red pen</u> for round three of the simulation.

If students use the prepared graph, ask them to label the Y axis of the graph (population of salamanders in the spring) and record the results for each simulation with the colors suggested above.

5. Using What We Learned

Answer these questions in your science journal.

- **Did your salamanders become extinct?**
- **If so, in which round did this happen? How many months did it take in that round for extinction to occur?**
- **What can you say about the habitat in which the salamanders became extinct?** (The habitat was deteriorating, because of natural and human caused changes.)

- **Which changes to the habitat were due to natural causes and which were due to human activities?** (Spring flow decrease may be due to either natural or human causes. Invasive species and chemical pollution are due to human activities.)
- **How would the simulation represent what may happen to other endangered species?** (Sensitive species have difficulty surviving in a changing habitat.)
- **How is our model limited?** (It may underestimate the influence of changes such as invasive species in the spring or drought reducing spring flow. It does not take into account the carrying capacity of the spring.)
- **What does your data tell you about the interaction of endangered species and habitat changes?** (Endangered species often don't survive changes to their habitat, because they have a narrow range of tolerance. Their adaptations are keyed to the habitat making their habitat requirements very specific.)
- **If the number of salamander becomes very small, what happens to the gene pool? If these are the only remaining members of the species, what will happen when they die?** (The gene pool may be so small that reproduction and survival is not possible. The gene pool will be completely gone if the salamanders all die.)
- **How might this affect other organisms in the spring?** (It may change food chains, population dynamics, etc.)
- **How could humans living in the environment where the spring exists enact better environmentally friendly practices to help preserve the endangered salamander?** (Using more natural pest control and fertilizer, not releasing non-native species, being more aware of water use and conserving water in the aquifer)

Vocabulary

Ecologist

Ecology

Endangered

Extinction

Habitat

Herpetologist

Recovery

Status

Taxonomy

Threatened

Extinction Game

The rules for the simulation are:

1. Your group will have 20 dice. Divide them as equally as possible among your group.
2. The number on the dice will tell you what happens to the Barton Springs Salamander living in your spring.

These are the possible outcomes:

The salamander could continue to live well for another month.

The salamander could die.

The salamander could reproduce.

If a salamander is killed (rolls a number that changes the habitat), remove that die from the game.

If a salamander reproduces, add an extra die to the game.

If a salamander keeps living, just leave that die in the game for the next round.

Each of the dice represents one salamander. The numbers on the dice stand for different things that can happen in the habitat in different rounds.

In round one:

1=loss of water in the spring kills off plants in the habitat where the salamander hides and hunts for food and the salamander dies.

2=the salamander reproduces.

3=the salamander keeps living for another month.

4=the salamander keeps living for another month.

5=the salamander keeps living for another month.

6=the salamander keeps living for another month.

In round two:

1=loss of water in the spring kills off plants in the habitat where the salamander hides and hunts for food and the salamander dies.

2=the salamander reproduces.

3=an invasive species is introduced to the spring and the salamander dies.

4=the salamander keeps living for another month.

5=the salamander keeps living for another month.

6=the salamander keeps living for another month.

In round three:

1=loss of water in the spring kills off plants in the habitat where the salamander hides and hunts for food and the salamander dies.

2=the salamander reproduces.

3=an invasive species is introduced to the spring and the salamander dies.

4=chemical pollution makes its way to the spring and the salamander dies.

5=the salamander keeps living for another month.

6=the salamander keeps living for another month.

How to play

Everyone rolls all the dice at the same time.

1) Do what the numbers tell you to do (removing or adding dice "salamanders."
2) On the data table, keep track of how many salamanders are still in the springs after each roll of the dice. (the number of dice still in the game)
3) Play the game for three rounds each representing 20 months. (Roll the dice 20 times for each round.)

Graphing Data

Graph your data. Use a blue pen for round one of the simulation, a green pen for round two of the simulation, and a red pen for round three of the simulation.

Answer these questions in your science journal.

1. **Did your salamanders become extinct?**
2. **If so, in which round did this happen? How many months did it take in that round?**
3. **What can you say about the habitat in which the salamanders became extinct?**
4. **How would the simulation represent what may happen to other endangered species?**
5. **Which changes to the habitat were due to natural causes and which were due to human activities?**
6. **How would the simulation represent what may happen to other endangered species?**
7. **What does your data tell you about the interaction of endangered species and habitat changes? How does it tell us about the cumulative effect of multiple negative changes to an environment?**
8. **If the salamander becomes endangered, what happens to the gene pool? If these are the only remaining members of the species, what will happen when they die?**
9. **How might this affect other organisms in the spring?**

10. How could humans living in the environment where the spring exists enact better environmentally friendly practices to help preserve the endangered salamander?

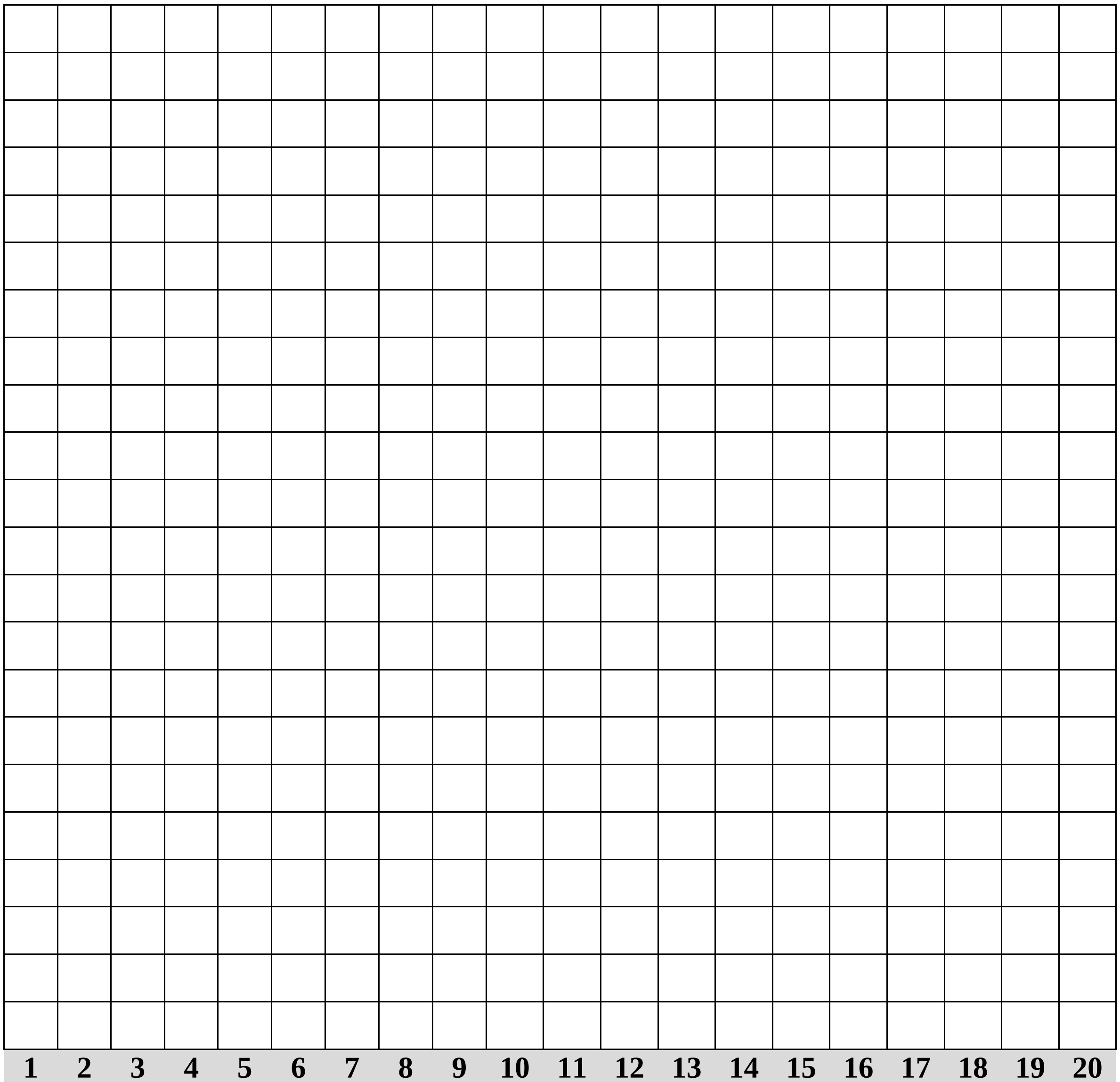
11. How is our model limited?

Extinction Game Data Sheet

	Simulation 1		Simulation 2		Simulation 3
Month	**Number of Salamanders**	**Month**	**Number of Salamanders**	**Month**	**Number of Salamanders**
1		**1**		**1**	
2		**2**		**2**	
3		**3**		**3**	
4		**4**		**4**	
5		**5**		**5**	
6		**6**		**6**	
7		**7**		**7**	
8		**8**		**8**	
9		**9**		**9**	
10		**10**		**10**	
11		**11**		**11**	
12		**12**		**12**	
13		**13**		**13**	
14		**14**		**14**	
15		**15**		**15**	
16		**16**		**16**	
17		**17**		**17**	
18		**18**		**18**	
19		**19**		**19**	
20		**20**		**20**	

Student Page

Graph of Salamander Population



MONTHS

Label the Y axis of your graph and record your results for each simulation. Use a blue pen for the first simulation, a green pen for the second simulation, and a red pen for the third simulation.

What does your data tell you about the interaction of endangered species and habitat changes?

Lesson 7.6: Weird Creatures
Aquifers and Springs

Essential Concept

Unique organisms with very specialized habitat needs live in aquifers and springs.

Objectives

1. Students will use the library and Internet to research an endangered species that lives in aquifers and streams including status, life history, taxonomy, and habitat.
2. Students will evaluate the suitability of the habitat of the aquifer and spring for an alien invaders.
3. Students will write at least a six-paragraph report on their organism.
4. Students will include information on the specialized habitat needs of organisms that live in aquifers and springs.
5. Students will draw a picture of the alien invader species showing some of its characteristics.
6. Student will make a diagram of levels of organization within the spring ecosystem including organisms, populations, communities, and ecosystem.

TEKS

6.2 C; 6.12 D, E, F; 7.2 C; 7.12 A; 7.13 A; 8.2 C; 8.11 A, B, C

Aquatic Science: 2 J; 4 A; 10 B; 11 A; 12 A, B, C, D

Environmental Science: 2 K; 3 B; 4 A, B, F; 7 A, D; 9 A, E

Estimated Time

Varies. Two to three class periods if done in class, or it can be done as homework.

Materials

Library

Internet

Computer

Science journal

Pencils/pens

Endangered and Threatened Animals of Texas by Linda Campbell from Texas Parks and Wildlife Department

Procedure

1. Alien Invasion

Tell students that they will pretend to be aliens planning an invasion on the Earth. They will need to do careful observation of springs and aquifers, because that is where they will live. Their reconnaissance will need to include the kinds of organisms that already inhabit these ecosystems in Texas. They are each to choose one organism that is found in Texas aquifers and springs. They will write a report about their organism and its habitat and the suitability of that habitat as a new home for the aliens.

Students should site sources of their information about Texas organism. (books or websites)

Students should include information about the organism much like scientists use when researching endangered organisms.

They should research:

The status of the animal (threatened, endangered, not threatened)

Its life history

Its taxonomy

The habitat it requires

Any threats to its habitat

All of this should be written from the point of view of someone who wants to live in the same habitat. Be sure to <u>state the characteristics and habitat requirements of the aliens that allow them to out compete the local species</u>.

Students <u>will draw a picture of their alien</u> showing some of its adaptations.

What are the characteristics of the aliens that help them survive in an aquifer and springs?

What atmospheric geological, hydrological, or biological features make this aquatic environment a habitat suitable for the alien invaders?

Will the aliens be able to co-exist with the native organism?

Will the aliens compete with the native organism for survival needs?

Does the native organism present a threat of any kind?

What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?

What impact will human populations have on the viability of the springs as a habitat for the aliens? Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of the spring.

Will human populations impact alien survival due to disease?

Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?

How will carrying capacity be affected by the reproductive rate of the aliens?

Have students make a diagram of the levels of organization within the spring ecosystem including organisms, populations, community, and ecosystem.

Give students the *Middle School* or *High School Rubric for Research Reports* before they start their project. There are also student instructions for middle school and for high school, as well as a list of endangered aquifer and spring organisms from which to choose a subject for research.

Students can choose from the following organisms for their research:

The Comal blind salamander

Rio Grande lesser siren

Pecos gambusia

Concho pupfish

Big Bend gambusia

Comanche Springs pupfish

Leon Springs pupfish

Texas wild rice

San Marcos salamander

Fountain darter

Texas blind salamander

Pecos gambusia

San Marcos gambusia

Clear Creek gambusia

Bone Cave harvestman

Tooth Cave pseudoscorpion

Bee Creek Cave harvestman

Tooth Cave spider

Tooth Cave ground beetle

Kretschmarr Cave mold beetle

Cave cricket

Vocabulary

Alien

Competition

Ecology

Habitat

Invasion

Taxonomy

Alien Invasion

You are an alien from Ach-Too-Oh-Mi, a watery planet. You are planning an invasion on the Earth and will need to do careful observation of springs and aquifers, because that is where you will live. Your reconnaissance will need to include the kinds of organisms that already inhabit these ecosystems.

You will also need to explain something about your alien characteristics that allow you to out compete the local species you have targeted, or fit into an unfilled niche, and what you will need in your habitat. You will write a report about a native organism and its habitat and the suitability of the habitat for your home.

You will choose one animal from an aquifer or spring habitat to research. (See attached list.) You should include information about the organism much like scientists use when researching endangered animals.

You should include in your research:

1. **The status of the organism (threatened, endangered, not threatened)**
2. **Its life history**
3. **Its taxonomy**
4. **The habitat it requires**
5. **Any threats to its habitat**

All of this should be written from the point of view of someone who wants to live in the same habitat. Keep in mind that these aliens evolved in similar habitat conditions. Be sure to <u>state the characteristics that make it superior to native species, or how they fit a different niche and habitat requirements of the aliens</u>.

Students <u>will draw a picture of their alien</u> showing some of its adaptations

1. **What are the characteristics of the aliens that allow it to survive in an aquifer and springs?**
2. **Will the aliens compete with the native organism for survival needs?**
3. **Does the native organism present a threat of any kind?**
4. **What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?**
5. **What impact will human populations have on the viability of the springs as a habitat for the aliens?**
6. **Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?**

Make a <u>diagram of the levels of organization</u> within the spring ecosystem including organisms, populations, community, and ecosystem.

Alien Invasion

You are an alien from Ach-Too-Oh-Mi, a watery planet. You are planning an invasion on the Earth and will need to do careful observation of springs and aquifers, because that is where you will live. Your reconnaissance will need to include the kinds of organisms that already inhabit these ecosystems.

You will also need to explain something about your physical structures and physiological functions that allow you to out compete the local species you have targeted, or fit into an unfilled niche and what you will need in your habitat. You will write a report about a native organism and its habitat and the suitability of the habitat for your home.

You will choose one organism from an aquifer or spring habitat to research. (See attached list.) You should include information about the native organism much like scientists use when researching endangered animals.

You should include in your research:

1. **The status of the organism (threatened, endangered, not threatened)**
2. **Its life history**
3. **Its taxonomy (its relationship to other species)**
4. **The habitat it requires**
5. **Any threats to its habitat**

All of this should be written from the point of view of someone who wants to live in the same habitat. Keep in mind that these aliens evolved in similar habitat conditions. Be sure to <u>state the characteristics that make them superior to native species, or how they fit a different niche and habitat requirements of the aliens</u>. <u>Draw a picture of your alien</u> showing some of its characteristics.

1. **What are the characteristics of the aliens to survive in an aquifer and spring?**
2. **What atmospheric, geological, hydrological, or biological features make this aquatic environment a habitat suitable for the alien invaders?**
3. **Will the aliens compete with the native organism for survival needs? How?**
4. **Does the native organism present a threat of any kind?**
5. **What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?**
6. **What impact will human populations have on the viability of the springs as a habitat for the aliens? Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of the spring.**
7. **Will human populations impact alien survival due to disease?**
8. **Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat in which the aliens wish to live?**
9. **How will carrying capacity be affected by the reproductive rate of the aliens?**

Native Organisms in Texas' Springs and Aquifers

Choose one organism that is found in Texas aquifers and springs from the list below for your research.

The Comal blind salamander

Rio Grande lesser siren

Pecos gambusia

Concho pupfish

Big Bend gambusia

Comanche Springs pupfish

Leon Springs pupfish

Texas wild rice

San Marcos salamander

Fountain darter

Texas blind salamander

Pecos gambusia

San Marcos gambusia

Clear Creek gambusia

Bone Cave harvestman

Tooth Cave pseudoscorpion

Bee Creek Cave harvestman

Tooth Cave spider

Tooth Cave ground beetle

Kretschmarr Cave mold beetle

Cave cricket

Rubric for Alien Invasion Research

I. Organization **Total 10 points**

1. Title
2. Clear concise information
3. Organized in a logical way
4. Includes illustrations (drawing of alien)

II. Appearance **Total 20 points**

1. Neat, clean, attractive
2. Easy to read and colorful
3. Information easy to understand
4. Diagram of levels of organization is neat

III. Accuracy **Total 10 points**

1. Includes all information required
2. Uses web sites and at least 1 book
3. Information is correct and communicated appropriately.
4. Correct writing, grammar, and spelling.

IV. Critical Thinking **Total 20 points**

1. Conclusions based on logical inferences and generalizations related to data collected on websites and in books
2. Sources noted
3. Reasons for conclusions stated
4. Diagram of levels of organization of the ecosystem included

V. Includes the Following Information for the Texas Organism **Total 15 points**

1. The status of the animal
2. Its life history
3. Its taxonomy (its relationship to other species)
4. The habitat it requires
5. Any threats to its habitat

VI. The essay is written from the point of view of the alien who wants to live in the same habitat. Total 25 points

1. What are the characteristics of the aliens that help them survive in an aquifer and springs?
2. Will the aliens compete with the native organism for survival needs?
3. Does the native organism present a threat of any kind?
4. What is the outlook for long-term maintenance and use of the habitat? Will natural events affect the habitat?
5. What impact will human populations have on the viability of the springs as a habitat for the aliens?
6. Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?

Possible Grand Total 100 points

Rubric for Alien Invasion Research

I. Organization **Total 10 points**

1. Title
2. Clear concise information
3. Organized in a logical way
4. Includes illustrations (drawing of alien)

II. Appearance **Total 15 points**

1. Neat, clean, attractive
2. Easy to read and colorful
3. Information easy to understand

III. Accuracy **Total 10 points**

1. Includes all information required
2. Uses web sites and at least 1 book
3. Information is correct and communicated appropriately.
4. Correct writing, grammar, and spelling.

IV. Critical Thinking **Total 15 points**

1. Conclusions based on logical inferences and generalizations related to data collected on websites and in books
2. Sources noted
3. Reasons for conclusions stated

V. Includes the Following Information on Texas Organism **Total 15 points**

1. The status of the animal
2. Its life history
3. Its taxonomy
4. The habitat it requires
5. Any threats to its habitat

VI. The essay is written from the point of view of someone who wants to live in the same habitat. **Total 35 points**

1. What are the characteristics of the aliens to survive in an aquifer and springs?
2. What atmospheric, geological, hydrological, or biological features make this

aquatic environment a habitat suitable for the alien invaders?

3. Will the aliens compete with the native organism for survival needs? How?
4. Does the native organism present a threat of any kind to the alien species? If so, what is the threat?
5. What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?
6. What impact will human populations have on the viability of the springs as a habitat for the aliens? Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of the spring.
7. Will human populations impact alien survival due to disease?
8. Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?
9. How will carrying capacity be affected by the reproductive rate of the aliens?

Possible Grand Total **100 points**

Chapter 7 Assessment

Multiple Choice Questions

Directions

Select the best answer for each of the following multiple-choice questions.

1. A confined aquifer has several parts including:

A Permeable material, karst, and springs
B Recharge zone, permeable material, and springs
C Impermeable material, recharge zone, and springs
D Permeable material, impermeable material, recharge zone, and springs

2. Animals in ecosystems in aquifers are adapted to which of the following conditions?

A Nutrient poor conditions
B Aerobic conditions
C No light
D A and C

3. The headwaters of a river is often found at–

A A spring
B An unconfined aquifer
C A recharge zone
D A low recharge aquifer

4. We can conserve groundwater by all of the below **EXCEPT–**

A Taking chemicals to hazardous waste disposal sites
B Using less fertilizer and herbicides
C Using impermeable materials for building
D Using less water from the aquifer

5. Aquifers are habitat for unique aquatic organisms that require clean, clear, free flowing water. These ecosystems are predictable environments with constant temperature. How would a drought affect these ecosystems?

A Increase temperature
B Decrease spring flow
C Increase carrying capacity
D Decrease aerobic conditions

Write In Questions

1. Draw a Venn Diagram comparing and contrasting ecosystems in aquifers and springs with those on land.

2. Draw a chart to compare the materials and surface interface of three kinds of aquifers.

3. Draw a diagram of how an aquifer can form a spring.

4. Explain how water moves through an aquifer.

5. Explain why both natural and human caused changes to habitat can affect species and cause them to become threatened or endangered.

Chapter 7 Assessment Answer Key

Multiple Choice Questions

1. A confined aquifer has several parts including:

D Permeable material, impermeable material, recharge zone, and springs

2. Animals in ecosystems in aquifers are adapted to which of the following conditions?

D A and C

3. The headwaters of a river is often found at–

A A spring

4. We can conserve groundwater by doing all of the below **EXCEPT–**

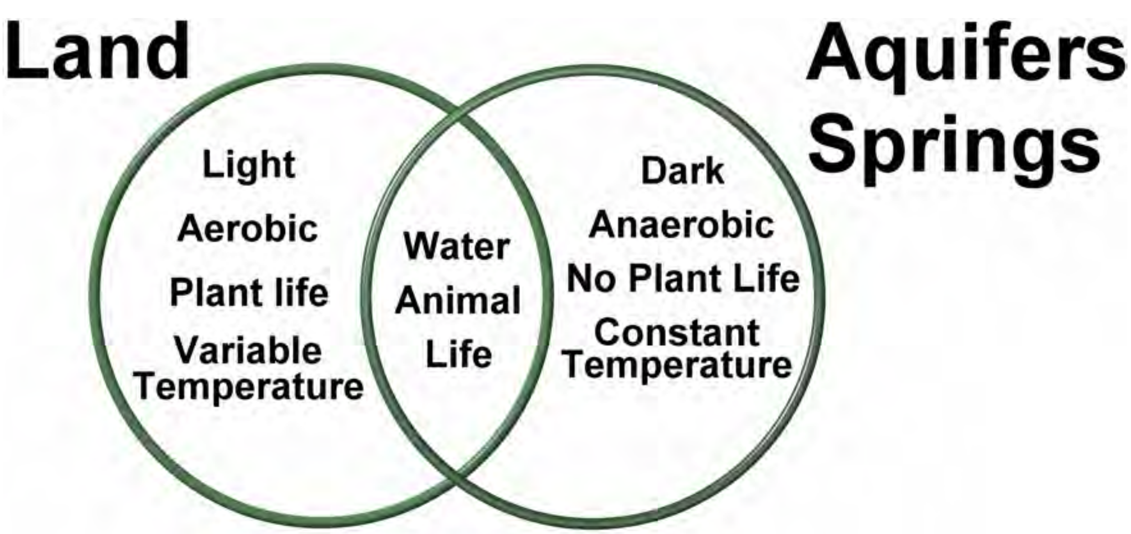
C Using impermeable materials for building

5. Aquifers are habitat for unique aquatic organisms that require clean, clear, free flowing water. These ecosystems are predictable environments with constant temperature. How would a drought affect these ecosystems?

B Decrease spring flow

Write In Questions

1. Draw a Venn Diagram comparing and contrasting ecosystems in aquifers and springs with those on land.



2. Draw a chart to compare the materials and surface interface of three kinds of aquifers.

Aquifer	Materials	Surface Interface
Confined	Permeable materials confined by impermeable materials	Feeds springs
Unconfined	Permeable materials	Directly connected to surface
Karst	Permeable limestone and Marble	Sometimes cave entrances or sinkholes open directly to the surface and lead deep into an aquifer

3. Draw a diagram of how an aquifer can form a spring.

May vary but should show permeable and impermeable material, recharge zone, and springs.

4. Explain how water moves through an aquifer.

Water in an aquifer can travel between grains of sand, through air spaces in gravel, or through pores and channels in limestone and marble. It can even travel in underground streams and rivers in Karst.

5. Explain why both natural and human caused changes to habitat can affect species and cause them to become threatened or endangered.

Because some organism have a narrow range of tolerances and specific habitat needs, any change to the habitat can leave populations decimated and gene pools limited, making reproduction rates fall and threatening the viability of the species.

Streams and Rivers

Texas' many different streams and rivers support diverse ecosystems influenced by the order of the stream and the part of the stream in which the organisms occur. The healthiest streams and rivers are those with the least altered natural processes.

Chapter 8

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Generate information about rivers and streams.
2. Use a graphic organizer to help plan an investigation into a local river or stream.
3. Diagram the parts of a stream and explain how biotic and abiotic factors that make up the stream ecosystem function together.
4. Compare and contrast the adaptations of plants and animals living in flowing water to those of other aquatic and terrestrial species.
5. Predict the impact of flooding on the organisms in a stream ecosystem.
6. Describe how technological solutions to problems, such as levees, dams and channelization, can have risks and unintended consequences.
7. Describe possible solutions to potentially harmful environmental changes within a stream ecosystem.
8. Predict the changes in the number and types of organisms in a stream ecosystem based on stream order. Recognize the factors that affect the number and types of organisms a stream ecosystem can support.
9. Diagram and describe the transfer of energy in a stream food web.
10. Diagram the organization within the stream ecosystem including organisms, population, community and ecosystem.
11. Read the chapter and answer the questions.
12. Explain how organisms respond to the external stimuli in these different habitats.
13. Explain how diversity contributes to sustainability of the stream ecosystem.
14. Explain what will happen to the stream food web if pollution occurs.
15. Make a model of the parts of a stream.

16. Use a three dimensional key to identify aquatic macro-invertebrates.
17. Use what they learned in the three dimensional key to key out an organism from the class native aquarium.
18. Examine maps or aerial photographs to find what order their local stream or river is and predict the types of organism to be found based on the stream order.
19. Conduct a field investigation to determine what organisms that live in the nearest stream or river.
20. Assess the health of the stream or river near them based on the aquatic invertebrates found there.
21. Compare adaptations of organisms from different stream habitats.
22. Use safe practices and conservation of resources in the field.
23. Collect data and record information in tables.
24. Draw conclusions based on data.
25. Make connections between testing of water quality and careers.
26. Identify ways human activity can affect aquatic environments.
27. Continue recording weather and chemical and physical characteristics of their stream or river for their long-term study.
28. Demonstrate the use of course apparatuses, equipment, techniques, and procedures.
29. Collect quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, nitrogen compounds, and turbidity.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, B, C, D, E; 6.3 B; 6.4 A, B; 6.12 E, F; 7.1 A, B; 7.2 A, B, C, D; 7.3 B; 7.4 A, B; 7.5 A, B; 7.7 C; 7.8 A; 7.10 A, B; 7.11 A, B; 7.13 A; 8.1 A, B; 8.2 A, B, C, D, E; 8.3 B; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 B, E, G, H, J; 3 B; 5 A, B, C, D; 7 C; 10 A, B; 11 A, B; 12 A, B, C, D

Environmental Science: 1 A, B; 2 B, E, F, G, H, I, K; 3 B, E; 4 A, B, E, F; 5 A, B, C; 7 A, C, 8 A; 9 A, B, C, E

Materials Needed

Activity 8.1

Science journals

Pencils/pens

White board, chalkboard or chart paper

Markers

KWHL Chart

Activity 8.2

Student Guide

Student journals

Pens/pencils

Activity 8.3

1 ball of yarn

1 set of *Aquatic Organisms* cards from Chapter 5

For each group of 6 students

1 set of stream anatomy cards

Art materials such as:

Construction paper

Scissors

Markers

Colored pens

Chalk

Glue sticks

Student journals

Pens/pencils

Activity 8.4

Laminated copies of two sets of drawings of macro-invertebrates (One set is for the signs and one set for students)

Laminated signs with instructions for each step in the Key

25 wooden stakes approximately 4 feet in length, or music stands, or masking tape

String or painter's tape

A large open area to set up the key/maze

Activity 8.5

Seines and nets including D-frame aquatic dip net and kick seine

Containers for specimen such as:

White trays

Ice cube trays

Hand magnifiers or magnifier boxes

Forceps

Student journals

Pens/pencils

Field guides

Thermometers and weather instruments

Physical Water Quality Indicators check sheet

Bug Picking Water Quality Indicators

High school students should also have secchi disc, stop watch, tennis ball or piece of wood, salinity test, water chemistry test kits

Safety goggles

Gloves

First aid kit

Safety Precautions

Review Field Safety Guidelines.

Vocabulary

- Abdomen
- Channels
- Diverse
- Ecosystem
- Floodplain
- Gills
- Headwaters
- Key
- Larva
- Nymph
- Pool
- Primary consumers
- Producers
- Proleg
- Riffles
- Riparian corridors
- River
- Run
- Secondary consumers
- Segmented legs
- Stream

- Stream banks
- Stream ecologist
- Stream order
- Streambed
- Tertiary consumers
- Thorax
- Wing covers

Enrichments

Project WET

- After Math
- Macro-invertebrate Mayhem

Project WILD Aquatic

- Blue Ribbon Niche
- Riparian Retreat
- To Dam or Not to Dam
- Water Canaries

Videos

Texas, The State of Flowing Water from Texas Parks and Wildlife Department

Texas, The state of Water: Finding a Balance, ”Forests of the River Bottom”

Extension

- Stream Table (*River Cutters* from GEMS)

Service Learning

- Litter pickup

Lesson 8.1: What Do I Know?
What Do I Want to Find Out?

Essential Concept

Rivers and streams are varied in Texas.

Objectives

1. Students will generate information about rivers and streams.
2. Students will use a graphic organizer to help them plan an investigation into a local river or stream.

TEKS

6.2 A, B, C; 7.2 A, B, C; 8.2 A, B, C

Aquatic Science: 2 B, E, J; 3 B;

Environmental Science: 2 B, E, K; 3 B

Estimated Time

1 Class period

Materials

Science journals

Pencils/pens

White board, chalkboard or chart paper

Markers

KWHL Chart

Special Instructions

Set up a KWHL Chart for the class to plan an investigation to a river or stream. The KWHL Chart lists what students **Know**, what they **Want** to find out, **How** they can find out, and what they **Learned.** The **How** of the chart is where students plan what they will do in order to answer the questions they decide to investigate in the **Want to find out** section. What they **Learned** is where they will draw conclusions. (See chart at the end of this lesson.)

Procedure

1. What Do I Know about Rivers and Streams?

Ask students to use their science journals to free-write for five minutes everything they know about rivers and streams.

Use the white board, chalkboard, or chart paper to lead a class discussion by asking each student to contribute something they have written in their science journals to the board without repeating an item. Have students add to their notebooks any information on the board that they hadn't already included.

2. What Do I Want to Find Out?

Start with the information above as the **K** in the KWHL Chart. Walk students through the KWHL chart as a class to plan a field study to investigate rivers or streams. Develop questions to investigate based on what the class **wants to find out. How** will you find the answers to your questions? Plan investigative procedures, data needed, equipment required, etc. When you return from your field trip, add conclusions to the KWHL chart based on what you **learned** during your investigation.

Or, for more advanced students you may have each small group work through the KWHL chart and generate one or two questions they would like to investigate and plan how they can answer their questions. Another possibility would be to have groups generate several questions and then have the class choose some of the questions to investigate and plan their procedures as a class.

Students may come up with a wide variety of ideas about what they want to investigate. Include something about what lives in different places in rivers and streams. You may wish to add to your KWHL chart right before your field trip to incorporate some things that students will learn during the lessons in this chapter.

3. Looking Ahead

Explain to the class that this chapter will help them understand what a stream ecosystem is and how it functions.

Vocabulary

- Diverse
- Ecosystems
- River
- Stream

PLANNING AN INVESTIGATION

What I **KNOW**	What I **WANT** to Find Out	**HOW** I Can Find Out	What I **LEARNED**

Lesson 8.2: Reading and Research

Essential Concept

There is a hierarchy of stream formation from headwaters to streams, to rivers. Streams and rivers have a particular structure with parts that provides habitats for a variety of organisms.

Objectives

1. Students will read the chapter and answer the questions.
2. Students will diagram and label the parts of a third-order stream and list the organisms that could live in each part.
3. Students will explain how the order of the stream influences what can live there.
4. Students will explain how the biotic and abiotic factors in a stream ecosystem function together.
5. Students will explain how organisms respond to the external stimuli in these different habitats.
6. Students will explain how this diversity contributes to sustainability of the stream ecosystem.
7. Students will diagram the organization within a first order stream ecosystem including organisms, population, community and ecosystem.
8. Students will explain how biotic and abiotic factors that make up the stream ecosystem function together.
9. Students will make connections to careers.

TEKS

6.2 C; 6.12 E, F; 7.2 C; 7.5 A, B; 7.7 C; 7.8 A; 7.10 A, B; 7.11 B; 7.13 A; 8.2 C; 8.11 B, C

Aquatic Science: 2 J; 3 B, E; 10 B; 11 A

Environmental Science: 2 K; 3 B, E

Estimated Time

Varies. Reading and answering questions may be done as homework or done in class as cooperative group projects.

30 minutes for *Diagramming Stream Parts*, and *Thinking Questions*

Materials

Student Guide

Student journals

Pens/pencils

Procedure

1. Student Reading

Have students read *Chapter 8: Streams and Rivers*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What are the parts of a stream? How do they function together?

Channel—the part of the stream where water collects to flow downstream

Pools—the deeper, slower-moving places in the stream channel

Riffles—the shallow, faster flowing places in the stream channel

Stream banks—the shoulder-like sides of the stream channel

Riparian zone—the land next to the stream that has plants growing on it (starting at the top of the stream bank)

Floodplain—the flat land on both sides of the river or stream where extra water spreads out during a flood

See also FIG. 8.1 and section titled “Anatomy of a stream” in student guide Chapter 8

2) What is the riparian zone? Why is it important to have plenty of plants growing alongside a stream?

The riparian zone is the land next to the stream that has plants growing on it (starting at the top of the stream bank). A riparian zone with heavy plant cover 100 feet on either side of the stream may be the stream’s best defense against pollution and other problems in the watershed. Plants growing in the riparian zone keep the stream healthy in many ways. Trees shade and cool the water, which increases the amount of dissolved oxygen the water can hold. Roots help hold the stream banks together. Leaves and branches falling into the water provide organic matter for aquatic food webs. Riparian plants offer habitat to birds, bats, and other wildlife.

3) What is the floodplain? Are floods natural disasters?

The floodplain is the flat land on both sides of the river or stream. During a flood, a stream’s extra water spreads out to cover the floodplain. Flooding is a natural characteristic of all streams. By allowing excess water to spread out, floodplains reduce the floodwater’s speed. As a result, less damage occurs in the stream and to regions downstream. While we tend to think of floods as natural disasters, they are really natural events and processes that have positive effects on stream ecosystems. The only disaster comes when humans build in the floodplains.

4) What is stream order? How can it help us understand the aquatic community living

in a particular place?

A first-order stream is a small stream with no tributaries coming into it. First-order streams combine to form larger second-order streams. These larger streams combine to form even bigger third-order streams and so on. A stream's order or size determines the aquatic community it can support. Headwaters, first- and second-order streams have few rooted or floating plants, so aquatic animals depend on debris that falls or is washed into the water. These conditions favor shredders and small fish. Third- through fifth-order streams have both rooted and floating aquatic plants and many more types of animals. In a big river, few rooted plants grow because the water is too deep and very cloudy. Big river conditions favor plankton, collectors, and large fish.

5) What can the presence or absence of aquatic invertebrates tell us about the health of a stream?

Water quality experts look for certain invertebrates that live in riffles on the stream bottom. Examples include the immature stages of stoneflies, caddisflies and mayflies. Many species of these insects are sensitive to pollution. The presence of such species generally indicates good quality water. When they are missing from a stream or when only pollution tolerant species such as black fly larvae and bloodworms are present, we know that something is wrong with the water. High biodiversity—the high number of species—as well as a high number of sensitive species living in a stream are good signs of a healthy stream.

6) How are plants and animals adapted to living in flowing water?

Plants living in moving water have long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place. Mussels burrow to avoid the current and snails use a broad, flat foot to stick to rocks. Water birds have long legs for wading and hunting or webbed feet for swimming and diving. River otters have an oily coat to keep them dry and warm. Fish such as Texas shiners have streamlined bodies that allow them to remain stable in currents. Sculpins and many darter species are adapted as bottom clingers. They tend to have flattened heads and large pectoral fins that are angled to help them stay on the bottom in swift currents. With these advantages they can stay in the swift water of riffles and pick invertebrates from the rocks.

7) How can rivers and streams be kept healthy?

The healthiest streams are those with the least-altered natural processes. A riparian zone with heavy plant cover 100 feet on either side of the stream may be the stream's best defense against pollution and other problems in the watershed. Avoid building roads, houses and levees in floodplains. Remember that everything that happens on the land in a watershed affects the water body into which it drains. Use land and water resources wisely and protect your watershed. Join a Texas Stream Team and help clean up a stream in your community, learn to check water quality, learn more about watershed conservation, and take part in protecting rivers and streams for the future.

8) What do stream ecologists do?

Freshwater stream and river ecologists study the animal and plant life in rivers and streams, and how these organisms interact with their environment. They may conduct surveys of stream life, run statistical analysis, or do research studies. Ecologists usually have masters or doctorate degree in aquatic biology or a related field.

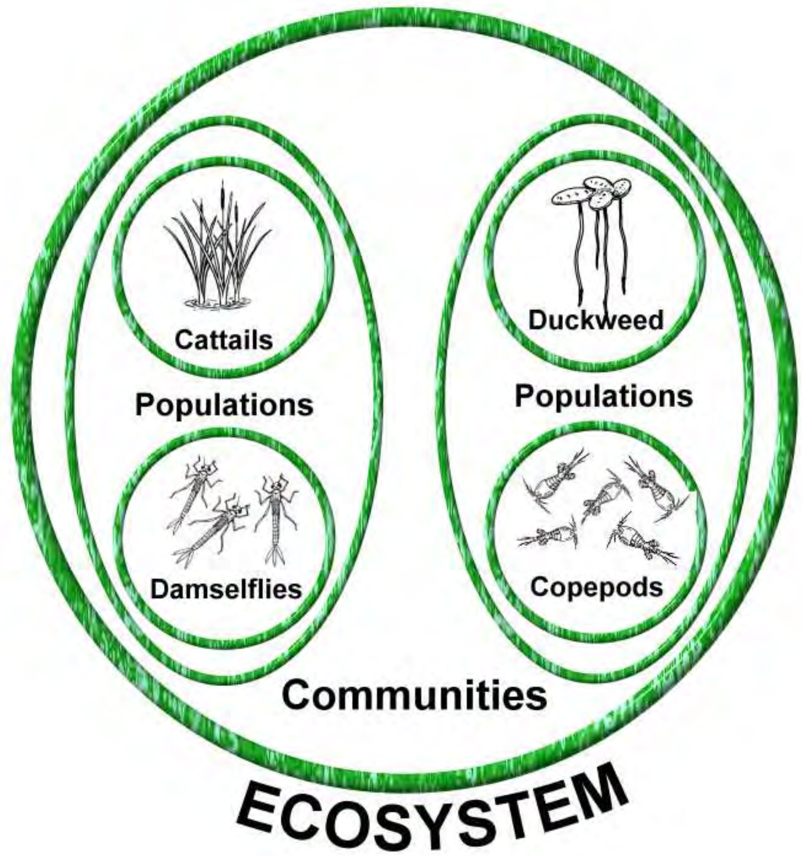
3. Using What We Learned: Diagramming Stream Parts

Ask students to diagram and label the parts of a third-order stream in their science journals.

Thinking Questions

- **List some organisms that would live in riffles, pools, channels, floodplains, stream bottoms, and riparian corridors.**
  1. Riffles: Mayfly nymphs, Stonefly nymphs
  2. Pools: Bluegills,
  3. Channels: plants with long flexible stems and strong roots, bleeding shiners
  4. Floodplains: grasses, bushes, maybe agricultural crops
  5. Stream bottoms: mussels
  6. Riparian Zones: cottonwood trees, willows
- **What are some examples of external stimuli in these different habitats to which aquatic organisms respond? (**Differences in oxygen level in riffles, amount of light for photosynthesis, number of insect larvae available for food, water depth for light penetration for plant growth, etc.)
- **How does the order of the stream influence what can live there?** (Each order of stream has its own set of characteristics such as flow rate, depth of water, amount of light getting to the bottom, amount of plants, amount of sediments, all of which determine the habitat characteristics available.)
- **How does this diversity contribute to sustainability of the stream ecosystem?** The more diverse the ecosystem, the more there are possibilities for provision of needs for survival of each population.

- **Diagram the organization within a first order stream ecosystem including organisms, population, community and ecosystem.**



- **Give an example of how biotic and abiotic factors that make up the stream ecosystem function together.** (**One Example:** Oxygen increases with increased water movement in riffles, allowing more insect nymphs that require more oxygen to survive.)

Vocabulary

- Channels
- First-order streams
- Floodplain
- Headwaters
- Pool
- Riffles
- Riparian corridors
- Rivers

- Run
- Second-order streams
- Stream banks
- Stream ecologist
- Stream order
- Streambed
- Third-order streams

Lesson 8.3: Where Do I Live? What Do I Eat?

Essential Concept

Stream order and stream anatomy affect habitat characteristics, which determine which organisms have their survival needs met.

Objectives

1. Students will use the *Aquatic Organism Cards* from Chapter 5 to make a food web for a stream.
2. Students will explain what will happen to the stream food web if pollution occurs.
3. Students will predict what will happen if a flood occurs or if all the trees are cut down along the riparian zone.
4. Students will make a model of the parts of a stream.
5. Students will explain the importance of stream order in aquatic food webs.
6. Students will diagram an aquatic food web for a specific stream order and label the producers, primary consumers, secondary consumers, and tertiary consumers.

TEKS

6.2 C; 6.3 B; 6.12 E; 7.2 C; 7.3 B; 7.10 A; 8.2 C; 8.3 B; 8.11 A

Aquatic Science: 2 H, J; 5 C; 11 A

Environmental Science: 2 I, K; 4 B; 8 A

Estimated Time

2 class periods

Materials

1 ball of yarn

1 set of Aquatic Organism Cards from Chapter 5

<u>For each group of 6 students</u>

1 set of stream anatomy cards

Student journals

Pens/pencils

Art materials such as:

Construction paper (white)

Tissue paper (blues and greens, browns and tans)

Scissors

Glue sticks

Markers

Colored pens/pencils

Chalk

Watercolors

Procedure

1. Aquatic Food Webs

Provide students with the aquatic animal cards from Chapter 5. Be sure to include all of the plant cards. Ask students to read the name of their organism and the information on their cards to the class. Have students sit in a circle on the floor. Allow one student to sit in the middle of the circle. This student will represent the Sun.

Give the "Sun" a ball of yarn. Ask the ***Sun*** to send energy to one of the plants, such as ***algae***, by holding on to the end of the ball of yarn and rolling the ball to a plant.

The ***algae*** will hold on to the yarn and roll the ball to send energy to one of the herbaceous consumers such as a ***copepod***. When that animal receives the yarn, it will roll the energy on to another consumer such as ***bloodworms.***

The ***bloodworms*** will send energy to a fish.

The fish will send energy to a decomposer such as a ***crayfish***.

Continue on sending energy to each new consumer. If you get to a top predator go from there to a decomposer and from a decomposer back to the plants until all the students are connected in an aquatic food web.

Have students hold up their part of the web so that they can all see how connected they are.

- **What would happen if a disaster struck such as pollution in the stream?** Have students who are stoneflies, which are sensitive to pollution drop their part of the web. Then have students, whose parts of the web touch stoneflies, drop their part of the web. Anyone who has a loose connection on one side of them should drop the web.

Students will see immediately that when one part of the food web is destroyed, it affects everything in the food web.

2. What Will Happen?

- **What will happen to the organisms in the stream ecosystem if flooding occurs?** (A flood could wash away some fish, plants, or other aquatic life, but would not cause long-term damage to the ecosystem. It could even have benefits, such as restoring wetland areas and bringing fresh nutrients.)
- **What will be the impact on the organisms in a stream ecosystem of cutting down all the trees and removing the plants from the stream banks and**

riparian zone? (Without plants to hold the rocks and soil in place, the stream banks would erode, filling the stream's pools with sediment. Major erosion and sedimentation can smother aquatic life and destroy their habitat.

Without plants growing in the riparian zone providing shade, the water would heat up in the sun, which would decrease the amount of dissolved oxygen the water can hold.

No leaves and branches falling into the water would deprive the stream food web of organic matter.

Lack of riparian plants would mean loss of habitat for birds, bats, and other wildlife.)

3. Cast Beyond Tomorrow

Conduct a class discussion to come to an understanding of the true significance of the phrase, **"Everyone lives downstream from someone else."**

- **What is the importance of keeping water flowing in streams and rivers?**
- **What are the threats and opportunities facing stream flow?**

4. Stream Anatomy

Provide the stream parts signs for each group of 6 students. Have each student take one sign and use the art materials to make a representation of that part of a stream. (They may wish to make a drawing, cut out paper shapes, or make a collage or use a combination of materials.) Ask students to arrange themselves in a way that would represent the stream's anatomy.

- **Why are these parts of the stream important?** (Different organisms can survive in different parts of the stream, because each provides different habitat conditions.)
- **How does stream order influence aquatic food webs?** (Smaller streams have less diverse ecosystems because they have fewer resources on which organisms depend.

(**Example:** No aquatic plants means only pieces of plants that fall into the water are available for herbivores/primary consumers. Fewer herbivores means fewer secondary consumers, etc. Larger streams provide more diverse resources and therefore can support more diverse organisms than smaller streams.)

5. Using What We Learned

Have students use markers or colored pencils to draw an aquatic food web in their journals indicating the order of the stream in which this food web would exist. Label: plants/producers, herbivores/primary consumers, omnivores or carnivores/secondary consumers, top predators/tertiary consumers, decomposers or scavengers.

Vocabulary

- First-order stream
- Floodplain
- Headwaters
- Pool
- Primary consumers
- Producers
- Riffles
- Riparian zone
- Run
- Secondary consumers
- Second-order stream
- Stream banks
- Stream channel
- Stream order
- Tertiary consumers

Stream Anatomy Cards

Stream Channel

The channel of the stream is where water concentrates to flow downstream. It includes the bed, the gravel bars and the stream banks. Stream channels always follow a downhill path.

Flood Plain

A relatively level area on one or both sides of the stream channel that carries excess water the channel cannot handle during a flood. Allowing excess water to spread out reduces the floodwater's speed, reducing damage downstream.

Pools

Deeper, slower-moving places in the stream channel.

Riffles

Shallow and fast-flowing water in the stream channel. Riffles mix oxygen into the water.

Riparian Zone

The land bordering a stream channel that begins at the top of the stream banks. A riparian zone at least 100 feet wide and full of plants helps protect the stream ecosystem from sediment and pollution.

Stream Bank

The stream banks are the shoulder-like sides of the stream channel from the water's edge up to the adjacent higher ground. Stable stream banks have plants growing on them that help hold the soil in place and minimize erosion

Lesson 8.4: The Key
to Invertebrate Identification

Essential Concept

We can assess the health of aquatic ecosystems by identifying the macro-invertebrates that live there.

Objectives

1. Students will move through a three dimensional key to identify aquatic macro-invertebrates.
2. Students will use what they learned to key out organisms from the class native aquarium.

TEKS

6.1 A; 6.2 C; 6.4 A; 7.1 A; 7.2 C; 7.4 A; 7.11 A; 8.1 A; 8.2 C; 8.4 A; 8.11 A

Aquatic Science: 1 A; 2 G, J; 10 A; 11 A

Environmental Science: 1 A; 2 G, K; 4 A

Estimated Time

1 class period

Materials

2 Copies of drawings of macro-invertebrates on card stock and laminated (1 set for the signs and 1 set for students

Signs with instructions for each step in the key

25 wooden stakes approximately 4 feet in length, or music stands, or masking tape

String or painter's tape

A large open area to set up the key/maze

Science journals

Pencil/pens/colored pencils

Special Instructions

See *Leader Instructions* at the end of this lesson.

Safety Precautions

This is not a running game. Students should take their time and make decisions about direction to go at each sign.

Procedure

1. Getting Ready

This key was designed for use with the specific invertebrates provided with this activity. Pictures of invertebrates are included with the key. You can match the invertebrate to the answer key to check student answers.

Note: The teacher should walk through the maze with a few different invertebrates to ensure that the maze is set up correctly.

Ask students to handle the drawings carefully so that they can be reused. Drawings should be printed on card stock and laminated before students receive them, and should not be rolled or folded.

Review with the class the important points of invertebrate anatomy before starting. These include: head, thorax, abdomen, gills, wing covers, prolegs, and segmented legs.

Clues for Identifying Invertebrates

To identify the organisms, use body shape, size and other characteristics (number of legs and tails), because the same family can vary in size and color. Ask yourself the following questions to identify an organism:

- How large is the organism?
- Is the body long and slender, round, or curved?
- Does the organism have any tails? How many?
- Does the organism have any antennae?
- Does the organism have legs? How many? Where?
- Is the body smooth and all one section or is it segmented (two or more distinct sections)?
- Does the organism have any gills (fluffy or plate-like appendages)?
- Where are the gills located? Sides, back, underside, under its legs?
- Does it have pinching jaws like a beetle larvae?
- What color is the organism?
- Does the organism swim underwater or remain on the surface?

2. Who Am I?

Today you are going to use an unusual key. This key is like a maze that you walk through. You will read the signs to make decisions about which way to go based on the characteristics of your invertebrate. **Your goal is to work your way through the maze and find the name of your organism.**

Allow students to select an invertebrate and review its anatomy. (You may want to have students draw an organism out of a hat or box to select the critter they will work with in the maze.) The key to success in the maze is in looking at the correct body part and noticing details.

Go over the first clue with the students and explain how to follow the maze. Tell them to read both options before making any decisions.

Each student should walk through the maze with the picture of the invertebrate in hand so that they can compare its features with those on the key signs. Students will make choices and eventually reach a dead end in the maze at the sign with the name of their invertebrate. (A drawing should also be posted at the answer, but should be face down on the back of the sign so that students can't just look for the picture.)

Sometimes students will need correction on a selection. Encourage them to back up or return to the start of the maze until their invertebrate is correctly identified.

If there is time, encourage students to select another invertebrate and repeat the process.

Note: Students can work with a partner to move through the maze or work individually, depending on the level of the students.

3. Using What We Learned

Have students look at the classroom aquarium and choose one of the organisms. Use colored pencils to draw a picture of it in their journals, noting important characteristics and details, and labeling parts. Use this drawing to let your fingers do the walking through the key in an aquatic field guide to find the name of the organism.

- What is the scientific name of your organism? (Write it under the drawing in your journal.)

Vocabulary

- Abdomen
- Gills
- Key
- Larva
- Nymph
- Proleg
- Segmented legs
- Thorax
- Wing covers

The Key to Invertebrate Identification

Instructions and Materials

Teacher Instructions for
The Key to Invertebrate Identification

This activity uses a kinesthetic method of helping students understand how a dichotomous key works to help identify an organism.

Instead of flipping pages in a book, students read signs and physically walk through the key, answering questions and checking descriptions of their organism until they find the name of their organism. The key can be set up outside with signs on stakes or can be set up inside the gymnasium using music stands for the signs or taping signs to the wall. Once students have keyed out a few organisms kinesthetically by walking through the key, they should be better prepared to use an identification key in a field guide and let their fingers do the walking.

Materials

- 2 Copies of drawings of macro-invertebrates (1 set for the signs and 1 set for students)
- Signs with instructions for each step in the Dichotomous Key
- 25 wooden stakes approximately 4 feet in length, or music stands, or masking tape
- String or painter’s tape to connect signs
- A large open area to set up the Key/maze
- Diagram for physical set up of the Key
- Teacher’s Answers to the Key

Setting Up the Key

This activity is a maze that uses a large open space such as a grassy field or a gymnasium. You may wish to have students help set up the maze. Use string and stakes to set up the key outdoor as shown in the diagram. Attach the signs with staples or Velcro and drive stakes into the ground for each station. Indoors you can use music stands or tape signs to the walls, and use painter’s tape on the floor to guide students from one sign to the next.

Print drawings and signs on paper or cardstock and laminate or place drawings and signs in plastic page protectors.

It helps to keep students from getting caught in cross traffic if you make lines connecting the stations at right angles. Use string connecting signs outdoors or painter’s tape on the floor inside.

An example of the key sign layout is included with these instructions to help with the set up.

Attach pictures of invertebrates to the appropriate signs in the key with blank sides out so answers aren't obvious but where students can check their organisms' identification when they have found the name.

Safety Precautions

This is not a running game. Students should take their time and make decisions about the direction to go at each sign.

Teacher Note

This key was designed for use with the specific invertebrates provided with this activity. Pictures of invertebrates are included with the key. You can match the invertebrate to the answer key to check student answers.

The teacher should walk through the maze with a few different invertebrates to ensure that the maze is set up correctly.

Student Instructions

Ask students to handle the drawings carefully so that they can be reused. Drawings should be laminated before students receive them, and should not be rolled or folded.

Review with the class the important points of invertebrate anatomy before starting. These include: head, thorax, abdomen, gills, wing covers, prolegs, and segmented legs.

<u>The key to success in the maze is in looking at the correct body part and noticing details.</u>

Go over the first clue with the students and explain how to follow the maze. Tell them to read both options before making any decisions.

Each student should walk through the maze with the picture of the invertebrate in hand so that they can compare its features with those on the key signs. Students will make choices and eventually reach a dead end in the maze at the sign with the name of their invertebrate. (A drawing should also be posted at the answer, but should be face down on the back of the sign so that students can't just look for the picture.)

Sometimes students will need correction on a selection. Encourage them to back up or return to the start of the maze until their invertebrate is correctly identified.

Aquatic Organism Key

Directions for the Teacher

This key consists of pairs of opposite choices or descriptive statements.

Answering one will take you to the next pair of statements.

Repeat the procedure until the organism is identified.

If you reach a point in the selection of descriptive statements at which neither of the statements apply, you can work your way back through the preceding pairs of statements and perhaps reconsider the choices.

