PROJECT TELLUS

Interactive Video Lessons for Middle School Students on
Global Change Issues Related to the Gulf of Mexico Region

PROJECT TELLUS

Teaching Modules for Global Change Issues

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VIDEO GUIDE

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USING PROJECT TELLUS

In Roman mythology Tellus was the goddess of earth. From her sprang forth the sky, the sea, and the mountains — in other words, the air, water, and land. Today, taxed by an ever-increasing human population and the development and use of technology, these three media (air, water, and land) and the life forms they sustain are being forced into change.

The purpose of *Project Tellus* is to provide middle school students an opportunity to examine five issues on global change as they relate to the states bordering the Gulf of Mexico. The issues (treated in separate modules) include **biodiversity**, **exotic species**, **climatic change**, **water quality**, and **overpopulation**. An additional program focuses on **the scientific method and process skills**. The environmental setting of the Gulf Coast region is ideal for illustrating some of the pressing ecological issues surrounding these current or impending global changes. Each module revolves around an interactive video which melds the global change issue with fundamental ecology concepts.

Teachers recognize that using video in instructional settings is often a passive activity for students. So, contrary to most, *Tellus* videos integrate hands-on activities at specific intervals to stimulate class discussion and participation. The questions and activities engage students in active learning, giving them opportunities to relate the video concepts to their everyday experiences. These scheduled interludes also enable the classroom teacher to "teach the moment." Learning can be monitored and misconceptions corrected immediately rather than at the end of the learning experience.

The topics selected for *Project Tellus* promote an understanding of the interdependence that exists among species and between the living and non-living components in the environment. Part of that interdependence is driven home as students consider the pros and cons associated with any human course of action aimed at correcting environmental problems.

The videos are also designed to encourage critical thinking and problem solving strategies. Students will learn to distinguish relevant from irrelevant information and to synthesize prior knowledge, experience, and values with new knowledge in order to form a conceptual network from which individual and community action may emerge.

Project Tellus is divided into six modules. Each module includes an 18-25 minute interactive video and a video guide which contains learning objectives, background information, vocabulary, previewing and post-viewing questions and answers, extension activities, teacher instructions for the activities, and student worksheets.

The following sequence describes how to effectively use the videos and project materials.

1. ***Read the background information and view the video prior to class.***

   - Some teachers may want to write additional discussion questions to link the video concepts to examples or situations more in keeping with their local area.

2. ***Review learning outcomes with the class.***

   - By telling the students exactly what information they are expected to know by the end of the module, they are cued to information that will be relevant in the upcoming video.

3. ***Review vocabulary words with the class.***

   - This allows students to understand each term separately before it is linked with other concepts.

   - Important terms are in **bold** type in the Background Information and are defined in the Vocabulary section of the video guide.

4. ***Ask the previewing questions.***

   - These questions are designed to activate students' prior knowledge. When

students relate new information in the video to information already in long-term memory, they are more likely to learn and remember the new information.

- An answer key is provided, however, most of the questions allow a variety of answers. Consider all logical and relevant responses valid.

5. ***Show the video and have each student participate in the questions and activities included within it.***

   - It is not necessary to turn out the lights for TV viewing — overtaxed students may find it tempting to nap in a darkened classroom. Viewing may be improved, however, if lights are dimmed over the screen.

   - Be prepared to pause the tape for short discussions or stop the tape for activities. The video tape will provide a clear signal to begin the discussion or activity.

   - These interactive breaks in the video change the student from a passive to an active learner involved in developing his or her own meaning from the information.

   - The questions and activities allow for immediate feedback to help the teacher identify and clarify concepts the student finds confusing.

6. ***Guide the class through the postviewing questions.***

   - These questions allow students to apply knowledge learned in the video. This generalization of new knowledge causes students to realize the relevancy of the information.

   - If teacher-generated questions were prepared prior to class, this is a good time to use them. A variety of applications encourages the students to remember and use the new knowledge.

   - Some of the questions can be used as the basis for homework or research projects.

   - An answer key is provided, however, as in the previewing questions, the key is not all-inclusive and other answers should be considered.

7. ***Assign the evaluation questions for homework and review the answers during the next class period.***

   - The questions may be graded at the teacher's discretion. Studies have shown that reinforcement and feedback help students learn new material.

TELLUS ABOUT SCIENCE

Project TELLUS: Interactive Science Videos on Global Change Issues

TELLUS ABOUT SCIENCE

LEARNING OBJECTIVES

Students should be able to:

1. Identify and use science process skills in problem solving situations.
2. Define the term "scientific method" and list the steps used in scientifically solving a problem.
3. Design and carry out a controlled experiment, identifying the control group and one or more experimental groups.
4. Distinguish between independent and dependent variables.
5. Use graphing as a means to illustrate and analyze data.
6. Form logical conclusions from collected data.

INTRODUCTION

Many students have the idea that science is a mysterious activity involving test tubes, bunsen burners, and smelly laboratories. Further, they perceive scientists as gray-haired, bespectacled men in white lab coats. The following definitions from two Raleigh, North Carolina, 6th-graders who were asked to describe a scientist reflect this common misconception:

A scientist is weird — probably never sleeps or eats because he is always working. He tries to make new discoveries. Scientists experiment a lot, and they are smart.

Emily Barnes, Raleigh, NC

Some scientists have big universities as labs, others just have a tree to lean against and a clipboard. When I think of scientists, I think of someone in a lab coat looking into a microscope, but I know a scientist can do many things.

John Troutman, Raleigh, NC

By helping students see that most people incorporate scientific principles and process skills in everyday problem-solving situations, this module will humanize the concepts of science and scientists while it moves students toward the stated learning objectives. Also, by recognizing and practicing science process skills, students will acquire the confidence to use these in all academic endeavors.

TELLUS About Science introduces the *Project Tellus* series and prepares students to conduct the interactive lessons that follow in the remaining modules — Biodiversity, Exotic Species, Water Quality, Climatic Change, and Overpopulation.

As these lessons proceed, students will become aware of critical environmental problems facing the Gulf Coast area. The activities in each module are designed to encourage creative thought and experiences and this module on the scientific process will provide students with the skills needed for investigating questions that arise.

BACKGROUND INFORMATION

The **scientific method** — an orderly approach to answering questions about nature — has been used by scientists since the early 1600s when Sir Francis Bacon proposed it as a way to accumulate knowledge.

Although the pattern called the scientific method is succinct and logical, it is contrary to the natural spontaneity of youth. The rigidity of following a list of steps often intimidates or mentally restricts students' abilities to think, observe, and brainstorm. In order to bridge the gap between what students perceive as "doing science" (which sometimes is considered boring) and the actual creative activity of inquiry, the teacher may choose to lead the class through the process once without identifying it as "the scientific method."

Present a situation which can be used as a springboard for observations, then usher the class through the process defining terms and describing good experimental design. Using an upbeat or local problem may stimulate student interest in the activity. The idea according to Don Herbert of the Mr. Wizard Studios is:

1. Catch their attention.
2. Arouse their interest.
3. Develop a conflict.
4. Resolve the conflict.

Suggestions for situations which may catch attention and arouse interest are:

- Drop a handful of acorns in a large beaker of water. (Some will float others will sink.)
- Put unopened cans of Classic Coke and caffeine free Diet Coke in a large beaker of water. (One will float, the other will sink.)
- Place several pillbugs on a desk and ask, "What type of environment do pillbugs prefer?"

The following scenario is an example of how developing a conflict and resolving it might be done using the case of the two types of soft drinks. (Adapted from "It's the Real Thing...," by Myra J. Halpin and Janice Coffey Swab, *Science and Children*, April 1990.)

1. Put the unopened cans of Coke into the water. (Usually, the Classic Coke sinks and the Diet Coke floats.)
2. Have students state their **observation**.
3. Ask students to suggest **hypotheses** based on their observation. Some are:
   - Sugar has more mass than nutrasweet.
   - There is more carbonation (CO_2) in Diet Coke than in Classic Coke.
   - The aluminum can containing Classic Coke weighs more than the can containing Diet Coke.
   - The density of Classic Coke is greater than the density of Diet Coke.

Write all of students' plausible ideas on the board. *Emphasize that a good hypothesis must be a testable statement.*

4. Ask each student to identify the hypothesis with which (s)he agrees most, then group the class accordingly in teams of 3-4.
5. Each team is to design a way to test its hypothesis, listing chronologically the steps of their proposed procedure.
6. After the brainstorming, have someone from each group list the procedure on the board under the appropriate hypothesis.
7. As a class, choose one procedure to discuss. In discussing the procedure's strong and weak points, identify, define, and explain the need for the following parts of a well designed experiment (definitions are in the Vocabulary section):

- **control** and **experimental groups**
- using a large number of organisms or trials for both control and experimental groups
- the value of using **metric measurements**
- the need for recording data in an orderly fashion
- the difference between the **independent** (manipulated) **variable** and the **dependent** (responding) **variable**
- the usefulness of math skills such as **averaging** and **graphing**

8. Have each group re-evaluate its procedure for good experimental design and make changes where necessary. Students should record changes on the board.

9. Allow time for the students to perform the experiments, record results, and form conclusions.

10. After each group reports its findings, decide as a class which hypothesis was most plausible.

11. Have students suggest other questions that could be investigated as extensions of this activity. Emphasize that most research leads to new questions.

When the activity is completed, review the steps followed and relate them to the scientific method as outlined below:

- Identify the problem or question.
- State a hypothesis. *Stress that in most cases the hypothesis is preceded by library research related to the topic.*
- Design a controlled experiment to test the hypothesis.
- Analyze the experimental data.
- Form a conclusion that states whether the hypothesis was supported or refuted by the experimental data.

During the video, emphasis will be placed on practicing science process skills. Each activity will build upon the preceding ones. Having defined and worked through the scientific method once will provide a common framework from which to begin the video information and activities.

TEACHING SEQUENCE

DAY 1 Introduction and Background

1. Lead the class through the scientific method using the procedure and one of the topics suggested in the Background Information. [50 minutes]

   Terms to include are: **scientific method, observations, hypothesis, controlled experiment, control group, experimental group(s), metric system, independent and dependent variables, averaging and graphing.** Refer to the Vocabulary section for definitions.

DAY 2 Group Experiment, Analysis and Discussion of Results

2. Allow time for students to complete their experiments, record data, and form conclusions. [25 minutes]

3. Have each group report its findings, and as a class, decide which hypothesis was most plausible. [20 minutes]

4. Review the steps that were followed in carrying out the activity and identify them as "the scientific method." [5 minutes]

5. Have the students answer the Previewing Questions (page 6) for homework.

DAY 3 Previewing Answers, Begin Video, and Do Activity I

6. Discuss the previewing answers then collect the drawings — they will be compared to drawings done at the end of the module. [10 minutes]

7. Show the video and do the first activity — Observing a Mystery Substance. (Instructions for making the mystery substance can be found on page 9.) Ask each group to contribute in compiling a list of the substance's characteristics on the board. [15 minutes]

8. Continue the video. [10 minutes]

9. At the pause, give each student a copy of the instructions for the second activity — Variation In the Mollusk Species *Donax variabilis*. Have them read the introduction. Briefly elaborate on the following concepts: **species, populations, variations** and optional terms — **adaptations** and **evolution**. [15 minutes]

10. The Prelab Activity (pages 13-14) can be assigned for homework.

DAY 4 Complete *Donax* Activity

11. Briefly discuss the answers to the Prelab Activity. [5 minutes]

12. Have the students work in cooperative learning groups to collect and analyze data on variations in *Donax*. [45 minutes]

    - Make a transparency of the diagram in step 3 to use in explaining the procedure for measuring shell size.
    - Prior to graphing the size and weight data (step 6), review skills related to graphing — a transparency of the grids may be helpful in doing this — relate the following:

    a. How to designate graph axes — *independent variable on the horizontal x-axis and dependent variable on the vertical y-axis.*

    b. How to divide and label the axes with appropriate scale numbers — *determine range of data for the axis, then divide by the number of grid marks on the axis and round up to an easily manipulated number; identify a scale number every 5 grid marks.*

    c. How to plot the data onto the graph.

13. If necessary, have the students complete the graphs and the Questions for Analysis (pages 15-17) for homework.

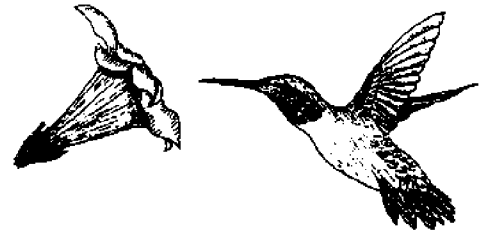
DAY 5 Discuss *Donax* Activity, Watch Remainder of Video, and Complete Postviewing Questions

14. Discuss the Questions For Analysis. [15 minutes]

15. View remainder of the video. [5 minutes]

16. Have each student complete the Postviewing Questions (page 7). Discuss the answers in class. [20 minutes]

17. [Optional] As a source of review and closure, pose the following situation and allow time for students to design an experiment to answer the question. (This problem is included in the Evaluation section as a bonus question. See pages 24-25 for an answer.)



A student notices hummingbirds coming to red flowers in her backyard and wonders if the birds are attracted to red more than to other colors. Demonstrate your understanding of the scientific method by designing an experiment which may answer her question. (HINT: hummingbird feeders filled with sugar-water can be used as a source of food.) Be thorough and creative in your explanation.

a. State a hypothesis.

b. Identify the control and experimental groups.

c. Which factors in the experiment must be controlled (be the same in all the groups)?

d. *What are the independent and dependent variables?*

e. *How will data be recorded and analyzed?*

18. At the teacher's discretion, the Evaluation section may be assigned for homework or used to accompany the next unit test. There are also activities in the Extension section that may be used for further study.

VOCABULARY

The following terms are used at various times throughout the module. The definitions may be adapted to suit your students' grade level.

Analyzing data: Determining what the information given in tables, charts, and graphs means and whether it is reliable.

Averaging: Determining a mid-range between extremes when measuring the same type of event or object.

Classifying: Grouping objects, organisms, or events into categories based on common characteristics.

Communicating: Using written or spoken words to describe an action, object, or event. Most scientific communication is done through journal articles or oral presentations.

Conclusion: A paragraph written at the end of a research project or paper that describes whether the hypothesis was supported or refuted by the research. Unusual circumstances that occurred during the research, new approaches to the problem, and new questions that arose as a result of the findings are also included in this section.

Control group: The group in an experiment that does not contain the independent variable (in all other regards, the control group is identical to the experimental groups). It is used by the investigator as a source of comparison to determine the effect of the independent variable.

Data: Measurements and observations recorded during an experiment. Data are usually organized into tables, charts, or daily logs.

Dependent (responding) variable: The factor being measured as the independent variable is changed by the investigator.

Experimenting: Testing a hypothesis or prediction by carrying out data-gathering procedures. In a controlled experiment all the factors affecting each group are the same except the factor being tested.

Experimental group: The group(s) in a controlled experiment that contain(s) the independent variable (manipulated factor).

Graphing: Plotting numerical data on a grid to show the relationship between independent and dependent variables.

Hypothesizing: Forming a testable prediction or trial answer to a problem or question.

Independent (manipulated) variable: The factor in an experiment that is being changed by the investigator.

Inferring: Drawing conclusions based on what evidence suggests rather than on direct observation.

Measuring: Determining numerical data such as temperature, distance, volume, mass, and time. In science the metric system is used for most measuring.

Metric system: A method of measuring based on factors of ten. It is accepted worldwide as the standard for scientific measurement.

Modeling: A means of describing something difficult to see or explain by using diagrams, formulas, or representative structures. Examples are road maps, bridges made from toothpicks, and 3-D models of molecules made of wire and jellybeans.

Observing: Using one or more of the senses — sight, smell, touch, taste and hearing — to gather information.

Organizing data: Placing observations and measurements in a logical order so they can be interpreted. Examples are charts, tables, graphs, and daily logs.

Predicting: Stating an expected result based on inferences from previous data or observations.

Process: A method of doing something.

Quantitative data: Information that can be measured or counted.

Science: The study of the natural world through observation, measurement, and experimentation.

Scientific method: A logical and orderly means of investigating questions and gaining knowledge.

Theory: The most probable explanation for the description of matter or an event. A theory is often the outgrowth of a hypothesis that has been supported repeatedly by experimental evidence.

Variables: Factors in an experiment that change.

PREVIEWING QUESTIONS & ANSWERS

1. Give each student a sheet of white lineless paper. Ask each to draw a scientist on one side of the paper and define what a scientist does on the other side. (The remaining previewing questions can also be answered on the back.)

   Many students will draw the scientific stereotype — a frizzy-haired male, wearing a white lab coat and thick glasses. ***Direct their attention to other careers requiring a science background — forest ranger, astronaut, engineer, veterinarian, nutritionist, physical therapist, etc.***

   (At the end of the previewing discussion collect the drawings, so they can be compared to the drawings done after the video.)

2. Why do scientists do experiments?

   Experiments are performed to answer a question, solve a problem, or study different conditions.

3. Name an everyday activity that could be related to science.

   Answers will vary but may include activities such as planting a garden, cooking, changing a flat tire, determining the easiest way to move a heavy object, or the fastest way to get to school. ***List the suggestions on the board then ask students to elaborate on how the activity is related to science.***

4. What types of characteristics can be noted by observing an object, event, or organism?

   Observations may include physical characteristics such as color, size, mass, shape, texture, and smell. Chemical characteristics may include how the object reacts when combined with substances such as water or oxygen. An organism's behavioral characteristics may include when it eats, how it gets its food, how it finds a mate, and if it is friendly or aggressive toward other species.

5. Give several examples of how we organize and classify things to make our everyday tasks easier.

   Answers will vary but may include some of the following:

   - *Students are classified by grades, divided into homerooms, and may be seated in alphabetical order in classes.*

- *The post office uses zip codes to speed up the arrangement and delivery of mail.*
- *High school athletic teams are assigned to divisions based on student population.*
- *Eating utensils are often placed in drawers with dividers for spoons, forks, and knives; cuptowels, pots and pans may be assigned to other drawers in the kitchen.*

POSTVIEWING QUESTIONS & ANSWERS

1. Give each student a sheet of white lineless paper. Ask each to draw a scientist on one side of the paper and define what a scientist does on the back side.

   Compare the pre- and postviewing drawings for the number of males versus females, number with glasses versus no glasses, and number with lab coat versus no lab coat. Look for diversity in the type of science being performed. As a class, decide on a description of what a scientist does. The answer should reflect the idea of seeking knowledge about the world (nature) through observation, measurement, and experimentation.

2. Why are graphs and charts useful in showing the results of an experiment?

   They permit the easy organization of information and rapid interpretation of the data.

3. Name some models that are used to explain things you have learned about in classes other than science.

   Examples may include:

   - *In social studies — maps, globes, graphs, and charts*
   - *In math — graphs, charts, formulas, and models of geometric shapes*
   - *In English — models of theaters such as the Stratford-On-Avon, dolls depicting the dress of a certain era of literature, and sentence diagrams*

4. Why are metric system measurements used in scientific experiments?

   The metric system is based on 10 and its multiples; it is therefore easy to represent very large numbers and very small numbers by merely moving the decimal or denoting the measurement with a prefix such as milli-, centi-, or kilo-. Because the metric system is used worldwide, communication among scientists from different countries is easier.

EXTENSIONS

1. **Graphing:** On a field trip from a marina in Ocean Springs, Mississippi, to Horn Island, a barrier island offshore, the following data were recorded:

Distance from Shore (km)	Salinity of Water (ppt)
2	5
4	12
6	18
8	20
10	23
12	30

   Prepare a line graph to represent these data, then write a statement summarizing what these data show.

2. **Classifying:** Divide the class into cooperative learning groups of two to three. Give each group a bag containing four to six related items. Have the students identify the characteristic that the items have in common, then have them subdivide the collection into smaller groups. Have each group tell the class the type of collection it has and the characteristics used to subdivided it.

   Suggestions for sets are: kitchen equipment, buttons, plastic lids, things that are red, things that measure, geometric shapes, beads, etc.

3. **Interview:** Identify an adult whom you think uses science process skills in his or her daily work. Interview the person to learn the following:
   - hours worked per week
   - education required to do the job
   - special talents needed
   - the easiest and hardest parts of the job

- the range of salary one can expect
- any other information that describes the profession

Use the interview notes to write a report describing the particular profession; be sure to relate how process skills are used in the work.

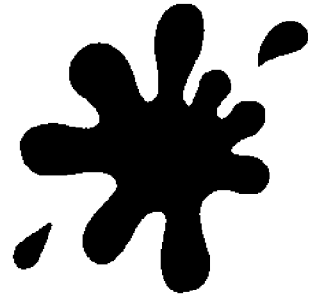
4. **Newspaper articles:** During one grading period, collect 20 science-related newspaper articles. For each article do the following:

   - Mount it on a page of paper and put it in a notebook.
   - Write a short summary describing its content.
   - Identify four important science-related words used in the article and determine the meaning of each.

ACTIVITY I

OBSERVING A MYSTERY SUBSTANCE

(Teacher Instructions)



Objective

- To practice making observations

Description

Students will work in small groups for five minutes to identify as many characteristics of a mystery substance as possible. The mystery substance is a gel-like compound called flubbergoo by some and oobleck by others.

Materials

For mystery substance:

Borax solution (9:1 mixture of water and Borax)
100 ml graduated cylinder
Tap water
White glue
Food coloring (box of 4 colors allows for various color combinations)
150 ml beaker
Stirring rod
Plastic wrap
Reclosable plastic bag for storage

For class activity (per group):

150 ml beaker
Plastic spoon
Sheet of paper
Pencil or pen
One plastic bag containing the mystery substance

Procedure

1. Make the mystery substance a few days before doing the activity. Prepare one recipe for each group of 3-4 students. Although the recipe can be multiplied to provide the desired amount, making separate batches allows each group to have a different color. Kept in an airtight container at room temperature, the compound will last several months.

   - Pour Borax into the graduated cylinder to the 10 ml mark. Add enough hot water to make 100 ml of solution. Mix and set aside.
   - Squeeze 40 ml of white glue into the beaker.
   - Stir in 20 ml of tap water.
   - Add 2 drops of food coloring (more may be added to attain desired color and intensity).
   - Stir well.
   - While stirring, slowly add the Borax solution (20-40 ml) until most of the liquid has reacted to form a solid glob.
   - Place the glob on a piece of plastic wrap and let it sit for two minutes. Because the compound is gel-like, it can be shaped into other forms, but will eventually flatten or take the shape of its container.
   - Store in a reclosable plastic bag until ready to use.

2. On the day of the activity, set out the following lab supplies for each group of 3-4 students:

   - 150 ml beaker containing about 100 ml of water
   - plastic spoon
   - sheet of paper
   - pencil

3. After starting the video, distribute one bag of the mystery substance to each group.

4. At the designated cue, stop the tape. Have each group observe the mystery substance and record as many of its characteristics as they can identify in five minutes.

   CAUTION: Because the compound contains Borax, warn students NOT to taste it.

5. Have the students return the substance *(by now they have surely given it a name)* to the plastic bag and wash their hands.

6. List their observations on the board, if time allows.

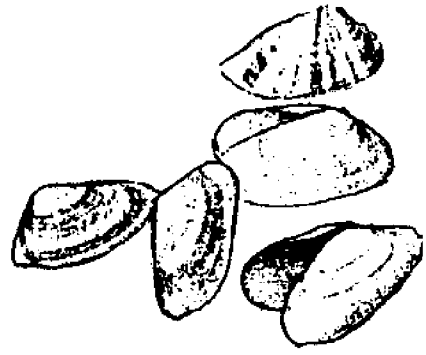
7. Continue the video, alerting students to check their observations with those provided by the narrator.

[NOTE: The recipe for Flubbergoo is adapted from one used by Flinn Scientific Inc.]

ACTIVITY II

VARIATION IN THE MOLLUSK SPECIES *Donax variabilis*

(Teacher Instructions)



Objectives

- To practice various science process skills
- To introduce the concepts of species, population, variation, and evolution

Description

Students will work in small groups to observe and measure variations among members of the mollusk species *Donax variabilis*. They will combine information in the activity's introduction with their collected data to answer questions and make inferences.

Materials

Activity sheets for each student (pages 13 -18)
Donax shells (enough for each group to have 25 shells)
Triple beam balances
Graph paper marked in 0.2 cm squares
Paper for labeling shells
Pencils

Procedure

A. On the day of the activity, set out the following lab supplies for each group of 3-4 students: paper for labeling, graph paper, pencils, a triple beam balance, and 25 *Donax* shells (you may opt to have students get their shells at the beginning of the activity).

B. At the cue designated for Activity II, stop the tape. Give each student a copy of the activity sheets and allow time for them to read the Introduction.

C. Explain the terms **species, population,** and **variation.** Relate how variation influences evolution. (Understanding this concept will help students to answer some of the Questions for Analysis.)

D. Have students answer questions 1-4 in the Prelab Activity. Suggested answers are:

1. *Do variations occur in the species Donax variabilis?* or
   What are some variations in the species Donax variabilis?
2. *The Introduction*
3. *Members of the species Donax variabilis will vary in color, size, and weight.*
4. *By observing the color and measuring the size and weight of a number of shells.*

E. Demonstrate how the students are to judge color, and measure shell size and weight.

F. Allow time for students to collect the data.

G. Review averaging and graphing skills, if necessary. (See Day 4 of the Teaching Sequence on page 4.)

H. Allow time for students to make graphs and answer the Questions for Analysis. *(This part may be assigned for homework.)*

I. Discuss answers to Questions for Analysis.

1. *Variations occur because parents differ from one another and offspring are combinations of the parents' traits. (Older students may mention concepts related to genetics.)*
2. *Variations are beneficial to species because they may equip some individuals to survive in a changing environment. For example, a clam with a shell color that blends with the color of the sand is more apt to avoid predators.*

3. *Evolution.* (Inheritable variations that are passed from one generation to the next may over time lead to adaptations and evolution in the species.)

4. Answers will vary. (This question provides practice in analyzing data.)

5. *Viewing the graphed data quickly shows the most typical size and weight for Donax shells. The most typical shell color can be determined by counting the number of shells in each color category — pink, tan, gray, yellow.*

6. Answers will vary but should be similar.

7. *The average shell size may change some. The greater the number of shells measured, the more reliable the average becomes.* (If the shells were collected randomly — without regard to size — measuring 25 shells should present a fairly reliable picture.)

8. *No. Based on observation, the shape of the shell is consistent regardless of color or size.*

9. *Members of the species Donax variabilis show variations in color, size, and weight.*

10. *(a)*

Observing — (Procedure) Used to gather data on shell color. Helped to form conclusion.

Measuring — (Procedure) Used to gather data on shell size and weight. Helped to form conclusion.

Organizing data — (Procedure) Used to record data in chart. Made the analysis of data easier.

Classifying — (Procedure) Used to separate shells into color categories.

Predicting — (Prelab Acivity) Used to form the hypothesis.

Hypothesizing — (Prelab Acivity) Told what would be observed and measured during the activity.

Experimenting — Not a part of this activity.

Analyzing data — (Graphing and Questions for Analysis) Gave meaning to the collected data and provided a basis for forming a conclusion.

Inferring — (Questions for Analysis) Helped in forming a hypothesis and in relating background information and collected data to a broader concept — evolution.

Modeling — Not a part of this activity.

Communicating — (Questions for Analysis) Provided an opportunity to share results with other interested people and, in this case, helped to establish whether the collected data was consistent and reliable.

10. *(b)*

Experimenting and modeling are the two process skills not used in the activity. Answers will vary in regard to possible ways of incorporating the skills. **Tell students to listen carefully for the suggestions offered by the video narrator.**

J. Watch the remainder of the video program.

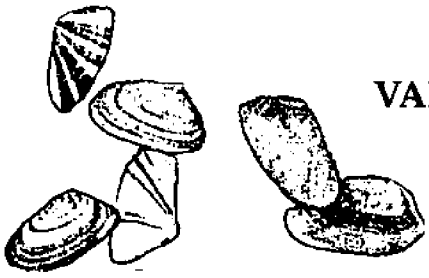
Variations for the Activity

- *Donax* shells (sometimes called butterfly clams) can be easily collected along coastal beaches. If a trip to the beach is not possible, try one of the following options.

- Use zebra mussel shells. Zebra mussels are exotic freshwater mussels that have invaded many Gulf Coast rivers. Be careful to kill the mussels in ethyl alcohol before transporting them to the classroom. Clean the organisms from the shells and rinse the shells in tap water before distributing them to students.

  After the activity, store the shells for future use.

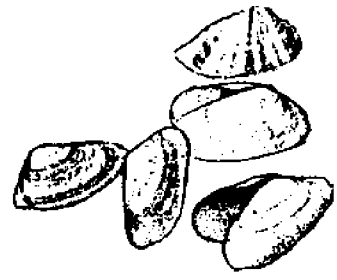
- Substitute ring openers from a variety of aluminum soft drink cans (each company's ring is slightly different). Use the rings as a model of variation within a living species.



ACTIVITY II

VARIATION IN THE MOLLUSK SPECIES *Donax variabilis*

(an activity on scientific processes)



Introduction

A ***population*** is composed of all the members of the same ***species*** living in a particular area. A forest near your home, for example, may have populations of squirrels, sparrows, and pine trees, to name a few. Members of the same species are usually easy to identify because they are very similar in appearance. You probably would have no trouble identifying the members of pine tree and squirrel populations.

Similar though they are, differences among members of the same species do exist. Sometimes the differences are easy to see, such as differences among your classmates. Other times, differences are more difficult to determine, as when comparing two crickets or two earthworms. Differences among members of the same species are called ***variations.***

Variations are important in establishing which members within a population will be the most successful. For example, the fastest deer will escape the most predators, owls with the keenest vision will kill the most prey for food, and plants that produce the most seeds will leave the most offspring for the next growing season.

In this investigation you will attempt to discover variations in a common marine mollusk, a small coquina clam of the intertidal zone belonging to the species *Donax variabilis.*

Materials (per lab group)

25 *Donax* shells
(about 1 tablespoon)
triple beam balance
graph paper marked in 0.2 cm squares
25 squares of paper for labeling shells

Prelab Activity

1. State the problem to be answered by this activity: _____

   _____

2. What part of this activity gives you the information you would normally get from doing research? _____

3. Based on the information that you have, state a hypothesis (a trial answer) for the problem: _____

_____

4. How will you test your hypothesis? _____

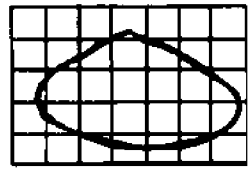
_____

_____

FOLLOW THE PROCEDURE, RECORD THE DATA, MAKE THE GRAPHS, AND ANSWER THE QUESTIONS FOR ANALYSIS.

Procedure

- Select 25 *Donax* shells at random from the container (do not try to pick special ones).
- Place each shell on a square of paper then assign each a number (1-25). Write the number of the shell on its square of paper.
- Place a shell on the graph paper and determine its size. To do this, draw around the shell with your pencil, remove the shell from the paper, and count the number of 0.2 cm squares that were covered by the shell. For those squares that were partially used, estimate the amount of area covered (if the amount is half or greater, count it as one, but if it is less than half, ignore the square). Add the numbers together to determine the shell's size. **(See example below.)** Record the shell's size in the appropriate space on your data sheet. Repeat this procedure for each of the shells.



total number of squares covered = 14

- Weigh each shell to the nearest 0.1 (tenth) of a gram and record the weight on the data sheet.
- Determine the predominant color of each shell and record it in the proper space on the data sheet.
- Using the guidelines given on the graph axes, enter your data and make line graphs.

Questions for Analysis:

1. Why do you think variations occur within a species? _____

   _____

2. Are variations beneficial or harmful to a species? Explain. _____

   _____

3. Over time, successful variations may lead to what phenomenon?

   _____

4. What is the most typical size, weight, and color for *Donax* shells?

   size: _____

   weight: _____

   color: _____

5. How did you determine the answers to question number 4? _____

   _____

6. How does your graph on shell size compare to those constructed by other lab groups?

   _____

7. Would your average shell size change if you measured a larger number of shells?

   _____ Explain. _____

8. Does there appear to be any relationship between color and shape? _____

   Explain. _____

9. Based on your analysis of the collected data, what conclusion can you form?

   _____

10. Below is a list of scientific process skills. All but two were used in this activity.

(a) Select the nine skills that were used to study the variation in the mollusk species *Donax variabilis*, identify where in the activity you used each skill, and explain why each was an important part of the activity.

Observing: _____

_____

Measuring: _____

_____

Organizing data: _____

_____

Classifying: _____

_____

Predicting: _____

_____

Hypothesizing: _____

_____

Experimenting: _____

_____

Analyzing data: _____

_____

Inferring: _____

_____

Modeling: _____

_____

Communicating: _____

_____

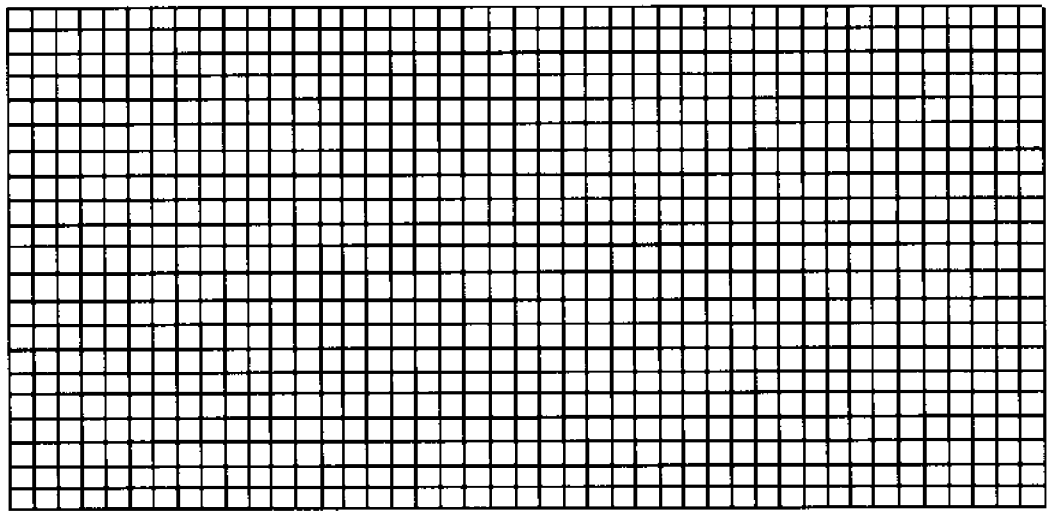
(b) Identify the two skills you did not use and explain how this exercise might be expanded to incorporate each one. _____

_____

_____

DISTRIBUTION BY SHELL SIZE

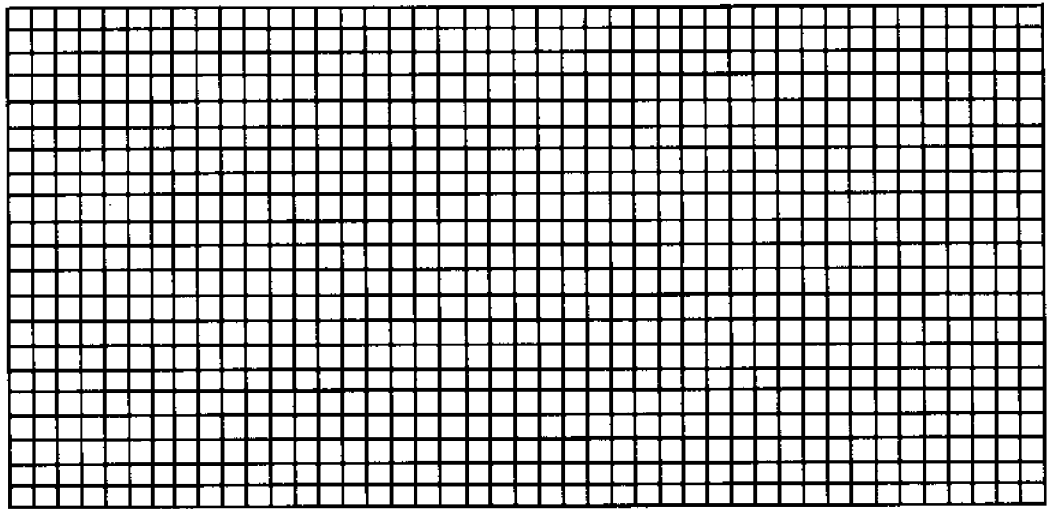
Number of shells



Number of 0.2 cm squares covered by a shell

DISTRIBUTION BY SHELL WEIGHT

Number of shells



Weight in grams

DATA SHEET

SHELL NO.	NUMBER OF SQUARES COVERED	WEIGHT OF SHELL	PREDOMINANT COLOR OF SHELL
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			

This activity was adapted from an exercise in *Man and the Gulf of Mexico*, "Diversity of Marine Animals," compiled and edited by Bobby N. Irby, Malcolm K. McEwea, Sheila A. Brown, and Elizabeth M. Meek, 1984, pages 53-56.

EVALUATION QUESTIONS

MULTIPLE CHOICE: Select the BEST answer for each statement.

1. Using the following table, determine the probable time of sunrise on Wednesday.

DAY	TIME OF SUNRISE
Sunday	6:14 am
Monday	6:12 am
Tuesday	6:10 am
Wednesday	?

A. 6:11
B. 6:09
C. 6:08
D. 6:06

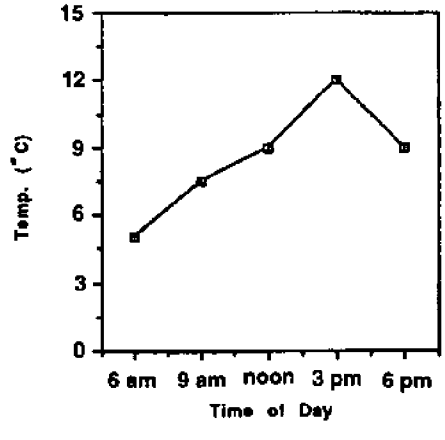
2. The answer to question 1 requires the use of which process skill?

A. prediction
B. measurement
C. experimentation
D. modeling

3. On a field trip to a barrier island, a teacher made the following four statements, which one is most likely an inference?

A. The island is two kilometers long.
B. Barrier islands serve as a buffer by protecting the mainland from strong winds and wave action during hurricanes and storms.
C. Barrier islands are thin, narrow ridges of sand.
D. The sand that formed this island was probably part of a different island years ago.

4. Using the graph below, determine which two times have the same temperature.



A. 6 am and 6 pm
B. 9 am and 6 pm
C. noon and 6 pm
D. 3 pm and 9 pm

5. Which property was used to classify the substances below?

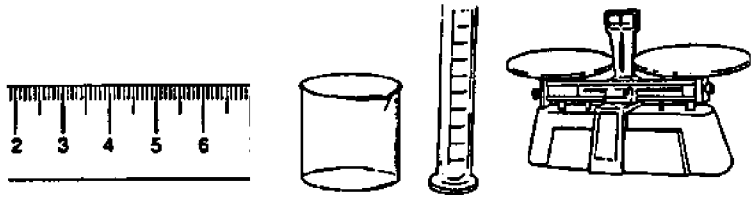
Group A	Group B	Group C
Helium	wood	water
water vapor	rubber	apple juice
methane	ice	Kool-aid

A. abundance on earth
B. chemical composition
C. size
D. state of matter (solid, liquid, gas)

6. Which of the following is an example of a model?

A. globe
B. ruler
C. encyclopedia
D. article in a scientific magazine

7. Instruments like the ones represented below are used to make



A. predictions
B. inferences
C. measurements
D. classifications

8. Which statement below could be considered a hypothesis?

A. Louisiana has over seven million acres of wetlands.
B. The bald cypress tree grows better in a wetland area than in a dry area.
C. The states of Texas, Louisiana, Mississippi, Alabama, and Florida border the Gulf of Mexico.
D. What happens when pollutants like pesticides, make their way into the water supply?

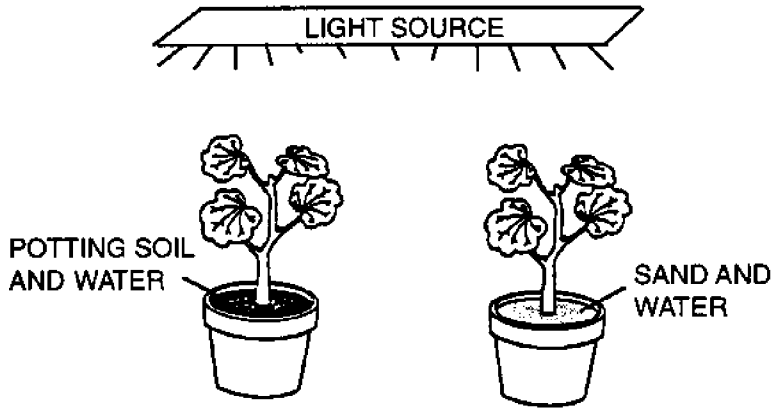
FILL IN THE BLANK: Some of the words below may be used to complete the statements.

communicate	dependent variable	data
English system	experiments	graph
inference	Metric system	analyze
scientific method	model	control
independent variable	observations	chart

1. Data obtained by using the senses — smell, sight, hearing, taste, touch — are called _____.
2. One student describes the liquid in a beaker as being clear and colorless. Another student immediately responds, "it's water!" The second student's comment is a(n) _____.
3. The system of measurement used in science is the _____.
4. A diagram produced by numerical data plotted on a gird is called a _____.
5. A logical and orderly way to investigate questions is called the _____ _____.
6. Oral presentations and written journal articles are ways that scientists _____ what they have learned.
7. Measurements and observations made during an experiment are called _____.
8. The group in an experiment used for comparison to show whether the independent variable is having an effect is called the _____.
9. In a controlled experiment the factor that the investigator changes is called the _____ and the factor that responds
10. to the change is called the _____.

SHORT ANSWER :

A student is preparing for the school science fair and has set up the plant study shown below.



1. What is the question (problem) being studied in this experiment?

2. State a hypothesis for this experiment.

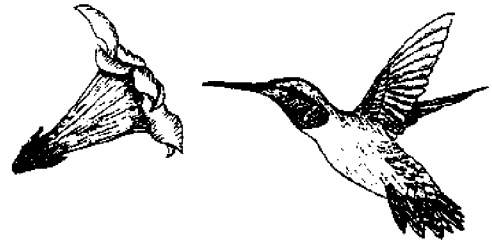
3. What type of measurements and observations could be made?

4. Identify the factors in the experiment that are apparently being controlled (the same for each group).

5. What is the independent variable? _____

6. How could this experiment be improved? _____

BONUS:



A student notices hummingbirds coming to red flowers in her backyard and wonders if the birds are attracted to red more than to other colors. Demonstrate your understanding of the scientific method by designing an experiment which may answer her question.

(HINT: hummingbird feeders filled with sugar-water can be used as a source of food.)

a. State a hypothesis.
b. Identify the control and experimental groups.
c. Which factors in the experiment must be controlled (be the same in all the groups)?
d. What are the independent and dependent variables?
e. How will data be recorded and analyzed?

Be thorough and creative in your explanations.

EVALUATION - ANSWERS

MULTIPLE CHOICE:

1. C
2. A
3. D
4. C
5. D
6. A
7. C
8. B

FILL IN THE BLANK:

1. observations
2. inference
3. metric system
4. graph
5. scientific method
6. communicate
7. data
8. control
9. independent variable
10. dependent variable

SHORT ANSWER:

1. Answers will vary, but should reflect the problem of determining the best growing medium for plants. For example:

   - *Do plants grow better in potting soil or in sand?* or
   - *What is the best type of soil for growing plants?*

2. The statement should be a testable answer for the problem stated in question 1. Examples are:

   - *The plant in potting soil will produce more new leaves.*
   - *The plant in potting soil will grow taller.*
   - *Plants will grow better in potting soil than in sand.*
   - *Plants will grow better in sand than in potting soil.*

3. Measurements may include:

   - *height of plant*
   - *number of new leaves*
   - *total mass of the plant at the end of the test period*
   - *amount of starch produced in the leaves.*

   Observations may reflect *the color and general health of the plant.*

4. Factors being controlled are:

   - *amount of light, growing medium, and water*
   - *type of plant*
   - *size of plant at the beginning of the experiment*

5. The independent variable is *the type of soil being used as a growth medium.*

6. This experiment could be improved by

   - *using more plants per category—control and experimental groups containing at least five plants each.*

BONUS:

Be flexible in evaluating this question, but look for the elements of good experimental design discussed during the unit:

- a hypothesis that is testable
- use of a control
- all factors identical in the experimental and control groups except the presence of or changes in the independent variable (in this case, colors other than red; red would be the control)
- good description of how collected data will be organized.

A typical response may be:

a. Hummingbirds are attracted to red more than to other colors.

b. To experiment:

- *Set up four hummingbird feeders in the same part of the yard.*
- *Put different colors of sugar water in each feeder.*
- *Count the number of times hummingbirds come to each feeder during a 30 minute period each day for two weeks.*

c. *Factors to control (keep the same) are:*

- *amount of sugar in the sugar-water solutions*
- *location of the feeders*
- *amount of sugar-water in the feeders at the beginning of each observation period*
- *length of observation period*

d. *The dependent variable is the number of visits that are made to the feeder during the observation period.*

e. *Data can be recorded on a chart that shows the number of visits observed per day at each feeder. The data can then be made into a graph which shows the relationship betweeen color of water and number of visits.*

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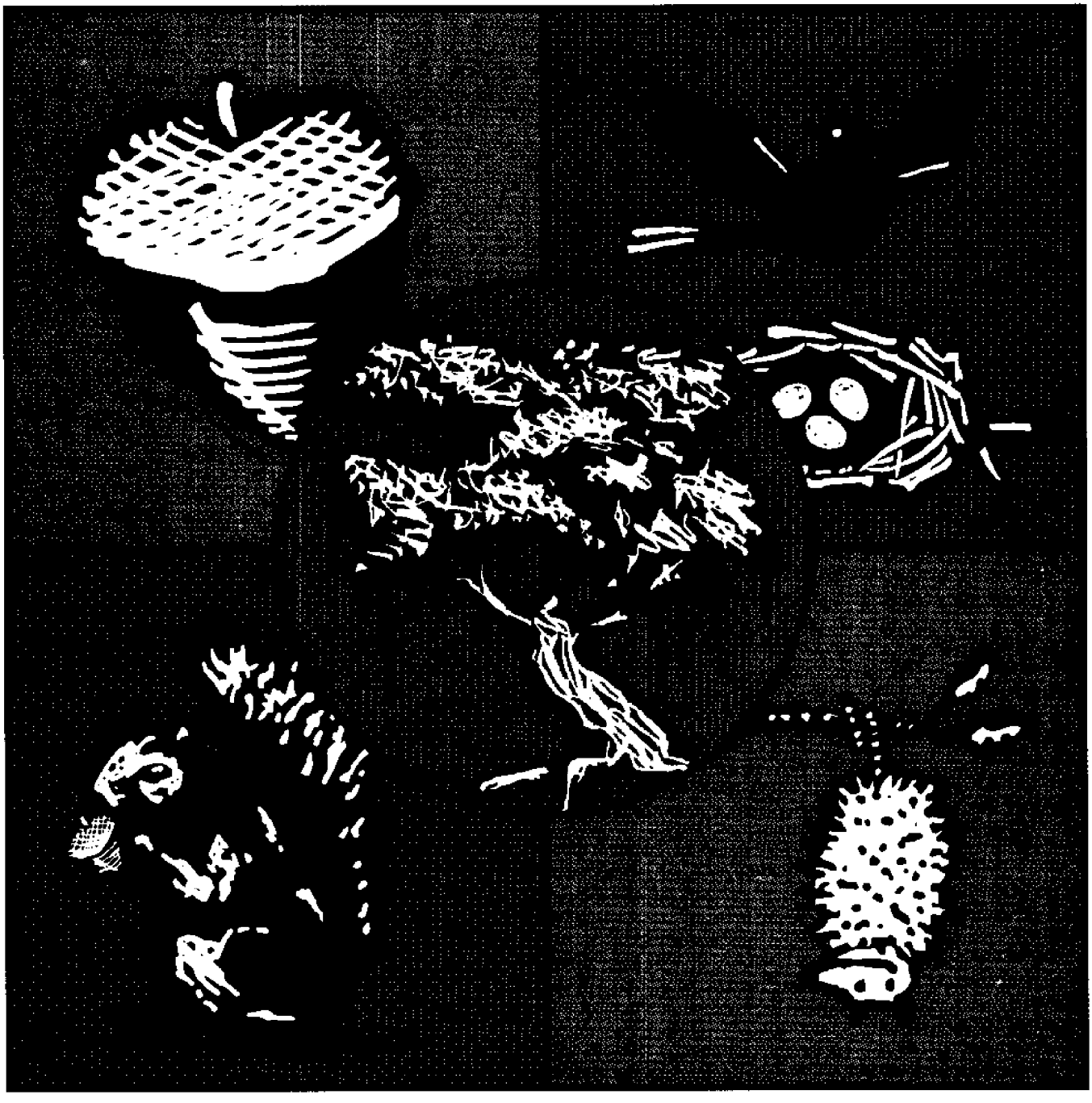
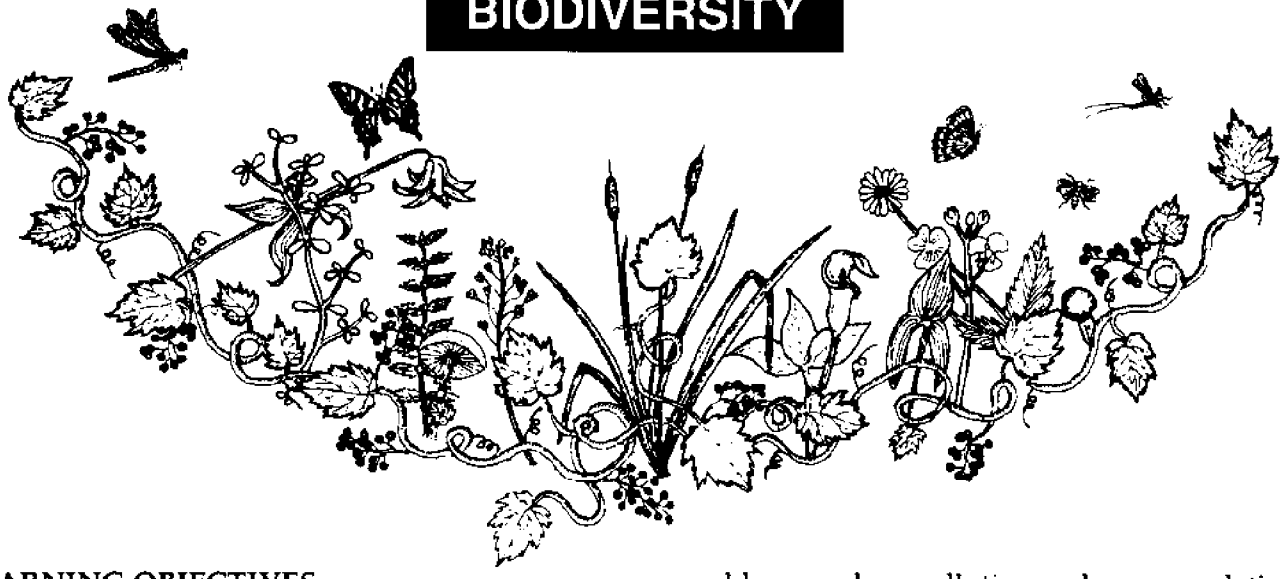
BIODIVERSITY



Project TELLUS: Interactive Science Videos on Global Change Issues

BIODIVERSITY



LEARNING OBJECTIVES

Students should be able to:

1. Define biodiversity in terms of genetic, species, and habitat variety.
2. Communicate the importance of biodiversity and reasons for maintaining it.
3. Identify factors contributing to declining biodiversity in the Gulf Coast region.
4. Recognize local, national, and international strategies that will encourage biodiversity.
5. Plan activities to help maintain biodiversity in their local area.

INTRODUCTION

An outcry on behalf of wildlife began in the early 1960s as Rachel Carson's warning in her now classic book, *Silent Spring*, stirred Americans to action against pesticide contamination in the environment. Among the species to claim attention because of declining populations were the bald eagles, brown pelicans, and gray whales. Today, in an environment protected by law, these species are making steps toward recovery, but the fate of many other species is still in question. Pollution is not the only environmental change adversely affecting wildlife — declining biodiversity is another.

Declining biological diversity, or biodiversity, is one of the most pressing environmental problems we face today. It is, in effect, the result of some of the more obvious problems such as pollution and overpopulation. What does this term, biodiversity, mean? Why is it important? Why are the number of species, their genetic variety, and the different types of ecosystems declining? Is there anything that can be done to reverse the trend?

The purpose of this program is to answer these questions while exploring several ecosystems commonly seen in the Gulf Coast region. The video program highlights some of the inhabitants in each ecosystem and shows how these species depend on each other and the physical environment. It also identifies some of the human induced changes that are causing stress and potential harm to the ecosystems' life support mechanisms. These life support mechanisms are the ecosystem's means of maintaining each species' habitat essentials — food, water, shelter, and space.

The theme, biodiversity, is developed through the concepts: **species, community, habitat, niche, food webs, adaptations, extinct species, threatened species, endangered species,** and **sustainable use.** (These terms and others, identified by bold type in the video guide, are defined in the Vocabulary section.)

The goals of the program are to help students:

- See themselves as part of the ecosystem in which they live.
- Develop an attitude of respect and appreciation for the beauty that exists in nature.
- Understand the economic, ecological, and ethical issues associated with preserving biodiversity.

- Form behavior patterns that translate into responsible action on behalf of preserving biodiversity.

The background information which follows will be helpful in discussing biodiversity prior to viewing the video and in guiding students toward logical and meaningful conclusions throughout the viewing and postviewing activities.

BACKGROUND INFORMATION

Biodiversity Defined

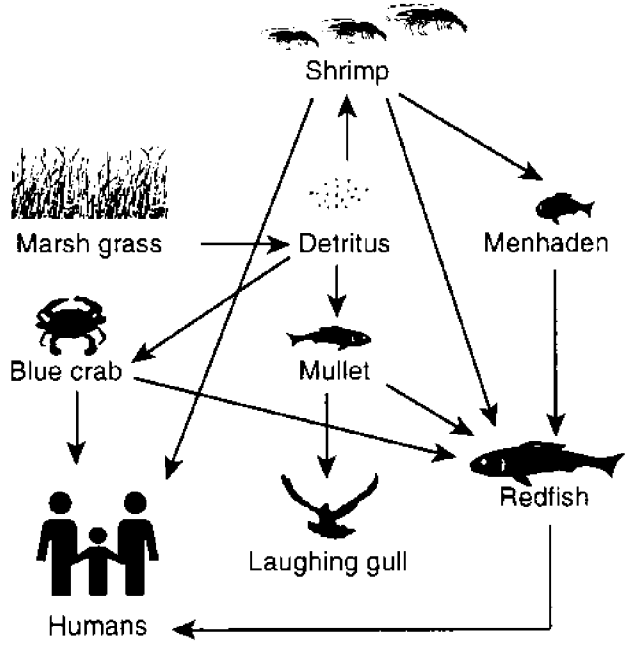
The term **biodiversity**, a contraction for biological diversity, is used most commonly to describe the variety of **species** in a given area — the entire earth, an **ecosystem** such as a desert or tropical rain forest, or a specific habitat such as the bank of a pond or the floor of a forest. The meaning of this relatively new (1980s) term has grown to also include the variety of habitats in a given area. Hence, the focus of this video module on biodiversity includes both the diversity of species and habitats common to the Gulf Coast region.

A third aspect of biodiversity refers to the genetic diversity within a species — the number of ways members of the same species are different from one another (for example, variations in skin color or body size in humans or color in pansies). Although an in-depth look at genetic diversity does not fall within the scope of this program, middle school is a good time to introduce the idea that differences among members of the same species provide opportunities for some individuals to survive when conditions in their environment change. By stressing the importance of **adaptations**, this program introduces students to the notion of genetic diversity. They begin to understand why biodiversity is advantageous for species, for ecosystems, and for the quality of life on earth.

Values of Biodiversity

In the words of Rachel Carson, "... all the life of the planet is interrelated ... each species has its own ties to others ... all are related to the earth." That means that no species can exist isolated from others or independent of the physical environment — air, water, minerals, weather. This truth is verified as one considers the values of biodiversity worldwide and more specifically in the Gulf Coast region.

The dependency that exists among plants, animals, and other living things within an ecosystem hinges primarily on food and shelter relationships. **Food webs** show the interconnectedness that exists among species living in the same ecosystem. A greater variety of food sources allows a greater diversity of species to inhabit an area. Consider the number of species that act as **predators** and **prey** in the salt marsh food web below.



What would happen if shrimp were removed from this salt marsh food web?

The loss of any one species weakens the entire food web by putting more stress on available prey or by opening a way for other species to expand or become established that could become a nuisance.

An ecosystem rich in diversity also provides more shelter options. The trees, shrubs, and other vegetation in a forest and the grasses in meadows, marshes, and bogs provide cover, hiding places, and nest sites for numerous animal species.

A diverse **community** provides other advantages to an ecosystem.

- Soil organisms breakdown and recycle substances vital for supporting the growth of plants.

- Plants and algae help maintain atmospheric gas compositions by consuming carbon dioxide and releasing oxygen during photosynthesis.

- Diverse predator-prey relationships contribute to the regulation of pests and diseases.

- Forests and wetlands protect groundwater and soil by filtering out pollutants, preventing erosion, and absorbing stormwater during floods.

When considering mankind's use of nature for food, medicine, raw materials, and recreation, the values of biodiversity become even more apparent.

- Gulf Coast estuaries provide an ideal habitat for many of the commercially valuable seafood species — oysters, blue crab, shrimp, redfish, trout, flounder, and menhaden — harvested in America. This biodiversity provides a livelihood for many coastal fishermen, a valuable food source for humans, and raw materials for products such as cosmetics and pet food.

- Three fourths of the world's population depends on folk medicines derived from plants or other organisms in nature. Nearly one-quarter of the prescriptions dispensed in the U. S. are based on medicine of natural origin, in fact, some of the most promising treatments for cancer and other diseases come from species once thought to be useless. The Pacific yew tree, once considered a nuisance by northwestern loggers, produces a chemical called taxol that is used in the treatment of breast cancer. The rosy periwinkle, a flowering plant from Madagascar, yields a substance used to treat childhood leukemia. The heart medicine digitalis is an extract from purple foxglove. Hundreds of medicinal products have been derived from a class of chemicals called alkaloids, and chemicals from the skin of certain frog species have proven useful as antibacterial agents.

- Wild plants and animals supply oils, gums, resins, construction materials, and other raw ingredients from which scientists make new products such as synthetic fabrics, plastics, paint products, solvents, and rubber.

- Many crops raised in the Gulf Coast region — pecans, corn, grapes, blackberries — have been improved by cross-pollinating them with wild relatives more resistant to diseases, pests, and weather damage.

- Bacteria and other decomposers break down and recycle organic waste. Organisms have been found recently that are even able to digest oil from oil spills. Their use as a natural means of pollution cleanup is called **bioremediation.**

- Biodiversity makes the world aesthetically pleasing to humans who use the diverstiy of habitats and species for recreational and spiritual activities such as hunting, fishing, birding, scuba diving, gardening, or meditating. Millions of dollars pour into the Gulf Coast region from the recreation and tourism industries as people bask on beaches, explore wildlife areas (swamps, lakes, forests, migratory bird flyways, etc.) and visit zoos and nature centers.

Extinction and Biodiversity

Just as death is an inseparable part of life, so extinction is an inseparable part of life's evolutionary story. When the environment changes, helpful variations in individuals magnify over time to become adaptations in the general **population,** and the species endures. Conversely, if a species cannot adapt to environmental change, it eventually becomes **extinct. Endangered species** are those that are in danger of extinction, and **threatened species** are those whose numbers are in rapid decline and are likely to become endangered within the foreseeable future.

The exact number of species existing in the world today is not known. About 1.5 million species have been identified, but experts agree that there are from 5 to 50 million more species living in secluded or uninhabited areas — tropical forests, coral reefs, deep in the ocean — that have not been identified. Experts also agree that the earth is experiencing a rapid loss of many species.

Aside from periods of **mass extinction** such as occurred 65 million years ago at the close of the Cretaceous Period, the extinction rate throughout history has been fairly stable — about one species per year. Today, however, the extinction rate is variously estimated from one to five species per day. This represents a yearly rate of 300 to 1500 times the historical average! And contrary to other periods of mass extinction, one species is primarily to blame for the dilemma — MAN.

Loss of biodiversity is largely due to the destruction or degradation of natural habitats. This is happening at an unprecedented rate in developing nations where the human population is seeking to raise its standard of living or, often, just trying to meet its habitat needs of food, water, shelter, and space. Habitat degradation and loss is also a problem in the Gulf Coast region where a growing number of people are moving into ecologically fragile areas.

During the last decade, the human population in the Gulf Coast region increased by 33 percent, and this trend is expected to continue. As the number of people increases, so does the need for habitat. People are developing wetland areas and cutting down forests to make way for new houses, businesses, shopping areas and highways. When the original habitats are lost, degraded, or changed into forms that the native species cannot use, the species disappear. During this century, many fish, crawfish, and mussel species have become rare or extinct, and native songbirds are declining at alarming rates.

Although habitat loss is the major cause of declining biodiversity, other factors contribute, including:

- *Pollution* — Excess fertilizer, improper use of pesticides, sewage from homes and boats, and toxic waste from industrial, agricultural, and residential runoff degrade the water, soil, and air. As these substances accumulate in an ecosystem, they may cause a variety of changes. Excess fertilizer in aquatic ecosystems stimulates rapid algal growth called blooms. When the algae die and decay, dissolved oxygen levels become low and the pond or lake can no longer support a high level of animal diversity. Pesticides that do not break down in the environment may accumulate in **food chains** and adversely affect organisms near the top of the food chain. (This caused the decline and near extinction of bald eagles, brown pelicans, and peregrine falcons during the 1960s.) Also, the accumulation of heavy metals (lead, mercury, cadmium) and toxins in plants and animals may interfere with normal cell and tissue physiology or reduce the organism's resistance to disease.

- *Introduction of exotic species* — If an exotic (non-native) species has aggressive growth and reproductive capabilities and has few predators (as in the cases of nutria, fire ants, kudzu, and water hyacinth), it may compete with the native species for habitat essentials. By reducing the native species' food, space, shelter and water supply, the exotic disrupts the ecological balance in the ecosystem.

- *Overexploitation* — When resources such as fish, game, and native plants are not managed, their populations may be reduced to levels which make recovery difficult or unlikely. This has happened with sea turtles in the Gulf of Mexico and with old-growth, longleaf pine forests in the Gulf Coast states.

- *Modern agriculture and forestry* — Fewer varieties of crops are used in agriculture and forestry. Traditional varieties and wild types have been abandoned in favor of higher yielding, disease resistant hybrid varieties. In the early 1800s there were 7,000 varieties of apples growing in the United States, today, 85 percent of those varieties are gone. In many areas of the Gulf Coast, the forest industry has replaced mixed forest ecosystems with **monoculture** pine forests. As the variety of plant species decreases, many of the insect, bird, and mammal species that feed on and find shelter in them also decrease.

- *Global climate change* — Many scientists believe that the earth is in the midst of a major warming trend. Increases in certain

atmospheric gases that trap the sun's heat, preventing its reflection back into space ("the greenhouse effect") may be the cause. If this warming trend continues, sea levels will rise and climates will change. Species that cannot adjust to changes in temperature, precipitation, and salinity are likely to become extinct.

As the human population swells along the Gulf Coast and coastal habitats are reduced or changed by residential and commercial development, agricultural use, and infrastructure development, wild inhabitants are pushed further and further into a spiral of decline. The Gulf's diverse habitats become more difficult to maintain.

Maintaining Biodiversity

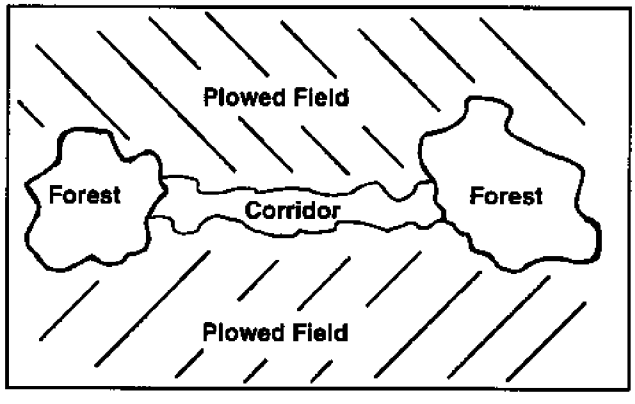
The World Resources Institute identifies three basic steps in maintaining biodiversity:

1. Save it.
2. Study it.
3. Use it sustainably.

These steps serve as a springboard for action.

During the 1970s the U.S. government took an active role in combating irresponsible environmental behavior by passing several laws. The Endangered Species Act regulates a wide rage of activities affecting plants and animals designated as endangered or threatened, and the Clean Air and Water Acts regulate and limit the amount and types of pollutants that can be released into the atmosphere and waterways. Other large scale efforts to save habitats and species include:

- *Maintaining corridors between forested areas* — This insures that species do not become separated from others of their kind when land is cleared for development or agricultural use.



A strip of trees and underbrush, called a corridor, connects two areas of forest in a plowed field.

- *Reintroducing endangered species in their native habitats* — Because of pesticide accumulation, brown pelicans had almost disappeared from Louisiana and Mississippi waters during the 1970s. With reintroduction and careful management, they have made a remarkable comeback and are once more gliding gracefully over coastal waters.

- *Sinking retired oil and gas platforms in marine habitats* — The platforms provide a hard surface upon which sessile marine organisms can attach. Once new colonies of marine plants and animals are established, the base of a marine food web is in place and the reef becomes habitat for many species. An example of this type effort is the Louisiana Artificial Reef Program sponsored by the Louisiana Department of Wildlife and Fisheries. To date there are 55 such structures in the Gulf of Mexico and each has been successful in providing habitat for barnacles, various corals, spiny oysters, and the numerous fish that feed on them.

As an individual, one can help conserve biodiversity by:

- *Taking part in environmental organizations* — Join ones that attempt to educate the public about the dangers of habitat and species destruction.

- *Writing letters to congressmen* — Urge them to take action on behalf of endangered and threatened species.

- *Providing a place for native plants to grow* — Use them in your own yard. Plan, plant, and maintain them in a school wildlife area. Collect seeds in the wild, then grow and sell the native plants as a club fund-raiser. (Be careful not to harm the plant when obtaining seeds. Harvest only one seed pod per plant, leaving plenty of seeds for natural dispersal.)

- *Participating in the Backyard Habitat Program sponsored by the Natural Heritage Program of the U.S. Fish and Wildlife Department* — Request information on this program by writing the National Wildlife Federation. 1400 Sixteenth Street, N.W., Washington DC 20036-2266.

The second step calls for **studying** biodiversity.

- *Learn by reading magazines, attending education programs at museums, zoos and nature centers, and watching nature programs on television.*
- *Work as a volunteer at a local park or zoo.*
- *Educate others to regard wild species as a source of beauty and economic potential.* Speak to local garden clubs about projects they can sponsor and carry out, such as community composting and preservation of wildflower meadows.

Finally, use the earth's resources **sustainably**. That means using them in a way that will not change or reduce them for future generations. To do this:

- *Make changes in buying habits and lifestyle to reduce consumption.* Carpool, bike, or walk whenever possible. Try to reuse or repair articles rather than buying new ones.
- *Follow responsible environmental practices.* Recycle paper, glass, and aluminum in your classroom. Cut six-pack rings before throwing them away. Carry litter bags to clean up recreational areas while on outings.

- *Support legislation to finance research for new medicinal, agricultural, and aesthetic uses of plants and animals.*
- *Use pesticides and fertilizers properly.* Follow the directions on the product's label for mixing and application.
- *Reduce the demand for biological resources by reducing population growth.*
- *Support businesses that donate to environmental research or take an active role in environmental protection.*

By safeguarding habitats, the wildlife that live within them is protected, but saving habitats often means restraining human activity. During the last 40 years there have been highly publicized confrontations between industry and environmentalists on issues concerning endangered species — logging industry and the spotted owl, Tennessee Valley Authority and the snail darter, chemical industry and the bald eagle, peregrine falcon, and brown pelican.

Because protecting species and habitats has in some cases cost people their jobs and stifled economic growth in a region, some in America have viewed these confrontations as battles in which man has emerged the loser. Today, however, as a result of intensified education on environmental issues through schools, the media, and environmental groups, most people agree that a middle ground must be found where human welfare and economic growth can exist in balance with the conservation of natural resources and biological diversity.

As the dominant species on earth, humans must embrace the challenge to choose a lifestyle that reflects respect and care for Earth's life support systems. This means responsible use of resources and management of species and habitats in ways that insure sustainability.

TEACHING SEQUENCE

DAY 1 Begin Background Information and Activity I

1. Use the procedure outlined in the Teacher Instructions for Activity I (page 13).
   - Introduce the theme — biodiversity.
   - Divide the class into investigative teams.
   - Allow time for students to collect and record data. [45 minutes]
2. Ask volunteers to do the same activity with a parent, sibling, or friend in an undisturbed area near their home — vacant lot, forest, stream, swamp, etc. [5 minutes]
3. Have students complete the graph on the Class Data Sheet for homework.

DAY 2 Complete Activity I and Continue Background Information

4. Using the chalk board or an overhead projector, show students how the graph of Total Diversity at Different Habitats should look. Afterwards, add data collected by students who did the survey at

undisturbed areas near their home. [10 minutes]

5. Discuss the results as outlined in the teacher instructions. [10 minutes]

6. Continue the background information by reviewing or teaching additional ecological concepts used in the first part of the video: **community, food chains, food webs, adaptations,** and **niche.** Ask various students to suggest examples for each concept. [10 minutes]

7. (Optional activity) Have students do the role playing extension activity (pages 11-12) associated with food chains and food webs. [15 minutes]

8. Give each student a copy of the four Previewing Questions to do for homework. Explain that the four ecosystems described in the questions will be the ones highlighted in the video. [5 minutes]

DAY 3 **Discuss Previewing Questions, Watch Video, and Do Niche Extension of Activity I**

9. Discuss the answers to the Previewing Questions. [10 minutes]

10. Encourage students to note values and environmental concerns associated with each habitat and write them on the homework sheet for future reference. Show the video until instructed to pause. [10 minutes]

11. Students will work with their biodiversity survey team to determine the niche of each organism they listed during Activity I. [10 minutes]

12. As a class, discuss the niche of several organisms (perhaps, one from each team's list). Ask students to identify the niche of humans. Is a human's niche the same throughout his or her life? Try to clarify any misconceptions and answer student questions before continuing the video. [5 minutes]

13. Remind students to note values and ecological concerns associated with the different habitats. Continue watching the video to the next pause. [10 minutes]

14. Tell students that they will play the game, Gulf Goners, during the next class meeting. For closure, ask them to share some things they learned about each habitat. [5 minutes]

DAY 4 **Background Information, Play Gulf Goners, and Watch Remainder of Video**

15. Continue teaching the background information. [10 minutes]

    - Distinguish among extinct species, endangered species, and threatened species. Give examples of species in each category. (Refer to the list provided on pages 26-28.)

    - Describe the **interdependency** among species in ecosystems. (See the introduction in the Teacher Instructions for the game Gulf Goners, page 17.)

16. Using the steps outlined in the Teacher Instructions, describe, play, and discuss the results of the game Gulf Goners (pages 17-19). [30 minutes]

17. Have students suggest ways to encourage and maintain the variety of species and habitats in their town, state, and throughout the world. (The Background Information at the beginning of the video guide should help in directing student responses.) Write suggestions on the board. [5 minutes]

18. Watch the last part of the video program. [2 minutes]

19. Give each student a copy of the Postviewing Questions (pages 10 -11) to answer for homework. [3 minutes]

DAY 5 **Discuss Postviewing Questions**

20. Discuss the homework assignment. [10 -15 minutes]

21. Activities in the Extension section (page 11) may be used for further study or enrichment.

22. At the teacher's discretion, all or part of the Evaluation section (pages 29-32) may be used to accompany the next test.

VOCABULARY

The following terms are used at various times throughout the module. The definitions may be adapted to suit the students' grade level.

Adaptation: A physical or behavioral characteristic that helps a species survive in its environment.

Biodiversity: The variety of life that exists in a particular area. It includes the genetic diversity within a species and the variety of species and habitats in a given area.

Bioremediation: The use of living organisms (usually bacteria) to digest and cleanup pollutants in the environment.

Community: All the organisms — plants, animals, fungi, and microbes — living in the same area during a particular time.

Ecosystem: An area where living things interact with each other and with their nonliving surroundings. Substances essential for life such as oxygen, water, and minerals are cycled, and energy flows from producers through consumers.

Endangered species: A species in immediate danger of becoming extinct.

Exotic species: Non-native plants and animals that have been introduced into an area.

Extinct species: Species that have died out and are gone forever.

Food chain: The sequence of organisms involved in a flow of energy from producer through consumers. (Producer → Herbivore → First Carnivore → Top Carnivore)

Food web: The complex feeding relationships among the organisms in an area. It describes the intertwining food chains of an ecosystem.

Habitat: The area where a particular kind of organism lives. It provides the requirements for the organism's life, namely, food, water, shelter, and space.

Habitat fragmentation: When natural habitats are divided, isolating species into smaller ecological communities. Causes include activities such as the building of highways, clearing of forests, and damming of rivers.

Interdependency: The intertwining relationships and processes that connect organisms to the physical environment and to each other.

Mass extinction: When an enormous number of species become extinct within a geologically short — 10,000 to 100,000 years — period of time.

Monoculture: An agriculture or forestry practice in which a large area of land is planted in only one variety of a crop.

Niche: The role or function of a species in its ecosystem.

Population: Members of the same species living in a specific area at a given time.

Predator: An organism that kills and eats another organism.

Prey: The organism eaten by a predator.

Species: A group of similar organisms that interbreed in nature to produce fertile offspring.

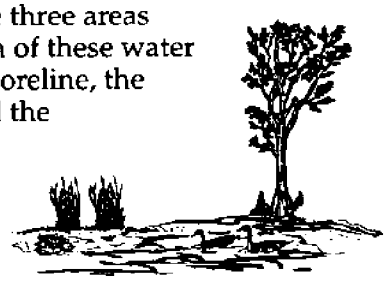
Sustainable use: Managing earth's resources in ways that will ensure a supply for future generations. For example, managing shrimp harvests so that the part harvested during one season can be replaced through reproduction and growth before the next shrimping season, ensures the probability that there will be shrimp each year.

Threatened species: A species whose population numbers are rapidly declining and is likely to become endangered in the near future.

PREVIEWING QUESTIONS AND ANSWERS

The Gulf Coast region of the United States includes all the states that border the Gulf of Mexico — Florida, Alabama, Mississippi, Louisiana, and Texas. Within this span of land there are many types of ecosystems, and each ecosystem provides habitat for a diverse group of plants, animals, fungi, and microbes. Among the most common ecosystems found in this region are freshwater lakes and ponds, pine forests, grassy meadows, and salt marshes; these ecosystems are the ones highlighted in this video module. Most students have some prior knowledge of these areas, therefore discussing the following questions should spark interest in the lesson.

1. Lakes and ponds are bodies of water completely surrounded by land. Lakes are usually larger and contain areas of differing depths and water temperatures. Ponds are smaller and more shallow than lakes. There are three areas common to each of these water bodies — the shoreline, the open water, and the bottom — the organisms that populate these areas may vary in kind (species) and/or number (density). Name a few kinds of organisms you would expect to find in each area of a freshwater lake or pond.



Shoreline *— Plants may include cattails, grass, water hyacinth, native iris, duckweed, and trees such as red maple, willow, tupelo gum, and cypress. Algae (phytoplankton) often form a green scum along the bank, especially during warm months. Common insects are dragonflies, caddisflies, water striders, and butterflies. Other animals such as nutria, beaver, ducks, herons, egrets, snakes, turtles, frogs, salamanders, and small fish, can also be found close to the water's edge.*

Open water *— Plants may include water lilies and duckweed (these also may be close to the shoreline). Algae float close to the water's surface where light is available. Fish often swim in deeper, open waters — common types are bass, perch, bream, catfish, and gar. Various insects may fly over open water.*

Bottom *— Because there is little if any light at the bottom of most lakes and ponds, vegetation (algae and plants) is usually absent. Bottom dwellers are primarily detritivores — decomposers such as bacteria and aquatic fungi and scavengers such as grass shrimp, crawfish, worms, and catfish. Freshwater mussels (filter feeders) may attach to hard surfaces or burrow partially into the mud or sand on the bottom.*

2. Pine forests are located in sandy soils throughout the Gulf Coast region. Although pines are the dominant plants, other vegetation — trees, shrubs, and herbaceous (non-woody) plants — coexists with the pines. What kinds of plants, animals and other organisms would you expect to find in a pine forest?

Answers will vary, but may include: loblolly, slash, spruce, and longleaf pines; other trees may include birch, willow, oak, hickory, magnolia, and bayberry (wax myrtle). Some shrubs are wild azalea and hawthorn parsley. Plants growing on the forest floor may include ferns, palmetto, and poison ivy. Some animals are white-tailed deer, squirrels, rabbits, snakes, and many birds. Mushrooms, bracket fungi, and lichen may also be mentioned.

3. Meadows are grassy fields which form after forested land has been cleared and left to repopulate. What kinds of organisms live in meadows?

Grasses may include Johnson grass, Bermuda grass, bahia grass, etc. Some wildflower examples are goldenrod, milkweed, yarrow, wild ageratum, and asters during late summer and fall, and ranunculus, clover, sage, lobelia, coreopsis, and black-eyed Susans during the spring. Animals which feed on and find shelter among the plants are small rodents (mice, rats, rabbits), snakes, lizards, turtles, and birds such as bobwhites, quail, meadow larks, blue birds, dove, and red-winged blackbirds. Other common organisms are insects, worms, and spiders.

When the soil in a meadow is acidic and stays wet most of the time, the meadow is called a bog. Bogs support a variety of carnivorous plants such as sundews, bladderworts, and pitcher plants.

4. Salt marshes are found in estuaries (places where saltwater from the ocean and freshwater from inland streams and rivers meet and mix) and along the coast where salt water from the Gulf merges with the land.

The land is covered with grass and is often subdivided by many narrow channels that wind inland. Daily tidal changes cause salt water from the Gulf to move into and out of the channels, changing the water depth and chemistry (salinity, pH, dissolved oxygen, etc.). Organisms that live in salt marshes must be able to adjust to these daily changes. Although the environment is harsh, salt marshes are teeming with life. Name some of the organisms you associate with salt marshes.

Plants include willows and a number of grasses, primarily cordgrass (Spartina) and black needlerush (Juncus). Algae grow on the plants and in the water. Wildflowers such as Indian blankets, oxeye daisy, goldenrod, morning glories, and saltmarsh mallow add color to the marsh from spring through fall. Animals living in the water include snails, oysters, barnacles, crabs, shrimp, and many types of fish. Nutria, muskrat, foxes, and water birds such as ibises, herons, rails, and laughing gulls are often seen in and around the water. The insects most often seen are mosquitoes and gnats.

POSTVIEWING QUESTIONS AND ANSWERS

The following questions are posed during the video. Answer them in class discussions during the viewing of the video, then allow the students to respond individually as a postviewing activity. A few options for answers are given here, more are identified in the Background Information, and of course, students may suggest answers from their own reasoning and creativity.

1. What is biodiversity?

Biodiversity is the variety of life that exists in an area. The variety may be described as the number of different species and habitats in an area, but may also include the genetic differences within a species.

2. What are some of the things that can harm biodiversity?

Destruction and degredation of natural habitats cause the greatest loss in biodiversity. Any of the following may be included as specific causes:

- *Deforestation*
- *Dredging and filling of wetlands*
- *Pollution of waterways — streams, rivers, lakes, estuaries, and the Gulf of Mexico*
- *Habitat fragmentation caused by the building of highways, shopping centers, new housing, etc.*
- *Monoculture farming and forestry*

3. Why is biodiversity important?

All the organisms in a habitat benefit from the complexity provided by a diverse community. Diversity provides more food and shelter options. Recycling essential nutrients is accomplished by a diverse community of decomposers. Diverse vegetation prevents erosion and filters pollutants from the soil and water.

Humans rely on the earth's variety of living things to provide the basics of life such as food, medicine, building materials, and clean air and water. Aside from these basic needs, diverse natural habitats provide recreational and spiritual enrichment for humans.

4. What can individuals do to maintain the variety of species and habitats in the Gulf Coast's ponds and lakes, forests, meadows and salt marshes?

Answers will vary according to the area discussed — pond, forest, meadow, marsh — but should revolve around ideas such as:

- *Learn about wildlife and their habitat needs.*
- *Take an active part in educating others about the need to protect habitats.*

- *Participate in beach clean-ups on a regular basis. Dispose of all waste wisely.*
- *Use native plants — trees, shrubs, and flowers — in their own yards and encourage others to do so as well.*
- *Follow good, sound environmental practices — reduce, reuse, recycle.*

5. What is your niche as a human being? Do you think your niche will be the same throughout life? Explain.

   Answers will vary but should reflect an understanding of the function of humans relevant to each other, other species, and the physical environment (i.e., as a part of the local and global ecosystems).

EXTENSIONS

1. **Research and writing:** Ask students to research one of the threatened or endangered species in the Gulf Coast area (refer to pages 26-28). Ask them to draw a picture of the organism and give some information about it. Where does it live? What might have led to a decline in its population? What part does it play in its habitat's food web? Why is it important? Have them conclude their assignment by writing a story or poem to describe the experience of being among the last of their species.

2. **Research and writing:** Examples of threatened habitats in the Gulf Coast region are: coral reefs, coastal wetlands, old-growth longleaf pine forests, and polluted rivers and lakes. Have students research a threatened habitat (ideally, a specific one with which they are familiar) and either write a story or take photographs to describe the habitat. They should identify and describe the activities of the plants and animals that live there, tell why the habitat is important to humans, why it is threatened, and how they would feel should it disappear.

   As another alternative, have students write the above information as if describing the habitat to a deaf or blind friend.

3. **Write a legislator:** On one side of a postcard, have students draw, color, identify, and relate the plight of an endangered or threatened species. Send the postcard to a state legislator.

4. **Make a commitment:** Provide an opportunity for students to commit to specific actions to protect biodiversity. Have them consider what they will do, plan a course of action, then write it in contract form. For example:

   I, (full name), will provide a habitat for bats in my backyard by providing a source of water and building a bat house to be placed in a tree away from our house. The bats' food will be the mosquitoes and other insects that fly through our neighborhood.

5. **Nature area:** Help students plan, plant, and maintain a natural area on the school grounds. Plant native trees and shrubs to provide shelter for animals. Make bird feeders and bird baths to supply food and water. Plant sweet smelling flowers to attract butterflies and bees. Develop a maintenance schedule to assure continuous care for the area.

6. **Debate:** Have students who enjoy debating argue the pros and cons of hunting and trapping *(cruelty to animals, the right of every animal to exist, income, food, clothes, recreation, population control).* In a class discussion, after the debate, identify each point of argument as being based on emotion or fact.

7. **Guest speaker:** Invite someone from a local wildlife organization to speak on species and habitats that are threatened or endangered in your area. Have each student write three questions to ask the speaker.

8. **Creative writing:** Using endangered coastal animals or plants as the focus of the stories, have students work in groups to compose kindergarden or lower elementary level children's books. Have them emphasize the role (niche) of the endangered species in the habitat.

9. **Role playing:** Assign each student a particular species to portray in an ecosystem (use only one ecosystem — pond, meadow, forest, or marsh — and have a food web in mind that incorporates each species). Give each student a piece of yarn 3-5 feet long and a large index-card-necklace with his/her species' common name in bold letters.

   - Have them mingle with classmates to find three or four others with whom to form a

believable food chain. The chain must include a producer, an herbivore, and two or three carnivores. Students will use the yarn to join one organism to another. Set a time limit of about 5 minutes for this part of the activity.

- Have each group justify its food chain to the class.

- Next, guide the students in forming a food web. Help them identify animals that eat more than one type of food. Using extra pieces of yarn, attach the animals to the extra food sources. (Some plants and animals may have many strings attached, indicating that they eat or are eaten by a variety of organisms.)

- Once the web is intricate, have one or two students, representing key species, leave the web (become extinct). Have students infer possible results to the ecosystem.

ACTIVITY I

WHO'S THERE?
SCHOOL YARD BIODIVERSITY INVESTIGATION

(Teacher Instructions)

Objectives

- To investigate the diversity of organisms in a habitat.
- To compare species diversity in disturbed vs. undisturbed areas.

Description

Students will work in teams to locate and identify the diversity of species in a particular school yard habitat. Some teams will investigate habitats that are subjected to much human use, while others will investigate less disturbed areas. After comparing data from the various groups, the class will discuss how human impact can affect biodiversity in a habitat.

Materials (per team)

Hand lens	Clipboard (or stiff
Pencil	cardboard with a clip)
Team tally sheet	

Preparation

1. This investigation should be done at the beginning of the module, before students view the video.
2. A few days before doing the activity, identify as many different habitats as you can find on your school campus. Examples of **undisturbed areas** are a ditch, a stream, pond or wetland area, large trees, and an overgrown flower bed. A playing field, a concrete play area or sidewalk, and a well kept flower bed are examples of **disturbed areas**. (Using a flower bed may give an interesting twist to your findings and be useful later when encouraging students to join the Backyard Habitat Program sponsored by the National Wildlife Federation.)
3. On the day of the activity, draw a chart on the chalkboard similar to the one on the Student Data Sheet (page 16). Make enough copies of the Student Data Sheet for each pupil to have one, and enough Tally Sheets (page 15) for each group to have one.

Procedure

1. Using examples that are familiar to your students, describe the major groups of organisms — bacteria, protists (algae and protozoans), fungi, plants, and animals. Teach the meaning of the terms habitat, species, and biodiversity.
2. Divide the class into teams of three or four students each, and assign each team a specific area (habitat) to investigate. (More than one team can investigate the same area, if needed.)
3. Explain that they will be trying to locate and identify all the different species that live in their assigned habitat. Relate the following:
   - Due to the time of day and the amount of activity on the school grounds, larger animals will be scarce — look for small ones such as insects, birds, and toads.

- Many organisms hide during the daytime; look carefully under leaves, logs, and straw.
- Look for plants such as grasses, wildflowers, vines, bushes, and trees.
- Some organisms grow on other organisms — Spanish moss, lichen, mistletoe.
- Students may record organisms that they hear (bird in a tree) or see evidence of (squirrel scratching a flea).
- Younger students may simply identify organisms as species 1, species 2, etc. and describe their appearance.

4. Give each team a tally sheet, pencil, clipboard, and hand lens. Have them select one person to record the team's findings on the tally sheet and on the class data chart.
5. Once outside, disperse the groups to their assigned habitat and allow 10-15 minutes for them to survey the area.
6. Return to the classroom and have each team record its findings in the correct place on the class data chart. (If two teams surveyed the same habitat, have them consolidate their data.)
7. Give each student a data sheet (page 16). Have each student copy the class data on his/her own worksheet and create a bar graph to represent the class results. (Help students determine the scale numbers for the y-axis, based on the range of data collected.)

Discussion of Results

1. Students should find the most species in areas that have been least disturbed by humans.
2. Ask students to predict the effects of habitat destruction — cutting down trees, filling in wetlands, polluting rivers and streams — on the variety of organisms in an area.
3. Emphasize that wild areas provide a huge variety of habitats that give many different organisms a place to live. When wild areas are reduced or destroyed, many species disappear from the area and along with them go their contributions to the web of life in that area.
4. Relate that during the lessons that follow on biodiversity, they will be learning more about the web of life in several types of wild areas located throughout the Gulf Coast states.

Extension

- Encourage students to join with a friend, sibling, or parent and do the same survey at a wild area near their home — forest, beach, swamp, vacant lot, etc. Have them report their findings to the class.

TEAM TALLY SHEET

HABITAT: _____

TEAM MEMBERS:

_____ _____

_____ _____

PLANT SPECIES	ANIMAL SPECIES
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15

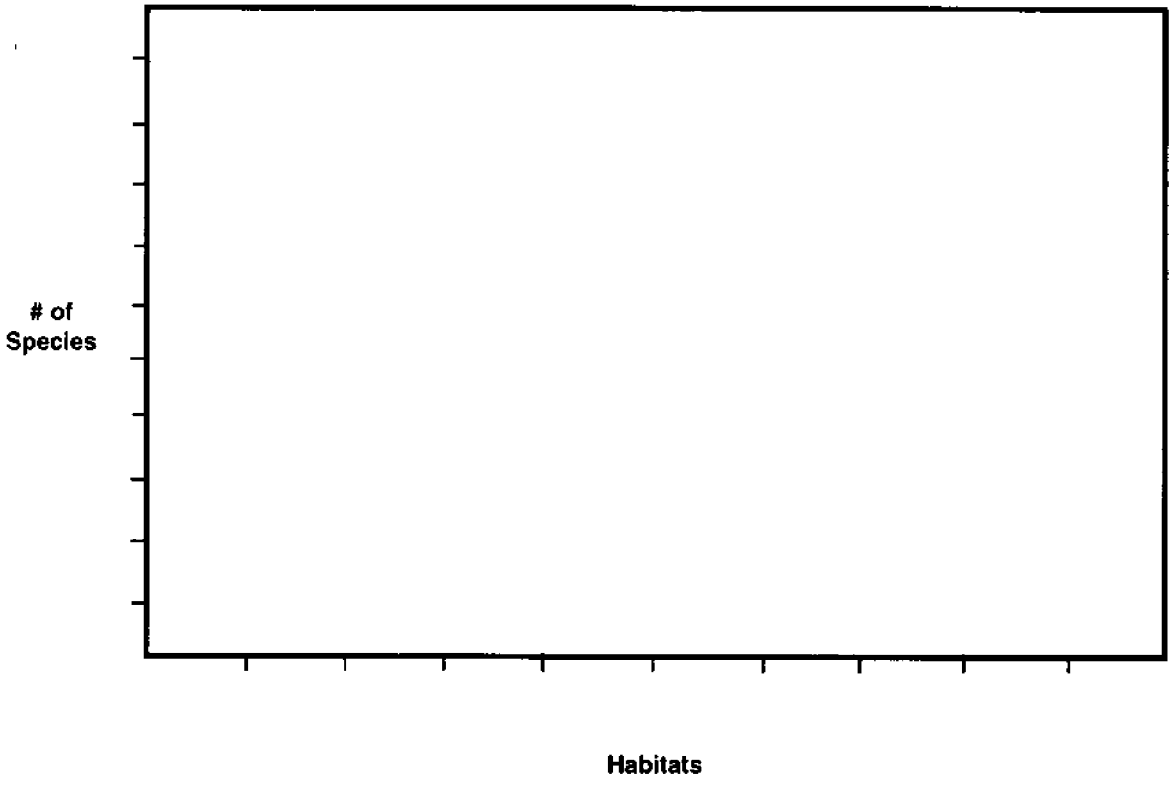
TOTAL DIVERSITY _____

STUDENT DATA SHEET

CLASS DATA CHART

Habitat	# Plant Species	# Animal Species	Total Diversity

TOTAL DIVERSITY at DIFFERENT HABITATS



ACTIVITY II

GULF GONERS

(Teacher Instructions)

Introduction

Interdependency is a thread woven throughout the theme biodiversity. Every species has a place to live (habitat) and a function (niche) in an ecosystem. Some species have multiple functions that cause them to affect the lives of many other species (i.e., oak trees produce food, provide shelter, and cycle oxygen into and carbon dioxide from the air). These affected species in turn impact many others. Therefore, when a species' habitat is lost or degraded to the point that the species can no longer live and function in the ecosystem, the loss of that species' niche may throw nature off balance.

Competition, predator-prey, and symbiotic relationships among species in an ecosystem help maintain an equilibrium known as the "balance in nature." When nature or man upsets that balance by altering the environment, factors that affect species such as the availability of food, water, shelter, and space change. These changes may create beneficial opportunities for some species, yet may jeopardize the survival of others.

Normal environmental changes, occurring gradually over thousands of years, provide enough time for natural selection to equip species with adaptations that allow their survival. But in the past two centuries, especially the last 50 years, changes to habitats have accelerated — deforestation, pollution, saltwater intrusion, invasion of exotic species, and erosion.

Changes in an ecosystem may benefit some species. More often, though, abrupt changes kill members of some species outright or interfere with their natural functions — niches. Either way, the loss of the species' contributions to the interconnected workings of the ecosystem results in a decline in biodiversity.

The following game, Gulf Goners, will help students identify ways that environmental changes affect species with various characteristics. It will also suggest some harmful and helpful human activities that impact biodiversity.

Objectives

- To relate the effects of environmental changes on animals with differing characteristics.
- To identify some human activities that affect biodiversity.

Description

Students will design and name an animal, using choices provided under the habitat, food, reproduction, and movement headings on the **Animal Characteristics** list. The teacher will then read a series of scenario cards. Each scenario describes an environmental change and tells its impact on animals with particular characteristics. If the animal is adversely affected by the change, the student will place a "gotcha" chip on her/his game card. If the species is helped by the change, the student will remove a chip from the card. After reading 12 to 15 scenarios, the results will be evaluated and discussed.

Materials

Gulf Goners game cards
Animal Characteristics list
Scenario description cards
"Gotcha" chips (dry beans, beads, pennies, etc.)
Pencils

Preparation

1. Make enough copies of the game cards for each student to have one.

2. Using colored card stock, make copies of the scenario pages, then cut out and laminate the individual cards.

3. Purchase enough "gotcha" chips to allow eight chips per student. (Dried red beans are ideal.)

4. On the day of the activity, display the Animal Characteristics list so it can be easily seen by all students. Use an overhead transparency, poster board, or write on the chalkboard.

Procedure

1. When directed by the video, stop the tape and distribute one game card and eight "gotcha" chips to each student.

2. Relate the purposes of the game — to show how animals with differing characteristics are affected when their habitat changes and to identify human activities that affect biodiversity.

3. Have each student create an imaginary animal by doing the following:

   - Select one characteristic from each category on the Animal Characteristics list.
   - Record the choices in the blanks on the left side of the game card.
   - Draw the animal in the space below the game grid.
   - Give the animal a name and write it at the top of the game card.

   (Once the game begins, students cannot change their animal's characteristics.)

4. Briefly describe the game

   - Scenario cards will be read that describe a change in the environment.
   - Depending on the animal's characteristics, it will be adversely affected by the change (add a "gotcha" chip), or helped by the change (lose a "gotcha" chip).
   - Students will record changes that harm and help their animal in the chart at the bottom of the game card.
   - The removal of "gotcha" chips cannot be "banked." (For example, if a scenario card says to remove two chips, but there is only one chip on the card, the student may not save the extra chip removal for later in the game.)
   - The goal is to finish the game with as few "gotcha" chips on the card as possible. Once a card is full — eight "gotcha" chips — the animal is extinct and the student must stop playing.

5. Before beginning the game, practice once by reading one of the scenario cards and relating the procedure. Answer any questions.

6. The scenario cards can be read by the teacher or a student. After reading a scenario card, set it aside or put it at the bottom of the stack. (OPTIONS: Have different students read scenarios to the class. Once students are comfortable with the game format, have them predict the effect of the change; remind them to consider all elements of the habitat — food, water, shelter, space.)

7. The duration of a game can be determined by the teacher — 12 to 15 scenarios should be sufficient to achieve the objectives.

Discussion of Results

1. Have each student evaluate the status of his or her animal.

   - A full card (eight "gotcha" chips) — the animal became **extinct**.
   - Five to seven chips — the animal is **endangered**.

- Three or four chips — the animal is **threatened**.

- Two or fewer chips — the animal is well enough **adapted** to survive in its modified environment.

2. Determine how many imaginary animals are in each category — extinct, endangered, threatened, well adapted.

3. Referring to their charts, have students discuss the helpful and harmful changes. Are they aware of such changes occuring in their neighborhood or in the town? Are they familiar with local and national groups that work to protect the environment?

4. Continue the video.

Extension

- Have students brainstorm some additional conditions that may be "gotchas" for species with specific characteristics and create both helpful and harmful scenarios for another game.