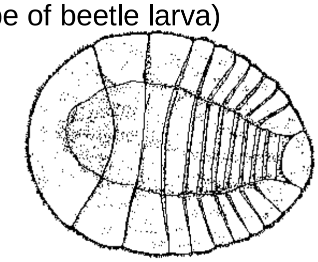
1 A Segmented legs.. Go to 2
  B No Segmented legs... Go to 10

2 A 6 legs... Go to 3
  B More than 6 legs... Go to 17

3 A No wings, or wings not fully developed and do not cover entire body... Go to 4
  B Wings cover entire body, but not legs, may appear beetle like.. Go to 20

4 A Body longer than it is wide.. Go to 5
  B Body oval and flat; head and legs concealed beneath body.. **Water Penny** (a type of beetle larva)

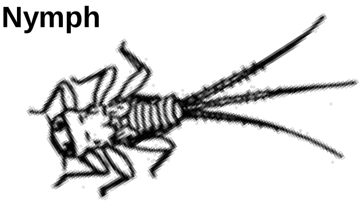
Order Coleoptera, Family Psephenidae
Feeding group: Scraper



5 A 2 or 3 distinct hairlike tails; tails not fleshy or hooked, but may be fringed with hairs..................................... Go to 6
  B Not as above.. Go to 7

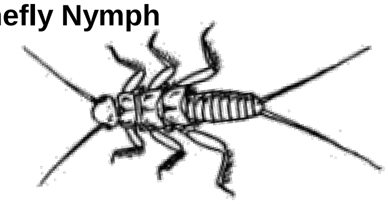
6 A 2-3 tails; platelike or hairlike gills along sides of abdomen; one hook on end of each leg.................... **Mayfly Nymph**

Order Ephemeroptera
Feeding Group: Varies

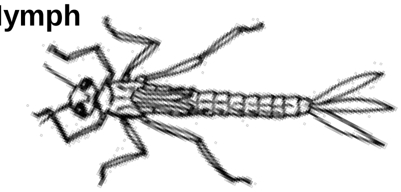


  B 2 tails; may have hairy gills under thorax; 2 hooks on end of each leg.. **Stonefly Nymph**

Order Plecoptera
Feeding Group: Varies



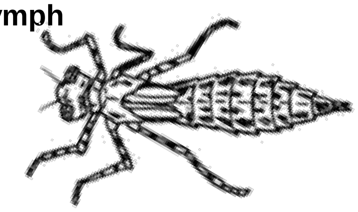
7 A 3 oar-shaped tails (gills) at *end of abdomen; no gills along* sides of abdomen.. **Damselfly Nymph**



Order Odonata, Suborder Zygoptera
Feeding group: Predator

B Not as above.. Go to 8

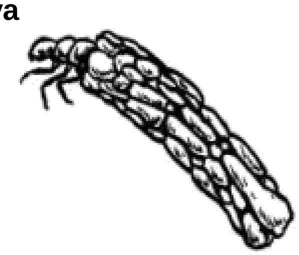
8 A Fat abdomen; large eyes; mask-like lower lip............ **Dragonfly Nymph**



Order Odonata, Suborder Anisoptera
Feeding group: Predator

B Not as above.. Go to 9

9 A May be in a case made of gravel or plant parts; abdomen ends in pair of prolegs which may be hidden by hairs; Each proleg has a single hook on end sometimes fused together.................................. **Caddisfly Larva**

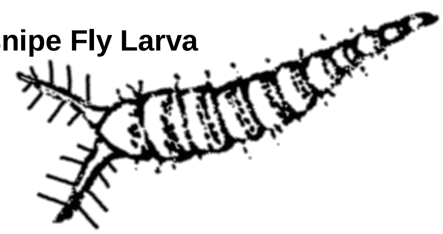


Order Trichoptera
Feeding Group: Varies

B Not as above.. Go to 10

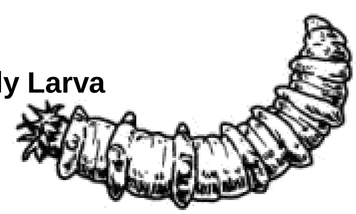
10 A Fleshy caterpillar-like body.. Go to 11
B Body not caterpillar like.. Go to 12

11 A Two feathered "horns" at back end; caterpillar-like legs.. **Watersnipe Fly Larva**



Order Diptera, Family Athericidae
Feeding Group: Predator

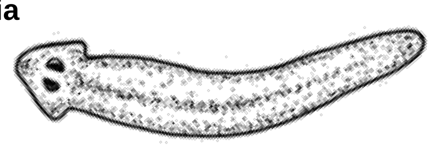
B Can be up to 4" long; head not apparent because it is retracted into body; may have fleshy finger-like extensions at one end.. **Cranefly Larva**



Order Diptera, Family Tipulidae
Feeding Group: Shredder or Predator

12 A Body without hard shell.. Go to 13
B Body with hard shell.. Go to 15

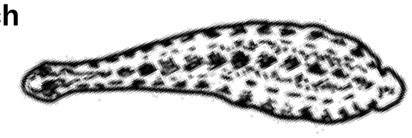
13 A Flattened, unsegmented, worm-like body; distinct eye spots; gliding movement .... **Planeria**



Flatworm, Class Turbellaria
Feeding Group: Predator or Parasite

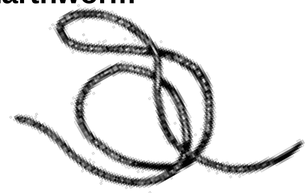
B Segmented body Go to 14

14 A Flattened body with suckers at each end.................... **Leech**



Flatworm, Class Hirudinea
Feeding Group: Predator or Parasite

B Segmented, earthworm-like body................................ **Aquatic Earthworm**



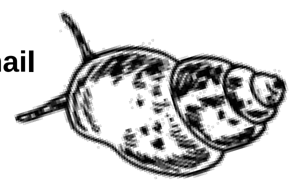
Class Oligochaeta
Feeding Group: Gatherer Collector

15 A Snail-like... Go to 16

B Body enclosed within two hinged shells...................... **Freshwater Clam or Mussel**

Class Pelecypoda
Feeding Group: Filterer Collector

16 A Has operculum (hard covering used to close the opening)... **Gilled Snail**

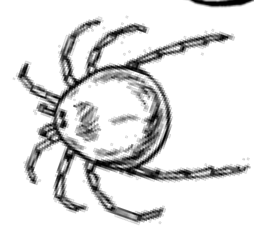


Class Gastropoda, Order Prosobranchia
Feeding Group: Scraper

B No operculum; may be spiral-shaped, limpet-like, or coiled in one plane... **Lung-Breathing Snail**

Class Gastropoda, Order Pulmonata
Feeding Group: Scraper

17 A Looks like spider; may be very tiny has 8 legs........... **Aquatic Mite**



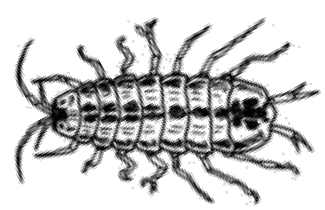
Class Arachnida, Order Hydracarina
Feeding Group: Predator

B Not as above... Go to 18

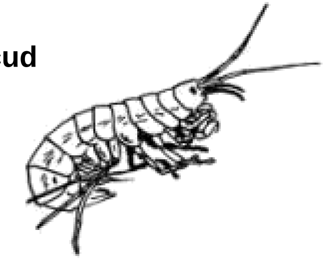
18 A Lobster or shrimp-like.. Go to 19

B Armadillo shaped body, wider than high; crawls slowly on bottom... **Aquatic Sowbug**

Subphylum Crustacea, Order Isopoda
Feeding Group: Shredder

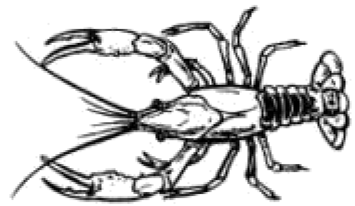


19 A Looks like tiny shrimp; swims quickly on its side......... **Scud**



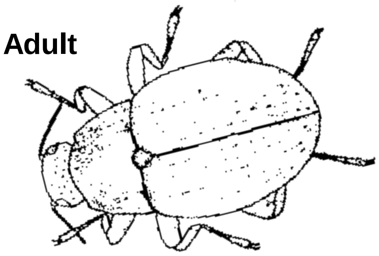
Subphylum Crustacea, Order Amphipoda
Feeding Group: Shredder

B Looks like small lobster; has 2 large front claws (10 legs total).. **Crayfish**



Subphylum Crustacea, Order Decapoda
Feeding Group: Gatherer Collector

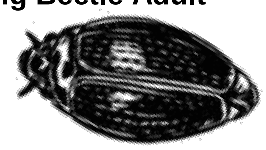
20 A Beetle-like, crawls slowly on bottom........................... **Riffle Beetle Adult**



Order Coleoptera, Family Elmidae
Feeding Group: Scraper or Gatherer Collector

B Beetle-like, swims quickly... Go to 21

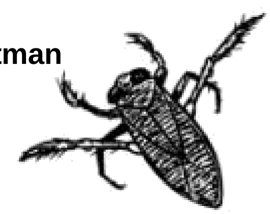
21 A Wings meet along the midline of back side of body, they do not overlap... **Whirligig Beetle Adult**



Order Coleoptera
Feeding Group: Most Are Predators

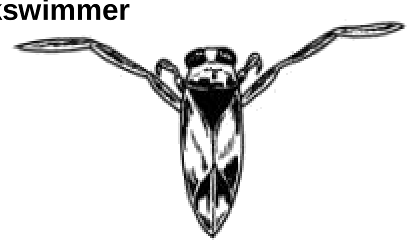
B Wings overlap on backside, usually form a visible triangular pattern just below head.............................. Go to 22

22 A Front legs shorter than mid and hind legs; propels itself with oar-like strokes... **Water Boatman**



Order Hemiptera, Family Corixidae
Feeding Group: Varies

B Similar to backswimmer but swims upside down, on its back... **Backswimmer**



Order Hemiptera, Family Notonectidae
Feeding Group: Predator

Directions for Use
Aquatic Organism Key and Signs for student activity

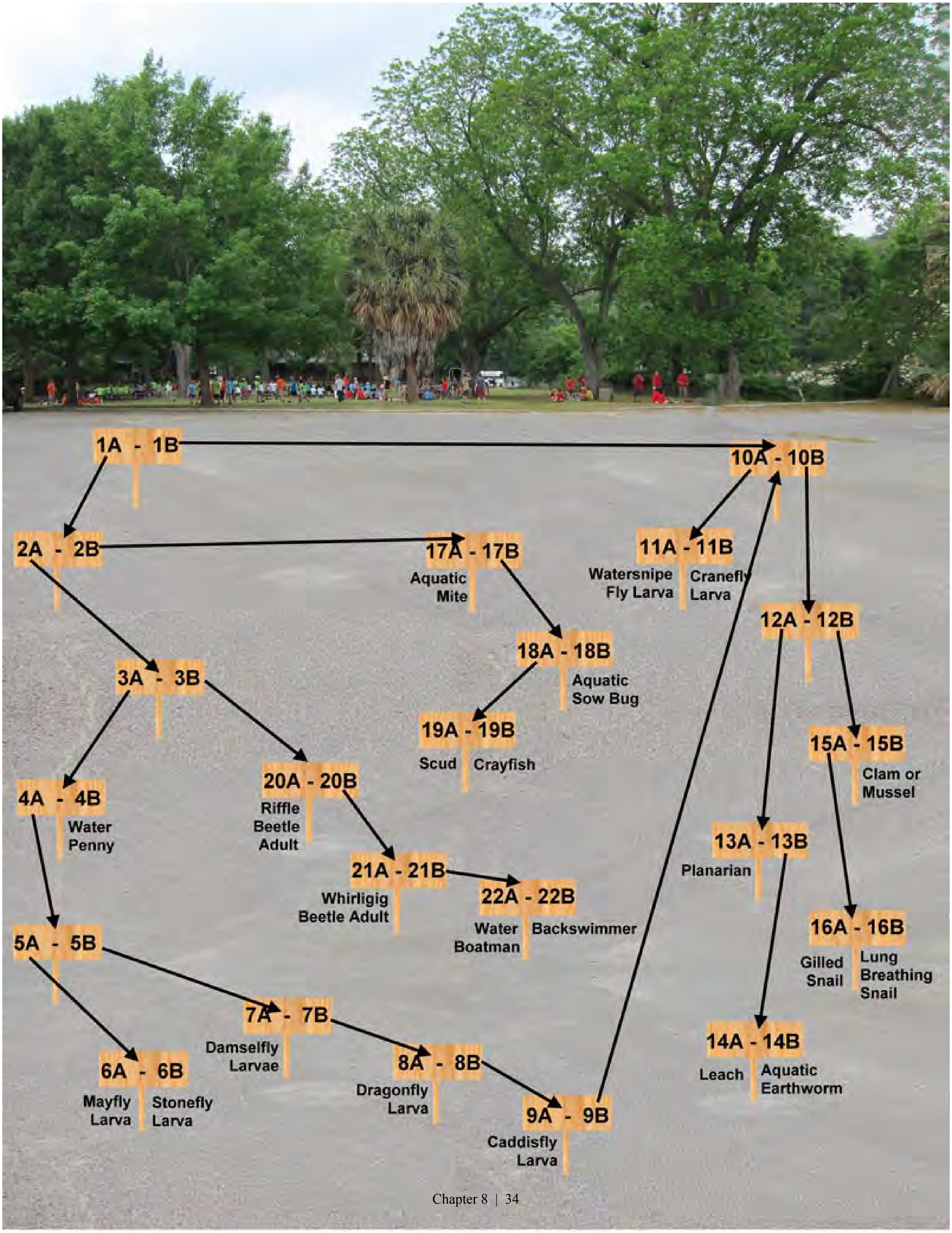
This Aquatic Organism Key consists of pairs of opposite choices or descriptive statements.

To use this key, start at the sign with NUMBER 1 and read the two statements. Decide which statement best describes the organism and walk to that number.

This will take you to the next pair of statements. Repeat the procedure until the organism is identified.

You will find the **organism** ***name and picture on the back of the sign under the flap.***

If you reach a point in the selection of descriptive statements at which neither of the statements apply, you can work your way back through the preceding pairs of statements and reconsider your choices.



1A - 1B
10A - 10B
2A - 2B
17A - 17B
Aquatic Mite
11A - 11B
Watersnipe Fly Larva
Cranefly Larva
12A - 12B
18A - 18B
Aquatic Sow Bug
3A - 3B
19A - 19B
Scud
Crayfish
15A - 15B
Clam or Mussel
4A - 4B
Water Penny
20A - 20B
Riffle Beetle Adult
13A - 13B
Planarian
21A - 21B
Whirligig Beetle Adult
22A - 22B
Water Boatman
Backswimmer
16A - 16B
Gilled Snail
Lung Breathing Snail
5A - 5B
7A - 7B
Damselfly Larvae
6A - 6B
Mayfly Larva
Stonefly Larva
8A - 8B
Dragonfly Larva
14A - 14B
Leach
Aquatic Earthworm
9A - 9B
Caddisfly Larva

NUMBER 1

A Segmented legs........... Go to 2

B No Segmented legs..... Go to 10

NUMBER 2

A 6 legs................................ Go to 3

B More than 6 legs........... Go to 17

NUMBER 3

A No wings, or wings not fully developed and do not cover entire body................................Go to 4

B Wings cover entire body, but not legs, may appear beetle like................................ Go to 20

NUMBER 4

A Body longer than it is wide.................................. Go to 5

B Body oval and flat; head and legs concealed beneath body.................................. Water Penny

Order Coleoptera, Family Psephenidae
Feeding group: Scraper

NUMBER 5

A 2 or 3 distinct hairlike tails; tails not fleshy or hooked, but may be fringed with hairs.................................. Go to 6

B Not as above................. Go to 7

NUMBER 6

A **2-3 tails; platelike or hairlike gills along sides of abdomen; one hook on end of each leg...** **Mayfly Nymph**

Order Ephemeroptera
Feeding Group: Varies

B **2 tails; may have hairy gills under thorax; 2 hooks on end of each leg...............................** **Stonefly Nymph**

Order Plecoptera
Feeding Group: Varies

NUMBER 7

A 3 oar-shaped tails (gills) at *end of abdomen; no gills on* sides of abdomen....... Damselfly Nymph

Order Odonata, Suborder Zygoptera
Feeding group: Predator

B Not as above................ Go to 8

NUMBER 8

A Fat abdomen; large eyes; mask-like lower lip.................................. Dragonfly Nymph

Order Odonata, Suborder Anisoptera
Feeding group: Predator

B Not as above................ Go to 9

NUMBER 9

A **May be in a case made of gravel or plant parts; abdomen ends in pair of prolegs which may be hidden by hairs; Proleg have a single hook on end sometimes fused together......................** **Caddisfly Larva**

Order Trichoptera
Feeding Group: Varies

B **Not as above......................** **Go to 10**

NUMBER 10

A Fleshy caterpillar-like body................................. Go to 11

B Body not caterpillar like.................................. Go to 12

NUMBER 11

A Two feathered “horns” at end; caterpillar-like legs……. **Watersnipe Fly Larva**

Order Diptera, Family Athericidae
Feeding Group: Predator

B Can be up to 4” long; head not apparent because it is retracted into body; may have fleshy finger-like extensions at one end………. **Cranefly Larva**

Order Diptera, Family Tipulidae
Feeding Group: Shredder or Predator

NUMBER 12

A Body without hard shell.................................. Go to 13

B Body with hard shell.... Go to 15

NUMBER 13

A Flattened, worm-like,
unsegmented body;
distinct eye spots;
gliding movement .... Planeria

Flatworm, Class Turbellaria
Feeding Group: Predator or Parasite

B Segmented body.......... Go to 14

NUMBER 14

A Flattened body with suckers at each end..... Leech

Flatwork, Class Hirudinea
Feeding Group: Predator or Parasite

B Segmented body, earthworm-like............. Aquatic Earthworm

Class Oligochaeta
Feeding Group: Gatherer Collector

NUMBER 15

A Snail-like...................... Go to 16

B Body enclosed within two hinged shells........................... Freshwater Clam or Mussel

Class Pelecypoda
Feeding Group: Filterer Collector

NUMBER 16

A Has operculum (hard covering used to close the opening)................................... **Gilled Snail**

Class Gastropoda, Order Prosobranchia
Feeding Group: Scraper

B No operculum; may be spiral-shaped, limpet-like, or coiled in one plane............................. **Lung-Breathing Snail**

Class Gastropoda, Order Pulmonata
Feeding Group: Scraper

NUMBER 17

A Looks like spider; may be tiny, has 8 legs........ Aquatic Mite

Class Arachnida, Order Hydracarina
Feeding Group: Predator

B Not as above.................. Go to 18

NUMBER 18

A Lobster or shrimp-like.................................. Go to 19

B Armadillo-shaped, wider than high; crawls on bottom........ Aquatic Sowbug

Subphylum Crustacea, Order Isopoda
Feeding Group: Shredder

NUMBER 19

A Looks like tiny shrimp; swims quickly on its side.. **Scud**

Subphylum Crustacea, Order Amphipoda
Feeding Group: Shredder

B Looks like small lobster; has 2 large front claws (10 legs total)....................................... **Crayfish**

Subphylum Crustacea, Order Decapoda
Feeding Group: Gatherer Collector

NUMBER 20

A Beetle-like, crawls slowly on bottom.............................. Riffle Beetle Adult

Order Coleoptera, Family Elmidae
Feeding Group: Scraper or Gatherer Collector

B Beetle-like, swims quickly............................ Go to 21

NUMBER 21

A Wings meet along midline of back of body, and do not overlap.. **Whirligig Beetle Adult**

Order Coleoptera
Feeding Group: Most Are Predators

B Wings overlap on backside, usually form a visible triangular pattern below head... **Go to 22**

NUMBER 22

A Front legs shorter than mid and hind legs; propels itself with oar-like strokes........................ **Water Boatman**

Order Hemiptera, Family Corixidae
Feeding Group: Varies

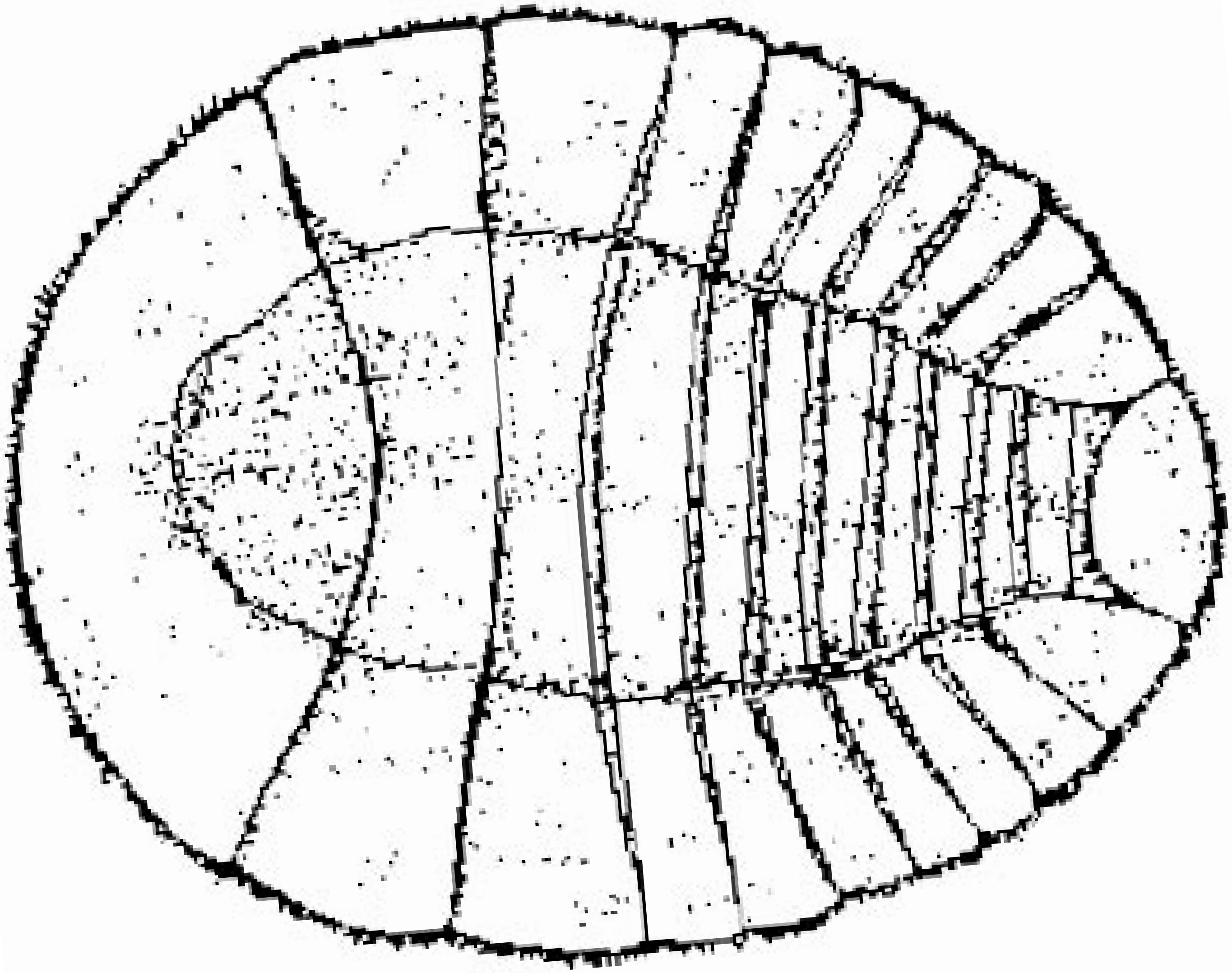
B Similar to backswimmer but swims upside down, on its back........................ **Backswimmer**

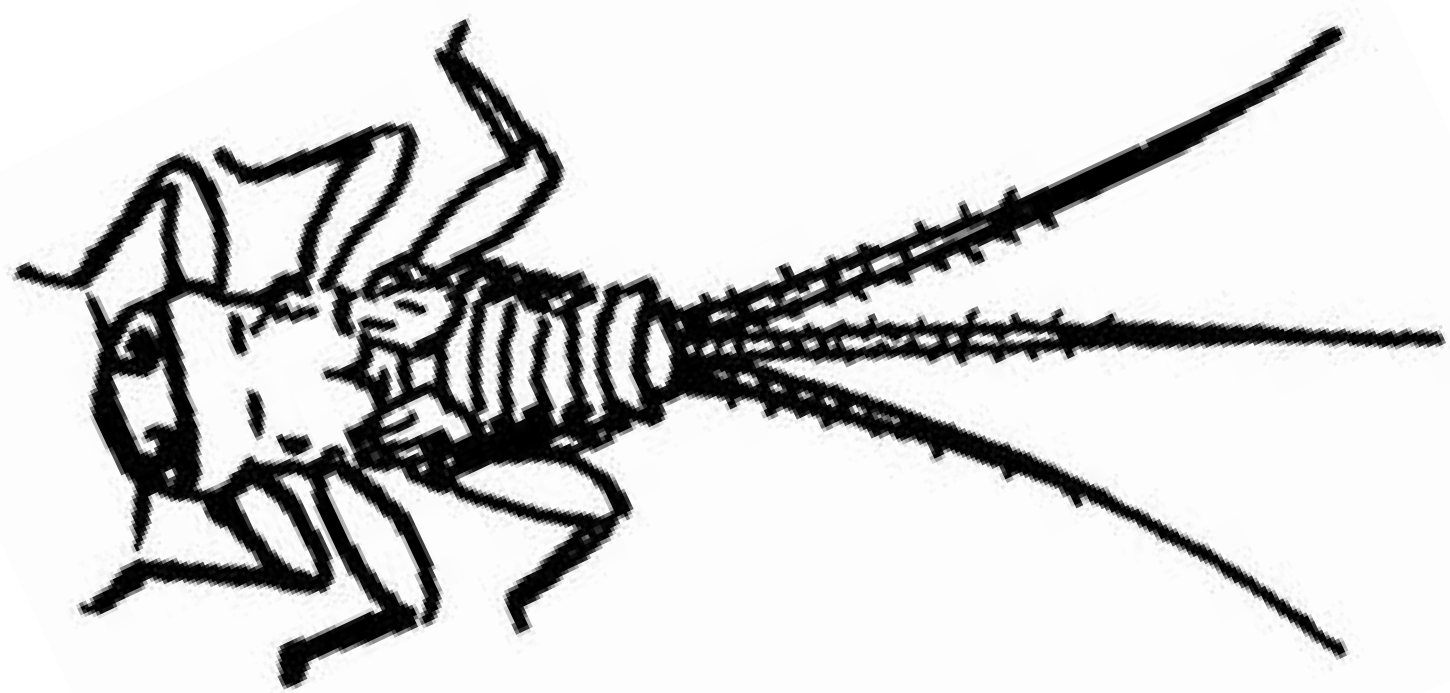
Order Hemiptera, Family Notonectidae
Feeding Group: Predator

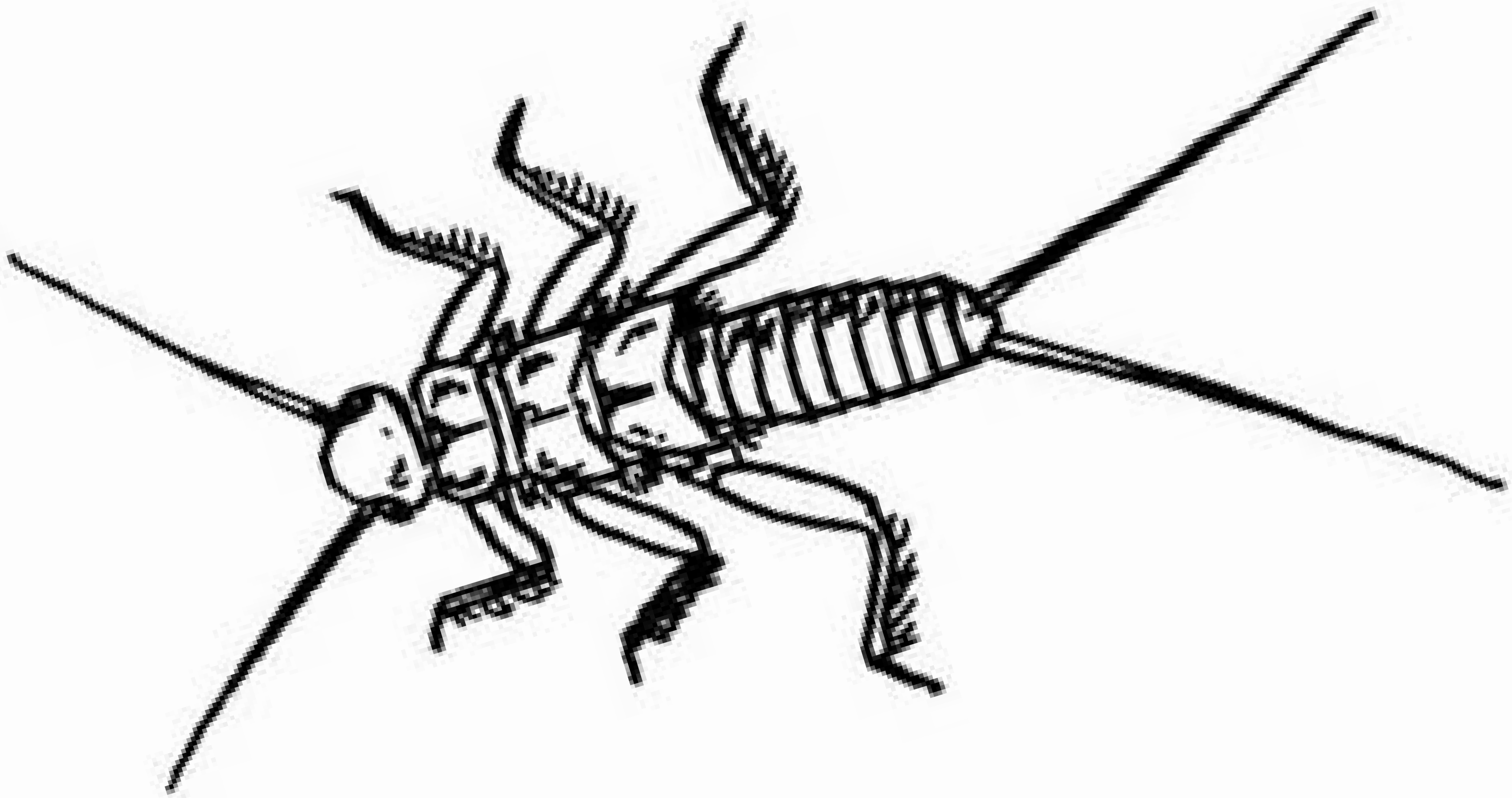
DRAWINGS

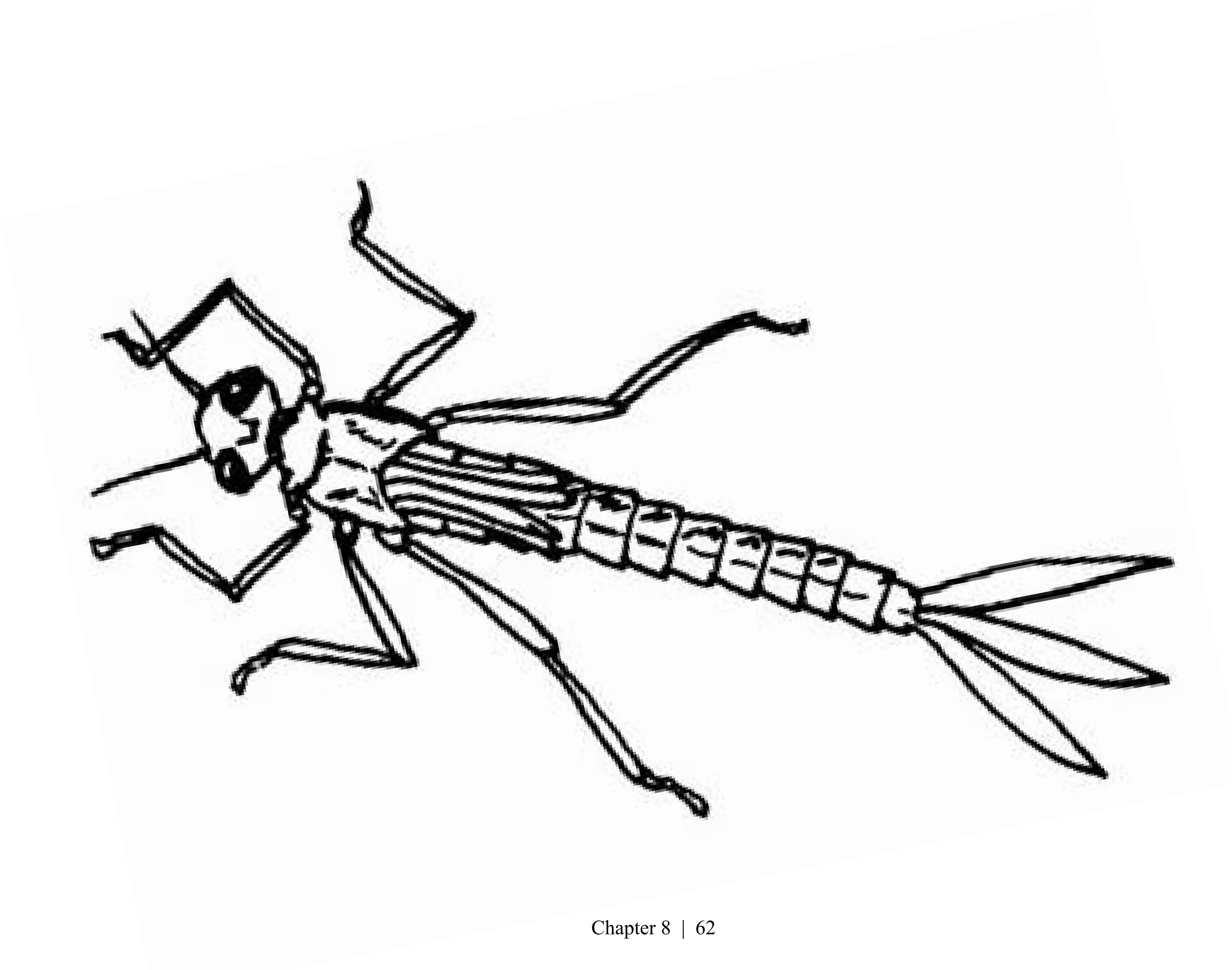
For students and for answers on back of sign

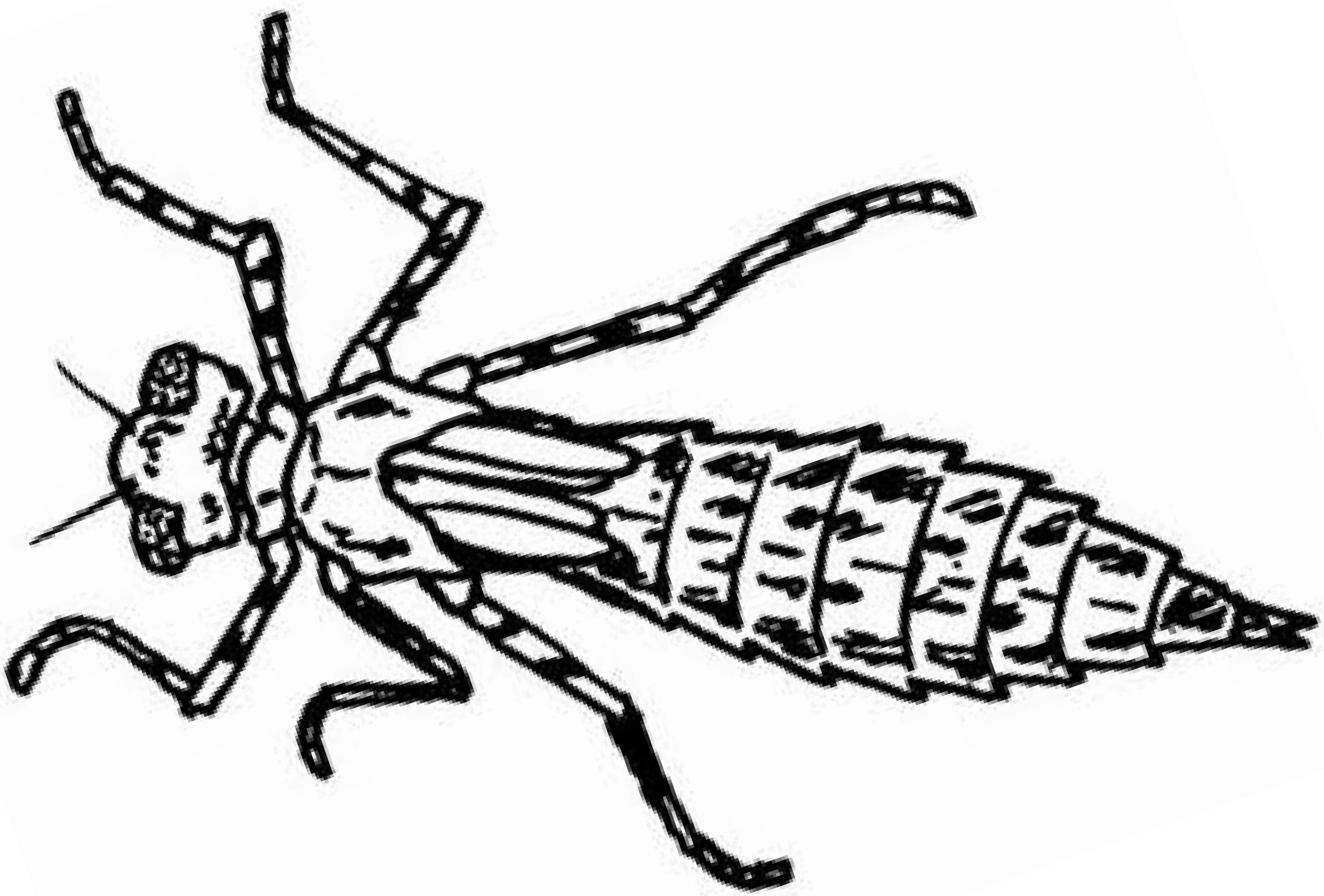
(Make 2 copies)

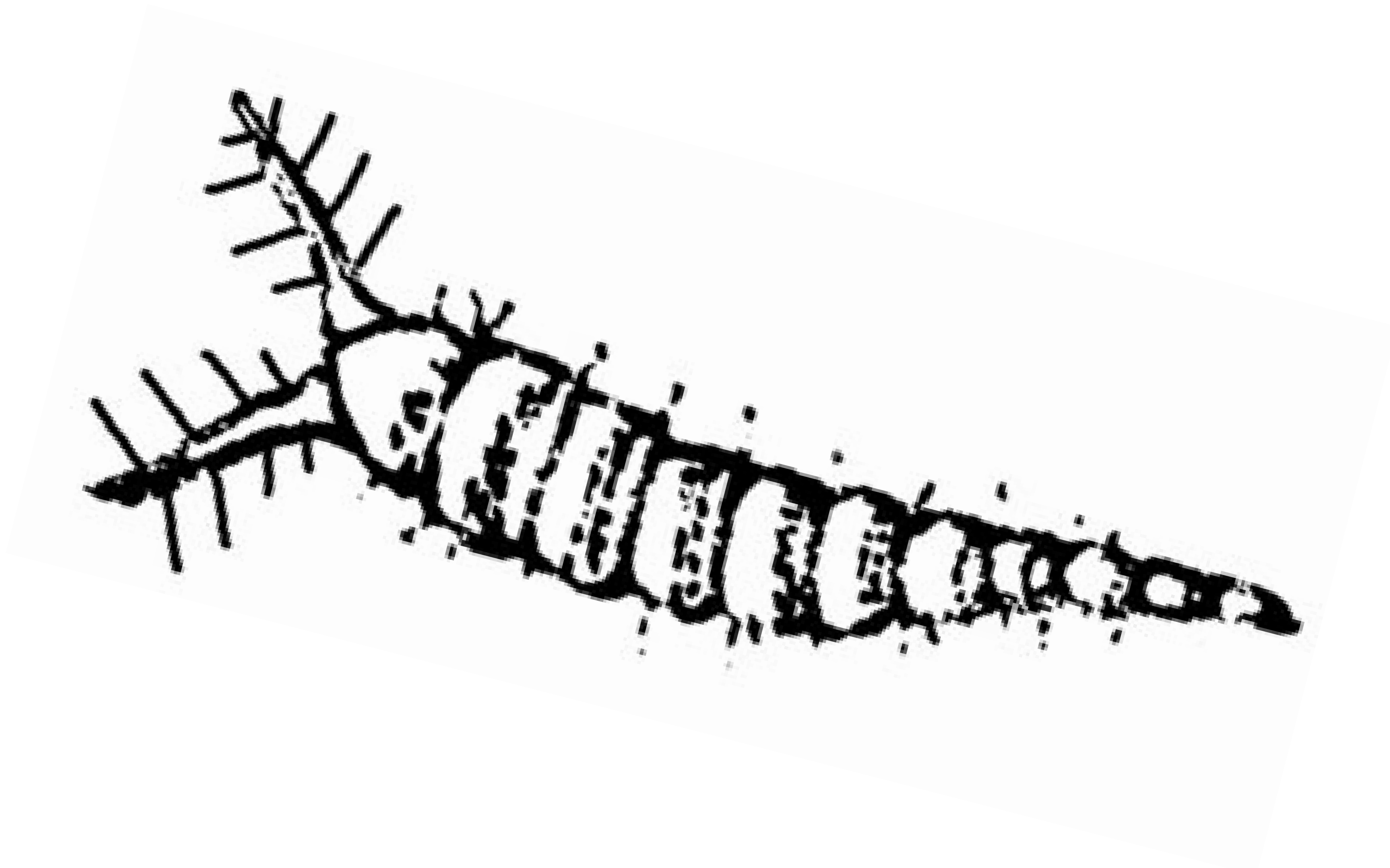


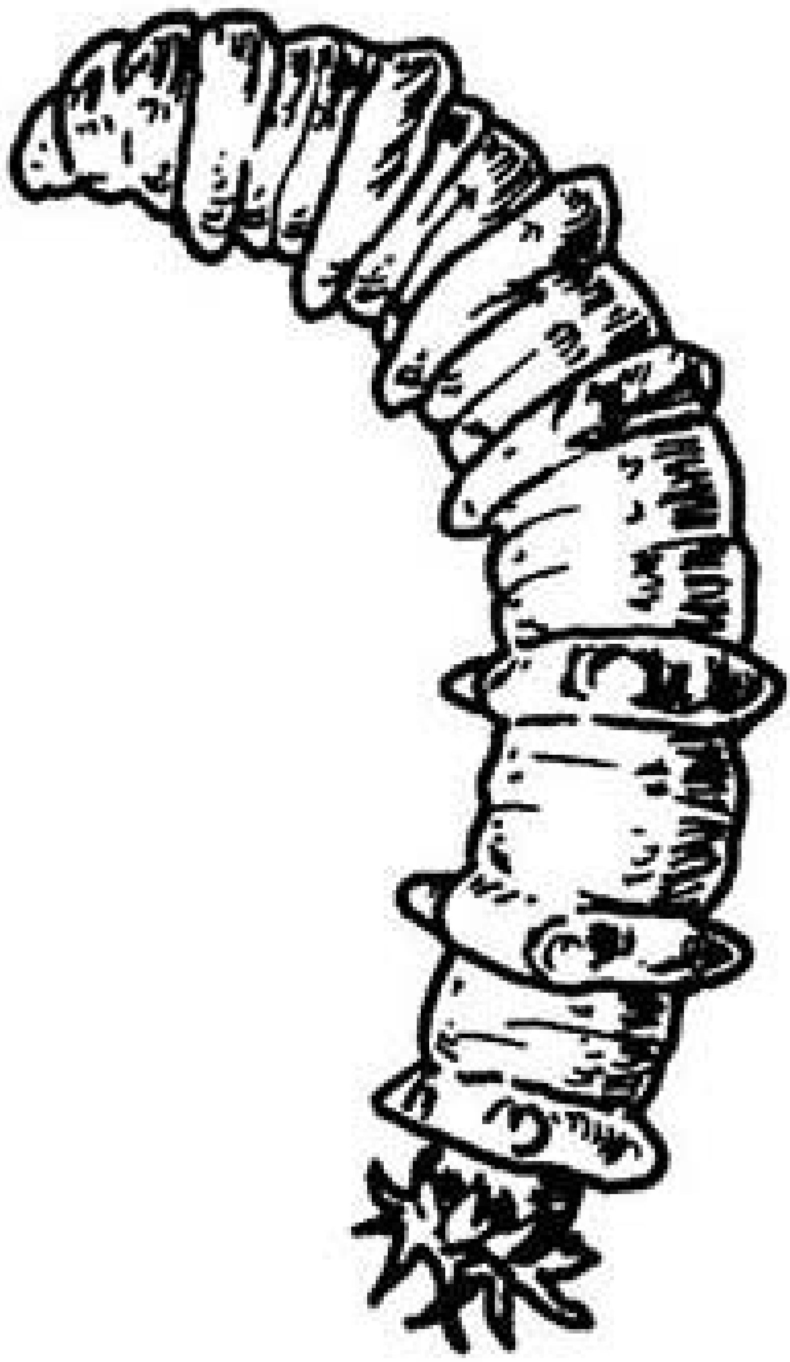


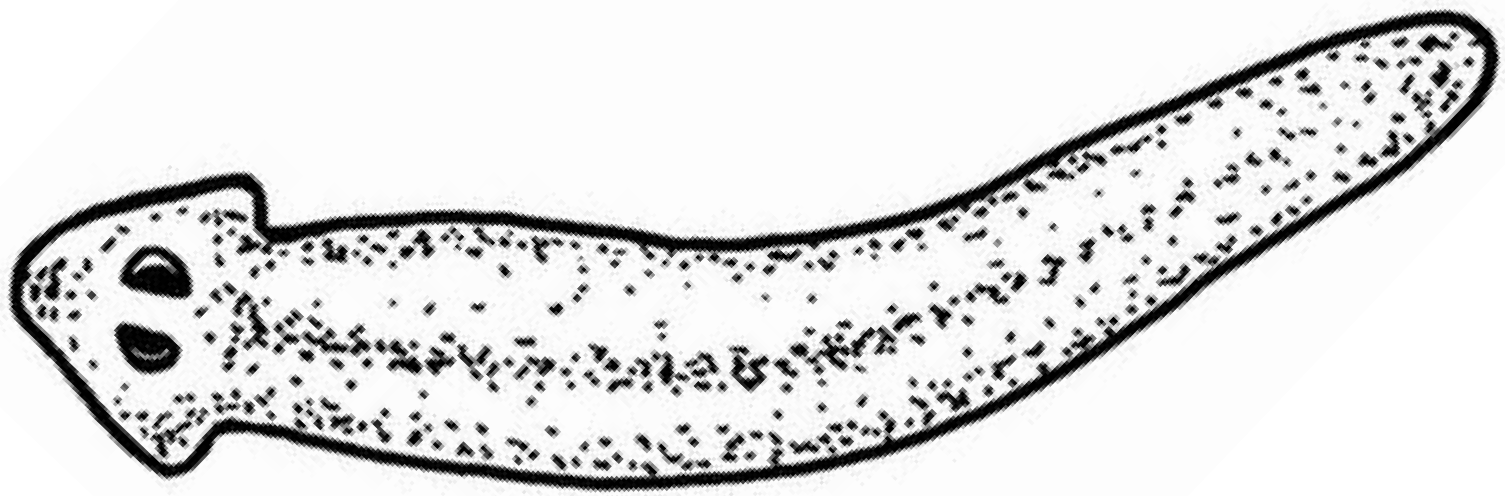


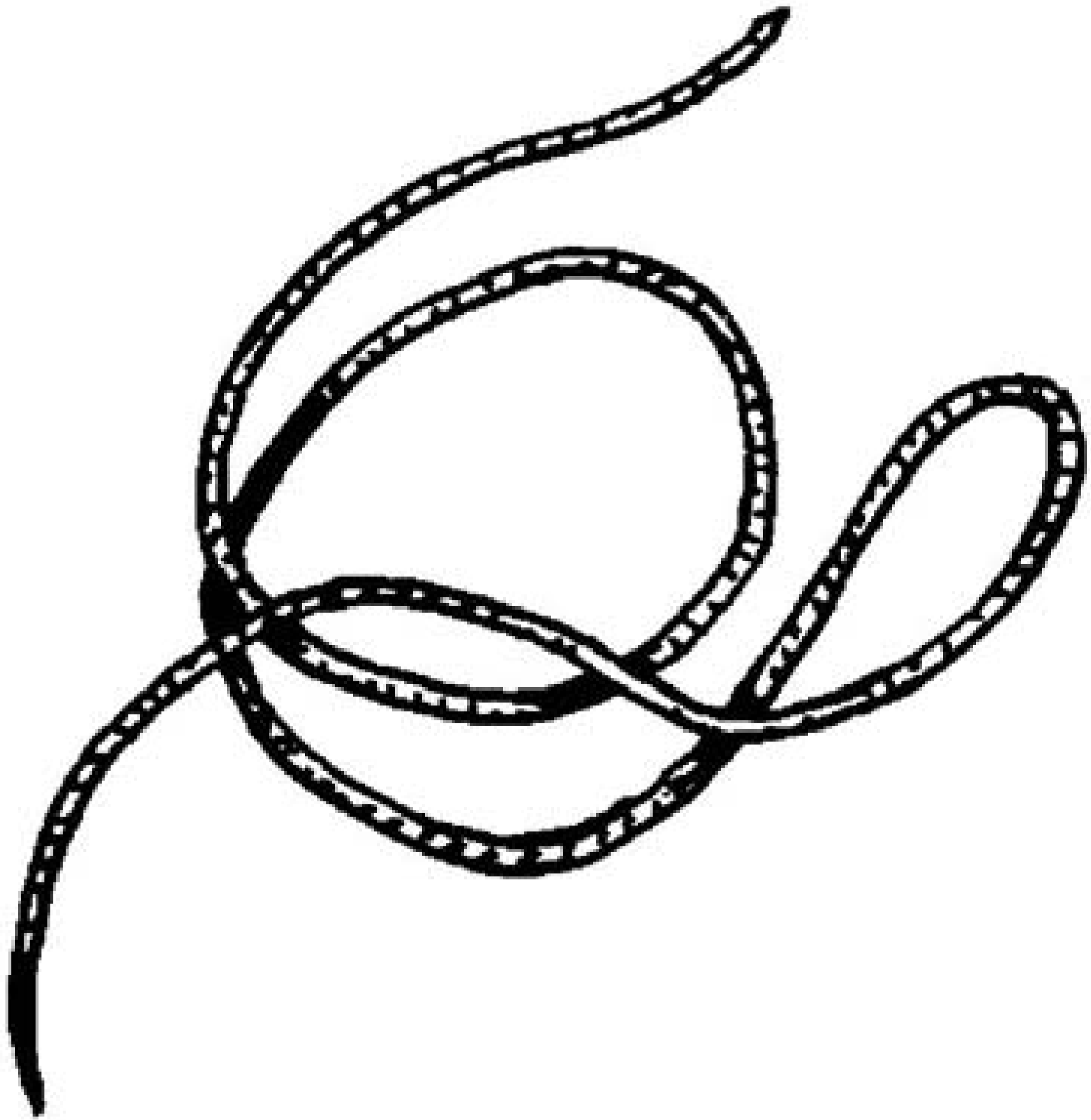


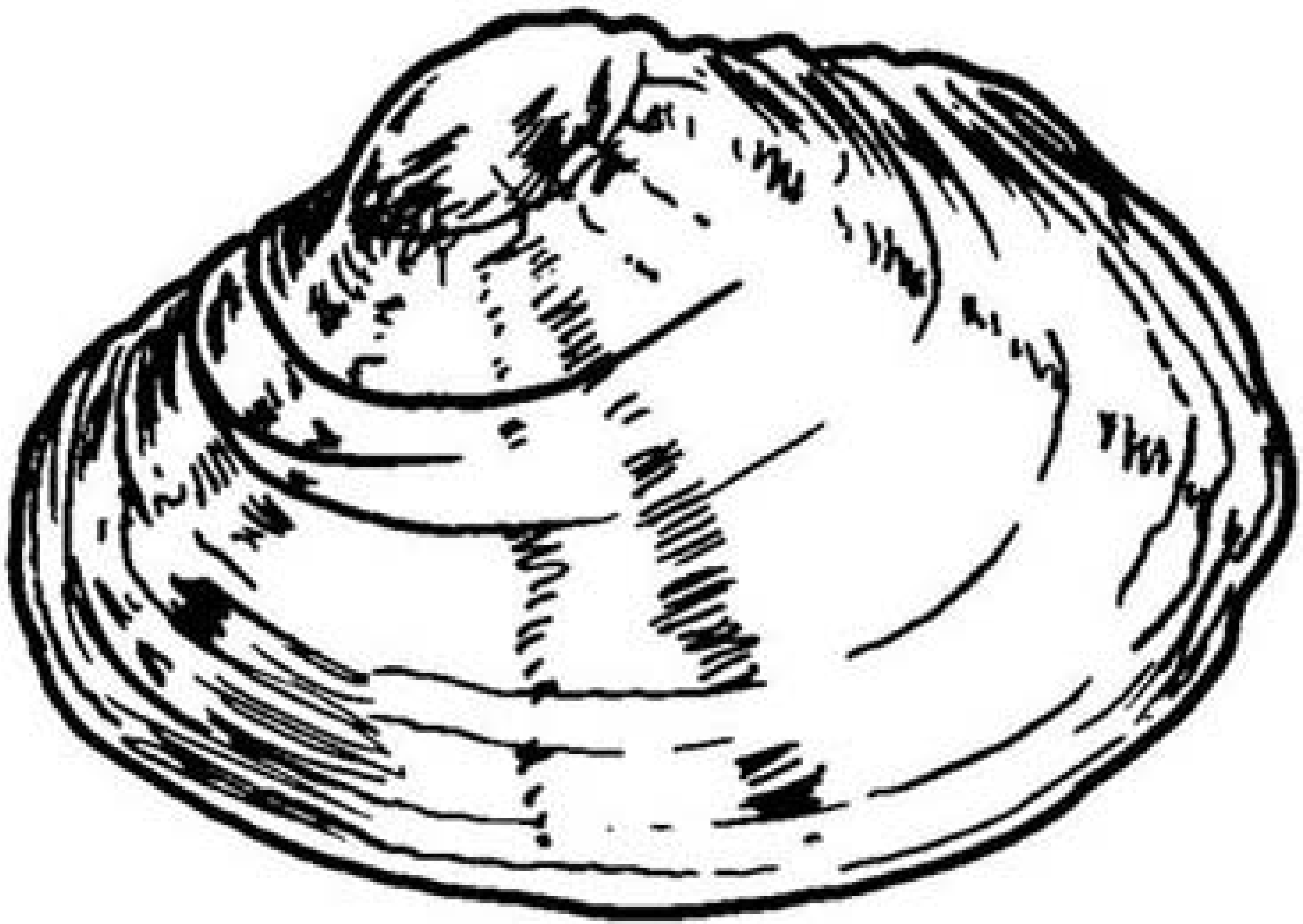


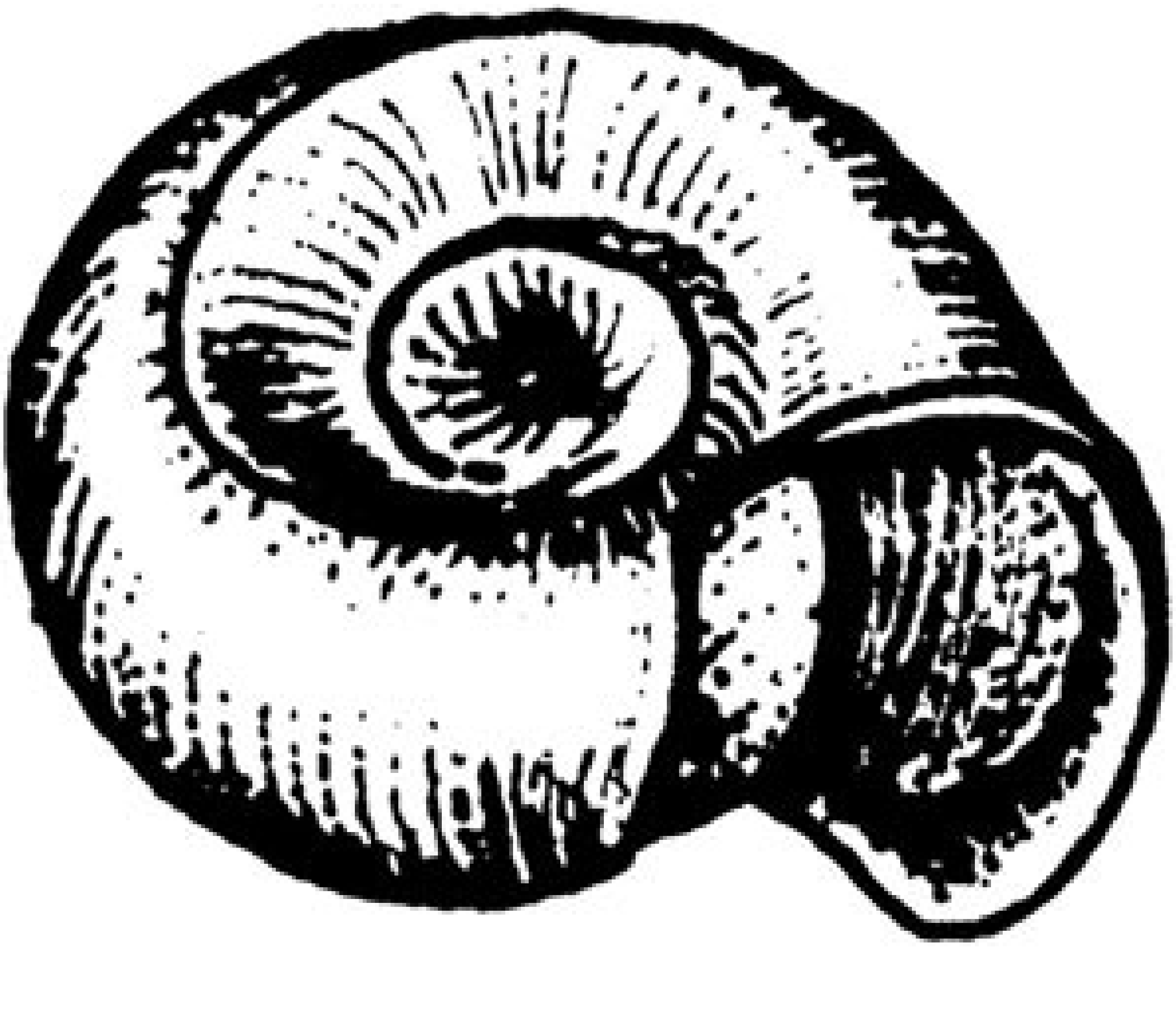


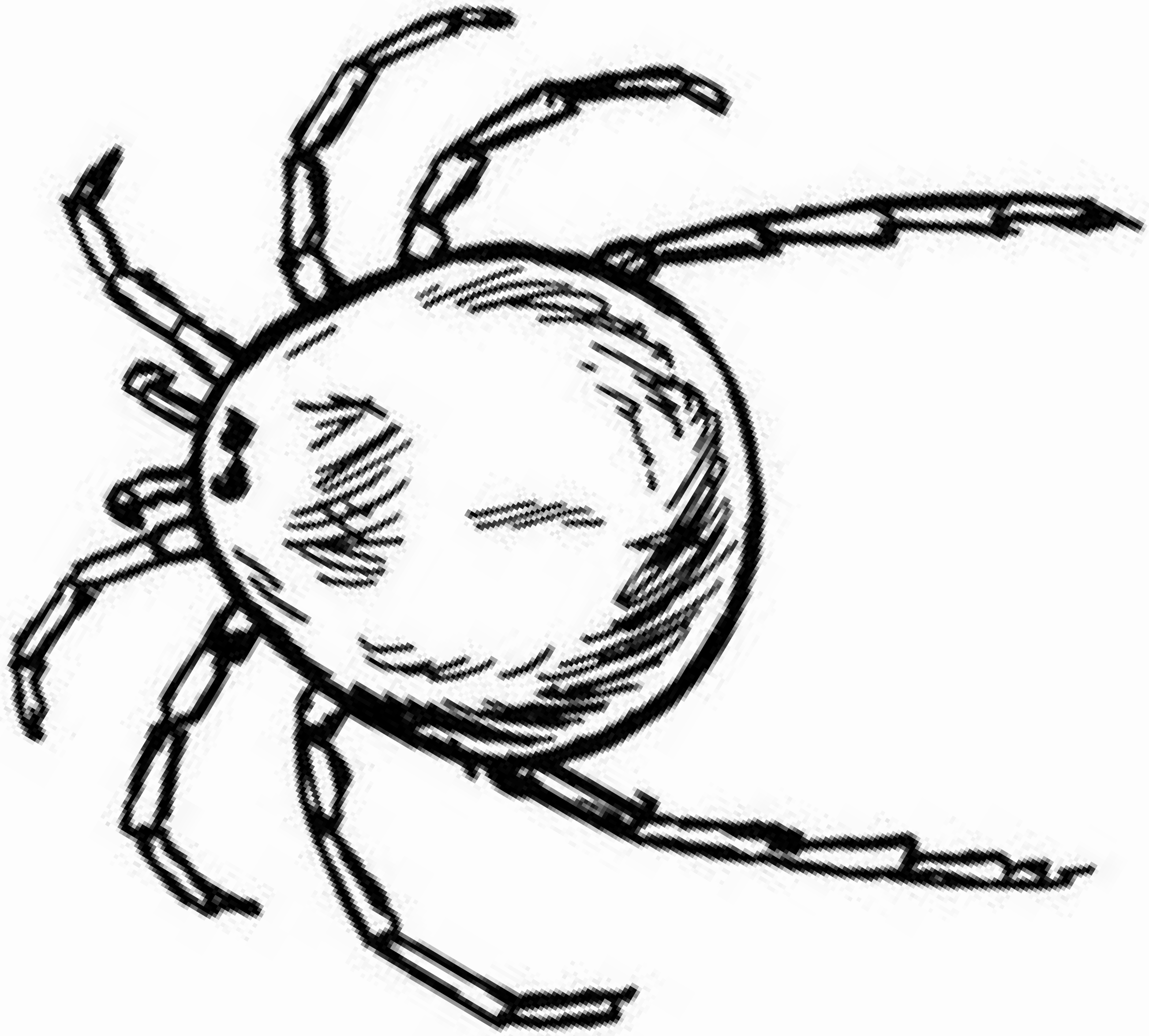


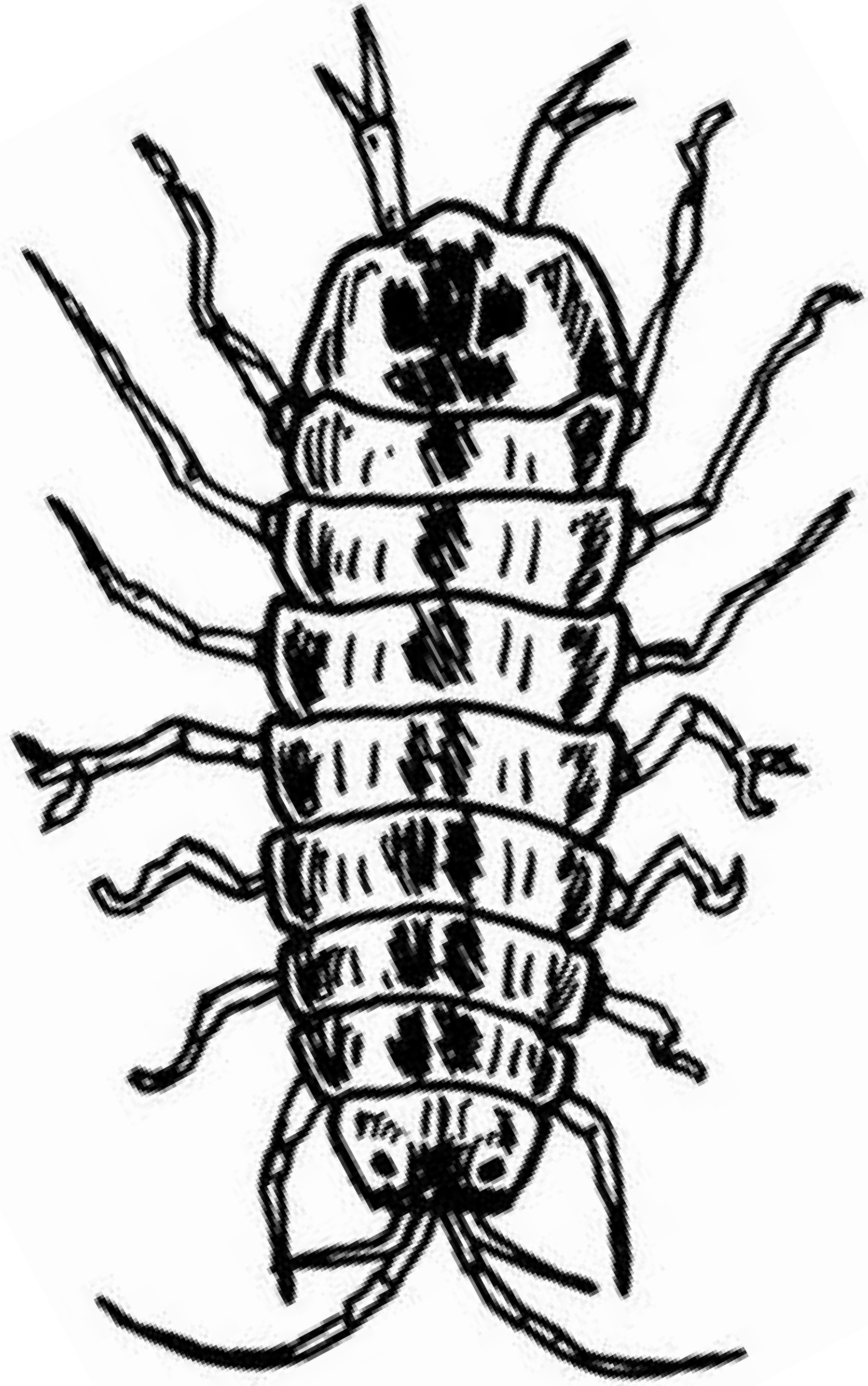


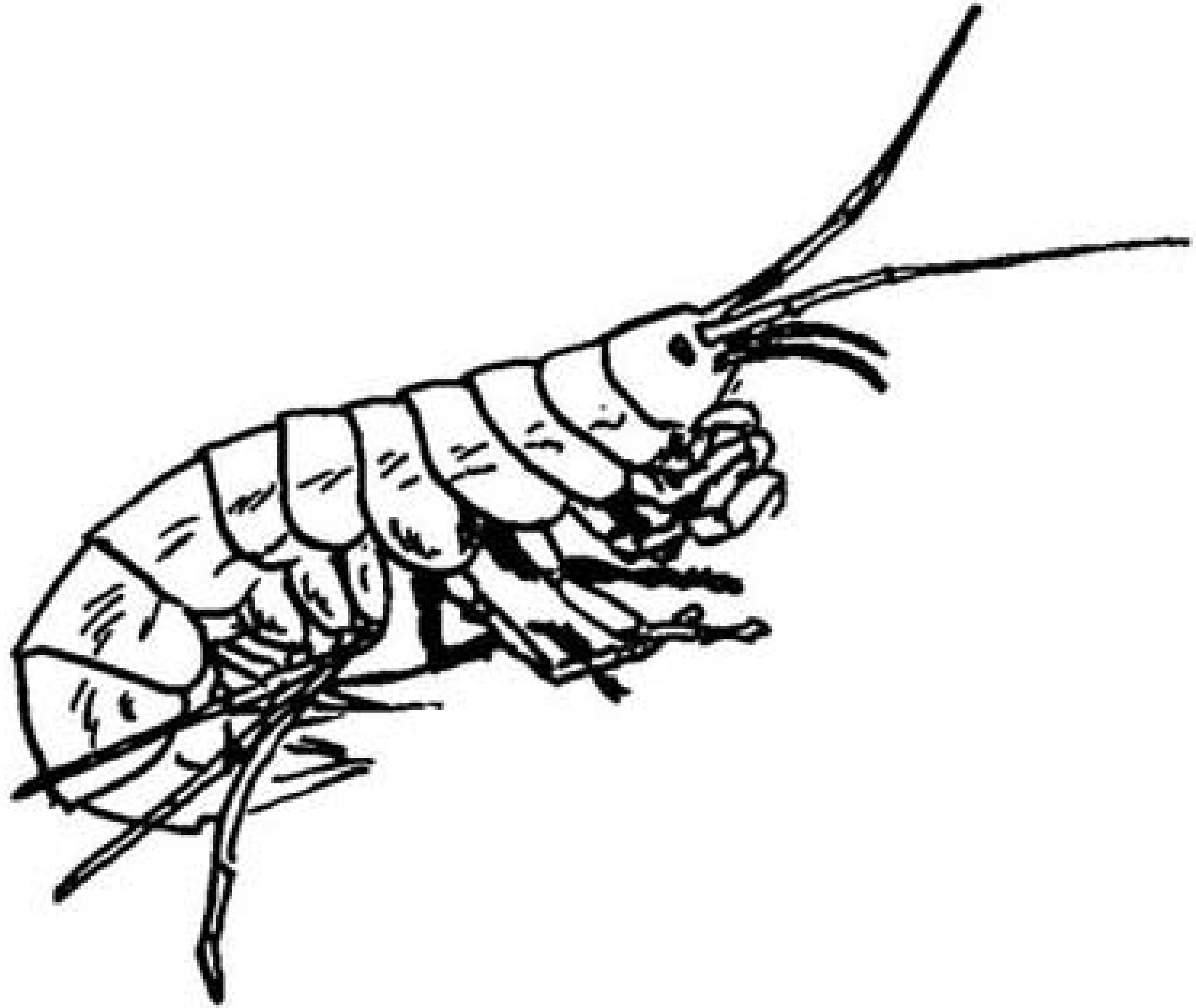


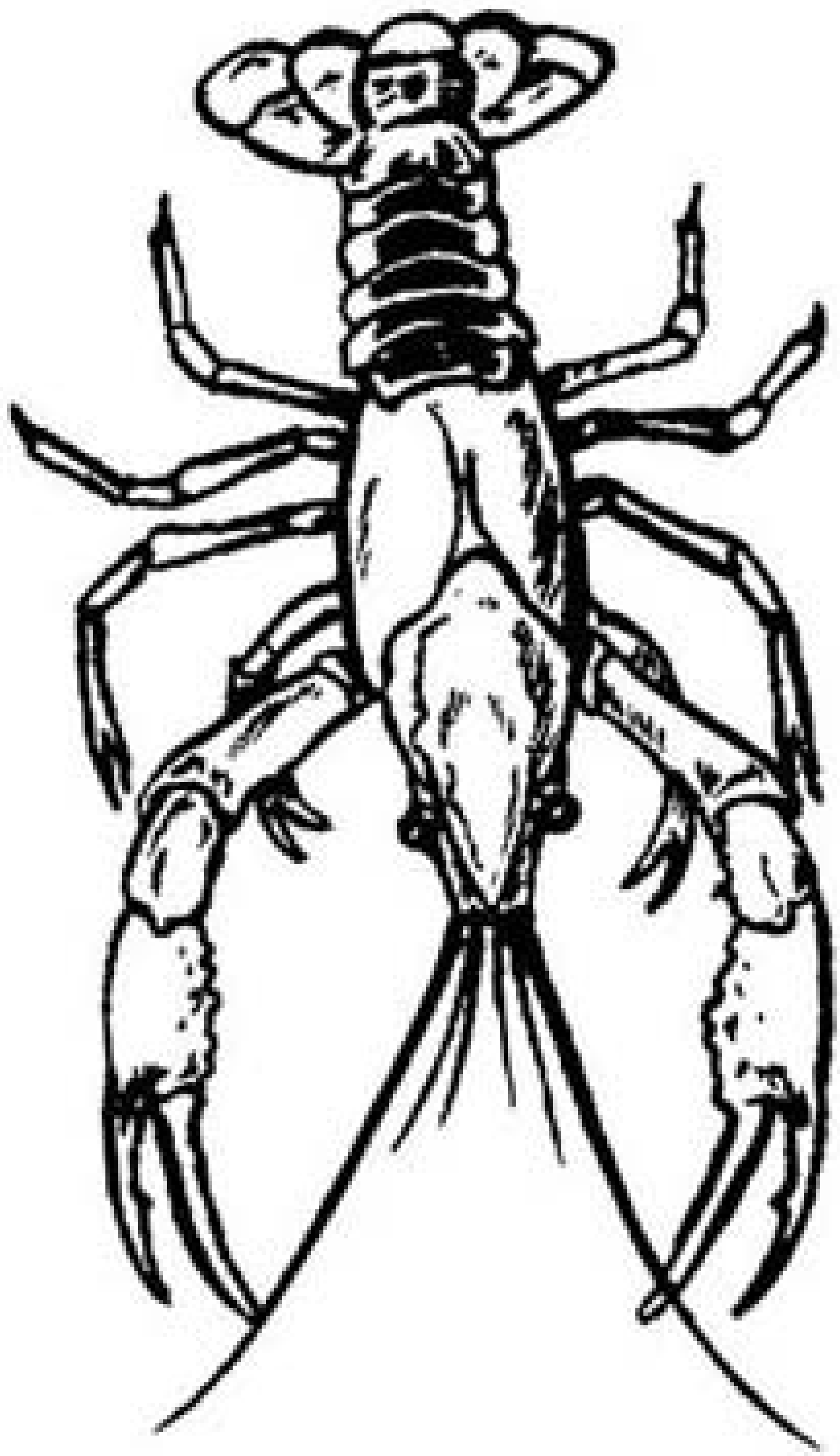


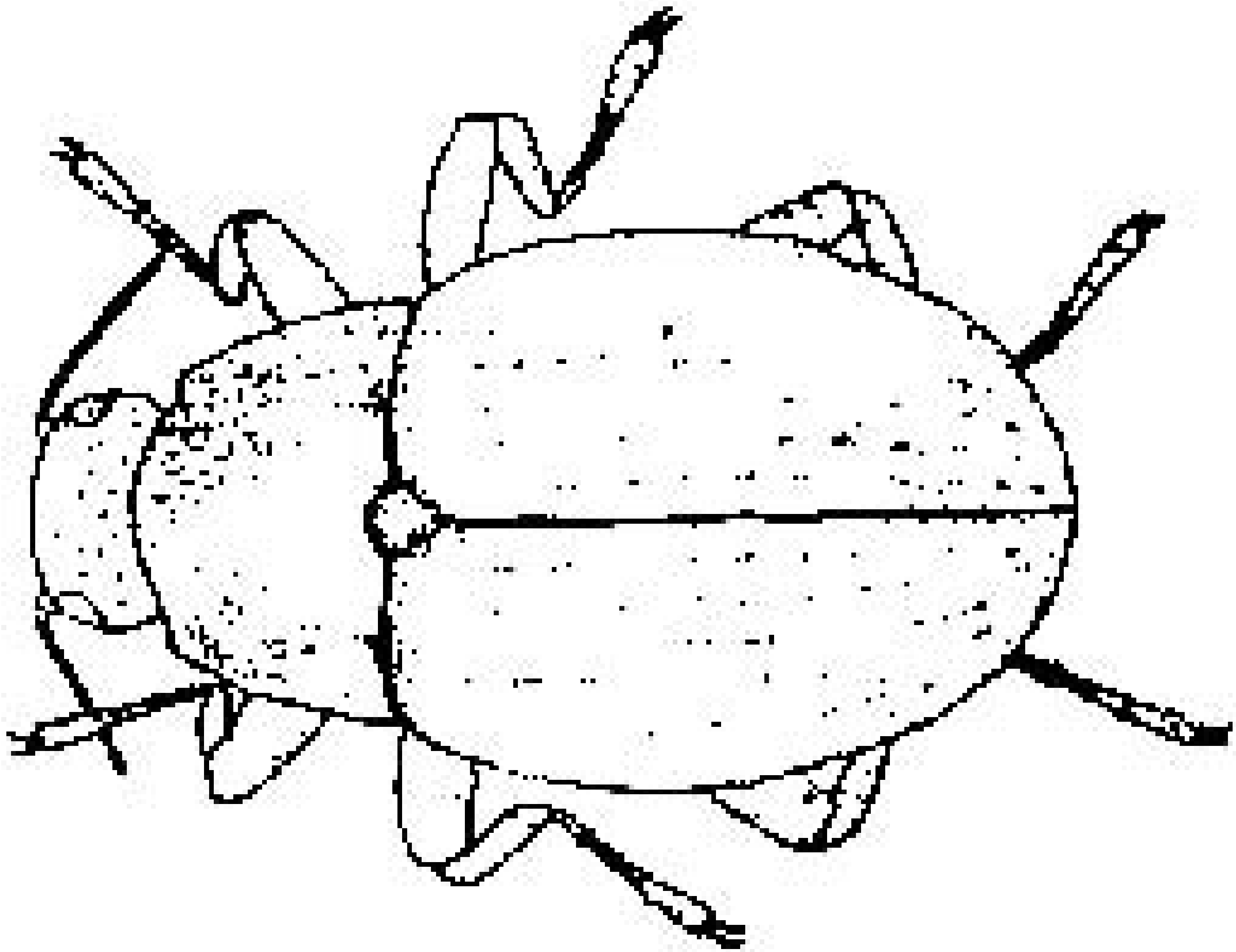


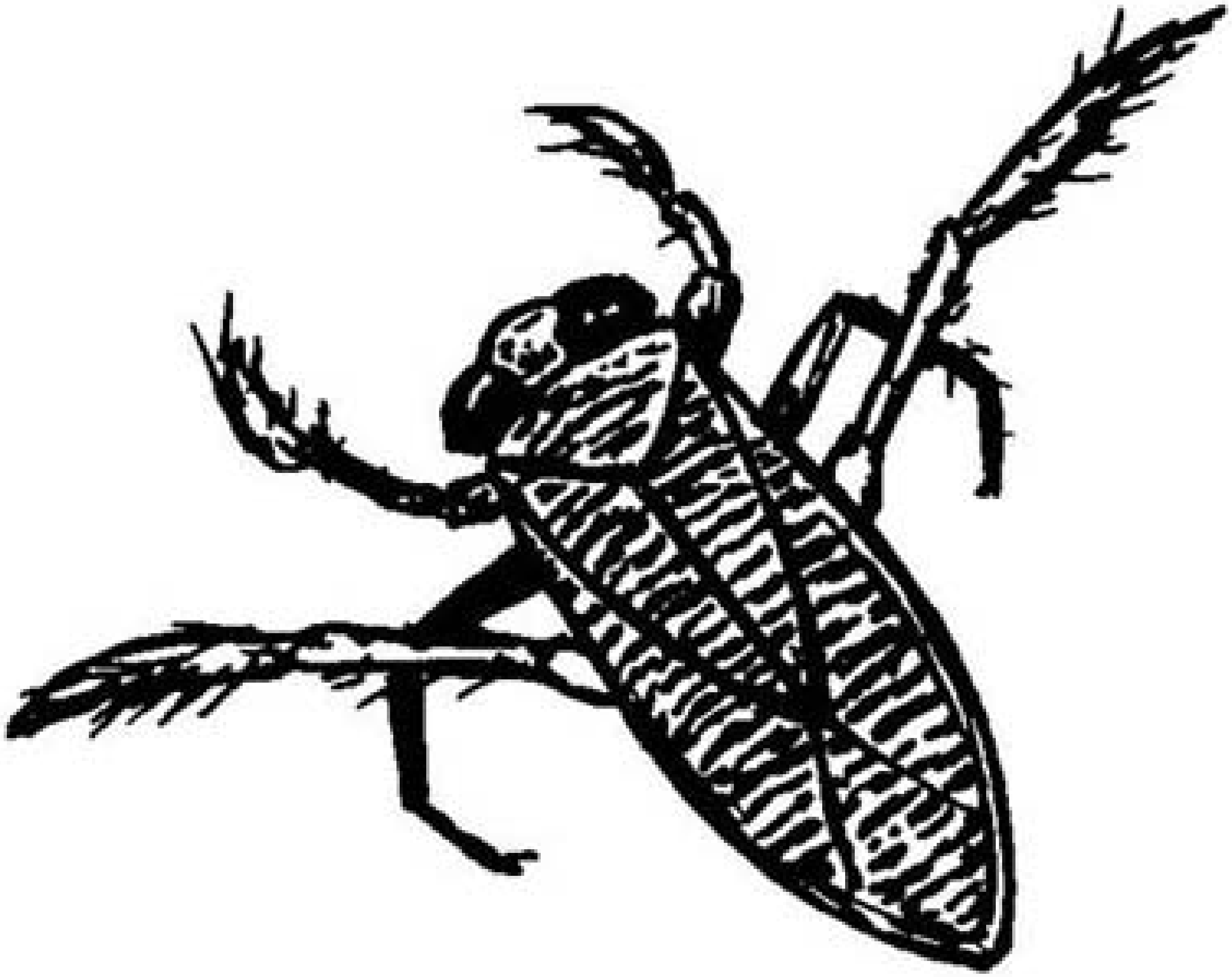












Lesson 8.5: Assessing Stream Health with Invertebrate Sampling

Essential Concept

The great diversity of aquatic life in Texas' rivers and streams reflects the great diversity of habitats found in these aquatic ecosystems. This diversity is an indication of the health of the river or stream.

Objectives

1. Students will review their KWHL chart and add questions if they feel there are questions that they have not included.
2. Students will look at maps or aerial photographs to find what order their local stream or river is and predict the types of organism to be found based on the stream order.
3. Students will conduct a field investigation to determine what organisms live in the nearest stream or river.
4. Students will assess the health of the stream or river near them based on the aquatic invertebrates found there.
5. Students will investigate which organisms live in riffles, pools, stream banks, on the stream bottom, and in channels of their stream or river.
6. Students will compare adaptations of organisms from different stream habitats.
7. Students will use safe practices and conservation of resources in the field.
8. Students will collect data and record information in tables.
9. Students will draw conclusions based on data.
10. Students will identify ways human activity can affect aquatic environments.

In Addition High School Students:

11. Will continue recording weather, chemical and physical characteristics of their stream or river for their long-term study.
12. Will demonstrate the use of course apparatuses, equipment, techniques, and procedures.
13. Will collect quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, nitrogen compounds, and turbidity.
14. Will identify water quality in a local watershed.
15. Will predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.10 A; 7.11 A; 7.13 A; 8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, J; 5 A, B, C, D; 7 C; 10 A, B; 11 A, B; 12 A, B, C, D

Environmental Science: 1 A, B; 2 E, F, G, H, I, K; 4 A, B, E, F; 5 A, B, C; 7 A, C, 8 A; 9 A, B, C, E

Estimated Time

Depending on the distance to the site, the field trip could take from 1 class period to 1 full day

Materials

Seines and nets including D-frame aquatic dip net and kick seine

Containers for specimen such as:

White trays

Ice cube trays

Hand magnifiers or magnifier boxes

Forceps

Journals

Pens/pencils

Field Guides

Thermometers and weather instruments

Physical Water Quality Indicators check sheet

Bug Picking Water Quality Indicators

High school students should also have secchi disc, stopwatch, tennis ball or wood,

salinity test, water chemistry test kits

Safety goggles

Gloves

First aid kit

Special Instructions

Copy and laminate the *Invertebrate Key* from Lesson 8.4 to take on the field trip.

Safety Precautions

Remind students of safety precautions in the field. See Field Trip Guidelines in the *Introduction* to the curriculum.

Procedure

1. Field Trip

Review with the class Indicators of Good Water Quality in Chapter 8 in the Student Guide. Review KWHL charts with the class to make additions or deletions as needed. Look at the maps or aerial photographs to find what order their local stream or river is and predict the types of organism to be found based on the stream order.

Ask students to determine what organisms live in the nearest stream or river by collecting organisms from various parts of the stream with seines and nets. Also have students check on the underside of rocks.

Using the *Bug Picking Sheet* from Lesson 1.9, assess the health of the stream or river near them based on the aquatic invertebrates found there.

- **Which organisms live in riffles, pools, near stream banks, on the stream bottom, and in channels of their stream or river and what adaptations do they have for life in that habitat?**

Ask students to compare adaptations of organisms from different stream habitats.

- **What human uses do they observe along the stream? How might these human uses affect the organisms in the river or stream?**

Have high school students continue recording weather and chemical and physical characteristics of their stream or river for their long-term study.

2. Field Study Data and Report

Ask students to record data and observations in appropriate tables for their science journals. When you return to the classroom ask students to analyze their observations and other data to draw conclusions about the quality of the water and any changes you have noticed to the stream since your last investigation. Use this information to write a report on your field investigation. (See Report Rubric.)

Vocabulary

- Channel
- Macro-invertebrates
- Pool
- Riffle
- Riparian zone
- Stream bank
- Stream bottom
- Stream order

Student Page

Rubric for Field Reports

I. Works well with cooperative group. 25 points

1. Gets along with others, taking part in discussions, but doesn't take over.
2. Completes assigned task for the group
3. Helps develop data tables.
4. Helps draw conclusions.

II. Takes part in field activities and keeps Science Journal up to date. 25 points

1. Presents data clearly and neatly in tables and graphs.
2. Develops tables with appropriate headings.
3. Develops graphs with appropriate labels, title, and intervals for data.

III. Uses data to make generalizations. 30 points

1. Discusses data with group.
2. Draws logical conclusions supported by the group's data.
3. Writes accurate field report including:
   A. Summary of what was done on the field study including a sentence about what the purpose of the field study was.
   B. Summary of observations made and data collected.
   C. Reasonable conclusions drawn from observations. Is there other information you need to know about the aquatic ecosystem studied? How could you obtain that information?
   D. Evaluate techniques for gathering and recording data. Is there something you could improve in your next field study? Were there potential sources for error in your data? How might this affect conclusions?
   E. Restate the question or questions you were investigating from the KWHL chart. Answer the question and justify your answer based on your data.
   F. What environmental problems did you find? How could you help solve the problem or conserve the aquatic ecosystem you studied?

IV Final Product 20 points

1. Science Journal is neat.
2. All entries are neatly written in clear language.
3. Written entries are correctly spelled.
4. Math is accurately computed.
5. Area around field site is cleaned-up.

Total Possible Points 100 points

Chapter 8: Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **Predict the impact of flooding on the organisms in a stream ecosystem.**

   A Some fish, plants or other aquatic life could be washed downstream.

   B It will promote subsequent growth of wetlands plants and animals once floodwaters recede.

   C Fresh nutrients would be brought in.

   D All of the above

2. **Predict the types of organisms in a fourth-order stream.**

   A Few rooted plants grow because the water is too deep and very cloudy; there are more collectors than shredders. Example: black willow, smartweed, buttonbush, cottonwood, sycamore, mayfly, gilled snail, stonefly, crayfish, green sunfish, creek chub and fathead minnow.

   B Both rooted and floating aquatic plants and many types of animals have a niche in which to live. Example: algae, water willow, coontail, sycamore, mayfly, snail, crayfish, damselfly, scud, channel catfish, bluegill, largemouth bass and gar.

   C There is little aquatic plant growth; animals depend on what falls or is washed into the stream.

   D None of the above.

3. **Sculpins and many darter species are adapted as bottom clingers. They:**

   A Have streamlined bodies that allow them to remain stable in currents

   B Have flattened heads and large pectoral fins that are angled to help them stay on the bottom in swift currents

   C Have upturned eyes and mouths to slurp down mosquito larvae

   D None of the above

4. **Which of the following statements is true:**

   A In a straight stretch of river, the main force of the current is usually in the middle. The deepest water is also usually in the middle.

   B When there is a sharp bend in the river, the strongest current and deepest water is at the outside edge of the bend.

   C In flowing water, there is less current near the bottom.

   D All of the above

5. **Plants living in moving water have:**

A Long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place

B Are tiny, free-floating species of algae, and are the food base of the ecosystem

C Are tall because they have greater support, enabling them to rise above other plants to reach the sun

D None of the above

Chapter 8: Assessment

Directions

Write your own answer for each of the following questions.

1. **Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:**

   - **Building a levee in the floodplain**
   - **Damming a stream**
   - **Channelizing (straightening) a river**

2. **Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.**

3. **Diagram the parts of a stream and explain how biotic and abiotic factors that make up the stream ecosystem function together.**

Chapter 8: Assessment Answer Key

Multiple-choice questions

1. Predict the impact of flooding on the organisms in a stream ecosystem.

   D. All of the above

2. Predict the types of organisms in a fourth-order stream.

   B. Both rooted and floating aquatic plants and many types of animals have a niche in which to live. Example: algae, water willow, coontail, sycamore, mayfly, gilled snail, crayfish, damselfly, scud, channel catfish, bluegill, largemouth bass and longnose gar.

3. Sculpins and many darter species are adapted as bottom clingers. They:

   B. Have flattened heads and large pectoral fins that are angled to help them stay on the bottom in swift currents

4. Which of the following statements is true:

   D. All of the above

5. Plants living in moving water have:

   A. Long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place

Write-in questions

1. Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:

Building a levee in the floodplain

Damming a stream

Channelizing (straightening) a river

Many answers are possible, but should resemble one of the following ex

Technological Solution	Potential risks or unintended consequences
Building a levee in the flood plain	Building levees prevents the natural functioning of the floodplain to allow excess water to spread out, slow down and release sediment and nutrients. This causes floodwaters to rise even higher, move faster and do more damage. It also prevents the natural replenishment of floodplain soil and wetland ecosystems. Some fish depend on flooding to trigger spawning, which takes place in the shallow water of the flooded floodplain. Levees prevent these fish from spawning, which could result in their loss from the location.
Damming a stream	Damming a river turns the stream ecosystem into a lake ecosystem. Species adapted to live in flowing water may not be able to survive or reproduce in the still water of the lake. Also, as dams slow and stop the flow of water, the sediment the water carried drops out and builds up, as the stream becomes a lake, further destroying stream habitat. Below the dam, the rushing water scours out the streambed, destroying more habitat and causing severe erosion downstream. Dams also prevent fish from moving up or down stream, potentially isolating them from other populations or from spawning grounds upstream.
Channelizing (straightening) a river	Channelizing or straightening a stream increases the water’s downhill speed. This worsens erosion and sedimentation as the stream tries to return to a natural path. In the process, habitat is destroyed and water quality is reduced.

2. Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.

Many answers are possible, but should resemble one of the following examples:

Technological Solution	Possible Solution to Ecosystem Damage
Building a levee in the floodplain	Remove or do not build levees. Instead allow floodplains to perform their natural function. Do not build in the floodplain. Instead use the land for low-impact agriculture and recreation.
Damming a river	Remove or do not build dams. If this is not possible, create new habitat elsewhere to make up for habitat lost to the dam. Dredging may be necessary to slow down succession in the lake or pond. Spawn fish in a hatchery. Create fish passages around the dam (fish ladders). Build something (partial barriers, check dams, grade control structures) to slow the water down when it comes out of the dam, to reduce damage downstream.
Channelizing (straightening) a river	Do not straighten streams. When channelization has already been done, try to dig a zig-zagging channel for the stream to return to, or just let the stream find a new path on its own. Protect the soil from erosion as much as possible by keeping plenty of plants, especially trees or prairie plants, growing in the area.

3. Diagram the parts of a stream and explain how biotic and abiotic factors that make up the stream ecosystem function together.

Refer to FIG. 8.1 and FIG. 8.5 in the Student Guide to assess potential responses.

Lakes and Ponds

Lakes and ponds provide habitat for many plants, insects, fish, birds and other wildlife, and important recreational opportunities for Texans.

Chapter 9

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Use what they know to Think-Pair-Share ideas on differences and similarities between lakes and ponds and rivers and streams.
2. Make a Venn diagram showing the similarities and differences between lakes and ponds, and rivers and streams.
3. Read the student guide and answer the questions.
4. Examine the future of water resources in Texas.
5. Diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together, including how depth zones determine where populations of species live in the lake.
6. Compare and contrast the characteristics of plants adapted to living in lakes and ponds to those of terrestrial species.
7. Predict the impact of storm water runoff on the organisms in a pond ecosystem.
8. Describe how technological solutions to problems, such as dams, intensive agriculture, and urban development, can have risks and unintended consequences.
9. Describe possible solutions to potentially harmful environmental changes within a pond ecosystem.
10. Build a model of pond succession.
11. Conduct an investigation observing and describing changes in an environment when some components are changed.
12. Collect and record data of how their model changes over time.
13. Make a poster, drawing, or PowerPoint presentation of the process of pond succession.
14. Predict the impact of manmade and natural disturbances on lakes and ponds.
15. Take part in a simulation of the introduction of an invasive species to a lake.

16. Synthesize information to produce a rap, song, poem, public service announcement, brochure, or other product to inform the public about invasive species and ways to combat their spread.
17. Describe energy transfer in a pond food web.
18. Observe microorganisms under a microscope.
19. Record observations.
20. Make drawings of microorganisms.
21. State that all organisms are made up of one or more cells.
22. Identify the basic characteristics of organisms including prokaryotic/eukaryotic; unicellular/multi-cellular; autotrophic/heterotrophic, and classify them in the currently recognized kingdoms.
23. Differentiate between structure and function in plant and animal cell organelles including cell membrane, cell wall, nucleus, chloroplast, cytoplasm, mitochondria, and vacuole.
24. Describe producer/consumer, predator/prey, and parasite/host relationships as they occur in food webs in freshwater.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, C, D, E; 6.3 B, C; 6.4 A; 6.12 A, D, E; 7.1 A, B; 7.2 A, C, D, E; 7.3 B, C; 7.4 A; 7.8 A; 7.10 C; 7.12 D; 7.13 A; 8.1 A, B; 8.2 A, C, D, E; 8.3 B, C; 8.4 A; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, I, J; 4 B; 5 C, D; 10 B; 12 A

Environmental Science: 1 A, B; 2 E, F, G, I, K; 4 D, F; 8 A, D

Materials Needed

Activity 9.1

Student science journals

Pencils/pens

Chalkboard, whiteboard, or chart paper with appropriate writing implements

Activity 9.2

Student Guide

Science journals

Pencils/pens

Activity 9.3

For each Group of 4 Students

Small clear plastic terrarium, or lettuce box

Bottom of a Petri dish or other small container

Gravel

Soil

Water

Spray or squirt bottle

Aquatic plant

Birdseed

Flower seeds such as sunflower seeds

Activity 9.4

A large playing field outside where students can have free movement without bumping into others.

<u>Nametags for each student</u>

Each nametag should have zebra mussels on the back

There should be 10 nametags with larval fish on the front

10 nametags with native mussels on the front

10 nametags with larger fish on the front

In addition, there should be 3 diving duck nametags with nothing on the back

150 blue poker chips or laminated poster board squares to represent dissolved oxygen

150 red poker chips or laminated poster board squares to represent zooplankton

Plastic quart size bags for each student to use to collect game pieces

Chalkboard, whiteboard, or chart paper

Student journals

Pencils/pens

Activity 9.5

Beaker or mayonnaise jar

Dried grass

Pond water

Pipette/eyedroppers

Antibacterial soap for clean-up

Containers of pond water with microorganisms or microorganisms purchased from science supply catalogs

Microscopes

Microscope slides

Cover slips for slides

Petri dishes

Corn syrup or quieting solution to slow down organisms (from science supply catalogs)

Field Guide such as Golden Guide's *Pond Life*

String or thread (optional)

Science journals

Pencils/pens

Safety Precautions

The *Aquatic Invasion* game is competitive. Be sure students are aware of others and there is no bumping or roughhousing.

Be sure to wash hands with anti-bacterial soap after handling cultures, which contain various bacteria. Also use Clorox wipes or diluted Clorox water to disinfect tables, counters and equipment.

Vocabulary

- Adaptation
- Antennae
- Biodiversity
- Cell membrane
- Cell wall
- Chloroplast
- Cilia
- Climax community
- Dams
- Dissolved oxygen
- Disturbance
- Ecological succession
- Erosion
- Eukaryotic
- Flagella
- Flowing water
- Invasive
- Lakes
- Microorganisms
- Mitochondria
- Multi-cellular
- Native species
- Nucleus

- Oxygen levels
- Photosynthesizing
- Phytoplankton
- Plankton
- Plant buffer
- Pollution
- Ponds
- Primary succession
- Prokaryotic
- Reservoir
- Runoff
- Secondary succession
- Still water
- Taxonomic
- Unicellular
- Vacuoles
- Watershed
- Zooplankton

Reference Material for Teachers

Brochure on preventive measures on Zebra Mussels and Boating

http://www.tpwd.state.tx.us/publications/pwdpubs/media/pwd_br_k0700_1099.pdf

Enrichments

Project WET

- Macro-Invertebrate Mayhem

Project WILD Aquatic

- Glass Menagerie
- Micro Odyssey
- Pond Successions

Texas Parks and Wildlife

- Hello Invasives–Goodbye Lakes Activity

http://www.texasthestateofwater.org/screening/pdf_docs/Invasives%20Lesson%20Plan.pdf

Service Learning

- Storm drain stenciling
- Litter pickup

Lesson 9.1: Lake and Pond Characteristics

Essential Concept

Lakes and Ponds are standing water while rivers and streams are flowing water. Most lakes and ponds in Texas are formed by dams on rivers and streams and are reservoirs for water. Lakes and ponds, and rivers and streams all support a variety of aquatic organisms.

Objectives

1. Students will use what they know to Think-Pair-Share ideas on differences and similarities between lakes and ponds, and rivers and streams.
2. Students will make a Venn diagram showing the similarities and differences between lakes and ponds, and rivers and streams.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

30 minutes

Materials

Student science journals

Pencils/pens

Chalkboard, whiteboard, or chart paper with appropriate writing implements

Procedure

1. Think-Pair-Share

Think about what the differences are between Rivers and Streams, and Lakes and Ponds. Get with your partner and share your ideas. Combine all your ideas into one Venn diagram to share with the class.

2. Class Share

Draw a Venn diagram on the board. Ask each pair of student to add one thing from their Think-Pair-Share Venn diagram to the class diagram until all new ideas have been added. Have students copy the class Venn diagram in their science journals.

3. Looking Ahead

Explain to students that in this chapter they will learn about parts of lakes and ponds and their ecosystems. This chapter will help them understand what a lake ecosystem is and how it functions.

Vocabulary

- Dams
- Flowing water
- Lakes
- Ponds
- Reservoir
- Still water

Lesson 9.2: Reading and Research

Essential Concept

Lakes and ponds hold water for use by people, wildlife, livestock, and industry and have ecosystems with a variety of organisms.

Objectives

1. Students will read the student guide and answer the questions.
2. Students will draw a diagram of parts of a lake and explain how biotic and abiotic factors function together including how depth zones determine where species live in a lake.
3. Students will examine the future of water resources in Texas.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science 2 K

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Materials

Student Guide

Science journals

Pencils/pens

Procedure

1. Reading the Chapter

Have students read Chapter 9: *Lakes and Ponds.* Introduce vocabulary terms as needed.

2. Answering the Questions

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

Questions to Consider

1) ***Where are ponds and lakes in your community? What role do they play in your economy?***

If students do not know the lakes in your area, look on a map to find the local lakes. Lakes provide a wide variety of recreational opportunities from fishing and boating to swimming and water skiing, which bring money into the economy as people buy equipment and supplies.

2) What kind of organism makes up the greatest amount of living material in a pond?

Plankton makes up about 87 percent of the living material in a pond.

3) Besides providing food, what other roles do plants have in lake and pond ecosystems?

As plants move in, they sink their roots into the pond bottom and hold the soil, making the water even clearer and allowing more plants to grow at greater depths. Plants give off oxygen as a byproduct of photosynthesis. Small animals seek shelter among the plants and parts of plants growing underwater, which offer hiding places from predators. Plant beds serve both as shelter from predators and as a food source for insects.

4) How are plants that live under water similar to plants that live on land? How are they different?

Plants that live underwater are like plants that live above water. They need water, carbon dioxide, sunlight and nutrients such as phosphorous and nitrogen. But water plants have special adaptations that help them thrive in their underwater environment. Waxy or slimy coatings protect them from drying out when water levels drop. Porous stems or leaves let them absorb minerals right from the water.

5) How do oxygen levels in ponds change during each 24-hour period?

Oxygen levels in a pond are high while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night.

6) How do ponds change over time?

As ponds age, they fill with sediment and organic material. They become smaller, shallower ponds. In time the pond will become a wetland, then as it fills even more, a meadow. This natural process is called pond succession.

7) How are lakes similar to ponds? How are they different?

Lakes are bigger than ponds. While lakes and ponds have much in common, a lake's larger size makes for some differences. In a lake, the amount of oxygen dissolved in the water stays pretty even over a 24-hour period. Wind on a lake can whip up high waves mixing air into the water. The ecology of the lake's shoreline zone is like a pond's ecology. A lake also has an open-water zone away from shore, as far down as sunlight reaches. Some species of fish spend most of their time in this zone, swimming into the shoreline zone now and then to feed or spawn. In the deep-water zone, below the open-water zone, not enough light reaches the bottom for plants to grow. Dead organic matter sinks to the lake bottom, where bacteria and other decomposers break it down. Dissolved oxygen continues to be used for decomposition, but no surface water mixes with the deep water and no light penetrates to allow photosynthesis which would replenish oxygen, so deep water is low in dissolved oxygen. The temperature in a lake is fairly even from day to day in a given season. However, in summer, lake water is much warmer on top in the shoreline zone and the open-water zone than in the deep-water zone.

8) How can lakes and ponds be kept healthy?

Because every water body is a reflection of its watershed, good watershed management is important to keeping a pond healthy. Stopping excess erosion and runoff loaded with excessive amounts of fertilizers, pesticides or other pollutants is key. Keeping a 100-foot-wide buffer of thick plant growth around the pond helps filter out pollutants and eroded earth before they reach the pond. A plant buffer will greatly improve the pond's health and extend its life. The same is true for lakes.

3. Diagramming the Parts of a Lake

Using the information in the Student Guide, diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together, including how depth zones determine where populations of species live in the lake.

4. Challenge Questions

Engage students in a class discussion to think about lakes and the future of water resources in Texas by asking them to think about the following question:

- **What are the benefits and costs of building new reservoirs (dams for lakes) as a solution for Texas' future water needs? Consider the economy and the environment in your discussion.**

Vocabulary

- Erosion
- Lake
- Oxygen levels
- Photosynthesizing
- Plant buffer
- Pollution
- Pond
- Runoff
- Watershed

Lesson 9.3: Changing Environments
Pond Succession

Essential Concept

Ponds are dynamic systems, changing over time as sediments and decaying matter fill them in and succession turns ponds into meadows.

Objectives

1. Students will build a model of pond succession.
2. Students will conduct an investigation observing and describing changes in an environment when some components are changed.
3. Students will collect and record data of how their model changes over time.
4. Students will make a poster, drawing, or PowerPoint presentation of the process of pond succession.
5. Students will predict the impact of manmade and natural disturbances on lakes and ponds.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.3 B, C; 6.4 A; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.3 B, C; 7.4 A; 7.8 A; 7.10 C; 7.13 A; 8.1 A, B; 8.2 A, C, D, E; 8.3 B, C; 8.4 A; 8.11 C

Aquatic Science: 1 A, B; 2 E, F, H, J; 4 B; 12 A

Environmental Science: 1 A, B; 2 E, F, G, I, K; 4 D; 8 A, D

Estimated Time

1 class period to set up the model, 5-10 minutes per day for observations and data recording, 20 minutes for class discussion and time during class or as homework for the project

NOTE: It is suggested that the teacher set up their own model before asking the class to do this activity. Teachers will then be aware of problems and complications that may arise.

Materials

<u>For each Group of 4 Students</u>

Small clear plastic terrarium, or lettuce box

Bottom of a Petri dish or other small container

Gravel

Soil

Water

Spray or squirt bottle

Aquatic plant

Birdseed

Flower seeds such as sunflower seeds

Student journals

Pencils/pens

Computer with PowerPoint program (optional)

Procedure

1. Building the Model

Ask each group of students to use the materials to set up a terrarium model of a meadow with a small pond. Use masking tape to put your table number on the lettuce box. Spread a layer of gravel in the lettuce box for drainage and add about 4-5 cm of soil on top. Make a small indention in the soil for the Petri dish. The top of the Petri dish should be level with the soil. Sprinkle a small amount of soil in the bottom of the Petri dish and fill it with water to represent a pond. Put a small aquatic plant in the pond such as duck weed or algae. Scatter birdseed over the soil and in the pond to represent seeds blown into the area, and spray with water. Place the terrariums in a sunny window. Do not put a lid on the lettuce box. Water every 2-3 days by spraying with water. You may spray the pond as well as the meadow, but do not add extra water to the pond. Sprinkle a few grass seeds on both the meadow and pond every few days.

- **What external stimuli are the aquatic plants responding to?** (the amount of water in the environment)
- **What external stimuli are the seeds responding to?** (the amount of water in the environment, sunlight, soil)

Water will evaporate from the pond and after several days the pond will dry up and the aquatic plant will die. Grass seeds will begin to grow. Continue to add a few birdseeds and begin to add some sunflower seeds to the terrarium after a week to represent the transition from pond to meadow. Continue to spray with water (rainfall) to keep soil damp.

Have students develop a data table to keep a record of changes they make to the environment and responses they observe in the terrarium such as: the number of squirts of water, the number and types of seeds added to the model, and the number of days they observe the model, along with changes they observe in the model environment such as percent of soil covered with plants, amount of water in Petri dish, condition of the aquatic plant.

Students may keep the terrarium going for up to two weeks.

2. Disturbance and Regrowth

Discuss the results of the experiment with the class. Any process, whether natural or manmade, that changes something in the habitat is called a disturbance.

- **What disturbance happened in the model that caused the changes in the environment?** (less water in the pond, more seeds in the environment–soil may have washed into the pond during watering, some seeds may have sprouted and died causing eutrophication, decaying plants also helped fill the pond)

Succession is the word we use to describe the changes in the environment that change the ecology including all the interrelationships in an environment such as changing from a pond to grassland, or grassland to brush, and brush to a forest. Ecological succession is going on all the time, even if we do not notice it. Succession turns small ponds into dry land, changes meadows to brush land, and helps areas burned by fires to come back to green fields and new trees.

- **If the plant life is changing, what other changes do you think might happen with ecological succession in the real world? (**Each step along the way in a series of changes brings a new plant community into the environment. If this were happening in the real world, each new step in the succession would also bring new animals to fill the niches created in the environment.)

Primary succession happens when bare rock begins to break down through growth of lichens and mosses. It may take hundreds of years before a climax community such as a forest is reached.

A climax community is a late stage or final stage in the development of an ecological community where composition of plants and animals is relatively stable and well matched to environmental conditions. Climax communities can maintain themselves over long periods of time if there are no disturbances to the environmental conditions.

Secondary succession begins in a place where a disturbance has occurred either by a natural or manmade change to the environment. A climax community such as a forest may be reached in fewer years than in primary succession, but it is still a slow process.

- **How has the system in our model changed?** (Less water was available, causing loss of aquatic plants. Erosion of soil into the pond, making it shallower. Growth and decay of some seeds, and growth of more seeds as the environment in the pond changes from aquatic to terrestrial.)
- **How does succession restore habitats and ecosystems?** (Example: A stream cuts through a field, the stream becomes a river, the river meanders as it flows, a flood increases the flow rate and cuts off the meanders from the river creating an oxbow lake, a wetland is created, a drought comes drying up the lake, slowly grasses and brush grow restoring the field.)
- **What are some natural and manmade disturbances that might cause succession to take place?** (Fires, storms, floods, volcanic eruptions, drought, diversion of rivers, deforestation for lumbering, building of office buildings or homes, draining of wetlands, etc.)

3. Predicting Changes Due to Disturbances

- **What impact will storm water runoff cause for the organisms in a pond ecosystem?** (As water runs downhill through the pond's watershed, it picks up small bits of soil. This erosion brings sediment to the pond, replacing water with soil and creating more shallow areas. Decaying plants and animals fall to the pond bottom, adding to and enriching the sediment. Plants thrive in the rich sediment and take up more space. In time the pond will become a wetland, then as it fills even more, a meadow forms. The surface water that fills a pond also can bring pollution. Excess soil and plant nutrients can overload the water in the pond and unbalance its growth cycle. A common result of this imbalance is too much algae growth. Algae overgrowth makes the water cloudy and shades out rooted plants. When the excess algae die, it creates a lot of decomposing material that uses up oxygen and chokes fish. This can speed up pond succession.)
- **How is our model like real succession of a pond? How is it different? What are the limitations of our model?**

4. Using What We Learned

Ask students to make a poster, drawing, PowerPoint, or other visual representation of ecological succession in a pond. They should show at least 3 steps in the succession from pond to a grassland/meadow. Students should also include any animals they would expect to live in the area in each stage of succession represented in the three drawings.

Vocabulary

- Climax community
- Disturbance
- Ecological succession
- Primary succession
- Secondary succession
- Systems

Lesson 9.4: Aquatic Invasion

Essential Concept

Invasive species can take over an ecosystem if they are able to survive and reproduce and have few predators.

Objectives

1. Students will take part in a simulation of introduction of an invasive species to a lake.
2. Students will synthesize information to produce a rap, song, poem, public service announcement, brochure, or other product to inform the public about invasive species and ways to combat their spread.

TEKS

6.2 C, D, E; 6.3 B, C; 6.12 E; 7.2 C, D, E; 7.3 B, C; 8.2 C, D, E; 8.3 B, C; 8.11 B

Aquatic Science: 2 F, H, J

Environmental Science: 2 F, I, K; 4 F

Estimated Time

1 period for the simulation game and another class or homework for the project

Materials

A large playing field outside where students can have free movement without bumping into others.

<u>Nametags for each student</u>

Each nametag should have zebra mussels on the back.

There should be 10 nametags with larval fish on the front

10 nametags with native mussels on the front

10 nametags with larger fish on the front

In addition, there should be 3 diving duck nametags with nothing on the back.

150 blue poker chips or laminated poster board squares to represent dissolved oxygen

150 red poker chips or laminated poster board squares to represent zooplankton

Plastic quart size bags for each student to use to collect game pieces

Chalkboard, whiteboard, or chart paper

Student journals

Pencils/pens

Special Instructions

These amounts are for a class of 30 students. You can adjust the numbers of nametags and poker chips as needed to fit your class size. Write *Zebra Mussels* on the back of each nametag except the diving ducks. Laminate the nametags so that they can be reused.

Safety Precautions

This game is competitive. Be sure students are aware of others and there is no bumping or roughhousing.

Procedure

1. Aquatic Invasion Game

The object of the game is:
to get enough dissolved oxygen and zooplankton to survive.

Species	Survival Needs Dissolved Oxygen	Survival Needs Zooplankton
Larval Fish	6	6
Native Mussels	6	6
Larger Fish	10	10
Zebra Mussels*	2	2
Diving Ducks*		14

*These two species will participate later in the game.

Ask students to put on the nametags. Scatter the poker chips in a large area so all students have access to the game pieces.
The teacher should keep a record of the number of non-survivors for each round and the number of zebra mussels in each round for use later in a data table and graph.

Round One

At a signal from the teacher, the students scramble to collect as many game pieces (poker chips) as possible. When the teacher calls time (20 seconds), students determine which native organisms have survived based on the needs of each species for dissolved oxygen and zooplankton. Each animal must have at least the required number of each game piece to survive. Survivors remain the same species for the next round.

Round Two

Meanwhile a boat has been brought to the lake with zebra mussels on the hull. Each animal that did not survive can turn their nametag over and become zebra mussels and reenter the game.

Collect all the game pieces and scatter them again. Have students collect as many as possible in 20 seconds. At the end of Round Two, have each animal count the number of pieces they have collected and see if they survived.

Select three students from those that did not survive to become diving ducks. Any other animals that did not survive become zebra mussels.

Round Three

The diving ducks and the larger fish may collect food tokens as before and also can eat any of the other animals by tagging them and taking all the game pieces from each animal as it is tagged. The tagged animal that has been eaten is out of the game and must go to the sidelines.

The round is over when all of the game pieces have been eaten.

Students should count the number of survivors of each species and discuss why each survived. (Refer to the chart above.)

Ask students to make a data table including changing conditions in all rounds of the game, with the number of survivors of each species, and the number of zebra mussels for each round.

For more information on zebra mussels and other invasive species in Texas go to the Internet and look at www.TexasInvasives.org

2. Analyzing the Data

- **What was the impact of the zebra mussels on the native species?**
- **Why did the zebra mussels affect the large fish?**
- **How do zebra mussels destroy an ecosystem and its biodiversity?**
- **How could we keep zebra mussels out of lakes?** (Clean boats after use to remove all vegetation and zebra mussels, and wash equipment with a high pressure spray to remove microscopic larvae, drain water from boat, engine, bilge, live-wells, and bait buckets before leaving the lake, open all compartments and allow boat and trailer to dry completely for a week or more before visiting another lake or river.)
- **How is the simulation like the real invasion of a lake by a non-native species? How is it different?**
- **What are the limitations of our model?**

3. Using What We Learned

Ask students to work together in groups of 3 or 4 to develop a rap, song, poem, brochure, public service announcement, or other product to inform the public about the problems in lakes with invasive species such as zebra mussels, and how this invasion can be combated. Students may use information from Texas Parks and Wildlife or other information on the Internet to research an invasive species.

Vocabulary

- Biodiversity
- Dissolved oxygen
- Invasive
- Native species
- Zooplankton

Name tags for the Game

Larval Fish
Native Mussels
Diving Ducks
Larger Fish

Lesson 9.5: Microorganisms in Ponds

Essential Concept

Plankton is important in the food chain and is made up of many different types of very small organisms found in ponds.

Objectives

1. Students will observe microorganisms under a microscope.
2. Students will record observations.
3. Students will make drawings of microorganisms.
4. Students will state that all organisms are made up of one or more cells.
5. Students will identify the basic characteristics of organisms including prokaryotic/eukaryotic; unicellular/multi-cellular; autotrophic/heterotrophic, and classify them in the currently recognized kingdoms.
6. Students will differentiate between structure and function in plant and animal cell organelles including cell membrane, cell wall, nucleus, chloroplast, cytoplasm, and vacuole.
7. Students will describe producer/consumer, predator/prey, and parasite/host relationships as they occur in food webs in freshwater.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A; 6.12 A, D; 7.1 A, B; 7.2 A, C, D, E; 7.4 A; 7.12 D; 8.1 A, B; 8.2 A, C, D, E; 8.4 A; 8.11 A

Aquatic Science: 1 A, B; 2 F, G, H, I, J; 5 C, D; 10 B

Environmental Science: 1 A, B; 2 F, G, I, K

Estimated Time

2 class periods and perhaps some homework to finish drawings

Materials

Beaker or mayonnaise jar

Dried grass

Pond water

Pipettes/eyedroppers

Antibacterial soap for clean-up

Containers of pond water with microorganisms, or microorganisms purchased from science supply catalogs

Microscopes

Microscope slides

Cover slips for slides

Petri dishes

Corn syrup or quieting solution to slow down organisms (available from science supply catalogs)

Field Guide such as Golden Guide's *Pond Life*

String/thread (optional)

Science journals

Pencils/pens

Special Instructions

Be sure the grass used for hay infusions has not had herbicides or pesticides The hay infusion needs to be made at least five to seven days in advance to obtain microorganisms. Ten to fourteen days will give you the most variety and density of organisms. Be sure to use a pipette to aerate the culture every day. In two to three weeks you should have several different types of organisms. You can continue adding pond water and new organisms will continue to develop including flagellates, ciliates, and diatoms during weeks four and five and amoeba and more flagellates in weeks nine and ten. Collect from different places in the culture to get the most variety of organisms (top, bottom, near debris, and middle of the jar).

Review microscope use with students. Note the importance of using the fine adjustment so as not to touch the cover slip with the lens.

Safety Precautions

Be sure to wash hands after handling cultures, which contain various bacteria. Also use Clorox wipes or diluted Clorox water to disinfect tables, counters and equipment.

Procedure

1. Getting Ready

You may wish to take students to a pond and collect water. If you are teaching aquatic science, students can also collect data for their long-term studies including weather, land use, invertebrates, water chemistry (dissolved oxygen, pH, nitrates, phosphorus, etc.) or other data that they have been collecting throughout the year. If you do not want students to collect, you can go to the pond and collect it yourself, or you can order microorganisms from science supply catalogues. You will need to order the organisms about a week in advance of this lesson to allow time for shipping. You can grow your own organisms in a hay infusion with dried grasses and a little pond water.

2. Hay Infusion Option

Put a handful of grass in the beaker or jar and add pond water. Put this in a place that will receive light, but not in direct sunlight since that will heat the water and reduce oxygen content.

Use a pipette to pump air into the jar to aerate the culture every day. Let the mixture incubate for 8-10 days at room temperature. Add more pond water if the water begins to evaporate.

Check the culture every two to three days to check on progress of microorganism growth. Be sure to wash hands with antibacterial soap after working with the culture in which bacteria will be growing. Bacteria are important as food for other microorganisms. Also disinfect equipment and countertops.

Use a pipette to collect small water samples from the top of the water, the bottom of the jar, and near the plants in the middle of the culture to find the widest variety of organisms. Look at each slide using various powers of magnification. If organism are moving too quickly to observe, add a drop of corn syrup to each sample or use quieting solution to slow them down. Look at the slide both before and after adding the corn syrup or quieting solution.

3. Pond Water/Option

Set up containers of pond water (Do not use tap water as chemicals will kill your organisms.) Students may put a little pond water in a Petri dish and collect organisms with eyedroppers. Or if you wish to collect and concentrate them ahead of time, you can set up containers using this technique several days before students will be using them.

- Suspend a slide in the pond water with a thin string or sewing thread.
- If the slide is plastic, you can make a hole at one end to tie the thread to the slide.
- If the slide is glass, tape the string to one end of the slide.
- Keep the slide and string from falling into the water by tying a pencil to the other end and placing it across the container.

Over several days microorganisms should collect on the slide. Dry one side of the slide and put a cover slip over the other side so that water will not get on your microscopes.

4. Review of Food Chains

You can connect this lesson to earlier lessons with a review of food chains/webs. You can pass out the cards from Lesson 5 to remind students of all the different parts of an aquatic food chain. Let each group put together at least one food chain with at least ten organisms and diagram it in their journals.

Pull the plankton cards out of the food webs. What phytoplankton do you have? (algae, diatoms) What zooplankton do you have? (rotifers, copepods, hydra, daphnia)

Ask students to recall the plankton (phytoplankton and zooplankton) that so many other animals depend on for food. The organisms that you look at today will provide some examples of the kinds of organisms that make-up the populations of plankton.

5. Micro-Organism Observations

In their science journals, ask students to write down questions that they have about microscopic organisms. Students may generate a variety of questions such as:

- **Is there more than one type of microscopic organism in the pond water?**
- **How many different kinds can we find?**
- **What do microorganisms look like?**
- **What are the different ways these organisms move?**
- **How do the organisms eat?**
- **Do the organisms have any sense organs that we can see (eyes, antennae, mouths, etc.)?**

Have each group share their questions with the class and use these to develop a list of class questions.

Ask students to work in groups of 2 or 3. While one student is using the microscope other students can be preparing their slides, making data tables, or drawing their organisms.

The groups should develop a table to record their observations including how each organism looks (color, shape, relative size, moving parts, or any other parts they can see).

- **How are the organisms acting? Are they just moving around randomly or are they looking for food or eating? If so, what are they eating?**
- **How do they move? Are they slow or fast, do they have appendages that help them move, are there flagella or cilia, etc.?**

Then students should try to identify their organism in a field guide (such as Golden Guide, *Pond Life*) or on the Internet.

Students should answer the class questions and the following questions.

- **How many different microorganisms were you able to isolate and identify?**
- **Which lens magnification was most helpful in viewing microorganisms?**

Have students identify the basic characteristics of microorganisms they observe.

- **Are these organisms prokaryotic or eukaryotic?**
- **Are they unicellular or multi-cellular?**
- **Are the organisms autotrophic or heterotrophic?**
- **What taxonomic kingdom do the organisms belong to?**
- **What adaptations do these organisms have? How do these adaptations help the organisms survive in an aquatic environment?**
- **Do you observe any predator/prey activity?**
- **Which organisms are producers and which are consumers?**

Ask students to look for parts of the cell in their organisms.

- **Can you see the cell membrane or cell wall?**
- **Are there chloroplasts?**

- **Can you see a nucleus?**
- **Do you see vacuoles?**
- **Can you find the mitochondria?**

6. Drawing Microorganisms

Ask each student in each group to choose one of the microorganisms and draw a picture of it showing its color, shape, and parts. Students should label parts that they saw in their observations.

Vocabulary

- Adaptation
- Antennae
- Cell membrane
- Cell wall
- Chloroplast
- Cilia
- Eukaryotic
- Flagella
- Microorganisms
- Mitochondria
- Multi-cellular
- Nucleus
- Phytoplankton
- Plankton
- Prokaryotic
- Taxonomic
- Unicellular
- Vacuoles
- Zooplankton

Chapter 9: Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **Predict the impact of sediment and nutrients brought by storm water runoff on a lake or pond ecosystem.**
   - **A** Lake water would rise.
   - **B** There would be no long-term damage.
   - **C** Pond succession would speed up.
   - **D** All of the above.

2. **Predict the oxygen level in a pond.**
   - **A** The amount of oxygen dissolved in the water stays pretty even over a 24-hour period.
   - **B** The water is too deep for plants to grow on the bottom, making it oxygen poor.
   - **C** Oxygen levels are high each day while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night.
   - **D** None of the above.

3. **Which of the following is important to slowing pond succession and keeping a pond healthy:**
   - **A** Keeping a 100-foot-wide buffer of thick plant growth around the pond.
   - **B** Stopping excess erosion.
   - **C** Stopping runoff loaded with fertilizers, pesticides or other pollutants.
   - **D** All of the above.

4. **A lake has most of its life:**
   - **A** In a ring around the shoreline, reaching out as far as it can survive.
   - **B** In open-water zone away from shore, as far down as sunlight reaches.
   - **C** In the deep-water zone.
   - **D** Both A and C.

5. **Plants living in lakes and ponds:**

A Have long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place.

B Include tiny, free-floating species of algae and are the food base of the ecosystem.

C Have waxy or slimy coatings protect them from drying out when water levels drop, and porous stems or leaves let them absorb minerals right from the water.

D Both B and C.

6. **Plankton in ponds:**

A Make up the base of pond food webs.

B Are tiny, often microscopic organisms.

C Make easy prey for other aquatic life.

D All of the above.

Chapter 9: Assessment

Directions

Write your own answer for each of the following:

1. **Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:**
    - Damming a stream to create a lake or pond
    - Urban development in the watershed of a lake or pond
    - Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond

2. **Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technological solution you chose in the previous question.**

3. **On a separate sheet of paper, diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together.**

4. **What is the importance of lakes to Texas populations and to the economy?**

Chapter 9: Assessment Answer Key

Multiple-choice questions

1. Predict the impact of sediment and nutrients brought by storm water runoff on the organisms in a lake or pond ecosystem.