ANIMAL CHARACTERISTICS

HABITAT REQUIREMENT

Salt Marsh
River
Pine Forest
Meadow

FOOD SOURCE

Mammals
Small Fish
Plankton
Plants

METHOD OF REPRODUCTION

Lay eggs in water
Lay eggs on land
Live birth
Fission (simple cell division)

METHOD OF MOVEMENT

Fly
Walk
Swim
Stationary

GULF GONERS
GAME CARD

My Name _____

My Animal's Name _____

Habitat Requirement:

_____

Food Source:

_____

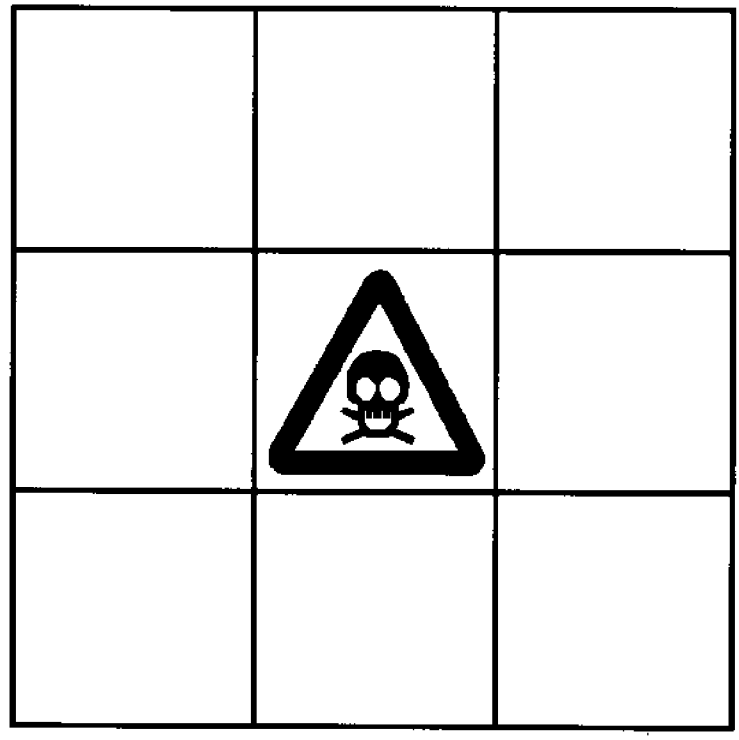
Method of Reproduction:

_____

Method of Movement:

_____

Sketch of Animal:



Ways my animal was helped and harmed:

HELPED	HARMED

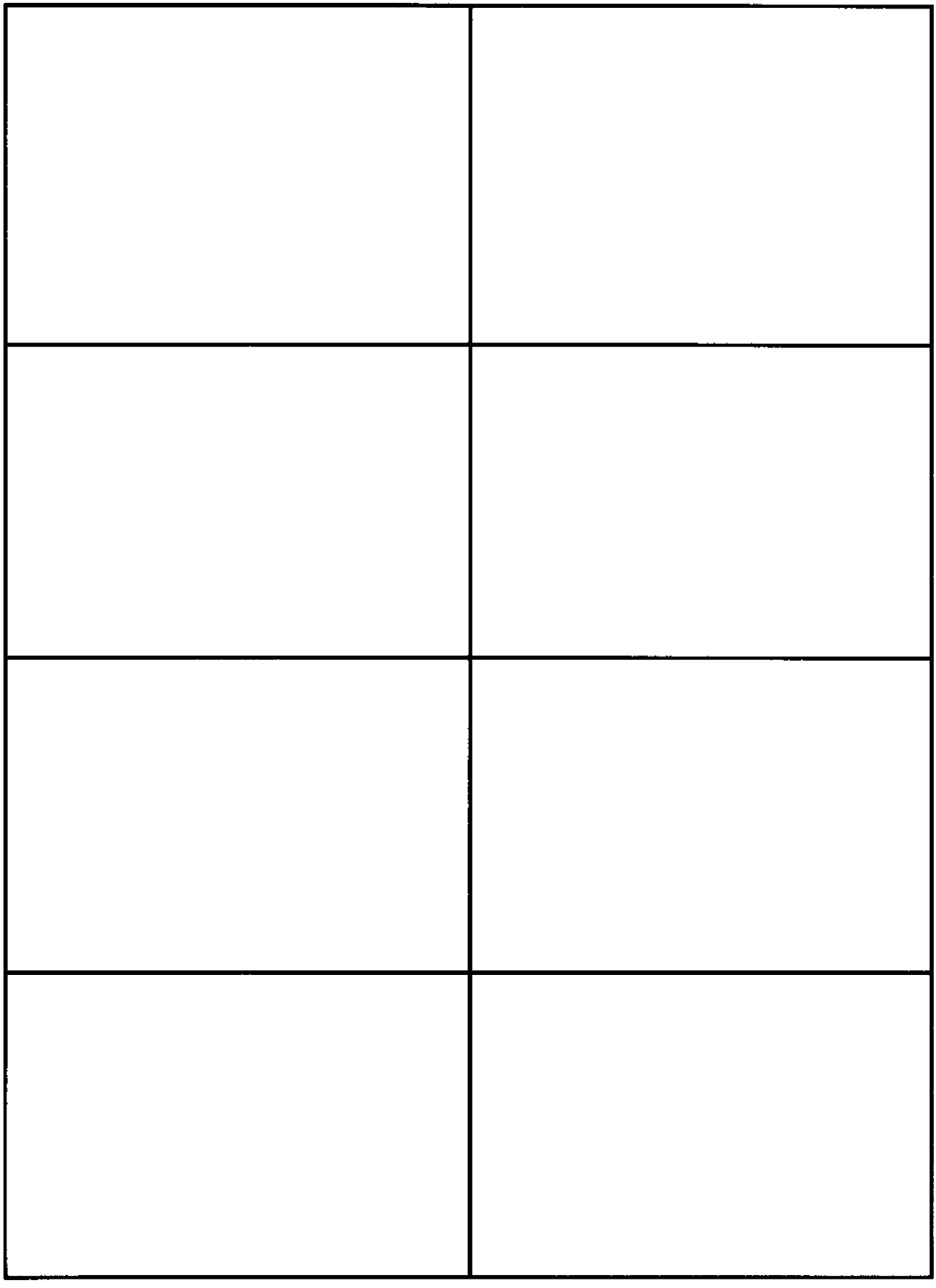
SCENARIO CARDS

A massive oil spill occurs. In an effort to remove the oil from the feathers of birds, well-meaning humans bathe the birds with liquid dish washing soap. The soap washes away natural oils in the feathers. Lacking the protection and water repellence from these oils, the birds have difficulty flying or swimming. If your method of movement is flight or swimming, add one "gotcha" chip to your card.	When vehicles are banned from a grassy meadow, the lives of many land-based organisms are saved. If your method of movement is walking, remove one "gotcha" chip. If your method of reproduction is to lay eggs on land, you may remove a "gotcha" chip.
A gambling boat has a sewage spill which contaminates the water. The sewage is toxic to many fish, causing a large fish kill. As the sewage decays, the released nutrients encourage rapid growth and reproduction of algae; this is called an algal bloom. If your habitat is the river, add one "gotcha" chip. If you eat small fish, add another chip. If you eat algae (plankton), take away a chip.	A ten year warming trend has resulted in melting glaciers and a rise in sea level. Many low-lying coastal areas, which were once brackish, are now under water and the soil and water have become more salty. Those species unable to adapt to this increased salinity have died off. If your habitat is the salt marsh, add one "gotcha" chip.
When a truck carrying hazardous waste collides with a bridge railing, the truck's tank is damaged and the waste spills into the river. The pollution interferes with cell division in living organisms. If your habitat is the river, add one "gotcha" chip. If your method of reproduction is fission (simple cell division), add another "gotcha" chip.	Ozone depletion has resulted in increased amounts of UV light penetrating earth's atmosphere. The excess UV light damages living cells and kills many types of plankton, a source of food for many small fish. If your source of food is plankton or small fish, add one "gotcha" chip to your card.
A factory releases heated water into a river. This thermal pollution makes it impossible for eggs to hatch that are laid in the immediate area by fish, amphibians and insects. The warmer water, however, creates a perfect environment for an exotic species of sea grass. If your environment is a river, and you lay eggs in the water, add one "gotcha" chip. If your environment is a river and you depend on plants for food, remove one "gotcha" chip.	A new shopping area is being built on a meadow. Bulldozers have destroyed your nesting area and have crushed the small, slow moving animals in the immediate area. If you live in a meadow and lay eggs on land, add one "gotcha" chip. If your method of movement is walking, add a "gotcha" chip.

An ocean liner is transporting chlorine to be used in coastal water treatment plants. The captain of the ship falls asleep at the helm and the ship runs aground in a marsh area. Damage to the ship causes the chlorine to leak into the water. Most of the mobile animals get away, but stationary animals such as oysters and barnacles die. If you are a stationary animal living in a marsh, add one "gotcha" chip.	Seven hundred acres of an old growth pine forest are about to be clear cut. An environmental group successfully lobbies for this area's preservation so that the forest is protected under federal law. You may remove one chip if your habitat is a pine forest.
For years, many pleasure boaters have dumped their trash in the middle of lakes, rivers, and bays. Plastic six-pack rings are especially dangerous to animals that swim; they get caught in the rings which then restrict their growth and movement. If you live in a river or marsh, add one "gotcha" chip. If your method of movement is swimming, add another "gotcha" chip.	CURE-ALL Pharmaceutical Company has discovered a new drug derived from the seed pods of a wildflower native to Gulf Coast meadows. In harvesting the plant, the environment is damaged. If your habitat is a meadow, add one "gotcha" chip. If you eat plants, add a second chip.
A local toxic waste disposal firm reports that high levels of poison were accidentally released. The toxins create a variety of health risks on land and in water, including spontaneous abortions in mammals. If your method of reproduction is live births, add one "gotcha" chip to your card.	When an alternative source of energy ends our need for fossil fuels, oil drilling along the Gulf of Mexico coastline is halted. If you live in a salt marsh, you may remove one chip.
A new phosphate plant and a fertilizer plant are both located on the same mouth of a river near a salt marsh. The phosphate plant has an accidental chlorine leak at the same time the fertilizer plant has an ammonia leak, resulting in the formation of deadly ammonium chloride. If your habitat is a salt marsh or river, add one "gotcha" chip.	When a power company sprays an herbicide under its power lines, trees, shrubs, and other vegetation are killed. If you eat plants, add one chip. If you live in a forest, add two chips.

Land developers are filling in a local marsh area to provide more waterfront property for building homes. If you live in a marsh add one "gotcha" chip. If you eat small fish or plankton, add one chip.	A garden club successfully campaigns to preserve the wildflowers in a local meadow. If you live in a meadow, remove one "gotcha" chip.
The voters of a city approve the building of an airport on a large local meadow. If you live in a meadow, add one "gotcha" chip. If your method of movement is flying, add a chip.	In order to earn money to repair and build streets, a city council votes to allow toxic waste incineration near your habitat. The harmful fumes enter the air, and are transported by wind in all directions, all habitats are affected. Everyone add one "gotcha" chip.
Local students join a beach cleanup program and over a year's time, collect two tons of garbage from local wetland areas. If your habitat is a salt marsh or river, remove one "gotcha" chip.	Some agricultural crops are sprayed with pesticides from crop duster airplanes. Wind transports the pesticides to areas beyond the planted fields, polluting water and coating other vegetation. If your food source is plants or plankton, add one "gotcha" chip.
Deforestation continues at an alarming rate, as forests are cleared for residential, agricultural, business, and highway development. The trees, shrubs and wildflowers in forests provide food and shelter for many animals. If you live in a pine forest, add one "gotcha" chip. If you depend on plants or mammals for food, add a "gotcha" chip.	Last year, legislation signed to stop the dredging in a local salt marsh allowed the community of organisms that live in the marsh to once again flourish. If you live in a marsh, remove one "gotcha" chip. If you depend on small fish for food, you may remove a second chip.

EXTRA SCENARIO CARDS



SOME THREATENED (T) AND ENDANGERED (E) SPECIES IN THE GULF COAST STATES

U. S. Fish and Wildlife Service

COMMON NAME	SCIENTIFIC NAME	STATE(S)	FEDERAL STATUS
PLANTS			
Alabama Canebreak Pitcher-plant	*Sarracenia rubra alabamensis*	AL	E
Alabama Leather Flower	*Clematis socialis*	AL	E
American Heart's-tongue Fern	*Phyllitis scolopendrium*	AL	T
Florida Golden Aster	*Chrysopsis floridana*	FL	E
Florida Skullcap	*Scutellaria floridana*	FL	T
Green Pitcher-plant	*Sarracenia oreophila*	AL, FL	E
Mohr's Barbara's Buttons	*Marshallia mohrii*	AL, FL	T
Pygmy Fringe Tree	*Chionanthus pygmaeus*	FL	E
Pondberry	*Lindera melissifolia*	MS, FL	E
Price's Potato-bean	*Apios priceana*	MS, AL	T
Smooth Coneflower	*Echinacea laevigata*	FL	E
Tennessee Yellow-eyed Grass	*Xyris tennesseensis*	AL, FL	E
Texas Prairie Dawn Flower	*Hymenoxys texana*	TX	E
Texas Trailing Phlox	*Phlox nivalis*	TX	E
INVERTEBRATES			
Alabama Moccasinshell Mussel	*Medionidus acutissimus*	MS, FL, AL	T
Fine-lined Pocketbook Mussel	*Lampsilis altilis*	AL, FL	T
Heavy Pigtoe Mussel	*Pleurobema taitianum*	MS, AL	E
Inflated Heelsplitter Mussel	*Potamilus inflatus*	AL, LA	T
Orange-nacre Mucket Mussel	*Lampsilis perovalis*	MS, AL	T
Ovate Clubshell Mussel	*Pleurobema perovatum*	MS, AL, FL	E
Southern Acornshell Mussel	*Epioblasma othcaloogensis*	AL, FL	E
Southern Clubshell Mussel	*Pleurobema decisum*	MS, AL, FL	E
Southern Combshell Mussel	*Epioblasma penita*	MS, AL, FL	E
Triangular Kidneyshell Mussel	*Ptychobranchus greeni*	AL, FL	E
Upland Combshell Mussel	*Epioblasma metastriata*	AL, FL	E

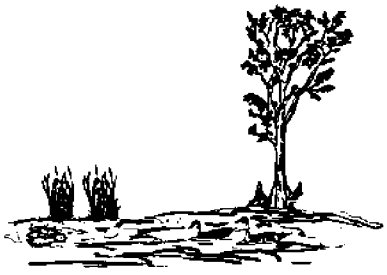
COMMON NAME	SCIENTIFIC NAME	STATE(S)	FEDERAL STATUS
FISH			
Bayou Darter	*Etheostoma rubrum*	MS	T
Blue Shiner	*Cyprinella caerulea*	AL	T
Gulf Sturgeon	*Acipenser oxyrhynchus desotoi*	MS, AL, LA, FL	T
Pallid Sturgeon	*Scaphirhynchus albus*	MS, LA	E
Snail Darter	*Percina tanasi*	AL, FL	T
AMPHIBIANS AND REPTILES			
Alabama Red-bellied Turtle	*Pseudemys alabamensis*	AL, FL	E
Blue-tailed Mole Skink	*Eumeces egregius lividus*	FL	T
Eastern Indigo Snake	*Drymarchon corais couperi*	MS, AL, FL	T
Gopher Tortoise	*Gopherus polyphemus*	MS, LA	T
Green Sea Turtle	*Chelonia mydas*	TX, LA, MS, AL, FL	
Hawksbill Sea Turtle	*Eretmochelys imbricata*	TX, LA, MS, FL	E
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	TX, LS, MS, AL, FL	E
Leatherback Sea Turtle	*Dermochelys coriacea*	TX, LA. AL, FL	E
Loggerhead Sea Turtle	*Caretta caretta*	TX, LA, MS, AL, FL	T
Red Hill Salamander	*Phaeognathus hubrichti*	AL	T
Ringed Sawback Turtle	*Graptemys oculifera*	LA, MS	T
Salt Marsh Snake	*Nerodia fasciata taeniata*	FL	T
BIRDS			
Attwater's Prairie Chicken	*Tympanuchus cupido attwateri*	TX, LA	E
Bachman's Warbler	*Vermivora bachmanii*	LA, FL	E
Bald Eagle	*Haliaeetus leucocephalus*	TX, LA, MS, AL, FL	T
Brown Pelican	*Pelicanus occidentalis*	TX, LA, MS	E
Florida Scrub Jay	*Aphelocoma coerulescens*	FL	T
Kirtland's Warbler	*Dendroica chrysoparia kirtlandii*	FL	E
Least Tern	*Sterna antillarum*	TX, LA, MS	E
Mississippi Sandhill Crane	*Grus canadensis pulla*	LA, MS	E
Peregrine Falcon	*Falco peregrinus*	TX, LA, FL	T
Piping Plover	*Charadrius melodus*	TX, LA, AL, FL	T
Red Cockaded Woodpecker	*Picoides borealis*	TX, LA, MS, AL, FL	E
Whooping Crane	*Grus americana*	TX, LA	E
Wood Stork	*Mycteria americana*	AL, FL	E

COMMON NAME	SCIENTIFIC NAME	STATE(S)	FEDERAL STATUS
MAMMALS			
Black Bear	*Ursus americanus luteolus*	MS, LA	T
Blue Whale	*Balaenoptera musculus*	LA	E
Finback Whale	*Balaenoptera physalus*	LA	E
Florida Panther	*Felis concolor coryi*	LA, FL	E
Gray Bat	*Myotis grisescens*	AL, FL	E
Indiana Bat	*Myotis sodalis*	AL, FL	E
Jaguarundi	*Felis yagouaroundi cacomitli*	TX	E
Key Largo Cotton Mouse	*Peromyscus gossypinus allapaticola*	FL	E
Lower Keys Rabbit	*Sylvilagus palustris hefneri*	FL	E
Manatee	*Trichechus manatus*	LA, FL	E
Ocelot	*Felis pardalis*	TX	E
Southeastern Beach Mouse	*Peromyscus polionotus*	AL, FL	E

T = threatened E = endangered

EVALUATION QUESTIONS

MATCHING: Using the choices in the left column, identify the habitat described in the right column. Write its name in the space provided. There is one **BEST** answer for each.



Pond or Lake

Pine Forest

Meadow

Salt Marsh

_____ 1. Provides wood for making homes, furniture, and paper

_____ 2. Decorates the land with many wildflowers during spring, summer, and fall

_____ 3. Body of water completely surrounded by land — home to species such as water lilies, beavers, and salamanders

_____ 4. Hiding place where many types of baby marine animals — shrimp, crab, turtles, and fish — grow

_____ 5. *Spartina*, commonly called cordgrass, is the vegetation most typical of this harsh coastal habitat

_____ 6. Place where people hunt deer, turkey, and squirrel for food

_____ 7. Resting place for many birds that migrate north in the spring and south in the winter

_____ 8. A cleared, open place where trees once grew — home to many insects, weedy plants, and small mammals such as mice and rabbits

MULTIPLE CHOICE: Select the **BEST** answer for each statement.

1. A species that has died out and is gone forever from the earth is described as

   A. threatened
   B. exotic
   C. endangered
   D. extinct

2. Which of the habitats below would suffer the most from the wreck of a fuel tanker transporting oil in the Gulf of Mexico.

   A. salt marsh
   B. freshwater pond
   C. grassy meadow
   D. pine forest

3. A squirrel's niche is to

   A. replenish the air with oxygen
   B. live in a meadow
   C. eat acorns and pine cones
   D. decompose dead plants and animals

4. The place that provides food, water, shelter and space for an organism is its

   A. niche
   B. habitat
   C. life cycle
   D. food chain

5. Sparrows, bluebirds, cardinals, and blackbirds are

   A. different species
   B. endangered species
   C. in the same food chain
   D. predators of hawks

6. A believable food chain is (arrows point to the consumer)

   A. beetle → clover → snake → toad
   B. pine tree → hawk → dandelions → rabbit
   C. algae → snail → raccoon → crawfish
   D. decaying leaves → earthworm → robin → cat

7. Which of the following statements best describes the relationship between biodiversity and the size of the human population?

   A. Greater diversity leads to increased human population.
   B. Greater human population leads to increased biodiversity.
   C. Greater human population leads to reduced biodiversity.
   D. There is no relationship between biodiversity and the size of the human population.

8. Which of the following changes could have caused the disappearance of a species of green frogs from a stream where it once lived.

   A. Weed killers entered the stream when a farmer over sprayed his nearby fields.
   B. Water levels dropped drastically when a newly built dam diverted the water to use in a power plant.
   C. Repeated insecticide spraying to kill the mosquitoes in a nearby town resulted in the death of many insects.
   D. All the changes could have harmed the frogs, causing them to disappear.

9. The biodiversity of a salt marsh would be harmed most by the loss of the

   A. grass shrimp
   B. marsh grass
   C. blue crab
   D. brown pelican

10. Biodiversity is

    A. the variety of species in an area
    B. the number of different habitats in an area
    C. the number of differences among members of the same species
    D. All of the above describe biodiverstiy.

11. Which of the following is an adaptation in bullfrogs?

    A. They help control the size of insect populations.
    B. They can produce their own food by photosynthesis.
    C. The color variations in their skin help hide them in the environment.
    D. All of the above are adaptations in bullfrogs.

12. A place where living things interact with each other and with the nonliving environment is called a(n)

    A. wetland
    B. ecosystem
    C. niche
    D. community

DISCUSSION: Use your best writing skills — spelling, punctuation, grammar — in responding to the following statements.

1. In your opinion, what is the most important ecological, economical, **or** ethical reason for maintaining biodiversity in the Gulf Coast region and throughout the world? Support your opinion with an example, and in your explanation, use at least two terms you learned during the lessons on biodiversity.

2. Demonstrate your understanding of food chains by diagramming a believable one in which you are the top consumer. Identify the producer, herbivore, and carnivores. Name the Gulf Coast habitat where these organisms live.

   - [BONUS: Create a food web using your food chain as the beginning.]

3. Name three things you, as a citizen of the Gulf Coast region, can do to help maintain biodiversity.

EVALUATION - ANSWERS

MATCHING:

1. Pine Forest
2. Meadow
3. Pond or Lake
4. Salt Marsh
5. Salt Marsh
6. Pine Forest
7. Salt Marsh
8. Meadow

MULTIPLE CHOICE:

1. D
2. A
3. C
4. B
5. A
6. D
7. C
8. D
9. B
10. D
11. C
12. B

DISCUSSION:

The following examples of answers should be modified by the teacher to fit appropriate grade level expectations.

1. Answers will vary but should describe some ecological, economical, or ethical reason for maintaining biodiversity. A specific example of why the reason is important should be cited in which several associated terms are used correctly or defined. For example:

   Ecological reason — *Biodiversity should be maintained in order to preserve the balance in nature. An example might focus on the nature of food chains and food webs, predator/prey relationships, or niches that, if disrupted, would weaken the ecosystem.*

   Economical reason — *The hunting, fishing, and trapping of various species provide a livelihood for many humans. Forestry provides wood for making homes, furniture, paper and other products. Diverse habitats offer a variety of recreational opportunities which in turn fuel the tourist economy. Associated terms may include sustainable use, species, habitats.*

   Ethical reason — *Humans, as the dominant species on earth, have a responsibility to use the earth and its resources in ways that insure a healthy and diverse environment for future generations. Examples may focus on the plight of endangered and threatened species and habitat loss and degradation. Associated terms may include sustainable use, extinct species, endangered species, threatened species, habitat fragmentation, deforestation, niche, etc.*

2. Look for three parts in this answer.

   a. The appropriate flow in a food chain: producer → herbivore → carnivore(s)

   b. Specific organisms (species) that fit the categories (part a) — student's name (or the word human) must be last in the chain.

   c. The identity of the ecosystem or habitat where the organisms live.

   Examples:

   SALT MARSH

   ALGAE → ZOOPLANKTON → TROUT → HUMAN
   (producer) (herbivore) (carnivore) (carnivore)

   or

   MEADOW

   GRASS SEEDS → DOVE → HUMAN
   (producer) (herbivore) (carnivore)

   - For the BONUS portion of the question, award points based on the number of correct branching connections shown. *(See example in the Background section on page 2.)*

3. There are a number of possible responses. Accept any that you think are reasonable. You might offer the HINT: Save, Study, Use Sustainably, then look for answers that reflect that philosophy.

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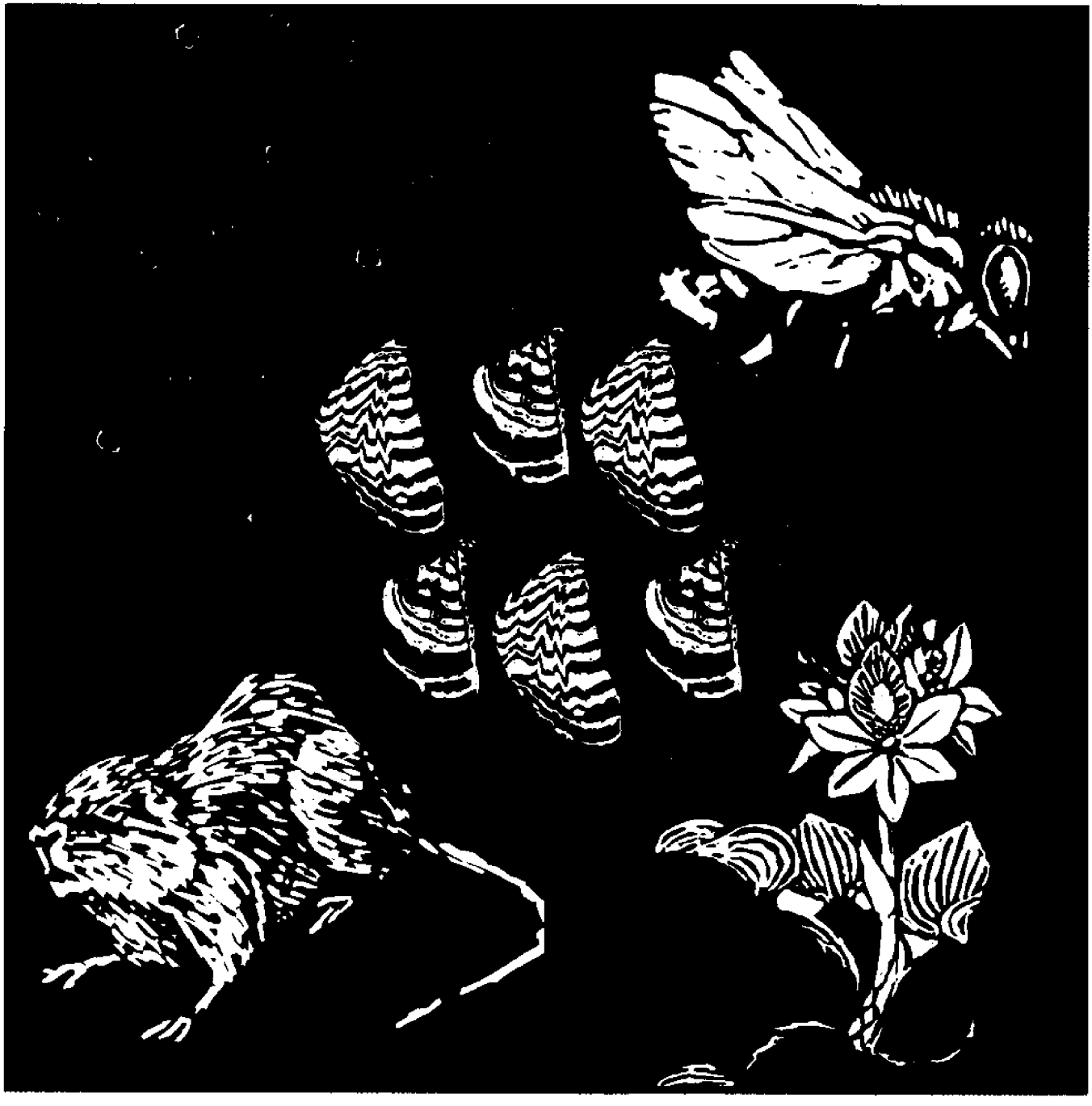
EXOTIC SPECIES



Project TELLUS: Interactive Science Videos on Global Change Issues

EXOTIC SPECIES

LEARNING OBJECTIVES

Students should be able to:

1. Define exotic and native species and cite examples of each from the Gulf Coast region.
2. Identify adaptations which allow exotic species to succeed in new areas.
3. Cite both positive and negative reasons for introducing exotic species in the Gulf Coast area.
4. Predict the impact of introducing a specific organism to a known environment.
5. Suggest possible plans for the containment of specific exotic species.

INTRODUCTION

Humans are not the only immigrants to the United States. Thousands of animal, plant, and microbial species are also newcomers to this country. Because they were brought to the United States from another country, they are called **exotic species**. Some exotics have been introduced intentionally by man, while others have entered accidentally in ships' ballast waters, in packing materials, attached to other plants or animals, or even in hurricane winds.

Man has introduced some exotic species in an effort to improve the quality of human life. Cattle, pigs, wheat, and soybeans are exotics that are controlled by farmers and are therefore agriculturally beneficial. Many Americans enjoy tropical fish, birds, and snakes as pets and use foreign plants such as roses and tulips to beautify their yards. But some exotic species are able to adjust successfully in the wild. These reproduce and spread outside their designated **habitat**.

Exotic species that make their way into natural ecosystems (into the wild) can threaten native habitats and the organisms in them. They may have **adaptations** that allow them to outcompete the **native species** for food, shelter, or space. Eventually they may even displace natives that occupy the same or similar **niches**. When no natural predators of an exotic species exist in its adopted **environment**, its population grows unchecked, causing further pressure on the established **ecosystem**. Populations of exotic species sometimes increase uncontrollably, interfering with human activitites such as industry, agriculture, and recreation.

Because of its mild climate and geographical location, the Gulf Coast region has been particularly susceptible to the invasion and spread of exotic species. Water hyacinth, kudzu, Africanized honey bees, nutria, Argentine fire ants, and zebra mussels are examples of exotic species that have adapted quickly and easily to the Gulf Coast environment.

BACKGROUND INFORMATION

The following information will be helpful in discussing exotic species prior to viewing the video and in guiding students toward logical and meaningful conclusions throughout the viewing and postviewing activities.

Water Hyacinth
Eichhornia crassipes

One of the most troublesome of the Gulf Coast's exotic plants is the water hyacinth. This beautiful, free-floating **aquatic** herb inhabits most lakes, bayous, **swamps**, and freshwater **marshes** of the coastal states from early spring through the first hard freeze of winter. It is easily recognized by its flowers, which are lavender and blue with a conspicuous yellow spot in the top petal. The flowers are arranged in a spike that is held erect above a floating cluster of leaves.

Water hyacinths are native to Central and South America but were brought into the United States for an exposition held in New Orleans in 1884. Because of their beauty, they were admired by many exposition attendees who enthusiastically divided the plants and took them home to add to backyard ponds. By 1900 they had escaped cultivation and had become a serious pest, clogging waterways throughout the coastal states.

The water hyacinth's success in its new habitat can be traced to a number of adaptations.

- They reproduce vegetatively through **fragmentation**. If a plant is broken into pieces (fragmented), each piece can root and grow into a new plant. Fragmentation may be caused by the churning blades of boat motors, the thrashing of swimming and grazing animals, and water agitation during stormy weather.
- Their stems are hollow in the middle and lined with spongy tissue, facilitating floatation.
- Their leaves are fanlike and slightly cupped; as the wind blows, the plants are spread from one area to another like little sailboats.
- The plants are fed nutrients, water, and carbon dioxide through a dense, feathery network of roots.

With these advantages, water hyacinths are able to cover the surface of their aquatic habitat in a relatively short period of time.

The effects of water hyacinths on natural systems can be devastating. As the hyacinths cover the water surface, they restrict life sustaining sunlight to submerged native plants. Eventually the shaded plants die and decay. The decaying process depletes the amount of dissolved oxygen in the water. As the oxygen level declines, fish such as bass, perch, and bream either die or seek new habitat areas leaving less desirable fish — catfish, carp, and gar — to populate the water.

Humans are also affected by the invasive overgrowth of water hyacinths. Dense mats of the plants interfere with boat navigation, clog drainage systems, and prevent fishing, swimming and other recreational activities. When water quality declines, everything that depends on the water for food, drink, habitat, or recreation suffers.

For the most part, efforts to control water hyacinth **populations** have been unsuccessful.

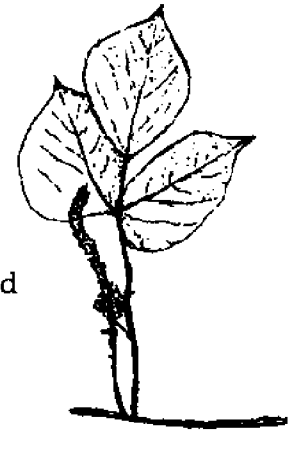
- Mechanical croppers cannot reach all the plants and may increase fragmentation among the plants that remain.
- Because the herbicides that are most effective have harmful side effects on the ecosystem, they are seldom used.
- The use of natural predators (a weevil species from Argentina and a carp species from the Soviet Union feed on water hyacinths) would mean introducing other exotic species that may, in time, become as much of a pest as the hyacinth itself.

When growing out of control, water hyacinths are a nuisance, but some researchers have suggested uses for this exotic that would make it a harvestable resource.

- Use as a food for cattle.
- Use as a fertilizer and soil conditioner.
- Produce a biogas fuel similar to natural gas to meet some energy needs.

Other research has shown that water hyacinths may be useful in removing harmful chemicals from polluted waterways. Even though these are all possible uses, so far, the negative impact of these aquatic plants on their adopted habitat far outweighs their contributions to the environment.

Kudzu
Pueraria lobata



Another exotic plant that is wreaking havoc throughout the Gulf Coast region is kudzu. This perennial, high-climbing, leafy vine can grow as much as 60 feet in a single growing season and as much as 12 inches in a day. As it grows, kudzu covers shrubs, trees, and everything else in its way.

From a distance, a forest or field covered with kudzu may appear to be a wavy sea of green leaves.

Kudzu was introduced to the United States from the Orient by a Japanese delegation exhibiting at the 1876 Centennial Exposition in Philadelphia. Because kudzu is a fast growing cover plant, the Japanese used it to shade and decorate their pavillion. To sweltering southern exposition attendees, kudzu seemed so effective in shading the pavillion that many took cuttings home to plant around their porches for shade. In the warm, humid south kudzu did indeed grow and spread like wildfire.

Kudzu's success in its adopted environment can be attributed to a number of factors.

- It spreads quickly by producing horizontal stems called runners. When these runners contact a moist surface, they begin to produce their own roots and eventually their own horizontal stems. Once rooted, the runner can continue to grow even if it becomes detached from the parent plant.

- Throughout the growing season, kudzu produces and stores an abundance of starch (a food source) in its extensive root system. These roots survive the winter months and provide a storehouse of quick energy for new growth when light and temperature conditions are favorable in the spring.

- Because farm animals — goats, hogs, chickens and cows — readily eat this vine, rich in protein and vitamins A, C, and D, farmers during the early 1900s planted kudzu on their land so it could be used as a feed supplement.

- Like clover and alfalfa, kudzu is a nitrogen-fixing legume, which means that it can convert atmospheric nitrogen into compounds that can be used by the plant for growth. Before kudzu became a nuisance, farmers were encouraged to grow and then plow under kudzu so that its decomposition would release nitrogen compounds to restore soil fertility.

- During the 1930s and 1940s, kudzu's ability to quickly cover eroding gullies was heralded as a quick fix for America's erosion problems. Subsequently, the government funded the planting of 84 million kudzu seedlings along highway and railway embankments. The seedlings thrived.

By the mid 1900s people throughout the south — especially in the Gulf Coast region where mild winters allow kudzu to grow year round — were becoming disenchanted with this exotic plant that was spreading over the landscape. It was adversely affecting the native ecosystem by:

- over-shading and causing the eventual death of the covered plants

- interfering with power lines and rights-of-way

- preventing the establishment of new tree seedlings

- destroying the food supply of many wild animals

Kudzu continues to cause the same problems today. The following methods are being used to help control its growth:

- overgrazing by farm animals

- regular cultivating or disking

- burning it with ground fires

- killing it with herbicides such as ©Roundup.

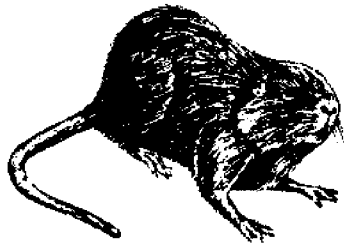
Even though kudzu becomes an environmental nuisance when unattended, some hold hope for its use as an agricultural product. In the Orient, where human overpopulation makes space a premium, this fast growing vine is a valuable resource.

- Its fibrous stems are used to make cloth and a high-quality paper.

- A powdered starch made from its roots is used as an ingredient in beverages, noodles, salads, jelled desserts, and sauces.

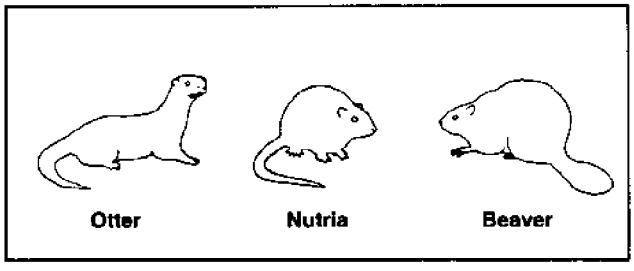
- Kudzu-based medicines are used for the treatment of ailments ranging from acid indigestion and gonorrhea to alcoholism.

Nutria
Myocastor coypus



The nutria is a South American animal species that has made a new home in the Gulf Coast region. These furry animals live in wetland areas and look very much like huge rats (an average adult nutria weighs about 12 pounds) hence their nickname, "swamp rats." Like their relatives — mice, beaver, muskrat, and gophers — nutria are gnawing mammals that belong to the order Rodentia.

With claws on their front feet and webbing on their hind feet, nutria move effectively on land and in water. During the day, they swim leisurely, resting occasionally in burrows that they build in the banks of the wetland areas they inhabit. During the night hours, they eat and seek mates.



Comparison of similar aquatic mammals

Nutria are **herbivores** that feed primarily on **aquatic** plants such as water hyacinth, alligator weed, and young cypress trees. Typical of most rodents, they have a high reproductive potential. When food supplies are plentiful and other habitat conditions are good, females may begin breeding by four months of age, and have litters of four to six young twice or three times a year. These two attributes — having a diverse diet and being prolific — have contributed to the nutria's success in adapting to their adopted habitats in the Gulf Coast region.

Like beaver, nutria have a dense, velvety fur, which is ideal for making into coats. In 1938, hoping to spur the Louisiana fur industry, E.A. McIlhenny (the Tobasco sauce magnate) imported 20 nutria from Argentina and placed them in specially constructed enclosures. In captivity, well fed, and free of natural **predators** — alligators, eagles, large snakes, garfish, and turtles — his nutria flourished. Unfortunately, during a hurricane some of the animals escaped.

Nutria were also imported and deliberately released in coastal states during the early 1940s to help curb the spread of undesirable aquatic plants that were clogging waterways. By 1943 (only five years after their introduction in Louisiana), the animals could be found in ponds, swamps, freshwater marshes, lakes, and rivers throughout the coastal area.

By the late 1940s trappers were harvesting nutria and selling their soft pelts. The fur industry began to grow; during its peak between 1977 and 1984, an average of 1.3 million pelts were being harvested annually from Louisiana alone. Then, in the late 1980s the demand for fur coats began to decline. With the fur industry on the wane, nutria were no longer trapped in numbers sufficient to counterbalance their high reproductive rate. Their populations began to grow exponentially.

Today, the number of nutria in some Gulf Coast areas such as southeastern Louisiana, where as many as 6,000 per square mile have been counted, has exceeded the **carrying capacity**. In these areas of high density, nutria are causing ecological and economical havoc.

- They eat all the available vegetation, leaving the land bare and vulnerable to storm damage and erosion.
- As nutria build burrows, they weaken and often destroy water retaining structures. Manmade levees and dikes used to regulate water flow for rice and sugarcane crops are often damaged and must be replaced.
- During the last ten years, the estimated annual damage to crops and land structures caused by nutria has exceeded one million dollars.

In the past, the trapping industry kept nutria populations in balance, but since there is less demand for fur and therefore less trapping, alternatives for population control must be found.

- Fences and walls have been used to reduce nutria invasion, but the high cost of installation limits their use.

- Zinc phosphide, a poison that is effective in killing nutria, is highly toxic to other wildlife and humans. Thus, it must be used carefully.

- Ultimately, nature may contain nutria. In areas where their numbers are extremely high, disease and starvation will eventually cause **population crashes**. Unfortunately, the damage done to native ecosystems before these crashes occur may be longlasting and in some cases permanent.

The story of the nutria's introduction, dispersion, and prominence throughout Gulf Coast wetlands demonstrates the negative impact an exotic species can have on a hospitable environment.

Zebra Mussels
Dreissena polymorpha

One of the most recently identified exotic species to affect American aquatic ecosystems is the zebra mussel. These tiny, freshwater bivalves — usually no larger than a fingernail — derive their common name, zebra, from a distinctive shell pattern of alternating light and dark bands. The exact pattern of stripes varies, reflecting the species name, *polymorpha.*

Zebra mussels were inadvertently introduced to the United States from Europe during the mid 1980s when ships emptied their ballast water in the Great Lakes.

Ships preparing for transoceanic voyages often take water into holding tanks to use as a stabilizing weight, or ballast. As water is sucked into these ballast tanks, a huge spectrum of marine life — everything from protozoa to fish — also enters. When the ships reach their destination, the ballast tanks are emptied and the hitchhiking organisms are released in a new location. These foreign organisms may or may not find the new environment hospitable.

In the case of zebra mussels, the Great Lakes provided an ideal habitat. In less than 10 years they have spread throughout the Great Lakes region and into the South Central United States.

Several environmental factors appear to be critical to the growth and reproduction of zebra mussel populations — water temperature, salinity, pH, mineral content, an abundant food supply (algae, zooplankton, and detritus), and a firm surface to which adults can attach.

Temperature	6 - 28°C (spawn at 12 - 23°C and die above 31°C)
Salinity	< 5 parts per thousand (ppt)
pH	7.4 - 9.4(slightly alkaline)
Magnesium and Calcium	> 20 parts per million (ppm)

Favorable ranges for factors affecting zebra mussel growth

Zebra mussels hatch from eggs into free-swimming larvae called **veligers.** During this larval stage, which lasts two to three weeks, downstream currents easily transport the mussels from one body of water to another.

By the third week, the larvae enter a "settling stage" and must attach to a firm surface — rocks, pier pilings, boats, concrete, or even another animal's shell. Each mussel secretes strong protein fibers called byssal threads that holds it to the substrate. The characteristic banded shell also develops during this adult stage.

As with most successful exotic species, zebra mussels possess a number of characteristics that allow them to outcompete native species and extend their range rapidly.

- Mature females produce from 30,000 to 1 million eggs per year.

- The microscopic, free-swimming larvae are easily moved downstream by currents.

- As adults, the mussels often attach to the outsides of boats and insides of boat bilge pumps and live wells; they are then readily moved to new locations.

Zebra mussels often form massive **colonies** that include thousands of individuals attached to each other. These densely populated colonies cause damage to the native ecosystem.

- They filter large amounts of plankton and **detritus** from the water, reducing the amount of food available for native species. The excessive removal of plankton and detritus which form the base of aquatic food chains eventually disrupts the entire **food web**.

- Zebra mussels weaken or kill other freshwater bivalves by attaching to their shells, interfering with the host's ability to open and close.

- When they populate an area to the extent of covering most available solid surfaces, they destroy the nesting places of other aquatic animals.

- Their colonies clog municipal and industrial water-intake pipes, cover pier pilings, docks, and buoys, interfere with recreational boating and beach use, and, in general, compromise the efficiency of anything to which they attach.

Although the northeastern region of the United States has suffered the most from zebra mussel damage, it is not the only area at risk. These tiny, colonizing mollusks have moved into southern waters by hitchhiking on barges and boats moving down the Mississippi River. They have been found as far south as New Orleans, Louisiana and have populations in Arkansas, Alabama, Mississippi, and Oklahoma as well.

Once established, zebra mussels are very difficult and expensive to control. In Europe, they are kept in check by a natural predator — a species of fish with a grinding mechanism that enables it to eat them. There are no such fish predators in the United States and other potential native predators, such as diving ducks and crawfish, have yet to adopt zebra musssels as a major part of their diet.

There are poisons that kill the mussels, but the toxins also harm native animals. The best hope for slowing the spread of this exotic is to raise public awareness about the problem and solicit the help of both industry and private citizens in cleaning boats before moving them from one body of water to another:

- Wash the outside of boats with hot, high-pressure water.

- Disinfect the inside of boat bilge pumps and live wells with a 10 percent chlorine bleach and water solution.

An aggressive campaign to deter the spread of this exotic is necessary to keep the waterways of America productive and enjoyable for humans and other organisms.

Argentine Fire Ants
Solenopsis invicta

More than 8,800 different species of ants have been identified in the world. One of those species, the Argentine fire ant, is a new migrant to the Gulf Coast area and is becoming a serious ecological problem.

Like most other members of the insect order Hymenoptera, these fire ants are social in behavior. They live in colonies that include an egg-laying queen, a few winged males and females, and many wingless female workers.

The males have one function in the colony — to mate with flying females. Once mating occurs, the males die. The fertile females, now queens, descend from the nuptial flight, shed their wings, and begin burrowing into the ground to begin new colonies. Within two days each new queen begins her life's work of laying eggs — hundreds of eggs a day.

The role of the workers, who may number from 500 to 500,000, is to protect, feed, and groom the queen. If something disturbs the colony, the workers aggressively attack, biting with their pinching jaws and injecting a venom with their lance-like stingers.

A fire ant nest, which appears to be only a foot or so high on the surface of the ground, is

really an extensive underground system of tunnels that may reach out 50 feet from the central mound and six feet down. The ants move up and down the tunnels according to the temperature and water level.

As with many other exotics, Argentine fire ants were accidentally introduced into the United States. They were brought from Brazil to Mobile, Alabama, in the hold of a ship during the 1940s. During the past 50 years, they have moved across farm lands, parks, orchards, and suburban lawns to extend their range from the Florida Keys westward through Texas and northward as far as Tennessee.

Entomologists believe that the success of these fire ants can be attributed to two factors.

- An abrupt change in the social behavior of some colonies that began during the 1970s. Mounds appeared that contained hundreds of egg-laying queens instead of one. As before, each queen produced her own horde of workers who recognized her **pheromone** (a chemical scent) and that of their nestmates. But instead of killing fire ants having a different scent, the workers of the various queens began to cohabit.

  With so many queens in one area, the population density increases drastically. Also, the workers produced by the consortium of queens build many more mounds per acre — instead of 50 there may be as many as 500 interconnecting mounds. These supercolonies have been located throughout Louisiana, Florida, Georgia, and Alabama, and are the dominant type in Texas.

- The Argentine fire ants have few natural predators in the Gulf Coast region. In South America, where they originated, a variety of predators (a protozoan parasite, a fly that attacks the queen, and a mimicing parasitic ant) help keep fire ant populations in check.

The ecological impact of these Argentine fire ants has been pronounced.

- In areas of severe infestation they are known to damage crops, expensive farm equipment, and electrical equipment.

- Farm animals and workers are continually annoyed with stings.

- Research has shown that biodiversity declines in areas where these ants settle. The variety of ant species declines by as much as 70 percent and the number of other arthropod species — insects, spiders, ticks, and fleas — drops by about 40 percent.

Efforts to control the growth and spread of Argentine fire ant colonies have followed serveral courses.

- Some chemical toxins have been effective in killing the ants. Because they also kill native species, these can no longer be used. Less toxic insecticides merely slow the ants' spread to new locations.

- Current emphasis is on the use of biological weapons. One is a pheromone that mimics the scent of the queen. The synthetic pheromone is added to a toxic bait which is then made available to the queen by the workers.

- Another approach is the use of a growth regulator that makes the queen incapable of egg production.

- Some think the introduction of South American predators highly specific for the ants would be the best method of control.

Although their presence reduces populations of some insect pests such as boll weevils and surgarcane borers, for the most part, Argentine fire ants are considered a blight on the landscape and a detriment to the ecosystem.

Africanized Honey Bees,
Apis mellifera scutellata

All honey bees are alien to North America. The European honey bee, common throughout the United States during the spring and summer, was imported to the New World by early settlers. In contrast to the other exotic species discussed in this background information, the European honey bee's assimilation into its adopted habitat is a success story for both the honey bees and the native species.

Today, European honey bees are a vital part of United States agriculture. Besides producing nearly 200 million tons of honey each year, honey bees are invaluable as pollinators. About one third of the American diet is directly or indirectly dependent on crops pollinated by bees as they seek pollen and nectar for food.

Because of their value to agriculture, European honey bees were introduced into South America during the 1900s, but they did not thrive in the hot, humid climate. So, in 1956 a Brazilian scientist, hoping to breed a honey bee variety more suited to the tropical environment, imported several hundred honey bees native to the savannas of Africa. He crossed them with the European variety, but before he could determine the outcome of his experiment, the hybrids were accidentally released. These experimental bees quickly interbred with the resident bees, creating the offspring now called Africanized honey bees.

Africanized honey bees look identical to the European honey bees but other characteristics set them apart. Compared to the European honey bees the Africanized bees

- have a shorter life span.
- produce less honey.
- are less efficient pollinators.
- live in smaller colonies.
- are more aggressive in defending their hive.

Because of their defensive behavior, the Africanized honey bees have gained much notoriety. But these insects, dubbed "killer bees" by Hollywood, are not as hostile as they have been portrayed. They generally react defensively only when their hives are threatened, and their sting is no more poisonous than that of the European honey bee. However, once provoked, they sting in greater numbers and will chase the offender farther.

In the opinion of most entomologists, the real danger presented by the Africanized honey bees is the negative impact that they will have on American agriculture. Ninety crops cultivated in this country depend on the pollination accomplished by honey bees. Interbreeding between the European and Africanized bees could be devastating to the $20-billion-a-year American farming industry.

The hybridized honey bees would become less useful as pollinators and honey producers and because of their defensive behavior, would be more difficult for beekeepers to handle.

Africanized honey bees first entered the United States during the fall of 1990 and have since spread through Texas. Entomologists expect them to extend their range westward into New Mexico and eastward into the Gulf Coast region. Various methods of controlling or mitigating their effects are being investigated. The following are some of the more promising ideas.

- Arrange for more domestic bees to interbreed with the Africanized bees in order to mitigate the undesirable traits.
- Develop a honey bee that is resistant to a bacterium that would kill only Africanized bees.
- Develop a hive for trapping swarms of the Africanized bees by attracting them with a specific scent. Once in the hive, they could be eliminated.
- Encourage beekeepers to identify their own queens by marking them with paint. Then, if an Africanized queen tries to take over the hive, she can easily be spotted and killed.

The solution for the general public is to stay away from all bee hives. If one is spotted, trained professionals should be asked to remove the colony. Should an individual accidentally provoke bees, (s)he should cover the head with a jacket or sweater and run to shelter or until the bees stop chasing. European bees will chase only about 25 feet and Africanized bees a few hundred feet. Most people can outrun a swarm.

TEACHING SEQUENCE

DAY 1 Introduction and Background

1. Review the meaning of the ecology terms used in the video. Ask students to cite examples for each term. Terms to include are: **environment, ecosystem, food web, species, population, community, habitat, aquatic, terrestrial, niche, predator, prey,** and **adaptation.** (Other terms listed in the vocabulary section can be taught during class discussions during or after viewing the video.) [30 minutes]

2. Relate the learning objectives for the module then distinguish between exotic and native species. Using the background information and a transparency of the illustrations on page 13, identify and tell a little about each of the exotic species to be highlighted in the video. If time permits and the specimen are available, provide a nutria pelt, a stem of kudzu, stereoscopes with a fire ant and a honey bee focused, and a petri dish containing a few zebra mussel shells (water hyacinth will be viewed during the first activity). [15-20 minutes]

3. Have students answer the Previewing Questions (page 11) for homework.

DAY 2 Part I of Video and Water Hyacinth Activity

4. Discuss the Previewing Questions. Tell students that, while watching the video, they are to note the adaptations that have allowed each species to be successful in the Gulf Coast region. [10 minutes]

5. Show the video until instructed to pause for Activity I — Investigating the Adaptations of a Water Hyacinth. [5 minutes]

6. Lead students through the activity (see Teacher Instructions on page 14). [15 minutes]

7. Continue the video, reminding the students to note the adaptations that have made each of the exotic species successful. Stop the video at the place indicated for Activity II — Introduce an Alien! [10 minutes]

8. Follow steps 1-3 in the Teacher Instructions (page 15), and allow students the remainder of class to begin the activity.

9. For homework, ask students to make a list of characteristics to include in their group's alien species.

DAY 3 Complete Activity II

10. Review the objectives for Activity II — Introduce an Alien! [5 minutes]

11. Have students follow their instruction sheet and combine ideas to create, draw and answer questions about their alien species. [30 minutes]

12. Have each group describe and give the impact of its alien species. Encourage other students to ask questions about the alien. [15 minutes]

DAY 4 Complete the Video and Postviewing Questions

13. Show the remainder of the video. [5 minutes]

14. Ask students to work with their group to complete the Postviewing Questions (pages 11-12). [15 minutes]

15. Discuss the postviewing questions, calling for input from each group. [30 minutes]

16. At the teachers discretion, the evaluation questions (pages 24-26) may be assigned for homework or used to accompany the next test. The Extension activities (page 12) may be assigned for further study.

VOCABULARY

The following terms are used at various times throughout the module. The definitions may be adapted to suit your students' grade level.

Adaptation: A physical or behavioral characteristic that helps a species survive in its environment.

Aquatic organisms: Organisms that live in the water.

Carrying capacity: The maximum number of a particular species that an ecosystem can support.

Colony: Members of the same species living together in a close association.

Community: All the organisms — plants, animals, fungi, and microbes — living in the same area during a particular time.

Detritus: Fragments of decaying organic matter — dead leaves, roots, feces, etc.

Ecosystem: An area where living things interact with each other and with their nonliving surroundings. Substances essential for life such as oxygen, water, and nitrogen are cycled, and energy flows from producers through consumers.

Endangered species: Species that are in immediate danger of becoming extinct.

Entomologist: A person who studies insects.

Environment: All the factors that act upon an organism — living factors like the presence of other plants and animals and nonliving factors like climate, light, and the availability of water.

Exotic species: Foreign plants, animals, or microbes that are introduced to a habitat.

Extinct species: Species that have died out and are gone forever.

Food web: The complex feeding relationships among the organisms in an ecosystem. It includes producers, herbivores, carnivores, and detritivores.

Fragmentation: A type of assexual reproduction that occurs when part of a parent plant breaks off and begins to grow independently.

Habitat: The area where a particular species lives. It provides all the species requirements for life — water, food, shelter, and space.

Marsh: A low-lying, grassy wetland. It can contain fresh or saltwater.

Native species: Species that originated or evolved in an area.

Niche: The role (function) of a species in its ecosystem.

Population: Members of the same species living in a specific area at a given time.

Population "crash": When a population dies back to a very low level in a short period of time. Some causes are disease and starvation caused by overpopulation.

Predator: An animal that kills and eats another organism.

Prey: The organism eaten by a predator.

Species: A group of similar organisms that interbreed in nature to produce offspring.

Swamp: Lowland areas that are saturated with water and studded with trees.

Terrestrial organisms: Organisms that live on land.

Threatened species: Species whose population numbers are rapidly declining and are therefore, likely to become endangered in the near future.

Veliger: The larval form of many mollusks.

PREVIEWING QUESTIONS AND ANSWERS

1. What is an adaptation?

   An adaptation is a special trait that helps an organism succeed (live and reproduce) in its environment.

2. An **exotic** is any non-native species that has made itself a home in a new area. Can you think of any exotic plants and animals in our area?

   Answers will vary but might include wheat, roses, cattle, armadillos, cattle egrets, and fire ants.

3. What is a food web?

   A food web is a diagram that shows the feeding relationships within a habitat — what eats what.

4. Do you think an exotic species that is introduced into an area will alter the food web? Why or why not?

   Answers will vary — accept any reasonable response, as long as it is explained. Explanations may include outcompeting native species for food, water, shelter and space, destroying property, providing a new food source for other species (predators), etc.

5. How do you think most exotic species get into a new area?

   Several answers are possible. Most students will reply that they are brought in by humans, either accidentally or on purpose. Emphasize that some manage to enter naturally like the armadillo, which slowly made its way up from South America.

Before viewing the video, remind students to note the:

- ***adaptations that have allowed each exotic species to become successful in the Gulf Coast region.***
- ***effects — both good and bad — that exotic species have had on their adopted environments.***

POSTVIEWING QUESTIONS AND ANSWERS

1. Name the most common ways that exotics enter new areas.

   - *Humans introduce them on purpose or accidentally.*
   - *Nature brings them in during storms.*
   - *They enter through natural migration.*

2. Describe at least three general characteristics of successful exotics.

   - *They are aggressive in getting food, water, shelter, and space.*
   - *They grow fast.*
   - *They have a high reproductive rate.*
   - *They have few, if any, natural predators.*

3. Some of the exotic species on the video are potentially beneficial. Name some which could be beneficial and explain how.

   - *Nutria have valuable pelts.*
   - *Water hyacinth and zebra mussels could help purify water.*
   - *Water hyacinth can be used to make a biogas and as a food for cattle.*

4. Identify some problems associated with each of the following exotic species:

   a. Africanized honey bees
   b. Zebra mussels
   c. Water hyacinths
   d. Nutria
   e. Argentine fire ants

   Africanized honey bees *— produce less honey, have a short life span, are poor pollinators, and are very aggressive in protecting their hive.*

   Zebra mussels *— filter plankton from water supplies depriving native species of food sources, clog water intake valves, cover the nesting areas of some native species.*

   Water hyacinths *— shade submerged plants from light, clog waterways interfering with recreation and transportation.*

   Nutria *— destroy wetlands by eating all the vegetation, disturb muskrat nests, cause agricultural damage.*

Argentine fire ants — reduce the arthropod diversity in a habitat, inflict painful bites to humans and other animals, produce unsightly mounds which damage expensive farm machinery.

5. Develop a plan to control or eliminate at least one exotic species presented in the video.

   Examples are:
   - *paying bounties for nutria pelts*
   - *setting poison baits for Africanized honey bees*
   - *developing herbicides that will kill or slow the growth of water hyacinths and kudzu without harming other plants.*

EXTENSIONS

1. **Adopt a Native Species:** Adopt a native species threatened by the invasion of an exotic species and decide on ways to help to support the adopted species.

2. **Exotic Species Book:** Prepare a booklet of exotic species in your area. Include pictures or silhouettes of each species.

3. **Map Time:** Using different colors of yarn for each species, have students identify points of origin and invasion of exotic species on a large world map.

4. **Wanted!** Make "wanted" posters for various exotic species.

5. **Reintroduce a Native:** Ask students to research how some endangered wildlife species have been reintroduced in their original habitats. Have the students distinguish between "reintroductions" and "exotics."

6. **School Yard Nature Walk:** Lead your students in a walk around the school grounds to identify any exotic plants that live there.

7. **Stop an Exotic:** Have students research exotic species that live in your area and plan a campaign to eliminate or curtail the spread of those species. Ideas include using signs, buttons, songs, poems, skits, bulletin boards, etc. to heighten public awareness.

8. **Future Shock:** The presence of some exotic species could make our world very different in the future. Have students write a story predicting how an exotic plant or animal might affect the Gulf Coast region during the next 100 years, if its population continues to spread.

9. **Exotic Cartoons:** Draw your favorite exotic species, cartoon-style.

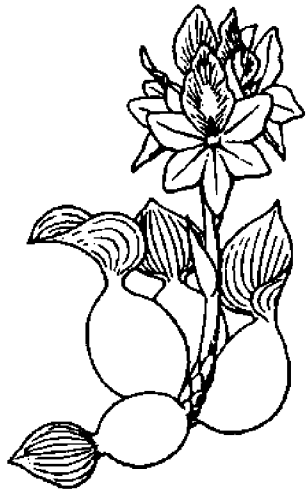
10. **Debate Time:** Have each student choose an exotic species and defend its place in its adopted habitat.

11. **Food Web Dramas:** Assign each student the role of an organism in the food web of a particular habitat. Some students should be exotics. Each should justify its own existence, "I have a right to be here because . . ."

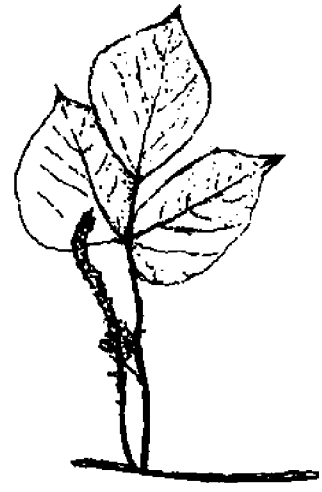
12. **Learn a Law:** Investigate state and federal laws regarding the import and export of native organisms.

13. **Here Comes Trouble:** Consult local agricultural extension agencies for information on the spread of potentially harmful exotic invaders. Predict their spread on a map of the United States.

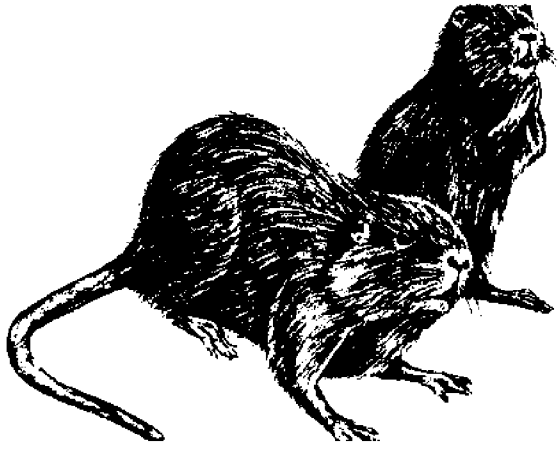
EXOTIC SPECIES IN THE GULF COAST REGION



Water Hyacinth



Kudzu



Nutria

Zebra Mussels

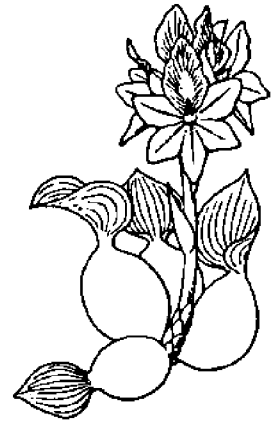
Argentine Fire Ant

Africanized Honey Bee

ACTIVITY I

WHAT ARE THE ADAPTATIONS OF WATER HYACINTHS?

(Teacher Instructions)



Water Hyacinth

Objectives

- To practice making observations and inferences
- To identify adaptations in water hyacinths

Description

Students will work in groups to identify the structural adaptations of water hyacinths and tell why the adaptations are helpful for survival.

Materials (per group)

Small clump of hyacinth plants (roots, stems, leaves)
Scapel or scissors
Small plastic tub or 5 gallon aquarium

Preparation

1. Obtain enough water hyacinths for each group to have a small clump of plants. They can be found in ditches, marsh channels, bayous, and ponds throughout the Gulf Coast region from May to frost.

2. Before class, fill each tub or aquarium with water and add one clump of hyacinth.

Procedure

1. At the designated point, stop the video tape. Have each group observe their hyacinth plants and make a list of the external characteristics.

2. Have one student in each group break a single stem loose from the clump and, using a scalpel or scissors, cut crosswise through the stem. Have the students make additional observations.

3. Based on their observations, students should suggest how each of the hyacinth's characteristics has helped it to successfully adapt to an aquatic environment.

4. Using suggestions from each group, make a list on the board of the water hyacinth's adaptive characteristics. **(Information on the hyacinth in the Background section will be helpful.)** Compare and contrast the hyacinth to other aquatic plants such as water lilies, duckweed, and algae.

5. Continue the video, alerting students to check their observations with those provided by the narrator.

ACTIVITY II

INTRODUCE AN ALIEN!

(Teacher Instructions)

Objectives

- To identify adaptations that help various types of organisms survive
- To predict the impact of an exotic species on a food web

Description

Students will read the description of a specific habitat and make inferences about environmental conditions within that habitat. They will then create an exotic (alien) species with adaptations designed to help it survive in the habitat. The students will predict the impact of the exotic on the habitat's food web and project its success/failure in its adopted environment.

Materials

Student instruction sheets for "Introduce an Alien!"
Habitat/Food Web Cards
Plant and Animal Cards
Unlined paper and pencils or pens
Markers or colored pencils

For the Plant and Animal Cards and the Habitat/Food Web Cards, copy matching pages (for example pages 17 and 18) on the back and front of one sheet of paper then cut and laminate the cards.

Procedure

1. Divide the class into groups of 3-4 students each.
2. Give each group a Habitat/Food Web Card, a Plant Card, an Animal Card, and a piece of unlined paper.
3. As a class, read the student instructions (page 16) step-by-step. Allow time for the students to interact and discuss options within their group at each step.
4. Help students synthesize the information about the habitats and food webs. Guide them, as necessary, in making inferences about the habitats. Inferences may include the following:
   - *Grassy Meadows:* sunny area, soil contains decaying organic material, wide variety of life, animals tend to be small, trees are nearby.
   - *Rivers and Streams:* wet area, wide variety of wildlife in and around the water, land and water come together at the shore or bank, water speed (current) is important.
   - *Salt Marsh:* rapid temperature and salinity changes, rich sediments, muddy with shallow water, water level changes with the tide, contains a variety of life, sunny, no trees — mostly grass.
   - *Pine Forest:* a few broadleaf trees are present but the dominant trees are pines, may have an understory of shrubs and wildflowers, shady, age of forest determines the variety of plants, and therefore the animals that live there.
   - *Sandy Beaches:* sunny, only the tough organisms survive — they must endure wind, salt spray, and the pounding of waves — getting food requires special adaptations, a large variety of animals live in the water, soil is sandy.
5. Allow time for students to complete the activity. Provide guidance as needed.
6. Have each group describe its alien species to the class.

Extension

Have students sketch or make a model of their habitat showing the presence of both native and exotic species. Display these on walls or in a media center, library, or other appropriate area for students, teachers, and parents to view.

INTRODUCE AN ALIEN!

(Student Instructions)

You are about to create a new exotic (alien) species and introduce it to a foreign environment. Read and follow the steps listed below to complete the assignment.

1. Read your Habitat Card. List the characteristics about the habitat that you need to remember in creating your new species.

2. A food web that occurs in the habitat is illustrated on the back of your Habitat Card. Study the food web and imagine how all the organisms in the habitat contribute to the well-being of each other and the habitat as a whole. Notice that some animals eat plants and others eat animals.

3. Now, look at your Plant and Animal Cards. Notice the questions on the back of the cards. Answering these questions will help you to describe the organism you are about to create. Work with your group to answer each of the questions.

4. Within your group decide whether to create an exotic plant or animal.

5. After agreeing on its characteristics and adaptations, draw a sketch of your alien species.

6. Include a food web, using the Habitat/Food Web Card as a guide. Show where your exotic fits into the food web.

7. Predict the impact of your exotic species on the habitat. Will any native species die out? How successful will your organism be in finding food, protecting itself, and adapting to the habitat? What benefits might it have? What harm might it cause?

8. Select one group member to describe your alien to the class. Everyone should be prepared to answer questions the class or teacher might ask.

PLANT CARD	PLANT CARD	PLANT CARD

ANIMAL CARD	ANIMAL CARD	ANIMAL CARD

Plant Adaptations

1. What are the plant's requirements for food, soil, water, light, and temperature?
2. What are its growth habits? (fast or slow growing? tree, shrub, vine or wildflower?)
3. What pollinates this plant?
4. What special adaptations does this plant have (thorns, poisons, color, scent, shape, etc.)?
5. How big does this plant grow?
6. How did your species get here?
7. How will you control it?

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Animal Adaptations

1. What does the animal eat?
2. In what temperature range is the animal active?
3. How does it reproduce? How often? In what numbers?
4. What is the behavior of the animal? (passive or aggressive)
5. Are there any other special adaptations (color, size, location of body parts, poison, claws, stingers, and fangs)?
6. How did your species get here?
7. How will you control it?

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HABITAT — FOOD WEB CARD

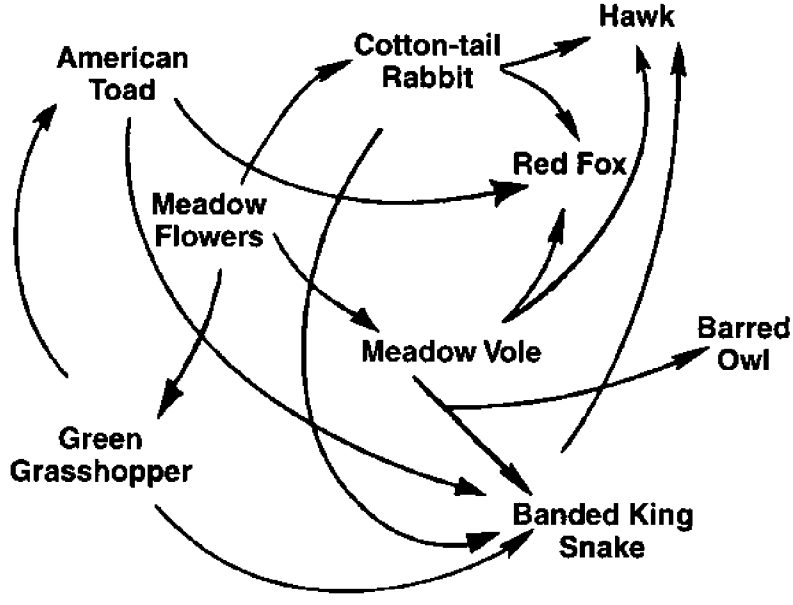
GRASSY MEADOW

In the Gulf Coast area, a grassy meadow is usually a temporary clearing in the midst of a forest, along a forest edge, or along a roadside. Some facts you should know in order to create an alien species that can live in a meadow are:

- Plants here thrive with a full day of sun, but do not grow well in shade.
- Grasses are successful because they spread through a network of underground stems. They do not have to rely on seeds to reproduce.
- Flowers are pollinated by wind. Their seeds are light and blow freely to new areas.
- As old leaves rot, they act as compost — they hold moisture in the soil, shade roots, and return nutrients to the soil.
- A thick mat of grasses and decaying leaves develops in the meadow, keeping most other plants from growing. Exceptions include wildflowers such as goldenrod, meadow beauties, and clovers, which force their way through the mat in early spring.
- Flowering plants attract insects that feed on them and help in pollination.
- Animals that live in the meadow include worms, insects, toads, snakes, tortoises, birds, and mammals. Mammals such as rabbits and mice eat plants and their seeds. Other mammals such as moles and shrews eat insects. Reptiles like snakes feed on small mammals and birds. Birds of prey — the hawks and eagles by day and the owls by night — also scan the meadow in search of food such as mice and small birds.
- Some animals find shelter in the ground or on the plants, while others return to trees that surround the meadow.

The grassy meadow may seem like a sunny and serene playground for buzzing insects, but in reality, it is an area of fierce competition for food, space, and shelter.

GRASSY MEADOW



HABITAT — FOOD WEB CARD
SANDY BEACH AND DUNE

Sandy beaches form as erosion breaks rocks into tiny grains of sand. Currents and wind move the grains of sand up and down the beach forming swells called dunes. Some facts you should consider in creating an alien species that can survive on the sandy beach are:

- Sea oats are plants that help hold grains of sand together on a beach. They grow horizontal, underground stems called runners that produce the blades of a new sea oat plant. These blades trap blowing sand to help form sand dunes.
- Plants must be adapted to the drying conditions caused by the perpetual wind. Some have a waxy covering on their leaves. Other plants prevent water loss by tilting their leaves away from the sun. Some store water in thick stems, and others have many fibrous roots that provide an increased surface area through which water and minerals can be absorbed.
- Animals living closest to the surf are the toughest for they are pounded by waves, tumbled by backwash, and then exposed to the drying sun and wind.
- Animals that live higher up the beach must endure high winds, salt spray, higher temperatures, and dry surface conditions. Their food often consists of dead organisms washed ashore by waves.
- Creatures such as coquina clams and mole crabs burrow into the sand when they are not scouring it for something to eat. Ghost crabs emerge from their holes to feed, while the clams filter food from the water.
- Various species of birds patrol the shoreline for food.
- Nocturnal animals like raccoons and opossums search the beach for food.
- Sea turtles and horseshoe crabs lay their eggs on the beach.
- Animals that live in the dunes include small reptiles and mammals; these attract bird predators such as hawks. Insects and their predators are also common in dune areas. Bog plants such as gentians and bayberries are found in the moist hollows between dunes.

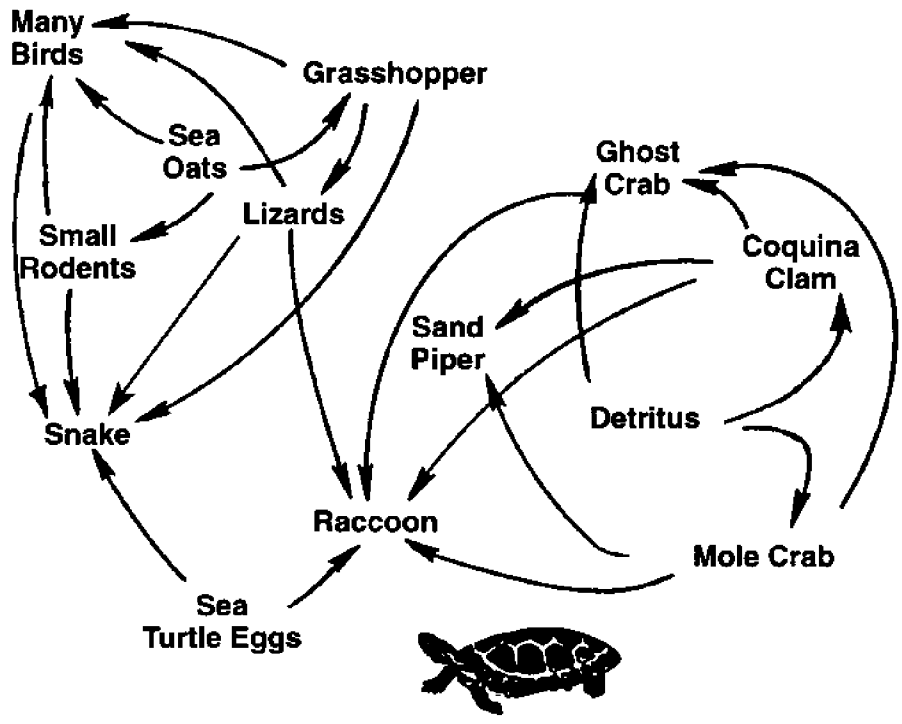
Each beach inhabitant has special adaptations that allow it to live in this rigorously drying environment. Some adaptations allow the organisms to store water or to go for long periods without moisture while others enable them to hide.

HABITAT — FOOD WEB CARD
PINE FOREST

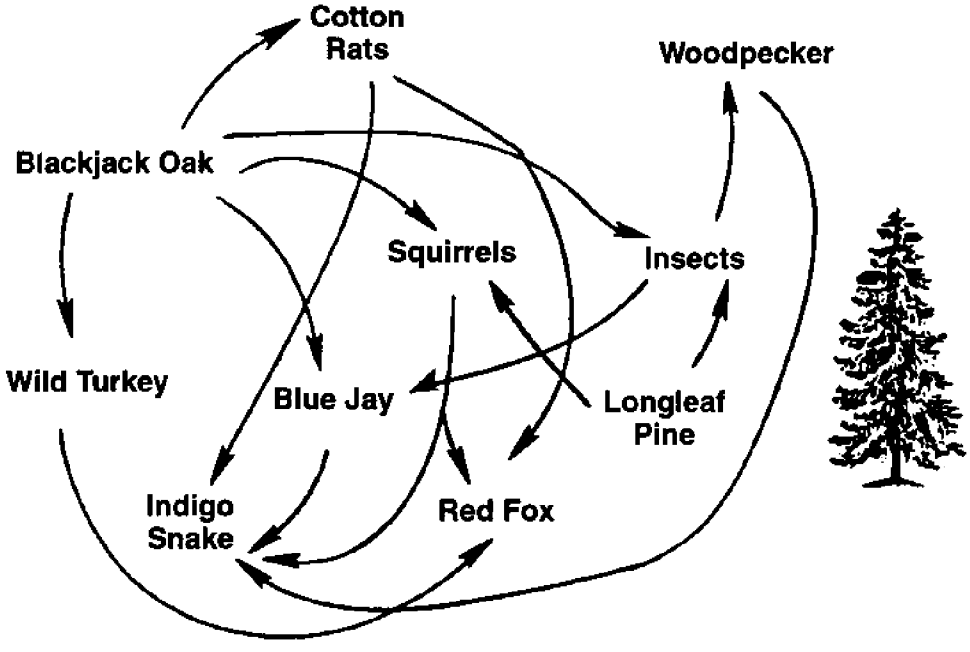
Many of the Gulf Coast's forests are dominated by pine trees. Some facts you should consider when designing an alien to live in a pine forest are:

- The soil of the pine forest is sandy and slightly acidic.
- Wild fires help to clear out the understory of slower growing hardwoods such as oak and hickory trees. Pines can survive these fires because of their thick bark and high growing branches. The saw-palmetto quickly recovers from a fire because new leaves grow from its large root to replace burned ones.
- Young pine forests have thick canopies that shade the understory.
- Ground-dwelling wildlife find little food in the young pine forest but animals that feed on bark-insects can find a wealth of food on pine trunks.
- As the pines get older, they allow enough light to the understory to support some other types of plants — deer's tongue, partridge pea, and poison ivy. Animals such as white-tailed deer, mice, and rabbits eat these plants. The understory provides food and cover for song birds like warblers and nuthatches. Squirrels, raccoons, wild turkeys, woodpeckers, bobcats, and black bears are all native to the pine forest.
- Old growth pine forests are mixtures of needle leaf and broad leaf plants. In this mixed forest you can find many species of oak trees; their acorns are used by about 185 different species of wildlife.
- Older pines may be infected by a kind of fungus that softens their inner wood. These trees are valuable nesting sites for the red-cockaded woodpecker. The holes this woodpecker makes may be used as hiding places by other wildlife like flying squirrel, bluebirds, and wood ducks.
- The gopher tortoise digs tunnels in the soil. These tunnels are then used for hiding and protection by other wildlife.

SANDY BEACH & DUNE



PINE FOREST



HABITAT — FOOD WEB CARD
RIVERS AND STREAMS

In a rainy area like the Gulf South, many rivers and streams drain the land. Some facts you should consider when designing an alien to live in a river or stream are:

- The speed of the river or stream depends on the amount of water in it and the slope of the land. Although most land in the Gulf Coast area is flat, at times enormous amounts of water from heavy rains flow over it toward the Gulf of Mexico.
- Some streams are clear. Others are a rich brown stained by dead vegetation. Others are muddied by eroded soil.
- Plants growing in or on the edges of rivers and streams must be able to adapt to the speed of the water, the changing water level, and the sediments in the water.
- In rivers and streams where the waters flow rapidly, currents carry the food and dissolved oxygen needed by aquatic organisms. Plants and algae that live here quickly recover after strong currents tear them apart. Some plants like watercress are flexible and have slick coverings so that water flows over them easily. Plants such as mosses form great cushions so that water flows around them.
- In rivers and streams where water does not flow rapidly, plants such as cattails, reeds, and lilies may grow. These plants offer food and shelter to many animals, including fish, like bass and bream, amphibians like frogs and salamanders, reptiles like water snakes and snapping turtles, insects like mosquitoes and dragonflies, and birds like kingfishers and bank swallows. Raccoons and otters are mammals that search for food at the edges of rivers and streams.

Water and land are intertwined in this habitat. Runoff from rain provides nutrients and water for aquatic organisms. Land organisms may depend on water for a variety of supplies, including food and shelter. (For example, cattails, with their roots in the water, provide a place for red-wing blackbirds to build nests.)

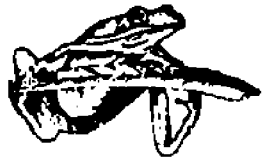
HABITAT — FOOD WEB CARD
SALT MARSH

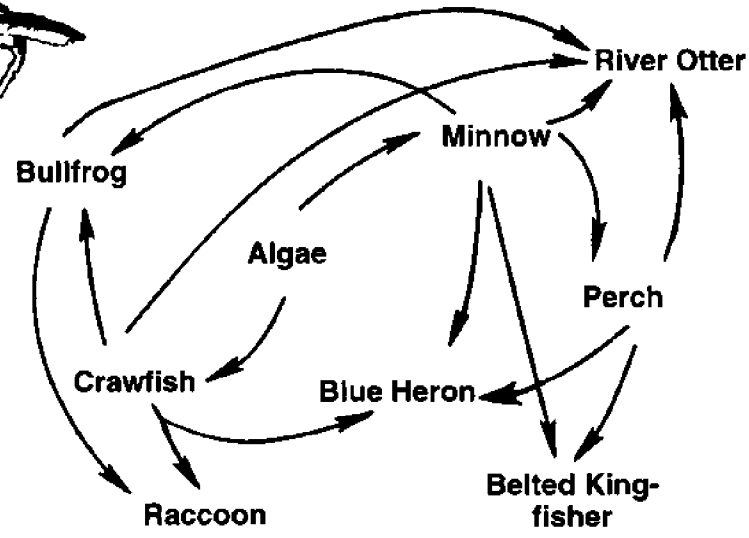
The salt marsh is a highly productive area that links the oceans with fresh water rivers and streams. Some facts you should consider as you design an alien species to live in the salt marsh are:

- All organisms that live here must adapt to harsh conditions — daily rise and fall of the tide causes periods of wetness and dryness and variations in salinity occur with each influx of fresh water from rain-swollen rivers.
- All organisms must have adaptations that allow excess salt to be removed from their bodies. *Spartina*, a marsh grass, excretes salt through its leaf pores.
- Sediments provide a rich bottom in which many different plants grow.
- Common grasses growing throughout the marsh are cordgrass and black needlerush. The tides wash dead fragments from these grasses into the marsh channels. This detritus becomes the basis for many salt marsh food webs.
- Shrubs grow in the sediments trapped by salt marsh grasses. Common bushes are bayberry, and yaupon holly. Blossoms from marsh pinks, swamp mallows, and oxeye daisies brighten the marsh.
- Tall grasses and shrubs provide cover as well as food for marsh animals like crabs, shrimp, and clams that live in the water surrounding the grasses.
- Birds nest in the stems of plant, and insects eat the leaves. Long legged birds hunt the muddy flats for insects and crustaceans. Other water fowl like ducks, gulls and pelicans eat fish for food. Crustaceans like shrimp, crab and crawfish eat detritus (decaying matter). In turn, they are eaten by otters, which also eat fish.
- Meadow voles scurry along the ground beneath the tall marsh plants. They are hunted by hawks, owls and snakes.
- Lizards stalk insects in the grass, and terrapins chase fish in the shallow waters.

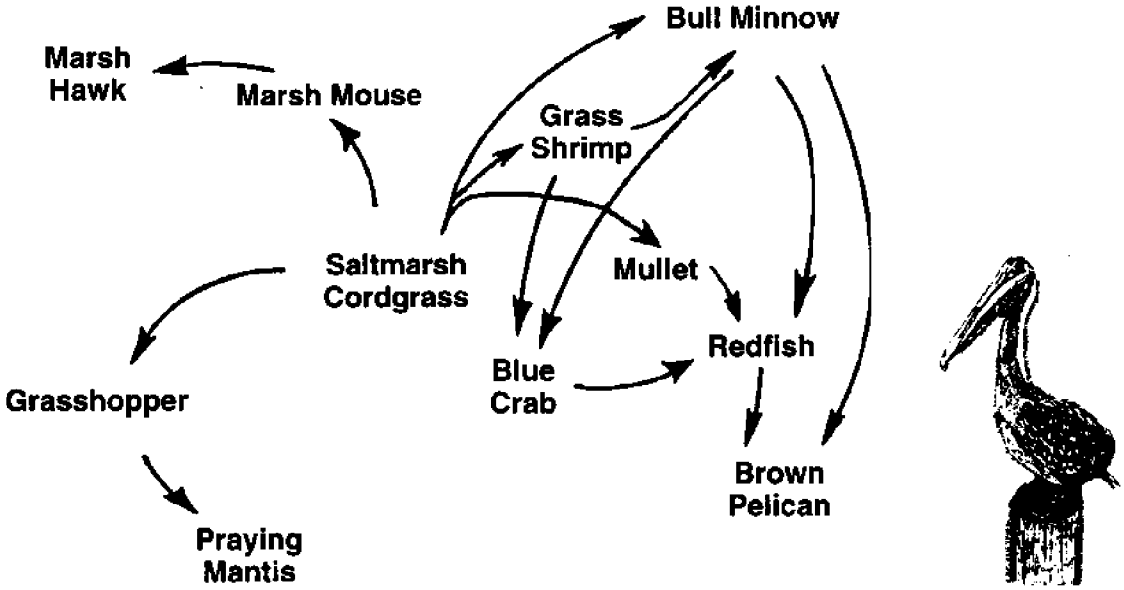
Although the grasses seem to dominate the marsh at first glance, closer examination reveals a large variety of wildlife.

RIVER & STREAMS





SALT MARSH



EVALUATION QUESTIONS

MULTIPLE CHOICE: Select the BEST answer for each statement.

1. Which of the following adaptations would **NOT** be helpful to an exotic species in a new habitat?

   A. a general diet
   B. a broad temperature tolerance
   C. a specific diet
   D. an aggressive lifestyle

2. The water hyacinth would be most damaging to

   A. submerged freshwater plants
   B. salt marsh grasses
   C. understory vegetation in pine woods
   D. sand dune sea oat populations

3. The zebra mussel most likely arrived in the United States

   A. through the port of Mobile, Alabama
   B. carried in the ballast water of ships
   C. by migrating through Central and South America
   D. during an exhibit at the Aquarium of the Americas in New Orleans

4. Africanized honey bees originated in

   A. Africa
   B. South America
   C. North America
   D. Europe

5. The most beneficial characteristic of the nutria is its

   A. fur
   B. ability to remove huge tracts of vegetation from marshes
   C. meat
   D. ability to build burrows in the banks of waterways

6. Which of the following pairs of exotics show possible commercial value in water purification (cleaning) systems?

   A. water hyacinths and nutria
   B. nutria and fire ants
   C. fire ants and zebra mussels
   D. zebra mussels and water hyacinths

7. Which of the following describes the harmful effect of exotics on native ecosystems?

   A. They cause the loss of native species.
   B. They disrupt food webs.
   C. They spread rapidly, taking over their new habitat.
   D. All of the above.

8. Which of the following is NOT a way that exotic species enter a new area?

   A. deliberate human introduction
   B. accidental human introduction
   C. natural migrations
   D. evolution

9. Species whose ancestors came from a foreign land are called

   A. endemics
   B. natives
   C. exotics
   D. floras

10. The role or function of a species in its environment is called its

    A. niche
    B. food web
    C. habitat
    D. ecosystem

11. Which of the following is an ecosystem?

    A. the sun
    B. a television
    C. the freezer section of a refrigerator
    D. an aquarium containing fish and algae

12. Species whose populations are declining and nearly extinct are classified as

    A. endangered
    B. endemic
    C. exotic
    D. threatened

DISCUSSION: Use your best writing skills — spelling, punctuation, and grammar — in responding to the following statements.

1. Identify an exotic species that lives in the Gulf Coast area and explain its impact on native organisms and habitats.

2. What usually happens to native species when an exotic species is successful in its adopted habitat? Explain you answer.

3. Describe two ways exotic species may be introduced in a new area and give an example for each.

   a.

   b.

4. Explain why an exotic animal that eats a wide variety of foods can adapt to a new area more quickly than one that eats only a few types of food.

5. A local nursery imports a beautiful, fast growing exotic plant. Once established in a yard, the plant spreads quickly because its roots give off a toxin that kills other plants growing near it. When temperatures dip below freezing, this exotic species dies. Predict its impact on local plants.

6. A storm washes several king snakes onto a small barrier island where some sea bird species come to nest each spring and summer. King snakes eat small birds and bird eggs. Predict the outcome of this situation. Will the snakes be able to survive in their new habitat? What will be the impact on the sea bird populations?

7. Attack or defend the statement, "all exotic species are harmful in their new environments."

EVALUATION — ANSWERS

MULTIPLE CHOICE:

1.	C	7.	D
2.	A	8.	D
3.	B	9.	C
4.	B	10.	A
5.	A	11.	D
6.	D	12.	A

DISCUSSION:

The following examples of answers should be modified by the teacher to fit appropriate grade level expectations.

1. Answers will vary. Refer to the Background Information section for the names and impact of the exotic species highlighted in the video.

2. *Successful exotic species usually harm native populations.*

   - *Native species have natural enemies such as parasites, disease, and predators. Because these natural enemies have little if any effect on a new exotic species, the exotic population may grow faster than that of the native species. Natives that are in direct competition with the exotic for food, water, shelter, and space may be deprived of their habitat needs.*

   - *Over time, these native populations may decline in number, die out completely, or move to new habitat areas where the exotic has not invaded.*

3. *Exotic species may be introduced:*

   - *accidentally by humans — as when attached to a boat or plant or in something like soil or ballast water being transported into an area.*

   - *on purpose by humans — to provide food, sport, beautification, pets, or as a treatment for another exotic.*

   - *by natural migration — as in the case of the armadillo and Africanized honey bee which migrated from South America.*

4. *An exotic animal that eats a variety of foods does not have to spend as much time and energy looking for food. This allows more time for it to find a mate and seek hiding and nesting space, all of which are necessary for survival. An exotic animal that eats only a few types of food may have to spend all of its time and energy looking for food. If its food is not available or is in limited supply, it will become weak and eventually die.*

5. *The exotic plant would spread rapidly the first year, but low winter temperatures would kill it. The following year, native plants would begin to grow again in the area where the exotic had grown, unless its root toxins were still in the soil. If the toxins continued to kill new native growth, erosion of the soil would eventually occur.*

6. *Since king snakes eat small birds (nestlings) and bird eggs, their impact on the sea bird population over a period of years would be catastrophic, especially if the snakes represented a breeding population. Fewer and fewer sea birds would survive to return and nest. The bird populations would dwindle and they may begin to nest at a different site. Eventually, with less food available, the king snake population would also decline. In time, as the snakes died off, new colonies of birds might return to the barrier island.*

7. Answers will vary. The following are some reasonable responses.

   Attack:

   - *Exotic pets provide entertainment and companionship for their owners.*

   - *Exotic plants such as roses and many ornamental shrubs and trees add beauty to neighborhood landscapes.*

   - *Exotic crops such as wheat, cotton, and soy beans provide food and clothing for humans.*

   Defend:

   - *Most exotic species that succeed in the wild cause harm to the established ecosystem. They may disrupt the food web, dominate and/or damage habitat shelter and nesting sites, and ultimately drive out native species with whom they compete for food, water, shelter, and space.*

REFERENCES

The following books, pamphlets, and journal articles were used in producing the module "Exotic Species." They may be helpful in directing student research.

Water Hyacinth:

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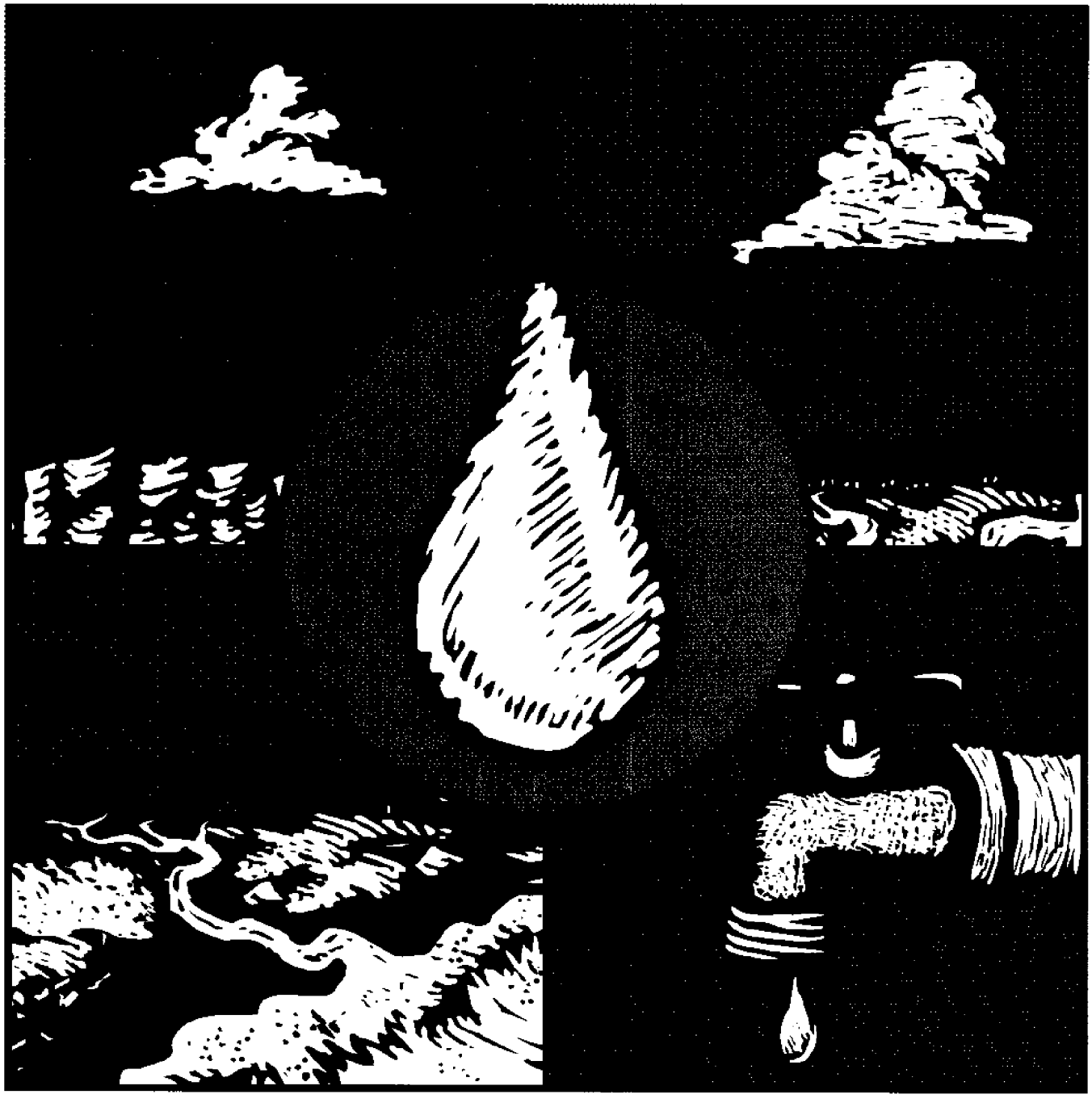
WATER QUALITY



Project TELLUS: Interactive Science Videos on Global Change Issues

WATER QUALITY

LEARNING OBJECTIVES

Students should be able to:

1. Relate the values of water.
2. Identify the major rivers in the United States' Gulf Coast region.
3. Explain the water cycle and relate its importance.
4. List the major types of water pollutants and describe their effects on aquatic ecosystems.
5. Explain how pollutants enter aquatic and marine ecosystems.
6. Name ways that individuals can protect water quality and reduce water consumption.

INTRODUCTION

It cleanses, cools, and refreshes the body....

It beautifies the landscape with the reflected light of sun and moon....

Its movement can be forceful to generate electricity or peaceful to lure the human soul to solitude and meditation....

WATER — the single most important substance found in nature -- is essential for life. It transports vital substances into, out, and throughout all organisms. It is the place where many organisms live. For these and other reasons, an environment with clean water acts like a magnet, attracting a wide variety of life.

The Gulf Coast region with its many aquatic habitats — ponds, lakes, bogs, rivers, streams, swamps, salt and freshwater marshes, bays, and the Gulf of Mexico — is among the most biologically diverse areas of the United States. But the water provided by these aquatic habitats is not limitless. It is finite. The water seen and used today is the same water that has been present since earth's beginning billions of years ago. Nature continually cleanses and replenishes this water through a process called the **water cycle**. However, if water becomes polluted or is used faster than the water cycle can renew and replenish it, the amount of usable water diminishes.

The modern industrial age, filled with things that make life easier, is also responsible for water pollution. Factories, which make the products we use, release foreign and sometimes toxic substances in wastewater. Chemicals that increase crop yields or protect plants from insects and disease are washed by rain into lakes and rivers. Used motor oil and antifreeze, which are necessary to modern transportation, are dumped into residential storm drains. These contaminated waters are less usable, difficult to clean, and often persist in the environment.

The abundance of fresh water throughout the Gulf Coast region has allowed residents to use it unsparingly. At a whim, it has been drawn from faucets for drinking, bathing, washing, and watering lawns. Except during floods and brief periods of summer drought, most people have taken fresh, clean water for granted. But those carefree days are changing.

As the increasing human population and its technological advances create a greater demand for the water resource, humans must find ways that will neither change nor reduce the water for future generations — that is, ways to use this resource **sustainably**. Classroom teachers are in a position to instill the knowledge and encourage the attitudes necessary to bring about this change from indulgent to responsible behavior.

This module on water quality will help students to identify the values of water and the causes and effects of water pollution. Students should then be able to deduce ways that they, as individuals and as communities, can help bring about a change toward sustainable use as we enter the twenty-first century. The Background Information and Activity suggestions

that follow will be helpful in discussing water quality prior to viewing the video and in guiding students toward logical and meaningful conclusions throughout the viewing and postviewing activities.