   C. Pond succession would speed up.

2. Predict the oxygen level in a pond.

   C. Oxygen levels are high each day while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night.

3. Which of the following is important to slowing pond succession and keeping a pond healthy:

   D. All of the above

4. A lake has most of its life:

   A. In a ring around the shoreline, reaching out as far as it can survive

5. Plants living in lakes and ponds:

   D. Both B and C

6. Plankton in ponds:

   D. All of the above

Write-in questions

1. Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:
   - Damming a stream to create a lake or pond
   - Urban development in the watershed of a lake or pond
   - Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond

Many answers are possible, but should resemble one of the following examples:

Technological solution	Potential risk or unintended consequence
Damming a stream to create a lake or pond	Damming a river turns the stream ecosystem into a lake ecosystem. Species adapted to live in flowing water may not be able to survive or reproduce in the still water of the lake or pond. Also, as dams slow and stop the flow of water, the sediment the water carried drops out and builds up as the stream becomes a lake or pond, further destroying stream habitat. Eventually the lake or pond will fill with sediment, becoming solid ground. Below the dam, the rushing water scours out the streambed, destroying habitat and causing severe erosion downstream. Dams also prevent fish from moving up or down stream, potentially isolating them from other populations or from spawning grounds upstream.
Urban development in the watershed of a lake or pond	Urban development can speed up erosion, and surface water from the watershed can bring sediment to the pond, replacing water with soil and creating more shallow areas. Excess soil and plant nutrients can overload the lake and unbalance its growth cycle. This can speed up succession. Water from sewage treatment plants may be piped back into lakes or ponds after treatment. Storm water that runs off paved roads, rooftops and parking lots flows into ditches and storm drains. This water then may drain directly into a lake or pond without any filtration or treatment. Excess fertilizer, pesticides, mud, motor oil and antifreeze, trash, even lawn clippings and pet waste wash off pavement into waterways during heavy rains, creating hazards for swimmers and for people using the lake for drinking water. Rainwater running off a hot asphalt parking lot after a summer storm can dump hot water into a pond, killing everything in it.
Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond	Plowing and overgrazing can speed up erosion, and surface water from the watershed can bring sediment to the lake or pond, replacing water with soil and creating more shallow areas. Excess soil and plant nutrients can overload the pond and unbalance its growth cycle. This can speed up succession. Organic pollution occurs when too much organic matter, such as manure or sewage, gets in the water. The decaying organic matter uses up oxygen. Animal waste and bacteria from feedlots can create significant hazards for swimmers and for people using the lake for drinking water. Organic pollution also can happen when inorganic pollutants such as nitrates and phosphates build up in the water. Farmers use nitrates and phosphates as fertilizers to help plants grow which can increase growth of water plants and algae. Too much plant growth at the surface can block light from reaching deeper water. As the plants and algae die and decompose, they use up the dissolved oxygen resulting in the death of fish and other animals in the lake or pond.

2. Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.

Many answers are possible, but should resemble one of the following examples:

Technological solution	Possible solution to harmful change in the environment
Damming a stream to create a lake or pond	Remove or do not build dams. If this is not possible, create new habitat elsewhere to make up for habitat lost to the dam. Dredging may be necessary to slow down succession in the lake or pond. Spawn fish in a hatchery. Create fish passages around the dam (fish ladders). Build something to slow the water down when it comes out of the dam, to reduce damage downstream.
Urban development in the watershed of a lake or pond	Because every water body is a reflection of its watershed, good watershed management is important to keeping a pond healthy. Stopping excess erosion and runoff loaded with fertilizers, pesticides or other pollutants is key. Keeping a 100-foot-wide buffer of thick plant growth around the pond helps filter out pollutants and eroded earth before they reach the pond. A plant buffer will greatly improve the pond’s health and extend its life. The same is true for lakes.
Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond	Because every water body is a reflection of its watershed, good watershed management is important to keeping a pond healthy. Stopping excess erosion and runoff loaded with fertilizers, pesticides or other pollutants is key. Keeping a 100-foot-wide buffer of thick plant growth around the pond helps filter out pollutants and eroded earth before they reach the pond. A plant buffer will greatly improve the pond’s health and extend its life. The same is true for lakes. Some farmers have switched to conservation farming techniques to reduce the amount of soil and other sediment in lakes and ponds

3. Diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together. Refer to FIG. 8.8 in the Student.

Refer to FIG. 9.8 in the Student Guide to assess potential responses.

4. What is the importance of lakes to Texas populations and to the economy?

Texans use lakes for industry and agriculture, providing electricity, food, fiber, and jobs to many Texans. Lakes are also used for recreation, providing opportunities to get outdoors for boating, fishing, swimming, water skiing, and many other relaxing pass times. In addition, lakes bring money into the economy as visitors to lakes buy boats and engines, equipment, groceries, lodging, gasoline, bait, and many other items.

Wetlands

Wetlands are among the most productive ecosystems in the world, and home to many specially adapted plant and wildlife species. Wetlands provide many important ecological services.

Chapter 10

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Carousel around the room to describe various wetlands that occur in Texas.
2. Generate information that they know about playa lakes, riparian wetlands, spring-fed wetlands, sand sheet wetlands, resacas, ciénegas, bottomland hardwoods, and coastal wetlands, tidal wetlands, prairie depressions and forested wetlands.
3. Choose one type of wetland with which they are familiar or a wetland they are interested in and draw a picture including plants and animals that live there.
4. List characteristics of Texas wetlands including playa lakes riparian wetlands, spring-fed wetlands, sand sheet wetlands, resacas, ciénegas, bottomland hardwoods, and tidal wetlands.
5. Design and draw a wetland plant based on a given plant adaptation and label the parts.
6. Describe their plant and its adaptation, the wetland in which it lives, and how that adaptation helps the plant survive.
7. Read the chapter and answer the questions.
8. Explain how biotic and abiotic factors that make up wetland ecosystems function together.
9. Diagram and describe the transfer of energy in a food web for the Texas coastal wetlands.
10. Describe the adaptations and diets of animals in the Texas coastal wetlands.
11. Simulate a flock of birds.
12. Simulate dangers and obstacles of bird migration, modeling the importance of wetlands to bird survival.
13. Write a children's story about bird migration.
14. Assess the health of a wetland based on the diversity of aquatic invertebrates.
15. Read the student guide and answer the questions.

16. Predict the impact of drainage on the organisms in a wetland ecosystem. Describe how technological solutions to problems, such as drainage and agricultural development, can have risks and unintended consequences. Describe possible solutions to potentially harmful environmental changes within a wetland ecosystem.
17. Research bird migration questions using the Internet.
18. Determine the soil percolation rate and observe the color, texture and odor of the soil.
19. Identify soil and water chemistry in a local wetland using soil and water chemistry test kits and equipment.
20. Use course apparatus, equipment, techniques, and procedures.
21. Collect quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, nitrogen compounds, and turbidity.
22. Identify ways human activity can affect aquatic environments.
23. Predict effects of chemical, organic, physical, and thermal changes caused by humans on the living and nonliving components of an aquatic ecosystem.
24. Analyze the cumulative impact of human population growth on an aquatic system.
25. Use safe practices and conservation of resources in the lab and field.
26. Collect data on soil and water, chemical, physical, and biological characteristics of a wetland, and record information in tables.
27. Draw conclusions based on data collected in the field.
28. Make connections between testing of water and soil chemistry and careers in aquatic science.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, C, D, E; 6.3 B, C; 6.4 A, B; 6.12 A, E; 7.1 A, B; 7.2 A, C, D, E; 7.3 B, C; 7.4 A, B; 7.5 A, B, C; 7.8 C; 7.10 A; 7.11 A, B; 7.12 A; 7.13 A, B; 8.1 A, B; 8.2 A, C, D, E; 8.3 B, C; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 B, E; 5 C, D; 9 C; 10 A, B; 11 A, B; 12 A, B, D

Environmental Science: 1 A, B; 2 E, F, G, H, I, K; 3 B, E; 4 A, B, E; 5 B; 6 E; 7 D; 9 E

Materials Needed

Activity 10.1

Chart paper

Print and laminate photos of various wetlands. **Download here:**
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/wetlands.pdf

Markers: a different color for each group

Student journals

Pencils/pens

Activity 10.2

Student Guides

Student journals

Pencils/pens

Student *Design a Plant* instruction sheet

Activity 10.3

Laminated copies of *Texas Coastal Wetlands* poster for each group and fact sheets for animals for the class. **Download here:**
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/coastal-wetlands.pdf

Science journals

Pens or pencils

Red, green and black Vis-a Vis

Activity 10.4

Computer with Internet connection for research

Chalk or masking tape

Habitat Destruction cards made from magazine pictures

Pictures of different types of wetlands from activity 10.1

Bird cards from magazine pictures or made by students

Activity 10.5

Science journals

Pens or pencils

Rulers

Garden spades or shovels

Stopwatches, watches or clocks

Safety goggles—one per student

Soil test kits may contain tests such as pH, phosphorus, nitrates, and potassium. (Available from science supply catalogs and sometimes local hardware or garden stores)

Water quality test kits, probes, meters or other equipment such as thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, etc.

High school students should also have secchi disc, stop watch, tennis ball or piece of wood, salinity test

Binoculars

Field Guides

Garbage bags for litter pick up

Disposable gloves for litter pick up

One copy of each of the following for each student

- Soil Sampling—Percolation and Characteristics student instructions and data sheets
- Data table
- Water Chemistry Investigation sheet for each student
- Physical Water Quality Indicators check sheet with data table
- Invertebrates & Vertebrates as Water Quality Indicators information sheet
- Bug Picking Data Sheet
- Aquatic plants adaptation instructions and information sheets
- Bird count and adaptations data table

Safety Precautions

During active games students will need to take care so that no one is bumped. Students cannot touch in the flocking activity.

Use extra care when handling glass. Only adults should pick up glass. Wear gloves.

Stress field safety.

Vocabulary

- Aerobic
- Anaerobic
- Bottomland
- Carnivore
- Ciénegas
- Coastal
- Consumer
- Decomposer
- Detritus
- Flock
- Habitat destruction
- Habitat restoration
- Herbivore
- Hydric soils
- Hydrophytes
- Migration

- Omnivore
- Percolation
- Playa
- Prairie depression
- Producer
- Resacas
- Riparian
- Sand sheet wetlands
- Spring-fed
- Tidal

Reference Material for Teachers

http://www.tpwd.state.tx.us/learning/resources/publications/posters.phtml
Poster and animal fact sheets, *Coastal Wetlands*

Enrichments

Project WET

- Capture, Store, Release
- Life in the Fast Lane
- Wetland Soils in Living Color
- Macro-Invertebrate Mayhem

Project WILD Aquatic

- Dragonfly Pond
- Wetland Metaphors
- Migration Headache
- Marsh Munchers

Service Learning

- Storm drain stenciling
- Litter pickup

Lesson 10.1: What is a Wetland?

Essential Concept

Every part of Texas has wetlands. These wetlands are varied depending on the climate and physiography of the part of the state where each occurs.

Objectives

1. Students will carousel around the room to describe various wetlands that occur in Texas.
2. Students will generate information that they know about playa lakes, riparian wetlands, spring-fed wetlands, sand sheet wetlands, resacas, ciénegas or desert springs, bottomland hardwoods, and coastal wetlands including tidal wetlands, and prairie depressions.
3. Students will choose one type of wetland with which they are familiar or in which they are most interested, and draw a picture including plants and animals that live there.
4. Students will list characteristics Texas wetlands including playa lakes, riparian wetlands, spring-fed wetlands, sand sheet wetlands, resacas, ciénegas, bottomland hardwoods, and tidal wetlands

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 A; 8.2 C; 8.11 A, B

Aquatic Science: 2 J; 10 B

Environmental Science: 2 K

Estimated Time

1 class period

Materials

Chart paper

Print and laminate photos of various wetlands (see end of lesson)

Markers: a different color for each group

Student journals

Pencils/pens

Markers, crayons, or colored pencils for drawing

Special Instructions

Attach photos and names of six regions of the state with the types of wetlands found in that region on separate posters. Hang the posters around the room.

Print and laminate photos of various wetlands. **Download here:** http://www.tpwd.state.tx.us/publications/learning/aquaticscience/wetlands.pdf

1. East Texas: Bottomland hardwoods
2. Gulf Coast Wetlands: Coastal wetlands, including tidal wetlands, prairie depressions
3. South Texas Wetlands: Sand sheet wetlands, resacas
4. High Plains and Rolling Plains Wetlands: Playas, riparian wetlands
5. Central Texas Wetlands: Spring-fed wetlands, Riparian wetlands
6. Trans-Pecos Wetlands: Mountain spring-fed wetlands, ciénegas or desert springs

Procedure

1. Wetlands Carousel

Put students in groups of 3 to 5 and give each group a different color of marker. Assign each group to start at one of the posters. Students should write on the poster everything they know about the wetlands in that region in 3 to 5 minutes. Students should use the pictures to help them describe the various wetlands. Then each group will rotate to the right to the next poster, review what is already there and add any other information that they know, and then repeat with each poster until all groups have contributed to every poster.

2. Class Discussion

Review the information on the posters and discuss any misconceptions. Review the locations of the wetlands and the climate and physiography of each region of the state. How do the characteristics of the region influence the types of wetlands that are located there? Keep posters on the wall to add new ideas as they come up.

3. Describe Texas Wetland Ecosystems

Ask students to use their journals to list the characteristics of Texas wetlands that they learned about in their discussion including playa lakes riparian wetlands, spring-fed wetlands, sand sheet wetlands, resacas, mountain springs, ciénegas, bottomland hardwoods, and tidal wetlands.

4. Drawing a Wetland

Ask students to choose one type of wetland with which they are familiar or are most interested in, and draw a picture including plants and animals that they think might live in that wetland.

Vocabulary

- Bottomland
- Ciénegas
- Coastal
- Playa
- Prairie depression
- Resacas
- Riparian
- Sand sheet wetlands
- Spring-fed
- Tidal

Lesson 10.2: Reading and Research

Essential Concept

Wetlands are among the most productive ecosystems in the world. Life gathers around wetlands and wetlands give life.

Objectives

1. Students will read the student guide and answer the questions.
2. Students will design and draw a wetland plant based on a given plant adaptation and label the parts.
3. Students will describe their plant and its adaptation, the wetland in which it lives, and how that adaptation helps the plant survive.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.11 B; 8.2 C; 8.11B

Aquatic Science: 2 J; 10 B

Environmental Science: 2 K

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion

Materials

Student Guides

Student journals

Pencils/pens

Student Design a Plant instruction sheet

Procedure

1. Read the Chapter

Have students read *Chapter 10: Wetlands* in the *Student Guide*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is a wetland? What three factors must be present for a place to be considered a wetland?

Wetlands are places where the land and water meet. In a wetland, the soil is saturated or covered with water at least part of the year. Staying wet gives the soil unique properties. In those places, the wetland becomes a home to plants that are specially adapted to live in saturated soil.

2) What are some of the different types of wetlands found in Texas? What are the differences and similarities between them?

Texas has two main types of wetlands: Freshwater wetlands and Coastal wetlands. All wetlands are wet for a major part of the growing season. Some wetlands may have standing water. Others may only appear slightly muddy, or may even seem dry at the ground's surface. But dig a hole and it will fill with water very quickly. The soil holds water like a sponge. Freshwater wetlands include playa lakes, resacas, spring-fed wetlands, riparian wetlands, ciénegas, prairie depressions, and bottomland hardwoods. Coastal wetlands include low-lying areas near bays and estuaries, and where rivers flow into bays and estuaries, and tidal wetlands.

3) What is different about wetland soil? How can we recognize it?

When soil is saturated the space between the bits of dirt is filled with water. This leaves little or no room for air, giving the soil a grayish color and a gooey texture. In the water, tiny creatures break down dead plant and animal matter called detritus. Because the detritus layer settles beneath the water and is not exposed to air, special kinds of decomposers are needed. Anaerobic bacteria, which do not need oxygen to live, are the stars of the wetland ecosystem. As they break down the detritus, they produce sulfur-containing compounds. The sulfur compounds smell like rotten eggs. But the smell tells us the wetland is healthy. The rich detritus nourishes a complex food web.

4) What are some examples of the special adaptations found in wetland plants and animals?

Wetland plants are adapted to take advantage of every ray of sunlight. They have special ways to expose their leaves to the sun and avoid being shaded by other leaves. They also have roots that can pull in water and still get air, too. Plants that grow in shallow water have roots that grow in the mud and hold onto silt. Most of these plants are tall because they have greater support, enabling them to rise above other plants to reach the sun. Cattails, buttonbush, rushes, sedges and arrowheads do this very well. Other plants such as water lilies grow in deeper water, but are still anchored. Plants such as duckweed grow in open water to avoid the shade of taller plants, but they float by using air spaces in their leaves. Their short roots hang free in the nutrient-rich water. Another challenge of wetland plants is how to get enough air for their cells. The cypress tree's roots (called knees) extend up and out of the water. Sedges and rushes have air spaces inside their leaves to take oxygen and carbon dioxide to the roots. Coastal wetland plants, such as mangroves and salicornia, can live in water having a high salinity. These plants are called halophytes.

Examples of adaptations of wetland animals

Whirligig beetles eyes can focus above and below water to help it find prey. Black necked stilt's long legs and specially adapted feet help it walk in mud. Their long slender beaks are able to snatch prey from under water. Frogs long spring-like legs and turtles' shells help them escape predators. Ducks have spoon-like, flattened bills to strain seeds and invertebrates from shallow water.

5) How are wetlands important to fish, birds, and other wildlife?

Wetlands are home to many invertebrates, amphibians, reptiles, fish, birds and mammals. In fact, you can find more animals and plants in an acre of wetland than in almost any other kind of ecosystem. Up to 90% of Texas saltwater and freshwater fish species depend on wetlands for food, spawning, and nursery grounds. Young fish can find protection from larger fish and other predators by staying in the plant-filled shallow water of wetlands. There is plenty of food for young fish in such places. They remain in this cover until they grow large enough to venture out into deeper waters. Without the wetlands, these species would disappear even though there may be plenty of deep water nearby where adult fish can live. Many freshwater fish and most of the important fish and invertebrates in the Gulf of Mexico are dependent on wetlands as a place for their young to feed and grow up safely.

Texas' wetlands serve the vital function of providing migrating waterfowl a place to rest and replenish energy reserves lost in flight. Texas is at the southern end of the Central and Mississippi Flyways. Migratory birds in Texas use these flyways to travel thousands of miles back and forth from our wetlands to nesting areas in the north where they breed, lay their eggs, and raise their young. Then the birds return to Texas in early fall and spend the winter feeding in Texas' wetlands getting ready for the trip back north in early spring. As a result, Texas wetlands are directly connected to wetlands in northern states, in Canada, and even as far away as the Arctic Circle.

Healthy and productive wetlands are needed at both ends of the birds' flight and all along the way. Texas wetlands play an especially important role for both wintering and migrating waterfowl. Texas' prairie and coastal wetlands provide food and lodging for 90% of all ducks and 75 % of all geese in the Central Flyway.

For migrating birds, Texas' 20,000 playa lakes in the High Plains provide important stopover habitat, supplying plants, seeds, and invertebrates that migrating birds must eat to get enough energy to continue their flight north or south.

Citizen conservation groups, together with Texas Parks and Wildlife Department and other state and federal wildlife agencies work to protect and restore wetlands in Texas and everywhere else migratory birds go. Migratory bird hunters buy special stamps to help pay for this wetland conservation.

6) How do wetlands improve water quality?

Wetlands filter out pollutants. Wetland plants absorb pollutants, store them, break them down and in some cases even use them as nutrients. For example, excess plant nutrients from fertilizers reduce water quality in many streams and lakes. But because wetland plants can store these nutrients, they use them as fuel for growth. Bacteria found in wetlands can even break these chemicals down into harmless gases and release them into the atmosphere. Wetlands also improve water quality by cleansing runoff that comes from higher in the watershed. Because of their flatness and lush plant growth, wetlands slow the flow of water coming into them. In the slow water, suspended soil particles settle out. Wetland plants also filter particles from water, keeping sediment out of streams and rivers.

7) How do wetlands provide natural flood control?

Wetlands act as giant sponges. Their organic matter and specialized plants take in up to 18 times their weight in water. During periods of heavy rains or runoff, wetlands first hold water then release it slowly back into the watershed. Wetlands slow the flow of water and help reduce damage caused by floods. By holding water and letting it go slowly, wetlands reduce the total amount of water going into lower watersheds. This reduces flood risk and peak flood volume downstream.

8) How do wetlands recharge aquifers?

Wetlands' flatness and lush plant growth slows down the flow of water when it rains. When this happens, water may seep into the aquifer increasing the amount of groundwater. This ability of wetlands to recharge groundwater is especially important in times of drought and in arid parts of the state where communities struggle to deal with declining water tables.

9) Why should we protect wetlands? How can we protect wetlands?

Wetlands help the economy and attract tourists. Texas fishermen catch 30 million pounds of wetland dependent shrimp with a value of $100 million per year. Texas is known around the world for great hunting and fishing. Without healthy wetlands the seafood, fish, birds, and animals we hunt and fish would not be here. Wetlands are also treasured by millions of photographers, boaters, hikers, and wildlife watchers, including tourist who come to Texas just to enjoy the natural beauty our wetlands provide.

To help stop wetlands loss, state and federal conservation agencies work together with wildlife conservation organizations to protect and restore wetlands. Everyone can support efforts to protect wetlands no matter where you live. Do your part to keep trash and other pollution from entering Texas' waters. Visit a wetland. They are easy to see and explore with many plants, and animals along the water's edge or on plants. Canoeing, kayaking, fishing, and birdwatching are just a few of the things you can do while enjoying the beauty of a wetland.

3. Design a Plant

Wetland plants have a variety of adaptations that help them survive. Each student will choose at least one plant adaptation for living in a wetland. Students must design a plant with that adaptation, tell about the kind of wetland in which the plant would live, and explain how the adaptation helps the plant survive. Post the list on the overhead and allow each student to choose at least one, but not more than two, adaptations for their plant. (Note: If you want to be sure that all adaptations are chosen, you can assign an adaptation to each student.)

Real Wetland Plant Adaptations

- Flexible stems
- Air bladders
- Digestive juices
- Roots in the air
- Air filled roots
- Hanging roots
- Gummy, waxy skin
- Exudes salt crystals
- Salt drops on tips of leaves
- Small flowers
- Sticky, sweet smelling
- Thick, fuzzy, rolled leaves
- Lives symbiotically with fungi
- Low sprawling form
- Buttress roots
- Rot resistant wood
- Large breathing pores
- Stomata on leaf's upper surface
- Finely cut leaves
- Floating flowers

Vocabulary

- Aerobic
- Anaerobic
- Bottomland
- Ciénegas
- Coastal
- Detritus
- Playa
- Prairie depression
- Resacas

- Riparian
- Sand sheet wetlands
- Spring-fed
- Tidal

Designing a Wetland Plant

Directions

Wetland plants have a variety of adaptations that help them survive.

1. **Choose at least one plant adaptation for living in a wetland.**
2. **Design a plant with that adaptation.**
3. **Tell about the kind of wetland in which the plant would live.**
4. **Explain how the adaptation provides an advantage to help the plant survive. What is the purpose of the adaptation?**
5. **Draw a picture of the plant, label the parts and point out the adaptation or adaptations you chose to use in your plant.**

Real Wetland Plant Adaptations

1. Flexible stems
2. Air bladders
3. Digestive juices
4. Roots in the air
5. Air filled roots
6. Hanging roots
7. Gummy, waxy skin
8. Exudes salt crystals
9. Salt drops on tips of leaves
10. Small flowers
11. Sticky, sweet smelling
12. Thick, fuzzy, rolled leaves
13. Lives symbiotically with fungi
14. Low sprawling form
15. Buttress roots
16. Rot resistant wood
17. Large breathing pores
18. Stomata on leaf’s upper surface
19. Finely cut leaves
20. Floating flowers

Lesson 10.3: Wetland Food Webs

Essential Concept

Wetlands have a large and varied food chain.

Objectives

1. Students will diagram and describe the transfer of energy in a food web of Texas coastal wetlands.
2. Students will learn about the adaptations and diets of animals in the Texas coastal wetlands.
3. Students will predict the impact of drainage of a wetland on organisms living there.
4. Students will list biotic and abiotic factors in a wetland system and explain how they function together.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.5 C; 7.10 A; 7.11 A, B; 8.2 C; 8.11 A

Aquatic Science: 2 J; 5 C; 10 B; 11 A

Environmental Science: 2 K; 4 B; 6 E

Estimated Time

1 class period

Materials

Laminated copies of *Texas Coastal Wetlands* poster for each group and fact sheets for animals for the class from Texas Parks and Wildlife Website

Science journals ·

Pens or pencils

Red, green and black Vis-a Vis

Special Instructions

Download, print, and laminate copies of *Texas Coastal Wetlands* poster for each group and fact sheets for animals for the class. **Download here:**
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/coastal-wetlands.pdf

Fact sheets and photos from website include the following: reddish egret, American oystercatcher, black-necked stilt, long-billed curlew, fiddler crab, stone crab, roseate spoonbill, eastern oyster, common blue crab, piping plover, Kemp's ridley sea turtle, lightning whelk, whooping crane, common raccoon, Texas diamondback terrapin, northern harrier, Atlantic croaker, Atlantic bay scallop, sheepshead minnow, seagrasses, spotted seatrout, red drum, pinfish, gulf salt marsh snake.

Procedure

1. Designing Coastal Wetland Food Webs

Give students a copy of the list of animals to be used in the food web. Give an 8 ½ inches X 11 inches laminated copy of *Texas Coastal Wetlands* poster to each group of 4 students.

Have each group work together to connect a coastal food web using the colored pens. Allow students 10 minutes to make th efood webs. Have students use the red Vis-a-Vis to connect a predator to its prey. Have students use the green Vis-a-Vis to connect primary consumers to producers. Use the black Vis-a-Vis to connect scavengers and decomposers to their food. Students may not know what all of the animals eat. Just have them use their best judgment.

Have each group present one part of the food web to the class. Put the names of the animals on the board and connect the food web as students instruct. When all three parts have been connected, ask students if anyone has a different food web. Continue presenting food webs until all ideas are presented. Discuss any conflicting ideas about what animals eat.

2. Learning About Animal Adaptations and Diets

Give each student one of the animal fact sheets and use the fact sheets to learn more about each of the coastal wetland organisms. Have students write a paragraph about the diet and adaptations of their animal in their science journals. Have each student provide information about their animal and its adaptations to living in a coastal wetland, and then, using what they learned, make corrections or additions to each group's food web and to the class food web on the board. Encourage the class to discuss changes and help decide where in the food chain the organism belongs. Is it a producer, herbivore/consumer, carnivore/consumer, omnivore/consumer, scavenger, or decomposer?

Have students copy the final food web diagram in their science journals. Indicate the transfer of energy in a wetland ecosystem.

3. Predicting Responses to Changes in the Wetland Environment

Ask students to predict the impact of drainage of a wetland on the organisms in a wetland ecosystem. (Drainage removes water—the most vital component of a wetland—from the ecosystem. If drainage is successful, the entire ecosystem and the organisms within it could be permanently lost.)

4. Using What We Learned

Have students write science journal entries listing the biotic and abiotic factors in a coastal wetland ecosystem and explaining how these biotic and abiotic factors function together.

Vocabulary

- Carnivore
- Consumer
- Decomposer
- Detritus
- Herbivore
- Omnivore
- Producer

Student Page:

Coastal Wetland Organisms for Food Webs

1. Reddish egret
2. American oystercatcher
3. Black-necked stilt
4. Long-billed curlew
5. Fiddler crab
6. Stone crab
7. Roseate spoonbill
8. Eastern oyster
9. Common blue crab
10. Piping plover
11. Kemp's ridley sea turtle
12. Lightning whelk
13. Whooping crane
14. Common raccoon
15. Texas diamondback terrapin
16. Northern harrier
17. Atlantic croaker
18. Atlantic bay scallop
19. Sheepshead minnow
20, Seagrasses
21. Spotted seatrout
22. Red drum
23. Pinfish
24. Gulf salt marsh snake

Lesson 10.4: Migration Stations

Essential Concept

Migrating birds need wetlands as places to stop and rest, and eat in order to complete their migrations.

Objectives

1. Students will take part in a game to simulate a flock of birds.
2. Students will research bird migration questions.
3. Students will take part in a simulation of bird migration modeling the importance of wetlands to bird survival.
4. Students will write a children's story about bird migration.

TEKS

6.3 B, C; 6.12 E; 7.3 B, C; 7.11 B; 7.12 A; 7.13 A, B; 8.3 B, C; 8.8 C; 8.11 C

Aquatic Science: 2 H, J; 3 B; 12 A, D

Environmental Science: 2 I, K; 4 A; 9 E

Estimated Time

1 class period

Materials

Computer with Internet connection for research

Chalk or masking tape

Habitat Destruction cards made from magazine or Internet pictures

Pictures of different types of wetlands from activity 10.1

Bird cards from magazine pictures or made by students

Special Instructions

The flocking game can be played in the gym or outside.

Preparation for *Migration Stations*: The migration stations simulation can be done either outside on the concrete or inside the classroom. You will need to draw a large grid (like *Hopscotch*) with 10 squares each about 3 ft. X 3 ft. You can draw the grid with chalk outside on the concrete or for inside, you may wish to use tape to put the grid on the floor. (For those of you who don't remember *Hopscotch*, you just draw connected boxes on the sidewalk and jump from box to box on one foot. If you put a rock in a square, you can't jump in it.) Make a start and finish line by labeling one end of the grid as **South America** and the other end could be labeled **Canada.**

Note: Be sure those students understand that these are not the only migration destinations. Some birds fly from the Arctic to the Antarctic. Each type of bird has its own migration pattern.

If possible, you can laminate magazine pictures of various birds. You may want to provide magazines and let students find the pictures. (**Note:** *Birds and Blooms*, *Audubon*, and *Texas Parks and Wildlife* have good pictures for use in this game.) If you don't have pictures, just let students write the name of their bird on a card and draw a picture of it. They can get ideas from a field guide. Students are to fly from one end of the migration grid to the other without stepping out of the boxes.

You will need to represent types of wetlands and put them on the grid. Use the photographs from Activity 10.1. (Spring-fed wetlands, playa lakes, riparian wetlands, resacas, bottomlands, ciénegas, mountain spring wetlands, coastal tidal wetlands) You can make more than one copy of some of the pictures and use some picture more than once.

You will also need some laminated sheets for *Habitat Destruction Cards.* Again, they can be magazine pictures, drawings, or just written words, but these cards should have a big red X on them. You will need to include cards for:

- Urban Sprawl in Wetland
- Development of a Big Resort on a Coastal Wetland
- Deforestation of a Bottomland Wetland
- Drought Dries Up a Spring-fed Wetland
- Corporate Agriculture on a Drained Playa Lake Wetland
- Succession Changes a Resaca to a Grassland and Brush
- Land Cleared and Houses Built along a Riparian Wetland

That will give you 7 *Habitat Destruction Cards*.

Safety Precautions

These are kinesthetic activities. Students will need to take care so that no one is bumped. Students can not touch in the flocking activity.

Procedure

1. Bird Migration Research

Assign each group of 2-3 students one of the following questions to research on the Internet:

- **What is bird migration?** (The seasonal movement of birds)
- **Why do birds migrate?** (As a response to internal and external stimuli to find a place with enough food, to return to an area where they breed and raise their young)

- **How do birds prepare to migrate?** (They eat more food, and store it as fat for the long migration.)
- **When do birds migrate?** (Some birds fly at night like songbirds and look for food and rest during the day. Other birds such as hawks migrate by day so that they can catch the thermal updrafts over the land. Insectivores, such as swallows and swifts, also fly during the day and feed on insects as they travel. Flocking birds such as waterfowl and finches also fly during the day. And some hummingbirds make part of their flight with no stops in 24 hours across the Gulf of Mexico to the Yucatan Peninsula. Many birds use wetlands along the migration route to rest and eat. Some stay only for a short time, while others may stay for weeks depending on the weather and how much fat they have stored.
- **How far do birds migrate?** (Different distances for different birds–The longest distance is flown by the arctic tern, which flies 18,600 miles from their breeding grounds in the Arctic to the Antarctic. This is possible because these terns eat fish and feed along the way. Some other bird species only fly as far as they need to find food.)
- **What dangers do birds face on their migration?** (Inadequate food supply, loss of resting places due to development or pollution, predators, storms, collisions with objects in their paths, becoming disoriented due to light pollution)
- **At what altitudes do birds migrate?** (Geese and ducks fly very high. Bar-headed geese have been recorded at altitudes as high as 29,000 feet when they migrate over the Himalayas. That is over 5 miles in altitude. Most night-migrating songbirds will fly below 2,000 feet when they are flying over land. They may fly as high as 6,500 feet, and sometimes higher to reach favorable winds. Birds fly lower in headwinds and higher in a tailwind so that they can get where the wind is the fastest.)
- **How fast do birds fly?** (Songbirds fly about 20-30 miles per hour. Waterfowl and shorebirds fly around 30-50 miles per hour. If they have a tailwind, birds can fly even faster.)
- **How do birds navigate during migration?** (Birds rely on visual landmarks, which may be learned, such as mountains, rivers, coasts, or even buildings. In addition, there is a genetic component to some birds' migration. Birds such as cuckoos, raised by another species, still find their way to the breeding grounds used by other cuckoos. Birds also use the sun, stars, and the Earth's magnetic field to help them find their way. Birds that fly at night use the patterns of the stars and special stars to help them. They may memorize the position of the constellations in relation to the North Star. Also, birds have an internal structure including a tiny grain of a mineral called magnetite just above their nostrils in their bill, or in their brains or eyes. This helps them use the Earth's magnetic field to orient their flight. In addition to the stars, sun and Earth's magnetic field, petrels and pigeons can even use their sense of smell to help them find their way.
- **How do we learn about bird migration?** (Scientific research, including bird banding, helps scientists learn about migration. Just as we did in the mark and recapture activity, scientists put bands on birds so that if they are recaptured or

found after they die, the band number can be reported to the Bird Banding Laboratory and the record tells them where the bird was first banded and how far it had traveled. Migration counts are also done each year to learn the numbers and species of birds that are in a given area. Even weather radar can give us information about migrating birds, which can be seen on radar when they migrate through an area in heavy concentrations.)

When the students finish their research, have them write a short report of what they found out and share it with the class. Students should take notes in their science journals so that everyone has the answers to all the questions.

2. Flocking Game

In this game the goal is for the students to **move as a group**, simulating a flock of birds, to show flock advantages in escape from predation.

You may want to do this activity outside or in the gym, depending on the number of students in your class. Have students gather in a tight "flock". They should stand with their arms to their sides. Their shoulders will represent their wings. Students must travel as a unit, but their shoulders must not touch. If their wing tips brush against another bird's wings, they will have a collision and the birds will crash and die.

Have the flock "fly" at a slow jog toward a point ahead. When they arrive at the spot they must veer off in another direction. (Do not tell them which direction to go.) Birds can not talk or use hand signals, so students should not either. The idea is for students to get the feel for the challenge that birds encounter while migrating in a flock. (There may be some confusion, or maybe students will choose a strategy to follow the leader.)

- **How do you think birds stay together in flocks without bumping into each other.** (Accept any ideas based on logical reasoning. No one knows for sure.)

Introduce the idea of a predator attacking the flock. Peregrine falcons use a technique of diving into flying flocks from above. The birds can't see the falcon above them. When the flock splits up the falcon captures stragglers. In this part of the game the teacher will be the falcon. The falcon kneels down a few yards ahead of the group. Remember, the flock can't see him, because the falcon is flying above them.

Have the flock fly straight toward the falcon. Have the falcon stand, which will indicate the time when the flock spots him. The flock must split to avoid being caught and eaten.

The falcon can only run straight ahead with arms extended as talons. The falcon can only tag birds that are directly in the line of flight. (This rule is made to simulate falcons diving, when they cannot maneuver very well. They are only able to fly straight in front of them.

- **Was the falcon able to catch any of the flocking birds?**

Try again and this time, run at an angle through the flock. Evaluate why any bird might have been caught.

- **Did the Peregrine catch a bird on every try?**
- **Where is the safest place in the flock?**
- **Would the safe place change depending on where the falcon split the flock?**

3. Migration Stations

You may want to do this activity outside or in the gym, depending on the number of students in your class. You will need to make a large vertical grid (like hopscotch) with 10 squares about 2 ft. x 2 ft. You can draw the grid with chalk outside on the concrete or inside with the grid taped to the floor.

See *Special Instructions* to set up the game. Place a wetland location card on each square.

You may wish to have each student choose a bird, draw a picture and make a nametag on a 3 in. X 5 in. card. (See *Special Instructions* above.)

Have students line up at the beginning of the course. Tell students that they are birds migrating north. Each of the squares represents a wetland along their route where they can stop and eat and rest. Students must hop on one foot from square to square. If two squares are side by side, the student can put down both feet.

Round 1

Ask students to migrate northward on the course. They do not have to step on every square, but they must stay within the course. All students should be successful on the first migration.

Round 2

Use the laminated *Habitat Destruction Cards* to destroy some of the wetlands. Example: Tell students you are a big developer in an urban area and you are draining and building condos on a wetland, which will destroy the habitat where migrating birds have been stopping to rest and eat. Students may not touch a foot in the square where the *Urban Development Card* is placed. If a student should touch that square, they die and must move to the sidelines.

Round 3

After all the students have been through the course destroy two more habitats and repeat the procedure. Try to X off the squares so that the intact wetlands are farther apart.

Round 4 and 5

Continue to destroy wetlands two at a time until you have used all of the *Habitat Destruction Cards* or until all students are unable to complete their migrations. Don’t cover every square, but put the *Habitat Destruction Cards* out in a way that not all the wetlands are destroyed, but they are so far apart that students cannot make the jump from one safe wetland to the next.

Round 6

Restore some of the wetlands by telling students that a conservation group has bought the land and is restoring it to a wetland habitat. You don’t have to restore every square, but put back two strategic wetlands so that students will be more likely to be able to complete the migration.

Ask students to make the migration journey again.

Extensions

You may want to make the rules a little harder by asking students to make it through the course in a certain amount of time. If students exceed the time limit, the migration was not successful and they die.

Or you may want the students to gather food on their journey. You can use bean bags or tokens such as poker chips to represent food. Take away food tokens when the Habitat Destruction Card is in place. Students will need to collect a certain amount of food on their migration to complete the trip successfully.

You could also use reproduction as a variable. Start with a few students, any surviving students get to reproduce by adding another student. When wetland breeding habitat is taken away, birds die.

What Does the Model of Bird Migration Show Us?

- **What happened on the migration when wetland habitat was destroyed?** (Some birds failed to complete their migration.) **Why did this happen?** (There was not enough food or places to rest close enough together so that birds either went hungry or just couldn't reach the next stop.)
- **What did you notice about the food supply when wetland habitat was destroyed?** (There was less food available.)
- **How is this model like the real migration of birds? How is it different?**
- **What are the limitations of the model?**
- **How do migrating birds depend on wetlands during their migration?**
- **How do you think that restoring wetlands helps migratory birds?**
- **What might happen to a species of birds that lost all their migratory stops?**

4. **Using What We Learned**

Use what you learned in the *Migration Station* model to write a story for younger children about a migrating bird's adventures on his/her first migration. You may use the Internet to do some research for your story. **Make at least 3 drawings to illustrate your story. Use the Rubric to help you write your story.**

Include the following in your story:

- **What kind of bird are you?**
- **What do you see on your migration?**
- **Where do you stop for food and rest?** Describe a favorite wetland where you stop.

- **What kinds of obstacles did you overcome to finish your migration to the nesting grounds?**

Vocabulary

- Flock
- Habitat destruction
- Habitat restoration
- Migration

Student page

Rubric for Stories

I. Story **20 points**

1. The beginning gets the reader's attention.
2. The story is appropriate for young children.
3. The purpose of the story is clear.
4. The story is clear, and detailed.

II. Illustrations **20 points**

1. The pictures are neat and clean.
2. The pictures are colorful.
3. The illustrations help move the story along.
4. The illustrations help to show the components of the ecosystem needed by the animal in the story.

III. Organization **20 points**

1. The title is interesting or catchy.
2. Information is clear and concise.
3. The story has a beginning, middle, and end.
4. The illustrations make the story easy to understand.

IV. Accuracy **20 points**

1. The story answers all the questions in the assignment.
   - What kind of bird are you?
   - What do you see on your migration?
   - Where do you stop for food and rest? Describe a favorite wetland where you stop.
   - What kinds of obstacles did you overcome to finish your migration to the nesting grounds?

V. Grammar and Punctuation **20 points**

1. Story should be neatly written.
2. Uses complete sentences.
3. Uses appropriate punctuation.
4. Uses correct spelling.

TOTAL **100 Points**

Lesson 10.5: Field Trip to a Wetland

Essential Concept

Wetlands are precious resources that supply valuable habitat and require protection.

Objectives

1. Students determine the soil percolation rate and observe the color, texture and odor of the soil.
2. Students use water and soil chemistry test kits and equipment to identify soil and water chemistry in a local wetland.
3. Students demonstrate the use of course apparatuses, equipment, techniques, and procedures.
4. Students collect quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, nitrogen compounds, and turbidity.
5. Students identify ways human activity can affect aquatic environments.
6. Students will predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
7. Students will analyze the cumulative impact of human population growth on an aquatic system.
8. Students use safe practices and conservation of resources in the lab and field.
9. Students collect data on soil and water, chemical, physical, and biological characteristics of a wetland, and record information in tables.
10. Students draw conclusions based on data.
11. Students make connections between evaluating wetland habitat and careers.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.5 A, B; 7.8 C; 7.10 A; 7.11 A; 7.13 A, B; 8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 C D; 7 C; 9 C; 10 A, B; 11 A, B; 12 A, B, D

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 B, E; 4 A, B, E; 5 B; 6 E; 7 D

Estimated Time

These activities can be done as an all-day field investigation or set up on the school grounds or nearby natural area to be completed on 3 consecutive days.

Minimum time 3 class periods, if done on the school grounds

Including field trip, you will need 1 whole day in the field and 1 class period for review of data and writing Field Report (reports can be finished as homework).

Materials

Clip boards

Science journals

Pens or pencils

Rulers

Garden spades or shovels

Stopwatches, watches or clocks

Safety goggles—one per student

Soil Test kits may contain tests for pH, phosphorus, nitrates, and potassium. (available from science supply catalogs and sometimes from local hardware and garden stores)

Water quality test kits, probes, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, or other tests or probes that are appropriate.

Binoculars

Field Guides

Garbage bags for litter pick up

Disposable gloves for litter pick up

High school students should also have secchi disc, stop watch, tennis ball or piece of wood, salinity test

One copy of each of the following for each student or have students make their own tables.

- *Soil Sampling—Percolation and Characteristics* student instructions and data sheets
- *Litter and Debris Tally*
- *Physical Water Quality Indicators* check sheet with data table
- *Invertebrates & Vertebrates as Water Quality Indicators* information sheet
- *Bug Picking Data Sheet*
- Aquatic plants adaptation instructions and information sheets and data table
- Bird count and adaptations data table
- Student made data tables for Soil and Water chemistry based on the tests that students use
- *Weather Observations and Measurements*

Special Instructions

Obtain Soil Testing kits and prepare students for using these new tests. A practice can be done using soil from the school grounds before going into the field. Keep data from school grounds for comparison with wetland samples.

Safety Precautions

When collecting litter and debris, use extra care when handling glass. Only adults should pick up glass. Wear gloves. Stress field safety. (See *Field Trip Information* at the beginning of the curriculum guide.) Always wear long pants and closed toe shoes for outdoor activities.

Procedure

1. Studying Soil in a Wetland

Explain to students that this field investigation has many parts. Some data tables are made for them and some data tables they will need to make in their journals. Students should answer questions in their science journals.

Students should visit a local wetland. There will be different types of wetlands in different parts of the state. For the High Plains plan to do this study when there is water in the playa lakes perhaps after a rain. Spring-fed wetlands will have water most of the time if a drought is not too severe. Riparian wetlands also will be wet except in severe drought. East Texas bottomland wetlands and most coastal wetlands have some water all of the time although prairie depressions may dry and salinity may increase in coastal wetlands in drought times. South Texas resacas and sand sheet wetlands are ephemeral and you will need to check to see if they are wet before taking students in the field.

Students will look at various characteristics of wetland soils. If you are doing the activities on the school grounds have students work in small groups in varying locations in order to compare results from different sites. In the field, choose 3 sites and assign student groups to each site.

Provide each student with a copy of *Soil Sampling—Percolation and Characteristics*.

See example below.

Lead the class through the procedure.

SOIL SAMPLING— PERCOLATION AND CHARACTERISTICS

Directions

1) If there is standing water at the site, use a ruler to measure the depth of the standing water. Measure in centimeters from the soil surface to the top of the water and record the result. If there is standing water**, do not dig a test hole**.

2) If there is no standing water at the site, dig a hole 30 centimeters square and 30 centimeters deep using a spade or shovel.

3) Measure the rise in water level in the hole during an approximate 30-minute period.

4) Calculate percolation rate in centimeters per minute and record it below.

5) Examining Soils. While waiting**,** examine some of the hydric soil from the hole. When soil is saturated the space between the bits of dirt is filled with water. This leaves little or no room for air, giving the soil a grayish color and a gooey texture. These gray, blue, even black wetland soils also may have irregularly shaped reddish-brown or orange-yellow mottles, indicating the presence of iron in the soil. Record your observations in the table under color and texture.

6) Soil Smell. In the water, tiny creatures break down dead plant and animal matter called detritus. Because the detritus layer settles beneath the water and is not exposed to air, special kinds of decomposers are needed. Anaerobic bacteria, which do not need oxygen to live, break down the detritus. They produce sulfur-containing compounds, which smell like rotten eggs. Remove a small piece of soil from the hole. Crush this piece between thumb and forefingers and smell it to determine if hydrogen sulfide is present. Record your observations.

7) Cleaning up. Fill in your soil hole when you are done!

Have students compare their results and place the completed data sheets (found as the end of this lesson) in their science notebooks.

2. Soil and Water Chemistry

Students will collect soil and water chemistry data and make observations using soil testing kits and water testing kits.

If you have an aquatic site on the school grounds, the water and soil chemistry data can be done there. If you make a field trip to a wetland all of your tests can be done there.

The water testing kit may include pH, salinity, nitrates, dissolved oxygen, and phosphorus. The soil testing kit may include tests for nitrates, phosphorus, potassium and pH. Have students make the same soil tests of a non-wetland at the school grounds. **Make a data table to record your results at your school grounds and three sites at the wetland.**

- **How does the chemistry of wetland soils compare to soil on the school grounds?**

3. Physical and Biological Indicators of Water Quality

Students should look at the *Physical Indicators of Pollution* check sheet, water temperature, turbidity, color, odor, foaming, and conductivity.

Have students also look at the *Invertebrate and Vertebrate Water Quality Indicators* information sheet, and macro-invertebrate identification sheets such as the *Bug Picking* sheet from Texas Parks and Wildlife Department and **decide what water quality they think may be indicated by the macro-invertebrates and vertebrates** they find in the wetland. If you are in a saline environment, you will have different invertebrates. Use a field guide to help you identify these organisms.

- **Where do humans impact of the water come from to this wetland ecosystem?**

Make a list of human activity near the wetland. Have students analyze the cumulative impact of human population growth on this wetland ecosystem. Students should predict how human activities impact physical, chemical, and thermal changes in the water, which will affect the living and nonliving components of the wetland ecosystem.

- **How might this impact changes in the wetland over the coming years?**

4. Plant Adaptations in a Wetland

Use the *Student Instruction* sheet for *Wetland Plant Adaptations Drawings and Descriptions* to investigate the ways that plants are able to survive in a wetland.

All plants need sunlight, oxygen and a way to reproduce. Hydrophytes, those plants that live in water-logged soils, have adapted unique ways to survive. Use your eyes and hand lens to observe closely and use the *Student Information* sheet, *Wetland Plant Adaptations* sheet to help you answer these questions and fill in the *Plant Adaptations Data Table.*

1) Find a plant living in a wetland. Notice its size and shape. Describe or draw it in your journal.

- **In what habitat is it living?**
- **How does its size and shape enable it to live in a wetland?**

2) Find a plant living in a wetland. Feel its texture. Describe it.

- **How does its texture help it survive in a wetland?**

3) Cut the stem of a plant crosswise. In your journal, draw or describe what you see. Use your hand lens to look closely.

- **How does what's inside help the plant obtain oxygen.**

4) Look at the leaves. Describe or draw what they look like in your journal.

- **Does the shape or position help them compete with other plants? How?**

5) Can you see flowers (or other reproductive parts)? Describe or draw them.

- **How are they adapted for reproduction in a wetland?**

6) Dig up one small plant whose species is found in abundance in the wetland and look at its roots. Describe or draw a picture of the roots.

- **How are these roots suited for living in hydric soils?**

7) If this is a salty wetland, how is this plant adapted for living with salt water?

5. Making Bird Count and Adaptations Observations

Provide binoculars and field guides for students to look for birds. Students should use their journals and write down the name of the bird (or a description and look for the name of the bird in a field guide later), and tally the number of each type of bird that is seen. Note any adaptations that birds exhibit to survive in wetlands. (Feet, beaks, legs, movements, etc.)

- **How many different types of birds did you see?**

- **Were there fewer or more birds at the wetland than at any of the other aquatic ecosystems you have visited?**
- **Are there fewer or more birds than at the school grounds?**
- **What kinds of adaptations did you find and what are the ways these adaptations help birds survive in a wetland?**

6. Litter and Debris Tally

Have a contest to see which group can pick up the most litter. Ask students to use disposable gloves and garbage bags to pick up litter in the wetland. Each group should have 2 garbage bags: one bag for recyclables and one bag for non-recyclables. Use the data sheet provided to tally the number of each type of material (glass, plastic, etc.) you find in the litter. Recycle items that are recyclable.

7. Classroom Discussion

Weigh the bags and find the average weight picked up per student. Determine how much litter could have been picked up if every student in the school came to the wetland and picked up an equal amount of litter and debris.

- **Which items were recyclable?**
- **What was the largest thing you found?**
- **What was the smallest thing you found?**

8. Field Study Report

Review data and answers to questions as a class and help students set up data tables and graphs as needed. Have students work in their groups to use all of the information you gathered to **write a report comparing the wetland with other aquatic ecosystems where you have collected data**.

Divide the report into four sections: 1) Physical Characteristics of the Wetland, 2) Chemical Characteristics of the Wetland and 3) Biological Characteristics of the Wetland. 4) Conclusions drawn based on your data about the similarities and differences in the wetland and another aquatic ecosystems you have studied.

- **What effects would urbanization and other human activities or natural occurrences such as migration, storms or other natural changes have on this wetland?**
- **If you found polluting chemicals in soil or water, were you able to determine the causes as point source or non-point source pollution?**
- **What types of things could we do to take care of this wetland?**

8. Challenge Question

Write the following questions on the board and have students discuss them in small groups and then share their group's ideas with the class.

Question:

- **Since we now know how valuable wetlands are to the environment, the Texas economy, and to people, why are we still losing wetlands?**
- **What could Texans do to prevent losing more wetlands?**

List at least five things that you could do.

9. Careers in Aquatic Science

Ask students to research careers in aquatic science on the Internet and relate careers to their experiences gathering data at the wetland. Search for careers in aquatic science first. Then search government entities such as Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, Natural Resource Conservation Service. Write a paragraph in your science journal about opportunities in aquatic science careers and what education is needed to qualify for those careers.

Vocabulary

- Anaerobic
- Detritus
- Hydric soils
- Hydrophytes
- Percolation

Student Check List for Field Activities

Directions

Collect data and fill in the data tables provided.
Answer the questions in your science journal.
Make 2 more data tables–1 for soil chemistry and 1 for water chemistry.
Check off each activity as you finish it.
Put all data sheets in your science journal.

1. Soil Sampling–Percolation and Characteristics
2. Physical Indicators of Pollution
3. Soil Chemistry (make your own table)
4. Water Chemistry (make your own table)
5. Invertebrate and Vertebrates as Water Quality Indicators
6. Bug Picking Tallies
7. Wetland Plant Adaptations Drawings and Descriptions
8. Plant Adaptations Data Table
9. Bird Data Table
10. Litter and Debris Tally

INSTRUCTIONS FOR SOIL SAMPLING PERCOLATION AND CHARACTERISTICS

Objective

Determine the soil percolation rate and observe the color, texture and odor of the soil.

Directions

1. **If there is standing water at the site**, use a ruler to measure the depth of the standing water. Measure in inches from the soil surface to the top of the water and record the result. If there is standing water, **do not dig a test hole**.

2. **If there is no standing water at the site, dig a hole** 12 inches square and 12 inches deep using a spade or shovel.

3. Measure the rise in water level during an approximate 30-minute period.

4. Calculate percolation rate in inches per minute and record it below.

5. While waiting the 30 minutes for soil percolation, examine some of the soil from the hole. When soil is saturated the space between the bits of dirt is filled with water. This leaves little or no room for air, giving the soil a grayish color and a gooey texture. These gray, blue, even black wetland soils also may have irregularly shaped reddish-brown or orange-yellow mottles, indicating the presence of iron. Record your observations under color and texture.

6. In the water, tiny creatures break down dead plant and animal matter called detritus. Because the detritus layer settles beneath the water and is not exposed to air, special kinds of decomposers are needed. Anaerobic bacteria, which do not need oxygen to live, break down the detritus. They produce sulfur-containing compounds, which smell like rotten eggs. Remove a small piece of soil from the hole. Crush this piece between thumb and forefingers and smell it to determine if hydrogen sulfide is present. Record your observations.

7. Fill in your soil hole when done!

Student page

Data for Percolation Rate

SOIL SAMPLING— PERCOLATION AND CHARACTERISTICS

Group: ____
(names)

Date: ______________________________

Location:____

Water level change after 30 minutes: __________ centimeters.

Percolation rate = water level change after 30 minutes ÷ 30 = __________ centimeters per minute.

Soil Characteristics

Site	Depth of standing water (centimeters)	Percolation rate (centimeters per minute)	Color	Texture	Odor

Student Page

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A musky smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A *chlorine* smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Data for Physical Characteristics of Wetlands

Water sample Site	Temperature (^oC)	Color	Odor	Foam	Conductivity	Turbidity
A						
B						
C						

Invertebrates and Vertebrates as Water Quality Indicators

Invertebrates

A stream with:

- A great variety of insects, with few of each kind, indicates clean water.
- Less variety of insects, with greater abundance of each kind, indicates that there is too much organic matter in the water.
- Finding only one or two kinds of insects in great abundance indicates severe organic pollution caused from excessive human or livestock waste or high algae populations.
- If no insects are found, but the stream appears clean there may be some type of toxic pollution, which includes chemical pollutants such as chlorine, acids, metals, pesticides, and oil.
- Excessive sediment may be caused by erosion or discharge from a pipe and may reduce the amount of water in the stream causing extreme temperatures, and causing a loss of oxygen, which may smother insects resulting in a reduction of the number of animals in the area.

Note about Invertebrates

The types of **invertebrates** found can help students know about the quality of the water. Use the *Bug Picking Data Sheet* to help identify invertebrates found in creeks and indicate which invertebrates are associated with clean water and which predominate in polluted water.

Vertebrates

- If fish are exhibiting some odd behavior such as jumping out of the water or being non-responsive, it may indicate toxins in the creeks. A chemical analysis is needed to find the source of the toxin. Contact the TCEQ.
- If there are no fish or other vertebrates in the creek, it may indicate that the creek is stressed from urban runoff, sewage, or toxins entering the stream. Chemical analysis is needed to the find the source of the problem. Contact the TCEQ.

Note: Coastal Wetlands may have no insect larvae, but may have other invertebrates. Record the invertebrates you find. Use a field guide to identify as many as possible or describe the invertebrate.

Student page

Invertebrate and Vertebrate Water Quality Indicators

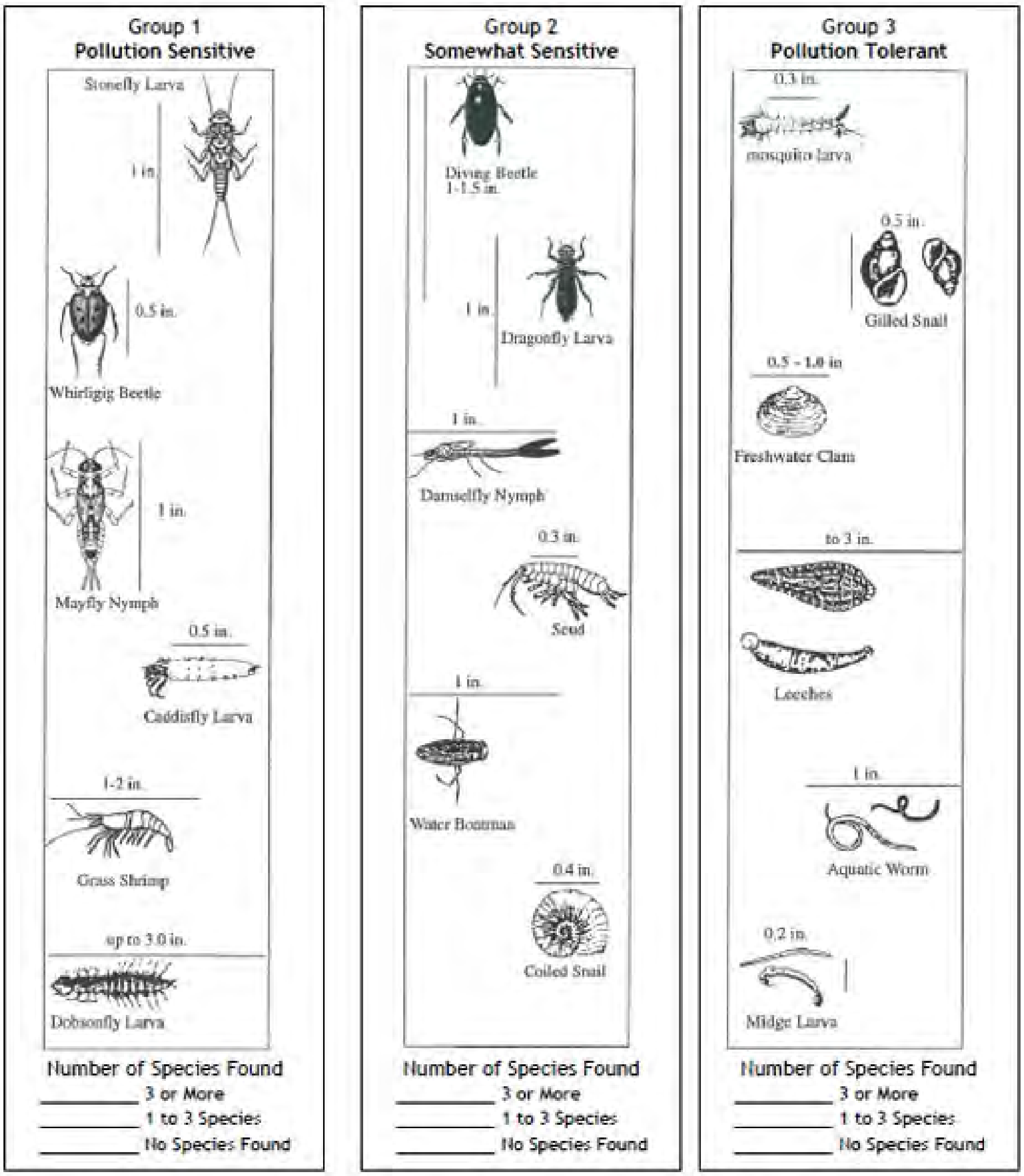
Invertebrate Species	Tally	Name or Describe Vertebrates Present	Tally	Vertebrate Behavior

Student page

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department

Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: **(Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)**

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: **Not Polluted** **OK** **Polluted**

Wetland Plant Adaptations Drawings and Descriptions

All plants need sunlight, oxygen and a way to reproduce. Hydrophytes, those plants that live in water-logged soils, have adapted unique ways to survive. Use your eyes and hand lens to observe closely and use the “Wetland Plant Adaptation Sheet” to help you answer these questions and fill in the *Plant Adaptations Data Table.*

1. **Find a plant living in a wetland. Notice its size and shape. Describe or draw it in your journal.**
   - In what habitat is it living?
   - How does its size and shape enable it to live in a wetland?