BACKGROUND INFORMATION

Sources and Uses of Water

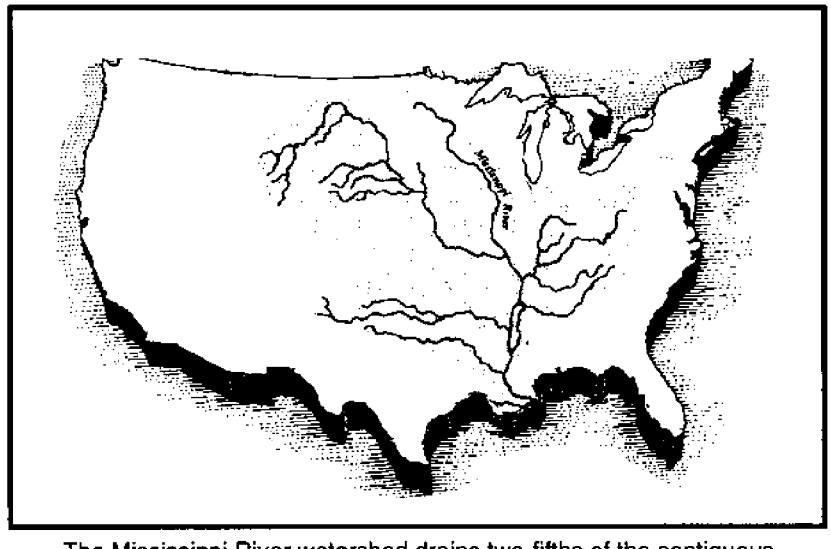
Many parts of the world suffer from a severe shortage of fresh water. Although three-fourths of the earth is covered with water, less than one percent is fresh water that is available for use by humans and other organisms. Ninety-seven percent is saltwater and another two percent is frozen in glaciers or trapped too deep in the ground to be economically retrieved. One advantage to living in the Gulf Coast region is the abundant supply of fresh water.

The average rainfall varies between 40 and 60 inches per year in the Gulf Coast states. Rain touching the ground either drains into **surface waters** (lakes, ponds, rivers, etc.) or soaks into the soil to become **groundwater**. A **watershed** (also called a drainage basin) is all the land that delivers runoff water to a particular body of water. A watershed may be as small an area as a ridge dividing one creek from another or as large an area as the Mississippi River watershed which drains two-fifths of the contiguous United States. Rain that drains from a watershed helps replenish surface and groundwater sources for both urban and rural areas.

In urban areas, the water for most human uses is withdrawn from a nearby lake, river, or **aquifer**. The water is pumped to a treatment station where bacteria and other harmful substances are removed. It is then made available to homes, businesses, and factories through water lines that run underground throughout the community. In rural areas, people dig wells that tap into aquifers. Because groundwater filters through layers of gravel and sand before collecting in an aquifer, this water is usually free of pollutants and can be used directly from the well.

Humans require fresh water for

- drinking
- bodily processes such as the transport of food, waste, hormones, oxygen, and blood cells
- growing plants for food, clothing, and building materials
- cooking
- bathing and waste removal
- manufacturing
- producing electricity for use in homes and industry
- transporting people and products
- recreation — swimming, canoeing, skiing, sailing, and fishing



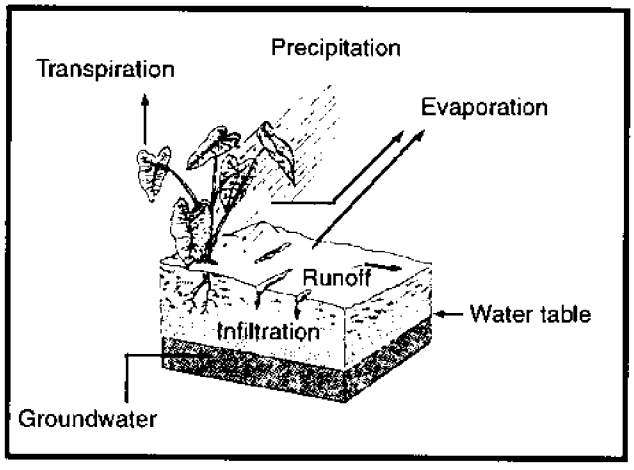
The Mississippi River watershed drains two-fifths of the contiguous United States.

Humans are not alone in their need for clean fresh water. All living organisms need water for survival. The earth is equipped with a natural and continuous process that provides this resource for life.

The Water Cycle

Water changes from a liquid to a gas and back to a liquid or solid as it circulates through a series of processes that purify and move it between the atmosphere and the surface of the earth. Rain, sleet, hail, and snow are forms of **precipitation** that move water to earth. The precipitation falls either on land or directly into surface water. On land, it moves across the surface as **runoff** or it **infiltrates** the soil and porous rock to become groundwater.

During **evaporation**, liquid water, heated by the sun or some other source, changes to water vapor (a gas) and rises, separating from impurities which are left behind. As the vapor continues to rise, it cools and **condenses** to form droplets. These droplets accumulate to form clouds. Eventually, the droplets fall to earth as precipitation and the cycle repeats.



Parts of the water cycle

Why, then, do we not always have enough water? What can affect this natural recycling process?

Water Pollution

As water falls through the atmosphere, traverses the land, and moves through soil and rock, it comes in contact with a number of substances that can reduce its quality. Some of these substances are attracted to and dissolved in water molecules. Substances like oil, dirt, and bacteria, which do not dissolve, are carried or suspended in the solution. But, whether dissolved or suspended, if these added substances change the usability of the water, they are called **pollutants**. Their presence decreases water quality and can make water unfit for use by wildlife and humans.

Factors that reduce water quality are divided into several categories.

- *Organic pollutants* — These pollutants are living organisms such as bacteria, or the waste and remains of organisms — feces, blood, hair, feathers, leaves, etc. Bacteria, viruses, and other pathogens thrive in animal wastes. If these wastes wash into rivers and streams, the pathogens, when consumed in drinking water, can cause illness and even death in humans and wildlife. Diseases such as typhoid, dysentery, and hepatitis are examples of serious waterborne diseases. The decay of these untreated wastes also reduces the level of dissolved oxygen in the water which can lead to **hypoxia** and the death of fish and other aquatic life.

- *Chemical pollutants* — These substances are of two types — plant **nutrients** and **toxic chemicals**. Plant nutrients such as nitrates and phosphates come from **fertilizers** and some detergents. During heavy rains, excess nutrients drain from fertilized lawns and agricultural areas and, once in surface waters, stimulate the rapid growth of algae and aquatic plants. As the excessive vegetation dies and decays, dissolved oxygen is depleted, reducing the quality of the water habitat.

  Toxic or poisonous chemical pollutants come from industrial and automotive discharges, leaking landfills, excessive **pesticides** dissolved in residential and agricultural runoff, and the natural leaching of metals such as mercury, cadmium, selenium, and lead from the soil. When mixed with runoff water, these toxic chemicals make water unfit to drink and harmful to living things.

- *Thermal pollution* — Industrial processes such as the manufacture of steel and the production of electricity create steam and hot water which is then released into surface waters. This heated water may kill organisms

directly or reduce the amount of dissolved oxygen in the waterbody. This can degrade the water for wildlife living in and around the water.

- *Physical characteristics* — Water quality is also affected by **turbidity**. Soil eroding from agricultural, logging, and construction sites adds suspended sediment to surface waters. These suspended sediments make water cloudy and prevent light penetration. With less light, fewer algae and aquatic plants are able to photosynthesize and grow, therefore the dissolved oxygen level and the food supply for many aquatic organisms declines. Excessive suspended sediments can also clog the gills of aquatic animals and can ruin spawning sites.

If the previously mentioned sources of water contamination come from a specific location such as the outflow pipe of a factory or power plant, they are called **point source pollution**. This type of pollution is moderately easy to monitor and correct. Most pollutants, however, are picked up by water as it flows over the land. Since the sites where these contaminants (insecticides, fertilizers, antifreeze, motor oil, animal wastes, etc.) enter the water are difficult to pinpoint, they are classified as **nonpoint source pollution**. Nonpoint source pollution is very difficult to control.

Although runoff has the potential to carry harmful substances, it is necessary to replenish surface waters that would otherwise dry up. With a concentrated effort from individuals and industry, contamination of runoff water can be reduced and water quality improved.

Water Consumption

Another water problem facing residents of the Gulf Coast region is overconsumption. In the United States, the average person uses about 188 gallons of water per day for drinking, cooking, and sanitation. If industrial uses of water are considered, that amount increases to over 1000 gallons per day. Since the amount of available fresh water is limited, increases in the human population means less water for each person. Increased population also means a greater demand for industrial and agricultural water usage and, as this use increases, supplies of clean water decrease. When groundwater is withdrawn at rates that exceed its replenishing (as during drought or through excessive irrigation) the **water table** drops (see illustration on page 3), the groundwater source becomes depleted, and the aquifer may be destroyed as pore spaces collapse and the land subsides.

Using Our Waters Sustainably

In 1972 the U.S. government enacted the Clean Water Act. In 1986 that law was revised and an additional law, the Safe Drinking Water Act, was enacted. These laws provide standards for pollution control and money to build **water treatment** plants. The U.S. Environmental Protection Agency (EPA) monitors public waters to make sure that cities comply with both laws. Since the mid-1970s, water quality has gradually improved and many once-polluted streams and rivers are now safe for swimming and fishing. But there is still work to be done.

We, as a country and as individuals, must strive to practice a philosophy of **sustainable use**, that is, using water in ways that will maintain its quality and supply for future generations. To accomplish this, we must look beyond our immediate personal or corporate inconveniences to future environmental benefits.

The following are actions that, if followed, will help ensure an adequate supply of high quality water for the future.

- Loggers can harvest trees in ways that do not expose the land to soil **erosion** (stop clear cutting forests).
- Engineers can design highways and roads to avoid affecting the flow of streams and rivers.
- People who raise animals can take measures to prevent animal wastes from washing into streams and rivers.
- Industry can continue to improve ways to prevent the release of toxic chemicals during manufacturing processes and waste disposal.
- Power plants can cool water in evaporation towers before releasing it into streams or lakes.
- Farmers can use purified **sewage** water to irrigate their crops rather than using water from wells that deplete aquifers.

Individuals can also help.

- Dispose of household chemicals such as paint and motor oil by taking them to a recycling station rather than pouring them directly on the ground or into a storm drain.
- Store household chemicals and chemical wastes in leak-proof containers.
- Conserve water that comes from the faucet by taking short showers instead of baths and turning off the water while brushing teeth and washing dishes.
- Install water saving devices on shower heads and toilets, and repair leaky faucets.
- Wash cars and boats over grass instead of concrete — the runoff will water the lawn instead of washing into storm drains.
- Landscape with native plants that, once established, can live on the water provided by rain.
- Buy environment-friendly products such as recycled and bleach-free paper products.
- Use pesticides only when necessary. Choose environment-friendly pesticides such as insecticidal soaps, or better yet, use natural deterrents such as ladybugs to help control insect pests or marigolds to ward off nematodes (roundworms).
- Use natural organic fertilizers such as cottonseed meal, blood meal, and bone meal to supply nitrogen, phosphate, and potash for plants.
- Plant ground cover on slopes and under trees to help prevent erosion.
- Compost grass clippings, leaves and other yard trimmings. Use the compost as a water absorbing mulch in flower beds and around trees.
- Participate in an adopt-a-stream program that monitors the health of local streams. Advise the regional EPA office if pollution or other signs of declining water quality are noticed.

Agriculture, industry, and individual citizens all contribute to water problems. All must unite to correct and prevent pollution and overconsumption, so that our waters will continue to be a source of health, beauty, and enjoyment.

TEACHING SEQUENCE

DAY 1 Introduction: Sources and Uses of Water

1. Introduce the topic, Sources and Uses of Water, by doing the following: [20 minutes]
   - Have students guess the amount of water that they use individually per day. Record student guesses on the board. The 1993 *Information Please Environmental Almanac* reports that the average American uses 188 gallons of water per day.
   - Have students cite reasons why water is a valuable resource, i.e. how they use water. Write their responses on the board. (Refer to the list in the Background Information on page 2.)
   - Begin Extension #3 (page 11) by giving each student a copy of pages 26 and 27. Over the coming weekend (Saturday and Sunday), each student will measure his or her family's approximate water consumption by recording the family's water use activities and the accompanying estimates in gallons on the Log of Water Use chart. The results will be discussed in class as a postviewing activity. [OPTION: You may want to delay introducing this activity until the Friday before it is to be done.]
2. Model the limited supply of fresh water on earth by doing the following: [5 minutes]
   - Display a one gallon container of water representing all the water on earth. Ask students to identify the measuring tool (cup, ladle, pitcher, tablespoon, teaspoon, eyedropper, etc.) that they think would most closely represent the amount of water from the container that is drinkable.

- Of all the water on earth, less than 1% *(about one tablespoon from the one gallon of water in the container)* is fresh water, 2% is trapped in the form of glacier ice, and 97% is saltwater. Fresh water is the only type that is usable for most human needs.

3. Familiarize students with the geography of the Gulf of Mexico by having them do Extension #1 as outlined on page 10. [25 minutes]

   - If time is a factor, assign each group of students a different state. Allow 5-10 minutes for groups to identify the water-bodies in their assigned state. Then, using an overhead transparency of the Student Map, have each group share their findings with the class.

   - Use a transparency of the Teacher's Map (page 23) and allow students to check their answers.

DAY 2 **Explain Water Cycle, and Do Watershed Activity and Previewing Questions**

4. Define the following terms while explaining the water cycle: **evaporation, transpiration, condensation, precipitation, runoff, surface water, groundwater, and aquifer**. Relate the value of the water cycle. (Refer to the Background Information about the water cycle on page 3, and the Vocabulary section on pages 8-9.) [20 minutes]

5. Develop an understanding of the **watershed** concept by explaining the term then having students do all or part (especially the third and fourth bulleted items) of Extension #2 found on page 10. [15 minutes]

6. Have students answer the three Previewing Questions (page 9). [15 minutes]

7. Begin making the Secchi disks to be used in Activity II (page 18).

DAY 3 **Discuss Previewing Questions, Begin Video, and Do Activity I**

8. Have students discuss their answers to the Previewing Questions. [7 minutes]

9. Show the video until instructed to pause for Activity I: First You See It .... Now You Don't. [8 minutes]

10. Introduce the activity by reminding students that water is considered the "universal solvent" because it dissolves so many different substances. Sometimes that characteristic is good and sometimes it is bad — ask students to give examples of both incidences. Follow the procedure outlined in the Teacher Instructions (pages 12-13) and allow the remainder of the period for students to complete the serial dilution procedure and the Data Sheet. [35 minutes]

11. For homework, encourage students to do one of the extension activities listed at the end of their instruction sheet (page 15).

DAY 4 **Discuss Activity I, Define Terms, Continue Video, and Demonstrate the Use of a Secchi Disk**

12. Discuss the results and answers to the questions on the Student Data Sheet. [10 minutes]

13. [Options]

    - Discuss the importance of the work done at water treatment plants.

    - Include time (one class period) for a guest speaker to talk to the class about water treatment (Extension #4, page 11).

    - Allow time for students who did an extension activity for homework to report their findings.

14. Give a general definition of **pollutant** and ask students to describe their first memory of seeing pollution in the environment. [10 minutes]

    - What was the pollutant?
    - Where was the pollutant?
    - Was anything being done to correct the pollution problem?

15. The next part of the video is about different types of pollutants. Have students note the **types, sources,** and **effects** of the pollutants described in the video. Continue the video

tape until instructed to pause for Activity II, Turbidity: A Mock Field Study. [8 minutes]

16. Explain the concepts of **eutrophication, dissolved oxygen**, and *(for more advanced students)* **hypoxia**. *(Saltwater intrusion will be considered in more detail in the module on Climatic Change).* [10 minutes]

17. Beginning at step C of the Procedure in the Teaching Instructions for Activity II (pages 18 -19), introduce the concept of turbidity and demonstrate the use of the teacher-made Secchi discs to measure turbidity. Allow time for students to practice measuring trial samples. [17 minutes]

DAY 5 **Begin Activity II**

18. Review the meaning of turbidity and how to use the Secchi disk to measure water clarity (turbidity). [5 minutes]

19. Follow the procedure outlined in the Teaching Instructions, steps E-I to explain the activity and how to do the team report. [20 minutes]

20. Have students collect data from the five test sites and begin writing their team reports. [25 minutes]

DAY 6 **Complete Activity II, Continue the Video, and Discuss Water Consumption Activity**

21. Have students complete their team reports. Discuss their findings and collect the reports. [25 minutes]

22. Watch the remainder of the video program. [10 minutes]

23. As directed in the video, discuss the water consumption activity done on Saturday and Sunday (Extension activity #3 on page 11). [10 minutes]

    - Have students compare their family's water use to the average water use in America.

    - Discuss ways to curb water use within the family.

24. Assign the four Postviewing Questions (pages 9-10) for homework. [5 minutes]

DAY 7 **Discuss the Postviewing Questions**

25. Discuss the Postviewing Questions. [10 minutes]

26. At the teacher's discretion the Evaluation Questions at the end of the video guide (pages 28-31) may be used as a test, or parts of it may be incorporated in the next unit test.
    [NOTE: Before duplicating the mapping section, make lines for the six locations that you want your students to identify.]

VOCABULARY

The following terms are used at various times throughout the module. The definitions may be adapted to suit the students' grade level.

Aquifer: Porus, water-saturated layers of rock or sediment through which groundwater moves easily.

Chemical pollution: Chemical substances (such as oil or phosphate) released into water and air. These often come from industrial waste (produced during manufacturing processes) and runoff.

Condensation: Water vapor molecules changing to a liquid state as they cool.

Erosion: The wearing away of soil by wind and water.

Eutrophication: Excessive algal growth in water bodies caused by nutrient-enriched runoff water. Hypoxia often occurs as the algae die and decay.

Evaporation: Liquid water molecules changing to the gaseous state (vapor) as they absorb heat.

Fertilizer: Substances containing nutrients (chemical compounds such as nitrate and phosphate) that encourage plant growth.

Groundwater: Water that accumulates and moves beneath the soil surface.

Hypoxia: A condition that occurs when the amount of dissolved oxygen in water is too low (less than 5 ppm) to support most life forms.

Infiltration: The movement of surface water into rock or soil.

Nonpoint source pollution: Pollutants (usually in runoff) that enter a water supply from many different and difficult to identify places.

Nutrients: Chemical compounds needed for the normal growth and development of organisms.

Pesticides: Substances (herbicides, fungicides, insecticides) used to kill pests such as weeds and insects.

Organic pollution: Substances from living or once living organisms (bacteria, manure, compost, fertilizers) released into water or air. These often come from agricultural and residential runoff.

Parts per million (ppm): A means of quantifying the concentration of a substance in solution by noting the number of parts of the particular substance in one million parts of the solution.

Point source pollution: Pollutants that enter the environment from a specific location such as the outflow pipe of a factory or sewage treatment plant.

Pollutant: Any substance that harms the environment, making it unfit for use.

Potable water: Water that is safe for drinking but not necessarily pure.

Precipitation: Water molecules that fall to the earth as rain, sleet, hail, or snow.

Runoff: Water that moves across the surface of the earth rather than infiltrating into the ground.

Saltwater intrusion: The movement of seawater into areas usually filled with freshwater.

Secchi disk: A device used to measure water clarity (turbidity).

Sediment: Small solid particles such as soil and mineral fragments that are transported by water, wind, or glaciers.

Sewage: Animal wastes carried by water through sewer pipes or storm drains.

Surface water: Water that is visible on top of the ground — rivers, lakes, bays, oceans, runoff.

Sustainable use: Managing earth's resources (in this case water) in ways that will insure a supply for future generations.

Thermal pollution: An artificial increase or decrease in normal water temperature that causes harm to aquatic wildlife.

Toxic chemicals: Substances such as hazardous waste, pesticides, and heavy metals that can cause serious illness, injury, or death to organisms.

Transpiration: The movement of water up, through, and out of a plant as water evaporates from pores (stomata) in the leaves of the plant.

Turbidity: Cloudiness in water caused by suspended substances such as soil sediments, bacteria, and algae. High turbidity is often an indicator of pollution.

Water cycle: The constant movement of water molecules from earth's surface to the atmosphere and back to earth's surface through evaporation, transpiration, condensation, and precipitation.

Watershed: All the land that delivers runoff water to a particular body of water.

Water table: The depth at which underground soil becomes saturated with water (water fills all the spaces between the soil particles).

Water treatment: The purification of water to remove harmful substances such as solid waste, bacteria, chemicals, and heavy metals.

PREVIEWING QUESTIONS AND ANSWERS

1. List at least three reasons why water is important to you.

   Typical answers include:

   - *health — drinking, bathing, cooling off*
   - *cooking — mixing with other ingredients or boiling, canning, etc.*
   - *cleaning — washing clothes, dishes, cars, etc.*
   - *recreation — swimming, fishing, sailing, etc.*
   - *watering the yard — to nurture grass, flowers and vegetables*
   - *agricultural uses — irrigation for growing crops*
   - *industrial uses — as coolant, solvent, ingredient (reactant)*

2. Name and give an example of four types of water ecosystems found in your state.

   - *Ecosystems cited may include: rivers, creeks, lakes, ponds, bayous, bays, marshes, swamps, estuaries, saltwater (marine)*

   - *Specific examples will vary depending on the state. For example, in Louisiana the answer might include:*

     River — Mississippi
     Lake — Pontchartrain
     Swamp — Atchafalaya
     Creek — Thompson

3. Why do you think so many people like living in the Gulf Coast region?

   - *The many rivers, lakes, and bayous provide opportunities for a variety of jobs, industry, food sources, recreation, and enjoying the beauty of nature.*
   - *The climate is mild.*

POSTVIEWING QUESTIONS AND ANSWERS

1. What is pollution? Name some water pollutants and physical contaminants.

   Pollution is anything that harms the environment, making it unfit for use. Examples of water pollutants are:

   - *harmful bacteria*
   - *chemicals found in runoff — nutrients (fertilizers), pesticides, metals, oil, antifreeze, and other petroleum products*
   - *chemicals released in wastewater from industrial plants*
   - *litter*
   - *suspended particles of dirt*

2. For each pollutant listed in question number one, suggest at least one individual or community action that could reduce the problem.

Answers will vary. Refer to the lists in Using Our Waters Sustainably on pages 4-5. Suggestions include:

- *Harmful bacteria — People who raise animals can take measures to prevent animal wastes from washing into streams and rivers.*
- *Chemicals in runoff — Use environmentally safe pesticides such as insecticidal soaps and horticulture oils.*

  Use organic or other slow release fertilizers and apply them at the rates and in the quantities described on the package.

  Dispose of household chemicals such as paint and motor oil by taking them to a recycling station rather than pouring them directly on the ground or into a storm drain.
- *Chemicals in industrial wastewater — Industry can continue to improve ways to prevent the release of toxic chemicals produced during manufacturing processes.*
- *Litter — Participate in a beach cleanup.*

  Always put trash in a wastebasket or proper receptacle.
- *Suspended particles of dirt — Landscape your yard to reduce soil erosion.*

3. Why is nonpoint source pollution considered more difficult to control than point source pollution?

   Nonpoint source pollutants enter a water supply (usually in runoff) from many different and difficult to identify places.

4. You are a member of a country club that has recently purchased a large parcel of land adjacent to a saltwater marsh. The club is planning to add another 18-hole golf course. You know that runoff containing pesticides and fertilizers from the golf course will contaminate the wetlands area. Will you

   a. stay in the club and do nothing?
   b. stay in the club and speak out strongly against the project?
   c. resign from the club?
   d. take some other action?

   Defend your answer.

   Answers will vary. Address the pros and cons of each response during a class discussion.

EXTENSIONS

1. **Geography:** Develop an awareness of Gulf Coast geography by giving each student a copy of the map shown on page 24 and having them label the following places:

Corpus Christi Bay	Tombigbee River
Colorado River	Alabama River
Brazos River	Coosa River
Trinity River	Tennessee River
Sabine River	Mississippi Sound
Toledo Bend Lake	Mobile Bay
Red River	Pensacola Bay
Atchafalaya River	Apalachicola River
Vermilion Bay	Suwannee River
Terrebonne Bay	Tampa Bay
Barataria Bay	Lake Okeechobee
Mississippi River	Rio Grande River
The Everglades	Yucatan Peninsula
Pearl River	Gulf of Mexico
Mexico	Cuba
Galveston Bay	Lake Pontchartrain

   - Provide a roadmap of the Gulf Coast states for students to use as a reference tool — one roadmap per group of three to four students should suffice.
   - You may want to add places more relevant to your region or simplify the list for younger students. *(If you add or delete names on the list, change the lines on the map accordingly before making copies for the students.)*

2. **Where is your watershed?** Every watershed is part of a larger watershed. Discuss the meaning of watershed (drainage basin), then have your students do some or all of the following:

   - Walk around their neighborhood after a rain to determine where the water drains.
   - Use a local topographical map to identify their neighborhood's watershed
   - Mark the general location of their town on the Gulf Coast Map (page 24), then use the Watersheds of the Gulf Coast Region Map (page 25) to identify the major watershed to which they belong.
   - Use a state or regional map, to determine how water from their watershed reaches the Gulf of Mexico.

- Explain to a friend or someone in their family how water from their neighborhood can affect the Gulf of Mexico.

3. **How much water do you use?** Develop student awareness regarding personal water consumption by having them calculate their family's water usage over one weekend (Saturday and Sunday). *This is the activity mentioned by the narrator at the end of the video tape.*

   - Give each student a copy of pages 26 and 27 for monitoring their family's weekend water usage.

   - After completing the video tape, have students discuss their findings and brainstorm ways that consumption could be reduced. (Refer to suggestions in the Background Information under Using Our Waters Sustainably, page 4.)

4. **Guest speakers:**

   - Ask someone from the water company to visit your class to talk about the local water supply — the source, how it is purified, how it is distributed, the average daily use citywide, etc. Ask the speaker to show students how to measure water usage on a residential water meter. As a follow up activity, have the students read their home water meter to determine their family's water usage over a three day period.

   - Invite a hazardous waste expert from a local environmental quality office to speak to your class about everyday chemicals (cleaning agents, paint, used motor oil, batteries, etc.) that pose a threat to water supplies. Ask the speaker to relate ways individuals can properly dispose of these chemicals.

5. **Math:** Call the local water company to inquire about the number of gallons of water used in residential areas citywide per day. Ask students to divide by the total population to get the average amount used by each person per day. Have students measure their family's daily use of water (see Extension #4) to determine if they use more or less than the average.

6. **Field Trip:** Visit a local water treatment plant. Have students prepare questions to ask concerning the treatment, distribution, and future availability of water.

7. **Class or club projects:**

   - After obtaining permission from the proper city authorities, stencil warnings such as "Protect Our Water: No Dumping" on neighborhood storm drains to alert people that chemicals and trash carried by storm runoff can pollute streams and ponds. (Make sure that the stencil design is neat and easy to read — network with the art teacher for this project.)

   - Make homemade water sampling/testing devices such as Secchi disks, invertebrate samplers, dip nets, sieves, etc. (The Tennessee Valley Authority manual, *Homemade Sampling Equipment*, Water Quality Series, Booklet 2 is a good resource for showing how to make these devices.

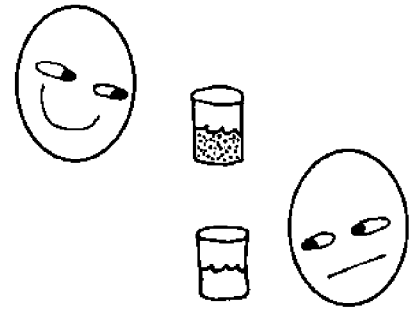
   - Participate in a clean-up campaign at a Gulf beach or local water body in your area. Recycle some of the materials you collect by making an educational display, a work of art, or a useful item.

   - Plant grass, coverplants, or trees in areas of the school yard that are subject to erosion.

8. **Research:** Have students collect information about ecological problems (pollutants, development, dredging, industrial discharges, etc.) affecting the waterbodies listed in your state from Extension #1. Have them report their findings to the class in an oral or written report. Have the class respond by suggesting possible solutions to the problems.

ACTIVITY I

FIRST YOU SEE IT .... NOW YOU DON'T!
(Teacher Instructions)



Introduction

When chemicals such as insecticides, fertilizers, gasoline, and motor oil are poured on the ground or down a storm drain, they seep into the ground or are carried by runoff to a stream, river, or lake. As they move through the environment, the chemicals mix with water and their concentration becomes so dilute that the substances can no longer be seen. Unfortunately, the invisible chemicals can still poison. For example, one gallon of used motor oil dumped into a storm drain may be invisible by the time it is discharged into a local river or lake, but that one gallon is enough to contaminate one million gallons of fresh water.

Because contamination is not always visible, people routinely test water for the presence of pollutants, and, when found, determine whether the concentration of the pollutant would be harmful to man or animal. That gallon of oil dumped into a storm drain will be diluted at least a thousand times before it is identified at a local **water treatment** station. Because of the magnitude of dilution, water technologists use mathematical ratios to measure the concentration of pollutants in parts per million (ppm) or parts per billion (ppb). These measurements can be difficult for students to comprehend. This activity on serial dilutions will help students to understand how pollutants are measured and that pollutants may be present even though they cannot be seen.

Objectives

- To relate how pollutants are measured.
- To strengthen math skills in place value, ratios, and scientific notation (optional).

Description

Students will work in small groups to perform a serial dilution using food coloring and tap water. They will describe each dilution visually by color and mathematically as a ratio of food coloring (dye) to total solution. They will make inferences and answer questions based on their observations.

Materials (per group)

2 medicine droppers or pipets
11 clear cups or small beakers
White lineless paper
Food coloring (blue, red, or green)
Grease pencil or marking pen

Procedure

A. Make enough copies of the Student Instructions and Data Sheets (pages 14-16) for each student to have a set.

B. Separate the required materials for each group before class begins.

C. When directed by the video narrator, stop the tape and distribute the Student Instructions and Data Sheets.

D. Have the students read the introduction, then discuss the concept of measuring in parts per million and billion. *(Percentage is the same concept expressed in parts per hundred rather than parts per thousand, million, or billion.)*

E. Review the meaning of place value, ratios, and — for more advanced students — scientific notation. *(Network with math teachers so they can explain the math concepts before you use them in science.)*

F. Demonstrate the procedure for preparing a serial dilution as outlined in the Student Instructions.

G. Assign students to groups and have one member of each group get the materials required for the activity.

H. Tell students to follow the procedure outlined in the Student Instructions and to answer the questions on the Data Sheet.

I. Discuss the results and the answers to the questions. (The answer key follows.)

J. Encourage students to do one of the extension activities suggested at the end of their activity sheet (page 15) and report their findings to the class.

[This activity was adapted from Activity #3 in *Urban Stormwater Runoff: How to Stem the Toxic Tide*, written by Sue Ellen Lyons and Mary M. Banbury, Ph.D. © Project CEED. University of New Orleans College of Education. 1993.]

ANSWER KEY FOR ACTIVITY I

1. Complete this chart based on the serial dilution activity.

Cup #	1	2	3	4	5	6	7	8	9
Color of solution (blue, red, or green)	dark	*The color becomes progressively lighter until it is invisible.*							
Concentration of food dye	1:10	1:100	1:1,000	1:10,000	1:100,000	1: 1 million	1: 10 million	1: 100 million	1: 1 billion
Color seen? (yes or no)	yes	*yes*	*yes*	*yes*	*yes*	*no*	*no*	*no*	*no*

2. Why was it necessary to rinse the dropper, tap out excess water, and refill cup B after each serial dilution?
   To avoid adding dye from the previous dilution

3. What was the purpose of the white paper? (Hint: It was not used as a spill mat.)
   The white paper provided a background that allowed the color to be seen more easily.

4. In which cup is the food dye at a concentration of 1 part per million? *#6* Can you see any of the dye? *No* In which cup is the food dye at a concentration of 1 part per billion? *#9* Can you see any of the dye in that cup? *No*

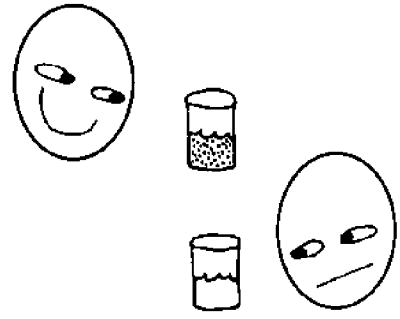
5. At which dilution did the solution first appear colorless to you? *#6*

6. Do you think "pollutants" (food dye) are present in the "colorless" solutions, even though you cannot see them? Explain.
   Yes. Some molecules of the dye were passed along in each drop that was transferred from cup to cup.

7. Predict what would happen if the water in cups 1-9 was allowed to evaporate?
   A film of powder the color of the dye would be left behind. (The color of the film would dim as the number of the cup increased.)

ACTIVITY I

FIRST YOU SEE IT ... NOW YOU DON'T
(Student Instructions)



Introduction

Pollutants enter our waterways from many different sources. Often the amount of pollution in the water is so small it cannot be seen, smelled, or tasted. Nevertheless, the pollution affects the water quality and can make the water unsafe for wildlife and humans.

Scientists determine whether the water is safe by measuring the type and amount of pollutants present in a sample of water. They report their findings in measurements called parts per million (ppm) or parts per billion (ppb). These measurements are ratios (comparisons) of the number of pollutant parts to the total number of solution parts in the sample. Although the numbers — millions and billions — are quite large, the concept is easy to understand in the following everyday terms:

- One part per million (ppm) is about the same as:

  One drop of food dye in 16 gallons of water

  One large mouthful in a lifetime of eating

  One dollar bill in a stack of dollar bills 250 feet high

- One billion is such a huge number that if you started counting to 1 billion right now, it would take you over 60 years to finish counting!

- A billion dollar stack of $10 dollar bills would be 2500 feet high. WOW! That's almost half a mile high.

So, you see, a few parts in a million or billion is a very small amount. You may not be able to detect that small amount of pollutant by smell, taste, or the unaided eye, but it may be enough to make an aquatic habitat unfit for some organisms.

This activity will help you to understand how pollutants can be present even when you cannot see them.

Procedure

1. Place 9 clear cups or beakers in a straight line on top of white lineless paper and use a grease pencil or marking pen to label them 1-9 as shown in the diagram below.

2. Label the remaining two cups A and B.

3. Fill cups A and B with clean tap water. Assign one dropper (pipet) for cup A and the other dropper for cup B. Cup A will be the source of water for each serial dilution. The water in cup B will be used to rinse dropper B between dilutions. **(Be careful to keep the droppers separated during the activity.)**

4. Squeeze 10 drops of food coloring from the original container into cup #1 (food coloring is a 1:10 dilution — *1 part dye in 10 parts of total solution*).

5. Squeeze 1 drop of food coloring from the original container into cup #2.

6. Using dropper A, add 9 drops of water from cup A to the one drop of food coloring in cup #2. Gently swirl the cup to mix the solution. **(Do not use the dropper to mix the solution.)** What part of the solution is dye? *(1/10 x 1/10 = ?)* Record the concentration in cup #2 on your Data Sheet as a ratio of parts dye : parts solution.

7. Use dropper B to transfer 1 drop of solution from cup #2 to cup #3. Rinse the dropper in cup B, tap out any excess water in the dropper, then replace the water in cup B with fresh tap water.

8. Using dropper A, add 9 drops of water from cup A to the solution in cup #3. Gently swirl the cup to mix. **Put dropper A back into cup A.** What part of this solution is food dye? *(1/100 x 1/10 = ?)* Record the concentration in cup #3 on your Data Sheet as a ratio of parts dye : parts solution.

9. Use dropper B to transfer 1 drop of solution from cup #3 to cup #4. Rinse the dropper in cup B, tap out any excess water in the dropper, then replace the water in cup B with fresh tap water.

10. Using dropper A, add 9 drops of water from cup A to the solution in cup #4. Gently swirl the cup to mix. **Put dropper A back into cup A.** What part of this solution is dye? *(1/1000 x 1/10 = ?)* Record the concentration in cup #4 on your Data Sheet as a ratio of parts dye : parts solution.

11. Continue the serial dilution process in this manner until all dilutions are completed (Remember to keep droppers A and B separated and to rinse dropper B and replace the water in cup B after each dilution.)

12. Record your observations and answer all the questions on your Data Sheet.

Extensions:

- Research one polluting substance from the list below. Investigate such things as its effect on humans and wildlife, how long it persists in the environment, how it is used, and how it gets into the environment.

arsenic	DDT
nitrates	cadmium
lead	selenium
chromium	mercury

- Call the regional Department of Environmental Quality (DEQ) to inquire about pesticide use in your community. Which pesticides (insecticides, herbicides, fungicides) have been found in local waters? In what concentrations have they been found?

Name _____

Period _____

FIRST YOU SEE IT .... NOW YOU DON'T!

(Student Data Sheet)

1. Complete this chart based on the serial dilution activity.

Cup #	1	2	3	4	5	6	7	8	9
Color of solution (blue, red, or green)	dark								
Concentration of food dye	1:10								
Color seen? (yes or no)	yes								

2. Why was it necessary to rinse the dropper, tap out any excess water, and refill cup B after each serial dilution?

_____

3. What was the purpose of the white paper? (Hint: It was not used as a spill mat.)

_____

4. In which cup is the food dye in a solultion of 1 part per million? _____ Can you see any of the dye? _____ In which cup is the food dye in a solution of 1 part per billion? _____ Can you see any of the dye in that cup? _____

5. At which dilution did the solution first appear colorless to you? _____

6. Do you think "pollutants" (food dye) are present in the "colorless" solutions, even though you cannot see them? Explain.

_____

7. Predict what would happen if the water in cups 1-9 was allowed to evaporate?

_____

ACTIVITY II

TURBIDITY: A Mock Field Study
(Teacher Instructions)

Introduction

Soil particles suspended in water are among the most troublesome physical contaminants in our Gulf Coast waterbodies. In high concentration, these sediments can reduce water quality by:

- clouding the water
- reducing photosynthesis
- interfering with some animal feeding habits
- carrying pesticides, bacteria, and other harmful substances

As the soil particles settle to the bottom, they can also destroy the spawning grounds of fish, and clog or fill the waterway with silt.

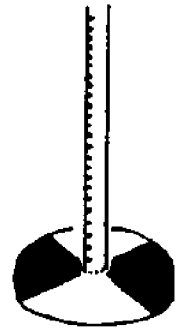
Most soil sediments enter water as a result of erosion nearby. Erosion can be particularly severe when human activities such as farming, construction, logging, and mining strip the land's surface of plants. (The rhizoids and roots of plants hold soil in place.)

As light hits and is scattered by the suspended soil particles, water takes on a turbid (cloudy) appearance. The amount of turbidity is an indicator of water quality.

One way to measure turbidity is to determine the depth of visibility in a waterbody or a sample of water. Because of its low cost and ease of use, a Secchi disk (illustrated above) is often used to measure depth of visibility.

The disk is lowered into the water until the black and white quadrants can no longer be differentiated. A low turbidity reading (shallow depth) indicates cloudy, sediment-laden water, while a high turbidity reading (increased depth) indicates clearer water.

In this activity, students will learn how to use a Secchi disk to measure turbidity, and will then participate in a mock field study to apply the use of the Secchi disk in determining a new source of physical contamination in a river system.



Secchi disk

Objectives

- To relate the definition, causes, and effects of turbidity
- To use a Secchi disk to determine the turbidity of a water sample
- To use turbidity readings to solve a problem presented in a mock field study

Description

The teacher will introduce the activity *(explain turbidity)*, model the use of a Secchi disk, and explain the field study scenario. Then, using teacher-made Secchi disks, students will work in teams to measure the turbidity of five different water samples. The five water samples will contain varying amounts of suspended soil and will represent different sites in a hypothetical river system. The data will be used to determine a new source of sediment contamination in the river. Each team will write a report that includes:

- a brief *introduction* explaining turbidity and its effects
- the *purpose* of the field study
- the *procedure* followed in discovering the new source of contamination
- the *data collected* (chart, graph, and map on the Student Data Sheet)
- a *conclusion* (the area responsible for the new input of sediments and suggestions for mediating the problem)

Materials for Secchi Disks

5 white, nine-inch plastic dinner plates
5 yardsticks with centimeter measurements
or 5, 30-36 inch wooden dowels
1 small can of black spray paint
5 thumb tacks or 10 sturdy push pins
Masking tape
Hot glue gun

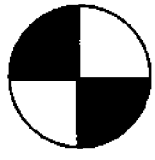
Materials for Mock Field Study

5 Secchi disks (one per site)
5, 5-gallon buckets (dark plastic) or classroom trash cans of comparable size
1 bag of sterile cow manure (soil)
5 long spoons or dowels for stirring
Instruction and Data Sheets for each student (pages 20-22)

Procedure

A. Make the Secchi disks ahead of time.

1. Use masking tape to mark-off and cover two quadrants on the back of each dinner plate as shown below.



2. Spray the unprotected quadrants with black paint and allow the plates to dry over night.

3. If using dowels instead of yardsticks, use a meter stick or metric ruler to calibrate the dowels in centimeters. Mark scale numbers every 2 centimeters.

4. The next day (or after the paint is dry), remove the masking tape from the plates.

5. Using the hot glue gun, fasten the zero-end of the yardsticks or dowels to the center of the painted side of the plates (at the intersection of the quadrants).

6. After the glue dries, press two push pins or a thumb tack through the bottom of each plate into the end of the yardstick or dowel to further secure the plate.

7. The Secchi disks are now ready to use.

B. Before class the day of the activity:

1. Label the five buckets A - E.

2. Fill each bucket with 4 gallons of water and add sterile manure in the amounts shown in the table below. *(Do not pack the manure into the cup.)*

Bucket	Amount (cups)	Name	Approximate Turbidity Reading
A	2 1/4	Muskrat Bay	4 cm
B	4 1/2	(students will name)	2 cm
C	3/4	Lily Pad Pond	9 cm
D	1	(students will name)	7 cm
E	1 1/2	(students will name)	5 cm

3. Using a Secchi disk, measure the turbidity in each bucket. (Stir the mixture before measuring.) *The relationship between turbidity and visibility is inverse, therefore, the greater the turbidity, the less the visibility. Bucket B should have the lowest turbidity reading since it contains the most sediment. Bucket C should have the highest turbidity reading since it contains the least sediment.* If necessary, make adjustments in the amounts of manure added to each bucket to obtain desired results.

4. Label Bucket A *Muskrat Bay* and Bucket C *Lily Pad Pond.* (Students will name the source of site B [the lake], site D [the river], and site E [the creek] before beginning the activity.)

C. Begin the activity by giving background information on the causes and effects of turbidity.

D. Explain and demonstrate the use of the Secchi disk.

- Use two buckets of water for the demonstration — one without any sediment and one containing one cup of manure.

- Stir the mixture in the bucket before taking a measurement.

- Read the measurement to the nearest half centimeter. (It is helpful to have a student read the measurement while the teacher raises and lowers the Secchi disk.)

  The Secchi disk will be visible to the bottom of the bucket containing no sediment and will be visible for about seven centimeters in the bucket containing one cup of manure.

- Optional: Provide students an opportunity to practice taking turbidity readings at one of the stations.

E. Divide the class into teams of 3 or 4 students each.

F. Give each student a set of Student Instructions and a Data Sheet. Ask the students to read the Introduction in the Student Instructions (page 20).

G. Using the map on the Student Data sheet, explain how measuring turbidity at sites upstream and downstream can help pinpoint an area where erosion or other sources of contamination are entering the water.

   If the turbidity reading upstream is higher (more visibility) than the turbidity reading downstream (less visibility), then sediments are entering the water between the two sites. (For this activity, the site with the lowest turbidity reading will represent the area contributing the new source of contamination.)

H. Ask the students to read the scenario and procedure in the Student Instructions.

I. Answer any questions concerning the procedure and explain the requirements for the team report. (See Description at the beginning of the Teacher Instructions.)

J. Allow time for the students to complete the activity and write their team report.

K. Discuss the results and collect the reports.

L. Return to the video.

Extension

- Invite a water technologist (field biologist) from the Department of Environmental Quality to talk to your class about (1) water quality in the local lakes, streams and rivers and (2) ways that individuals and communities can become better stewards of the water resource.

[This activity was adapted from a classroom exercise written by Patti McGehee, Hammond Junior High, Hammond, Louisiana.]

ACTIVITY II

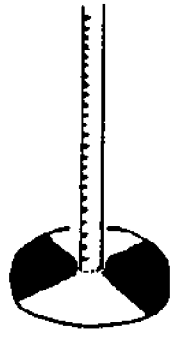
TURBIDITY: A Mock Field Study
(Student Instructions)

Introduction

Turbidity is a term used to describe the cloudiness in water caused by suspended substances such as soil sediments, algae, and bacteria. Water with low turbidity appears fairly clear because it contains few suspended particles. Because it is clear, you can see objects in the water. On the other hand, water with high turbidity appears cloudy because it is transporting suspended matter. Once an object is a few centimeters under the surface of water with high turbidity, you can no longer see it.

Scientists and water technologists measure the amount of turbidity in water to help determine water quality. When a waterbody becomes extremely turbid, photosynthesis decreases, the waterway may become clogged with silt, and the spawning sites of some animals may be destroyed. High turbidity may indicate a new pollution source or a new area of soil erosion. Examples of human activities that can lead to the erosion of soil and therefore an increase in water's turbidity are improper farming methods, highway construction, and harvesting timber too close to a stream or river.

Most river systems have many adjoining waterways — small creeks, ponds, lakes, and sometimes a bay or the ocean. Navigating all the adjoining waterways to locate a hidden or new source of contamination can be difficult. However, by using a Secchi disk to measure turbidity above and below each one, scientists can determine where excess sediments are entering a river system. Action can then be taken to correct the problem.



Secchi disk

The map on your Data Sheet describes a picturesque river system that could be located in the Gulf Coast region. Imagine yourself in the following scenario and complete the procedure outlined below to discover where a new source of contamination is entering the river system.

Scenario

You belong to a team of biologists employed as water technologists by the State Department of Environmental Quality (DEQ). About three months ago, fishermen began reporting excess sediment in one of the state's most beautiful rivers. Two months ago, citizens living along the river near Muskrat Bay reported a color change in the water. The normal color, a transparent tea-brown, changed to a muddy yellow-brown. Fishing has declined during the last three months and no fish have been caught near the mouth of the river during the last two weeks.

Your team has been assigned the task of locating the new source of water contamination. A map of the river system showing its adjoining lake, pond, tributaries (streams and creeks that feed into the river), and bay is shown on the Student Data Sheet.

Procedure

1. With your team, decide on names for the river, lake, and creek. Label them on the map.

2. Your teacher has prepared buckets of water representing the different test sites identified on the map.

3. Use the Secchi disk provided at each site to measure the water's turbidity.

- Stir the mixture in the bucket with a dowel or spoon (NOT the Secchi disk!) before taking the turbidity reading.

- To take the turbidity reading, slowly lower the Secchi disk into the water until the disk visually disappears (all the quadrants appear the same color).

- Measure the turbidity reading to the nearest half (0.5) centimeter and record the measurement in the appropriate space on your Data Sheet.

4. Create a bar graph to display your results.

5. Use your graph and map to determine which area in the river system is the probable source of new contamination.

6. Write a group report to submit to your DEQ supervisor (teacher) giving the following information:

   - An **introduction** — background information about the causes and effects of turbidity.

   - The **purpose** of the field study.

   - The **procedure** you followed in collecting the data — write it in story form telling your observations as you investigated each test site — be creative!

   - The **results** of the turbidity tests — include the labeled map, turbidity readings, and a graph of the data (your Data Sheet).

   - A statement of your **conclusion** (where the contaminant is entering the water and what is the probable cause) and suggestions for solving the problem.