2. **Find a plant living in a wetland. Feel its texture. Describe it.**
   - How does its texture help it survive in a wetland?

3. **Cut the stem of a plant crosswise. In your journal, draw or describe what you see. Use your hand lens to look closely.**
   - How does what’s inside help the plant obtain oxygen.

4. **Look at the leaves. Describe or draw what they look like in your journal.**
   - Does the shape or position help them compete with other plants in some manner?

5. **Can you see flowers (or other reproductive parts)? Describe or draw them in your journal.**
   - How are they adapted for reproduction in a wetland?

6. **Dig up one small plant whose species is found in abundance in the wetland and look at its roots. Describe or draw a picture of the roots.**
   - How are these roots suited for living in hydric soils?
   - If this is a salty wetland, how is this plant adapted for living with salt water?

Wetland Plant Adaptations	Advantage	Examples
Submerged Plants:		
thin skin	to absorb nutrients from water	milfoil, pondweed
flexible stems	will bend. not break	most wetland plants
finely cut leaves	to increase surface area for absorbing sunlight to photosynthesize	milfoil, elodea
Floating Plants:		
air bladders	for floating (no roots)	bladderwort
digestive juices	to eat insects for nutrients	bladderwort
hanging roots	to absorb nutrients	duckweed
Rooted Plants:		
stomata on leaf's upper surface	to allow gas exchange	lilies
flowers smell,	to attract insects to pollinate	yellow water lily
Emergent Plants:		
spongy stem	to transport gases	cattails
large breathing pores	to exchange gases	willows
air filled roots	get gases from upper plant	willows
roots in air	to get oxygen	mangroves
buttress roots	to get oxygen	cypress
gas-transporting tissues	to transport oxygen and carbon dioxide	cordgrass
rot-resistant wood	to prevent decay	cedar, cypress

Wetland Plant Adaptations	Advantage	Examples
Salt-Tolerant Plants		
gummy, hairy, waxy skin	to prevent salt absorption	cinquefoil, sea thrift gumweed, pickleweed,
holds water in cells	to maintain water supply	pickleweed
oxygen-rich layer around roots	to obtain oxygen	cordgrass
exudes salt crystals	to get rid of excess salt	saltgrass
salt drops on tips of leaves	to get rid of excess salt	pickleweed
large, hardy seeds to keep salt water from flowing in	to maintain salt balance in cells	pickleweed
low, sprawling form	to reduce water loss from wind exposure	pickleweed, jaumea
small flowers	uses little energy	sedges, rushes, bulrushes
parasitic	to obtain nutrients from other plants	salt marsh dodder
Bog Plants		
sticky, sweet smelling	to attract insects for nutrients	sundew, pitcher plant
leaves upright,	to reduce surface area for drying out from exposure to the sun	Labrador tea, cranberry
thick, fuzzy, rolled leaves,	to prevent water loss from evapotranspiration	Labrador tea
live symbiotically with fungi	to obtain nutrients	orchids, heath plants

Plant Adaptations Data Table

Species	Size	Shape	Texture	Stem Cross section	Leaves	Flowers	Roots	Salt Adaptation

Bird Data Table

Bird Name	Tally	Adaptations	Advantage of Survival	Migratory or Resident

Questions:

1. **How many different types of birds did you see?**
2. **Were there fewer or more birds at the wetland than at any of the other aquatic ecosystems you visited?**
3. **Are there fewer or more birds on the school grounds?**
4. **What kinds of adaptations did you find and what are the ways these adaptations help birds survive and reproduce in this wetland?**

Student page

Litter and Debris Tally

Record the trash you collect.

Item	Tally	Total
Plastic		
Glass		
Metal		
Paper		
Styrofoam		
Rubber		
Wood		
Cloth		
Other		

Questions:

1. **Which items are recyclable? Mark an R by the recyclable items.**
2. **Which was the largest item you found?**
3. **Which was the smallest item you found?**

Student page

WEATHER OBSERVATIONS AND MEASUREMENTS

Name: ____

Date: ____________________

Location: ____

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Chapter 10: Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. **Which of these statements is true about Texas wetlands?**

   A There are wetlands in all parts of Texas.

   B Wetlands provide places for migratory birds to rest and feed.

   C Wetlands have standing water all year round.

   D A and B

2. **Plants living in wetlands have:**

   A Have thick stems adapted to hold water

   B Have thorns and spines for protection

   C Have roots that can pull in water and still get air

   D None of the above

3. **Predict the impact of flooding on the organisms in a wetland ecosystem.**

   A Some fish, plants or other aquatic life could be washed downstream.

   B Floods could promote subsequent growth of wetland plants once the waters recede.

   C Fresh nutrients would be brought in by the flood..

   D All of the above

4. **What three factors are required for a place to be considered a wetland?**

   A Saturated soil, diverse plant and animal community, standing water

   B Standing water, plants specially adapted to live in saturated soil, water year around

   C Saturated soil, wet for a major part of the growing season, plants specially adapted to live in saturated soil

   D Standing water, wet for a major part of the growing season, plants specially adapted to live in standing water

5. **What is detritus?**

   A A complex web of relationships between living and non-living things

   B The variety and number of different organisms and populations, and the way they live together

   C Dead plant and animal matter in the process of decay

   D None of the above

Chapter 10: Assessment

Directions

Write your own answer for each of the following questions.

1. **What is detritus? What are anaerobic decomposers? Explain how the biotic and abiotic factors that make up the wetland ecosystem, including detritus and anaerobic decomposers, function together.**

2. **Technological solutions to perceived problems can have risks and unintended consequences. Justify this statement by using the drainage of a Texas wetland as an example.**

3. **Suggest a possible solution to potentially harmful environmental changes within a wetland ecosystem caused by the drainage of a Texas wetland.**

Chapter 10: Assessment Answer Key

Multiple-choice questions

1. Which of these statements is true about Texas wetlands?

   D A and B

2. Plants living in wetlands have:

   C Roots that can pull in water and still get air

3. Predict the impact of flooding on the organisms in a wetland ecosystem.

   D All of the above

4. What three factors are required for a place to be considered a wetland?

   C Saturated soil, wet for a major part of the growing season, plants specially adapted to live in saturated soil

5. What is detritus?

   C Dead plant and animal matter in the process of decay

Write-in questions

1. What is detritus? What are anaerobic decomposers? Explain how the biotic and abiotic factors that make up the wetland ecosystem, including detritus and anaerobic decomposers, function together.

Detritus is dead plant and animal matter in the process of decay. Anaerobic decomposers are bacteria that do not need oxygen to live. Because the detritus layer settles beneath the water and is not exposed to air, anaerobic decomposers are needed. Anaerobic bacteria are the stars of the wetland ecosystem. As they break down the detritus, they may produce sulfur-containing compounds. The rich detritus nourishes a complex food web.

2. Technological solutions to perceived problems can have risks and unintended consequences. Justify this statement by using the drainage of a Texas wetland as an example.

Answers may include:

Wetlands have had a bad reputation. To some people, the word "wetland" means a stinky, bug-infested wasteland. Others think wetlands should be drained and put to "better" use. Texas has lost over half the wetlands it had before settlement by Europeans. Many wetlands were destroyed by being drained and filled with dirt to use for farming or as land on which to build our homes and businesses. Many of the wetlands that are left have been partially filled by sedimentation, polluted, or altered to the point they no longer function naturally.

3. Suggest a possible solution to potentially harmful environmental changes within a wetland ecosystem caused by the drainage of a Texas wetland.

Answers may include:

Taking care of the wetlands that are left and putting some back are some of conservation's biggest challenges. One of the best ways to protect the wetlands we have left is to understand how their many benefits serve us all. The future of Texas' wetlands depends on citizens who value and enjoy them. To learn more about conserving Texas' wetlands, go outside and visit a wetland. Begin thinking of it as YOUR wetland. Always bring a trash bag when you visit, and take a moment to leave the spot in better shape than you found it. Follow the rules of ethical conduct in the use of aquatic resources and teach others to do so, too. Volunteer to become a Master Naturalist. If you're up to the challenge, choose a career in conservation and make wetland conservation your life's work. Above all, enjoy your aquatic resources and use them wisely.

Bays and Estuaries

Texas bays and estuaries provide vital ecosystems and nursery habitat for most important Gulf species, feeding and resting places for migrating birds, and billions of dollars to the Texas economy.

Chapter 11

Grade Levels/Courses

6^{th}, 7^{th}, 8^{th}, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Locate bays on a map of Texas.
2. Identify the importance of bays and estuaries.
3. Use a Venn diagram to compare estuaries and freshwater wetlands.
4. Read the student guide and answer the questions.
5. Compare and contrast bays and estuaries.
6. Identify the importance of freshwater inflow to bays and estuaries.
7. Define *hypersaline,* and identify a hypersaline body of water in Texas.
8. Determine the kinds of plants found in estuaries.
9. Compare adaptations of closely related species.
10. Define tides.
11. Explain how tides may differ in different places in bays and from bay to bay.
12. Identify why the Texas coast is important to birds.
13. Explain the importance of conservation of water inland to healthy ecosystems and the production of seafood on the Texas Coast.
14. Synthesize information to develop a public information/media presentation educating the public about important issues concerning estuaries.
15. Conduct an investigation to observe the ways that saltwater and freshwater mix.
16. Draw a diagram showing how freshwater and saltwater mix in an estuary.
17. Play a game to model changing conditions in an estuary and the consequences for fish or other organisms living in the estuary.
18. Draw conclusions based on what they learn from the model.

19. Use the model to experience biotic and abiotic changes to which organisms react in an ecosystem.
20. Model how drought affects an estuary.
21. Model the effects of human activity on groundwater and surface water.
22. Model how organisms respond to external stimuli.
23. Describe predator and prey relationships in their model.
24. Describe how organisms depend on biotic and biotic factors in the estuary.
25. Describe how short and long-term changes affect organisms.
26. Explain the model showing changing populations in an estuary and its limitations.
27. Identify and evaluate factors that affect aquatic populations.
28. Predict how species extinction may alter the food chain and affect existing populations in an estuary.
29. Identify the land uses of humans and affects of those uses of the land on an estuary.
30. Synthesize what they learned from the game/model in a 3-paragraph essay on affects of changes in an estuary.
31. Work cooperatively to learn information about ecosystem services to teach others the concepts.
32. Classify ecosystem services into appropriate categories.
33. Synthesize information on ecosystem services to write a television news story.
34. Describe how biotic and abiotc parts of the ecosystem contribute to ecosystem services.
35. Describe how biodiversity contributes to the sustainability of an ecosystem.
36. Describe how short and long term environmental changes affect organisms and traits in subsequent populations.
37. Describe how organisms and populations in an ecosystem depend on and may compete for biotic and abiotic parts of the ecosystem.
38. Describe human dependence on ocean systems and explain how human activities have modified these systems.
39. Explain how human activity is affecting aquatic viability in the Texas bays and estuaries.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 C, D, E; 6.3 C; 6.4 A; 6.12 E; 7.1 A, B; 7.2 C, D, E; 7.3 C; 7.5 A; 7.8 A; 7.10 A, B; 7.11 B; 7.13 A; 8.1 A, B; 8.2 C, D, E; 8.3 C; 8.4 A, B; 8.7 C; 8.11 A, B, C, D

Aquatic Science: 1 A, B; 2 F, G, H, J; 4 A; 9 A; 10 B, C; 11 B; 12 A, B, C, D

Environmental Science: 1 A, B; 2 F, G, I, K; 3 B, G; 4 B, D; 5 A, B; 8 A, B; 9 A, D, E

Materials Needed

Activity 11.1

Map of Texas showing bays:
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/maps.pdf

Science journals

Pencils/pens

Activity 11.2

Student Guide

Science journal

Pencils/pens

Activity 11.3

Student journals

Pencils/pens

For each pair of students

Water

Graduated cylinder or measuring cup

Salt

Scale

2 clear cups or beakers

Blue food coloring

Red food coloring

Spoon

Eyedroppers (optional)

Activity 11.4

Science journals

Pencils

For each team of 4 players

1 sheet of blue construction paper to represent the estuary

Goldfish Colors crackers or other tokens (approximately 40)

1 set of game cards found at the end of the activity

Activity 11.5

Copies of *Ecosystem Services Cards*

Science journals
Pencils/pens

Vocabulary

- Artificial reef
- Barrier island
- Bay
- Cultural
- Ecosystem services
- Estuary
- Fertilizer
- Freshwater
- Habitat
- Hypersaline
- Inflows
- Migratory
- Pesticide
- Pollution
- Provisioning
- Regulating
- Salinity
- Saltwater
- Supporting
- Tides

Enrichment

Project Aquatic Wild

- Wetland Metaphors
- Marsh Munchers

Video

The State of the Gulf
from Texas Parks and Wildlife Department

Activity 11.1: What Do We Know about Bays and Estuaries?

Essential Concept

Bays and estuaries are important to the environment. Estuaries have some similarities to freshwater wetlands, but also have important differences.

Objectives

1. Students will find bays on a map of Texas.
2. Students will identify the importance of bays and estuaries.
3. Students will use a Venn diagram to compare estuaries and freshwater wetlands.

TEKS

6.2 C; 6.12 E; 7.2 C; 8.2 C

Aquatic Science: 2 J; 9 A

Environmental Science: 2 K

Estimated Time

1 class period

Materials

Map of Texas showing bays:
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/maps.pdf

Science journals

Pencils/pens

Procedures

1. Importance of Bays and Estuaries

An estuary is a partly enclosed body of water along the coast where one or more streams or rivers enter and mix freshwater with seawater. We've learned about wetlands in the last chapter. Now we will look at a particular kind of wetlands which may occur in estuaries. An estuary may or may not contain wetlands, but along the Gulf coast there usually are extensive areas of wetland associated with estuaries. You can have an estuary that is mostly mud bottoms and bare, low-lying mud islands. More typical are estuaries that are a mix of wetlands and bare areas. It's the mixing of freshwater and saltwater in a transition zone that defines an estuary, not the wetlands. Wetlands are defined by the presence of plants.

Estuaries may occur at river deltas where the river extends out into the Gulf, or at bays that are partially enclosed by land, but open directly to the ocean.

- **Where might we see a delta type estuary?** (Most students will think of the Mississippi River delta.)
- **Do any Texas rivers form deltas?** Look on *Google Maps*, satellite view, and see if you can find a delta where a river in Texas enters the gulf.
- **Can you think of some bays along the Texas Gulf Coast?**

If students have difficulty coming up with names of bays, give out Texas road maps to each group and allow students time to find the bays along the Texas coast. They should look for the seven major bays. (Sabine Lake, Galveston, Matagorda, San Antonio, Aransas, Corpus Christi bays, and the Laguna Madre) There are other smaller bays, which they might also notice, but these are the larger bays.

Ask students to write down the names of the seven major bays in their science journals.

Ask each group to make a list in their journals of the things that they think are important for the environment about the bays and the estuaries. (**Examples:** Bays and estuaries are important to fish and shellfish as safe nurseries for their young, help maintain climate through absorption of carbon dioxide, provide habitat for a wide variety of organisms from bacteria to birds, etc.)

2. Sharing Ideas

Have students share their groups' thinking about the importance of bays and estuaries to the environment. Write students' ideas on the board. Each group should give one contribution to the class list. The teacher may call on each group to continue to add new ideas until all ideas are on the board. Provide opportunity for discussion among class members. Have students add new ideas to their group's list in their science journals.

3. Comparing Estuaries to Freshwater Wetlands

Ask students to make a Venn diagram to compare estuaries and freshwater wetlands.

- **How are estuaries like freshwater wetlands?**
- **How are they different from freshwater wetlands?**

Vocabulary

- Bay
- Estuary
- Freshwater
- Saltwater

Activity 11.2: Reading and Research

Essential Concept

Bays and estuaries provide for widely diverse ecosystems that require adequate freshwater inflow to maintain the necessary conditions for supporting uniquely adapted plants and animals.

Objectives

1. Students will read the student guide and answer the questions.
2. Students will compare and contrast bays and estuaries.
3. Students will identify the importance of freshwater inflow to bays and estuaries.
4. Students will define *hypersaline,* and identify a hypersaline body of water in Texas.
5. Students will determine the kinds of plants found in estuaries.
6. Students will compare adaptations of closely related species.
7. Students will define tides. Students will explain how tides may differ in different places in bays and from bay to bay.
8. Students will identify why the Texas coast is important to birds.
9. Students will explain the importance of conservation of water inland to healthy ecosystems and the production of seafood on the Texas Coast.
10. Students will synthesize information to develop a public information/media presentation educating the public about important issues concerning estuaries.

TEKS

6.2 C; 2.12 E; 7.2 C; 7.11 B; 8.2 C; 8.7 C; 8.11 C

Aquatic Science: 2 J; 4 A; 9 A; 10 B; 12 A, C

Environmental Science: 2 K; 5 B; 8 A; 9 A, E

Estimated Time

1 class period

Materials

Student Guide

Science journal

Pencils/pens

Procedure

1. Read the Chapter

Have students read *Chapter 11: Bays and Estuaries*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) How do bays differ from estuaries? How are they similar?

Bays are bodies of water partially enclosed by inward curving land that are directly open to the ocean. In Texas many bays are also estuaries. Estuaries are partly enclosed bodies of water along the coast where one or more streams or rivers enter and mix freshwater with seawater. There is not always a clear point at which the estuaries end and the bays begin. Some estuaries extend out into the Gulf where there are no bays. These places are called river deltas. Bays and estuaries are similar in that they are both partially enclosed bodies of water. They are different in that estuaries may occur where there are no bays and bays are open directly to the ocean.

2) Why is freshwater inflow important in bays and estuaries?

Freshwater inflows create salinity gradients that expand and contract with seasons, droughts, tides, and floods. Life in the estuaries has adapted to normal rainfall patterns inland. Estuaries receiving freshwater inflow from East Texas rivers are adapted to higher amounts of freshwater inflow than estuaries in South Texas, which are fed from rivers farther west that receive far less rainfall. Texas' estuaries need higher freshwater inflows during late spring and early summer. Along with freshwater, the inflows bring nutrients and sediments that support fish, wildlife, invertebrates, plankton, and wetland plants.

3) What is a hypersaline bay?

A hypersaline bay is a bay where salinity frequently exceeds that of seawater. Example: the Laguna Madre, which is technically a lagoon because it is separated from the ocean by a barrier island, is considered a hypersaline bay. It has higher salinity than the Gulf of Mexico.

4) What kind of plants are there in coastal wetlands?

As salinity increases, seagrasses replace the freshwater grasses as cover and places for animals to feed. In addition other plants in estuaries have special adaptations to survive in saturated and salty soils and water such as Spartina and salicornia.

5) How do closely related species adapt differently to life in bays and estuaries?

Because conditions may be very different in different bays, closely related species can have very different adaptations to survive. For example: Sea trout use the food-rich cover of seagrass beds and oyster reefs as long as the shallow waters are warm enough. When it gets too cold, seatrout move into the Gulf and wait for the bays and estuaries to warm back up. Red drum, on the other hand, stay in Texas bays and estuaries until they become mature when they move into the Gulf of Mexico and live there the rest of their lives, usually staying within about five miles of shore.

6) What are tides? How can tides differ from place to place in a bay, and between different bays?

Tides are the alternating rise and fall of sea level produced by the combined gravitational attraction of the moon, sun, and Earth on our oceans.

Tides differ from place to place because gravitational forces that cause tides are constantly changing and have varying effect depending on where you are located, and because of differences in the size and shapes of bays and inlets, and local wind and weather patterns.

7) Why would you go to the Texas coast to bird watch? Why is the Texas coast important to a bird that nests in Canada or Venezuela?

Coastal barrier islands and wetlands provide habitat and protection from storms for millions of migrating waterfowl, shorebirds, and songbirds from throughout the western hemisphere, providing rich opportunities for observation of a wide variety of birds. Texas is the winter home for many species that nest in northern areas.

3. What Is the Economics? Debate the costs and benefits to the economy of oil production versus the tourist industry, and the fishing industry.

Ask students to do some Internet research of the costs and benefits of oil production, the tourist industry, and the fishing industry in a coastal city or town of Texas. Ask each group to select a Texas coastal town or city and research the local economy. Allow 2 days of homework for research. Students should take notes in their science journals of information they discover. Students should choose what they think is the most beneficial industry for the citizens, the city, and the environment.

On the third day ask students to debate which industry is most important to the local economy oil production, the tourist industry, or the fishing industry.

4. How is the seafood we catch and eat from the Texas Coast related to water conservation in places like Dallas, Austin, Houston, and San Antonio?

Ask students to discuss the question in small groups and write down their ideas. Meet as a class and share the ideas generated.

(Cities influence the amount of inflow of fresh water to bays and estuaries, because of their large populations and therefore large water use. When they conserve water, it increases freshwater inflows providing a better mix of saltwater and freshwater for various organisms that have nurseries in bays and estuaries.)

5. Cast Beyond Tomorrow Question

Ask the class to think about this question in light of the discussion in the activity above.

- **How can you help maintain healthy coastal ecosystems in Texas?**

No matter where we live in the state, what we do affects the coastal waters. So if we conserve and maintain the quality of water in our area we are also helping conserve and maintain healthy coastal ecosystems.

6. Spreading the Word

Choose one important issue from the chapter and work with your group to develop, and present to the class, a brochure, PowerPoint slide presentation, TV public service announcement, poster, jingle or rap, or other media to help the general public learn about the importance of bays and estuaries.

Remember, these need to be short, eye catching, colorful, and entertaining as well as educational to meet the goal of keeping the attention of people and informing them of important issues.

Your group will present your project to the class. Use the *Rubric for Projects and Presentations* to help you develop and present your project.

Vocabulary

- Barrier island
- Bays
- Estuaries
- Hypersaline
- Inflows
- Migratory
- Tides

Rubric for Projects and Presentations

I. Organization **Total 20 points**

1. Title
2. Clear, concise, and easy to understand information
3. Organized in a logical way
4. Includes photos or illustrations

II. Appearance **Total 10 points**

1. Neat, clean, attractive
2. Easy to read and colorful

III. Accuracy **Total 20 points**

1. Includes all information
2. Uses web sites and at least 1 book for references
3. Information is correct and communicated appropriately
4. Correct writing and spelling

IV. Critical Thinking **Total 15 points**

1. Conclusions are based on logical inferences and generalizations related to data collected on websites and in books
2. Sources are noted.
3. Reasons for conclusions are stated.

V. Group Skills **Total 20 points**

1. Works cooperatively with others
2. All students took part in doing the tasks and in the presentation
3. Student is willing to provide leadership and/or share ideas freely
4. All members of the group are heard and all ideas are respected

VI. Originality and Motivation **Total 15 Points**

1. Project is appealing to the senses
2. Project inspires understanding of the importance of bays and estuaries
3. Project motivates action to protect the environment

Possible Grand Total **100 points**

Activity 11.3: Salinity

Essential Concept

Estuaries have freshwater inflows, which mix with salt water from a bay or the Gulf of Mexico. This mixture of freshwater and saltwater creates a wide variety of salinities in which many organisms can find a niche in which to survive.

Objectives

1. Students will conduct an investigation to observe the ways that saltwater and freshwater mix.
2. Students will make a diagram showing how freshwater and saltwater mix in an estuary.

TEKS

6.1 A, B; 6.2 C, D, E; 6.4 A; 6.12 E; 7.1 A, B; 7.2 C, D, E; 7.10 A; 13 A; 8.1 A, B; 8.2 C, D, E; 8.4 A, B; 8.11 B, C

Aquatic Science: 1 A, B; 2 F, G, H, J; 4 A; 9 A; 10 B, C

Environmental Science: 1 A, B; 2F, G, K; 4 B, D

Estimated Time

1 class period

Materials

Student journals

Pencils/pens

<u>For each pair of students</u>

Water

Graduated cylinder or measuring cup

Salt

Scale

2 clear cups or beakers

Blue food coloring

Red food coloring

Spoon

Eyedroppers (optional)

Procedure

1. Salinity

Because estuaries have differing amounts of freshwater flowing into them, the salinity of each estuary is different. We call these mixtures of freshwater and saltwater *brackish water*. In addition, depending on how close one is to the freshwater inflow, and how much mixing is going on due to winds and inflow amounts, the salinities in any one estuary will vary from location to location. All of these variables create many niches in which different types of organisms can find a home.

- **How does all this mixing of freshwater and saltwater occur?** (Students may have various ideas. Write all ideas on the board.)

Today we are going to mix freshwater and saltwater in various ways to see what happens.

2. Investigating Saltwater and Freshwater Mixtures

Use the graduated cylinder to measure 250 ml (1 cup) of water into a clear container (beaker or cup). Add 54 g (3 Tablespoons) of salt and stir until completely dissolved. Add 4 drops of yellow food coloring. This will represent salty seawater.

Measure another 250 ml of water into another clear container and add 4 drops of blue food coloring. This represents freshwater inflows.

Pour half of the saltwater into a clean, clear container. Very slowly and gently add 4 teaspoons of freshwater down the side of the cup into the salt water. Wait a few minutes for the water to settle. Be sure to observe the cup with your eye at the same level as the water. (Don't jiggle or pick up the cup. It will mix the freshwater and saltwater.)

Write your observations in your science journal.

- **What do you observe? Why do you think this happens?** (You will see 2 layers. The yellow layer on the bottom is the saltwater. It stays on the bottom because saltwater is denser than freshwater. The fresh water will mix with some of the salt water and turn from blue to green.)

Repeat the experiment, but this time, find at least 2 different ways to put the freshwater and saltwater together. (Slowly pour saltwater into freshwater, drip saltwater into freshwater, or drip fresh water into saltwater or any other ideas students may have.)

- **What do you observe?** (Answers will vary and may include one color [all green] 2 colors [green and yellow] or 3 colors blue on the top green in the middle and yellow on the bottom.)
- **Why would this layering of saltwater and freshwater be important in an estuary?** (Organisms have adapted to different salinities so having various salinities provides more kinds of places for organisms to live.)
- **What other things happening in an estuary would provide a variety of salinities to provide more places for organisms to live? (**The location in relation to the freshwater inflow and the saltwater tides–Closer to freshwater will be lower salinity and closer to the saltwater will be higher salinity. Together with the larger and smaller amounts of freshwater coming into the estuaries and along with the layering effect, many different habitats are possible. Also some

organisms are able to survive in changing salinities, which happen with each change in the tides and changes in seasons and climatic conditions such as drought.)

3. Using What You Learned

Make a diagram showing how the different salinities might occur in an estuary and **label the parts**. Be sure to include the freshwater inflow source and the saltwater source. Show the different layers. **Label your diagram showing where higher and lower salinities might occur.**

For High School

Research adaptations of 3 organisms that can survive in an estuary. Explain how these adaptations help the organism survive. Compare these adaptations to the adaptations of organisms in a freshwater environment.

Vocabulary

- Inflow
- Salinity

Activity 11.4: The Ups and Downs In an Estuary

Essential Concept

Conditions in estuaries are constantly changing.

Objectives

1. Students will play a game to model changing conditions in an estuary and the consequences for fish or other organisms living in the estuary.
2. Students draw conclusions based on what they learn from the model.
3. Students use the model to simulate biotic and abiotic changes in an ecosystem to which organisms react.
4. Students model how drought affects an estuary.
5. Students model the effects of human activity on groundwater and surface water.
6. Students model how organisms respond to external stimuli.
7. Students describe predator and prey relationships in their model.
8. Students describe how organisms depend on biotic and abiotic factors in the estuary.
9. Students describe how short and long-term changes affect organisms.
10. Students will explain the model of changing populations in an estuaryand its limitations.
11. Students will identify and evaluate factors that affect aquatic populations.
12. Students will predict how loss of a particular species in a habitat may alter the food chain and affect existing populations in an estuary.
13. Students will identify the land uses of humans and affects of those uses of the land on the estuary.
14. Students will synthesize what they learned from the game in a 3-paragraph essay on affects of changes in an estuary.

TEKS

6.2 E; 6.3 C; 6.12 E; 7.2 E; 7.3 C; 7.5 A; 7.8 A; 7.13 A; 8.2 E; 8.3 C; 8.11 A, B, C

Aquatic Science: 2 F, H, J; 11 B; 12 B, C, D

Environmental Science: 2 F, I, K; 3 G; 5 A; 8 A, 9 E

Estimated Time

1 class period

Materials

Science journals

Pencils

For each team of 4 players

1 sheet of blue construction paper to represent the estuary

Goldfish Colors crackers or other tokens (approximately 40)

1 set of game cards found at the end of the activity

Special Instructions

Copy, cut and laminate a set of game cards for each group

Procedure

1. Changing Conditions

Each day conditions change in an estuary.

- **What changes can you think of that might happen in a bay or estuary?** (Allow students to brainstorm some changes. They may come up with things like: A drought resulting in too little inflow of freshwater raising salinity, pollution from nearby farms fertilizing, fishing by humans, predators catching prey, a big hurricane, eutrophication causing red tide, boaters spilling gasoline/oil, new wildlife sanctuary, tidal changes, etc.)
- **How do you think these changes would affect organism that live in the bay or estuary?** (Some things will bring positive changes, enhancing life in the environment and some will bring negative changes that kill off some of the organisms.)

2. Playing *Ups and Downs in an Estuary*

Today we are going to play a game that simulates some of these changes and how those changes affect the populations of organisms in the estuary.

Give out the materials and the rules. Each team should begin with 24 goldfish, 6 of each color, in their estuary. Players shuffle the cards and put them in a pile in the middle of the desk, and take turns drawing a card from the pile and carrying out the instructions. Each player will use a different color of *Goldfish* to represent a different species in the estuary. When a player has no more *Goldfish* in the estuary, their species has died off and they are out of the game. Students should keep a record in their science journals the conditions that caused them to lose fish.

For High School

Instead of using 24 fish in the estuary, give each player 10 of one species of fish. (a total of 40 fish in the estuary) Keep a data table for your species. Write down the number of fish of your species that are in the estuary for each round. Figure the mean, median, and range for your data.

Each group should discuss the fate of their estuary. If all the fish are taken out of the estuary, conditions changed to make life impossible. Look at the notes on each round of the game in your science journal. Discuss what caused the problems that killed off all of your species of fish. **Was it just one thing or did several things contribute to the disappearance of your species?**

3. Class Discussion

- **Did your estuary remain a viable habitat? Did you end with fewer fish or more fish than when you started?**
- **If you gained fish, what changes helped you add fish to your estuary?**
- **What other kinds of changes did your estuary experience?**
- **What were the results of those changes?**
- **What predator/prey relationships did you experience?**
- **How did drought affect the estuary?**
- **What were the effects of human activity on the estuary?**
- **How did organisms respond to external stimuli in the estuary?**
- **What biotic and abiotic factors that organisms depend on to survive were changed in the estuary? What were the consequences of these changes?**
- **What short and long term changes happened and how did they affect organisms in the estuary?**
- **What role did human recreation, fishing, and transportation activities have on the estuary?**
- **What role did humans have in eutrophication in the estuary? How was land use related to this change? What are the costs and benefits of using fertilizer for farming? Is the trade-off worth it? Are there other methods that could be considered?**
- **What factors affected the aquatic population of your estuary and which of those factors was the most important in determining the final population?**
- **What was the cumulative effect of humans on the estuary?**
- **If all of your fish population was taken out and your species were gone from the estuary, how might that alter the food chain and affect existing populations in the estuary?**
- **How is this model like a real estuary?**
- **How is this model different from a real estuary**
- **What are the limitations of our model?**

4. Using What We Learned

Ask students to write a 3-paragraph essay in their science journals summarizing what happened in their estuaries illustrating the effects of change and answering these questions. You may wish to use the game cards as your data for writing your essay. Classify each card by the type of change it represents (predator, freshwater inflow changes, human pollution, human conservation, human recreation, etc.) Further categorize the cards by classifying each set you have made as either short-term or long-term changes. Examine each category to see the impact of these kinds of changes. Use this information to help you draw some conclusions about the effects of changes in an estuary.

Paragraph 1

- **Were there many changes in the estuary? What were some of them?**
- **What caused the changes?**
- **Was there one big thing that caused the most problems? Or were there many things that contributed to any problems in the estuary?**

Paragraph 2

- **Is there anything that you learned that you could do that would help the estuary? What would that be and how would it help?**
- **Paragraph 3**
- **What conclusions can you draw about the effects of changes in the estuary from what you learned in the *Ups and Downs in an Estuary* game?**

Vocabulary

- Artificial reef
- Estuary
- Fertilizer
- Habitat
- Inflows
- Pesticide
- Pollution

Student Page

Rules for Ups and Downs in the Estuary

You will need:

1 sheet of blue construction paper to represent an estuary

24 Color Goldfish (6 of each color) in your estuary

30 extra Goldfish

A set of cards

1) **Put your estuary in the middle of the desk and add 12 goldfish. Each player will represent one color (or species) of fish.**
2) **Assign one person to be the aquatic biologist and keep the rest of the fish at the fish hatchery.**
3) **Shuffle the cards and put them in the middle of the desk next to your estuary.**
4) **Take turns drawing a card from the stack and completing the action on the card, adding or taking away fish as directed. <u>You can only take out your own fish.</u> <u>The aquatic biologist can add fish</u> to any species that still has fish in the estuary.**
5) **You are out of the game when your fish are all gone from the estuary.**
6) **The game continues until all cards have been drawn or your estuary has no fish left.**

Read the following information:

Estuaries and bays are transition zones between the land and the ocean along the coast. This is where rivers meet the ocean, mixing freshwater that has travel from far inland with the saltwater of the Gulf of Mexico. We call this *brackish* water. Conditions are always changing in an estuary.

Life in estuaries has adapted to receiving freshwater inflow bringing water, nutrients, and sediments that nourish fish, wildlife, invertebrates, plankton, and wetland plants. This shallow water is the nursery for many aquatic organisms including fish, shrimp and crabs. Estuaries often have a high biodiversity.

Sometimes pollution also comes with the inflow of water. This pollution may include fertilizers that cause algae to grow and too much algae can cause loss of light and result in death of the algae. Decay of the algae can use up all the oxygen in the water. When there is not enough oxygen, fish and other organisms can die.

Sometimes people can come to clean up trash in the water or set aside habitat for wildlife or they just follow the rules for catching only the appropriate number and size of fish. This helps species survive.

Many things can happen in a bay or estuary. Lets find out what happens in your estuary.

Ups and Downs in the Estuary Game Cards

Spotted Seatrout closes in on a school of smaller fish. **TAKE OUT 3 FISH**	**Mr. Farmer sprayed pesticide for insects in his field on the edge of the waterway. When it rained, the runoff killed 3 fish** **TAKE OUT 3 FISH**
The Legislature just passed legal protection for your fish species. **ADD 5 FISH**	**Volunteers do a "Clean the Wetland" day in the estuary.** **NO FISH LOST**
Mrs. Gardner fertilized her tomato crop. Extra algae grew in the water. Fish die. **TAKE OUT 2 FISH**	**Drought has limited freshwater inflow. Salinity is very high. The fish nursery has lost 3 fry.** **TAKE OUT 3 FISH**
3 Fish are caught by vacationers **TAKE OUT 3 FISH**	**Seagrasses hold soil, stop erosion, and create places for organisms to take cover** **Add 3 fish**
A new marina just opened and attracts 20 old boats that leak oil to stay in the estuary. **LOSE 3 FISH**	**Rain in the watershed increases freshwater inflows to help keep the habitat healthy** **ADD 3 FISH**
A boater spilled a can of gasoline in the water and 3 fish died. **TAKE OUT 3 FISH**	**A seagull flies over and eats a fish for dinner.** **TAKE OUT 1 FISH**

The estuary is left undisturbed. **ADD 2 FISH**	**New fry hatch.** **ADD 3 NEW FISH**
Industrial pollution in the water kills fish. **TAKE OUT 6 FISH**	**A vacationing family went fishing. Mr. and Mrs. Thompson, little Tim, and Tina. They caught 4 fish and released one.** **TAKE OUT 3 FISH**
Plants conduct photosynthesis adding more oxygen to the water for more fish. **ADD 2 FISH**	**Someone builds a new dock without a permit. Fish are killed when pilings damaged their habitat.** **TAKE OUT 2 FISH**
The area becomes a protected wildlife area and fishing is prohibited. **ADD 5 FISH**	**A big algae bloom due to over fertilization of a golf course. No oxygen left in the water.** **TAKE OUT 8 FISH**
A fish ate a plastic bag that Mr. Thompson lost while fishing. The fish dies. **TAKE OUT 1 FISH**	**Oyster shells are recycled to build an artificial reef. New habitat for fish.** **ADD 3 FISH**
A fish ate a piece of plastic foam floating in the water and dies. **TAKE OUT 1 FISH**	**Seagrasses restored making new nurseries.** **ADD 5 FISH**

Questions to Answer in your Essay

Directions

Write 3 paragraphs in your science journal summarizing what happened in your estuary illustrating the affects of change and answering these questions.

Paragraph One:

- **Were there many changes in the estuary? What were some of them?**
- **What caused the changes?**
- **What effect did these changes have on the organisms in the estuary?**
- **Was there one big thing that caused the most problems? Or were there many things that contributed to any problems in the estuary?**

Paragraph Two

- **Is there anything that you learned that you could do that would help the estuary? What would that be and how would it help?**

Paragraph Three

- **Based on the model in the *Ups and Downs in an Estuary* game, what conclusions can you draw about the effects of changes in an estuary?**

Activity 11.5: Ecosystem Services

Essential Concept

Bays and estuaries provide ecological services that benefit everyone by providing resources and processes to help maintain a healthy environment.

Objectives

1. Students will work cooperatively to learn information about ecosystem services.
2. Students will classify ecosystem services into appropriate categories.
3. Students will teach others about the ecosystem service which their group studied.
4. Students will describe how biotic and abiotc parts of the ecosystem contribute to ecosystem services.
5. Students will describe how biodiversity contributes to the sustainability of an ecosystem.
6. Students will describe how short and long-term environmental changes affect organisms and traits in subsequent populations.
7. Students will describe how organisms and populations in an ecosystem depend on and may compete for biotic and abiotic parts of the ecosystem.
8. Students will describe human dependence on ocean systems and explain how human activities have modified these systems.
9. Students will explain how human activity is affecting aquatic viability in the local bay and estuary.
10. Students will synthesize information on ecosystem services to write a TV news story.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 B; 8.2 C; 8.11 B, C, D

Aquatic Science: 2 J; 3 B; 12 A, B, D

Environmental Science: 2 K; 3 B; 8 B; 9 A, D

Estimated Time

1 class for jigsaw and writing, with possible homework to finish writing assignment,

1 or 2 class periods for presenting news stories and discussion depending on size of class

Materials

Copies of *Ecosystem Services Cards*

Science journals

Pencils/pens

Special Instructions

Copy, cut apart, number from 1-8 on the back, and laminate the *Ecosystem Services Cards.*

Procedure

1. Jigsaw

Ask students to number off from A to D. Ask each group (Group A, etc.) corresponding to each of the ecosystem service categories below, to move to different corners of the room. These will be the *Expert Groups*. Each *Expert Group* will receive one type of *Ecosystem Service Cards* to learn about one of the 4 types of ecosystem services with some concrete examples. These cards should all be one category of ecosystem service, but the teacher will not tell them which ecosystem service category they have.

Put the definitions of the ecosystem service categories on the board and ask students in each group to discuss their cards and decide which ecosystem service their group is discussing.

Ecosystem Service definition:

Ecosystem services are **resources** and **processes** that are supplied by ecosystems, generally grouped into four broad categories:

- **Group A, Provisioning Services:** providing products from the ecosystem such as food, fiber, and water.
- **Group B, Regulating Services:** services that maintain climate, and disease control such as improving water and air quality.
- **Group C, Supporting Services:** materials needed for production of all other ecosystem services including nutrient cycles, oxygen and carbon cycles, erosion control and habitat preservation.
- **Group D, Cultural Services:** including intangibles such as artistic inspiration, spiritual renewal, education, and recreation.

Each member of the group will receive a numbered ecosystem service card.

Group members will share their information with each other so that all learn about the particular ecosystem service category. The group should talk about their cards and decide what ecosystem service the group is learning about and find the best way to teach all of the information about their ecosystem service category to other students. Students should take notes in their science journals to help them teach other members of the class. These experts will disperse and reform in **new groups based on the numbers on their numbered ecosystem service cards.** All the ones together, all the twos, threes, and fours, etc. will form new groups in which they will teach the other members of the new group about their ecosystem service, and learn about each of the other group member's ecosystem services. (This will give 8 groups each with one member from the original 4 groups.) All students should make notes on what they learn from the other group members to use later in synthesizing what they have learned.

2. Using What We Learned

When each student has learned about all four types of ecosystem services, students will go back to their desks and work in pairs or individually (their choice) to **research and write a television news story (3–5 minutes long: NO MORE THAN 5 MINUTES LONG)** about ecosystem services in a bay front community. (Give your community a name.) The student should choose one question from each of the 3 categories and answer these questions in their news story. Be sure that all questions are covered by at least 1 of the news stories. **Note: Category 1 only has one question, which is required.**

Category 1: Required

- **How do these ecosystem services contribute to the community economy, health, character?**

Category 2

- How do biotic and abiotc parts of an ecosystem contribute to ecosystem services?
- How does biodiversity contribute to the sustainability of an ecosystem?
- How do short and long term environmental changes affect organisms and traits in subsequent populations?
- How do organisms and populations in an ecosystem depend on and compete for biotic and abiotic factors in the ecosystem?

Category 3

- How are humans dependent on ocean systems and how have human activities modified these systems?
- What is the result of human activities on the ability of bays and estuaries to provide the ecosystem services needed by the community?
- How is human activity affecting aquatic viability in the local bay and estuary?
- How does the community plan and implement conservation?

3. TV News Story Presentations

Provide time for each group or (in some cases) individuals to present their news story. Allow a few minutes for questions from the class or discussion of issues with each story.

4. Summary Paragraph

At the end of the presentations, ask the class to summarize what they have learned about ecosystem services in a paragraph in their journals.

Vocabulary

- Cultural
- Ecosystem services
- Provisioning
- Regulating
- Supporting

ECOSYSTEM SERVICES CARDS

PROVISIONING SERVICES

Seagrasses **Ecosystem Service:** Production of oxygen **Benefit:** Oxygen essential for life.	**Healthy Plants and Animals** **Ecosystem Service:** Food Production **Benefit:** Sustains life. Estuary nurseries are critical to continued supply of fresh seafood.
Oyster Reefs **Ecosystem Service:** Food Production **Benefits:** Maintains life Economic benefits	**Spotted Seatrout** **Ecosystem Service:** Food Production **Benefit:** Maintains life Economic benefits
Red Drum **Ecosystem Service:** Food Production **Benefit:** Sustains life, enhances the economy.	**Crabs** **Ecosystem Service:** Food Production **Benefit:** Maintains life. Economic benefits
Oyster Reef **Ecosystem Service:** Filters water **Benefit:** Clean water for people and the ecosystem. Maintains life.	**Shrimp** **Ecosystem Service:** Food Production **Benefit:** Maintains life. Economic benefits

CULTURAL SERVICES

Beauty of Nature **Ecosystem Service:** Recreation Motivation **Benefit:** Exercise and relaxation such as walking, camping, fishing, hunting, swimming, nature study, photography, birding.	**Natural Sounds and Sights** **Ecosystem Service:** Spiritual Renewal **Benefit:** Find inner peace, become one with nature.
Biodiversity and Abiotic Cycles **Ecosystem Service:** Education **Benefit:** Learning about cycles, patterns, and functions of nature. Learn about and participate in conservation.	**Beauty and Complexity of Nature** **Ecosystem Service:** Arts Inspiration **Benefit:** Aesthetic response in artistic ideas in various forms including painting, photography, sculpture, writing, and music.
Beauty, Warmth, Peace of Nature **Ecosystem Service:** Recreation **Benefit:** Attracts people to find winter homes for those who live in colder climates. Economic benefits	**Beauty and Peace of Nature** **Ecosystem Service:** Recreation **Benefit:** Vacation spots for families, seniors, and students to relax and get away from day to day responsibilities. Economic benefits
Endangered Species **Ecosystem Service:** Recreation **Benefit:** Eco-tourism. Brings many birders, enhancing the economy.	**Abundant Aquatic Species** **Ecosystem Service:** Recreation **Benefit:** Many opportunities for fishing and observing wildlife. Economic benefits

SUPPORTING SERVICES

Freshwater Inflows **Ecosystem Service:** Habitat **Benefit:** Freshwater mixing with saltwater provides varying salinities for a variety of niches. Provides food, shelter, water, and space for fish, plants, and other aquatic organisms.	**Photosynthesis** **Ecosystem Service**: Gas Regulation **Benefits:** Clean, breathable air, and dissolved oxygen in water for living things.
Wetlands and Barrier Islands **Ecosystem Service:** Protection from storms for people and nature **Benefit:** Helps prevent damage and flooding	**Plants** **Ecosystem Service:** Nutrient Cycling **Benefit:** Help maintain nitrogen balance.
Seagrasses **Ecosystem Service:** Erosion Control **Benefit:** Retain soil and take sediments out of the water. Maintains cleaner water.	**Abiotic and Biotic Cycles** **Ecosystem Service:** Habitat **Benefit:** Maintain biodiversity and a healthy ecosystem. Provides food, water, shelter and space for a wide variety of organisms including migratory birds, shore birds, and songbirds.
Seagrasses **Ecosystem Service:** Nursery Habitat **Benefit:** Helps maintain the numbers of shrimp, fish, and shellfish. Increased nursery area increases catch for fishermen. Provides employment and economic activity.	**Oyster Reefs** **Ecosystem Service:** Habitat. **Benefit:** Increases places for fish, invertebrates and other organisms to live.

REGULATING SERVICES

Plants **Ecosystem Service:** Absorb carbon dioxide **Benefit:** Clean air and helps maintain healthy climate.	**Gulf of Mexico** **Ecosystem Service**: Sink for carbon dioxide. **Benefit:** Maintain healthy climate.
Oyster Reefs **Ecosystem Service:** Filters wastes from industry. **Benefit:** Help provide clean water to prevent disease.	**Soils** **Ecosystem Service:** Absorb water and capture waste products. **Benefit:** Soils help clean water to prevent disease.
Wetland Organisms **Ecosystem Service:** Cycling biotic and abiotic materials. **Benefit:** Helps maintain healthy ecosystems to prevent disease.	**Wind off of the Water** **Ecosystem Service:** Brings clean air onshore **Benefit:** Improves air quality to prevent disease.
Ocean **Ecosystem Service:** Evaporation for the water cycle **Benefit:** Keep freshwater inflows coming into estuaries and bays keeping them healthy and functioning to maintain climate and prevent disease.	**Wetland Plants** **Ecosystem Service:** Treating municipal waste. **Benefit:** Clean water and prevent disease.

Rubric for Stories

I. News Story for Television **25 points**

1. The beginning gets the reader's attention.
2. The story has local interest.
3. The purpose of the story is clear and provides details.
4. The story is no longer than 5 minutes.

II. Organization **25 points**

1. Information is clear and concise.
2. The story has a beginning, middle, and end.
3. Ideas for video footage to illustrate important points is included.

III. Accuracy **25 points**

1. Includes all 4 types of ecosystem services.

Answers at least one question from each of the following categories:

Note: Category 1 only has one question, which is required.

Category 1: Required

1. How do these ecosystem services contribute to the community economy, health, character?

Category 2

1. How do biotic and abiotc parts of an ecosystem contribute to ecosystem services?
2. How does biodiversity contribute to the sustainability of an ecosystem?
3. How do short and long term environmental changes affect organisms and traits in subsequent populations?
4. How do organisms and populations in an ecosystem depend on and compete for biotic and abiotic factors in the ecosystem?

Category 3

1. How are humans dependent on ocean systems and how have human activities modified these systems?
2. What is the result of human activities on the ability of bays and estuaries to provide the ecosystem services needed by the community?
3. How is human activity affecting aquatic viability in the local bay and estuary?
4. How does the community plan and implement conservation?

IV. Grammar and Punctuation **25 points**

1. Stories should be neatly written.
2. Story uses complete sentences.
3. Story uses appropriate punctuation.
4. Story uses correct spelling.

Chapter 11: Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

Seagrasses have special roots that let them live in the somewhat salty water where rivers meet the ocean. These roots collect sediments, debris, and mud. Seagrasses also provide shelter for wildlife.

1. The high winds of hurricanes often destroy seagrasses. The destruction of these plants most likely affects ecosystems by___________ .

A Reducing beach erosion in sea-turtle nesting areas.

B Reducing the amount of saltwater flowing into lakes.

C Forcing aquatic organisms to find other places for nurseries.

D Causing pollution in inland rivers and streams.

2. How does freshwater inflow affect bays and estuaries?

A Provides freshwater for plants.

B Provides for many niches in an estuary ecosystem.

C Provides nutrients to feed fish, wildlife, and invertebrates.

D B and C.

3. Tides are:

A Variable, but predictable.

B Heights and timings vary daily.

C Produced by the gravitational attraction of the Moon, Sun, and Earth on our oceans.

D All of the above.

Use the following data to answer question number 4.

A marine biologist does an investigation into the salinity of bays in Texas to study optimum salinities for oyster reefs. Salinity is measured in parts per thousand (ppt).

Source of Sample	Salinity Reading
Seawater	35 ppt
Bay 1	19 ppt
Bay 2	38 ppt
Bay 3	15 ppt

4. Based on the data of the biologist, which bay is hypersaline?

A Bay 1

B Bay 2

C Bay 3

D None of the above

5. Seagrasses:

A Are related to algae.

B Have strong supportive stems**.**

C Provide nurseries for young organisms and reduce erosion.

D Are not affected by extreme currents.

Chapter 11: Assessment

Directions

Write your own answer for each of the following questions.

1. How do bays and estuaries contribute to the economy of Texas.

2. What kinds of changes happen in an estuary and what are the affects on organisms that live there?

3. What are some examples of ecosystem services of bays and estuaries and why are they important?

4. Why are oysters important?

5. What are some adaptations that help spotted seatrout and red drum to survive in bays and estuaries?

Chapter 11: Assessment Answer Key

Directions

Select the best answer for each of the following multiple-choice questions.

1. **The high winds of hurricanes sometimes destroy seagrasses. The destruction of these plants most likely affects ecosystems by ____________ .**

   C Forcing aquatic organisms to find other places for nurseries.

2. **How does freshwater inflow affect bays and estuaries?**

   D B and C

3. **Tides are:**

   D All of the above

4. **Based on the data of the biologist, which bay is hypersaline?**

   B Bay 2

5. **Seagrasses:**

   C Provide nurseries for young organisms and reduce erosion.

Chapter 11: Assessment Answer Key

1. How do bays and estuaries contribute to the economy of Texas?

One third of the oil and gas production in the United States takes place on the Texas coast providing many jobs contributing to the Texas economy. Texas also has 10 large seaports and 420 miles of the Gulf Intracoastal Waterway providing opportunities for shipping for industry. Texas estuaries produce up to $250 million per year in seafood. Tourism is the third largest industry in Texas after oil and gas, and agriculture, providing $5.4 billon in economic activity.

2. What kinds of changes happen in an estuary and what are the affects on organisms that live there?

Changes occur in the amount of freshwater inflow, which can provide variation in salinity that may provide more habitat choices for organisms.

Photosynthesis increases oxygen in the water increasing the number of organisms that can survive.

Seagrasses hold soil and stop erosion and create places for organisms to take cover.

New organisms hatch providing more populations of species.

People can improve habitat in the estuary when they volunteer to clean up the wetland, restore oyster reefs and seagrass beds, leave the estuary undisturbed or protect a wildlife area. Legislation can protect various threatened or endangered species.

People also can damage habitat by using pesticides and fertilizers or allowing industrial pollution that can run off into the estuary causing eutrophication and fish kills. People also cause death of organisms when they leave behind litter and plastic and inedible baits or fishing line, or spill gasoline or oil into the water.

Increasing human use by building new docks or marinas increases pollution, which can cause deaths of organisms.

Fishing without paying attention to size and number limits reduces fish populations.

Predators eat some organisms to continue the food web.

3. What are some examples of ecosystem services of bays and estuaries and why are they important?

Treating municipal wastes and diluting industrial discharges, are ecosystem services of bays and estuaries.

Wetlands also protect communities from storm surges.

There are four types of ecosystem services:

1) Provisioning services such as food and fiber production and water.
2) Regulating services such as control of climate and disease, and water and air quality.

3) Supporting services such as nutrient cycles, erosion control, habitat provision, and crop pollination.
4) Cultural services such as spiritual, educational, and recreational opportunities.

Ecosystem services are important, because they help us clean up our environment, produce materials we need, keep our ecosystems going and help maintain a stable climate. For humans to carry out all these tasks would be very expensive and difficult, requiring intense research, effort, time, and expense.

4. Why are oysters important?

Oysters are important because they provide essential habitat and nursery areas for important seafood species. They help clean up pollution by filtering water through their gills. They are also one of our most important seafoods. As such oysters provide jobs that are an important part of the coastal economy.

5. What are some adaptations that help spotted seatrout and red drum to survive in bays and estuaries?

Spotted seatrout spawn in coastal bays, estuaries, and lagoons in shallow grassy areas where eggs and larva have cover from predators. They prefer to remain near seagrass beds and oyster reef throughout their lives, but they have adapted to move into the Gulf of Mexico if this shallow water gets too cold in the fall and winter. As water temperatures warm in the spring and summer, they return to the bays and estuaries.

Red drum adults live in the Gulf of Mexico. However they spawn in high salinity waters near an entrance to a bay where high tidal current flow will carry the eggs and larval fish into the bay and estuary. These young red drum live in the shallow water where there are seagrass beds. They are also found around other structures, such as along jetties and pier pilings. They stay in Texas' bays and estuaries until they become mature. Then they move into the Gulf of Mexico and live there the rest of their lives, usually staying within 5 miles of shore.

Oceans - Gulf of Mexico

The Gulf of Mexico is one of the most productive waters in the world, and it is among the most threatened by human actions and neglect.

Chapter 12

Grade Levels/Courses

6^{th}, 7^{th}, 8^{th}, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Brainstorm words associated with the Gulf of Mexico.
2. Use the words they generate to write a paragraph about what they know about the Gulf of Mexico.
3. Make a mural illustrating words about the Gulf of Mexico from the list generated by the class.
4. Identify and describe the biotic and abiotic parts of the Gulf ecosystem.
5. Describe some of the micro-habitats that exist in the Gulf of Mexico.
6. Identify producer/consumer, predator/prey, or parasite/host relationships in a marine environment.
7. Describe some adaptations of aquatic organisms found in the Gulf of Mexico.
8. Choose one word that is new to them or of special interest from the class list on the board and do a quick Internet search for information on what that word tells about the Gulf of Mexico.
9. Work in groups of four to combine information and to report on their research on the Gulf of Mexico.
10. Read the chapter and answer the questions.
11. Describe how different environments support different varieties of organisms.
12. Identify and diagram how energy flows in saltwater aquatic systems including food webs.
13. Evaluate the effects of human activities on the environment including habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, ecotourism.
14. Generate a list of actions people could take to protect Gulf ecosystems.
15. Make predictions, observations, and diagrams about layering of different temperatures and salinities of water.

16. Plan and implement an investigation to show how different salinities and temperatures of water cause currents in the ocean.
17. Identify how their model is similar to and how it is different from real currents in the ocean.
18. Identify the limitations of their model.
19. Identify the role of oceans in the formation of weather systems such as hurricanes.
20. Explain how ocean currents are important to the ocean food web.
21. Use a model to demonstrate how waves form.
22. Test variables to see how different depth of water, wind speed, and obstructions in the water such as an island change the patterns of waves.
23. Explain and diagram wave action.
24. Identify how the model is like waves in the ocean and how it is different from waves in the ocean.
25. Identify the limitations of their model of waves.
26. Research one organism that lives in the Gulf of Mexico.
27. Identify the common and scientific names of the organism.
28. Identify the source of energy of the organism.
29. Determine if the organism is endangered or threatened and what caused the species to become endangered or threatened.
30. Create a product to illustrate what they learned in their research about their organisms.
31. Demonstrate the use of course apparatus, equipment, techniques, and procedures.
32. Predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
33. Observe and describe invertebrates and vertebrates seen on a trip on a bay trawler.
34. Analyze the cumulative impact of human population growth on an aquatic system.
35. Use safe practices and conservation of resources in the lab and field.
36. Collect data on soil and water, chemical, physical, and biological characteristics of an estuary or beach, and record information in tables.
37. Draw conclusions based on data.
38. Make connections between evaluating Gulf of Mexico habitats and careers in aquatic science.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, C, D, E; 6.3 B, C; 6.4 A, B; 6.9 A, B; 6.12 C, D, E, F; 7.1 A, B; 7.2 A, C, D, E; 7.3 B. C; 7.4 A, B; 7.5 C; 7.8 C; 7.10 A; 7.11 A, B; 7.12 A; 7.13 A, B; 8.1 A, B; 8.2 A, C, D, E; 8.3 B, C; 8.4 A, B; 8.10 A; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, J; 3 B, E; 5 C, D; 6 B; 7 C; 8 A; 9 C; 10 A, B; 11 A, B; 12 A, B, D

Environmental Science: 1 A, B; 2 E, F, G, H, I, K; 3 B, E; 4 A, B, E; 5 B; 6 C, E; 7 D; 8 B; 9 E

Materials Needed

Activity 12.1

Science Journals

Pencils/Pens

Computers

Internet access

Art materials for mural

Long strips of butcher paper

Activity 12.2

Student Guide

Science journals

Pencils/Pens

Art materials

Activity 12.3

Science journals

Pencils/pens

<u>For Each Group of 4 Students</u>

A wooden block or large book

Clear baking dish, clear plastic shoebox, or aquarium

50 ml beaker or baby food jars (possibly up to 5)

Pitcher of ice water

Yellow, blue, and red food coloring

Salt

800 ml of room temp water

Access to hot tap water

Colored pencils

Activity 12.4

Science journals

Pencils/pens

<u>For Each Group of 4 Students</u>

1 or 2 containers such as a 13 inch X 9 inch Pyrex baking dish

Ruler

1 container, about 4-5 inches deep or larger, such as clear plastic boxes or aquariums

1 electric hairdryer to generate wind

Water

Large rock

5 large marbles

Ring stand (if available, to hold hair dryer)

Activity 12.5

Library

Computers

Internet access

Science journals

Pencils/pens

Activity 12.6

Science journals

Pens/pencils

Rulers

Garden spades or shovels

Stopwatches, watches or clocks

Safety goggles

Soil Test kits may contain tests for pH, phosphorus, nitrates, and potassium. (available from science supply catalogs and sometimes from local hardware and garden stores)

Water quality test kits, probes, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, or other tests or probes that are appropriate.