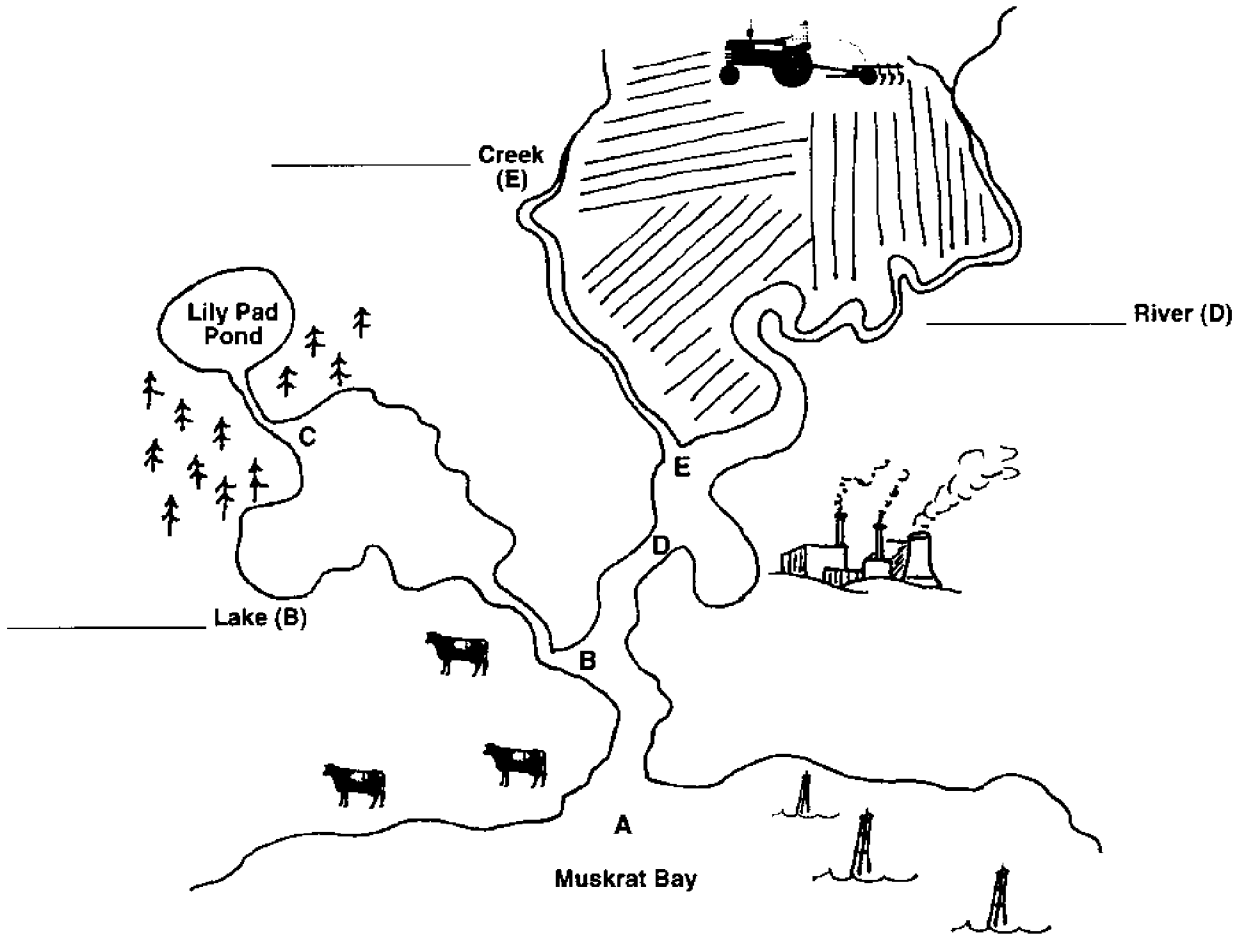
You may use your textbook, class notes, and information on this activity sheet as references. Be creative and have fun!

Extensions

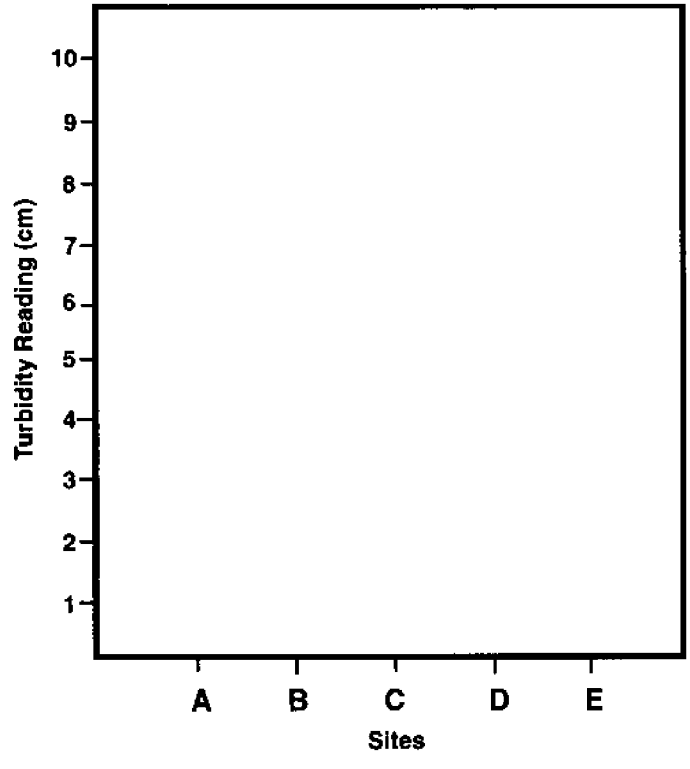
- Look at all the land uses described on your map. What can people who are in charge of these various activities do to protect the aquatic ecosystem from pollution and erosion?

- Use a state or regional map to determine the names and locations of aquatic ecosystems located downstream from your community. What can you personally do to reduce pollution in these aquatic ecosystems?

STUDENT DATA SHEET

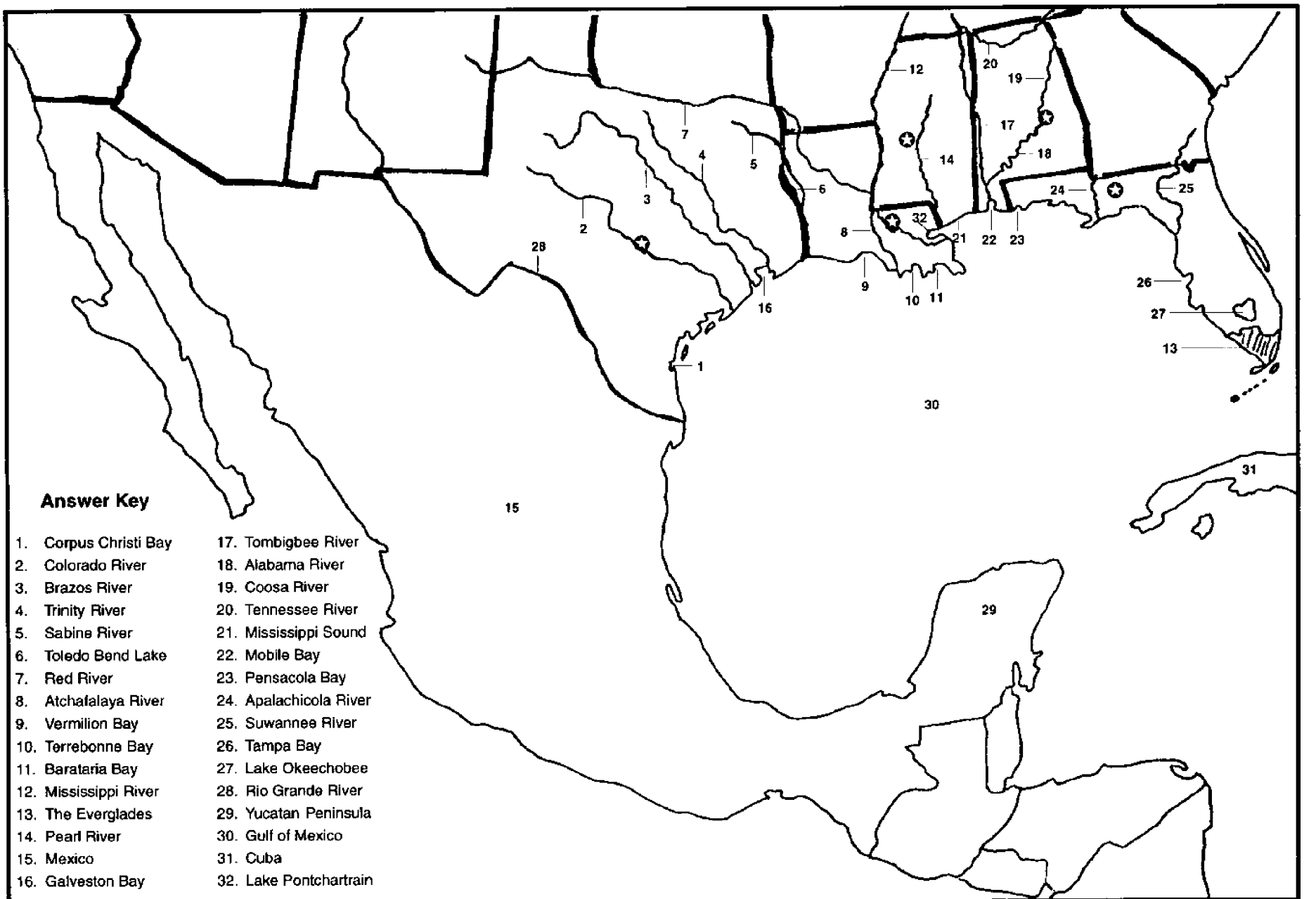


SITE	NAME	TURBIDITY READING
A	Muskrat Bay	
B	_____ Lake	
C	Lily Pad Pond	
D	_____ River	
E	_____ Creek	



MAP OF THE GULF COAST REGION

(Teacher's Map)

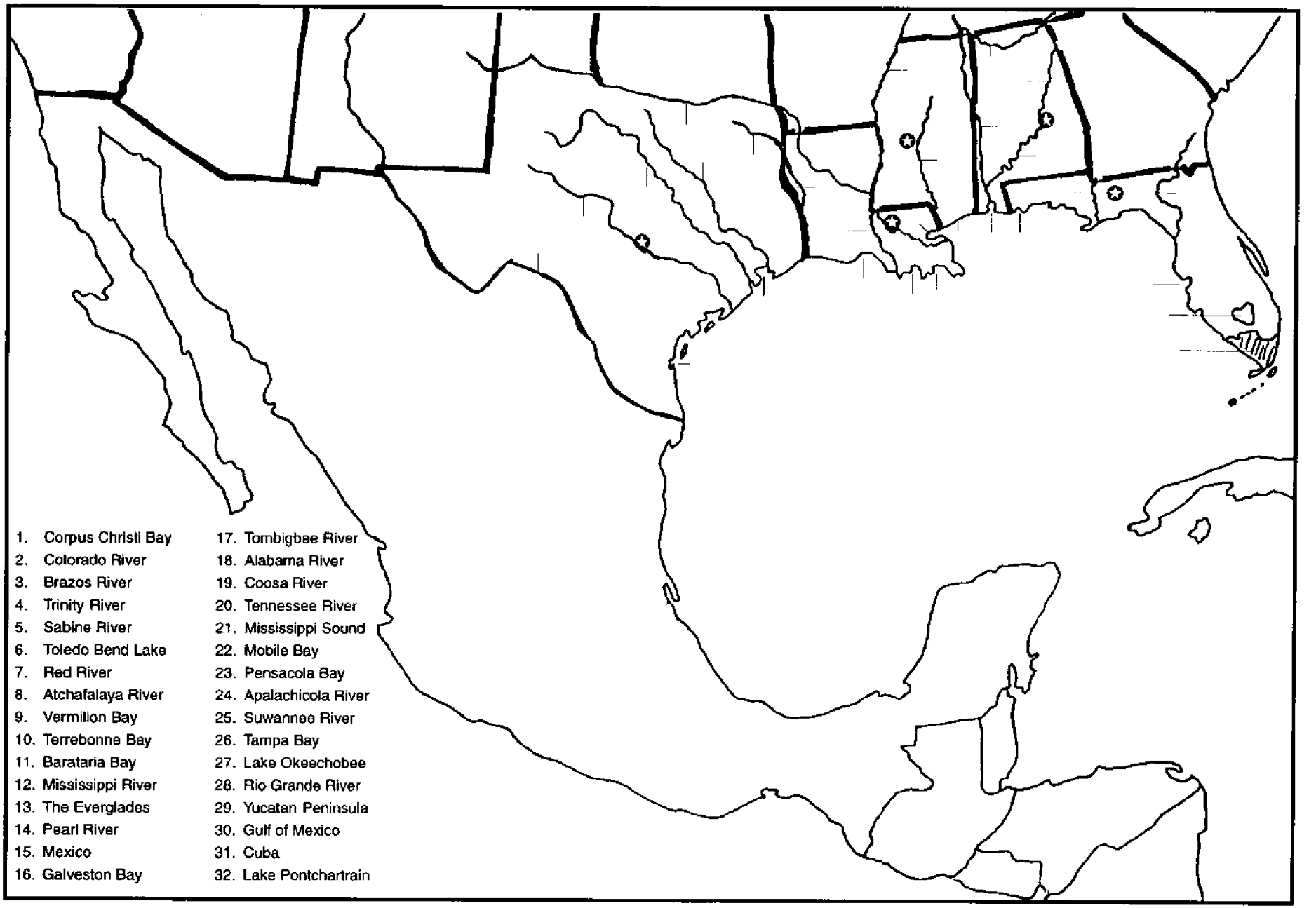


Answer Key

1. Corpus Christi Bay
2. Colorado River
3. Brazos River
4. Trinity River
5. Sabine River
6. Toledo Bend Lake
7. Red River
8. Atchafalaya River
9. Vermilion Bay
10. Terrebonne Bay
11. Barataria Bay
12. Mississippi River
13. The Everglades
14. Pearl River
15. Mexico
16. Galveston Bay
17. Tombigbee River
18. Alabama River
19. Coosa River
20. Tennessee River
21. Mississippi Sound
22. Mobile Bay
23. Pensacola Bay
24. Apalachicola River
25. Suwannee River
26. Tampa Bay
27. Lake Okeechobee
28. Rio Grande River
29. Yucatan Peninsula
30. Gulf of Mexico
31. Cuba
32. Lake Pontchartrain

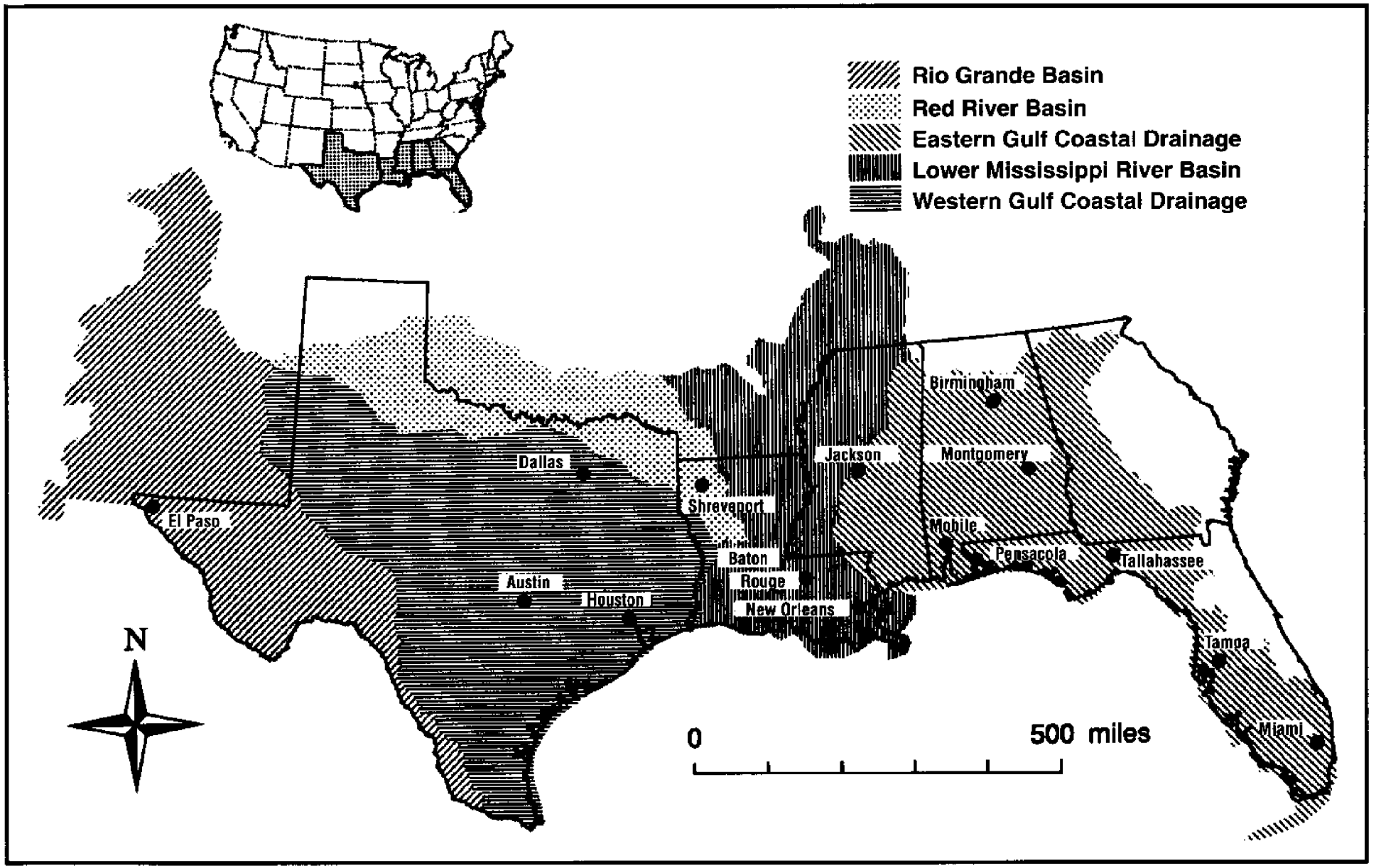
MAP OF THE GULF COAST REGION

(Student Map)



1. Corpus Christi Bay
2. Colorado River
3. Brazos River
4. Trinity River
5. Sabine River
6. Toledo Bend Lake
7. Red River
8. Atchafalaya River
9. Vermilion Bay
10. Terrebonne Bay
11. Barataria Bay
12. Mississippi River
13. The Everglades
14. Pearl River
15. Mexico
16. Galveston Bay
17. Tombigbee River
18. Alabama River
19. Coosa River
20. Tennessee River
21. Mississippi Sound
22. Mobile Bay
23. Pensacola Bay
24. Apalachicola River
25. Suwannee River
26. Tampa Bay
27. Lake Okeechobee
28. Rio Grande River
29. Yucatan Peninsula
30. Gulf of Mexico
31. Cuba
32. Lake Pontchartrain

MAJOR WATERSHEDS OF THE GULF COAST REGION



Map by John Sheehan, Louisiana Department of Environmental Quality.

Log of Water Use

DATE	TIME	WATER USE ACTIVITY	GALLONS USED

COMMON WATER USES

USE	AVERAGE GALLONS
Clothes washing	35-50 gallons
Flushing toilet	6 gallons/flush
Dish washing (by hand)	10 gallons/meal
Electric dishwasher	60 gallons/load
Cooking	10 gallons/meal
Drinking	6-8 ounces/ glass
Bathing	36-45 gallons/bath
Showering	5-6 gallons/minute
Washing hands	0.25 gallons
Brushing teeth	
(with water running)	2-4 gallons
(without water running)	1 gallon
Car washing	20-30 gallons/car
Yard watering	8 gallons/minute

EVALUATION QUESTIONS

MULTIPLE CHOICE: Select the **BEST** answer for each statement.

1. Rain, sleet, and snow are common forms of _?_.

   A. condensation
   B. pollution
   C. precipitation
   D. participation

2. A place where groundwater is trapped.

   A. aquarium
   B. aquifer
   C. cave
   D. watershed

3. The process of liquid water becoming water vapor (a gas).

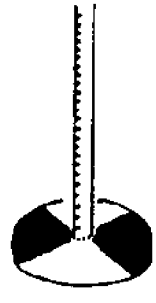
   A. condensation
   B. evaporation
   C. precipitation
   D. eutrophication

4. All the land that delivers runoff to a particular water body is called a _?_.

   A. reservoir
   B. shoreline
   C. watershed
   D. all of the above

5. The measuring device shown in the illustration below is a _?_.

   A. sieve plate
   B. turbidity stick
   C. Sushi bisque
   D. Secchi disk



6. The device shown in question #5 is used to measure the _?_ in a water body.

   A. number of bacteria
   B. types of invertebrates
   C. amount of turbidity
   D. number and types of fish

7. Two-fifths of the runoff in the contiguous United States drains into the Gulf of Mexico through the _?_ watershed.

   A. Gulf Stream
   B. Mississippi River
   C. Tombigbee River
   D. Rio Grande River

8. Which of the following is NOT a pollutant in waterbodies (lakes, rivers, estuaries, etc.)?

   A. insecticides
   B. fertilizers
   C. heavy metals such as mercury, lead, and zinc
   D. dissolved oxygen

9. Which of the following measurements is used in describing the concentration of pollutants in water?

   A. parts per million (ppm)
   B. grams per liter (g/L)
   C. centimeters of visibility (cm)
   D. grams per gallon (g/gal)

10. Which of the following may cause the amount of dissolved oxygen in water to decrease?

    A. wind
    B. waves
    C. photosynthesis in aquatic plants and algae
    D. high concentrations of soil sediment in water

SHORT ANSWER: Use the space provided to answer the following statements.

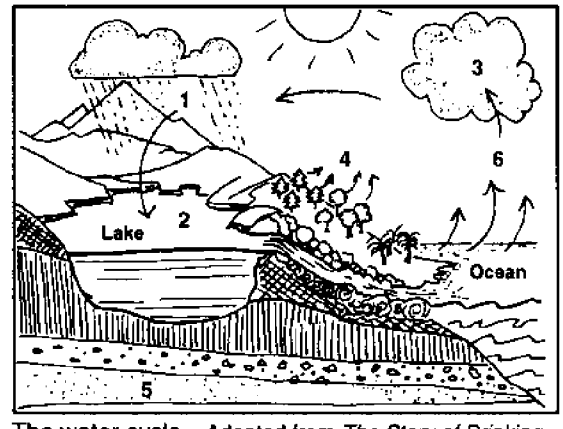
1. Why is runoff after a rain both an advantage and a disadvantage to local water bodies?

2. Use the following terms to identify the parts of the water cycle indicated by numbers in the diagram. Write the term on the blank that corresponds to its number in the diagram. **(transpiration, precipitation, condensation, evaporation, surface water, groundwater)**

(1) _____ (4) _____

(2) _____ (5) _____

(3) _____ (6) _____



The water cycle. Adapted from *The Story of Drinking Water*, by permission. © 1992, American Water Works Association.

3. Name two **types** of pollutants and describe at least one **cause** for each.

TYPE	CAUSE
a.	
b.	

4. Explain how fertilizers can harm lakes, ponds, and rivers when they are used improperly in agricultural and residential areas.

5. List four ways that you and your family can reduce water consumption at home.

a.

b.

c.

d.

DISCUSSION: Use your best writing skills — spelling, punctuation, grammar — in responding to the following instructions.

News Flash! An explosion at a chemical plant located on the banks of the Mighty-Mighty River has sent poisonous gases into the air and water for a one hundred mile radius. The local water source has been contaminated and is unusable. Write a paragraph relating four reasons why clean, fresh water is important to humans and describing how peoples' lives will change since water will be scarce. **(Write your paragraph at the top of the next page.)**

DISCUSSION:

MAP LABELING: Name the Gulf Coast locations identified by numbers on the map below. Write the names on the blanks provided below the map. You may use the list that follows as a reference.

Corpus Christi Bay	Tombigbee River	The Everglades
Pearl River	Gulf of Mexico	Mississippi River
Mexico	Cuba	Barataria Bay
Galveston Bay	Lake Pontchartrain	Terrebonne Bay
Colorado River	Alabama River	Yucatan Peninsula
Brazos River	Coosa River	Rio Grande River
Trinity River	Tennessee River	Lake Okeechobee
Sabine River	Mississippi Sound	Tampa Bay
Toledo Bend Lake	Mobile Bay	Suwannee River
Red River	Pensacola Bay	Apalachicola River
Atchafalaya River	Vermilion Bay	

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____

EVALUATION ANSWERS

MULTIPLE CHOICE:

1.	C	6.	C
2.	B	7.	B
3.	B	8.	D
4.	C	9.	A
5.	D	10.	D

SHORT ANSWER:

The following examples of answers should be modified by the teacher to fit appropriate grade level expectations.

1. Advantage — *Runoff replaces water that has evaporated or been used from lakes, streams, and other waterbodies, insuring the continuation of the water cycle (or, runoff keeps waterbodies from drying up).*

   Disadvantage — *When substances that reduce water quality such as excessive fertilizers, pesticides, heavy metals and soil sediments are dissolved in surface water, they move as part of runoff to rivers, lakes, and other aquatic habitats.*

2. Labels for the water cycle diagram:

(1)	*precipitation*	*(4)*	*transpiration*
(2)	*surface water*	*(5)*	*groundwater*
(3)	*condensation*	*(6)*	*evaporation*

3. Refer to the Background Information on pages 3 -4 for types of pollutants and their causes. Possible responses might include:

   - *Biological or organic pollutants — fecal coliform bacteria from animal wastes and the decaying remains of living organisms such as hair and feathers from animals and grass clippings and leaves from plants*

   - *Chemical pollutants — runoff carrying fertilizer and pesticides from residential and agricultural areas and petroleum residues from streets and parking lots*

   - *Thermal pollutants — abnormally hot or cold water released from plants that manufacture steel or produce electrical power*

   - *Physical contaminants — erosion of soil from agricultural, logging, or construction sites*

4. *When excess fertilizer, carried by runoff, reaches a waterbody, it stimulates the rapid growth and reproduction of aquatic plants and algae (eutrophication). As the excessive vegetation dies and decays, the amount of dissolved oxygen declines and many fish, amphibians, and other aquatic wildlife cannot survive.*

5. Answers will vary. Refer to the list on page 5 of the Background Information under the heading *Using Our Water Sustainably.*

DISCUSSION:

Answers will vary, but should include references to at least four values of water to humans plus a description of changes in life style caused by a reduction in water supply. The list on page 2 of the Background Information, *Sources and Uses of Water,* provides possible answers to the first part of the question. The second part of the question should contain description that points toward the *increasing expense of water, decreasing sanitation for both the individual and the community, or more preoccupation with obtaining water than enjoying it.* Be flexible, and encourage creativity regarding the second part of the answer.

MAP LABELING:

Answers will vary depending on the particular sites numbered by the teacher.

REFERENCES

The following books, pamphlets, and journal articles were used in producing the "Water Quality" module. Some of the resources are available to educators upon request or at a low cost; addresses of those resources are given in the reference citation.

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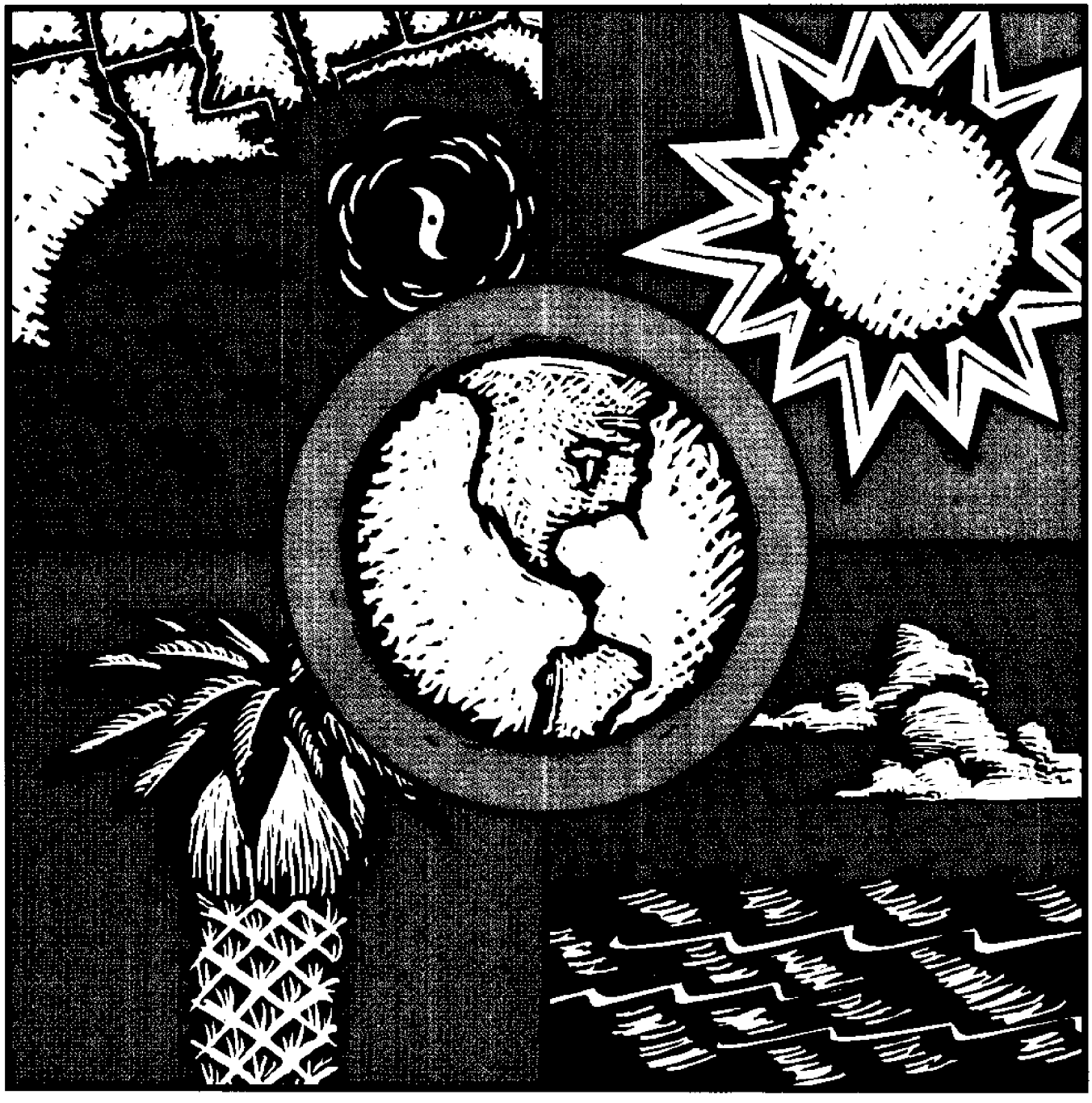
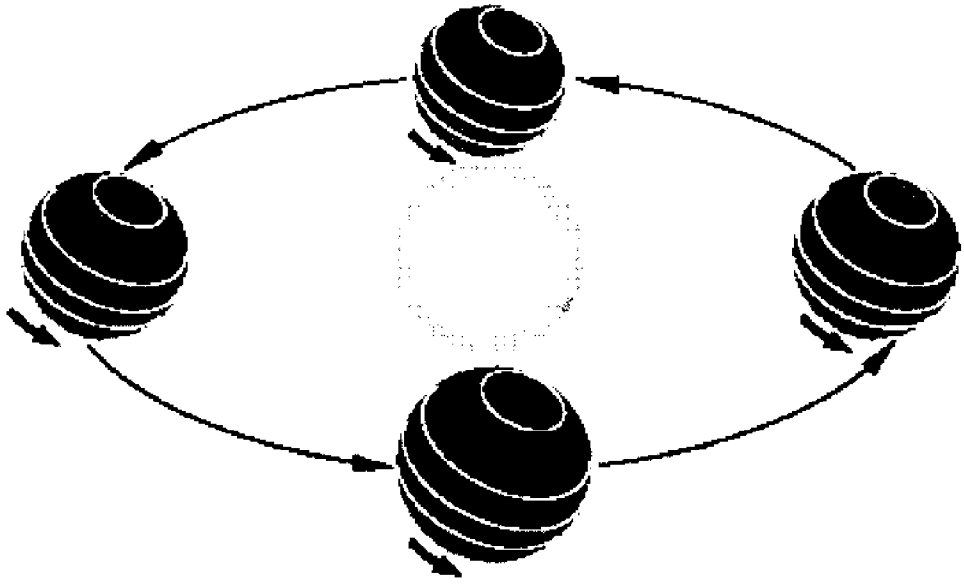
CLIMATIC CHANGE



Project TELLUS: Interactive Science Videos on Global Change Issues

CLIMATIC CHANGE



LEARNING OBJECTIVES

Students should be able to:

1. Describe some of earth's past climate changes and cite reasons for those changes.
2. Compare earth's atmosphere to a greenhouse.
3. Name the greenhouse gases and identify factors contributing to their increase in earth's atmosphere.
4. Recognize some possible consequences of global warming.
5. Identify personal and corporate actions to control the volume of greenhouse gases and reduce the impact of climatic change on the environment.

INTRODUCTION

The Gulf Coast region that we enjoy today ....

its meadows, marshes, and forests ....
its lakes, rivers, and bays ....
its rich biodiversity ....
and, yes, its sunny, mild climate ....

is the result of changes that have occurred on the earth over billions of years. Climate has been a driving force in shaping those changes in the earth. Climate continues to influence the contour of the land, the level of the waterways, and the types of vegetation and wildlife present. However, during this era of history, human activities may be accelerating the changes that nature would otherwise take thousands of years to accomplish.

Earth's history, as recorded in rocks, fossils, ice, and ocean floor sediments, shows that the dinosaurs of 150 million years ago lived in a warm, tropical environment. Conversely, our Cro-Magnon ancestors of 35,000 years ago experienced an ice age environment in which a third of the earth was covered by **glaciers**. *(See Geologic Timetable on page 28.)*

Historical examples of climate change seem to be caused by huge swings in temperature, because people tend to look at each period as a separate entity. Actually, during a climate change from cold to warm or vice versa, temperatures increase or decrease by small increments in a definite direction over long periods — thousands of years. This gradual change is good, because it allows species time to adapt through natural selection or to migrate, as their required habitat moves.

Earth's average temperature has increased by 1°F over the last 100 years. Relative to past records of change, this is rapid. However, this

increase has failed to alarm the public. Unfortunately, most people do not realize that it only takes a little change in the planet's average yearly temperature to upset the balance in nature.

The greenhouse effect and earth's position in relation to the sun are responsible for our planet having a climate that will support life. But, some people think the climate may be changing.

- Are human activities responsible for causing an **enhanced greenhouse effect** that may be fueling the current warming trend?
- How will rapid global warming affect life on earth?
- Can the warming be slowed or halted?
- Could the current warming trend be a mere quirk in the climatic pattern that will correct itself with time?
- Should we as citizens of the next century take a "wait and see" stance or should we change our lifestyles in terms of consumption of goods and energy to mediate the predicted effects of climatic change?

The answers to these questions are not clear, and drastically changing our consumption patterns could cause far reaching economic problems. Therefore, the issue of climatic change is a topic of hot dabate. People on both sides — those who believe that imminent climatic change is too speculative to have credibility and those who believe that earth's environment, as we know it, is headed for drastic change, if not doom — are leading campaigns to sway public sentiment.

Only time will tell the outcome; however, today's students will be faced with making personal and political decisions that may affect the future outcome. To make intelligent, responsible choices, they must understand

- the greenhouse effect — its causes and consequences
- the need for maintaining a balance in nature
- the wisdom of using resources sustainably

This module will help your students to understand climatic change so they can make informed choices concerning their opinions and actions.

The background information which follows will be helpful in discussing climatic change prior to viewing the video and in guiding students toward logical and meaningful conclusions throughout the viewing and postviewing activities.

BACKGROUND INFORMATION

Change Happens

Earth's global **climate** is primarily determined by three conditions. The orbital pattern of the earth around the sun, the tilt of the earth toward the sun, and an atmospheric phenomenon called the **greenhouse effect**.

Earth's orbital pattern changes from circular to elliptical and back to circular in a 100,000 year cycle. Earth also tilts on its axis toward and away from the sun over a 40,000 year cycle. The coldest climate occurs when the most elliptical orbit coincides with the greatest tilt away from the sun. It was such a situation that probably triggered the beginning of the last major **ice age** about 80,000 years ago.

Because of these orbital and tilt cycles, the earth goes through cold periods, commonly called ice ages, followed by shorter times of warm climate called **interglacial periods**. During ice ages, much of the earth's water freezes and accumulates in glacial sheets of ice. Sea level is low. It was probably during an ice age that land bridges allowed early man to migrate from one continent to another. Conversely, during interglacial periods, when the climate warms, the ice melts, sea level rises, and migration is slowed or made difficult.

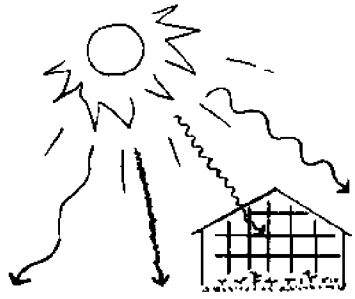
Scientists have learned a great deal about earth's past climate through studying the fossil record, the annual rings of trees, and most recently, by analyzing sediments from the floor of the ocean for the amount of silicate present.

(Silicates help grasses stand upright, therefore the amount of silicate in sediment samples indicates the extent of grasslands during various periods of history.) Scientists analyze deep core samples from permanently frozen areas in Antarctica and Greenland for relative amounts of a heavy isotope of hydrogen to learn more about atmospheric conditions of the past. *(During warm periods, more water evaporates, causing the snow for those periods of time to contain more of the heavy isotope.)*

These sources all show that climatic change is a regular occurrence. Ice ages last for tens of thousands of years (the last ice age lasted 70,000 years) and are followed by shorter interglacial periods of 10,000 to 12,500 years. During the last million years, the earth has gone through a series of ice ages; we are obviously in an interglacial period at present. Based on this pattern, climatologists say that temperatures should be cooling during the next few thousand years, as the earth moves into another ice age.

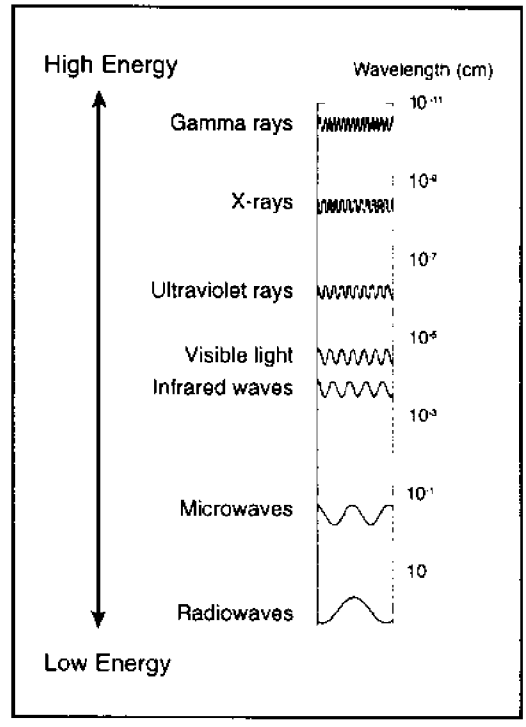
The third phenomenon, commonly called the greenhouse effect, modifies the earth's climate, making it suitable for life regardless of ice age or interglacial conditions.

The Greenhouse Effect



Energy emitted from the sun moves through space as varying types of radiation. Each type has a different wavelength and a different effect on the matter that it contacts. The amount of energy possessed by each type of radiation corresponds to its wavelength — the shorter the wavelength, the greater the energy.

The energy in some types of solar radiation, such as short-wave gamma and ultraviolet rays, can harm living tissue, while radio waves, which have long wavelengths, are harmless to matter.



As the wavelength of radiation increases, the energy it possesses decreases.

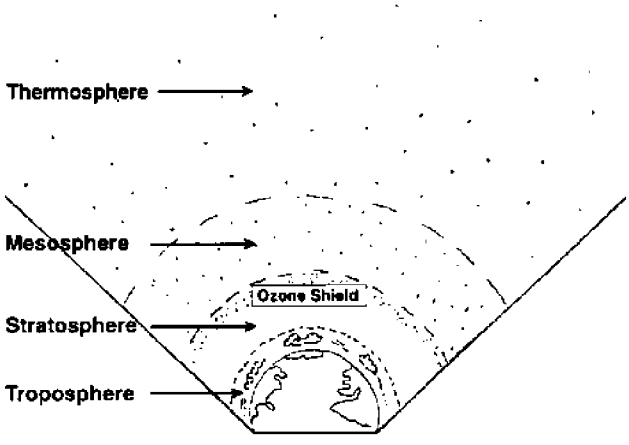
Fortunately, the combination of solar radiation reaching the earth affects matter in life-sustaining ways. For example, waves of visible light fuel photosynthesis and enable some animals to see, while warmth from **infrared radiation** heats the environment and drives the water cycle.

Earth's neighbor planets, Venus and Mars, receive enough radiation to support life, but the resulting temperature on Venus produces a blistering inferno while Mars resembles a desolate, frozen desert. The difference between earth and these two planets, besides their distances from the sun, lies in earth's unique **atmosphere**, a mixture of gases, droplets, and dust that serves as a heat trap and a shield. Without its unique atmosphere, earth's average global temperature would be about 27°F (- 3°C) instead of a comfortable 59°F (15°C), and many life forms would die from exposure to the cold and to the sun's harmful forms of radiation.

Earth's atmosphere extends several hundred miles into space and contains four distinct layers. The layer closest to the earth and extending about six miles into space is called the **troposphere**; it is the only region of the atmosphere where life can exist and where the phenomena we call **weather** occurs.

The second layer, the **stratosphere**, contains a very special layer of gases called ozone. Ozone absorbs most of the harmful **ultraviolet radiation** entering earth's atmosphere and converts the energy into heat. *(Ultraviolet radiation that penetrates the atmosphere can burn or kill living cells, tissue, and simple organisms.)*

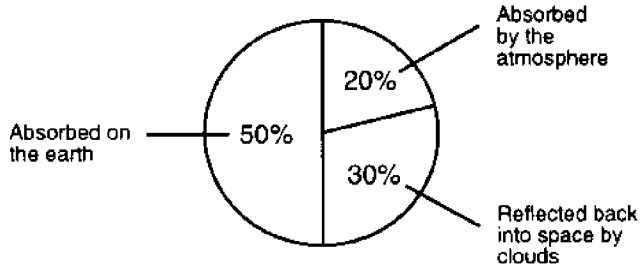
In the outer two layers of the atmosphere — the mesosphere and the thermosphere — the number of gas molecules decreases until they blend with the atoms of helium and hydrogen found in outer space.



About 99 percent of the atmospheric gases are contained in the troposphere and stratosphere. Among the gases which make up the atmosphere, 78 percent is nitrogen and 21 percent is oxygen. Both nitrogen and oxygen, though vital to life, are not significant in terms of the greenhouse effect, because both are transparent to solar radiation.

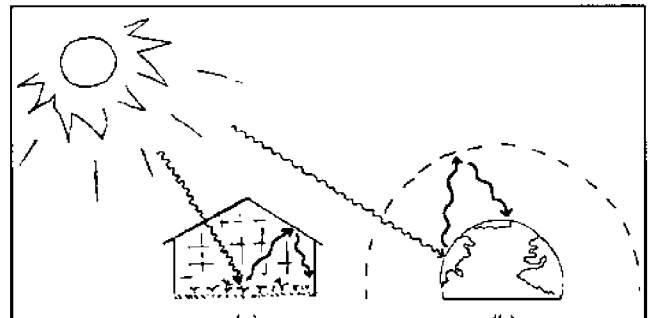
The remaining one percent of the atmosphere is a mixture of trace gases that absorbs incoming and outgoing infrared radiation, thus warming the air and serving as a heat trap. Because these trace gases — carbon dioxide, methane, nitrous oxide, chlorofluorocarbons (CFCs), and ozone — prevent the escape of infrared waves in a manner similar to the panels of a greenhouse, they are called **greenhouse gases**.

Earth depends on the work of the greenhouse gases to preserve a climate conducive to life. About 30 percent of the solar radiation moving toward earth is reflected by clouds and dust in the troposphere, another 20 percent is absorbed by the atmosphere. The remaining 50 percent reaches earth's surface and is absorbed by the water, ground, and living things.



The fate of solar radiation bound for the earth.

Matter that is warmed by solar radiation gives off infrared radiation which then returns toward space. At this point, the greenhouse gases play their major role, for the infrared radiation emitted from earth's surface (which would otherwise escape back into space insuring earth a subfreezing average global temperature) is absorbed by the greenhouse gases. This heat energy is then reradiated back toward earth, warming the air and raising the average global temperature.



The Greenhouse Effect

The plants and soil inside the greenhouse (a) absorb sunlight and then emit weaker infrared heat waves. These weaker heat waves cannot escape the glass so the temperature of the air inside the greenhouse gets warmer. Matter warmed by sunlight on the surface of the earth (b) also emits infrared radiation. This heat is then absorbed by greenhouse gases in the atmosphere, preventing their escape into outer space. Thus, earth's surface temperature, like the inside of a greenhouse, stays warmer than it would otherwise.

It appears that the amount of greenhouse gases in the atmosphere is directly proportional to the amount of warming that occurs on a planet. Venus' atmosphere is 96 percent carbon dioxide. Therefore, virtually all incoming radiation is trapped, boosting Venus' surface temperature to an average 840°F (449°C). Mars, on the other hand, has very little atmosphere, so

virtually all of the solar energy it receives is reflected or radiated back into space, leaving the planet with an average surface temperature of -10°F (-23°C). As the concentration of greenhouse gases increases, more heat is trapped and the average global temperature rises.

Geological records show that warm periods in earth's past have been accompanied by higher levels of atmospheric carbon dioxide and other greenhouse gases. During the warm Cretaceous Period, increased volcanic activity released huge amounts of carbon dioxide into the atmosphere.

The amount of greenhouse gases in earth's atmosphere is growing at an alarmingly rapid pace. Could this increase enhance the natural greenhouse effect to the extent of disrupting present environmental conditions? Many scientists think it can and will.

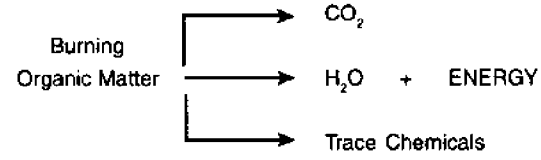
The Enhanced Greenhouse Effect

Natural processes have generally kept the amount of greenhouse gases in balance. The amount being produced through **respiration**, decay, volcanic action, and natural forest fires has been used by plants and algae during photosynthesis or absorbed by the oceans.

However, with the advent of the Industrial Revolution in the late 1700s and the subsequent exponential growth of the human population, excessive amounts of the greenhouse gases have been added to the atmosphere through various human activities. The **enhanced greenhouse effect** is the term used to distinguish the natural greenhouse effect from the current warming that might be caused by these excessive amounts of greenhouse gases in the atmosphere.

A description of each of the greenhouse gases and their sources follows.

- ***Carbon dioxide*** (CO_2) accounts for 50 percent of the greenhouse gases in the atmosphere. It is naturally emitted from decaying plants and animals, during volcanic eruptions, during respiration in living organisms, and anytime organic matter (especially the **fossil fuels** — coal, oil, natural gas, and wood) burns.



Carbon dioxide emissions are 25 percent higher today than they were 200 years ago, and human activities are mostly to blame. Today's highly mechanized world burns fossil fuels to produce the energy needed for transportation, manufacturing, and producing electricity. This energy is not recyclable. As these activities increase, more fossil fuel must be burned, and an increase in atmospheric carbon dioxide occurs.

Deforestation also adds to the increase in CO_2 levels. When forests are cleared for agricultural, residential, and industrial development, fewer trees remain to use CO_2 from the atmosphere during photosynthesis.

- ***Methane*** (CH_4) is produced naturally as microbes break down organic matter in the absence of oxygen. This happens in water logged conditions such as rice paddies and marsh areas, and in the digestive tracts of farm animals and termites.

  As human population growth has escalated during the past century, more and more rice and cattle have been raised, driving the emission of methane to higher levels. Today, methane accounts for 20 percent of greenhouse gases.

  To make matters worse, methane has the capacity to absorb more heat per molecule than carbon dioxide, so its impact on global warming could be immense, should levels continue to rise.

- ***Nitrous oxide*** (N_2O), better known as "laughing gas" by those who depend on its anxiety-relieving properties in the dentist's office, is emitted during the burning of fossil fuels and the breakdown of nitrogen-containing fertilizers used in agriculture. It makes up 15 percent of the greenhouse gases.

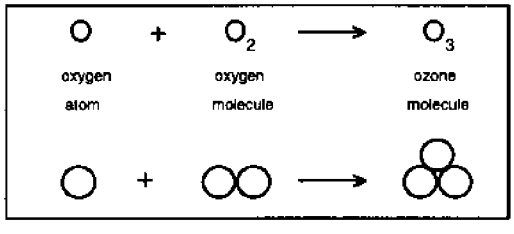
- ***Chlorofluorocarbons*** (CFCs) are a family of manmade chemicals that have been used in a number of industrially important processes since their invention in the 1930s. The best

known CFC is freon, which is used as a coolant in refrigerators, freezers, and air conditioning systems. Other CFCs are used as foaming agents to produce materials such as styrofoam, as cleaning agents for sensitive electronic equipment such as computer chips, and as propellants in aerosol cans.