High school students should also have secchi disc, stop watch, salinity test

Binoculars

Field Guides

Garbage bags for litter pick up

Disposable gloves for litter pick up

One copy of each of the following for each student or have students make their own tables:

- Check list for field trip
- *Soil Sampling—Percolation and Characteristics* student instructions - data sheets

- *Physical Indicators of Pollution* information sheet and data table
- *Invertebrates & Vertebrates as Water Quality Indicators* information sheet
- Aquatic plant adaptations instructions and information sheets, and data table
- Bird count and adaptations data table
- Litter and Debris Tally Sheet
- Student made data tables for Soil and Water chemistry based on the tests that students use
- Gulf Boat Trip data sheet

Special Instructions

Texas A & M University at Corpus Christi has a field trip boat, the Karma, for the Floating Classroom Program. You can contact them at: (361) 825-3460 or go to their website at: http://floatingclassroom.tamu.edu/StudentCruises/ArrangingYourTrip.html

The University of Texas Marine Science Institute in Port Aransas also has a boat, the Katy, which takes classes out on the bay. You can contact them at: (361) 749-6729, ext. 3 or check out their website at:

http://www.utmsi.utexas.edu/outreach/visiting-class.html

Coastal Bend Bays & Estuaries Program has activities available at the Nueces Delta Preserve. You can call (361) 673-6829 or check out their education website at: http://nuecesdeltapreserve.org/. Email address: mailto:education@cbbep.org.

Padre Island National Seashore also has school field trips. Contact the park Education Specialist at (361) 949-8068 or visit their website at:
http://www.nps.gov/pais/forteachers/index.htm

Texas State Aquarium may be able to help with the estuary investigation. Contact their educator at (361) 881-1200 or 1(800) 477-GULF or visit the website at:

http://www.texasstateaquarium.org/

The Lower Colorado River Authority's Outdoor Education and Recreation Programs at Matagorda Bay Nature Park has field trips and public programs. For additional information call (800) 776-LCRA, Ext. 4778.

http://www.lcra.org/parks/outdoor_programs/index.html

All of these organizations have programs and are also able to set up special arrangements to meet your needs.

Safety Precautions

Do not let any part of the hair dryer touch the water!!

Wear goggles for handling hot water and chemicals.

Vocabulary

- Abiotic
- Adaptations
- Algae bloom
- Anaerobic
- Artificial reefs
- Barrier islands
- Bay
- Beach
- Benthic
- Biodiversity
- Biotic
- Cetaceans
- Chemosynthesis
- Chemosynthetic
- Climate
- Cold seep
- Conservation
- Consumer
- Contaminants
- Coral reef
- Current
- Density
- Detritus
- Estuary
- Extinction
- Filter feeders
- Gulf of Mexico
- Host
- Hydric soils
- Hydrophytes
- Hypoxic
- Mainland
- Manatee

- Marine
- Micro-habitats
- Parasite
- Pelagic
- Percolation
- Photosynthesis
- Plankton
- Predator
- Prey
- Producer
- Salinity
- Sand bars
- Shellfish
- Swash zone
- Temperature
- Trophic levels
- Wave
- Wind

Enrichment

Project Aquatic Wild

- Whale of a Tail
- Marsh Munchers
- Wetland Metaphors
- When a Whale is Right
- Sea Turtles International
- Mermaids and Manatees
- Net Gain, Net Effect
- Water We Eating
- Plastic Jellyfish
- Turtle Hurdles
- Kelp Help

Videos

Texas The State o f the Gulf by Texas Parks and Wildlife Department

Guest Speakers

While on the field trip to the Gulf of Mexico, students may have the opportunity to interact with a variety of people in careers that are in organizations that will help facilitate the field trip.

- Marine biologist
- Ornithologist
- Science Educators
- National Park Service Rangers

Organizations

- Texas A & M University at Corpus Christi: Hart Institute for Gulf Studies
- Texas A & M Galveston
- The University of Texas Marine Science Institute
- Coastal Bend Bays and Estuaries Programs in Corpus Christi
- Padre Island National Seashore
- Texas State Aquarium
- Lower Colorado River Authority Outdoor Education and Recreation Program at Matagorda Bay Nature Park

Lesson 12.1: ABC's of The Gulf

Essential Concept

The Gulf of Mexico is a biologically diverse and beautiful place where many people come for recreation.

Objectives

1. Students will brainstorm words associated with the Gulf of Mexico.
2. Students will use the words they generate to write a paragraph about what they know about the Gulf of Mexico.
3. Students will draw a mural illustrating words from the Gulf of Mexico list generated by the class.
4. Students will identify and describe the biotic and abiotic parts of the ecosystem.
5. Students will describe some of the micro-habitats that exist in the Gulf of Mexico.
6. Students will identify producer/consumer, predator/prey, or parasite/host relationships in a marine environment.
7. Students will describe some adaptations of aquatic organisms found in the Gulf of Mexico.
8. Students will choose one word that is new to them or of special interest from the class list on the board and do a quick Internet search for information on what that word tells about the Gulf of Mexico.
9. Students will work in groups of four to report on their research on the Gulf of Mexico.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 A; 8.2 C; 8.11 A

Aquatic Science: 2 J; 10 B

Environmental Science: 2 K

Estimated Time

2 class periods

Materials

Science Journals

Pencils/Pens

Computers

Internet access

Art materials for mural

Long sheet of butcher paper

Special Instructions

List A, B, C's on the board to prepare for your discussion so that students can add a word for each letter.

Procedure

1. Brainstorming with the ABC's

- **How many have been to the Gulf of Mexico for a vacation or a day at the beach?**

Give those students who have been to the Gulf a few minutes to tell what they did on their trip.

Ask students to work in pairs to make a list of the ABC's in their science journals. They will work together to brainstorm a word that tells something they know about the Gulf of Mexico for each letter of the alphabet. They have about 10 minutes to generate as many ideas as they can.

When time is up, call on each pair to come up one at a time and put one of their words on the letters on the board. Ask the students to explain the word they chose and how it relates to the Gulf of Mexico. Continue around the room until everyone has had a chance to add a word to the list. If all letters have a word, students can still add new words to some of the letters. Some ideas may include: Artificial reef, barrier island, currents, dolphins, estuary, fish, grouper, habitat, invertebrate, jellyfish, Kemps ridley sea turtle, etc. When you discuss each word it will give you a good idea of students prior knowledge about the Gulf of Mexico.

2. Using Our ABC Words

Ask each student to write a short paragraph in their science journals about what they know about the Gulf of Mexico using some of the words in their list. Students should include something about the biotic and abiotic parts of the ecosystem, a description of some of the different habitats that exist in the coastal area, some producer/consumer, predator/prey, or parasite/host relationships in a marine environment, and adaptations of aquatic organisms found in the Gulf coastal area.

3. New Information

Ask students to choose one word that they don't know or that they are most interested in from the class list on the board. They will use that word along with *Gulf of Mexico* and *Texas* to do a quick *Google Search* and print out a short article to read and report to the class on what they learned. **For Example: Jellyfish in the Gulf of Mexico in Texas.**

Students can work in groups of four to share their information and then combine the information from all group members to provide a quick “slice of life” about the Gulf of Mexico. (Reports may be done on the same day or may be continued the next day.)

4. Extension: Making a “Word” Mural

Ask students to use the words they generated as topics for drawing a mural of the Gulf of Mexico. Provide a long strip of butcher paper tacked to the wall and art supplies and allow the class to work on the mural either as a group or individually when they finish their work. Each student should pick one word from the ABC list (Example: artificial reef, barrier island, currents, dolphins, estuary, fish, grouper, habitat, invertebrate, jellyfish, Kemps ridley sea turtle, etc.) and incorporate a drawing representing that word in the mural. Display the finished product in the hall.

Vocabulary

- Abiotic
- Adaptations
- Biotic
- Consumer
- Gulf of Mexico
- Host
- Marine
- Micro-habitats
- Parasite
- Predator
- Prey
- Producer
- Other words may vary depending on your class discussion

Lesson 12.2: Reading and Research

Essential Concept

The Gulf of Mexico is, biologically, incredibly diverse, and requires our help in safeguarding its aquatic ecosystems.

Objectives

1. Students will read the chapter and answer the questions.
2. Students will describe biotic parts of an ecosystem in which organisms interact.
3. Students will describe how different environments support different varieties of organisms.
4. Students will identify and diagram how energy flows in saltwater aquatic systems including food webs.
5. Students will describe producer/consumer, predator/prey relationships in marine ecosystems.
6. Students will evaluate the effects of human activities on the environment including habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, and ecotourism.
7. Students will generate a list of actions they could take to protect Gulf ecosystems.

TEKS

6.2 C, D; 12 E; 7.2 C, D; 7.5 C; 7.10 A; 8.2 C, D; 8.11 A

Aquatic Science: 2 J; 11 A; 12 B

Environmental Science: 2 K; 9 E

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 40 minutes for in-class questions and discussion, and generating a list of actions needed to protect Gulf ecosystems.

Materials

Student Guide

Science journals

Pencils/Pens

Art materials

Procedure

1. Student Reading

Have students read *Chapter 12: Oceans–The Gulf of Mexico*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) Which states share Gulf waters? Which other countries share the Gulf?

Five states share the Gulf waters: Florida Alabama, Mississippi, Louisiana, and Texas. Mexico and Cuba are countries that share the Gulf

2) What are some of the industries in the Gulf? How can people in these industries help keep the Gulf waters healthy for aquatic life?

The Gulf is an intense oil and gas development site and contains many of the U.S.'s largest ports and most active shipping lanes. In addition it provides some of the worlds largest commercial and recreational fisheries and is well known for the seafood that is harvested in Texas. Tourism is another big contributor to the economy of the Texas Coast. Keeping pollution out of the water and air, curtailing over-fishing, keeping litter out of the environment, and leaving endangered species undisturbed are all things that these industries must do to keep the Gulf waters healthy for aquatic life.

3) What influence does the Mississippi River have on the Gulf of Mexico? What is a hypoxic zone? How are hypoxic zones formed? How can they be prevented?

One of the most important influences on aquatic ecosystems is the Mississippi River, which accounts for nearly 90% of all freshwater inflow to the Gulf. The watershed for the Mississippi River includes 31 states and 2 Canadian provinces. The natural flow from the Mississippi River has always influenced productivity in the Gulf. Freshwater inflow provides nutrients that are carried by currents throughout the Gulf. The nutrients promote growth of phytoplankton. These are primary producers that form the base of an extensive food chain including zooplankton, macro-invertebrates, fish, whales, sea turtles, sea birds and many other forms of marine life.

The hypoxic zone is also called the "dead zone". This is an area of very low to no dissolved oxygen. Many species can experience stress or die as a result of this low dissolved oxygen. Hypoxia adversely affects production of seafood and other aquatic life as food webs are disrupted and organisms at all trophic levels are harmed.

The hypoxic zone is formed because human activities have added wastes, pollutants, fertilizers, and extra sediments to the flow of the Mississippi River. Increased amounts of sediment and nitrogen and phosphorus fertilizers in the Mississippi River's watershed have caused over-enrichment and direct pollution of Gulf waters. These nutrients create a rapid massive growth of phytoplankton at the water's surface, called an algae bloom. The increase in phytoplankton affects the Gulf food chain, increasing food for zooplankton and other aquatic life. This phytoplankton production is well beyond the capacity of primary consumers to graze it down and has a relatively short life span, so it dies before it can be consumed. Then it sinks to the bottom where decomposers, such as bacteria, break it down. This happens when the water column is stratified, and temperature and salinity differences prevent the layers from mixing. This isolates bottom waters from being re-supplied with oxygen from the surface. Decomposition by bacteria quickly depletes the dissolved oxygen and creates a hypoxic zone.

The only way to prevent the formation of the hypoxic zone is to cut down on the amounts of nitrogen and phosphorus that run off into the Mississippi River by cutting down on fertilizer used in agriculture, and on lawns and golf courses. Without these nutrients the large algae blooms will not occur.

4) ***What are some of the ecosystems in the Gulf of Mexico and what kinds of organisms would you find in them?***

Many ecosystems are found in the Gulf including seashore beaches, chemosynthetic communities in deep waters near hydrogen sulfide and methane cold seeps, benthic areas, pelagic areas, coral reefs and artificial reefs on oil rigs, coastal rivers and estuaries,

See chart.

Ecosystem	Organisms
Beaches	Sand crabs, nesting sea turtles, clams, marine worms, sand dollars, land animals in dunes
Chemosynthetic communities (cold seeps)	Chemosynthetic bacteria, worms
Benthic areas	Bacteria and macro-invertebrates such as crabs, mollusks, shrimp, and jellyfish
Pelagic areas	Tuna, mackerel, phytoplankton, whale sharks, Bryde’s whale, menhaden, marine mammals such as dolphin and whales, sea turtles
Coral and artificial reefs	Invertebrates such as sponges and corals, small fish, groupers, amberjack, and snappers, sea turtles, sea birds, rays, sharks, marine mammals, polychaetes, mollusks, echinoderms, hogfish, puffers, angelfish, hammerhead sharks, algae
Rivers and estuaries	West Indian manatee, many invertebrates, fish, shore birds, migratory and song birds

5) How are oil and gas rigs similar to coral reefs?

Oil and gas rigs are similar to coral reefs because they give invertebrates such as corals sponges, polychaetes, mollusks, echinoderms and other animals the hard surface they need to grow and thrive. Energy from organisms accumulates over time then flows up the food chain as primary producers feed consumers, and predators feed on prey. New habitat is then created for larger predator species, such as snapper, grouper, mackerel, shark, and other fish. Even sea turtles benefit from the new feeding opportunities.

6) What might you see on a Texas beach?

Aquatic life is abundant including burrowing organisms such as clams, marine worms, and sand dollars. There are also sand crabs and occasionally nesting sea turtles, and shore birds. Trash, seaweed, and jellyfish also accumulate along the shore.

7) What are currents? What do they do in the Gulf?

Currents are the part of a body of water continuously moving in a certain direction. Currents create areas of upwelling and mix nutrients in the water that enable primary producers, such as phytoplankton to grow and become food for other organisms.

8) How can you help marine mammals and sea turtles?

We can help marine mammals and sea turtles by conserving fresh water, limiting use of fertilizers, herbicides, and other pollutants, volunteering for beach clean up or turtle patrol, joining a conservation organization, and helping educate others about good conservation practices.

3. Challenge Questions

Scientist Sylvia Earle refers to the Gulf of Mexico as America’s Sea.

- **Do you agree? What responsibilities come with that title?**
- **How can you help protect the Gulf of Mexico’s ecosystems from harm?**

Work as a class to generate a list of actions that people can take to help protect Gulf ecosystems. Be sure to include the effects of human activities on the environment that might improve the ecosystem such as habitat restoration projects, species preservation efforts, nature conservation groups, hunting, fishing, and ecotourism.

- **How have conservation projects made a difference in the Gulf coast area?**
- **What would you say to students from the states of Montana, Ohio, Minnesota, and Missouri about their role in protecting the Gulf?**

(Students may generate a number of ideas. See answer to #8 above. Midwestern areas are the farming areas of the country. Like all of us, these states need to be able to use less fertilizer and other chemicals on their farms. Research is important in helping these farmers learn ways to maintain good crops for economic survival while taking care of the environment.)

4. Using What We Learned

Work with a partner to choose one habitat in the Gulf of Mexico and diagram or make a model of the flow of energy through living systems in a food web with at least 10 different organisms. Indicate in your diagram or model how larger quantities of organisms at lower tropic levels are needed to support the organisms at higher trophic levels.

Vocabulary

- Algae bloom
- Artificial reefs
- Barrier islands
- Beach
- Benthic
- Biodiversity
- Cetaceans
- Chemosynthetic
- Cold seep
- Conservation
- Contaminants
- Coral reef
- Current
- Extinction
- Filter feeders
- Hypoxic
- Mainland
- Manatee
- Pelagic
- Sand bars
- Shellfish
- Trophic levels

Lesson 12.3: Ocean Currents

Essential Concept

Ocean currents are divided into two types based on the forces that drive them. Most currents in the upper kilometer of the ocean are driven by wind. Mixing, affected by density due to temperature and salinity, drives deeper currents.

Objectives

1. Students will make predictions, observations, and diagrams about layering of different temperatures and salinities of water.
2. Students will plan and implement an investigation to show how different salinities and temperatures of water cause currents in the ocean.
3. Students will explain how currents in the Gulf of Mexico help bring more nutrients for phytoplankton.
4. Students will identify how their model is similar to and how it is different from real currents in the ocean.
5. Students identify the limitations of their model.
6. Students will identify the role of oceans in the formation of weather systems such as hurricanes.
7. Students will explain how ocean currents are important to the ocean food web.

TEKS

6.1 A, B; 6.2 A, C, E; 6.3 B, C; 6.4 A, B; 6.9 A, B; 7.1 A, B; 7.2 A, C, E; 7.3 B. C; 7.4 A, B; 8.1 A, B; 8.2 A, C, E; 8.3 B, C; 8.4 A, B; 8.10 A

Aquatic Science: 1 A, B; 2 E, F, G, H, J; 6 B; 8 A

Environmental Science: 1 A, B; 2 E, G, H, I, K; 6 C; 8 B

Estimated Time

1 class period

Materials

Science journals

Pencils/pens

<u>For Each Group of 4 Students</u>

A wooden block or large book

Clear baking dish, clear plastic shoebox, or aquarium

50 ml beaker or baby food jars (possibly up to 5 jars)

Pitcher of ice water

Yellow, blue, and red food coloring

Salt

800 ml of room temp water

Access to hot tap water

Colored pencils

Safety Precautions

Wear goggles and be safe with hot water.

Procedure

1. Density Gradients

In our last chapter we looked at how salinity gradients form when salt and fresh water mix. Now we will also look at affects of temperature on density.

Ask students to work in groups of four. Prop the clear baking dish, plastic box, or aquarium with 800ml of water on the wooden block. Students should draw a diagram of their set up.

Note: Observations of the experiment should be done with your eye level with the clear container.

Have students measure 40 ml. of water and add 2 drops of yellow food coloring. Add a teaspoon of salt and stir until salt is dissolved.

Have students predict what they think will happen to the saltwater when they pour it into the clear container. Students should write their predictions in their science journals.

Ask students to slowly pour the saline solution into the higher end of the container and observe where the saltwater moves. (The saltwater will flow to the bottom of the container and make a layer under the room temperature water.) Students should use colored pencils to add their observations to their diagrams.

Have students measure 40 ml. of cold water and add 2 drops of blue food coloring. Ask students to write a prediction of where this water will move when poured into the clear container. Then have student pour the cold blue water into the higher end of the container and observe what happens. Students should use colored pencils to add their observations to their diagrams. (Blue cold water will layer between the salt water and the fresh water.)

Have students measure 40 ml. of very hot tap water and add 2 drops of red food coloring. Have students predict where this water will move when poured into the clear container and write it in their journals. Students should pour the hot, red water into the higher end of the clear container and observe what happens. (Hot, red water will form a layer at the top of the water.) Students will use colored pencils to add their observations to the diagram and label each layer.

- **What caused the different layers of water to form in the clear container?** (Salt water and hot, cold, and room temperature water all have different densities.)

- **How might these different densities affect the water in the ocean?** (Cold salt water sinks to the bottom while surface water is warmer and less dense.)

2. Designing an experiment

Ask students to design an experiment to answer the following question:

- **How could this affect the currents in the ocean?**

Whatever ideas students generate, try to allow students to be creative in planning this investigation by providing materials that they will need or allowing them to bring materials from home.

Have students draw and label diagrams showing how they think the movement of water due to density happens in the ocean.

- **How can they set up their experiments to show this movement?**

Example: Students should come up with some variation of the following experiment. In an aquarium of room temperature water, place an empty beaker upside down on the bottom of the aquarium and set a jar of blue cold water on its side on top of it. (Or students may think of using a blue ice cube floating in the water.) Place another upside down empty beaker on the other end of the aquarium, and set a jar of room temperature yellow salt water on its side on top of it. Put a baby food jar or 50 ml beaker of hot, red colored water on its side in the center bottom of the aquarium

The different colors of water will begin to come out of their containers and move through the water. The red water will move up, the blue water will move down, and the yellow water will sink to the bottom. The colors will help you see how all of the water moves creating currents in the aquarium.

Students should use colored pencils to draw arrows to indicate directions of movement of each color of water.

- **What will happen to the water if we leave it as it is?** (Temperatures and salinity will stabilize and the colors will all eventually mix together.)

Watch as currents continue mixing colors and salinity of water. Describe what happens.

- **Why does this stabilization not happen in the ocean?** (Cold dense water sinks to the bottom near Greenland, Norway, and Antarctica. As the cold water mixes with warmer water, more cold water is allowed to sink. Climate controls salinity and temperature of water providing constantly changing conditions. Deeper water is even affected by long-term variability of climate.)
- **How is your experiment a model of ocean currents?** (We can see movement of currents due to differences in density, but on a smaller scale.)
- **How is your model of currents different from the real ocean currents?** (It is smaller and is not a continuous process.) **How is it like real ocean currents? (**There is movement of the water due to differences in density.)
- **What are the limitations of your model?** (It is much smaller than real density currents. It becomes stable when salinity and colors are mixed. It is not very deep, etc.)

Note: Ocean currents are also affected by the bottom topography providing deeper and shallower areas where cold water can sink to different depths and warm water can move into the area to replace the sinking cold water. Also the Earth's rotation creates movement in air (winds) and in water as the Earth spins on its axis affecting currents in the upper kilometer of the oceans.

3. Research Question:

Ask students to do a quick Internet search to find information on hurricanes.

- **Where do hurricanes start?** (answer will vary)
- **What is the role of oceans in the formation of weather systems such as hurricanes?** (Warm water increases energy in hurricanes.)

4. Using What We Learned

Ask students to write a paragraph in their journals explaining how currents in the Gulf of Mexico affect ocean food webs. (Currents bring up more nutrients from the ocean bottom for phytoplankton to survive and increase the food at the base of the food pyramid so that more zooplankton and filter feeders such as oysters and other shellfish and giant whale sharks all have food.)

- **Why are ocean currents important?** (More phytoplankton, increases other organisms, increases biodiversity of ocean ecosystems. More biodiversity provides more stability in the ecosystem.

For High School

Ask students to research El Niño and La Niña and explain how they are affected by and how they affect temperature and salinity in the ocean.

Vocabulary

- Climate
- Density
- Salinity
- Temperature

Lesson 12.4: Wind and Waves

Essential Concept

Most ocean waves are caused by wind.

Objectives

1. Students will use a model to show how waves slow down at the beach.
2. Students will use a model to demonstrate how waves form.
3. Students will change variables to see how depth of water, different wind speed, and obstructions in the water such as an island change the patterns of waves.
4. Students will explain and diagram wave action.
5. Students will identify how the model is like waves in the ocean and how it is different from waves in the ocean.
6. Students will identify the limitations of their model of waves.

TEKS

6.1 A, B; 6.2 C, D, E; 6.3 B, C; 6.4 A, B; 7.1 A, B; 7.2 C, D, E; 7.3 B, C; 7.4 A, B; 8.1 A, B; 8.2 C, D, E; 8.3 B, C; 8.4 A, B

Aquatic Science: 1 A, B; 2 G, H, J

Environmental Science: 1 A, B; 2 E, F, G, H, I, K

Estimated Time

1 class period

Materials

Science journals

Pencils/pens

<u>For Each Group of 4 Students</u>

Slowing Waves

1 or 2 containers such as 13 inch X 9 inch Pyrex baking dish

Ruler

Making Waves

1 container, about 4-5 inches deep or larger, such as clear plastic boxes or aquariums

1 hairdryer to generate wind

Water

Large rock

5 large marbles

Ring stand (to hold hair dryer)

Safety Precautions

Do not let any part of the hair dryer touch the water!!

Procedure

1. Slowing Waves

Get two identical containers or use the same container and conduct 2 trials by repeating the activity with different amounts of water. (A 13 inch X 9 inch baking dish will work.) Fill the container with 2 inches of water. In the other container or on the second trial use only 1 inch of water. Create a single wave in the container by propping the end up on an object like a ruler and letting the container plop down to create one single wave in the container. Have the students clap with the rhythm of the waves bouncing back and forth in the container to help them see in which water depth waves move faster and in which water depth waves continue for a longer time.

- **Which trial or container shows waves going faster?** (The one with the deeper water)
- **Which trial or container shows waves going slower?** (The one with the shallower water)
- **Which wave lasts longer?** (The wave in the deeper water)
- **What is the only difference in the trials or containers?** (The depth of the water)

The deeper wave should travel noticeably faster. The deeper water will have a faster rhythm and will continue for a longer time. The wave in the shallower water “drags” on the bottom of the container and it slows the wave down. The shallow wave will also die out faster. Waves slow down and run into each other as the wave drags on the bottom in shallower water. This is why waves get closer together as they come to the beach.

2. Making Waves

When we see waves coming into the beach, we often don’t think about what causes those waves.

- **What do you think causes waves?** (Students may think that waves are somehow connected to ocean currents or tides or that they are somehow produced by the water. Other students may already know that wind causes waves.)

Trial 1

Provide materials to each group. Explain how materials are to be used and safety precautions for using electrical equipment near water. Ring stands should be firmly holding the hair dryers and should be a few inches away from the container and a few inches higher than the water. No part of the hair dryer should touch the water at any time.

Have students work in groups of 3 or 4. Put 2-3 inches of water in the containers or fill them about ¾ full of water.

Allow water to smooth and quiet.

Make a Prediction

- **What do you predict will happen when the hair dryer blows across the water's surface?** Write your predictions in your science journal.

Set the ring stand at one end of the container. Attach the hair dryer so that it is a few inches from the edge of the container and a few inches above the water.

With the hair dryer on low setting, note the time you turn the wind generator on and let it blow for three minutes.

- **What did you observe.**

Describe what you saw happening to the water.

Describe what happens to the waves as they hit the end and sides of the container.

Note: Try not to slosh water out of the container during your trials. If water begins to slosh out, turn off your "wind generator" (hair dryer).

Trial 2

Make a Prediction

- **What do you think will happen if the winds blow harder?**

Increase the speed of the hair dryer to medium and repeat the steps in *Trial 1*.

Trial 3

Make a Prediction

If you have 3 speeds on the hair dryer, increase the speed and repeat the steps again recording your results.

- **What do you think will happen if the wind is blowing harder?**

Observations

- **What effect did the wind that blew harder have on the surface of the water?** (more and higher waves)
- **How did the water move in relation to the direction of the wind?** (moved in the direction that the wind was blowing)
- **Were their differences in the height of the waves with changes in the force of the wind? What happened?** (stronger wind causes higher waves)
- **What happens to the waves when they hit the end and the sides of the container?** (Waves bounce back and turn to the side on the end. Waves on the side turn back toward the other end of the container.)

Draw a diagram showing the direction of the wind and the behavior of the waves. Label the parts.

Trial 4

Add the large rock to the container to represent an island and repeat the steps again.

Make a prediction

Predict how the island will affect the waves. Draw a picture.

Turn on your wind generator and observe what happens. Write down your observations.

- **Did the waves change when they hit the island? Describe what happens.** (Waves parted and moved around the island on the windward side of the island and ran into each other on the far side of the island.)

Draw a diagram of what happened. Did this agree or disagree with your prediction?

3. Slow It Down to See What Is Happening

Discuss the connection between wind and waves. To help students better observe what the water is doing when waves form, do this activity.

Give each group 5 large marbles. Have them set the marbles touching each other on the desk in a row. Ask students to predict what will happen if they use one of the marbles to gently roll into the end of the row. The marbles represent the water. The student moving the marble represents the wind, providing the energy that moves into the system.)

After students have written down their predictions, have one student in each group roll a marble into the last marble in the row in such a way that the marbles in the row will each bump into the next marble.

- **What happens? Is it what you predicted?** (The marble at the far end of the row will roll away and the others will remain in place.)

Ask each student in the group to take a turn trying this.

- **Why do you think this happened?** (Energy in the rolling marble was transferred to the first marble it hit. The energy from the first marble in the row was transferred to the next marble and on up the row to the last marble. The energy then made the last marble roll away. Wave energy moves through the water in the same way. The energy of the wave transfers through the water molecules and the water stays in one place while the wave energy moves through it and into the next water molecules just as the energy moved through the marbles and into the next marble.

Look at the sidebar on waves in the *Student Guide* to see a diagram of how waves move.

4. Explaining What We Learned

Ask students to write a paragraph in their science journals explaining how wind affects waves. Also ask students to make a diagram of how the wind is moving the wave through the water.

Vocabulary

- Wave
- Wind

Lesson 12.5: Researching Ocean Organisms and Food Webs

Essential Concept

The Gulf of Mexico is a place of incredible biodiversity. These marine organisms interact to transfer energy throughout the ecosystem.

Objectives

1. Student will research one organism that lives in the Gulf of Mexico.
2. Students will describe the organisms and note adaptations that help it survive.
3. Students will identify the common and scientific names of the organism.
4. Students will identify and describe where in the Gulf of Mexico the organism lives.
5. Students will identify the source of energy for the organism.
6. Students will identify the role of the organism in the ecosystem.
7. Students will determine if the organism is endangered or threatened and what caused the species to become endangered or threatened.
8. Students will create a product to illustrate what they learned in their research about their organisms.

TEKS

6.12 C, D, E, F; 7.11 A, B; 7.12 A; 7.13 A; 8.10 A

Aquatic Science: 3 B; 5 C; 10 B; 11 A

Environmental Science: 3 B; 4 B; 6 E

Estimated Time

1 class period and homework for setting up assignment and doing research and project

2 class periods for presentations

Materials

Library

Computers

Internet access

Science journals

Pencils/pens

Procedure

1. Researching Ocean Organisms

Each student will choose an organism from one of the following categories to research in preparation for a field trip to the Gulf of Mexico. Numbers below indicate the number of students who can research that topic so that all categories will be covered. Numbers are set up for a class of 22 and can be adjusted up or down for larger or smaller classes.

These categories can be put on slips of paper and students can draw for their research topic.

1.	Phytoplankton	1
2.	Zooplankton	1
3.	Plants	2
4.	Shellfish	2
5.	Jellyfish	1
6.	Other marine invertebrates	2
7.	Small Fish	3
8.	Large Fish	3
9.	Marine Mammals	2
10.	Sea Turtles	1
11.	Shore birds	2
12.	Other birds	2

Within their categories, students can choose the organism that they wish to research. The only requirement is that students check with the teacher to be sure no other students are researching their organisms.

Students should find an illustration of their organism. This may be a photograph or a drawing.

Research should answer the following questions:

- **Describe your organism.**
- **What adaptations does your organism have to survive in a marine environment?**
- **What are the common and scientific names of the organism?**
- **Where in the Gulf of Mexico does the organism live?** (beach, estuary, bay, ocean, etc.)
- **Where in the water does it live?** (For example: is it benthic, or pelagic, or is it found in a coral reef, or does it live in an estuary or bay, or is it free floating?)
- **Where does it get its energy?** (photosynthetic or chemosynthetic producer, decomposer or consumer) **What level and what kind of consumer is it?**
- **What eats it?**
- **What is its role in the ecosystem?**

- **Is it endangered or threatened? If so, what caused the species to become endangered or threatened?**
- **Is this an organism that we are likely to see on a field trip to the Gulf of Mexico? What are your reasons for thinking we might or might not see this organism?**

2. Gulf Food Web

Cut a Sun from construction paper. Tack it in the middle of the bulletin board.

Ask students to decide where their organisms fit in a Gulf food web.

- **Whose organism would come next in the food web?**

Ask students to come one at a time to tack the illustration of their organism on the bulletin board in the appropriate place in the food web and attach each organism to its source of energy with yarn. **Note: Some organisms may have more than one connection in the food web.** For example: Phytoplankton may be the source of energy for zooplankton, shellfish, marine invertebrates, some kinds of fish, and even whales.

Ask each student to make a diagram in their science journals to show the levels of organization within the ecosystem, including their organism, population, community, and ecosystem.

3. Using What We Learned

Ask students to develop a presentation using the information they researched. This presentation can be developed in a form the student chooses. Students should let the teacher know what type of presentation they propose. The presentation may be in the form of a poster, PowerPoint, poem, essay, art project, story book for young children, musical composition, news story, diarama etc.)

The actual research must be written down to answer all questions and sources cited.

Students will present their research to the class in a 3-5 minute presentation.

Vocabulary

- Bay
- Beach
- Benthic
- Chemosynthesis
- Estuary
- Pelagic
- Photosynthesis
- Plankton

Student Page

Researching Gulf of Mexico Organisms

Within your category, you can choose the organism that you wish to research. The only requirement is that you check with the teacher to be sure no other students are researching your organism.

First: Find an illustration of your organism. This may be a photograph or drawing.

<u>You must answer the following questions about your organism in writing.</u>

1. Describe your organism.
2. What adaptations does your organism have to survive in a marine environment?
3. What are the common and scientific names of the organism.
4. Where in the Gulf of Mexico does the organism live? (beach, estuary, bay, coral reef, ocean, etc.)
5. **Where in the water does it live?** (For example: is it benthic, or pelagic, or does it live in an estuary or a coral reef, or is it free floating?)
6. Where does it get its energy? (photosynthetic or chemosynthetic producer, decomposer, or consumer) What level and what kind of consumer is it?
7. What eats it?
8. What is its role in the ecosystem?
9. Is it endangered or threatened? If so, what caused the species to become endangered or threatened?
10. Is this an organism that we are likely to see on a field trip to the Gulf of Mexico? What are your reasons for thinking we might or might not see this organism?

Using My Research:

Students will present their research to the class in a 3-5 minute presentation.

Develop a presentation using the information you researched.

This presentation can be developed in a form that you choose.

You should let the teacher know what type of presentation that you propose.

The presentation may be in the form of:

- poster
- PowerPoint
- poem
- essay
- art project or diarama
- story book for young children
- musical composition
- news story
- other idea that you may generate

Student page

Rubric for Products and Presentations

Criteria	Quality 20 pt	Quality 16 pt	Quality 14 pt	Quality 10 pt
1. Did I get my audience's attention?	Creative Beginning	Average Beginning	Slow Beginning	Inadequate Beginning
2. Did I tell the purpose of my product?	Purpose told with details.	Purpose told with few details.	Purpose told with no details.	Purpose is not clear.
3. Did I make the presentation clear and detailed?	Presentation creative, clear and interesting with many details	Presentation clear, but has few details	Presentation is clear, but has no details.	Presentation is unclear.
4. Was art and/or written work interesting and done neatly	Art and/or writing are interesting and done very neatly.	Art and/or writing are interesting but not done very neatly	Art and/or writing are interesting, but are not neat.	No art was created and/or no writing was created.
5. Did your product provide correct information and was it presented in a manner appropriate for the subject?	Information was correct and product was clearly appropriate for the subject.	Information was correct and product was somewhat appropriate for the subject.	Information was not correct, but product was appropriate for the subject.	Information was incomplete or information was not correct and product was not appropriate for the subject.
OR If your product was for younger children, it is age appropriate and is appropriate to the subject. Information was correct	Product was very appropriate for the age of the child and the subject. Information was correct.	Product was somewhat appropriate for the age of the child and the subject. Information was correct.	Product was appropriate for the subject, but not appropriate for the age of the child. Information was correct.	Product was incomplete or not appropriate for the age of the child and the subject. Information was incomplete or incorrect.

Total Possible Points 100

Lesson 12.6: Field Trip to the Gulf of Mexico

Essential Concept

The Gulf of Mexico is a precious resource that supplies valuable habitat and requires protection.

Objectives

1. Students determine the soil percolation rate and observe the color, texture and odor of the soil.
2. Students use water and soil chemistry test kits and equipment to identify soil and water chemistry in a local estuary or beach.
3. Students demonstrate the use of course apparatuses, equipment, techniques, and procedures.
4. Students collect quantitative data from an aquatic environment, including pH, salinity, temperature, mineral content, nitrogen compounds, and turbidity.
5. Students identify ways human activity can affect aquatic environments.
6. Students will predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
7. Students observe and describe invertebrates and vertebrates seen on a trip on a bay trawler.
8. Students will analyze the cumulative impact of human population growth on an aquatic system.
9. Students use safe practices and conservation of resources in the lab and field.
10. Students collect data on soil and water, chemical, physical, and biological characteristics of an estuary and/or beach, and record information in tables.
11. Students draw conclusions based on data.
12. Students make connections between evaluating Gulf of Mexico habitat and careers.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.5 A, B; 7.8 C; 7.10 A; 7.11 A; 7.13 A, B; 8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 E; 5 C D; 7 C; 9 C; 10 A, B; 11 A, B; 12 A, B, D

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 B, E; 4 A, B, E; 5 B; 6 E; 7 D

Estimated Time

These activities can be done as an all day field investigation. If you do not live near the coast and are coming for the field trip, you might want to make it a Friday, Saturday and possibly Sunday field trip so that you can visit an estuary, beach, and take a boat trip. If you can afford a boat trip out on the Gulf, that would be a great addition to the field trip.

Prices vary, but it may be possible to get businesses to sponsor the cost of a boat trip for the class.

You will need one class period for review of data and writing Field Report (reports can be finished as homework).

Materials

Science journals

Pens or pencils

Rulers

Garden spades or shovels

Stopwatches, watches, or clocks

Safety goggles

Soil Test kits may contain tests for pH, phosphorus, nitrates, and potassium. (available from science supply catalogs and sometimes from local hardware and garden stores)

Water quality test kits, probes, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, or other tests or probes that are appropriate.

High school students should also have secchi disc, stop watch, salinity test

Binoculars

Field Guides

Garbage bags for litter pick up

Disposable gloves for litter pick up

One copy of each of the following for each student or have students make their own tables.

<u>Student Check List</u>

Soil Sampling—Percolation and Characteristics student instructions and data sheets

Physical Indicators of Pollution information sheet with data table

Invertebrates & Vertebrates as Water Quality Indicators information sheet and data table

Estuary an beach plant adaptations instructions and information sheets, and data table

Bird count and adaptations data table

Litter Data table

Gulf Boat Trip data sheet

Student-made data tables for Soil and Water Chemistry based on tests that students use

Special Instructions

If you're making a special trip to the coast and would like to set up some special arrangements, you might want to contact one of these organizations. You will need to make arrangements well in advance. Costs vary.

Be sure to invite parents to accompany the students. You will need at least 1 adult for each small group of 4 students.

Texas A & M University at Corpus Christi has a field trip boat, the Karma, for the Floating Classroom Program. You can contact them at: (361) 825-3460 or go to their website at: http://floatingclassroom.tamu.edu/StudentCruises/ArrangingYourTrip.html

The University of Texas Marine Science Institute at Port Aransas also has a boat, the Katy, which takes classes out on the bay. You can contact them at: (361) 749-6729, ext. 3 or check out their website at: http://www.utmsi.utexas.edu/outreach/visiting-class.html

Coastal Bend Bays & Estuaries Program has activities available at the Nueces Delta Preserve. You can call (361) 673-6829 or check out their education website at: http://nuecesdeltapreserve.org/.

Padre Island National Seashore also has school field trips. Contact the park Education Specialist at (361) 949-8068 or visit their website at: http://www.nps.gov/pais/forteachers/index.htm

Texas State Aquarium may be able to help with the field investigation. Contact their educator at (361) 881-1200 or 1(800) 477-GULF or visit the website at: http://www.texasstateaquarium.org/

The Lower Colorado River Authority's Outdoor Education and Recreation Programs at Matagorda Bay Nature Park has field trips and public programs. For additional information call (800) 776-LCRA, Ext. 4778: http://www.lcra.org/parks/outdoor_programs/index.html

All of these organizations have programs and are also able to set up special arrangements to meet your needs. Prices vary, but are reasonable.

Obtain Soil Testing kits and prepare students for using these tests. A practice can be done using soil from the school grounds before going into the field. Data from the school grounds can be compared with data from the field sites at the Gulf of Mexico.

Safety Precautions

When collecting trash, use extra care when handling glass. Wear gloves. Only adults should pick up glass.

Stress field safety (See *Field Trip Guide Lines* at the beginning of the curriculum guide.) Always wear long pants and closed toe shoes for outdoor activities.

Wear goggles when using chemicals.

Procedure

1. Salt Water Ecosystems Field Trip

This field trip will be different from any others you might have taken since you will be assessing the characteristics of salt water ecosystems. Depending on the amount of time you have available, you can use all of these assessments or choose key assessments to help you make comparisons with the data you have already collected about freshwater ecosystems. It is important that you collect some of the same data as you have collected for freshwater ecosystems so that students can make the comparisons.

Activities can be set up as stations at the field site and students can rotate through all stations. You will need at least one adult at each station.

2. Preparing Students for the Field Trip

Explain to students that this field investigation has many parts. You will be calling on all the skills learned throughout the year.

Some data tables are set up so that students just have to fill in the data. Students will need to make other data tables in their journals. <u>All questions should be answered in their science journals.</u>

One part of the trip might be made to an estuary such as the Nueces Delta Preserve and another part to a beach such as the Padre Island National Seashore. You may also be able to visit the Laguna Madre side of Padre Island National Seashore to visit a hypersaline area, visit a beach on Padre Islandand/or take a boat trip to trawl in the bay or in the Gulf.

3. Studying Soil in an Estuary and/or Beach

Students will look at various characteristics of estuary and beach soils.

Provide each student with a copy of *Soil Sampling—Percolation and Characteristics*.

See example below.

Lead the class through the procedure.

SOIL SAMPLING— PERCOLATION AND CHARACTERISTICS

Directions

Collect data at an estuary and on a beach. If possible go to the Laguna Madre side of Padre Island National Seashore to visit a hypersaline environment.

1) If there is standing water at the site, use a ruler to measure the depth of the standing water. Measure in centimeters from the soil surface to the top of the water and record the result. If there is standing water**, do not dig a test hole**.

2) If there is no standing water at the site, dig a hole 30 centimeters square and 30 centimeters deep using a spade or shovel.

At the beach, dig a hole back from the tide line to measure percolation. Dig another hole in the tidal area and compare the percolation rate for each.

- **What is the color and texture of the soils at the estuary and at the beach?**

3) Measure the rise in water level in the hole during an approximate 30-minute period. If the hole fills more quickly, record the time it takes to fill with water.

4) Calculate percolation rate in centimeters per minute and record it.

5) Examining Soil Texture and Color. While waiting**,** examine some of the hydric soil from the hole. When soil is saturated the space between the bits of dirt is filled with water. This leaves little or no room for air, giving the soil a grayish color and a gooey texture. These gray, blue, even black, estuary soils also may have irregularly shaped reddish-brown or orange-yellow mottles, indicating the presence of iron in the soil. Record your observations in the table under color and texture. Beach soils will be different from soils in an estuary.

6) Soil Odor. In the water, tiny creatures break down dead plant and animal matter called detritus. Because the detritus layer settles beneath the water and is not exposed to air, special kinds of decomposers are needed. Anaerobic bacteria, which do not need oxygen to live, break down the detritus. They produce sulfur-containing compounds, which smell like rotten eggs. Remove a small piece of soil from the hole. Crush this piece between thumb and forefingers and smell it to determine if hydrogen sulfide is present. Record your observations.

7) Cleaning up. Fill in your soil holes when you are done!

Have students compare their results and place the completed data sheets (found as the end of this lesson) in their science notebooks.

4. Soil and Water Chemistry

Students will collect soil and water chemistry data and make observations using soil testing kits and water testing kits. Don't forget to wear goggles when handling chemicals.

Students will need to make their own data tables based on the test they will conduct.

The water testing kit may include pH, salinity, nitrates, dissolved oxygen, and phosphorus. The soil testing kit may include tests for nitrates, phosphorus, potassium and pH.

Make a data table to record your results at three sites at the estuary. (If you go to the Laguna Madre, be sure to use the soils at that site for one of your entries.) Also record data for three sites at the beach.

- **How does the chemistry of estuary and beach soils compare to the soil at your school?**

5. Physical and Biological Indicators of Water Quality

Students should look at the *Physical Indicators of Pollution* instruction sheet, water temperature, turbidity, color, odor, foaming, and conductivity.

Have students also look at the *Invertebrate and Vertebrate Water Quality Indicators* information sheet. If you are in a saline environment, you will have different invertebrates from what you found in freshwater ecosystems. Use a field guide to help you identify these organisms. The more diversity you find, the healthier the ecosystem.

- **Where does the water come from to this estuary or beach ecosystem?**

Example: Freshwater inflows to the Nueces Bay come from the Nueces River.

Make a list of human activity near the estuary or beach. Have students analyze the cumulative impact of human population growth on this estuary or beach ecosystem. Students should predict how human activities impact physical, chemical, and thermal changes in the water, which will affect the living and nonliving components of the wetland ecosystem.

Note: It helps if you have something like the *TEXMAPS Coastal Bend Atlas* to help to identify land use in the area. Industrial locations are labeled on the maps.

Example: The land near the Nueces Delta Preserve and Nueces Bay has two Flint Hills Resources Oil Refineries, Qualitch Steel Corporation, Dredge Material Placement Areas, Citgo Oil Refinery, Valero Oil Refinery, and the Nueces Bay Power Plant. Padre Island National Seashore is near large ranches and near housing areas.

- **How might this impact changes in the estuary or beach over the coming years?**

6. Plant Adaptations in a Wetland

Use the *Estuary or Beach Plant Adaptations* instruction, information and data sheets to investigate the ways that plants are able to survive in an estuary or beach environment

All plants need sunlight, oxygen and a way to reproduce. Hydrophytes, those plants that live in water-logged soils, have adapted unique ways to survive. Use your eyes and hand lens to observe closely and use the *Estuary or Beach Plant Adaptation* information sheets to help you answer these questions.

1) **Find a plant living in an estuary or on a beach. Notice its size and shape. Describe or draw it in your journal.**
   - **In what habitat is it living?**
   - **How does its size and shape enable it to live in an estuary or on a beach?**
   -
2) **Find a plant living in an estuary or on a beach. Feel its texture. Describe it.**
   - **How does its texture help it survive in an estuary or on a beach?**

3) **Cut the stem of a plant crosswise. In your journal, draw or describe what you see. Use your hand lens to look closely.**
   - **How does what's inside help the plant obtain oxygen.**

4) **Look at the leaves. Describe or draw what they look like in your journal.**
   - **Does their shape or position help the plant get sunlight or oxygen? How? Does the shape or position help them compete with other plants? How?**

5) **Can you see flowers (or other reproductive parts)? Describe or draw them.**
   - **How are they adapted for reproduction in a estuary or beach environment?**

6) **Dig up one small plant whose species is found in abundance in the estuary or beach and look at its roots. Describe or draw a picture of the roots.**
   - **How are these roots suited for living in hydric soils?**
   - **If this is a salty wetland, how is this plant adapted for living with salt water?**

5. Making Observations of Bird Adaptations and Taking a Bird Count

Provide binoculars and field guides for students to look for birds. Students should use their journals and write down the name of the bird (or a description and look for the name of the bird in a field guide later), and tally the number of each type of bird that is seen. **Note any adaptations that birds exhibit to survive in estuary or beach environment.**

- **How many different types of birds did you see?**
- **Were there fewer or more birds at the estuary or beach than at any of the other aquatic ecosystems you have visited?**
- **Are there fewer or more birds than at the school grounds?**
- **What kinds of adaptations did you find and what are the ways these adaptations help birds survive in an estuary or beach?**

7. Litter and Debris Tally

Safety Note: Warn students not to pick up glass. Ask them to have an adult pick up any glass they see.

Have a contest to see which group can pick up the most litter. Ask students to use disposable gloves and garbage bags to pick up litter in the estuary or beach. Each group should have **2 garbage bags:** one bag for recyclables and one bag for non-recyclables. Use the data sheet provided to tally the number of each type of material (glass, plastic, etc.) you find in the litter. Recycle items that are recyclable.

Weigh the bags and find the average weight picked up per student. Determine how much litter could have been picked up if every student in the school came to the estuary or beach and picked up an equal amount of litter and debris.

- **Which items were recyclable?**
- **What was the largest thing you found?**
- **What was the smallest thing you found?**

8. Boat Trip in the Bay

Your trip may include observation of marine mammals that might be nearby and a variety of organisms brought up in the trawl net. You will need to record a description, adaptations and the number of each type of organism.

9. Field Study Report

Review data and answers to questions as a class and help students set up data tables and graphs as needed. Have students work in their groups to use all of the information you gathered to **write a report comparing the estuary and beach with other aquatic ecosystems where you have collected data**.

Divide the report into four sections:

1) Physical Characteristics of the Estuary and Beach (or bay or the Gulf)
2) Chemical Characteristics of the Estuary and Beach (or bay or the Gulf)
3) Biological Characteristics of the Estuary and Beach(or bay or the Gulf)
4) Conclusions drawn based on your data about the similarities and differences in the estuary and beach and another freshwater aquatic ecosystems you have studied.

- **What affects would urbanization and other human activities or natural occurrences such as migration, storms or other natural changes have on an estuary or beach?**
- **If you found polluting chemicals in soil or water, were you able to determine the causes as point source or non-point source pollution?**
- **What types of things could we do to take care of the estuary and beach?** (or bay or the Gulf)

10. Careers in Marine Science

Ask students to research careers in marine science on the Internet and relate careers to their experiences gathering data at the estuary or beach. Search for careers in marine science first. Then search specific entities such as Coastal Bend Bays and Estuaries Program, Texas A & M University, The University of Texas Marine Science Institute, Texas Parks and Wildlife Department, Texas Commission on Environmental Quality, Natural Resource Conservation Service. Write a paragraph in your science journal about opportunities in marine science careers and education needed to qualify.

Vocabulary

- Anaerobic
- Detritus
- Hydric soils
- Hydrophytes
- Percolation

Student Check List for Field Activities

Directions

Collect data and fill in the data tables provided.

Answer the questions in your science journal.

Make 2 more data tables–one for soil chemistry and one for water chemistry.

Check off each activity as you finish it.

Put all data sheets in your science journal.

1. Soil Sampling–Percolation and Characteristics
2. Soil Chemistry (make your own table)
3. Water Chemistry (make your own table)
4. 4 Physical Indicators of Pollution
5. Invertebrates and Vertebrates
6. Estuary and Beach Plant Adaptations Drawings and
7. Descriptions
8. Plant Adaptations Data Table
9. Bird Data Table
10. Litter and Debris Tally
11. Gulf Boat Trip

INSTRUCTIONS FOR SOIL SAMPLING PERCOLATION AND CHARACTERISTICS

Objective

Determine the soil percolation rate and observe the color, texture and odor of the soil.

Directions

Collect data at an estuary and on a beach. Record your data on the data table on the next page.

1) ***If there is standing water at the site***, use a ruler to measure the depth of the standing water. Measure in cm. from the soil surface to the top of the water and record the result. If there is standing water**, do not dig a test hole**.
2) ***If there is no standing water at the site, dig a hole*** 30 cm square and 30 cm deep using a spade or shovel.

   At the beach, dig a hole back from the tide lines to measure percolation. Dig another hole in the tidal area and compare the percolation rate for each.
3) ***Measure*** the rise in water level in the hole during an approximate 30-minute period. If the hole fills more quickly, record the time it takes to fill with water.
4) ***Calculate percolation rate*** in centimeters per minute and record it.
5) ***Examining Soil Texture and Color.*** While waiting**,** examine some of the hydric soil from the hole. When soil is saturated the space between the bits of dirt is filled with water. This leaves little or no room for air, giving the soil a grayish color and a gooey texture. These gray, blue, even black, estuary soils also may have irregularly shaped reddish-brown or orange-yellow mottles, indicating the presence of iron in the soil. Record your observations in the table under color and texture.
6) Beach soils will be different from the soils in an estuary. Record separate data for beach soils.
   - **What is the color and texture of the soils at the estuary and at the beach?**
7) ***Soil Odor.*** In the water, tiny creatures break down dead plant and animal matter called detritus. Because the detritus layer settles beneath the water and is not exposed to air, special kinds of decomposers are needed. Anaerobic bacteria, which do not need oxygen to live, break down the detritus. They produce sulfur-containing compounds, which smell like rotten eggs. Remove a small piece of soil from the hole. Crush this piece between thumb and forefingers and smell it to determine if hydrogen sulfide is present. Record your observations.
8) ***Cleaning up.*** Fill in your soil holes when you are done!

Data for Percolation Rate

SOIL SAMPLING— PERCOLATION AND CHARACTERISTICS

Group: ____
(names)

Date: ______________________________

Location:____

Water level change after 30 minutes: __________ cm.

Percolation rate = water level change after 30 minutes ÷ 30 = __________ cm. per minute.

Soil Characteristics

Site	Depth of standing water (centimeters)	Percolation rate (centimeters per minute)	Color	Texture	Odor

Student Page

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A musky smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A *chlorine* smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Data for Physical Characteristics of Wetlands

Water sample Site	Temperature (^oC)	Color	Odor	Foam	Conductivity	Turbidity
A						
B						
C						
D						
E						
F						
G						

Invertebrates and Vertebrates

Invertebrates

Record the invertebrates that you find in estuaries and on the beach. Use a field guide to identify these invertebrates. Estuaries are nursery grounds for various shellfish so you may find many small invertebrates in the shallow water or hiding in plant cover.

Vertebrates

If there are no fish or evidence of other vertebrates in or near the water, it may indicate that urban runoff, sewage, or toxins are entering the water.

You may be lucky enough to see jellyfish or dolphin in the bay. Note their adaptations and behaviors.

Invertebrate Species & Tally	Description	Name of Vertebrates Present	Vertebrate Description & Adaptations	Vertebrate Behavior

Estuary and/or Beach
Plant Adaptations Drawings and Descriptions

All plants need sunlight, oxygen and a way to reproduce. Hydrophytes, those plants that live in water-logged soils, have adapted unique ways to survive. Use your eyes and hand lens to observe closely and use the “Estuary or Beach Plant Adaptation Sheet” to help you answer these questions.

1. **Find a plant living in an estuary or beach. Notice its size and shape. Describe or draw it in your journal.**
    - In what habitat is it living?
    - How does its size and shape enable it to live in an estuary or beach?

2. **Find a plant living in a estuary or beach. Feel its texture. Describe it.**
    - How does its texture help it survive in an estuary or beach?

3. **Cut the stem of a plant crosswise. In your journal, draw or describe what you see. Use your hand lens to look closely.**
    - How does what’s inside help the plant obtain oxygen.

4. **Look at the leaves. Describe or draw what they look like in your journal.**
    - Does their shape or position help the plant get sunlight or oxygen? How? Does the shape or position help them compete with other plants in some manner?

5. **Can you see flowers (or other reproductive parts)? Describe or draw them in your journal.**
    - How are they adapted for reproduction in an estuary or beach?

6. **Dig up one small plant whose species is found in abundance in the estuary or beach and look at its roots. Describe or draw a picture of the roots.**
    - How are these roots suited for living in hydric soils?
    - How are these plants adapted for living with salt water?

Wetland Plant Adaptations	Advantage	Examples
Salt-Tolerant Plants		
gummy, hairy, waxy skin	to prevent salt absorption	cinquefoil, sea thrift gumweed, pickleweed,
holds water in cells	to maintain water supply	pickleweed
oxygen-rich layer around roots	to obtain oxygen	cordgrass
exudes salt crystals	to get rid of excess salt	saltgrass
salt drops on tips of leaves	to get rid of excess salt	pickleweed
large, hardy seeds to keep salt water from flowing in	to maintain salt balance in cells	pickleweed
low, sprawling form	to reduce water loss from wind exposure	pickleweed, jaumea
small flowers	uses little energy	sedges, rushes, bulrushes
parasitic	to obtain nutrients from other plants	salt marsh dodder
Bog Plants		
sticky, sweet smelling	to attract insects for nutrients	sundew, pitcher plant
leaves upright,	to reduce surface area for drying out from exposure to the sun	Labrador tea, cranberry
thick, fuzzy, rolled leaves,	to prevent water loss from evapotranspiration	Labrador tea
live symbiotically with fungi	to obtain nutrients	orchids, heath plants

Student page

Plant Adaptations Data Table

Species	Location	Size	Shape	Texture	Stem Cross section	Leaves	Flowers	Roots	Salt Adaptation

Bird Data Table

Bird Name	Tally	Location	Adaptations	Advantage for Survival	Migratory or Resident

Questions:

1. How many different types of birds did you see?
2. Were there fewer or more birds at the estuary or beach than at any of the other aquatic ecosystems you visited?
3. Are there fewer or more birds on the school grounds?
4. What kinds of adaptations did you find and what are the ways these adaptations help birds survive and reproduce in this estuary or beach?

Student page

Litter and Debris Tally

Record the trash you collect.

Item	Tally	Total
Plastic		
Glass		
Metal		
Paper		
Styrofoam		
Wood		
Cloth		
Other		

Questions:

1. Which items are recyclable? Mark an R by the recyclable items.
2. Which was the largest item you found?
3. Which was the smallest item you found?

Student page

Gulf Boat Trip

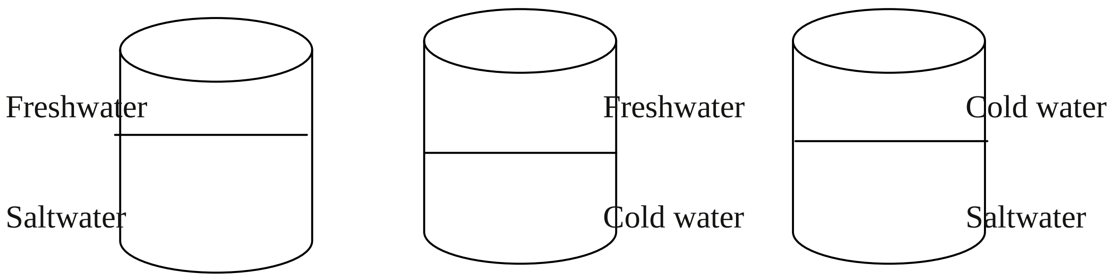
NAME of ORGANISM	DESCRIPTION	ADAPTATION	TALLY

Chapter 12 Assessment

Directions

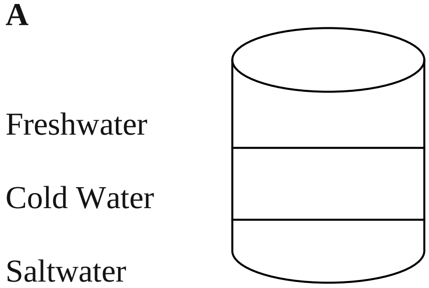
Select the best answer for each of the following multiple-choice questions.

1. The diagram below shows one container with freshwater and saltwater, another container with cold water and freshwater, and another with cold water and saltwater.

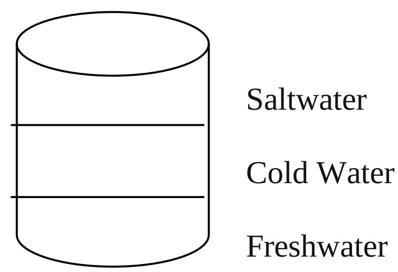


Which diagram shows what would most likely happen if freshwater, saltwater, and cold water were all placed in one container?

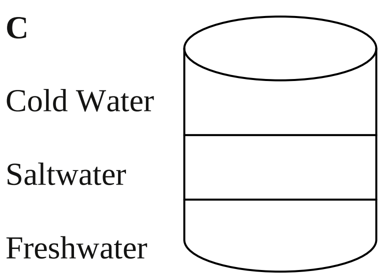
A



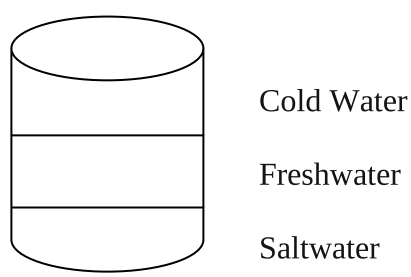
B



C



D



2. A fish has a flat speckled body. How does the appearance of this fish most likely help it survive?

- **A** It helps it sneak up on prey.
- **B** The head-on view of this fish attracts predators.
- **C** The flat body allows this fish to live in deeper water.
- **D** Predators have a hard time seeing this fish when it hides on the bottom.

3. A type of organism is missing from the food chain below.

? **clam** **blue crab** **people**

Which statement about the type of organism that correctly completes this food chain is <u>NOT</u> true?

- **A** It is unable to move from one place to another.
- **B** It produces its own food.
- **C** It breaks down nutrients from decaying organisms.
- **D** It gets its energy from the sun.

4. Waves are caused by:

- **A** Currents
- **B** Wind
- **C** Tides
- **D** Properties of Water

Chapter 12 Assessment

Write your own answer for each of the following questions.

1. Explain what a hypoxic zone is and how it is formed?

2. Where is a hypoxic zone in the Gulf of Mexico? What are its effects?

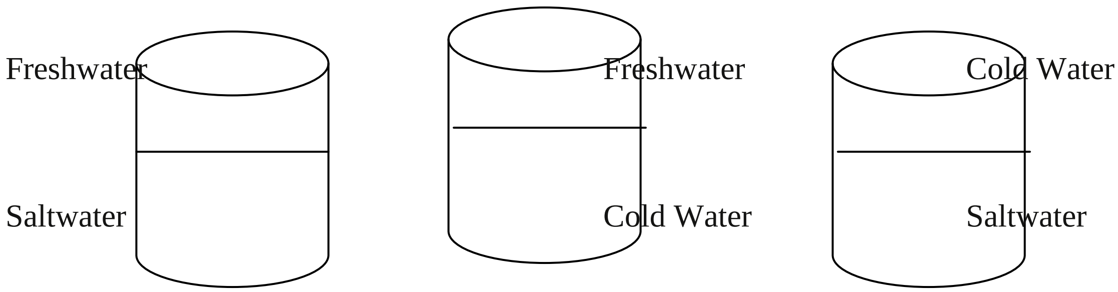
3. Draw a food web for pelagic areas in the Gulf of Mexico.

Chapter 12 Assessment Answer Key

Directions

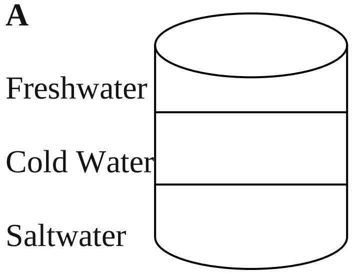
Select the best answer for each of the following multiple-choice questions.

1. The diagram below shows one container with freshwater and saltwater, another container with cold water and freshwater, and another with cold water and saltwater.



Which diagram shows what would most likely happen if freshwater, saltwater, and cold water were all placed in one container?

A



2. A fish has a flat speckled body. How does the appearance of this fish most likely help it survive?

D Predators have a hard time seeing this fish when it hides on the bottom.

3. A type of organism is missing from the food chain below.

?	**clam**	**blue crab**	**people**

Which statement about the type of organism that correctly completes this food chain is <u>NOT</u> true?

C It breaks down nutrients from decaying organisms.

4. Waves are caused by:

B Wind

Chapter 12 Assessment Answer Key

Write your own answer for each of the following questions.

1. Explain what a hypoxic zone is and how it is formed?

A **hypoxic zone** is often called the "dead zone." This is an area of very low to no dissolved oxygen.

Human activities add wastes, **pollutants**, fertilizers, and extra **sediments** to the flow of the Mississippi River. The additional materials, especially increased amounts of nitrogen and phosphorous fertilizers, have caused over-enrichment and direct pollution of Gulf waters that has upset the natural balance of aquatic production.

The nutrients create a rapid massive growth of phytoplankton at the water's surface. This results in a biomass of primary producers far beyond what would occur naturally, often called an **algae bloom**. The increase in phytoplankton then affects the Gulf food chain, increasing food for zooplankton and other aquatic life. But the amount of phytoplankton produced in such a short time is well beyond the capacity of **primary consumers** to graze it down to a balanced level. Phytoplankton have a relatively short life span, so much of the phytoplankton dies before it can be consumed. After dying the phytoplankton organisms sink down to the bottom where **decomposers**, such as bacteria, break them down.

At the time of year this usually happens, the water column is stratified, meaning that temperature and salinity differences between surface and bottom water layers prevent the layers from mixing. This isolates bottom waters from being resupplied with oxygen from the surface. The **plankton** that has sunk to the bottom is decomposed by **bacteria**, but large amounts of **dissolved oxygen** are consumed by this process and the dissolved oxygen is quickly depleted. The result is creation of a **hypoxic zone.**

2. Where is a hypoxic zone in the Gulf of Mexico? What are its effects?

The hypoxic zone is where the Mississippi River feeds into the Gulf of Mexico. The zone expands from the mouth of the river and into the Gulf along the coasts of Louisiana and Texas each summer. Hypoxic zones occur elsewhere in the world's oceans, but the one in the Gulf is now the second largest on Earth, sometimes extending all the way from Texas to Florida.

This is an area of very low to no dissolved oxygen. Organisms capable of swimming away such as fish and shrimp may leave the area, but life that lives in or on the bottom has nowhere else to go. They experience stress or die as a result of this low dissolved oxygen. **Hypoxia** adversely affects production of seafood and other aquatic life as food webs are disrupted and organisms at all **trophic levels** are harmed. Hypoxia can last for several months until the water layers mix, which can happen due to storms or when the water cools in fall and winter.

3. Draw a food web for pelagic areas in the Gulf of Mexico.

Answers will vary. The answer may include something like the following:

- The food web always starts with the Sun. Phytoplankton get energy from the Sun.
- Phytoplankton are eaten by jellyfish. Jellyfish are eaten by sea turtles.
- Phytoplankton are eaten by mullet. Mullet are eaten by dolphins.
- Phytoplankton are eaten by Zooplankton. Zooplankton are eaten by squid. Squid are eaten by Mackerel. Mackerel are eaten by tuna. Tuna are eaten by sharks.

Fishing for Conservation

Understanding Texas aquatic ecosystems helps us enjoy, appreciate, and conserve our precious aquatic resources.

Chapter 13

Grade Levels/Courses

6^{th}, 7^{th}, 8^{th}, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Discuss recreational activities at aquatic sites.
2. Review Newton's Laws of Motion.
3. Identify Newton's Laws of Motion in everyday activities including casting a fishing lure.
4. Examine a fish, make a drawing, and label the parts.
5. Research unfamiliar fish and note characteristics.
6. Research fish adaptations.
7. List safety precautions to use when fishing.
8. Read the chapter and answer the questions.
9. Make a drawing showing the habitat of the kind of fish they would like to catch.
10. Apply knowledge of species adaptations in the conservation of Texas' aquatic resources.
11. Apply knowledge of the roles of producers, consumers, and decomposers in the transfer of energy in an aquatic food web in Texas.
12. Demonstrate ethical judgment with regard to the conservation of Texas' aquatic resources.
13. Design an experiment to test the strength of three types of fishing line.
14. Compare actual strength of fishing line to advertised strength.
15. Play a game to learn about fishing regulations.
16. Discuss career requirements and opportunities with a game warden.
17. Conduct a field investigation to find out what fish live in their local aquatic ecosystem.
18. Compare adaptations of fish in their sample.
19. Use safe practices and conservation of resources in the field.
20. Collect data and record information in tables.

21. Draw conclusions based on data.
22. Demonstrate the use of course apparatuses, equipment, techniques, and procedures.
23. Collect quantitative data from an aquatic environment, including pH, dissolved oxygen, salinity, temperature, mineral content, nitrogen compounds, and turbidity.
24. Identify ways human activity can affect aquatic environments.
25. Predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
25. Analyze the cumulative impact of human population growth on an aquatic system.
26. Use safe practices and conservation of resources in the lab and field.
27. Continue recording weather and chemical and physical characteristics of their local aquatic ecosystem for their long-term study.
28. Assess water quality in a local watershed.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 B, C, D, E; 6.4 A, B; 6.8 B, C, D; 6.12 D, E; 7.1 A, B; 7.2 B, C, D, E; 7.4 A, B; 7.7 C; 7.10 A, B; 7.11 A, B; 7.12 A, C; 7.13 A; 8.1 A, B; 8.2 B, C, D, E; 8.4 A, B; 8.6 A, C; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, J; 3 B, C, E; 5 C, D; 10 A, B; 11 A, B; 12 C, D

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3 B, C, E; 4 A, B; 6 E; 9 A, E, G

Materials Needed

Activity 13.1

Science journals

Pencils/pens

Copy of *Casting Instructions* for each student

Rod-and-reel combinations set up with casting plugs (Advanced preparation is required.) Hula-hoops, Backyard Bass or other suitable casting targets such as small “kiddie” wading pools, or wash-tubs (optional)

For each group of 2 students

Ping-pong balls

Two empty two liter soda bottles

String

Spring scales calibrated in Newtons

Activity 13.2

Fish for examination and/or dissection (Obtain from friendly fisherman, seafood store, or science supply catalogue)

Texas Freshwater and Saltwater Fish Flash Cards:
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/fish_flash_cards.pdf
Science journals
Pencils/pens

Videos about learning to fish:
http://www.tpwd.state.tx.us/fishboat/fish/programs/gofishing/videos/08freshwater.phtml
1 copy of *Fishing Instructions* for each student ·
1 copy of *Fish Matrix* for each student
Information on freshwater fish identification:
http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/inland.phtml
Information on saltwater fish identification:
http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/marine.phtml

Activity 13.3
Student Guide
Science journals
Pens/pencils

Activity 13.4
Texas Parks and Wildlife website with fishing regulations
http://www.tpwd.state.tx.us/regulations/fish_hunt/#fish.html
1 copy of the *Scavenger Hunt for Texas Fishing Regulations* for each student
Science journals
Pencils/pens
3 types of fishing line of different strengths

Other possible materials
Scissors
Metric ruler
5 gallon buckets, or other container
Scales
Metric measuring cup, beaker, or graduated cylinder
Water
Tree limb or other strong place to hang buckets

Activity 13.5

May vary depending on the site chosen for the field trip. It could be to freshwater or saltwater.

Rods and reels

Bait

Lures

Casting Instructions

Fishing Instructions

Field Guides

First Aid Kit

Science Journals

Pencils/pens

Copies of Fish Matrix or Data Tables made by students to record fish caught

Invertebrate Sampling:

Bug Picking Water Quality Indicators

Seines and nets including D-frame aquatic dip net and kick seine

Containers for specimen such as:

White trays

Ice cube trays

Hand magnifiers or magnifier boxes

Forceps

In bays or estuaries, use a field guide to identify the invertebrates collected

Water Chemistry Tests

Salinity test, and other water chemistry test kits

Safety goggles

Gloves

In addition, high school students should continue to collect data for their long-term study.

Weather and Water Temperature

Thermometers and weather instruments

Physical Water Quality Indicators check sheet

High school students should also have:

Secchi disc, stopwatch, tennis ball or piece of wood

Special Instructions

If time allows, invite a local game warden to come and talk about the fishing regulations.

Safety Precautions

Make sure students watch others carefully when practicing casting and handling a rod and reel. Practice casting should be done with no hooks, only practice plugs. Sunglasses are not only for the sun when fishing. They help protect eyes.

If the class does a full dissection, students must wear gloves, goggles, and observe safety with sharp objects.

Activities use heavy weight, be sure that the weight is suspended close to the ground (no more than 20 cm.) and keep students back at least 6 feet so as not to have weight fall on feet.

Review field safety guidelines.

Vocabulary

- Acceleration
- Action and Reaction
- Anal
- Anterior
- Anus
- Bony rays
- Casting
- Caudal
- Conservation
- Cover
- Dorsal
- Ethical
- Ethics
- Force
- Gills
- Heart
- Inertia
- Intestine
- Kidney
- Liver
- Motion
- Operculum
- Ovary

- Pectoral
- Pelvic
- Posterior
- Regulations
- Ribs
- Spine
- Stomach
- Swim Bladder
- Tensile strength

Teacher Resources

http://www.tpwd.state.tx.us/fishboat/fish/programs/gofishing/videos/
http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/inland.phtml
http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/marine.phtml
http://www.tpwd.state.tx.us/regulations/fish_hunt/#fish.html

Enrichments

Project WILD Aquatic

- Living Research: Aquatic Heroes and Heroines
- Net Gain, Net Activity

Guest speaker

- Texas Parks and Wildlife Department Angler Educator
- Texas Parks and Wildlife Department Game Warden

Fishing Opportunities for Students

There are several avenues to introduce students to the sport of fishing either for leisure or competition.

Competitive:

- The Federation of Student Anglers: www.fishingstudents.com
- http://www.texashighschoolbasschampionship.com/
- The Bass Federation: www.thebassfederation.com
- Bassmaster series: http://www.bassmaster.com/youth

Noncompetitive

- National Fishing in the Schools Program: http://www.schoolofflyfishing.com/
- Texas Parks and Wildlife Angler Education program: http://www.tpwd.state.tx.us/learning/angler_education/learnfish.phtml

Lesson 13.1: Gone Fishing?

Essential Concept

Fishing and other aquatic activities are an important way to learn about aquatic environments.

Objectives

1. Students will discuss recreational activities at aquatic sites.
2. Students will review Newton's Laws of Motion.
3. Students will identify Newton's Laws of Motion in everyday activities including casting a fishing line.

TEKS

6.1 A; 6.2 C; 6.8 B; C, D; 7.1 A; 7.2 C; 7.7 C; 8.1 A; 8.2 C; 8.6 A, C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

1 class period

Materials

Science journals

Pencils/pens

Copy of *Casting Instructions* for each student

Rod-and-reel combinations set up with casting plugs (Advanced preparation is required.)
Hula-hoops, Backyard Bass or other suitable casting targets such as small "kiddie" wading pools, or wash-tubs (optional)

<u>For each group of 2 students</u>

Ping-pong balls

Two empty two liter soda bottles

String

Spring scale calibrated in Newtons

Safety Precautions

Make sure students watch others carefully when practicing casting and handling a rod and reel. Practice casting should be done with no hooks, only practice plugs. Sunglasses are not only for the sun when fishing. They help protect eyes from hooks.

Procedure

1. Big Fish Stories

Ask students to work individually to write short answers to the following questions in their journals. Then work in small groups to tell about any experiences they have had fishing, and to explore the following questions:

- **Have you ever been fishing? If so, tell about the experience. If not, would you like to go?**
- **How do people find and catch fish?**
- **What are the rules for fishing?**
- **Is anyone in the group an expert fisherman?**
- **What else do people do to enjoy Texas' aquatic resources? Have you ever done any of those things? If so, tell about the experience. If not, would you like to?**
- **What can you do to help conserve Texas' aquatic ecosystems? Have you ever done any of those things? If so, tell about the experience. If not, would you like to?**

Ask each group to report the results of their discussions to the class. Make a note of any students that fish on a regular basis. They may be able to help novices on the field trip.

2. Casting Instructions

Explain to the class that this chapter will help them understand how to find and catch fish, follow the rules for fishing, and enjoy and conserve Texas' aquatic ecosystems.

Distribute one copy of *Casting Instructions* for each student.

Have students read *Casting Instructions*—class time may be provided or reading may be assigned as homework in advance of class. Have students keep the instructions in their notebooks for use on the field study day.

3. Practicing Casting

Take the class outside to a suitable open area such as a ball field, empty parking lot or open lawn. Alternatively, this activity may be done indoors in a suitably large space with a high ceiling, such as a gymnasium. Set out casting targets, (Hoola Hoops will work, or for more fun, use small wading pools or wash tubs with water.)

Guide the class through the casting process. Have students refer to the copy *of Casting Instructions* in their notebooks.

Allow students to practice as time allows; they may need to take turns. Give lots of positive reinforcement and guidance as needed.

4. How Does It Work: Newton's Laws of Motion

Review Newton's Laws of Motion. Put students in pairs, and give each pair a ping-pong ball. Have students sit on the floor about 3 feet from the wall. (The wall needs to be clear so students can use it in their investigation. The hall might be a good place if students aren't too loud.)

Inertia

Have students set the ball on the floor about 3 feet from a wall.

Ask students to observe the ball.

- **What is happening to the ball?** (It is sitting still/not moving. It is a body at rest.)

If students do not come up with this immediately, continue questioning until they do. For example, you might ask what kind of movement they observe in the ball.

- **Will the ball move if you do not do anything to it?**

The tendency to stay at rest is called **inertia**. Inertia is also the tendency to stay in motion (think of throwing something out in space with no gravity.) It requires some kind of force to overcome inertia.

NEWTON'S FIRST LAW OF MOTION SAYS THAT AN OBJECT AT REST TENDS TO STAY AT REST, AND AN OBJECT IN MOTION TENDS TO STAY IN MOTION (AT THE SAME SPEED AND IN THE SAME DIRECTION) UNLESS ACTED ON BY A FORCE.

Acceleration

Have students devise a force to act on the ball. Don't tell the students how to do this. They may come up with a variety of ways to move the ball. (Throw, roll, blow [if they try this you can supply them with straws to focus the air], thump, etc.)

- **What happened to the ball when you applied a force?**
- **What kind of force did you use?**
- **Did your ball move?**

Have students write down their results in their science journals.

When a force is applied, the ball moves and will continue to move in a straight line until some other force (such as friction or an obstruction) acts on it to slow it down, stop it, or change the direction it is moving. This movement or change of direction or speed is called **acceleration**.

NEWTON'S SECOND LAW OF MOTION SAYS, A CHANGE IN MOTION (IN SLOWER OR FASTER SPEED, OR IN DIRECTION) REQUIRES FORCE.

The larger the mass of the object, the more force is required and the force must also be greater than any other forces working on the object such as gravity or friction.

The formula for acceleration says:

acceleration equals net force divided by mass

a = F/m

The unit of measure for force is Newtons. Spring scales are available calibrated in Newtons. You can actually figure the acceleration rate by measuring how much force it takes to move an object and dividing by the mass of the object.

Example: You can try this with 2 empty 2-liter soda bottles. **Write down your data in your science journal**. Fill one soda bottle about ¼ full of water or sand. Fill the other ¾ full with water or sand. Tie a string around each bottle. Use the hook on a spring scale calibrated in Newtons to hook on to the string and pull on each bottle until it moves across the desk. Look at the spring scale and record the number of Newtons (indicating the amount of force) needed to move the bottle. Now find the mass of each bottle and apply your data to the formula above. **Do the math in your science journal.** You will have the rate of acceleration.

- **Which bottle required the most force to move? Why?**

Action/Reaction

- **When you accelerated the ball, what happened next?** (If you rolled the ball hard enough, it bumped into the wall and bounced off.)

Have students roll the ping-pong ball into a wall. They may try this from different angles.

- **What happens to the ball?** (The ball bounces off at an equal angle, but in the opposite direction from which it hit the wall.)

Have students answer the following questions and make a <u>labeled diagram</u> in their science journal that shows what the ball does.

- **What forces are working on the ball?**
- **Where are the forces operating?**
- **What is the direction of each force?**
- **What is the direction of the motion?**

NEWTON'S THIRD LAW OF MOTION SAYS FOR EVERY ACTION THERE IS AN EQUAL AND OPPOSITE REACTION.

5. Application of Newton's Laws of Motion

We can see examples of Newton's Laws of Motion in real life in many things from walking to rocket flight. Have students explain some ways that forces affect motion in every day life. (Rocket propulsion, swimming, shooting basketballs, riding a skateboard, etc.) **Have students draw a diagram of one of the activities and indicate the forces involved and the direction of the force and direction of the motion**.)

6. Casting and Motion

When we are casting our fishing lure, we are utilizing Newton's Laws of Motion.

Diagram a person casting a fishing lure:

- **What forces are working on the lure?**
- **Where are the forces operating?**
- **What is the direction of each force?**
- **What is the direction of the motion?**

(We apply a **force** to the fishing rod, using our body by pulling the rod back, and then moving the arm forward. As the rod moves forward the line swings, too. We exert a **force** holding the reel still. As we swing, we release the button holding the reel from moving and the line begins to unwind. The hook, bait, sinker, and bobber (float) attached to the end of the line fly high into the air away from you. The **force** of gravity takes over, pulling the hook, bait, sinker, and bobber back toward Earth. They splash into the water. We overcame **inertia**, by applying a **force** (our swing), the hook, bait, sinker, and bobber **accelerated** out from us. Gravity exerted another **force** and pulled the hook, bait, sinker, and bobber down toward Earth where they entered the water. The **action** was the swing we gave to start the motion. When the hook, bait, and sinker enter the water they sink until they reach the end of the line between them and the bobber, at which point we will see a **reaction** as the bobber bobs in the water suspending the hook, bait, and sinker in the water.)

Vocabulary

- Acceleration
- Action and Reaction
- Casting
- Force
- Inertia
- Motion

Student Page

CASTING INSTRUCTIONS

1. Casting is a mechanical activity. The fishing rod extends your arm and allows you to "throw" your lure or bait a long distance with little effort. Casting is a matter of timing and technique, not strength. You don't need to "beef up" to become a good caster. In these directions, left-handers should substitute left for right.
2. **Safety Alert:** Look behind you to make sure that there are no trees or bushes around the area to interfere with your cast and to make sure that no one is standing behind you to get caught by the hook when you are casting. For safety, always practice with plugs, but no hooks to help you learn the basics first.
3. Lightly grip the fishing rod in your dominant hand. Start with your shoulders square to your target, elbow near the front of your rib cage, forearm and rod pointing in the direction of the cast. Let out 5 to 10 inches of line from the tip of your rod to the practice plug, bait or lure which, because the rod is motionless, hangs straight down. Look at your target.
4. Push the button on the reel with your thumb and hold it in.
5. Lift your forearm straight up, keeping the elbow in place or allowing it to rise just a little. The rod will follow backwards. Continue until your hand moves to about the level of your ear.
6. Sweep your forearm forward, again keeping the elbow pretty much in place. When your arm is about halfway back to its original position, or your hand passes your face, let loose the line, by releasing the button. The plug, bait or lure will be propelled forward, pulling line off the reel until the lure lands.
7. Picture a clock face. Think of your elbow as the hub of the clock and your forearm as the hour hand. . Noon is straight up, 9 o'clock is directly in front of you, 6 o'clock is at your feet and 3 o'clock is directly behind you. Start the cast with the pole at about 10 o'clock. Bring your forearm slowly but steadily back so the tip of the pole is at 2 o'clock. Sweep the forearm forward back to 10 o'clock, releasing the line somewhere near 11 o'clock.
8. If your lure shoots up in the air and doesn't go very far or lands on the ground behind you, the line was released too early. If the lure smacks into the ground in front of you, you released the line too late.
9. Remember that the cast has no sudden or jerky motions. Practice until it becomes smooth and nearly effortless.
10. Accuracy is often more important than distance. Many fish remain near protective cover and will strike only those lures that come into their immediate vicinity. Improve your accuracy by casting to definite targets. Make sure you focus on your target while casting.

Lesson 13.2: Which Fish Am I?

Essential Concept

Knowing fish characteristics and adaptations is important in helping anglers catch fish and in making ethical decisions for maintaining adequate fish populations to provide a balanced community in aquatic ecosystems.

Objectives

1. Students will examine a fish, make a drawing, and label the parts.
2. Students will research unfamiliar fish and note characteristics.
3. Students will research fish adaptations.
4. Students will make a list of safety precautions to use when fishing.

TEKS

6.1 A; 6.2 C; 6.4 A, B; 6.12 D; 7.1 A; 7.2 C; 7.4 A, B; 7.11 A, B; 7.12 A, C; 8.1 A; 8.2C; 8.4 A, B; 8.11 A

Aquatic Science: 1 A; 2 G, J; 10 A, B

Environmental Science: 1 A; 2 F, G, K; 4 A, B

Estimated Time

1 class period.

Materials

Fish for examination and/or dissection from a friendly fisherman, a seafood store, or science supply catalog

Science journals

Pencils/pens

Texas Freshwater and Saltwater Fish Flash Cards. **Download here:**
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/fish_flash_cards.pdf

Videos about learning to fish:
http://www.tpwd.state.tx.us/fishboat/fish/programs/gofishing/videos/08freshwater.phtml

1 copy of *Fishing Instructions* for each student ·

Information on freshwater fish identification:

http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/inland.phtml

Information on saltwater fish identification:

http://www.tpwd.state.tx.us/landwater/water/aquaticspecies/marine.phtml

Safety Precautions

If the class does a full dissection, students must wear gloves, goggles, and observe safety with sharp objects.

Procedure

1. Parts of the Fish

Provide a fish for each group of 2–4 students to examine. Have students draw a picture of their fish in their science journals and label the parts. For younger students that may be as far as you want to go. External parts that students might label include: scales, nostrils, mouth, tongue, teeth, eye, fins (dorsal, pelvic, pectoral, anal, caudal), lateral line, gill covers (operculum).

For older students, after you do the external drawing, you may wish to do a full dissection. In that case have students make another drawing of the internal parts and label them. They may be able to figure out some of the organs, but they may need to do some library or Internet research to help them figure out other parts. Internally they might include the following parts: stomach, swim bladder, kidney, bony rays in fins, anus, ovary, testes, intestine, liver, heart, gills, spine, ribs.

When students have finished drawings and labels, ask them to share their ideas with the class. Add new vocabulary words as needed. You may want to introduce words to indicate the locations of the different fins on the fish. Possible new vocabulary might include: anterior dorsal and posterior dorsal fins, pectoral, pelvic, anal, and caudal fins. Also you might add operculum for gill cover.

2. Identifying Fish

Post a copy of the fish flash cards on the bulletin board. Post names of fish on the bulletin board but do not match the names with the pictures of fish. Ask students to work as a class to place the names of any fish that they know with the correct fish. You can either cut the names apart or you can use yarn to connect the name with the correct fish. Ask students to classify fish as saltwater or freshwater species. If you are using yarn to connect fish, use blue yarn for freshwater fish and green yarn for saltwater fish. If students, are unable to identify and classify all of the fish, keep the bulletin board up and do the identification again after students do their research.

Texas Freshwater and Saltwater Fish Flash Cards. **Download here:**
http://www.tpwd.state.tx.us/publications/learning/aquaticscience/fish_flash_cards.pdf

Use the fish flash cards to assign each student 1 fish to research. Students can then choose 2 other fish to research. Tell students that each of them will become a "Fish Expert" on 3 species of fish. They will learn about 3 kinds of fish and help other students identify those fish when they are caught. Ask students to go to either the freshwater or marine aquatic species websites, in the materials list, depending on where you will be fishing or what fish they might be curious about, and either assign each student 2 additional fish or allow students to choose 2 additional fish from the websites to fill in the fish matrix. The goal is to get information to help students identify what they catch, so the more fish descriptions you have the better. Students will fill in the fish matrix with information about fish characteristics and adaptations as they do their research. Each student will present their research to the class and help identify and classify any fish on the bulletin board that have not yet been identified.

For High School

Students will become experts on 3 or 4 closely related species and will learn how to tell them apart. **Examples:** Longnose, spotted, and short nosed gar; largemouth, smallmouth, and spotted bass; white bass, hybrid, and striped bass; channel, blue and flathead catfish; bluegill, green and pumpkin seed; or threadfin and gizzard shad.

Extension: Hold a Fish ID-A-Thon

Have students compete to see which student can identify the most different kinds of fish from photos taken from the Parks and Wildlife Websites. If you have something for a prize, it would be more fun. (Maybe packages of Fish Crackers or Gummy Worms)

3. Sharing What We Learned

Ask students to “share their expertise” with the class by presenting information on their three fish and their characteristics. Keep a list of fish identified and the names of the students who are the “fish expert” for those fish. When someone catches a fish of that type, the “fish expert” will help identify it.

4. Learning to Fish

If you would like to show a short video on learning to fish there are several related videos at the website found in the materials list for this activity. Each video is only about 3 minutes long. Sometimes it helps students to see what to do and then try it themselves.

Distribute one copy of *Fishing Instructions* for each student.

Have students read Fishing Instructions**—**class time may be provided or reading may be assigned as homework in advance of class. Have students keep the instructions in their science journals for use on the field study day.

5. Safety Precautions

Have students work in groups of 4 to make a list in their science journals of safety precautions that they need to know in order to be safe when fishing. Remind students of appropriate dress for outdoor activities including: hats, sunglasses, sunscreen, etc.

Vocabulary

- Anal
- Anterior
- Anus
- Bony rays
- Caudal

- Dorsal
- Gills
- Heart
- Intestine
- Kidney
- Liver
- Operculum
- Ovary
- Pectoral
- Pelvic
- Posterior
- Ribs
- Spine
- Stomach
- Swim bladder

Texas Fish and Their Characteristics
Comparison Matrix

Species	Average Size Weight Length	Niche in the Food Web Predator or Prey	Coloration Adaptation Advantage	Adaptation Advantage	Adaptation Advantage
Example: Channel Catfish	20-40 lbs. 24 in.	Predator	Slate blue on the back shading to white on the belly-camouflage	Males guard the nest to protect eggs and young–better survival rate	Upper jaw protrudes to help in catching prey

FISHING INSTRUCTIONS

Safety Alert:

1. Handle rod carefully at all times.
2. Carry rod with both hands and hold rod tip up. Secure hook in rod guide and tighten the line so the hook cannot swing around.
3. Lean the pole so that it will not fall over, or have a friend hold the pole to bait hook.
4. Before casting, look behind you and to the side to see that no one is near.
5. Never leave hooks baited when you are not fishing. Pets and wildlife can find the bait and get hooked.

Fishing

6. Cast your lure into the water. When the lure has stopped, turn the handle of the reel once or twice to make your line tight.
7. Now wait for a fish to bite.
8. If you are using a bobber and your bobber jiggles, plunges downward or skates across the water, you have a bite. If you are holding your fishing pole, you may feel a tap, a tug or a pull, or the line may go slack.
9. When you suspect a bite, set the hook with a powerful <u>upward</u> jerk of the rod.
10. Keep the rod up high, so your arms and the bend of the fishing pole absorb some of the power of the fighting fish.
11. Small fish can probably be reeled in directly, but if the fish is a large one, trying to haul it in quickly will only break the line. For big fish, allow the fish to swim away, taking line from the reel. (The reel will probably be making a strange sound.) When you can, lift the rod tip up to pull the fish closer, and as you lower the rod tip, reel up any excess line you that you can, repeating this process “pumps” the fish closer.
12. Repeat this process until the fish is close enough to reach.
13. You can draw fish <u>up the bank</u> with your fishing rod until it is close enough <u>to grab by hand</u>, or by backing slowly away from the water.
14. Don’t let fish flop on the ground. They could injure themselves. Dip your hands in water prior to picking up a fish. This protects the fish so that your hand doesn’t remove the slime layer. Don’t put fingers in their gills or eyes. Be careful not to hook yourself when you grab the fish.
15. The fins of sunfishes and bass become rigid when the fish is threatened. Slide your hand down over the fins of small fish starting from the head to lay the spines down and hold them firmly (wetting your hands first). Grasp larger fish over the back of the head, above the gills. Bass, crappie, and small catfish can be safely held by putting your thumb into their mouth, and pinching their lower lip. For catfish, protect

yourself by holding the fish from the underside, with your fingers firmly beneath the pectoral spines. Remember, the barbels are harmless.

16. Immobilize fish by holding them upside down. Remove the hook by hand or with needle-nose pliers. If the fish is hooked deeply in the gills or stomach where the hook cannot easily be removed, clip the line as close to the hook as possible. The hook will fall out after a time, with minimal damage to the fish.
17. Measure the fish from the tip of the snout to the end of the tail, with the fish laid flat and the tail lobes pressed together. Weigh and identify the fish quickly and make a data table to record bait, tackle and location caught.
18. Release fish as soon as possible. The longer the fish remains out of the water, the less its chances of surviving. Stressed fish, often just sit there in the water without moving. Fish can often be revived if you hold them upright in the water, and move them slowly back and forth, until they can swim away under their own power. Fish have a good chance of surviving after being caught many times, if they are handled carefully.
19. If the line becomes snagged, ask for adult help. Carefully pull or cut the snagged line. Jerking the line is dangerous and may result in a hook flying through the air.

Lesson 13.3: Reading and Research

Essential Concept

Fishing requires knowledge of fish and their habitat, niches, food webs, and communities. Fishing has rules and requires ethical behavior in order to protect the environment and living things in it.

Objectives

1. Students will read the chapter and answer the questions.
2. Students will make a drawing showing their fishing strategy and the habitat of the kind of fish they would like to catch.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 A; 7.13 A; 8.2 C; 8.11 A, B, C

Aquatic Science: 2 J; 10 A; 12 C, D

Environmental Science: 2 K; 9 A, E, G

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 40 minutes for in-class questions and discussion, and drawing diagram.

Materials

Student Guide

Science journals

Pens/pencils

Procedure

1. Student Reading

Have students read *Chapter 10: Fishing for Answers*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What does it mean to think like a fish?

It means that you use what you have learned about fish, habitats, food webs, niches, trophic levels, and aquatic ecosystems to help improve your fishing success.

2) How can knowing about aquatic communities and food webs be used to improve fishing success?

Use bait that looks or smells like a fish's natural food. Cast your line where you think fish are feeding. Fish may scour the bottom, hunt near the surface or swim anywhere between. Their need for cover attracts them to structures such as rocks, logs and plants. Fish use cover to escape predators and to help them ambush prey. Ask yourself, "If I were a fish, where could I hide from enemies and find food?"

3) How can knowledge of fish adaptations be used to improve fishing success?

- Bluegill have a small mouth because they eat small insects.
- Channel catfish are adapted to feed at night. They depend on barbels or "whiskers" with many taste buds and a good sense of smell to guide them to food even in dark, muddy waters. They can taste food even before taking it into their mouths.
- Largemouth bass are predators. Their large mouths enable them easily to catch frogs, fish, crayfish and other animals.
- All fish are nearsighted, but the placement and shape of their eyes allows them to see almost all the way around their bodies.
- Lateral lines let them sense water vibrations coming from each direction.
- Fish have good hearing, but they are especially good at hearing low-frequency sounds. "Keep quiet or you'll scare away the fish" is good advice when you're on a fishing trip.

4) What is cover for fish and why is it important in fishing? What weather factors improve fishing success?

Cover is the place that a fish might hide from predators or wait for prey to swim near. Structures such as rocks, logs, docks, coral reefs, undercut banks, and aquatic plant beds provide cover for fish.

Weather affects fish, but not always in predictable ways. Fish seem to prefer eating during the low light conditions of morning and evening rather than in the bright sun of midday. Cloud cover mimics these low-light periods and may help get fish to bite. A light to moderate wind is often better than no wind. Fish will move into shallower water to feed in windy conditions.

5) List at least five observations that would help an angler be successful?

- The edge of a lake's shoreline zone usually produces the most fish.
- In rivers, fish often feed where the flow changes direction or slows down.
- In flowing water, there is less current near the bottom. Because of this, many fish in fast-flowing streams rest with their bellies almost touching the bottom or tend to rest downstream behind rocks where they are shielded from current. Most fish in a river face the flow of water and wait for food to come to them. Fish in current rarely move

far for food.

- Look for minnows or signs of other prey such as sounds of frogs jumping, or small fish splashing, or look for birds eating small fish or for hatching insects.
- Young fish can find protection from larger fish and other predators by staying in the plant-filled shallow water of wetlands.

6) Why are rules about how many fish you are allowed to catch important?

These rules help Texans share limited resources and keep our ecosystems healthy. Length limits give fish a chance to grow and spawn before people are allowed to catch and keep them. Number limits assure that no one takes too many. Taking too many of a particular species can upset the balance in the food web affecting all organisms in the community. Rules about fishing limits can help us to make sure our aquatic ecosystems and other resources stay diverse, balanced and healthy far into the future.

7) What is an ethical angler? What are some important things an ethical angler does?

Ethical people use good judgment, respect property rights, and respect the rights of others who are using the water. Ethical behavior includes picking up your trash, collecting and properly disposal of fishing line, never dumping any pollutants, never releasing live bait fish into the water, and carefully handling and releasing alive all fish you catch but do not intend to keep. Ethical anglers value and respect the aquatic environment and all living things in it.

8) How do anglers contribute to fish conservation?

To learn more about conserving Texas' aquatic resources, visit the Texas Parks and Wildlife Department's web site. You can also visit your local TPWD office or a nature conservation center.

- Better yet, go outside and visit your favorite local aquatic resource.
- Begin thinking of it as YOUR lake, pond, river, stream, wetland or estuary.
- Always bring a trash bag when you visit, and take a moment to leave the spot in better shape than you found it.
- Report invasive species.
- Be a mentor and take someone fishing.
- Start or join a Stream Team and adopt a water body (you're not limited to streams). Learn more about checking water quality by taking a Stream Team Volunteer Water Quality Monitoring class.
- Volunteer to become a Master Naturalist.
- And if you're up to the challenge, choose a career in conservation and make aquatic resources your life's work.
- Above all, enjoy your aquatic resources and use them wisely!

3. Cast Beyond Tomorrow Question

Ask students to discuss the following question.

- **What are some things you can do as an angler to improve aquatic ecosystems for the future?**

4. Where Will I Fish?

Ask students to do some research to find 3 places nearby where they can fish.

- Find out how to get access to the place
- Tell what type of fish would be available
- Write directions to the site in their journals
- **What safety precautions would you need to take?**
- **Is there any other information or requirements you would need to know in order to fish at this place?**

Ask students to make drawings of themselves fishing. In the drawing show the underwater habitat of their fish and show where they would be on the surface and where to cast their line to catch the fish.

- **Why is where you cast your line important?**
- **What kind of fish would you try to catch?**
- **What strategy would you use to find the fish?**
- **What would be appropriate bait for your fish?**

Vocabulary

- Conservation
- Cover
- Ethical
- Ethics

Lesson 13.4: Fishing Line Experiment

Essential Concept

Fishing line has a test number that tells the amount of weight that it will take to break it. Because of its strength, leftover fishing line can be a hazard for many aquatic organisms when left behind. Fishing regulations include the importance of keeping fishing line out of the environment and other rules to help keep our aquatic ecosystems healthy.

Objectives

1. Students will design an experiment to test the strength of three types of fishing line.
2. Students compare <u>actual strength</u> of fishing line to <u>advertised strength</u>.
3. Students will play a game to learn about fishing regulations.
4. Students will discuss career requirements and opportunities with a game warden.

TEKS

6.1 A, B; 6.2 B, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 B, C, D, E; 7.4 A, B; 7.10 A, B; 7.11 A, B; 7.12 A; 7.13 A; 8.1 A, B; 8.2 B, C, D, E; 8.4 A, B; 8.11 A, B

Aquatic Science: 1 A, B; 2 E, F, G J; 3 B, C, E; 5 C, D; 10 B; 11 A, B

Environmental Science: 1 A, B; 2 E, F, G, H, K; 3B, C, E; 4 B; 6 E; 9 G

Estimated Time

2 class periods

Materials

Texas Parks and Wildlife website with fishing regulations:

http://www.tpwd.state.tx.us/regulations/fish_hunt/#fish.html

1 copy of the *Scavenger Hunt for Texas Fishing Regulations* for each student

Science journals

Pencils/pens

3 types of fishing line of different strengths

<u>For each group of 4 students</u>

(Possible materials that might be suggested by students)

Scissors

Metric ruler

5 gallon buckets, or other container

Scales

250 ml. measuring cup, beaker, or graduated cylinder

Water

Tree limb or other strong place to hang buckets

Special Instructions

If time allows, invite a local game warden to come and talk about the fishing regulations and careers.

Safety Precautions

Activities use heavy weight, be sure that the weight is suspended close to the ground (no more than 20 cm.) and keep students back at least 6 feet so as not to have weight fall on students' feet.

Procedure

1. Testing Tensile Strength of Fishing Line

Each package of fishing line has a test number listed on the package. Usually it is stated in pounds and kilograms. This information is provided to let anglers know how much weight it takes to break the line. It is called **tensile strength.** Tensile strength is the amount of tension from a force that a material will withstand before it breaks, tears, or stretches.

- **How could you test fishing lines to find out if they actually hold the weight that the package claims.**

Put this question on the board and ask students to generate some ideas for testing their fishing line. Write down all ideas students generate. Help students evaluate each idea. Work with the class to come up with one method for their experiment.

Discuss controlling variables.

To be able to compare two different experiments only one variable may be changed. Everything else must be the same. **For Example:** The type of knot used to tie the line to a weight must be held the same on all trials. Discuss the fact that if all groups conduct the same experiment using the same method, it is like repeating the experiment several times. Repetition of the experiment provides a more reliable answer than only doing the experiment once.

Divide the class into groups of four and have them conduct the experiment. Students should develop a table to record their results. Have students graph their results for all 3 types of fishing line. Students should draw conclusions based on the data that they collect. When all students have completed the experiment, have them share their information with the class. Find class averages for each type of fishing line. Graph the average results for each type of fishing line compared to the advertised strength on the box.

- **Did all fishing line hold the weight described in the promotional materials on the package?**
- **Did all groups get similar answers?** (If one group's data doesn't agree with the data of other groups, discuss why the differences may exist.)
- **Did they follow the same procedures?**
- **Did they measure carefully?**

Discuss outliers and how we treat incongruous data.

- **Why is the tensile strength of fishing line important?** (Students will probably say that it helps the angler know if his line will hold a big fish.)

If they don't think of environmental implications, ask:

- **What is the importance of the strength of fishing line to the environment?** (Any fishing line left behind is a hazard for all living things in an aquatic environment. Because it is so strong, it is difficult for an animal to get untangled from it or break loose from it. It can also get hung on things under water and make it difficult for the animal to move around and find food.)

Extension

Anglers have to tie a lot of knots. Perhaps have the class learn a few fishing knots and conduct strength experiments on different knots. Use the same type of fishing line for every trial. They should find that some knots are much stronger than others and that some people tie better knots than other people. This is a variable that needs to be controlled. The same person should tie all knots in order to have results that can be compared. Some knots that you might try include, the normal square knot, the improved clinch knot, Palomar, Trilene knot, etc.

2. Fishing Regulations

Have students go to the website in the materials list. It will take you to *Recreational Fishing and Hunting Regulations*. Put in "fishing line" in the Search box. It will take you to a page where you will find "TPWD: Fishing Ethics: Do the Right Thing" will be the second thing down. Click on it and scroll down to "Conserve Fish and Aquatic Ecosystems".

Under #2 is the regulation. "Place excess **fishing line**, bait boxes, and litter in trashcans or pack it out with you. A major cause of injury for fish and wildlife along waterways is getting tangled in abandoned **fishing line**, not to mention that people and boat propellers can also get tangled."

There are other important fishing regulations that we need to know about. We will do a scavenger hunt to find out what some of these regulations are. Hand out the *Scavenger Hunt for Texas Fishing Regulations.* Have students use the TPWD website for the scavenger hunt: http://www.tpwd.state.tx.us/regulations/fish_hunt/#fish.html

3. **Guest Speaker**

Invite a Game Warden or Texas Parks and Wildlife Angler Educator to come to answer questions about fishing rules and talk about careers.

Vocabulary

- Regulations
- Tensile strength

Student Page

SCAVENGER HUNT FOR TEXAS FISHING REGULATIONS

Directions

Find answers to questions or complete the statements on fishing rules using the *Texas General Fishing Rules* on: http://www.tpwd.state.tx.us/regulations/fish_hunt/#fish.html

Use the **Search** box as needed to help you.

Permits General Information

1. At what age must you have a fishing permit? _______
2. Do you need a fishing permit to fish in a pond or lake completely located on your own property? _______
3. Do you need a fishing permit to fish in a river that passes through your property? ____
4. Does a Texas resident who is mentally disabled need to purchase a fishing permit to be legal to fish? _______

Texas Fishing Permits

1. How much does a resident fishing permit cost? _______
2. Who can buy a lifetime fishing permit? _________________________________

Length and Bag Limits for Fish

1. What is the length limit of a largemouth black bass caught in Texas? ____
2. What is the daily bag limit on a flathead catfish? ___________________
3. What is the length limit on walleye?_____________
4. What is the length limit for red drum? ______________
5. Can you keep a 35-inch red drum? ____________

Name five Texas freshwater fish.

1. ___________________________________
2. ___________________________________
3. ___________________________________
4. ___________________________________
5. ___________________________________

Do You Know the Fishes of Texas?
Identify and match the following Texas fish to the description given:
(There is one extra fish in the list.)

A. Amberjack
B. Bluegill
C. Flounder
D. Tarpon
E. Red drum
F. Spotted seatrout
G. Channel catfish

1. These fish have a dark spot at the base of the dorsal fin, vertical bars on their sides, and a relatively small mouth. The back and upper sides are usually dark olive green blending to lavender, brown, copper, or orange on the sides, and reddish-orange or yellow on the belly. Colors are more intense in breeding males, and vertical bars may take on a reddish hue.

2. Males of this fish average 19 inches (48 cm) in length. Females are 25 inches (63 cm) long on average. Males and females weigh 2 to 3 pounds (1 to 1.3 kg). Distinguishing characteristics include a dark gray or green back and silvery-white below, with distinct round spots on back, fins and tail; black margin along the edge of tail; soft dorsal (back) fin with no scales; and one or two prominent canine teeth usually present at the tip of the upper jaw.

3. The most distinguishing mark on this fish is one large black spot on the upper part of the tail base. Having multiple spots is not uncommon for this fish but having no spots is extremely rare. Its colro ranges from a deep blackish, coppery color to nearly silver. The most common color is reddish-bronze. It is a fast growing fish reaching approximately 11 inches and one pound in its first year, 17-22 inches and 3 1/2 pounds in two years, and 22-24 inches and 6-8 pounds in three years. prefer shallow waters (1-4 feet deep) along the edges of bays with submerged vegetation such as seagrasses. They are found over all bottom types but they seem to prefer areas with submerged vegetation and soft mud. These fish are also commonly found around oyster reefs.

4. This fish is compressed laterally and spend most of its life lying and swimming along the bottom on its side. The left side is always the "up" side. They grow rapidly and may reach 12 inches in length by the end of their first year. Males seldom exceed 12 inches, but females grow larger than males and often reach a length of 25 inches.

5. This is a large reef fish found in the Gulf. The back is bluish purple, the sides yellowish and the underside silver. They have a distinctive dark band on the sides of the head which angles from the front of the back fin, through the eye to the mouth. The tail fin is lunate or moon-shaped. Although they average about 20 pounds, they can weight in at more than 170 pounds. The Texas record is 115 bounds and 66.5 inches.

6. This fish has no scales, a single bony spine in each pectoral fin and the dorsal fin, and 8 barbels around the mouth. They have a deeply forked tail and the upper jaw is longer than the lower jaw. The dorsal and pectoral spines are sharp. They are typically 15-25 inches, can reach over 40 inches. Usually weigh 2-10 pounds, can reach 37 pounds.

All endangered fish species must be returned unharmed immediately to the water. Name two of these species in Texas.

1. ______________________________________

2. ______________________________________

How to Measure a Fish (total length)

1. The total length of a catfish is measured from the _______________ to the _______________ with the mouth closed and the tail lobes pressed together.

Catch on to Catch-and-Release Fishing

Although practicing catch-and-release fishing is not a requirement, the regulations booklet provides guidelines anglers can follow that will increase a fish's chances of survival. In addition, if you catch an undersized fish, you get to practice "catch-and-release." Name two techniques for catch-and-release. Some possibilities include:

1. ____

2. ____

SCAVENGER HUNT FOR TEXAS FISHING REGULATIONS
Answer Key

Permits General Information

1. At what age must you have a fishing permit? **17 years of age**

2. Do you need a fishing permit to fish in a pond or lake completely located on your own property? **No**

3. Do you need a fishing permit to fish in a river that passes through your property? **Yes**

4. Does a Texas resident who is mentally disabled need to purchase a fishing permit to be legal to fish? **No**

Texas Fishing Permits

1. How much does a resident fishing permit cost? **$11–$47**

2. Who can buy a lifetime fishing permit? **Any Texas resident**

Bag and Length Limits

1. What is the length limit of a largemouth black bass caught in Texas? ____14 inches___

2. What is the daily bag limit on a flathead catfish? __________5____________

3. What is the length limit on walleye? _No minimum______

4. What is the length limit for red drum? _____3_________

5. Can you keep a 35-inch red drum? Only if you attach a Red Drum Tag

Name Texas freshwater fish.

Any five of the following:

Black bass (largemouth, smallmouth, spotted, Guadalupe)

Catfish (channel, blue, flathead, black bullhead, yellow bullhead)

Crappie (black, white)

White, yellow and striped bass

Bluegill, sunfish, carp, buffalo, drum, gar

Paddlefish

Trout (rainbow and brown)

Do You Know the Fishes of Texas?

Identify and match the following Texas fish to the description given:

A. Amberjack

B. Bluegill

C. Flounder

D. Tarpon

E. Red drum

F. Spotted seatrout

G. Channel catfish

1. These fish have a dark spot at the base of the dorsal fin, vertical bars on their sides, and a relatively small mouth. The back and upper sides are usually dark olive green blending to lavender, brown, copper, or orange on the sides, and reddish-orange or yellow on the belly. Colors are more intense in breeding males, and vertical bars may take on a reddish hue.

   B. Bluegill

2. Males of this fish average 19 inches (48 cm) in length. Females are 25 inches (63 cm) long on average. Males and females weigh 2 to 3 pounds (1 to 1.3 kg). Distinguishing characteristics include a dark gray or green back and silvery-white below, with distinct round spots on back, fins and tail; black margin along the edge of tail; soft dorsal (back) fin with no scales; and one or two prominent canine teeth usually present at the tip of the upper jaw.

   F. Spotted seatrout

3. The most distinguishing mark on this fish is one large black spot on the upper part of the tail base. Having multiple spots is not uncommon for this fish but having no spots is extremely rare. Its color ranges from a deep blackish, coppery color to nearly silver. The most common color is reddish-bronze. It is a fast growing fish reaching approximately 11 inches and one pound in its first year, 17-22 inches and 3 1/2 pounds in two years, and 22-24 inches and 6-8 pounds in three years. prefer shallow waters (1-4 feet deep) along the edges of bays with submerged vegetation such as seagrasses. They are found over all bottom types but they seem to prefer areas with submerged vegetation and soft mud. These fish are also commonly found around oyster reefs.

   E. Red drum

4. This fish is compressed laterally and spend most of its life lying and swimming along the bottom on its side. The left side is always the "up" side. They grow rapidly and may reach 12 inches in length by the end of their first year. Males seldom exceed 12 inches, but females grow larger than males and often reach a length of 25 inches.

   C. Flounder

5. This is a large reef fish found in the Gulf. The back is bluish purple, the sides yellowish and the underside silver. They have a distinctive dark band on the sides of the head which angles from the front of the back fin, through the eye to the mouth. The tail fin is lunate or moon-shaped. Although they average about 20 pounds, they can weight in at more than 170 pounds. The Texas record is 115 bounds and 66.5 inches.

   A. Amberjack

6. This fish has no scales, a single bony spine in each pectoral fin and the dorsal fin, and 8 barbels around the mouth. They have a deeply forked tail and the upper jaw is longer than the lower jaw. The dorsal and pectoral spines are sharp. They are typically 15-25 inches, can reach over 40 inches. Usually weigh 2-10 pounds, can reach 37 pounds.

   G. Channel catfish

All endangered fish species must be returned unharmed immediately to the water. Name two of these species in Texas.

smalltooth sawfish; fountain darters; Big Bend, San Marcos, Pecos or Clear Creek gambusia; or Leon Springs or Comanche Springs pupfish

How to Measure a Fish (total length)

1. The total length of a fish is measured from the **tip of the snout to the end of the tail** with the mouth closed and the tail lobes pressed together.

Catch on to Catch-and-Release Fishing

Although practicing catch-and-release fishing is not a requirement, the regulations booklet provides guidelines anglers can follow that will increase a fish's chances of survival. In addition, if you catch an undersized fish, you get to practice "catch-and-release." Name two techniques for catch-and-release. Some possibilities include:

- **Minimize the time fish is out of the water (no longer than you can hold your breath).**
- **Use barbless hooks.**
- **Avoid removing the slime/mucus layer, which protects fish from parasites and infections. Wet your hands before handling the fish.**
- **Avoid excessive handling of the fish.**
- **Do not squeeze or drop the fish.**
- **Don't put your fingers in the fish's gills or eye sockets.**
- **Place fish in the water, gently supporting the mid-section and tail until it swims away.**

Lesson 13.5: Fish Sampling and Ecosystem Assessment

Essential Concept

Fishing helps us learn about aquatic environments.

Objectives

1. Students will conduct a field investigation to find out what fish live in their local aquatic ecosystem.
2. Students will compare adaptations of fish in their sample.
3. Students will use safe practices and conservation of resources in the field.
4. Students will collect data and record information in tables.
5. Students will draw conclusions based on data.
6. Students demonstrate the use of course apparatuses, equipment, techniques, and procedures.
7. Students collect quantitative data from an aquatic environment, including pH, dissolved oxygen, salinity, temperature, mineral content, nitrogen compounds, and turbidity.
8. Students will identify ways human activity can affect aquatic environments.
9. Students will predict effects on the living and nonliving components of an aquatic ecosystem of chemical, organic, physical, and thermal changes caused by humans.
10. Students will analyze the cumulative impact of human population growth on an aquatic system.
11. Students use safe practices and conservation of resources in the lab and field.

In Addition High School Students:

12. Will continue recording weather and chemical and physical characteristics of their local aquatic ecosystem for their long-term study.
13. Will assess water quality in a local watershed.

TEKS

6.1 A, B; 6.2 A, C, D, E; 6.4 A, B; 6.12 E; 7.1 A, B; 7.2 A, C, D, E; 7.4 A, B; 7.10 A; 7.11 A; 7.13 A; 8.1 A, B; 8.2 A, C, D, E; 8.4 A, B; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 E, F, G, H, J; 5 A, B, C, D; 7 C; 10 A, B; 11 A, B; 12 A, B, C, D

Environmental Science: 1 A, B; 2 E, F, G, H, I, K; 4 A, B, E; 5 A, B, C; 7 A, C, D; 8 A; 9 A, B, C, E

Estimated Time

Depending on the distance to the site, the field trip could take from 1 class period to 1 full day.

Materials

May vary depending on the site chosen for the field trip. It could be to freshwater or saltwater.

Rods and reels

Bait

Lures

Casting Instructions

Fishing Instructions

Field Guides

First Aid Kit

Science Journals

Pencils/pens

Copies of *Fish Matrix* or data tables to record fish caught

Invertebrate Sampling:

Bug Picking Water Quality Indicators

In bays or estuaries, use a field guide to identify the invertebrates collected

Seines and nets including D-frame aquatic dip net and kick seine

Containers for specimen such as:

White trays

Ice cube trays

Hand magnifiers or magnifier boxes

Forceps

Water Chemistry Tests

Salinity test, and other water chemistry test kits

Safety goggles

Gloves

In addition, high school students should continue to collect data for their long-term study.

Weather and Water Temperature

Thermometers and weather instruments

Physical Water Quality Indicators check sheet

High school students should also have:

Secchi disc, stopwatch, tennis ball or piece of wood

Safety Precautions

Remind students of safety precautions in the field.

Procedure

1. Fishing

To cut down on the number of rods and reels that you need, you may want to have students in two or three groups For these activities, it is best to practice catch and release fishing. Use pliers to mash down the barbs on hooks to facilitate releasing the fish. While one group is fishing, another group can collect and identify invertebrates, and a third group can test water chemistry. You will need at least three adult leaders to guide these groups. Then groups can switch so that all students have an opportunity to participate in all activities.

Ask students to determine what fish live in the nearest local aquatic ecosystem by collecting fish from various places in the ecosystem. Ask student “Fish Experts” to help identify fish caught. Record Size and adaptations in the *Fish Matrix*. Record bait, tackle, and location (near brush, in open water, etc.) in *Fishing Data* table.

- **How many different types of fish were caught by your group? By the whole class?**
- **Was there a difference in numbers of fish caught at different times of the day? Why or why not?**
- **Were more fish caught in some locations than in other locations? Why or why not?**
- **Was one kind of bait more successful in catching fish than other baits? Why or why not?**
- **Were you surprised by how many or how few fish you caught? What is the most important component of fishing as a sport?** (Patience)

Note: Is students do not catch any fish, you might wish to try seining to get a few to identify.

2. Invertebrate Sampling

For Freshwater: Using the *Bug Picking Sheet* assess the health of the aquatic ecosystem based on the aquatic invertebrates found there. Tally numbers of each invertebrate collected.

For Saltwater: If you are in a saltwater ecosystem, you will find very different invertebrates. Use a field guide to help you identify them, make a data table in your science journal, and tally the numbers of invertebrates collected or observed.

- **Which organisms live in riffles, pools, near banks, on the bottom, and in channels of their stream or in the estuary or bay and what adaptations do they have for life in that habitat?**

Ask students to compare adaptations of organisms from different habitats.

- **What do the invertebrates found in the environment tell you about the quality of the water and habitat?**

3. Water Chemistry

Use the water testing kits to find the salinity, pH, nitrates, phosphorus, dissolved oxygen and other water chemistry results.

Have students conduct tests and make data tables in their science journals to record results.

- **What do the water chemistry tests tell you about conditions in the ecosystem?**
- **Answer the following questions in your journal:**
- **What human uses do you observe along the aquatic ecosystem?**
- **How might these human uses affect the organisms in the aquatic ecosystem?**
- **What effects on the living and nonliving components of an aquatic ecosystem would you predict given chemical, organic, physical, and/or thermal changes caused by humans in this area?**
- **What do you see as the cumulative impact of human population growth on this aquatic system?**

Have high School students continue recording weather and chemical and physical characteristics of their aquatic ecosystem for their long-term study.

4. Field Study Data and Report

Ask students to record data and observations in appropriate tables for their science journals. When you return to the classroom ask students to analyze their observations and other data to draw conclusions about the quality of the aquatic ecosystem, and any human caused pollution noted. Use this information to write a report on your field investigation. You may wish to have students make reports individually, or you may wish to have each group make a report to which all members of the group contribute. Use the *Field Report Rubric* for grading. Give the rubric to students before they take part in the field trip so they know what is expected of them on the field trip and in their reports.

Vocabulary

- Bay
- Channel
- Estuary
- Macro-invertebrates
- Marsh

- Pool
- Riffle
- Riparian zone
- Salinity
- Streambed
- Stream bottom
- Stream order

Student page

Rubric for Field Trip and Field Reports

I. Works well with cooperative group. — 25 points

1. Gets along with others.
2. Takes part in discussions, but doesn't take over.
3. Completes assigned task for the group.
4. Helps develop data tables.
5. Helps draw conclusions.

II. Takes part in field activities and keeps Science Journal up to date. — 25 points

1. Presents data clearly and neatly in tables and graphs.
2. Develops tables with appropriate headings.
3. Develops graphs with appropriate headings, labels, and intervals for data.
4. Includes sufficient detail in journal entries.