At the outset, these synthetic chemicals were heralded as a boon to modern life. They were easy and inexpensive to make, had a variety of useful applications, and appeared safe to use. Today, they account for 15 percent of earth's greenhouse effect and, like methane, have a greater heat-absorbing capacity than carbon dioxide, molecule for molecule.

CFCs have also been linked to a breakdown in the stratospheric ozone layer which protects organisms on earth from the harmful effects of ultraviolet radiation.

- *Ozone* (O_3) is produced naturally in the outer reaches of the stratosphere. High energy solar radiation breaks apart free oxygen (O_2). Some of these highly reactive oxygen atoms combine with oxygen molecules to form the three-atom molecules called ozone.



These three-atom molecules of oxygen form a thin, protective shield around the earth that absorbs and reflects most of the harmful ultraviolet radiation from the sun. Since ozone gains heat in the process of absorbing solar radiation, it is considered a greenhouse gas. It does not, however, contribute to the enhanced greenhouse effect, for the amount of stratospheric ozone appears to be decreasing rather than increasing.

- *Water vapor* (H_2O) is part of the water cycle on earth, and as such, is vital to life. However, one of the properties that makes water so important to life — its ability to absorb and hold heat, thus modifying the environment — also makes it a greenhouse gas in the atmosphere. As the climate warms on earth, liquid water evaporates, becoming water vapor in the atmosphere. This vapor, in turn, holds more heat energy radiating from the earth.

Possible Consequences of Global Warming

Past geologic records show a correlation between warm interglacial periods and higher levels of atmospheric greenhouse gases. As the emission of these gases continues to increase, a similar warming trend is likely to occur. A major difference between previous periods of **global warming** and today's occurrence is the element of time. Then, the change was gradual, over thousands, sometimes tens of thousands of years. The present warming trend is likely to occur in a hundred years or less.

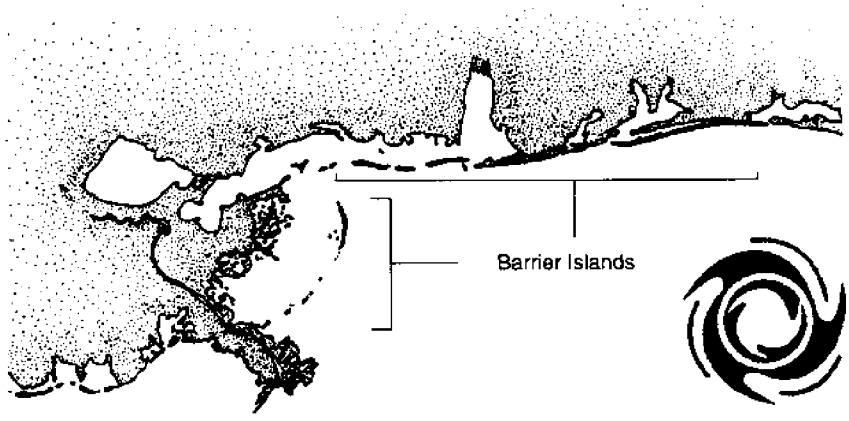
The exact effect of the increased levels of greenhouse gases on the global climate and, ultimately, on aquatic and terrestrial habitats is uncertain. However, scientists have combined laws of physics, mathematical equations, and descriptions of natural physical processes such as cloud formation and deep ocean mixing to develop computer models that present a picture of possible change.

Models sometimes lack all variables of the systems they portray. Thus, they provide a glimpse of what might happen, rather than what is certain to happen. But, as models become more advanced, predictions become more reliable. Among the current predictions for climatic change in the next century are:

- Average global temperature increases of 5°F to 9°F (1.5°C - 4.5°C). This will vary depending on the insulating effect of clouds and the capacity of the oceans to absorb CO_2 from the atmosphere.

- A sea level rise of 2 to 7 feet caused by the melting of polar ice caps and mountain glaciers coupled with the effect of **thermal expansion** in the oceans. *(As molecules become warmer, they spread apart filling more volume.)*

The effects of such abrupt changes in average temperatures and sea level are for the most part negative.



Sea level rise will initiate several negative effects.

1. Many low-lying Gulf Coast lands will become inundated with water. Among the first to be affected will be the Florida Keys and other **barrier islands**. Flooding may drive people from homes and businesses in coastal cities such as Houston, Biloxi, Mobile, New Orleans, and Tampa. The cost of battling the onslaught of the sea will be enormous; options will include raising homes and buildings off the ground and building dikes, sea walls, elevated beaches and artificial barrier islands.

2. Some wetland habitats such as estuaries, salt marshes, mangrove swamps, freshwater marshes, and bogs will diminish, be partially displaced inland, or completely disappear. These habitats are home to many species of small animals, nesting or resting sites for migratory birds, and nurseries for a variety of fish and shellfish species. The fishing industry will be severely affected by the loss of these wetlands.

3. People living in coastal areas that depend on groundwater as a source of drinking water will find their water supply tainted as salt water seeps into coastal aquifers.

Weather extremes may increase.

1. The number and severity of tropical storms and hurricanes in the Gulf of Mexico may increase.

2. Forest fires may increase as drought makes the soil dry and vegetation brittle.

3. Winter storms resulting from the collision of air masses may increase in number and severity. When moist, warm air from the Gulf of Mexico collides with a cold, polar, northern front, blizzard conditions result.

Agriculture patterns will change.

1. Higher atmospheric temperatures will cause more evaporation of water from lakes, rivers, oceans, and the soil. In areas where water bodies are few, the evaporation will lower water tables, deplete aquifers, and result in periods of severe drought. The opposite will occur in areas where surface water is abundant. Increased evaporation will produce more clouds, rain, and increased incidences of flooding.

2. Many of the crops that clothe and feed people — cotton, soybeans, corn, wheat, rice — are sensitive to changes in temperature and precipitation. As climate patterns change, the yield of these crops will decline.

3. Less land will be available for agriculture as sea level rise and flooding inundate and erode coastal and river delta crop lands.

Biodiversity will decline as more species become threatened, endangered and extinct.

1. A warming global climate will cause a change in the distribution of species. Forests will move away from the equators, toward the poles — some coniferous forests may become deciduous forests, while some deciduous forests may be replaced with grasslands. As the dominant vegetation in a habitat changes, so do the type of animal species that inhabit it.

2. As oceans warm, current patterns and the distribution of marine life will change. Some organisms will die in the warmer water.

Coral reef communities will be hard hit for two reasons. First, the survival of the tiny coral animals, which build the reef, depends on a symbiotic relationship with certain algae. When water temperature rises, the coral expel the algae and eventually die.

Second, rising sea level will cause the water to become deeper over the reef. This will prevent the penetration of light required by algae for photosynthesis. *(The algae provide food for the coral.)*

Coral reefs provide habitat for about a third of the ocean's tropical fish and other marine organisms. Thus, as the coral in the Gulf of Mexico decline, so will the entire reef community; this, in turn, will affect the commercial fishing industry.

3. Insect species will possibly benefit from global warming, for fewer will freeze during the winter. That means that more insects will survive to destroy crops and spread diseases such as malaria, yellow fever, and encephalitis.

Can Anything Be Done To Slow Or Halt The Predicted Changes?

The consequences of global warming, described in the previous section, present a bleak picture. However, scientists are not certain about the duration of this warming trend or the effects on specific regions of the globe.

This uncertainty has made many people skeptical of the predictions. But to do nothing to deter global warming is to invite the worst consequences. Besides, many efforts to halt the possible causes of global warming are beneficial to individuals as well as the environment. The following are actions that may help.

1. Conserve energy and save money by
   - turning off lights when leaving a room.
   - driving less and walking more.
   - buying cars that get better gas mileage.
   - turning the thermostat down in the winter and up in the summer.
   - buying energy efficient appliances when replacing old ones.
   - using fluorescent lights whenever possible. *(They use one fourth the energy of incandescent bulbs and last up to 10 times as long.)*
2. Reduce the emission of greenhouse gases by supporting or encouraging
   - a tax on fuel and power consumption.
   - research for chemicals that do not harm the environment to replace CFCs.
   - a worldwide ban on using CFCs as a propellant in spray cans.
   - less use of nitrogen-based fertilizers by the agriculture industry, farmers, and gardeners. *(Seek alternative methods for encouraging plant growth.)*
   - the research, development, and use, when possible, of alternative, non-combustion energy sources such as solar, wind, and wave power.
3. Limit and recycle waste. This will reduce the landfill problem while cutting down on the amount of fossile fuels needed to manufacture new products.
4. Reduce deforestation, and plant trees in areas that have been previously clear cut.
5. Support research that may help humans and other living things adapt to the global changes that do occur. Examples are
   - genetically engineering varieties of crops that are more resistant to drought and heat.
   - designing irrigation systems that waste less water.
   - setting up migration corridors, so animals can easily move to suitable habitats.

Climatic change is an issue of global concern. Efforts to avert possible hardships and loss from such a change can begin with individuals and progress to international action. Teachers have a unique opportunity to encourage actions in their students that can ultimately affect local, state, national, and international policy.

TEACHING SEQUENCE

DAY 1 **Previewing Questions and Answers**

1. To introduce this module, have students work independently to answer the previewing questions given on page 12. [10 minutes]

2. Discuss student responses, emphasizing the following concepts and the answers given in italics on page 12. [40 minutes]

- The importance of earth's atmosphere as a life support system containing oxygen for respiration, carbon dioxide for photosynthesis, and solar radiation for powering the water cycle and photosynthesis.

- The difference between weather and climate. *(See Vocabulary on pages 10 and 11.)*

  Degrees Celsius (°C) is the internationally accepted standard for measuring temperature, however, Americans are usually more familiar with temperature measurements in degrees Fahrenheit (°F), since weather reports are issued in those terms. In the video, references to temperature are made in °F so students will be able to focus on the message of global warming and climatic change rather than focusing on mentally translating from °C to the more familiar °F. The video guide, on the other hand, cites temperatures in both °F and °C so the teacher can choose the standard of measurement best suited to his or her particular classroom situation.

  [Option: Have students do Extension #1 (page 14) following the viewing of the video to practice math skills in multiplying with fractions and to increase their familiarity with the Celsius system of measurement.]

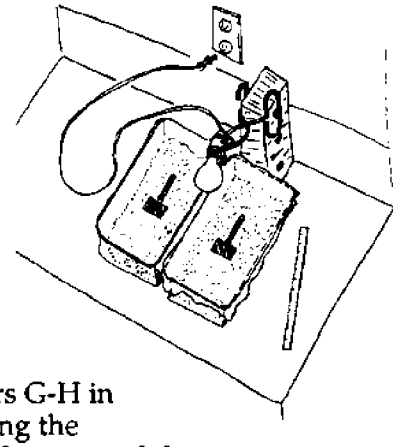
- Climate changes during earth's history. Emphasize the three major factors that affect climate — earth's rotation pattern and tilt toward the sun plus the greenhouse effect. *(Refer to the Background Information on pages 2-3 and the Geologic Timetable on page 28.)*

  [Option: Use all or part of Extension #8 (page 15) to demonstrate the current warming trend, to have students practice graph interpretation, and to distinguish between glacial (ice age) and interglacial periods in earth's history.]

DAY 2 **Begin Video and Activity I**

3. Remind students that this module is about the climate changes that may occur in the Gulf Coast region as a result of global warming. Begin the video and continue watching until instructed to pause for the first activity. [7 minutes]

4. Using the procedure outlined in the Teacher Instructions (letters C-F) on pages 16-17, introduce Activity I: The Greenhouse Effect. [20 minutes]



5. Follow letters G-H in demonstrating the experimental setup and the zeroing of thermometers. [10 minutes]

6. Divide the class into groups of 4 students each and allow time for them to set up their experiment and determine who will be recorders and observers in the group (letters I-K). [13 minutes]

DAY 3 **Complete Activity I: The Greenhouse Effect**

7. Make sure each group's apparatus is set up correctly, then follow steps L-O in leading the class through the experiment. [25 minutes]

8. Allow time for the students to graph their data and answer the Summary Questions. [15 minutes]

9. Discuss the results and answers to the Summary Questions. [10 minutes]

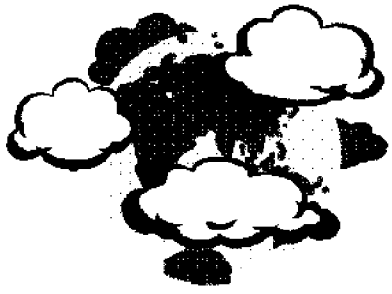
DAY 4 Continue the Video and Begin Activity II

10. Ask students to comment on things they have learned about the importance of the atmosphere and climatic change.

    Tell them that in the next part of the video they will be learning about ways that earth's atmosphere is like a greenhouse and types of gases that may be enhancing the greenhouse effect on earth. [5 minutes]

11. Continue the video until instructed to stop for Activity II: Lafitte's Island. [10 minutes]

12. Follow the Procedure outlined in the Teacher Instructions on page 24 to have groups compose and rehearse Jean's daydream. [35 minutes]



DAY 5 Read or Dramatize Daydreams and Complete the Video

13. Allow each group 3-5 minutes to read or dramatize Jean's daydream. [20 minutes]

    Option: List on the board the consequences of sea level rise mentioned in the daydreams.

14. Lead the class in a brief discussion about actions individuals can take to control the volume of greenhouse gases and reduce the impact of climatic change on the environment. *(Refer to Background Information on page 8.)* [5 minutes]

15. Watch the remainder of the video program. [8 minutes]

16. Have students work cooperatively in their group to answer the Postviewing Questions on pages 12-14. [10 minutes]

17. Discuss answers to the Postviewing Questions. [7 minutes]

18. At the teacher's discretion, the Evaluation section (pages 29-32) may be assigned for homework or used to accompany the next unit test. There are also activities in the Extension section(pages 14-15) that may be used for further study.

VOCABULARY

The following terms are used at various times throughout the module. The definitions should be adapted to suit the students' grade level.

Atmosphere: The mixture of gases that surrounds a planet. Earth's atmosphere, which is primarily nitrogen and oxygen, goes several hundred miles into space and is composed of four distinct layers — the troposphere, stratosphere, mesosphere, and thermosphere.

Barrier islands: Long, narrow, low-lying ridges of sand that develop parallel and close to a shoreline. They help break the force of tropical storms and hurricanes and therefore serve as a protective shield for the mainland.

Biosphere: The living portion of the earth — microbes, fungi, algae, plants, and animals.

Climate: A description of the average weather conditions — rainfall, temperature, humidity, etc. — for a region over an extended period of time (several years).

Cryosphere: The frozen part of the earth — snow, ice, glaciers, icebergs, and polar ice caps.

Deforestation: Clearing a forest of all its trees. This is usually done to provide space for agriculture or construction, or to provide the raw materials for wood products.

Enhanced greenhouse effect: Global warming attributed to human activities that are increasing greenhouse gas concentrations beyond that caused by natural means.

Fossil fuels: Energy sources — coal, oil, and natural gas — derived from the remains of organisms that lived millions of years ago.

Glacier: A slowly moving mass of ice that covers mountains or large areas of land.

Global warming: The current increase in average temperatures worldwide.

Greenhouse effect: The warming of earth's atmosphere, as solar energy is trapped by certain atmospheric gases.

Greenhouse gases: Atmospheric gases that cause the greenhouse effect by absorbing infrared radiation, then radiating it toward earth. Although these gases — carbon dioxide, methane, nitrous oxide, water vapor, ozone, and chlorofluorocarbons (CFCs) — comprise only a small portion of the atmosphere, they account for virtually all of the atmosphere's ability to trap heat.

Hydrosphere: All of the earth's lakes, rivers, streams, seas, oceans, and groundwater.

Ice ages: Long periods of cold climate during which glaciers expand worldwide. The last ice age began about 80,000 years ago and lasted 70,000 years.

Infrared radiation: Solar radiation just beyond the range of visible light; often identified as heat.

Interglacial periods: Periods of warm climate between ice ages; these periods usually last 10,000 to 12,500 years.

Lithosphere: The earth's land mass — rocks, soil, and minerals.

Respiration: The process used by all organisms to take in oxygen and release carbon dioxide.

Sea level rise: An increase in the amount of saltwater covering the earth's surface.

Solar (electromagnetic) radiation: Waves of energy emitted from the sun. Types of solar radiation are identified by their wavelength and energy — the shorter the wavelength, the higher the energy. They range from short, high energy gamma rays to long, low energy radio waves.

Stratosphere: The second layer of the earth's atmosphere. It extends about 30 miles into space and contains a thin layer of ozone gas that protects the earth from most of the sun's harmful ultraviolet radiation.

Sustainable use: Managing earth's resources in ways that will ensure a supply of the resources for future generations.

Thermal expansion: An increase in the amount of space occupied by a substance as its molecules absorb heat and spread out.

Transpiration: The movement of water vapor out of a plant through its leaves.

Troposphere: The layer of the atmosphere closest to earth's surface. It extends about seven miles into space and is the region where living things can survive and weather phenomena — clouds, thunderstorms, hurricanes — occur.

Ultraviolet radiation: A form of high energy radiation that has the ability to burn living tissue. The earth is shielded from most of the sun's harmful UV radiation by the ozone layer in the stratosphere.

Water vapor: The gaseous state of water.

Weather: Atmospheric conditions that occur at a particular place and time, for example, the temperature, humidity, precipitation, and wind velocity in a city on a certain day or an event such as a blizzard or thunderstorm.

PREVIEWING QUESTIONS AND ANSWERS

1. Earth's atmosphere (air) is part of the sky. Name as many things in the sky as you can.

   Some responses include:

   - *Clouds, rain, fog, sleet, and snow*
   - *Sun, moon, and stars*
   - *Birds, bats, and insects*
   - *Airplanes, hot air balloons, kites*
   - *Gases (oxygen, nitrogen, argon, and carbon dioxide)*
   - *Dust and chemicals from factories (pollution such as ozone, nitrous oxide, carbon monoxide and sulfur dioxide)*

2. A resource is something that is useful. For example:

   - Water is used for drinking and cleansing.
   - Forests provide food and shelter for animals and raw materials for building.
   - Oil is used to make gasoline, crayons, deodorant, bubble gum, and many other useful products.
   - When burned, oil provides energy for producing electricity and running engines.

   Why is the atmosphere (air) a valuable resource?

   The atmosphere contains:

   - *Gases necessary for life.*

     *[**Carbon dioxide** is used by plants to make food. **Oxygen** is used by organisms during cellular respiration (the breakdown of food that releases energy, carbon dioxide, and water). **Nitrogen** is used by some bacteria to make nitrates. These compounds are then used by other organisms to produce cells and the chemicals necessary for life.*

   - *Water vapor that condenses to form clouds — part of the water cycle.*
   - *Solar energy that drives the water cycle and fuels photosynthesis.*
   - *Wind that spreads seeds, enables the flight of insects and other flying animals, and can be used to generate electricity.*

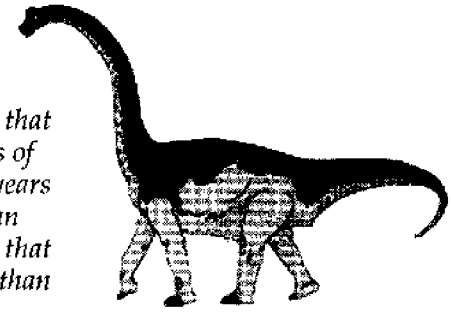
3. The climate of a particular place is a description of its average weather conditions — rainfall, temperature, humidity — over an extended period of time (many years). Describe the climate where you live.

   The climate of the states bordering the Gulf of Mexico tends to be mild and dry in the winter — very few days of freezing temperatures and rain. Summers are hot, humid, and rainy — high temperatures often range from 95°F to over 100°F (33°-38°C) and daily afternoon showers are common along the coast.

   Hurricanes periodically occur from June through November and the threat of tornadoes is present during the spring and fall.

4. Has the climate on earth always been like it is today? Explain your answer.

   No. The fossil record and other geologic studies show that the dinosaurs of 100 million years ago lived in an environment that was warmer than today. These records also show that the earth has gone through many ice ages followed by periods of warming.



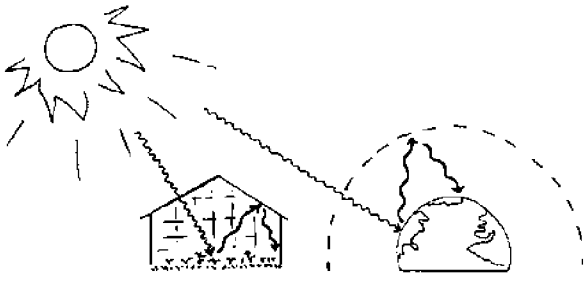
POSTVIEWING QUESTIONS AND ANSWERS

1. Describe ways that a greenhouse and earth's atmosphere are similar.

   Basic:

   - *The roof and walls of a greenhouse are made of a substance (usually glass or plastic) that is transparent to solar radiation; earth's atmosphere (air) is also transparent to solar radiation.*

- *A greenhouse protects tender vegetation from the cold of the outside environment by trapping warm infrared radiation inside its glass or plastic walls and roof. Similarly, certain gases in the atmosphere keep earth's surface temperature at a level that will support life by absorbing infrared radiation and radiating it toward earth.*



Advanced:

Solar radiation enters a greenhouse and is absorbed by the objects and organisms inside. In turn, the warmed objects and organisms give off radiation in the form of infrared waves. However, the infrared radiation does not have enough energy to move out through the roof and walls of the greenhouse. As a result, the environment inside the greenhouse stays warmer than the environment outside the greenhouse. Certain gases in earth's atmosphere act like the transparent panels of a greenhouse. They allow a portion of solar radiation to move through the atmosphere to earth's surface but then absorb warm infrared radiation emitted from the earth that would otherwise radiate into outer space. This warmed air allows earth to maintain a temperature that will support life.

2. Name the type of greenhouse gas being described in each of the following sentences.

   a. Manmade chemicals used as coolants in refrigerators and air conditioners and as propellants in some aerosol cans.

   b. Its concentration in the atmosphere rises as deforestation increases and as fossil fuels are burned.

   c. This gas is produced naturally in oxygen-poor, water-logged areas such as swamps, marshes, and rice paddies.

   d. The breakdown of nitrogen-containing fertilizers releases this gas into the atmosphere.

   e. A layer of this gas in the stratosphere provides a shield around the earth that blocks out most of the sun's harmful ultraviolet radiation.

   f. This gas can both cool and warm the atmosphere. It is part of the water cycle.

   a. Chlorofluorocarbons (CFCs)
   b. Carbon dioxide (CO_2)
   c. Methane (CH_4)
   d. Nitrous oxide (N_2O)
   e. Ozone (O_3)
   f. Water vapor (H_2O)

3. How would your state be affected if the average global temperature warmed by about 5°F? What might happen to the land, the water, the vegetation, and the weather patterns? Give reasons for your responses.

   Answers will vary. Refer to the Background Information on pages 6-8. Some responses are:

   Increased temperatures would cause water in the Gulf of Mexico to occupy more volume leading to sea level rise. Land along the coast may become flooded with saltwater. This saltwater intrusion may kill many of the plants and animals adapted to freshwater wetlands.

   Lands upstate from the coast (where there is less surface water) would become drier because the extra heat would cause more evaporation of water from the soil. The land would crack and there would be more erosion because the plants that hold the soil together would die from lack of water.

   Streams and ponds would dry up because of increased evaporation. The water level in rivers and lakes would recede. The amount of freshwater available for consumption by people would decrease.

   Plants that require a lot of water such as rice, corn, irises, ferns, and azaleas would die. They may be replaced by plants such as tumble weeds, mesquite, and cactus that do not require as much water.

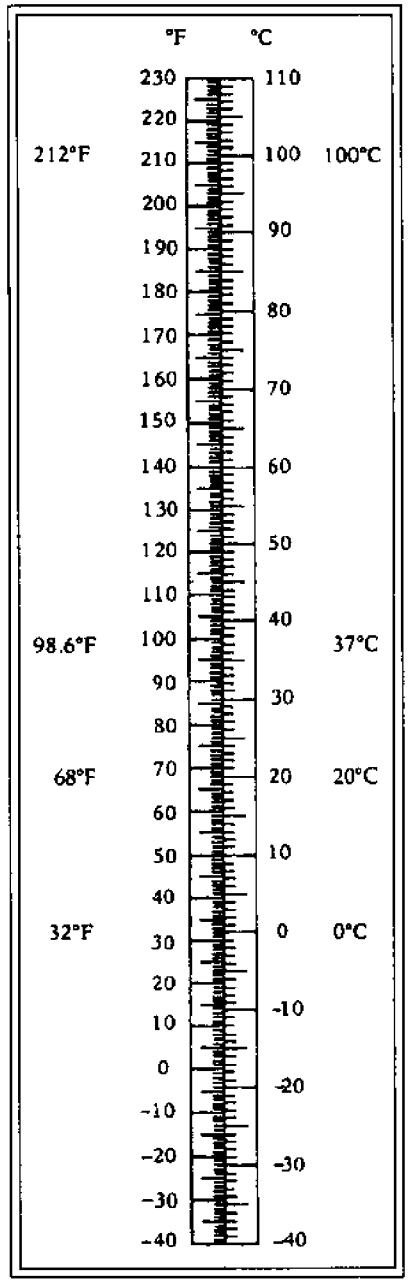
   Weather along the coast where water is plentiful would be warm and balmy, because the increased heat and subsequent evaporation rate would cause the relative humidity (amount of moisture in the air) to increase. The increased humidity

may lead to more cloud cover and thunderstorms.

Upstate areas, where surface water is not as plentiful as it is along the coast, might experience times of drought that are more severe and longer in duration. Humidity would decrease as the air lost its moisture.

4. The average global temperature is rising. Many scientists believe this warming trend is being caused by an increase in human activities that add excessive amounts of greenhouse gases to the atmosphere. Name four things that you can do to help reduce the volume of greenhouse gases.

   Answers will vary. Refer to the list on page 8 of the Background Information.



EXTENSIONS

1. **Math:** Have students note temperature references made in degrees Fahrenheit during the video. Tell them to use the following formula to convert those measurements to degrees Celsius.

   $$°C = (°F-32) \times 5/9$$

2. **Set a goal:** Ask your students to list several practices that, if followed, would reduce CO_2 emissions in your community *(See page 8 in the Background Information for suggestions.)* Ask each student to commit to practicing at least three.

3. **Field trip:** Plan a trip to the local power company or invite someone from the power company to talk to your class. Ask the students to compile a list of questions to ask such as the following.

   a. Is the power company doing anything to cut down on their emission of CO_2?

   b. Is the company researching ways to supplement fossil fuel-generated electricity with renewable energy sources such as solar power, geothermal power, and wind power?

   c. Does the company have a rebate program for households that save energy?

4. **Debate:** Have students research and then debate the following questions.

   a. Currently, oil companies pay royalty taxes to the federal government when they pump oil from the land, and consumers pay both state and federal taxes on gasoline purchases. Should taxes on the extraction and use of fossil fuels — oil, natural gas, coal — be increased? What might be the advantages and disadvantages to further taxation?

   b. Should the use of renewable, non-combustive forms of energy — solar, wind, and geothermal power — be encouraged by federal and state governments through tax breaks?

   c. Should the U.S. government take measures to curb CO_2 emissions, even though the effects of rising atmospheric CO_2 levels on the global climate are not certain?

5. **Keep a record:** Clouds can modify average daily temperatures by trapping heat that radiates from the earth at night and by blocking solar radiation from the earth during the day; thus, the temperature range over a 24 hour period is smaller *(warmer nights and cooler days)*. Have students:

   - Record the daily temperature range (high and low temperatures) and the amount of cloud cover (clear, slightly cloudy, mostly cloudy, heavy cloud cover) for your town for two weeks to a month.

- Graph the data.
- Compare the amount of cloud cover vs. daily temperature range.
- Write a summary of the results.

6. **Modeling:** Have students research the physical and chemical layering of the atmosphere. After the information has been collected, have them prepare a scale model of the atmosphere and identify the position of the ozone layer, auroras, plane flight, altitudes of the shuttle, and any other zones of interest.

7. **Sea level rise:** Prepare a mound of dirt in a plastic storage box. Add water to create a shoreline around the dirt — ask students to note the water level and the contour of the mound. Add a block of ice *(representing a glacier)* to the soil and allow it to melt. Periodically, as the ice melts, ask students to observe and comment on changes in the water level and contour of the land. *(Water level will rise and some erosion should be evident.)*

8. **Interpreting graphs:** Have students use the activity on pages 15, 16, and 19 in *Global Warming and the Greenhouse Effect*, a GEMS publication. *(The address for this publication is found in the References on page 34.)* The activity contains two graphs — one shows changes in the average global temperature during the past 130 years to demonstrate the current warming trend, and the other depicts average surface temperatures of the ocean for the past 450,000 years to compare temperatures during ice ages and interglacial periods.

9. **Bulletin board:** Ask students to collect newspaper and magazine articles on climatic change and prepare an informative, interactive bulletin board display using the articles.

10. **Alternative energy sources:** Ask students to research and report on one of the following alternative energy sources: nuclear power, solar energy, wind energy, hydroelectric power, geothermal energy, and tidal (wave) power. Have them include information such as:

    - How the alternative source produces usable energy.
    - The advantages and disadvantages of using the alternative source of energy *(for example, its effect on the environment, the cost of building the power plant, the amount of land needed, the time required to generate the power, and the number of employees needed to maintain the facility).*
    - The amount (percent) of the United States' energy needs currently derived from the alternative energy source.

ACTIVITY I

THE GREENHOUSE EFFECT
(Teacher Instructions)

Objectives

- To describe earth's atmosphere.
- To simulate the greenhouse effect in a controlled experiment.

Description

The teacher will briefly describe the concepts covered in the activity — earth's atmosphere, types of solar radiation, models in science, and the greenhouse effect. *(The Background Information on pages 3-5 will be helpful.)* Afterwards, students will work in small groups to carry out a controlled experiment that demonstrates the greenhouse effect. The students will graph their collected data, and answer questions regarding the design of the experiment and the trends shown in the results.

Materials (per group)

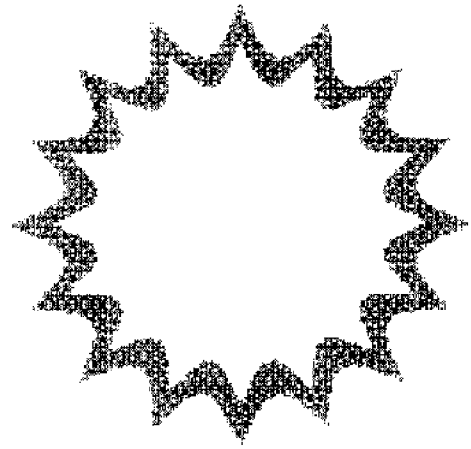
2 Plastic storage boxes (6" x 12" x 3")
12 Cups potting soil (6 cups per box)
2 Thermometers *(aquarium thermometers are inexpensive and show both °C and °F)*
2 Strips of lightweight cardboard (2" x 3")
1 Clamp lamp with 100 watt light bulb
1 Brick or block of wood
Ruler
Plastic wrap to cover one container
Rubber band
Blue and red map pencils or pens

Procedure

A. Make enough copies of the Student Instructions and Data Sheets (pages 20-23) for each student to have a set.

B. Separate the required materials for each group's experiment prior to class. *(Put the required amount of potting soil in the storage boxes before class.)*

C. When directed by the video narrator, stop the tape and distribute the Student Instructions and Data Sheets.



D. Have students read the Introduction in their instructions.

E. Using Background Information from pages 3-4,

- Describe the four layers of earth's atmosphere. Explain the importance of the troposphere and the stratosphere.
- Distinguish among the types of solar energy and explain the relationship between wavelength and amount of energy. Cite the effects of ultraviolet, visible light, and infrared waves on living things.
- Describe how infrared radiation reacts with greenhouse gases to warm the air around the earth — the greenhouse effect. *(Use a transparency of the diagram shown on page 4 of the Background Information.)*

F. Explain the significance of models in science.

A model is a means of describing something by using diagrams, formulas, or representative structures. Examples are road maps, bridges made from toothpicks, and 3-D models of molecules made of wire and jellybeans. When dealing with an object or idea that in reality is very difficult to work with (because it is large, small, or complex), scientists often experiment with models in order to learn more about the phenomenon.

Tell the students that they will be making and using a model of earth's atmosphere to investigate the greenhouse effect.

G. Following the diagram in the Student Instructions, demonstrate how to set up the experiment. While demonstrating:

- Ask students to correlate the various parts of the model — light, soil, air, plastic wrap — to the corresponding parts of the earth system — *sun, surface of the earth, atmosphere, greenhouse gases.*
- Have students distinguish the experimental setup *(covered container)* from the control setup *(open container).*
- Ask students to predict whether temperatures will vary between the two containers. Have them give reasons for their predictions.
- Explain how and why the thermometers used in the experiment must be zeroed.

  In order to get a true picture of the difference in temperature change between the control and experimental setups, both thermometers must have the same initial reading (room temperature) at the beginning of the experiment.

  (See letter L below for a description of how to zero the thermometers.)

H. Temperature readings will be taken from both containers every minute for 15 minutes. The teacher will keep track of the time and alert students when to read the thermometers.

I. Divide the class into groups of 4 students each. Each group will choose two persons to read the thermometers (the observers) and two to record data (the recorders).

J. Ask one person from each group to get the materials for the experiment.

K. Allow time for the students to set up their equipment.

L. Tell students to take an initial temperature reading (time - 0), before covering the experimental setup with plastic. If the thermometer readings do not agree:

- Determine the difference between the high and low reading.
- Add the difference to the low thermometer's reading so the initial reading for both thermometers will be the same. *(This is called zeroing the instruments.)*
- This number must be added to each reading taken from the low thermometer throughout the experiment.

  (Tell the recorders for each group to add the number of degrees for zeroing into each box under the low thermometer on the Data Sheet, now, so they will not forget as the experiment progresses.

M. Make sure each group's experiment is set up correctly.

N. Make the classroom as free of drafts and light as possible — close windows, window shades, doors, and turn off the lights.

O. At the signal to begin, each group will turn on its light. Alert the class as each minute passes. At each signal, the observer will determine the thermometer's temperature to the nearest 0.5 °C and the recorder will write the temperature in the appropriate box on the Data Sheet.

P. After the experiment is finished, have students within the same group swap data so they have results from both the control and the experimental containers.

Q. Allow time for students to graph their data — control data in blue and experimental data in red — and answer the Summary Questions on the back of the Data Sheet.

R. Call on one student from each group to summarize the changes observed during the experiment.

The temperature in each container warms and then levels off. The temperaure in the covered container (experimental setup) levels off at a highter temperature. Explain that when the amount of heat and light entering the container is equal to the amount leaving the container, an equilibrium temperature has been reached.

S. Discuss the answers to the Summary Questions at the end of the Data Sheet.

T. Continue the video program.

Extension

Have students vary the experiment to test the effect of the following:

- Moist soil.
- Soil type — garden soil, sand, and sod (soil and grass).
- Increasing the amount of carbon dioxide. *(Place a dish of marble chips and dilute hydrochloric acid on the soil to produce extra CO_2 in the experimental setup; cover both containers with plastic wrap).*
- Amount of ventilation. *(Vary the amount of covering on several containers — one-fourth, one-half and three-fourths open.)*

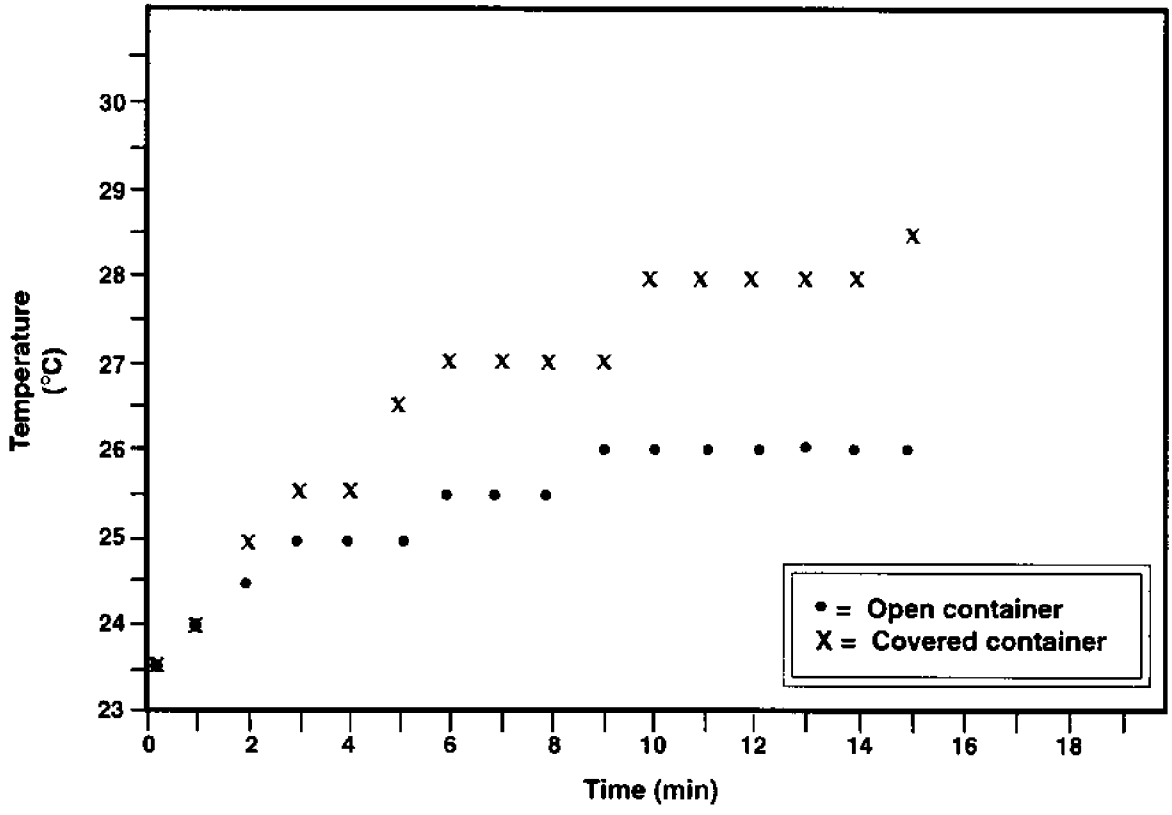
[This activity was adapted in part from Session 2: "Modeling the Greenhouse Effect" which is part of *Global Warming and the Greenhouse Effect*, a GEMS Project published by Lawrence Hall of Science, University of California at Berkeley. 1990.]

TEACHER KEY — ACTIVITY I

Data will vary slightly depending on room temperature and type of thermometers used, however, the trend should be similar to the one shown on the table and graph that follow.

THE GREENHOUSE EFFECT

Time (min)	Control Setup (°C)	Experimental Setup (°C)
0 [initial reading]	23 (+ 0.5) = 23.5	23.5
1	23.5 (+ 0.5) = 24	24
2	24 (+ 0.5) = 24.5	25
3	24.5 (+ 0.5) = 25	25.5
4	24.5 (+ 0.5) = 25	25.5
5	24.5 (+ 0.5) = 25	26.5
6	25 (+ 0.5) = 25.5	27
7	25 (+ 0.5) = 25.5	27
8	25 (+ 0.5) = 25.5	27
9	25.5 (+ 0.5) = 26	27
10	25.5 (+ 0.5) = 26	28
11	25.5 (+ 0.5) = 26	28
12	25.5 (+ 0.5) = 26	28
13	25.5 (+ 0.5) = 26	28
14	25.5 (+ 0.5) = 26	28
15	25.5 (+ 0.5) = 26	28.5



Summary Questions

1. Why did the temperature rise in both containers?

   Light and heat energy from the light bulb entered both containers warming the air around the thermometer.

2. Why did the temperature in the container covered with plastic wrap rise higher than the temperature in the open container?

   The warm air in the open container mixed with cooler air outside the container, but the warm air inside the closed container was separated from the cooler air by the plastic wrap.

3. How was this experiment similar to what happens inside a closed car parked in a sunny location on a cold, winter day.

   Light and heat energy from the sun move into the car, but because the windows are closed, the heat energy cannot escape, so the air inside the car becomes warm even though the temperature outside the car is cooler.

4. In this activity you made a model of the earth and its atmosphere. Tell what each of the following parts represented.

   The light bulb — *the sun or solar energy*
   The potting soil — *the earth*
   The air in the container — *earth's atmosphere*
   The plastic wrap — *greenhouse gases*

5. Did your group observe other similarities between the greenhouse model (the covered container) and the real earth's atmosphere?

   Condensation collected on the inside surface of the plastic wrap similar to the way water droplets condense in the atmosphere to become clouds — part of the water cycle.

6. Models, though useful, are not perfect examples of the phenomena they represent, because variables are often involved that cannot be represented in the model. In what ways was this model different from the real earth's atmosphere.

   - *Earth's atmosphere does not have a solid barrier, like the plastic wrap.*
   - *The light bulb emitted visible light and infrared radiation; the sun emits these plus cosmic rays, gamma rays, ultraviolet radiation, and radio waves.*
   - *Weather conditions such as wind and rain, which are a part of the real earth's atmosphere, could not be included in this model.*

ACTIVITY I

THE GREENHOUSE EFFECT
(Student Instructions)

Introduction

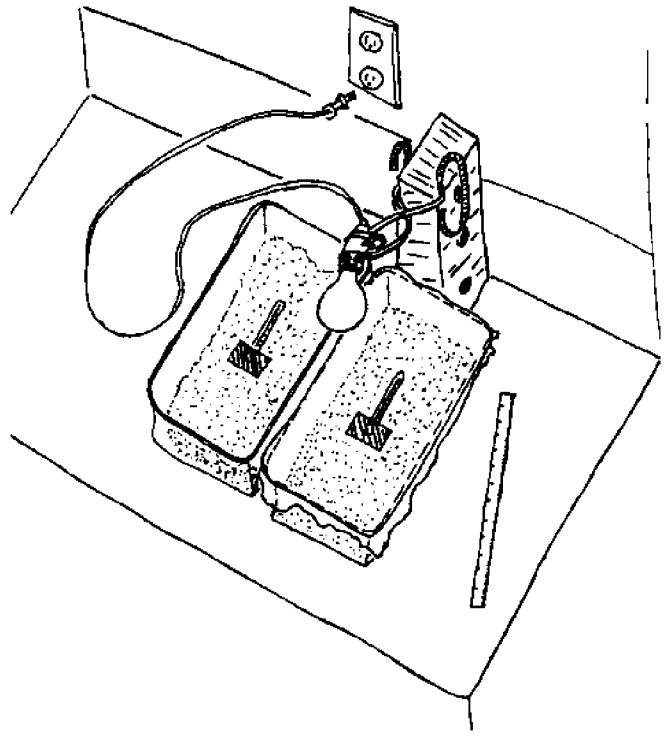
Many objects and events (phenomena) studied in science are too small, too large, or too complicated to work with directly. In these cases, scientists often create representations (**models**) of the phenomenon in question and then experiment with the model to learn more. The greenhouse effect is a phenomenon that occurs in earth's atmosphere. In this activity you will create a model of earth's **atmosphere** in order to investigate this phenomenon.

The greenhouse effect involves the interaction between various gases in earth's atmosphere and a type of radiant energy called **infrared waves**. Radiant energy from the sun travels through space in waves. The shorter the wavelength of the radiation, the greater its energy.

Some types of radiation have so much energy that they can harm or even kill living cells and organisms; gamma radiation and some forms of ultraviolet radiation are in that category. Other types of radiation, such as radio waves, have such long wavelengths (some more than six miles long) that their energy is harmless to organisms. Infrared radiation has wavelengths a little longer than visible light. These rays give a feeling of warmth on our skin. In fact, anything giving off heat — a fire, a hot iron, a toaster, or even your body after strenuous exercise — is emitting infrared radiation.

Most of earth's atmosphere (99 percent) is composed of nitrogen and oxygen. Both of these gases are transparent to infrared radiation, but some gases in the remaining one percent absorb the heat of infrared radiation, thus warming earth's atmosphere. Because these gases — carbon dioxide, water vapor, nitrous oxide, methane, chlorofluorocarbons (CFCs), and ozone — trap heat in a manner similar to the transparent panels of a greenhouse, they are collectively called **greenhouse gases**.

Using the following procedure, your group will make a model of earth's atmosphere and



will carry out a controlled experiment that demonstrates the greenhouse effect.

Procedure

1. Collect the materials required for setting up the experiment.

2. Select two from the group to be observers and two to be recorders. One observer-recorder team will monitor the control container and the other team will monitor the experimental container.

3. Work together to set up the experiment as shown in the diagram above.

   - Lay a thermometer on top of the soil in each container so that the numbers can be easily read. Cover the bulb end of each thermometer with a piece of cardboard to protect it from the direct rays of the light bulb.

     Adjust the clamp lamp on the brick or block of wood so that the bulb is about 10 cm from the surface of the soil.

     Once the experiment begins, you will be recording temperature readings to the nearest 0.5 °C each minute for 15 minutes — your teacher will keep track of the time and signal when to read the thermometer.

- Which container will be the control setup? _____
- Which container will be the experimental setup ? _____
- What is the temperature on each of your thermometers? (All group members should agree on the temperature readings.)

CONTROL SETUP _____ °C

EXPERIMENTAL SETUP _____ °C

Both thermometers should have the same reading — room temperature. If they do not agree, determine the difference between the high and low reading.

DIFFERENCE BETWEEN HIGH AND

LOW READINGS = _____ °C

Add that number (the difference) to the low reading so the number of degrees recorded on the Data Sheet for both thermometers at the beginning of the experiment is the same — *this is called zeroing the instruments.*

The same number of degrees must be added to each reading taken from the low thermometer throughout the experiment. On the Data Sheet, add the number of degrees for zeroing into each box under the low thermometer, so you will not forget as the experiment progresses.

4. Cover the experimental setup with plastic wrap, then secure the plastic with the rubber band. The control setup will not have a cover.

5. Attach the clamp lamp and bulb to a block of wood or ring stand so the bottom of the bulb is about 10 cm from the top of the soil and centered between the two containers. Plug the lamp's cord into the nearest electrical outlet, but DO NOT turn the lamp on.

6. Ask your teacher to check your setup.

7. When all groups are ready, the teacher will give the signal to turn the lamp on. At the end of each minute, the teacher will signal for the observers to determine the temperature in the containers. The recorders will write the temperature on the Data Sheet.

8. At the completion of the experiment, dismantle the setup and put the supplies in their storage site.

9. Exchange data within your group so each person has all the data for both the experimental and control groups.

10. Graph your data in the space provided on the Student Data Sheet.

    - The x-axis is for the independent variable (time) and the y-axis is for the dependent variable (temperature).
    - Use blue and red pens or pencils to distinguish the control data (blue) from the experimental data (red).

11. Answer the Summary Questions on the back of the Data Sheet.

Extension

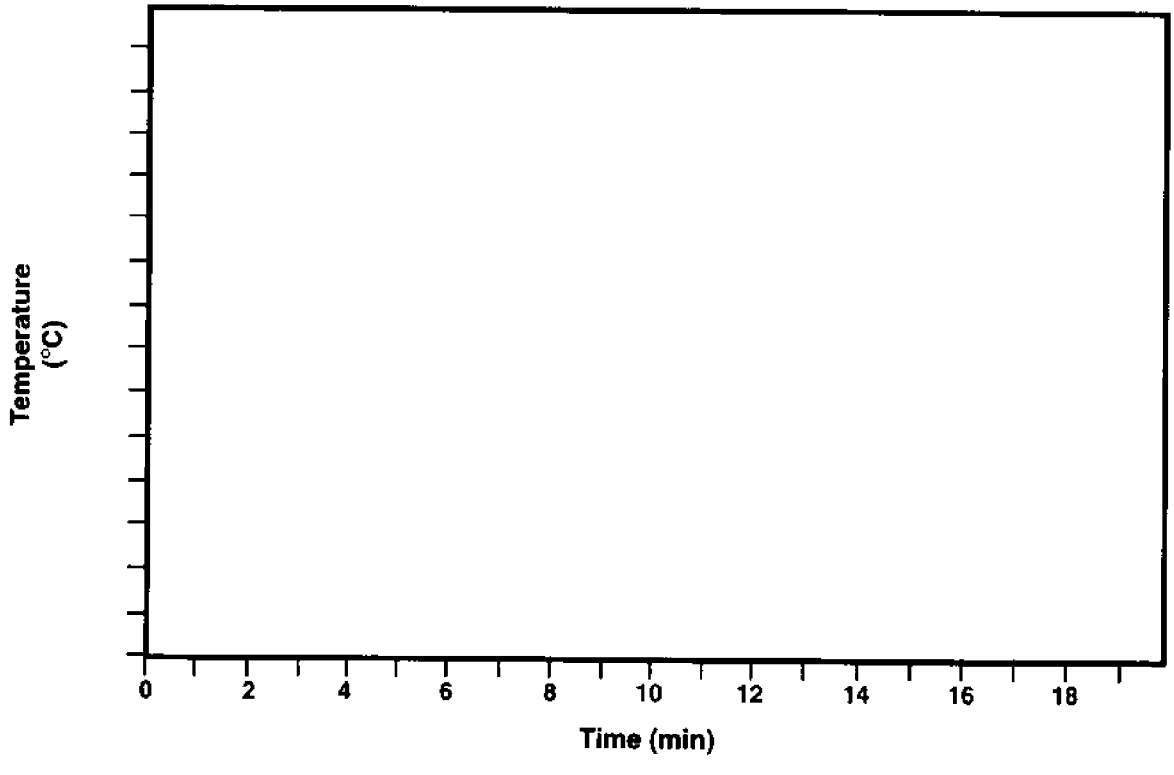
Follow the same basic directions, but vary the experiment by testing one of the following:

- Moist soil.
- Soil type — garden soil, sand, and sod (soil and grass).
- Increasing the amount of carbon dioxide (place a dish of marble chips and dilute hydrochloric acid on the soil to produce extra CO_2 in the experimental setup; cover both containers with plastic wrap).
- Amount of ventilation (one-fourth, one-half and three-fourths open).