III. Uses data to make generalizations. — 30 points

1. Discusses data with group.
2. Draws logical conclusions supported by the group's data.
3. Writes accurate field report including:
   A. Summary of what was done on the field study including a sentence about the purpose of the field study.
   B. Summary of observations made and data collected.
   C. Reasonable conclusions drawn from observations. Is there other information you need to know about the aquatic ecosystem studied? How could you obtain that information?
   D. Evaluate techniques used for gathering and recording data. Is there something you could improve in your next field study? Were there potential sources for error? How might this affect your conclusions?
   E. What environmental problems did you find? How could you help solve the problem or conserve the aquatic ecosystem you studied?

IV. Final Product — 20 points

1. Science Journal is neat.
2. All entries are neatly written in clear language.
3. Written entries are correctly spelled.
4. Math is accurately computed.
5. Area around field site is cleaned-up.

Total Possible Points — 100 points

Student Page

Fishing Field Trip

Answer the following questions in your journal:

Fish

1. How many different types of fish were caught by your group? By the whole class?
2. Was there a difference in numbers of fish caught at different times of the day? Why or why not?
3. Were more fish caught in some locations than in other locations? Why or why not?
4. Was one kind of bait more successful in catching fish than others? Why or why not?

Aquatic Invertebrates

For Freshwater: Using the *Bug Picking Sheet* assess the health of the aquatic ecosystem based on the aquatic invertebrates found. Tally numbers of each invertebrate collected.

For Saltwater: If you are in a saltwater ecosystem, you will find very different invertebrates. Use a field guide to help you identify them, tally numbers of each invertebrate collected or observed, and answer the questions.

1. Which organisms live in riffles, pools, near banks, and in channels of their stream or in the estuary or bay and what adaptations do they have for life in that habitat?
2. Compare adaptations of organisms from different habitats.
3. What do the invertebrates found in the environment tell you about the quality of the water and habitat?

Weather and Water Chemistry

1. What happens in this aquatic ecosystem when not enough rain falls?
2. What might happen to this ecosystem if urbanization expands to this area?
3. What might happen to the ecosystem if flood, hurricane or other event hit this area?
4. If the results of your tests and observations indicate pollution in this aquatic ecosystem, what might have caused it? What types of pollution did you detect?
5. Did you see evidence of habitat restoration or other conservation measures?

Human Uses of Habitat

1. What human uses do you observe along the aquatic ecosystem?
2. How might these human uses affect the organisms in the aquatic ecosystem?
3. What affects on the living and nonliving components of an aquatic ecosystem would you predict given chemical, organic, physical, and/or thermal changes caused by humans in this area?
4. What do you see as the cumulative impact of human population growth on this area?

Texas Fish and Their Characteristics
Comparison Matrix

Species	Average Size Weight Length	Niche in the Food Web Predator or Prey	Coloration Adaptation Advantage	Adaptation Advantage	Adaptation Advantage
Example: Channel Catfish	20-40 lbs. 24 in.	Predator	Slate blue on the back shading to white on the belly-camouflage	Males guard the nest to protect eggs and young–better survival rate	Upper jaw protrudes to help in catching prey

Fishing Data

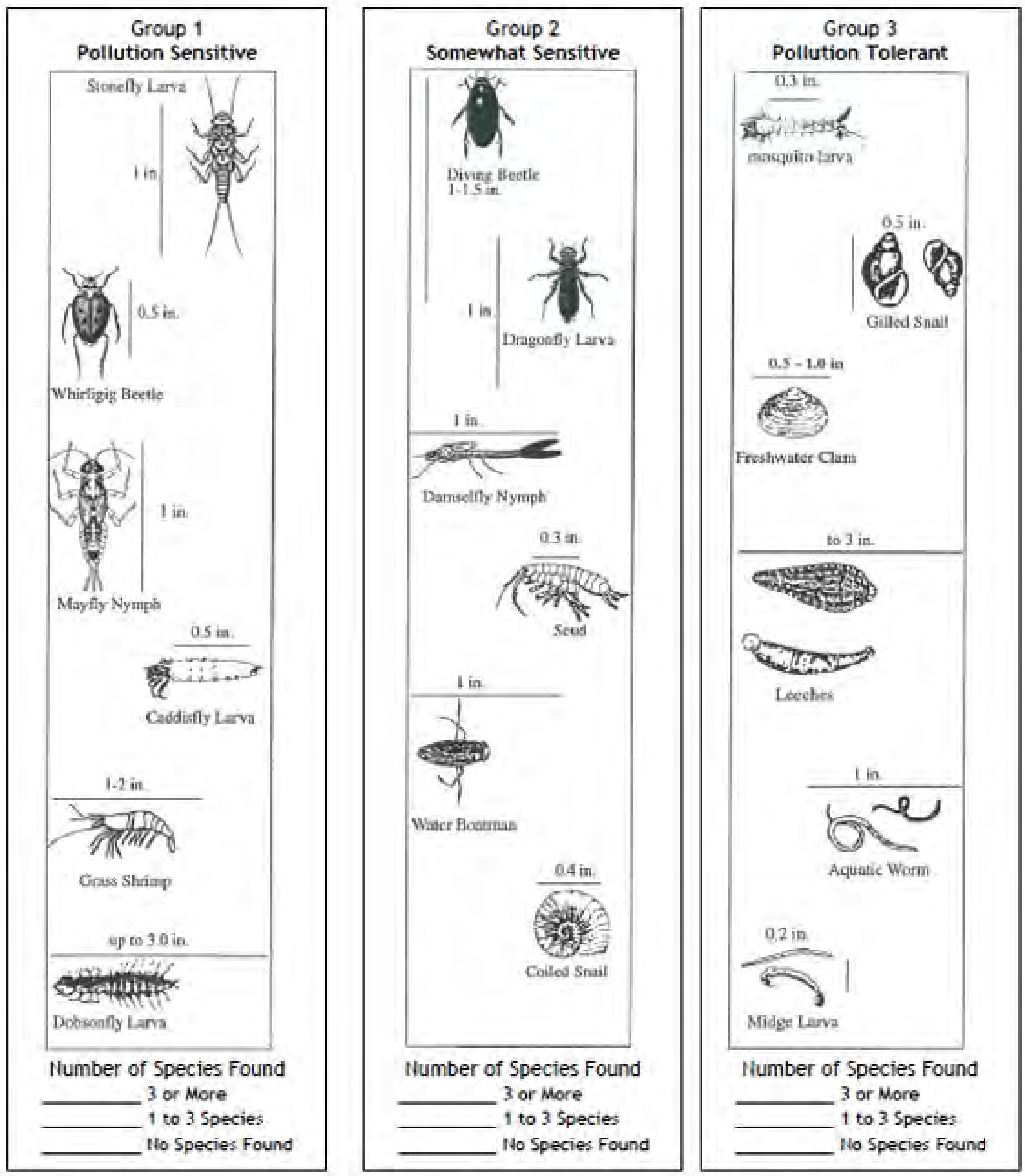
Name of Fish	Bait Used	Tackle Used	Location Caught

Student page

Note: Bug Picking Data Sheet courtesy of Texas Parks and Wildlife Department

Use tally marks to keep count of each type of invertebrate.

Bug Picking Data Sheet



Conclusions: **(Remember that the data you are taking will not give conclusive evidence of clean or polluted water, but might indicate the need for further investigation.)**

1. What conclusion can you draw if you found species in Group3, but not in Groups 1 or 2?
2. What conclusion can you draw if you found several different species in each of the groups?
3. What could be happening upstream, on land around the water upstream, or in your present location to affect the water quality where you are sampling?

This water appears to be: **Not Polluted** **OK** **Polluted**

Physical Indicators of Pollution

Some stream conditions may be indicated by observations of **physical indicators** of water pollution such as color, odor, and foaming.

Color of Water

Green color may indicate the possibility that nutrients from fertilizer or manure runoff may be flowing into the stream and feeding algae.

Orange-red color may indicate the possibility of acid draining into the creek from mining or industrial waste.

Light brown (muddy or cloudy) color indicates sediment caused by erosion, which may come from ground that is disturbed and left open upstream.

Yellow color coating the streambed may indicate sulfur entering the creek from industrial waste or some operation using coal.

A multi-colored *sheen* on the water may indicate oil floating on the water and may come from ***nonpoint source runoff*** from cars and roads or dumping of oil along the stream.

Yellow brown to dark brown may indicate acids released from decaying plants such as dead leaves collecting in the stream. This color is common in streams that drain marshes or swamps.

White cottony masses on the creek beds indicate the possibility of a fungus found in sewage. Check for sewage or other organic pollution.

Odor

The smell of **rotten eggs** is an indicator of sewage pollution, but may also be present in swamp or marshy land.

A musky smell may indicate the possibility of untreated sewage, livestock waste, algae, or other conditions.

A *chlorine* smell may be caused by a near-by sewage treatment plant chlorinating their effluent.

Foaming

White foam greater than 1-3 inches high may indicate the presence of detergents from industrial or residential waste entering the creek.

Conductivity

If you have a conductivity meter, it can indicate the presence of inorganic solids such as chloride, nitrate, and sulfate, (ions which carry a negative charge) and phosphates such as sodium, magnesium, calcium, iron, and aluminum (ions which carry a positive charge). Organic compounds such a oil, phenol, alcohol, and sugar do not conduct electricity very well and therefore have a low conductivity when in water.

Student page

WEATHER OBSERVATIONS AND MEASUREMENTS

Name: ____

Date: ____________________

Location: ____

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Chapter 13 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. How do weather conditions affect fishing success?

- **A** Hot weather makes fish seek cooler water.
- **B** Not always in easily predictable ways
- **C** Snow and ice guarantee fishing success.
- **D** Both A and B

2. Fish in flowing water tend to face:

- **A** Upstream
- **B** Downstream
- **C** Perpendicular to the current
- **D** No particular direction

3. The best time to fish is:

- **A** Mid-day
- **B** Morning and evening
- **C** When there is no wind blowing
- **D** From 2 to 4 p.m.

4. Aquatic resource conservation is:

- **A** Best left to professionals
- **B** Limited to certain times of the year
- **C** Unnecessary because Texas has plenty of water
- **D** Everyone’s responsibility

Apply your knowledge of these species’ adaptations and their roles in the transfer of energy in Texas’ aquatic food webs to predict the best bait or lure to use to catch:

5. Largemouth bass

- **A** Live minnow
- **B** Bare treble hook
- **C** Plastic worm dipped in stink bait
- **D** Artificial fly that mimics a mayfly

6. Bluegill

- **A** Live minnow
- **B** Bare treble hook
- **C** Plastic worm dipped in stink bait
- **D** Artificial fly that mimics a mayfly

7. Channel catfish

- **A** Live minnow
- **B** Bare treble hook
- **C** Plastic worm dipped in stink bait
- **D** Artificial fly that mimics a mayfly

Apply your knowledge of these species' adaptations and habitat needs to predict where to find:

8. Largemouth bass

- **A** In a shallow weedy area
- **B** In weeds adjacent to open water
- **C** In a big hole in an underwater log on the bottom of a pond
- **D** Open water zone of a lake

9. Bluegill

- **A** In a shallow weedy area
- **B** In weeds adjacent to open water
- **C** In a big hole in an underwater log on the bottom of a pond
- **D** Open water zone of a lake

10. Channel catfish

- **A** In a shallow weedy area
- **B** In weeds adjacent to open water
- **C** In a big hole in an underwater log on the bottom of a pond
- **D** Open water zone of a lake

Chapter 13 Assessment Directions

Write your own answer for each of the following questions.

1. More effective fishing methods represent a technological solution to the problem of obtaining food for humans. Predict how this could have both potential benefits and drawbacks such as risks or unintended consequences to aquatic ecosystems.

2. Justify the following statement: Fishing regulations, limits, and seasons are among the best solutions to preventing overuse of fishery resources and allow all Texans to enjoy fishing.

3. Apply your knowledge to recommend another solution to potentially harmful environmental changes within aquatic ecosystems in Texas.

4. Tell one way to make science experiments more reliable and why this is important.

5. Explain an everyday occurrence that illustrates Newton's Laws of Motion.

   Explain where the forces are operating, the direction of the forces, and the direction of the motion.

Chapter 13 Assessment Answer Key

Multiple-choice questions

1. How do weather conditions affect fishing success?

B Not always in easily predictable ways

2. Fish in flowing water tend to face

A Upstream

3. The best time to fish is

B Morning and evening

4. Aquatic resource conservation is

D Everyone’s responsibility

Apply your knowledge of these species’ adaptations and their roles in the transfer of energy in Texas aquatic food webs to predict the best bait or lure to use to catch:

5. Largemouth bass

A Live minnow

6. Bluegill

D Artificial fly that mimics a mayfly

7. Channel catfish

C Plastic worm dipped in stink bait

Apply your knowledge of these species’ adaptations and habitat needs to predict where to find:

8. Largemouth bass

B In weeds adjacent to open water

9. Bluegill

A In a shallow weedy area

10. Channel catfish

C In a big hole in an underwater log on the bottom of a pond

Write-in questions

1. More effective fishing methods represent a technological solution to the problem of obtaining food for humans. Predict how this could have both benefits and drawbacks such as risks or unintended consequences to aquatic ecosystems.

Answers may include:

Potential benefits:

More effective fishing methods could lead to easier to obtain, cheaper and more abundant food. This could provide better nutrition and greater health for humans. This could result in wealth accumulation and population growth. Less time and energy spent pursuing food could allow time and energy to be spent developing technology, art and culture.

Potential drawbacks:

More effective fishing methods could lead to over-exploitation of the resource, or over-fishing—taking out more fish than natural processes can replenish. Over-fishing could result in a decline in fish populations and destabilization of the ecosystem. Fish and other species in the aquatic community could decline or become extinct. Humans could exceed their carrying capacity in the region and also begin to decline.

2. Justify the following statement: Fishing regulations, limits and seasons are among the best solutions to preventing overuse of fishery resources and allow all Texans to enjoy fishing.

Answers may include:

Fishing regulations, limits and seasons help Texans share limited resources and keep our ecosystems healthy.

- **Rules protect species by limiting the time of year during which they may be taken.**
- **Length limits give fish a chance to grow and spawn before people are allowed to catch and keep them.**
- **Number limits assure that no one takes too many.**
- **Texas' rules are based on scientific data and research provided by fisheries biologists. The regulations, limits and seasons they prescribe can help us to make sure our aquatic ecosystems and other resources stay diverse, balanced and healthy far into the future. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is, and the more resilient it is to potentially harmful environmental changes.**

3. Apply your knowledge to recommend another solution to potentially harmful environmental changes within aquatic ecosystems in Texas.

Answers vary but may include some of the following:

- **Always bring a trash bag when visiting aquatic resources, and take a moment to leave the spot in better shape than you found it.**
- **Avoid spilling and never dump any pollutants, such as gasoline or oil, into the aquatic environment.**
- **Be careful not to harm fish when doing catch-and-release fishing. Wet hands before handling fish. Carefully handle and release alive all fish that are unwanted or not allowed, as well as other animals that may be caught accidentally.**
- **Choose a career in conservation and make aquatic resources your life's work.**
- **Follow rules of ethical conduct in the use of aquatic resources and teach others to do so, too.**
- **Get involved with nature—go outside and visit local aquatic resources.**
- **Join a Texas Stream Team and help clean up a stream.**
- **Keep buffer zones of plant growth around water bodies.**
- **Keep no more fish than needed for eating, and never waste fish.**
- **Learn and obey angling and boating rules, and treat other anglers, boaters and property owners with courtesy and respect.**
- **Learn more about watershed conservation.**
- **Learn to check water quality.**
- **Practice good watershed management by stopping excess erosion and runoff loaded with fertilizers, pesticides or other pollutants.**
- **Put all trash, including used lines, leaders and hooks, in proper containers and help to keep fishing sites litter-free.**
- **Replenish fish populations by hatchery spawning and stocking.**
- **Respect property rights, and never go on to private lands or waters without permission.**
- **Support enforcement of water laws and rules that penalize polluters.**
- **Take action to prevent the spread of invasive plants and animals, and never dump live bait into the water.**
- **Take part in conservation activities.**
- **Value and respect the aquatic environment and all living things in it.**
- **Visit a Texas Parks and Wildlife office or a conservation nature center.**
- **Volunteer to become a Master Naturalist.**
- **Work to pass legislation protecting aquatic ecosystems in Texas.**
- **Work with Ducks Unlimited and other citizen conservation groups to protect and restore wetlands.**

- **Work with farmers, ranchers and other land users to help them prevent erosion, improve water quality, manage nutrients and protect and preserve wildlife habitat.**
- **Become part of a Texas Stream Team.**

4. Tell one way to make science experiments more reliable and why this is important.

Repeating an experiment either by the same researcher or by other researchers using the same procedure should provide us with the same or similar results. If it doesn't, either the procedure was not followed exactly, something being tested did not remain constant, or the experiment does not answer the question we were investigating. Repeating the experiment is important because it helps us know that our results are accurate.

5. Explain an everyday occurrence that illustrates Newton's Laws of Motion.

Explain where the forces are operating, the direction of the forces, and the direction of the motion.

The illustration in the lesson is casting a fishing line, but others are acceptable.

We apply a force to the fishing rod, using our body by pulling the rod back, and then moving the arm forward. As the rod moves forward the line swings, too. We exert a force holding the reel still. As we swing, we release the button holding the reel from moving and the line begins to unwind. The hook, bait, sinker, and bobber (float) attached to the end of the line fly high into the air away from you. The force of gravity takes over, pulling the hook, bait, sinker, and bobber back toward Earth. They splash into the water. We overcame inertia, by applying a force (our swing), the hook, bait, sinker, and bobber accelerated out from us. Gravity exerted another force and pulled the hook, bait, sinker, and bobber down toward Earth where they entered the water. The action was the swing we gave to start the motion. When the hook, bait, and sinker enter the water they sink until they reach the end of the line between them and the bobber, at which point we will see a reaction as the bobber bobs in the water suspending the hook, bait, and sinker in the water.

Water for People and the Environment

Water is important for people, but water is also essential for a healthy environment and the organisms that live there. How much water we have for the future will depend on what we do to conserve water today.

Chapter 14

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Become familiar with some of the history of water laws in Texas.
2. Identify ways *Prior Appropriation* and *Riparian Law* can work for or against the environment.
3. Brainstorm ideas for meeting the need for water for people and the environment.
4. Read the chapter and answer the questions
5. Explain how the *Clean Water Act* regulates point source pollution.
6. Differentiate between point source pollution and non-point source pollution.
7. Generate a list of ways that they can help manage water use at home, at school, and in their community.
8. Use a model to investigate how point source pollution affects a watershed.
9. Investigate how non-point source pollution affects a watershed.
10. Investigate human impact on water.
11. Identify laws or regulatory entities responsible for controlling pollution.
12. Discuss cost/benefits of controlling pollution or "going green."
13. Diagram a watershed and label parts and tell who owns the water and the law or entity that regulates the use of the water.
14. Take part in a game to model the progression of water consumption by humans.
15. Research water conservation or aquatic organism conservation organizations.
16. Present information on one organization that they think the class could help with their conservation efforts.
17. Make a persuasive talk and create a visual or electronic product to help them describe the water conservation organization they wish to support.

18. Work as a class to choose one organization and participate in a project to aid that organization in water conservation.
19. Publicize their project through local media. (Optional)
20. Make an individual commitment to be responsible in specific ways to take part in water conservation.

TEKS

6.2 C; 6.3 B, C; 6.12 E; 7.2 C; 7.3 B, C; 7.8 C; 8.2 C; 8.3 B, C; 8.11 C

Aquatic Science: 2 H, J; 7 A, B; 12 A, B, D, E

Environmental Science: 2 I, K; 5 B, C; 9 A, E, F, J, K

Materials Needed

Lesson 14.1

3 large pieces of butcher paper for each group of 4 students

Markers

Lesson 14.2

1 copy of *Instructions for Student Groups* to cut apart

Science journals

Pencils/pens

Lesson 14.3

For each group of 4 students

1 Rectangular container, such as a cookie sheet, or disposable metal baking pan, or large plastic storage container

Two sheets newspaper

White garbage bag

Spray bottle

Water

Cocoa powder, orange or red colored drink powder, chocolate cake sprinkles, and colorful cake sprinkles (about two tablespoons of each)

Colored pencils

Lesson 14.4

Water for our Village Game

5-gallon bucket,

A large area outside

About 6 of each size cups: tiny cups (2 oz. cup), small cups (8 oz. size), standard 12 oz. drinking cups, large 24 oz. cups

Water

6-two quart pitchers (1 for each group of 4 students)

Internet connection

Computer

Science journals

Pencils/pens

Vocabulary

- Clean Water Act
- Commitment
- Conservation
- Diffused surface water
- Environmental flow
- Groundwater
- Gulf of Mexico
- Headwaters
- Non-point source pollution
- Point source pollution
- Prior appropriation
- Riparian law
- River
- Spring
- Stakeholders
- Surface water
- Texas Commission on Environmental Quality
- Texas State Soil and Water Conservation Board
- Volunteer
- Watershed action planning committee

Enrichments

Project Wild Aquatic

- Silt A Dirty Word
- Dam Design
- Kelp Help

- Dragonfly Pond
- When is a Whale Right?
- Sea Turtles International

Project Learning Tree

- Publicize It!

Video

- *Texas the State of Water: Vol. II. Finding a Balance* by Texas Parks and Wildlife Department. Contains the following short programs:
  - Dealing with Drought–How Corpus Christi is working on water for the future
  - Prescription to Burn–Fire as a tool for managing and restoring natural areas
  - Diggin' School–Constructing a "Wildscape" at school
  - Forests of the River Bottom–Flooding cycles in bottomland hardwood forests
- *Texas the State of Water: Vol. I.* by Texas Parks and Wildlife Department

  Raises awareness of the variety of complex demands on aquifers, rivers and bays of Texas, interconnected ecosystems and the role of each in overall ecological health of our state.

Lesson 14.1: Who Owns the Water?

Essential Concept

Texas is unique in its laws about who owns the water. These laws come from merging legal systems from our diverse history.

Objectives

1. Students will become familiar with some of the history of water laws in Texas.
2. Students will identify ways *Prior Appropriation* and *Riparian Law* can work for or against the environment.
3. Students will brainstorm ideas for meeting the need for water for people and the environment.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

1 class period

Materials

3 large pieces of butcher paper for each group of 4 students

Markers

Procedure

1. What's the Law?

Ask if there are any students who live on a farm or a ranch in the class. If so, have them tell where they get their water and ask if they know what the law says about who owns the water on or under their land.

Some students may get their water from wells and may know that they have the right to pump and capture groundwater under their land. Others may not know anything about where the water comes from that they have in their homes.

- **If you owned a ranch, with a pond, and a river that cut through your property, would you get to use your pond water?**
- **Would you get to use the river water?**

2. Prior Appropriation

- **What do you think the idea of "prior appropriation" means?** *(Prior* means before and *appropriation* means to set aside) Water that is set aside before others has priority on the supply of water.
- **What do you think this has to do with Texas water?** (It means that whoever got permits from the government to use the water first has the rights to the water.)

For example: A pecan farm and a power plant may both have permits for water out of a river nearby. They don't have to be located on the river to have these permits. The pecan farm has had their permit for 30 years. The power plant has had their permit for 3 years. The pecan farm has the rights to use the water first. If there is water left, then the power plant can have the right to use the water.

Our water laws come from different countries. *Prior appropriation* is from Spanish Law when Texas was a part of Mexico and ruled by Spain.

3. Riparian Law

- **What do you think "riparian law" means?** (Riparian areas are the places with plants along steams so it has to do with laws governing stream water ownership.)
- **What do you think this has to do with Texas water?** (This law gives people who own land with a stream running through it the right to use the water from the stream.)

For example: If the Colorado river runs next to your back yard, you have the right to pump water out of it for your garden. You don't have to get a special permit.

Riparian law comes from our English background. It is an English law that reflects the conditions in England that allows people to take water from nearby streams. England has many streams and water is plentiful.

In Texas we have merged these two systems into a "dual doctrine", which recognizes both riparian and prior appropriation rights. The water in streams and rivers is owned by the state. The water is allocated to people by the state as a water right assigned through a permitting system of prior appropriation.

4. Who Takes Care of Nature?

Give students 3 large pieces of butcher paper to make notes of their ideas. Ask students to work in groups of 4 and brainstorm how they think these laws might work for or against the environment and the needs for water and aquatic life.

1) On one sheet of paper make a T diagram for *Prior Appropriation* with *For the Environment* on one side and *Against the Environment* on the other side.
2) On another sheet of paper make another T diagram for *Riparian Law* in the same manner.

For Example: Ways that Prior Appropriation works **For** the environment might include that water could be left in the stream to run undisturbed. Ways that Prior Appropriations Works **Against** the environment might include water could all be used up by the first person with a right to the water, or water may be polluted by the use made of the water by the first person with a right to the water, or the first person with a right to the water might dam the stream and keep the water on his property.

Ways that Riparian Law works **For** the environment might include that water could be left in the stream to run undisturbed. Ways that Riparian Law works **Against** the environment might include water could all be used up by the owner of the property, or water may be polluted by the use made of the water, or the owner might dam the stream and keep the water on his property

3) On the third sheet of paper answer the following questions from your experience in doing the aquatic ecosystems activities this year.

- **What are some of the needs of people for water?**
- **What are some of the needs for water in our aquatic ecosystems?**
- **How would you prioritize water use in your area?**
- **How can we meet the needs of homes, farms, ranches, cities, towns, industries, aquatic organisms, wildlife, and plants for water every day?**

5. Sharing Ideas

Have each group share their ideas with the class and post their work where everyone can see it. Take a few minutes to think about the ideas that were shared.

- **What is similar about what the groups generated?**
- **What was different?**
- **How is the need for water in the environment taken into account with the allocation of water under these systems?** Student should come away understanding that there are no guarantees that there will be water for the environment under these systems.

Vocabulary

- Prior appropriation
- Riparian law

Lesson 14.2: Reading and Research

Essential Concept

Texas has limited water resources, which must be shared among cities, towns, farms, ranches, homes, industries, and the environment. In order to meet all of these needs, we must conserve water in every way possible.

Objectives

1. Students will read the chapter and answer the questions.
2. Students will explain how the *Clean Water Act* regulates point source pollution.
3. Students will differentiate between point source pollution and non-point source pollution.
4. Students will generate a list of ways that they can help manage water use at home, at school, and in their community.
5. Students will synthesize what they have learned to create a public service announcement to make people aware of the importance of managing water use to conserve water.

TEKS

6.2 C; 6.12 E; 7.2 C; 8.2 C; 8.11 C

Aquatic Science: 2 J; 12 A, B, D, E

Environmental Science: 2 K; 9 A, E, F, J, K

Estimated Time

1 class period

Materials

1 copy of *Instructions for Student Groups* to cut apart

Science journals

Pencils/pens

Procedure

1. Jigsaw

Put students in 7 groups. Give out slips with instructions for each group. (See *Instructions for Student Groups* at the end of the lesson) Ask each group to read the chapter in the *Student Guide* together and find the answer to their question. **All students should read the first two paragraphs.** When all groups are finished reading and answering the question, each group will teach their section of the chapter to the class and share the answer to their question.

Group 1 answers question 1. What is the purpose of the *Clean Water Act*? What kind of water pollution is it intended to prevent? Why does the Act not stop all water pollution?

This group needs to read the first three paragraphs under "Clean water–it's the law!". (3 paragraphs)

Group 2 answers question 2. What is watershed action planning? What should people where you live consider when conducting watershed action planning?

This group needs to read the section starting with paragraph three under "Clean water–it's the law!" and going down to the section that is "Texas water law". (4 paragraphs)

Group 3 answers question 3. In Texas, who "owns" surface water? Who "owns" groundwater? Since all water is connected, why do we have different systems of regulation?

This group needs to read the section on "Texas water law" and "Classes of water allocation" and the first paragraph under "Natural Surface Water". They also need to read the first paragraph under "Groundwater". (8 paragraphs)

Group 4 answers question 4. What is a "water right?" What are the impacts of prior allocation?

This group needs to read "Texas water law". Then start reading at the second paragraph under "Natural Surface Water" and read three paragraphs ending with "Groundwater". (8 paragraphs)

Group 5 answers question 5. What is "rule of capture?" What rights and responsibilities are associated with it?

The group needs to read the section on "Groundwater" over to "Water for the environment". (6 paragraphs)

Group 6 answers question 6. What are environmental flows? How are they obtained?

This group needs to read the section on "Water for the environment" over to the section on "Texas' Water Future". (6 paragraphs)

Group 7 answers question 7. What will influence Texas' water supply for the future?

This group should start reading with "Texas' Water Future?" and read to the end of the chapter. (6 paragraphs)

1) ***What is the purpose of the Clean Water Act? What kind of water pollution is it intended to prevent? Why does the Act not stop all water pollution?***

In 1972 the U.S. Congress passed the *Federal Water Pollution Control Act*, best known as the ***Clean Water Act***. The goal of the Act is to make surface waters of the US fishable and swimmable.

The Act made it unlawful to release any **pollutant** from a **point source** into most major waters of the US without obtaining a permit to do so. It also made filling of **wetlands** unlawful without a permit. The Act does not include waters that do not connect to a **navigable waterway**, although not everyone agrees which waters are exempt. The Texas

Commission on Environmental Quality monitors pollution and issues permits for discharge of pollutants in Texas.

Because of its diffuse nature, non-point source pollution can be more difficult and costly to describe and control than point source pollution. That's among the reasons there is no single law and permitting system for non-point source pollution as there is for point source pollution.

2) ***What is watershed action planning? What should people where you live consider when conducting watershed action planning?***

One of the ways non-point pollution is addressed is through **watershed action planning**.

Landowners, scientists, local government officials, and staff from responsible agencies consider sound science to design, implement, and monitor water quality management strategies to protect and restore water quality.

Answers will vary, but should include something about the kinds of water resources available in the local area and how non-point source pollution affects them.

3) ***In Texas, who "owns" surface water? Who "owns" groundwater? Since all water is connected, why do we have different systems of regulation?***

Natural surface water found in waterways, such as **rivers** and **streams**, is owned by the State of Texas and managed for the citizens of the state. This includes the ordinary flow in streams and **tidal** waters on the coast. Water from rains and floodwater found within natural rivers, streams, and lakes, and in manmade reservoirs on waterways is also state owned water. Water in springs that form **headwaters** is also considered surface water.

Whereas surface water is considered state property, the water beneath a landowner's property is private property. Landowners have a legal right to pump and capture whatever groundwater is available, regardless of the effect of that pumping on neighbors' wells or springs that may be fed by the groundwater. This is called **rule of capture**.

The legal rights to own and use water in Texas came from the cultures and legal systems of Mexico and England. Early Spanish settlers in Texas used extensive systems of ditches to move water from place to place, and to irrigate their crops. These early water systems were managed by the communities for the people served. This centralized control of water was generally based on Spanish law and is the origin of Texas' system of **prior appropriation**.

Prior appropriation gives the right to a certain amount of water to certain users. It divides available water among people who want it based on a government-issued permit that includes the principle of first come, first served. Senior water rights holders have first rights to a prescribed amount of whatever amount of water is available. This is also often referred to as the "first-in-time, first-in-right" rule.

Anglo-American settlers, who moved into Texas in the early 1800s, brought with them a different system granting rights to water, called **Riparian Law**. This gives people who own land bordering streams the right to use water from the stream. It is based on English law and reflects conditions in England where, unlike in Texas, water is plentiful and there are many streams everywhere.

Over time, these systems were merged, with Texas becoming what's called a **dual doctrine** state, recognizing both riparian and prior-appropriation rights.

4) What is a "water right?" What are the impacts of prior allocation?

A water right is like a ticket for a place in line for available water. Prior appropriation gives the right to a certain amount of water to certain users. It divides available water among people who want it, based on a government-issued permit that includes the principle of first come, first served. Senior water rights holders have first rights to a prescribed amount of whatever amount of water is available. This is also often referred to as the “first-in-time, first-in-right” rule.

In times of drought when water in streams and lakes may be very low, the person who holds the first water right permit, may take their full amount first from the water that's available. The next most senior permit holder may then take their full amount, and so on. Some people who have permits for water may not receive any water in drought years. In some Texas streams, more water has been allocated than flows in them in dry years.

5) What is “rule of capture?” What rights and responsibilities are associated with it?

Landowners have a legal right to pump and capture whatever groundwater is available, regardless of the effect of that pumping on neighbors' wells or springs that may be fed by the groundwater. This is called **rule of capture**.

Since groundwater exists underground, the surface landowner does not actually own the water until they take it from the ground, or capture it. Once captured, they have the right to use the water, or sell it to others. The right to capture the water can even be sold to others. Once sold or leased, any water captured may be transported by the new owners wherever they want.

There are some limits. Landowners are not to pump an unlimited amount of water when it is done maliciously to harm a neighbor, in a wasteful manner, or in a negligent manner to cause nearby land to collapse.

The amount of groundwater a landowner can take may also be restricted when the water is from an underground river or is regulated by a **groundwater conservation district**. There are about 100 groundwater conservation districts now in Texas, formed to create rules for conserving, protecting, recharging, and preventing waste of underground water. Some exert more control over use of groundwater than others. They can register and permit wells, keep drilling and well records, regulate how far apart wells are drilled, require a permit for water transfers, buy and sell water, and generally conserve and protect the aquifer.

6) What are environmental flows? How are they obtained?

While in the past, many people did not think about leaving much water in a stream or river for aquatic life, there are new laws in Texas that require **environmental flow**. Also called instream flow, this is an amount of freshwater, or flow, left in a river or other water body that is adequate to support an ecologically sound aquatic environment.

New laws require that some water be set aside for environmental flows in areas where water is still available. Where all the water has already been allocated to someone, environmental water will need to be acquired over time. For example, existing water rights owned by others could be donated or purchased and allocated to environmental flows. We could also improve ways to use water efficiently, leaving more water to return to our water bodies.

7) What will influence Texas' water supply for the future?

How much water we will have for the future will depend on what we do to conserve water today. We can't make it rain more, but we can more efficiently manage the water we get from the **hydrologic cycle** and water in our **aquifers**.

Texans will need to commit to more intensive water conservation and pollution prevention practices to reach a sustainable water goal that also protects aquatic ecosystems. It will take an understanding of water, watersheds, and life in Texas' many aquatic environments. It will obligate us to reserve water for species and habitats from our headwaters to ocean. It will require the combined efforts of our leaders in business and industry, our elected officials, our teachers, and you.

2. Class Presentation

After all groups finish reading and answering their question, they will work as a group to decide the best way to teach the information they read to the rest of the class.

All groups will write their question on butcher or chart paper and write the answer in a different color on the same paper.

Each group will present the information and the answer to their question to the class. All students should write the chapter questions and answers in their science journals.

3. Managing and Conserving Water: How can we help?

Ask the class to work together to generate ideas to address the following questions.

- **What are some of the causes of point source and non point source pollution?**
- **What effects may be expected of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of an aquatic ecosystem?**
- **What is the cumulative impact of human population growth on an aquatic system?**
- **What kinds of effects do human activities such as fishing, transportation, dams, and recreation have on aquatic environments?**
- **What are some types of water pollution?**
- **How does "going green" (organic gardening and farming, natural methods of pest control, hydroponics, xeriscaping, energy efficient homes and appliances, and hybrid cars) affect the quality of water?**
- **Why don't more farmers take up organic farming? What is the cost- benefit**

trade off?

- **What is the impact of the *Clean Water Act* on aquatic systems?**
- **What are some things that people do that actually help the environment (specifically, keeping water clean and available)?**

4. Listing Ways We Can Help Conserve Water

Each group will contribute to a list of ways that they can help conserve water and manage its use at home, at school, and in the community. This list should be recorded in their journals.

5. Using What We Learned

Ask students to work in pairs to synthesize what they learned from the chapter and write a public service announcement to help make people aware of the importance of managing water use. This could be a jingle, a cartoon, a rap, a song, a short skit, a diagram, or other visual and auditory product to get the message across.

Vocabulary

- Clean Water Act
- Conservation
- Diffused surface water
- Environmental flow
- Non-point source pollution
- Point source pollution
- Prior appropriation
- Riparian law
- Stakeholders

Instructions for Student Groups

Cut between each group assignment and give one slip of paper with instructions to each group.

All students should read the first two paragraphs in the Student Guide.

Group 1 answers question 1. What is the purpose of the *Clean Water Act*? What kind of water pollution is it intended to prevent? Why does the Act not stop all water pollution?

This group needs to read the first three paragraphs under "Clean water–it's the law!". (3 paragraphs)

Group 2 answers question 2. What is watershed action planning? What should people where you live consider when conducting watershed action planning?

This group needs to read the section starting with paragraph three under "Clean water–it's the law!" and going down to the section that is "Texas water law". (4 paragraphs)

Group 3 answers question 3. In Texas, who "owns" surface water? Who "owns" groundwater? Since all water is connected, why do we have different systems of regulation?

This group needs to read the section on "Texas water law" and "Classes of water allocation" and the first paragraph under "Natural Surface Water". They also need to read the first paragraph under "Groundwater". (8 paragraphs)

Group 4 answers question 4. What is a "water right?" What are the impacts of prior allocation?

This group needs to read “Texas water law”. Then start reading at the second paragraph under “Natural Surface Water” and read three paragraphs ending with “Groundwater”. (8 paragraphs)

Group 5 answers question 5. What is “rule of capture?” What rights and responsibilities are associated with it?

The group needs to read the section on “Groundwater” over to “Water for the environment”. (6 paragraphs)

Group 6 answers question 6. What are environmental flows? How are they obtained?

This group needs to read the section on “Water for the environment” over to the section on “Texas’ Water Future”. (6 paragraphs)

Group 7 answers question 7. What will influence Texas’ water supply for the future?

This group should start reading with “Texas’ Water Future, and read to the end of the chapter. (6 paragraphs)

Lesson 14.3: What's the Pollution?

Essential Concept

Point source pollution is regulated by the *Clean Water Act*. Non-point source pollution is not regulated by a single law, but is controlled through permitting, education, water quality management programs, and assistance to motivate and assist in reduction.

Objectives

1. Students investigate how point source pollution affects watersheds.
2. Students investigate how non-point source pollution affects watersheds.
3. Students distinguish between point source and non-point source pollution
4. Students investigate human impact on water.
5. Students identify laws or regulatory entities responsible for controlling pollution.
6. Students discuss cost/benefits of controlling pollution or "going green."
7. Students will diagram a watershed and label parts and tell who owns the water and the law or entity that regulates the use of the water.

TEKS

6.2 C; 6.3 B, C; 6.12 E; 7.2 C; 7.3 B, C; 7.8 C; 8.2 C; 8.3 B, C; 8.11 C

Aquatic Science: 2 H, J; 7 A, B; 12 A, B, E

Environmental Science: 2 I, K; 5 B, C; 9 A, E, F, J, K

Estimated Time

1 class period

Materials

<u>For each group of 4 students</u>

1 Rectangular container, such as a cookie sheet or disposable metal baking pan or large plastic storage container

Two sheets newspaper or butcher paper

White garbage bag

Spray bottle

Water

Permanent marker

Cocoa powder, orange or red colored drink powder, and chocolate cake sprinkles and colorful cake sprinkles (about two tablespoons of each)

Colored pencils

Procedure

1. Making the Model

Crumple two sheets of newspaper or butcher paper to represent hills, the high places in the model, and place them side-by-side in one end of the container. Cover your hills with a white plastic garbage bag. Press the plastic down into the container on the opposite end from the hills. This should form a shallow depression, which represents the Gulf of Mexico.

Use pebbles or centimeter cubes to represent homes, and construction sites on the lower area of the model. Use a permanent marker to mark areas for parking lots and roads. Mark an area off to represent a farm. At the top of the watershed mark a spring that forms the headwaters of the stream or river, add a paper cut out to represent an industry that requires a lot of water such as a paper mill.

Sprinkle orange or red drink powder as pollution at the paper mill site.

Use cocoa powder on the farm to represent fertilizer.

Use colorful cake sprinkles to represent motor oil on roads and parking lots.

Use chocolate cake sprinkles on construction sites to represent sediment.

2. Making Predictions

Use your science journal to answer these questions.

- **Where would you expect point source pollution?** (at the paper mill)
- **Where would you expect to find non-point source pollution?** (In the agricultural fields, on the roads, at homes and in parking lots in the city and at construction sites.)

Predict where the pollution will flow and how many watersheds you think you have.

3. What Happens When It Rains?

Now use the squirt bottle to make it rain on the hills and all over the area to show how rainfall carries pollution into the ocean and other water bodies.

- **Were your predictions accurate?**
- **What happens to the water as the rain runs off the land and into streams?**
- **How was this experiment NOT like the real world?**
- **How might we do this differently to better represent real world conditions?**

4. Comparing Point Source and Non-Point Source Pollution

- **What happened to the point source pollution?** (Some runs off into a river, some runs down to the Gulf of Mexico.)
- **What happened to the non-point source pollution**? (A lot of it spread out all over the land, some runs into rivers and down to the Gulf of Mexico.)

- **Which type of pollution seemed to have the most impact on the river, the land and the Gulf of Mexico?** (Non-point source pollution)
- **How would these changes affect organisms living in the water?**
- **Over time, what do you think the cumulative affect will be for organisms living in the water?**

5. Research Questions

Assign each group 1 question to research. Have groups share their research with the class

- **What laws or regulatory bodies could have an impact on improving the water quality in the watershed?** (*Clean Water Act*, Texas Commission on Environmental Quality, Texas Soil and Water Conservation Board, Groundwater Conservation Districts)
- **Humans caused these problems in the watershed. What might motivate humans to improve the watershed?**
- **How do we estimate cost-benefit trade-offs for human economic activities such as farming, industry, driving a car, constructing new buildings and parking lots, etc.?**
- **What advantages and disadvantages would there be for a farmer of "going green"?**

6. Using What We Learned

Ask students to diagram the river investigation. Include different categories of water. (Natural surface water [such as river, springs at headwaters, tidal waters], diffused surface water [such as runoff not in streams or rivers, floodwater] and indicate where groundwater would be [below the spring]).

Label the diagrams as to the type of water and as to who owns the water (the state, private landowner). Then label the law or entity that regulates, monitors, or designs management strategies for the use of the water of each type (Texas Commission on Environmental Quality, Texas State Soil and Water Conservation Board, Groundwater Conservation Districts, and local and regional watershed action planning committees.)

Draw the diagram in pencil.

Label the type of water in blue.

Label the owners of the water in red.

Label the law that applies in green.

Label the regulatory or planning and monitoring entity in purple.

7. Non-Point Source Pollution Hike and Photo Scavenger Hunt

Taking the students on a walk around campus. (The teacher should do this walk ahead of time to locate potential non-point source pollution such as oil in the parking lot, litter near garbage bins behind the school, etc. as potential sources of non-point source pollution.)

- **Where does the water drain from the school parking lot?**

Since so many students have cameras on their phones, challenge them to find examples of non-point source pollution in their daily lives, photograph it and show the class. (Make sure to tell them not to photograph people or signs that identify businesses in the photos.)

Download the photos and make a PowerPoint presentation to educate and encourage others to be careful with the ways they may contribute to non-point pollution. Show the PowerPoint in the halls or at parent meetings to help educate the community.

Vocabulary

- Clean Water Act
- Diffused surface water
- Groundwater
- Groundwater conservation districts
- Gulf of Mexico
- Headwaters
- Non-point source pollution
- Point source pollution
- River
- Spring
- Surface water
- Texas Commission on Environmental Quality
- Texas State Soil and Water Conservation Board
- Watershed action planning committee

Lesson 14.4: Water Conservation

Essential Concept

Water is a limited resource. We must conserve it in order to survive.

A variety of organizations work for conservation of water and aquatic resources.

Objectives

1. Students will take part in a game to model the progression of water consumption by humans.
2. Students will research water conservation or aquatic resource conservation projects.
3. Students will present information on one organization that they think the class could help with their conservation efforts.
4. Students will create a visual or electronic product to help them describe the water conservation organization they wish to support.
5. Students will work as a class to choose one organization and participate in a project to aid that organization in water conservation.
6. Students will publicize their project through local media. (Optional)
7. Students will make an individual commitment to be responsible for water conservation in specific ways.

TEKS

6.2 C; 6.3 B; 7.2 C; 7.3 B; 8.2 C; 8.3 B

Aquatic Science: 2 H, J; 12 B

Environmental Science: 2 I, K; 5 B

Estimated Time

1 class period for the *Water For Our Village Game*

1-2 days for set up of activity and student presentations

Time for volunteering varies depending on the project the class chooses to work on. It might be as little as a one day bake sale to raise money for an organization or as much as water testing with a Texas Stream Team on a regular basis.

Materials

Water for our Village Game

5-gallon bucket,

A large area outside

About 6 of each size cups: tiny cups (2 oz. cup), small cups (8 oz. size), standard 12 oz. drinking cups, large 24 oz. cups

Water

6-two quart pitchers (1 for each group of 4 students)

Internet connection

Computer

Science journals

Pencils/pens

Procedure

1. Water for our Village

Students will play a game to model the changes in humans' increasing demand for water.

Setting up the model:

Split the class into groups of 3-4 students per group. They are "tribes" and they have separate villages.

Set the 2-quart pitchers around in random areas, different distances around. Try to create a good mix of distances with one group much further than the others, one obviously closer than the others. The pitchers are their villages. They cannot be moved.

Fill the 5-gallon bucket with water. The bucket is the water source for the villages and cannot be moved.

Everyone uses the same water source, the 5 gallon bucket, and only one team member at a time can go get water.

Use a tag team method to rotate the person who will go get water; each team member must go before a person goes twice.

Students must use the provided water gathering utensils.

The goal is to get as much water as possible.

Playing the Game

Round I - Primitive Man and Water

<u>Water has to be hauled in small quantities in animal skins.</u>

Using only the tiny cups, teams start to fill their pitchers from the central water source. When you say, "Go!" the teams will begin to carry water to their villages.

Allow students to continue until most students have been able to have at least 1 turn carrying water.

Allow time for a short discussion.

This round of the game represents primitive times when water was difficult to transport, and couldn't be transported in large amounts.

- **Which group got the most water? Why?**

Each village MUST have collected 1 quart of water or it cannot live.

- **Were there any villages that did not get enough water to survive?**
- **What would people in that village have to do to get the water to the village?** (What often happens is that the village closest to the water source gets the most water, and sometimes a village that is far from the water cannot sustain itself.)
- **What could the villagers that did not survive do to be better able to collect enough water? (**Students will probably suggest that the group should move closer to the water supply, but the villages should all stay in the same places to control variables so that we can compare water left in each round.)

Round II: Development of Technology

<u>Irrigation Ditches Are Invented.</u>

Have the students dump their pitchers back into the 5-gallon bucket. Remind them that the amount of water on our planet is basically stable. But now we'll exchange our tiny 2 oz. cups for full 8 oz. cups to represent the progress in technology.

Repeat instructions for Tag Teams.

Allow students to continue to get water until all the students have had at least 1 turn to collect water. Some students will have more than one turn.

Allow time for another short discussion.

- **How much water was taken out of the bucket this time?**
- **How much water is left in the bucket?**
- **What groups have the most water?**
- **Are there any villages that did not collect enough water to survive?**
- **What made the difference in the number of villages that could survive?**

Round III: Technology Improves

<u>Water Is Hauled in Barrels on Carts</u>

This invention helps those that live farther from the water source to survive.

Return all water to the bucket. Some water may have been sloshed out as students hurried to empty their cups. You might have to refill it to be sure there is enough water for the villagers to collect what they need.

Our populations are growing, so we need to draw water faster.

Exchange the 8 oz. cups with 12 oz. drinking glasses.

Repeat instructions from Tag Teams.

Allow students enough time so that each student gets at least 1 turn to collect water. Some groups will have enough time, so students may have more than one turn.

Allow time for a short discussion.

- **How much water was taken out of the bucket this time?**
- **Is there any water left in the bucket?**

- **How much water is left in the bucket?**
- **What groups have the most water?**
- **Were there any villages that did not get enough water to survive?**

Round IV: More Improvements in Technology

Humans Learn to Build Dams.

Building dams doesn't "create" more water. It just keeps water in a particular place for a little longer instead of flowing downstream as it normally would. Dams and other technology allow us to draw water even faster.

Have students return all water to the bucket, and replace the 12-ounce drinking cups with 24 oz cups.

Repeat instructions for Tag Teams.

Allow students to continue to get water until all the students have had at least 1 turn to collect water. Some students will have more than one turn.

Provide time for students to discuss the changes they see in the source of their water.

- **How much water was taken out of the source this time?**
- **Is there any water left in the bucket?**
- **How much water is left in the bucket?**
- **What groups have the most water?**
- **Were there any villages that did not get enough water this time?**
- **What problems do the villagers face now?** (The source of water is drying up.)
- **How could these problems be resolved?** (There could be rules that say you can only take out enough water to support your village, 1 quart. This would allow the village to survive and keep some of the water at the source to be used over a longer period of time and allow time for rains to replenish the water.)
- **How does this activity model our water issues as our population grows?**
- **In real life, what does the bucket represent?** (The finite amount of water on the Earth)
- **What do the cups represent?** (Humans using more water as they get better methods of transport and larger populations)
- **Can we, using our modern technology, similarly drain the source of water in our area?**
- **How can we ensure that we do not deplete our water resources?**

2. Using What We Learned

Ask students to work in their groups to come up with some ideas about how we can keep from depleting our water resources. Ask them to think about the many ways water is necessary for our survival and list them in their science journals. Then have student prioritize the uses to show where water is needed most.

Examples include:

- Agricultural uses
- Drinking
- Generating electricity
- Industries
- Cleaning
- Personal Hygiene
- Recreation
- Spiritual renewal
- Household waste removal
- Transportation
- Wildlife
- Aquatic environments

3. Conservation Organizations

We want be able to help conserve and manage our water resources. The state and federal government makes laws and regulations concerning water use and pollution and many conservation organizations are trying to help protect and maintain our water.

If we want to help, we can work individually to monitor our use of water and protect its quality with the actions we take daily. In addition, we can work with some of the conservation groups on special projects.

- **What are some organizations that we could work with to help maintain the quality and quantity of water needed in Texas?** (Texas Stream Teams were in our reading. Do we know of other organizations?)
- **What interests as an individual would you like to pursue to help maintain water quality and protect aquatic species?** (Some students may be interested in saving sea turtles or marine mammals, others may be interested in water quality monitoring, others might want to raise money for a cause such as The Nature Conservancy that buys land to protect it and the water on it, or an organization that provides education to the general public or to students about the importance of water conservation, etc.)
- **Are there local problems or projects with which you would like to work?** (Neglected park ponds or streams, litter on trails that will wash into streams, an endangered species that you would like to work to protect, etc.)

4. Researching Conservation Organizations

Ask students to work individually to research some water organizations that work for their particular interests. Ask each student to look on the Internet under their special interest and find a group that they might be interested in working with. If possible, a local group would work best, if you live in Amarillo, it is difficult to do beach clean up on a regular basis, but it would be possible to do litter clean up at a stream or lake in your area or to join a water quality monitoring group.

If students have difficulty finding organizations, here are a few websites to get you started. Remember websites come and go, so be sure to check these before giving them to students.

http://txstreamteam.meadowscenter.txstate.edu/

Texas Stream Team is a network of trained volunteers and supportive partners working together to gather information about the natural resources of Texas and to ensure the information is available to all Texans. Established in 1991, Texas Stream Team is administered through a cooperative partnership between Texas State University, the Texas Commission on Environmental Quality (TCEQ), and the U.S. Environmental Protection Agency (EPA). Currently, hundreds of Texas Stream Team volunteers collect water quality data on lakes, rivers, streams, wetlands, bays, bayous, and estuaries in Texas.

Texas Stream Team is a program of the Meadows Center for Water and the Environment at Texas State University-San Marcos.

http://www.tmmsn.org/

The Texas Marine Mammal Stranding Network (TMMSN) is a non-profit organization created in 1980 to further the understanding and conservation of marine mammals through rescue and rehabilitation, research and education. The TMMSN consists of seven regions along the Texas coast and Louisiana, which provide a coordinated response to all marine mammal strandings.

The TMMSN is the only Stranding Network in the State of Texas and receives no state funding and receives only limited institutional support in the form of grants. TMMSN relies on the donations of time and funds from generous supporters. There is no other team in the State of Texas with the authority, experience, and ability necessary to care for the marine mammals of the Texas Gulf Coast.

http://www.ccatexas.org/

Coastal Conservation Association Texas (CCA Texas) is a non-profit marine conservation organization comprised of tens of thousands of recreational anglers and coastal outdoor enthusiasts. Founded in 1977, CCA started in Texas and has grown to a national organization. CCA Texas' unmatched breadth and depth of volunteer involvement has made it the largest marine conservation group of its kind. CCA Texas has been engaged in hundreds of local, state and national programs and projects related to marine conservation, such as initiating scientific studies, supporting local marine law enforcement, working to pass pro-resource legislation, funding marine science scholarships, initiating habitat-restoration projects, funding state-of-the-art hatcheries, fighting for quality and quantity of freshwater inflows for coastal bays & estuaries.

http://www.glo.texas.gov/adopt-a-beach/

The Texas General Land Office has been sending the Adopt-a-Beach message across the state for twenty-six years, and Texans have responded. Since the first cleanup in 1986, more than 446,000 Texas Adopt-A-Beach volunteers have picked up more than 8,500 tons of trash from Texas beaches, some of it originating from as far away as South America.

Due to tide patterns in the Gulf of Mexico, trash dumped anywhere in the gulf is likely to end up on a Texas beach. Volunteers record information such as the source and type of debris collected on data cards. This data has been instrumental in the passage of international treaties and laws aimed at reducing the amount of offshore dumping.

http://www.seaturtleinc.org/

At Sea Turtle Inc., our mission is to rescue, rehabilitate, and release injured sea turtles, educate the public, and assist with conservation efforts for all marine turtle species. As part of our mission of sea turtle conservation, Sea Turtle, Inc. administers nesting sea turtle patrols on the beaches of South Padre Island and Boca Chica. The primary sea turtle that nests on these beaches is the Kemp's ridley. During nesting season, specially trained volunteers and interns search our beaches for nesting female sea turtles and their tracks. This allows us to find the nests and relocate them to a safe location. Sea turtle nests are protected through the spring/summer incubation period.

5. Presenting our Research

Students should check with the teacher to see if anyone else is interested in the same organization. If so, students can work together on their presentation to the class.

Have students make a 3-5 minute report to the class about a water conservation organization that they think is important in protecting water or aquatic organisms. They should explain:

- What the purpose of the organization is
- What the organization does
- How it raises money
- Why they think it is doing a good job
- Why they think it is an important organization making a contribution to water conservation.

Students should use some type of graphic organizer or other visual method to display their information. It might be a diagram, a poster, a PowerPoint presentation, a short video, etc. The main requirement is that they stay under 5 minutes.

They will use their presentation to try to persuade the class that this organization is one that the class could support through volunteer participation in projects or through fund raising or informing the public about the organization.

At the end of the presentations, the class will vote on the organization that they feel they can support with volunteer work from the class. The volunteer work might be monitoring water quality on a monthly or quarterly basis or it might be publicizing water conservation projects, or it might be raising money for an organization. Students and teachers can make the decision on the type of participation and amount of time and work they can provide to the organization.

Enrichment

Project Learning Tree

Project Learning Tree has an activity called “Publicize It!.” This activity gives instructions for how to contact media and publicize class projects. A volunteer conservation project would be a good opportunity to involve the media. Any coverage that students get will reinforce their interest in continuing their conservation projects.

Television, radio, and newspapers like to use stories about students participating in community projects and taking responsible action. This *Project Learning Tree* activity is a straightforward way of helping the class make the contacts needed to get media coverage.

6. Taking Responsibility: What Can I Do?

Ask students to use their lists of water priorities and their ideas on conservation to write an essay of at least 3 paragraphs on the importance of water, the need for conservation, and how they can help protect the quality and quantity of water in their community.

Ask students to make a commitment to themselves of ways they can participate in water conservation on a daily basis. Have each student make a list of things they can do to conserve water. (Everything from using a bucket to wash the car instead of leaving the hose running, to writing a letter to the editor, or contacting a state representative about changing laws and regulations)

Students should make their lists and decide how they can remember to do these things on a daily basis. Then they should write a pledge and sign it and turn it in with their lists.

Vocabulary

- Commitment
- Conservation
- Volunteer

My Conservation Action Pledge

I Pledge to take Responsibility For Conserving Water and Keeping Water Clean by Doing the Following Things in My Daily Life.

1.
2.
3.
4.
5.

In addition I pledge to make a special effort to help change the way we use water in the community by:

____

____

____

Signed ____

Chapter 14: Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Predict the impact of human activity in a watershed.

A Sediments could be brought into the water

B Nitrates could be brought into the water

C Toxic chemicals from roads could be brought into the water

D All of the above

2. What is an example of a source of point-source pollution?

A An agriculture field

B An industrial site that collects its pollution and discharges it through a pipe into a river

C A construction site where water just runs off the site in all directions

D All of the above

3. What is an example of a possible source of non-point source pollution?

A An agriculture field

B An industrial site that collects its pollution and discharges it through a pipe into a river

C A construction site where water just runs off the site in all directions

D A and C above

4. What kind of pollution does the *Clean Water Act* address?

A Point source pollution from industry

B Non-point source pollution from agriculture

C Local pollution from cities

D Statewide pollution running off roads containing oil from cars and trucks

5. What is the basis for Texas' water laws?

A Prior Appropriation

B Riparian Law

C Water rights

D All of the Above

Chapter 14: Assessment

Directions

Write your own answer for each of the following questions.

1. What are the three categories of water under Texas' law and who "owns" each category?

2. What are environmental flows and why are they important?

3. What will influence Texas' water supply in the future? Who are the primary users and why do they need the water? How can their use be changed or improved?

Chapter 14: Assessment Answer Key

Multiple-choice questions

1. **Predict the impact of human activity in a watershed.**

   D All of the above

2. **What is an example of a source of point-source pollution?**

   B An industrial site that collects its pollution and discharges it through a pipe into a river

3. **What is an example of a possible source of non-point source pollution?**

   D A and C

4. **What kind of pollution does the Clean Water Act address?**

   B Point source pollution from industry

5. **What is the basis for Texas' water laws?**

   D All of the Above

Chapter 14: Assessment

Directions

Write-in questions

1. **What are the three categories of water under Texas' law and who "owns" each category?**

Category	Owner
Natural Surface Water	The State of Texas
Diffused Surface Water	Landowner
Groundwater	Landowner

2. **What are environmental flows and why are they important?**

Environmental Flow is the water left in a stream or river for aquatic life. It is important because without water there will be no habitats for aquatic organisms. Without freshwater inflows there will be no nurseries for fish, shell-fish, and other marine organisms.

3. **What will influence Texas' water supply in the future? Who are the primary users and why do they need the water? How can their use be changed or improved?**

How we are able to conserve water by using it more efficiently will determine the amount and quality of water that we will have available in the future.

The primary users of water are farmers and ranchers who grow our food, and industry and business who make and sell products we need, and urban areas where most of us live.

Answers may vary, but might look something like this.

Scientific research can help us learn new ways to improve irrigation and water conservation in agriculture, and reduce pollution from business and industry, and may help us find new ways to fuel our cars, power our electric plants, or clean our water.

Conservation measures can help reduce use.

Improving prevention of pollution can help maintain water quantity and quality. Having enough water for future uses will require all of us to be aware of what we do in our everyday lives. Do we waste water or do we conserve it? The choice is ours. Texas' water future is in our hands.