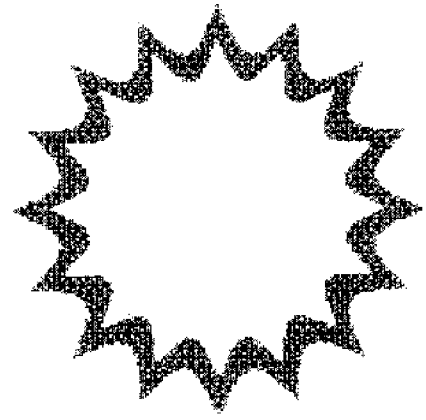
STUDENT DATA SHEET

THE GREENHOUSE EFFECT

Time (min)	Control Setup (°C)	Experimental Setup (°C)
0 [initial reading]		
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		



Summary Questions



1. Why did the temperature rise in both containers?

2. Why did the temperature in the container covered with plastic wrap rise higher than the temperature in the open container?

3. How was this experiment similar to what happens inside a closed car parked in a sunny location on a cold, winter day.

4. In this activity you made a model of the earth and its atmosphere. Tell what each of the following parts represented.

   The light bulb —

   The potting soil —

   The air in the container —

   The plastic wrap —

5. Did your group observe other similarities between the greenhouse model (the covered container) and the real earth's atmosphere?

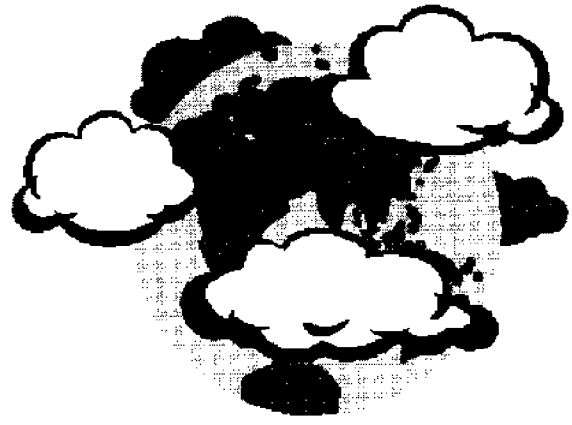
6. Models, though useful, are not perfect examples of the phenomena they represent, because there are often variables that cannot be represented in the model. In what ways was this model different from the real earth's atmosphere?

The greenhouse effect allows the earth to maintain an average temperature warm enough for living things to survive. What would happen if the atmosphere contained more greenhouse gases? Some scientists believe that the greenhouse effect is becoming stronger. Continue watching the video to find out more about the enhanced greenhouse effect.

ACTIVITY II

LAFITTE'S ISLAND

(Teacher Instructions)



Objectives

- To brainstorm possible consequences of global warming
- To practice creative writing skills.

Description

Students will work in small groups to brainstorm possible consequences to a small **barrier island** and its inhabitants should average global temperatures rise by 5°F (2°C) during the next 50 years. They will use their predictions to write an ending for the scenario described in "Lafitte's Island." Someone from each group will read the ending to the class.

Materials (per group)

One copy of the Student Instructions for Activity II — Lafitte's Island

Procedure

A. Make copies of the Student Instructions (pages 25-27) for each group.

B. When cued by the narrator, stop the video and divide the class into groups of 4 to 5 students each.

C. Ask the students to close their eyes and imagine that they are Jean while you read the story. *(Jean is both a male and female name.)*

D. Keeping their eyes closed, have the students silently reflect on the story by considering the following:

- How did the story make them feel?
- Would they like living on Lafitte's Island? Why ?
- What were some of the characteristics of the island that might be affected by sea level rise?
- How might the peoples' lives change, if sea level rises?

E. Working within their group, have the students follow the directions in their Procedure section:

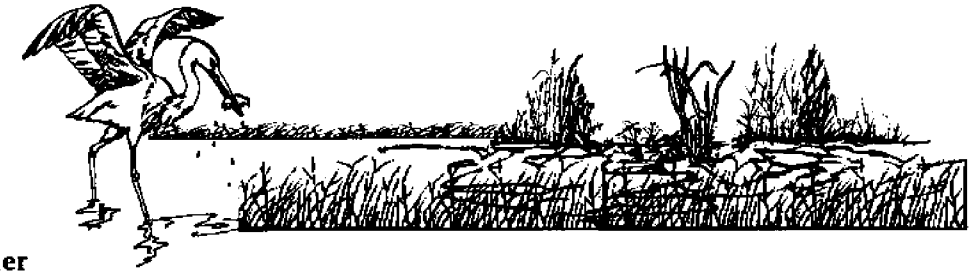
1. Estimate how much the Gulf of Mexico might rise if there is an average temperature increase of 5°F (2°C) over the next 50 years. *(This is a hypothetical situation, but students should try to be realistic — advise them to choose between one and twelve feet.)*
2. Predict how this sea level rise will affect Lafitte's Island and the people who live there. *(Encourage students to reread the story for ideas.)*
3. Write a description of the daydream that includes possible consequences to the island and its inhabitants. Bring Jean back to the present and relate a possible course of action in response to his/her futuristic thoughts.
4. Have each group choose one person to read the ending to the class. If time permits, groups could act out rather than read the ending.

F. Return to the video for the remainder of the program.

ACTIVITY II

LAFITTE'S ISLAND

(Student Instructions)



Imagine that you are a teenager who lives on a **barrier island** along the coast of the Gulf of Mexico. Your name is Jean. Your family has lived on this sandy, marsh island since your great-great grandparents settled here in the late 1800s. Your family members are not the only inhabitants of the island. Your village has a population of 556 people.

The island is 20 miles long and 5 miles wide. At its highest point, it is only four feet above sea level. The water surrounding the white-sand island is clear and has a deep blue color. A coral reef teeming with anemone, starfish, sponges, and a huge variety of tropical fish has formed atop several sunken oil platforms. This artificial reef borders the gulf side of the island. On the mainland side, the land curves inward to form a quiet lagoon frequented by playful dolphins and, occasionally, sea turtles.

Weather on the island is usually warm and breezy — even during the winter, there are very few cold days. The air is humid and smells of the salty, gulf spray. Tropical storms and hurricanes come in the summertime and fall, but the village people have learned, through the years, to prepare for the strong winds, waves, and rain. Damage can usually be repaired within a few days after a hurricane passes.

The island is so beautiful and rich in biodiversity that tourism has begun to grow. People boat to the island for snorkeling, sunbathing, picnicking, and shopping for crafts. In fact, the island has become so popular that the state is planning to build a bridge to connect the island to the mainland. Presently, the only way to the mainland is by ferry, by private boat, or in emergencies, by helicopter.

Small as the island is, it has provided a means of livelihood for the village for many generations. With the exception of a few store owners, most families make a living by fishing the coral reef, lagoon, and bay waters. When not in school, you help your dad set crab traps, gig in the lagoon for flounder, and trawl for shrimp and fish. He sells most of the catch on the mainland at the fish market. The remainder becomes gumbo, etoufee, or bisque in the family's stock pot. Modern conveniences such as radios, televisions, and bicycles are purchased on the mainland with money made from fishing.

Vegetables for the family are grown in a community garden located in the center of the island, where the saltwater rarely intrudes. Several people from the village make reed baskets from the smooth cordgrass that grows on the bayside of the island. Tourists are eager to buy these baskets when they visit the island.

The growth of plants on the island depends on freshwater from daily afternoon showers. The people of the village also depend on these showers, because the rain keeps the island's pond and cisterns full of fresh water. The pond and cisterns are the source of fresh water for the entire village. The pond also provides habitat for frogs, freshwater fish, and wading birds. During the spring and fall, many colorful migratory birds stop along the grassy edge of the pond to rest and eat as they fly to and from nesting sites on the mainland.

Experiences on the island teach you many things about life, but you must also go to school. Nine months out of each year you and your friends climb aboard a ferry at 6 am in the morning to make the 8 mile trip to a school on the mainland. There, you learn history, math, science, and English. You also learn about ways the world is changing. Every village is not exactly like yours.

Further inland, there are huge cities. People zoom by in automobiles, driving hurriedly to and from work and shopping. Airplanes fly through the sky, taking people to and from far away places. Factories smoke with activity, producing all sorts of modern

conveniences — appliances, plastics, gasoline, and fertilizer. Even the fields between cities are full of activity as tractors plow and plant row after row of crops such as cotton, soybeans, corn, and rice. Yes, life on the mainland is quite different from life on the island.

Although you enjoy learning about city life, you are most happy back on the island. After school and on weekends, your time is spent mending nets, washing down boats, laughing with friends, and searching for treasures that might have washed up on the beach. Life on the island is slow paced, peaceful, predictable, and safe. But that, too, may be changing.

You have learned at school that the average global temperature is rising. Some scientists are predicting that, as the temperature rises, polar ice will begin to melt into the ocean and seawater will warm. Both of these events will cause the sea level to rise, covering more land. Some scientists are also predicting that hurricanes will occur more often and with more severity in the Gulf of Mexico. Because you live on an island, sea level rise could threaten your whole way of life. You begin to read books and watch television programs concerning this global warming trend.

One afternoon on the boat ride home from school, you begin to daydream .....

What if the earth's average temperature does rise 5°F by the middle of the next century? How will this affect Lafitte's Island? What will life on the island be like then?

Procedure

1. Estimate how much sea level will rise *(choose a number between 1 and 12 feet)* if the average global temperature increases by 5°F during the next 50 year period.

   _____

2. Using your estimate as a guide, answer the following questions about possible changes to Lafitte's Island.

   a. How might some of the island's physical characteristics (amount of land, location and amount of salt and fresh water, type of weather) change?

   b. How will plant species be affected?

   c. How will animal species be affected?

   d. How will the change affect recreation (swimming, sailing, picnicking, etc.) and tourism?

e. Will the fishing industry be affected? How?

f. Will Jean's community be more crowded than it is now? Why?

3. Using your responses to these questions plus any other ideas discussed in your group, write a description of Jean's daydream in the space provided below. At the end of the daydream, bring Jean back to the present, and relate what course of action could be taken in response to his/her futuristic thoughts.

4. Choose one person from your group to read Jean's daydream to the class. (If time permits, your group may choose to act out the daydream.

JEAN'S DAYDREAM

GEOLOGIC TIMETABLE

[with important events in earth and life history]

ERA	PERIODS AND EPOCHS	MILLIONS OF YEARS AGO	AVERAGE SURFACE TEMPERATURE OF OCEAN	GEOLOGICAL EVENTS	BIOLOGICAL EVENTS
Cenozoic	Quaternary				*Homo sapiens* spread over planet; many birds and large mammals
	Recent	10,000 to present	15°C (59°F)	Last ice age ends	
	Pleistocene	2	0-2°C (32-36°F)	Numerous ice ages	*Homo sapiens* evolve
	Tertiary				
	Pliocene	6	2°C (36°F)	Drastic cooling	Large extinction of early mammals
	Miocene	23	7°C (45°F)	Climate drying; cold	First hominids
	Oligocene	36	13°C (55°F)	S. America separates from Antartica	Modern flowering plants; primitive apes
	Eocene	54	13°C (55°F)	Formation of Alps	Seed plants dominate
	Paleocene	65	10°C (50°F)	Continents continuing to separate	Age of Mammals begins
Mesozoic	Cretaceous	135	13°C (55°F)	Asteroid collides with earth; dust obscures sun	Massive extinction; dinosaurs die out
				Africa and S. America separate; seas over Europe	Dinosaurs reach peak
	Jurassic	197	13°C (55°F)	Continued mountain building; inland seas	Earliest anglosperms; first birds
	Triassic	225	8-13°C (46-55°F)	Continental drift begins (Pangaea breaks up)	Gymnosperms; first dinosaurs
Paleozoic	Permian	280	1-8°C (34-46°F)	Very cool; glaciation; seas drain	Extinction of many dominant life forms
	Carboniferous	345	13°C (55°F)	Pangaea; lowlands, shallow seas	Coal age forests; first winged insects; Age of Amphibians
	Devonian	405	11-13°C (52-55°F)	Appalachians forming; atmospheric oxygen stabilizes at present level	First seed plants; first amphibians; Age of Fishes
	Silurian	425	11-13°C (52-55°F)	Flattened landscape	First terrestrial plants and invertebrates
	Ordovician	500	10-13°C (50-55°F)	Sea level low	First vertebrates (fish)
	Cambrian	570	0-10°C (32-50°F)	Steady increase in temperature	Algae and marine invertebrates dominate
Precambrian		1 billion years ago		Earth cooling (algae, fungi?)	Multicellular life
		2 billion years ago		Tropical climate	First eukaryotes
		3 billion years ago		Accumulation of free oxygen (O_2)	Photosynthetic prokaryotes
		4 billion years ago		Oldest rock formation	Origin of life
		4.5-5.7 billion years ago		Chemical evolution	Organic synthesis

[Dates and events are based on a geologic timetable in *Biology the Science of Life*, second edition, by Robert A. Wallace, Jack L. King, and Gerald P. Sanders, 1986.]

EVALUATION QUESTIONS

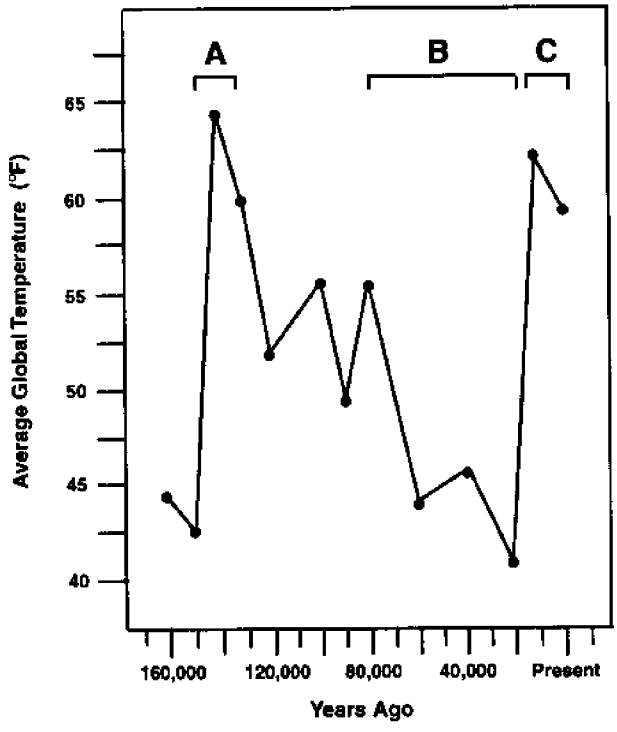
MULTIPLE CHOICE: Select the **BEST** answer for each statement.

1. The phenomenon that explains how certain gases trap heat in earth's atmosphere is called the

   A. hot house syndrome.
   B. hydrologic cycle.
   C. greenhouse effect.
   D. thermal incline.

2. Which area on the graph below represents a glacial (ice age) period?

   A. A
   B. B
   C. C



3. Infrared radiation is

   A. felt as heat.
   B. a type of solar radiation.
   C. absorbed by greenhouse gases.
   D. all of the above.

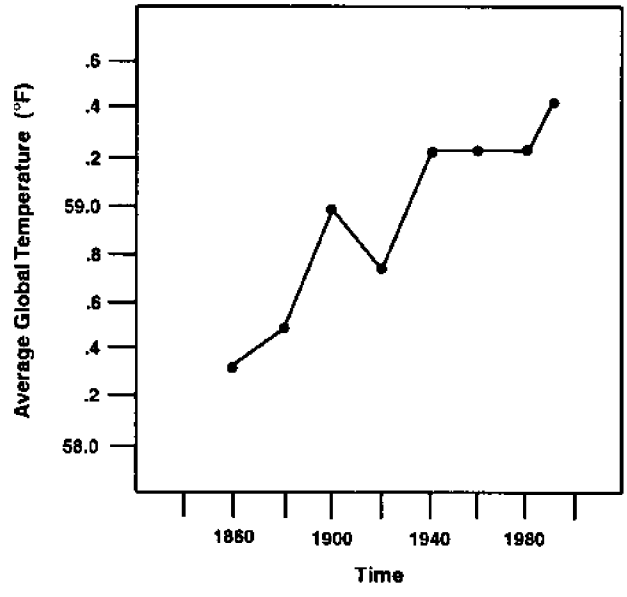
4. Which of the following situations might cause the earth's climate to warm?

   A. Earth tilts on its axis away from the sun.
   B. The amount of atmospheric oxygen increases.
   C. The amount of carbon dioxide dissolved in the ocean increases.
   D. Chlorofluorocarbon (CFCs) levels in the atmosphere increase.

5. Water vapor is considered a greenhouse gas because it

   A. absorbs heat.
   B. condenses to form clouds that, in turn, prevent some solar radiation from reaching earth.
   C. is part of the water cycle.
   D. combines with sulfur dioxide in the atmosphere to form sulfuric acid.

6. The graph below shows



   A. the greenhouse effect.
   B. what the temperature will be in the year 2000.
   C. an increase in the average global temperature during the last 100 years.
   D. that global warming is being caused by an increase in atmospheric carbon dioxide.

7. Deforestation is the mass removal of trees from an area. Deforestation contributes to global warming by

   A. reducing the amount of oxygen produced during photosynthesis.
   B. increasing the amount of carbon dioxide released during respiration.
   C. reducing the amount of carbon dioxide used by trees for photosynthesis.
   D. increasing the amount of water vapor released into the atmosphere during transpiration.

8. The layer of the atmosphere where weather — rain, snow, wind, hurricanes — occurs is called the _?_.

   A. thermosphere
   B. mesosphere
   C. stratosphere
   D. troposphere

9. Ozone in the upper atmosphere protects the earth from the harmful effects of

   A. ultraviolet radiation
   B. visible radiation (light)
   C. infrared radiation
   D. radio waves

10. Which layer of the atmosphere contains the protective ozone shield?

    A. thermosphere
    B. mesosphere
    C. stratosphere
    D. troposphere

11. Besides coal, another example of a fossil fuel is

    A. geothermal heat
    B. wind
    C. natural gas
    D. sunlight

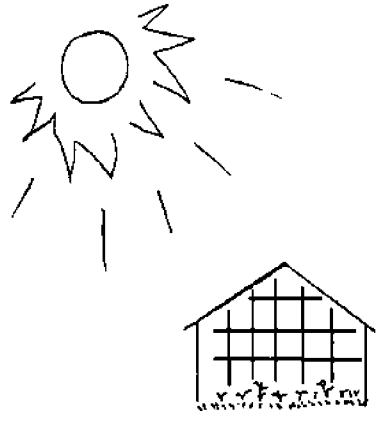
12. If used more often, which energy source listed below could help reduce the amount of carbon dioxide accumulating in the atmosphere?

    A. electricity
    B. sunlight
    C. gasoline
    D. coal

13. The Gulf Coast mainland is protected from the full force of hurricanes by natural formations that form parallel to the shoreline. They are called

    A. barrier islands
    B. levees
    C. sea walls
    D. spoil banks

Use the diagram and chart below as a reference in answering questions 14 and 15.



Time	Outside Temp. (°C)	Greenhouse Temp. (°C)
6 am	12	12
8 am	13	14
10 am	14	18
noon	17	22
2 pm	21	26
4 pm	19	24
6 pm	17	23

14. The highest temperature was recorded at

    A. noon, outside the greenhouse
    B. noon, inside the greenhouse
    C. 2 pm, inside the greenhouse
    D. 2 pm, outside the greenhouse

15. At what rate did the temperature rise inside the greenhouse between 10 am and noon?

    A. 1 °C/hour B. 2 °C/hour C. 3 °C/hour D. 4 °C/hour

SHORT ANSWER: Using your best writing skills — spelling, punctuation, grammar — respond to the following statements.

1. Explain the similarities between earth's atmosphere and a greenhouse.

2. Name three possible consequences of global warming and climatic change.

   a.

   b.

   c.

3. Describe three actions that you, as an individual, can take to reduce greenhouse gases in the atmosphere.

   a.

   b.

   c.

EVALUATION ANSWERS

MULTIPLE CHOICE:

1.	C	6.	C	11.	C
2.	B	7.	C	12.	B
3.	D	8.	D	13.	A
4.	D	9.	A	14.	C
5.	A	10.	C	15.	B

SHORT ANSWER:

1. Similarities between earth's atmosphere and a greenhouse include:

   - *The glass (plastic) panels of a greenhouse and earth's atmosphere are both transparent to solar radiation (sunlight).*
   - *Light that hits plants and soil in the greenhouse is absorbed and then emitted as infrared radiation; the same phenomenon occurs as light hits earth's surface, objects, and living things.*
   - *The air inside a greenhouse is warmer than the air outside because infrared radiation is trapped inside by the glass panels of the greenhouse. In a similar way, the air around the earth is kept warm because carbon dioxide and other greenhouse gases absorb infrared radiation (heat), preventing its escape into outer space.*

2. Possible consequences of global warming and climatic change include: *(Refer to Background Information for further explanation.)*

   - *Sea level rise will cause flooding, loss of wetland habitats, and saltwater intrusion into drinking supplies.*
   - *Severe weather may increase — tropical storms, hurricanes, winter storms, drought.*
   - *More forest fires will occur during droughts.*
   - *Agriculture patterns will change.*
   - *Biodiversity will decline.*

3. Many individual actions can help reduce greenhouse emissions. *Refer to the Background Information on page 8 for possible answers.*

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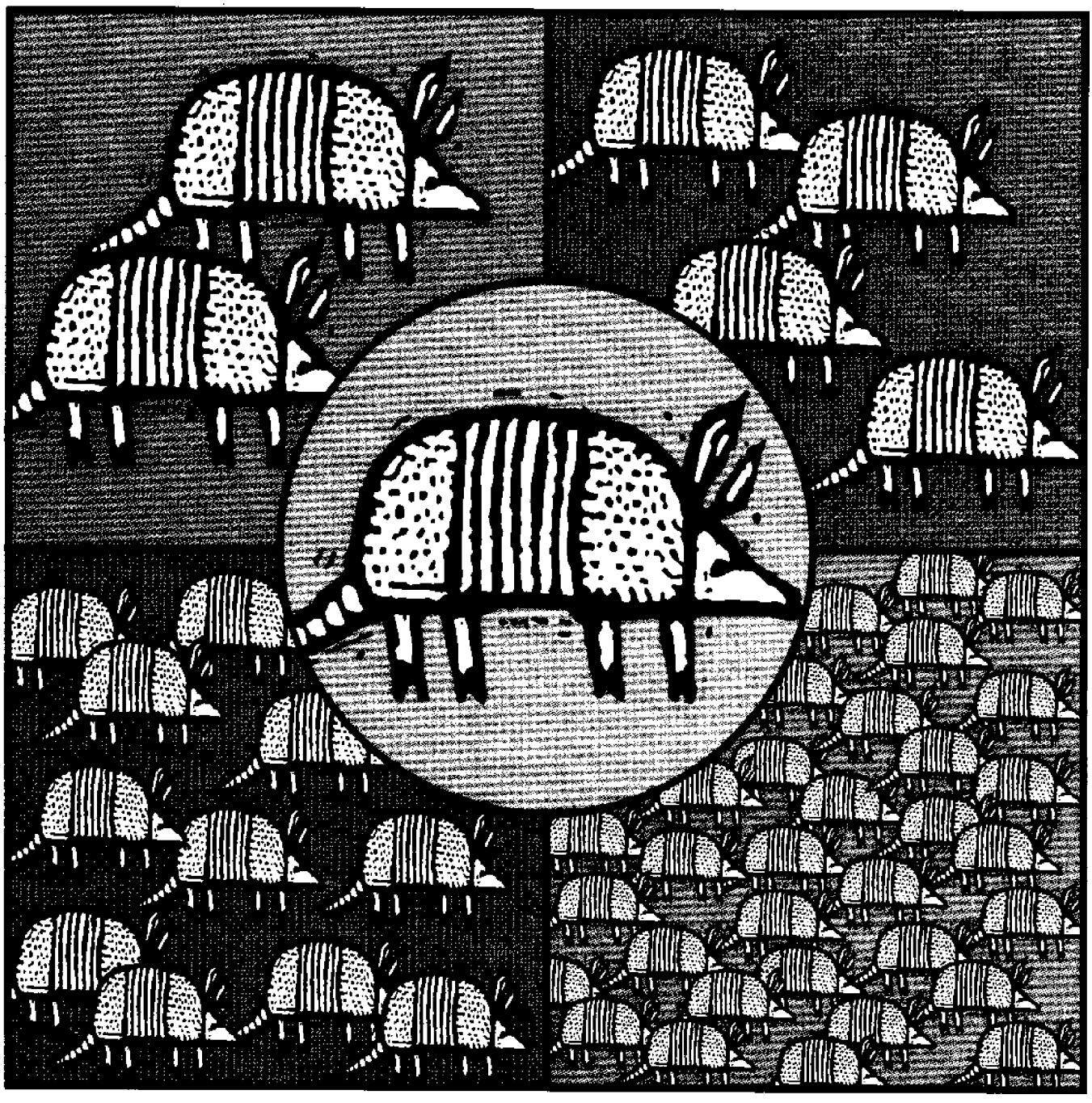
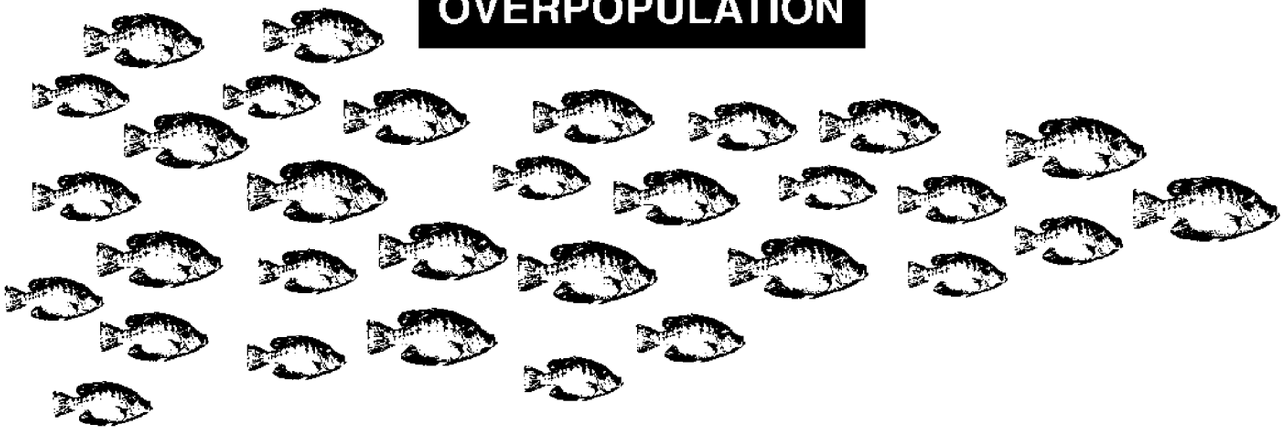
OVERPOPULATION



Project TELLUS: Interactive Science Videos on Global Change Issues

OVERPOPULATION



LEARNING OBJECTIVES

Students should be able to:

1. Name the living and nonliving components of an ecosystem and explain some interactions between them.
2. Recognize the earth as an ecosystem with finite resources.
3. Explain the impact of birth rate, death rate, and migration on population growth.
4. Explain the relationship between limiting factors and carrying capacity in a given habitat.
5. Distinguish between a population in dynamic equilibrium and one growing exponentially.
6. Correlate human population growth and overconsumption of earth's resources with other global change issues.
7. Cite actions that reflect a personal commitment to conservation and using earth's resources sustainably.

INTRODUCTION

A scheme of checks and balances sustains life on earth. Through intracommunity relationships — competition, predator-prey, and symbiosis — and biogeochemical cycles, lifestyles of a huge variety of species are woven together to create a unified whole. However, just as a woven basket often has irregularities in its design, so, at times, some species play havoc with nature's balanced design. Overpopulation is such an irregularity.

Through the previous *Project Tellus* lessons on global change issues, your students have learned of environmental problems occurring in the Gulf Coast region:

- Declining biodiversity.
- Upheaval in habitats caused by invasive exotic species.
- Deteriorating water quality in the lakes, rivers and estuaries.
- Anticipated sea level rise and climatic change.

All of these environmental problems stem from or are aggravated by two much deeper problems covered in this module on overpopulation, namely,

- The current exponential growth of the human population, and
- Overconsumption and waste of earth's resources, especially by people in developed nations.

The lessons on overpopulation will build on some concepts covered in previous lessons — populations, communities, food webs, predator-prey relationships, interdependence among species, and sustainable use — while it focuses on concepts central to understanding overpopulation — limiting factors, carrying capacity, dynamic equilibrium, and exponential growth.

Overpopulation is not a phenomenon restricted to the human species. It is recurrent in nature. The difference between human

overpopulation and overpopulation in other species, though, is that humans have been able, through ingenuity and the development of modern technology, to delay natural adjustment.

Other species are not so adept at modifying their environment. When their populations exceed the habitat's carrying capacity, disease, famine, and sometimes violence (cannibalism) occur to bring the population back into balance.

By examining overpopulation in Gulf Coast species other than humans, students will be able to understand the consequences that are possible if the human population continues to grow exponentially. They will also learn that the painful adjustments for overpopulation can be avoided if humans act now to stabilize population growth and use earth's resources sustainably.

The Background Information and Activity suggestions that follow will be helpful in discussing population concepts and issues prior to viewing the video and in guiding students toward logical and meaningful conclusions throughout the viewing and postviewing activities.

BACKGROUND INFORMATION

Everything Is Connected

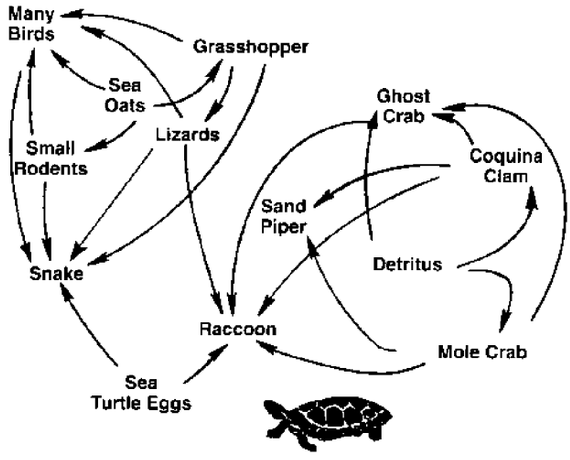
Some say that the First Law of Ecology can be summarized in the statement "everything is connected to everything else." This truism is evident as one considers the number of interdependent relationships that occur within an ecosystem. The term **ecosystem** itself reflects connectedness for it is defined as a place where living (biotic) things interact with each other and with their nonliving (abiotic) environment.

The organisms that inhabit an ecosystem can be separated into smaller groups called **species**. All the members of the same species that live in the ecosystem comprise a **population**, and the specific area where the population lives is called its **habitat**. All the various populations living and interacting in the ecosystem form a **community**.

Interactions in an ecosystem are of two types. One type occurs within or between species. The other type occurs between organisms (species) and the nonliving environment — air, water, minerals, weather, etc. These two types of interactions provide a means for both survival and balanced population growth among the ecosystem's inhabitants.

Some community interactions include:

- *The transfer of the sun's energy from* ***producers to consumers*** —Photosynthetic plants and algae produce food using energy from the sun and inorganic materials (carbon dioxide and water) in the environment. **Herbivores** eat plants and they, in turn, are eaten by **carnivores**. Scavengers and decomposers (**detritivores**) eat or break down organisms after they die. These interconnected feeding relationships in an ecosystem form **food chains** and **food webs**. The energy transferred as food at each junction in the chain or web fuels the life processes (growth, reproduction, movement, etc.) in the consuming organism.



Salt marsh food web

- *Predator/prey relationships* — One animal (the **predator**) kills and eats another animal (the **prey**). In this relationship the predator obtains food and the prey population is kept at a level the ecosystem can support.

- *Competition* — Members of the same species or different species vie for the same habitat needs — food, shelter, water, space, etc. Competition insures that those organisms most suited to the environment will survive and provide offspring for the next generation.

- *Symbiotic relationships* — Two different species live together in a close, long-term

association. A classic example of symbiosis is the algae-fungi association known as lichen; the fungus provides a moist place for the algae to live and the algae provides nutrition (food) for the fungus.

In some symbiotic relationships both species benefit (mutualism), in others one benefits at the expense or harm of the second (parasitism). In the third (commensalism) one species benefits and the other species is neutral — neither helped nor harmed. These relationships allow at least one of the participating species to live in an environment that would otherwise be inhospitable.

Some interactions between living things and the nonliving environment include:

- *Cycling of materials necessary for life* — water, oxygen, carbon, nitrogen, phosphorus, sulfur, etc. These cycles are called **biogeochemical cycles** because organisms (producers and consumers) interact with the air, water, and soil of earth to recycle the chemicals.

- *Use of solar energy* — Organisms use infrared radiation for heat and visible light for vision and photosynthesis.

- *Use of water* — Water is a major component in cells and is a transport medium in all organisms. Surface water (lakes, rivers, estuaries, etc.) provides habitat for many species.

- *Intake of oxygen from the air or from the water* — Most organisms require oxygen to chemically break down food to release energy for life processes.

Generally, the earth is considered a closed system, so the substances that are vital for life are **finite** — in limited supply. That means that all the matter that will ever be on the earth is here now; no material is being created, and none is being destroyed; it is merely changing form (the Law of Conservation of Mass) as it cycles from elements to organisms then, through decomposition, back to elements.

Some of the interactions previously described insure that these finite substances are recycled and reused generation after generation.

The concepts of finite resources and interconnectedness among species are pivotal in understanding the impact of overpopulation on an ecosystem. When more resources are used by one group, less are available for other organisms and for the nonliving part of the environment.

Since everything is interconnected, if one part is depleted, weakened, or missing, balance is lost and the entire ecosystem suffers. Limiting factors generally keep each species' population growth in check.

Growth Patterns in Nature

The growth rate of a population is determined by three factors — birth rate, death rate (mortality), and, if the organisms are mobile, migration.

Birth rate is the number added to the population through reproduction during a year per 1000 individuals. **Death rate**, is the number that die in a population during a year per 1000 individuals.

For most animal groups, **migration** (the movement of individuals into or out of the population in a given area) also affects population size. A population of raccoons, for example, may be increased by individuals moving into the habitat from another place — immigration — or decreased by individuals leaving the habitat — emigration.

High birth rates and immigration serve to increase a population while high death rates and emigration reduce population size.

Additionally, a number of habitat conditions affect birth rate, death rate, and migration. These **limiting factors** in a habitat (which often hinge on the interactions listed in the previous section) help keep population sizes in check — equal to what the habitat can support with its resources. They include the amount or type of:

- nutrients (food)

- fresh water

- living space

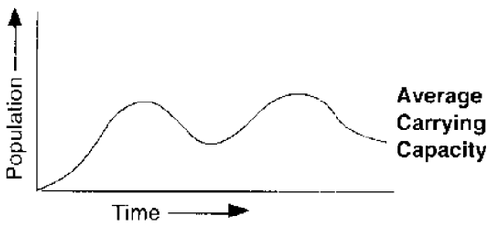
- minerals

- interactions with other organisms (predation, competition, and symbiosis)
- climate and weather (precipitation, temperature, wind, and weather events such as hurricanes, tornadoes, and floods)
- disease

Population size is dynamic (continually changing) as limiting factors in the habitat change from season to season and year to year. When habitat conditions are favorable for growth, a population increases, but when food, water, and space begin to grow scarce, or adverse weather conditions occur, death rate increases and the population size declines. Once the habitat recovers, a period of growth begins again.

Limiting factors determine the **carrying capacity** of a habitat — the maximum number of individuals the habitat can support. Generally, a species' population size fluctuates (rises and falls) as the carrying capacity varies.

A population that shows this fluctuating pattern around the average carrying capacity of the habitat is said to be in **dynamic equilibrium** (changing but balanced) with its environment.

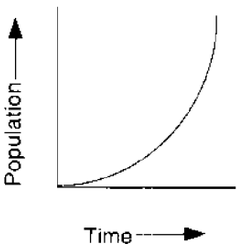


Growth pattern for a population in dynamic equilibrium with the environment.

A different growth curve forms when a population is not being affected by limiting factors. Because nothing impedes its growth, birth rate is high, mortality is low, and the number of individuals in the population increases by a large percentage each generation.

Exponential growth is similar to the growth of money earning interest in a savings account. The base amount grows by a certain percentage each time the interest is compounded. Although the initial amount may be small, and growth may be slow at first, over a period of time, the sum in the account grows quite large, if no money is withdrawn.

The graph of a population growing exponentially slowly begins to curve upward then suddenly bends and goes straight up to form a J-shape.



Applying that analogy to a population, consider that a pair of field mice migrate into a meadow where there are no other mice and no mouse predators — snakes, hawks, cats, etc. Food is abundant and places to find shelter for protection and nesting are plentiful.

At first, the population increases from the offspring of the pair alone. *(Field mice generally produce 6 babies per litter and may have up to 17 litters per year — that's potentially 102 baby mice in one year from one pair!)* But, once offspring begin to reach reproductive maturity (between two to three months after birth), and have litters of their own, the number of mice quickly swells. By the end of a year, the population would be in the thousands and the meadow would be overrun with mice!

Examples of exponential growth in populations include:

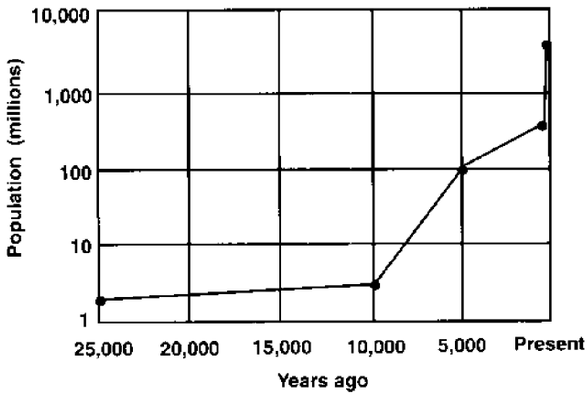
- mold growing on a piece of bread
- weeds growing in a newly plowed field
- an exotic species in a habitat where resources are abundant and predators are few (zebra mussels and nutria)
- the current worldwide growth of the human population

Ultimately, all populations are controlled by some limiting factor because the resources in any habitat are finite. When the number in a population exceeds the carrying capacity, famine, starvation, disease, and violence may result in a decline or crash of the population.

Unfortunately, the natural corrective action sometimes comes after much damage has been inflicted on the habitat by the population growing out of control. The current exponential growth and overconsumption of resources by the human population is a case in point.

Human Population Growth and Overconsumption

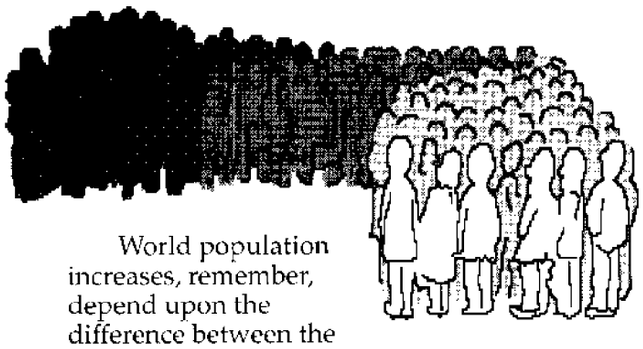
The growth curve for *Homo sapiens*, modern man, reflects the classic exponential pattern. It is estimated that 25,000 years ago humans may have numbered about three million. Over the next 15,000 years (until the end of the last ice age, about 10,000 years ago), population growth was slow (indicated by the gentle slope upward in the human population graph). The estimated human population 10,000 years ago was about five million. However, the population has increased at an accelerated rate since that time — 5,000 years ago it reached 100 million and by 1850 AD it was one billion.



About two hundred years ago the human population's growth pattern began to turn straight up forming the characteristic J-shaped exponential curve.

- By 1930 the world population had doubled to 2 billion.
- By 1975 (45 years later) it had doubled again to 4 billion
- In 1995 the population was 5.7 billion.
- At the present growth rate of 1.7% per year, the human population is expected to reach 6 billion by the turn of the century.

The reasons for this change from slow, stable growth to exponential growth are written in the social and economic history of man.



World population increases, remember, depend upon the difference between the number of births and deaths (if the birth rate is higher than the death rate, the population increases; if the opposite is true, the population decreases). Limiting factors in the environment influence both the birth rate and the death rate.

Homo sapiens of 25,000 years ago lived as nomadic hunter-gatherers. Weather conditions were harsh (ice age) and the availability of food varied seasonally. Poor nutrition and disease resulted in high death rates that kept the average life span at about 28 to 30 years.

Birth rates, on the other hand, were low. Studies suggest that females in primitive hunter-gatherer societies did not reach child-bearing age until 19 or 20. Children were breast-fed for three or four years, and during that time, the women did not ovulate. This increased the interval between children and therefore reduced the birth rate. Since birth rates and death rates were about equal, the population grew slowly for 15,000 years.

Approximately 10,000 years ago, *Homo sapiens* began to raise animals and grow crops; agricultural communities replaced hunter-gather societies. With this change came improved nutrition, longer life span, and higher birth rates. The population curve began to turn upward.

Growth rate increased steadily until about 200 years ago when the Industrial Revolution together with advancements in science and medicine drastically changed human society and its relationship to nature.

- People began to leave the farm and cluster in cities to work in factories; in industrialized nations, a more affluent middle class developed.
- Communication and transportation advancements allowed the sharing of ideas and goods.
- The cause of disease was discovered and vaccines and antibiotics were developed to

control or eliminate once fatal diseases — small pox, diphtheria, tuberculosis, etc.

- Improved agricultural practices — the use of commercial fertilizers and pesticides and the invention of modern farm equipment — increased food productivity. Human nutrition improved and fewer died from famine and starvation.
- New methods of solid waste disposal and sewage and water treatment provided better sanitation and living conditions.

These examples represent a few of the advancements in science and technology that have improved human living standards, driving the birth rate up (less infant mortality) and the death rate down (increased life span). The increased difference between birth and death rates has, in turn, accelerated the population growth rate of the last 200 years.

Fortunately, the need to reduce population growth has been recognized by people and governments worldwide. Population statistics are beginning to show decreased birth rates in most countries.

Overpopulation, however, is more than just a problem of too many individuals. These individuals are living longer and, therefore, placing an increased demand on the earth's finite resources by consuming more food, water, materials for shelter, and fossil fuels.

Plus, humans now use resources for things other than subsistence. For example, grain, the basic ingredient in bread, is also used to make snacks, fuel, and pet food, while oil, the basic ingredient in gasoline, is also a major ingredient in plastics and synthetic fabrics.

Although the rate of population growth in some nations has begun to level off (and in some cases decline), the rate of consumption is still growing exponentially. People in **developed (industrialized) countries**, especially the United States, are consuming a disproportionate share of the resources. A child born into a middle-class American family, for example, will consume in his or her lifetime twice the amount of food and five times the amount of energy as a child born into an average family in a **developing (non-industrialized) country** such as India.

Both problems, rapid population growth and overconsumption, are causing stress on earth's life support systems — biogeochemical cycles, food webs, ozone protection. As the human population increases, demand for earth's resources of water, food, materials to build shelter, fossil fuels, minerals, and space also increase.

With the increased use of these resources, more pollution occurs, more habitat becomes degraded or destroyed, and more opportunistic species dominate at the expense and decline of the less aggressive species.

These forms of stress are evidenced by the environmental problems discussed in previous *Project Telfus* modules:

- *Declining biodiversity* — caused by habitat degradation from pollution, deforestation, residential and commercial development, wetland drain-and-fill projects, and the introduction of exotic species.

- *Ozone depletion* — from the release of chlorofluorocarbons used to make products such as Freon and foam packaging.

- *Depletion of aquifers* — as groundwater is pumped for crop irrigation, industrial use, and human consumption faster than it can be renewed through the water cycle.

- *Pollution of surface waters* — due to fertilizers, pesticides, and toxic substances from agricultural, residential and industrial runoff and dumping.

- *Air pollution* — from the burning of fossil fuels in vehicles, factories, and power plants.

- *Possible global warming and climatic change* — from the excessive release of heat-trapping greenhouse gases into the atmosphere.

- *The erosion of soil and depletion of its nutrients* — through poor management of agricultural and forested areas.

- *Overfishing, overhunting, and overgrazing* — as demands for food and recreation increase, the world's oceans, forests, and grasslands are depleted.

Managing Population Growth and Consumption

Continued population growth and overconsumption have placed man on a collision course with limiting factors in nature. Some **demographers**, people who study population dynamics, predict that the earth's simple carrying capacity for humans (maximum number for which it can meet basic needs) is between 10 and 14 billion.

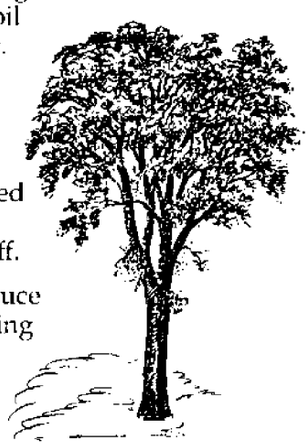
However, if the planet is stressed with 5.7 billion people, what will be the impact of twice that number? What will the living standard for humans be like with that many people competing for resources?

If humans are truly wise, as our species name, *sapiens*, implies, then we must each

- recognize the limits imposed on all of us by exponential human growth.
- encourage people to slow population growth.
- manage our resources sustainably.

Individuals can help sustain resources by reducing waste and overconsumption. As consumers, they must make conscious choices to:

- Buy reusable products rather than disposable ones.
- Reuse or recycle packaging items such as wrapping paper, grocery bags, ribbon, etc.
- Buy products made from recycled materials.
- Try to drive less. Plan meals and other household needs to avoid multiple trips during the week to the supermarket; walk, bike, or carpool as much as possible.
- Compost yard clippings to produce garden soil rather than buying it.
- Use water wisely, without waste.
- Use pesticides and fertilizers as instructed on the packaging to avoid excess in runoff.
- Think of ways to reduce energy used for cooling and heating. Plant trees to shade property and help reduce cooling costs.



- Wear extra clothes when it is cold so the thermostat can be set lower in the house, at school, and at work.
- Before buying, ask the question, "Do I need this, and will I use it, or do I just want it?" Practice buying more of what is needed and less of what is simply desired.

Homo sapiens, just like any other species, are subject to limiting factors in the environment, but they have some power to manipulate those factors. This power can be used to sustain life on earth at a comfortable level, or it can result in a decline in the quality of living conditions.

Life as we know it could end if people do not take steps to conserve resources. It also could end if the exponential increase in population worldwide is not recognized and controlled. If waste and consumption are replaced by conservation and wise use, existing resources can support the *Homo sapien* population for this and future generations.

TEACHING SEQUENCE

DAY 1 Previewing Questions and Answers

1. Divide the class into cooperative learning groups and have them answer/brainstorm the Previewing Questions given on page 10. [20 minutes]

2. Discuss student responses. Emphasize the meaning of the following vocabulary terms during the discussion: ecosystem, species, population, community, producers, consumers, detritivores, competition, predator/prey relationships, symbiotic relationships, and habitat. [20 minutes]

3. **Collect the previewing questions and answers; question # 4 will be the basis for a class discussion at the end of the module.** [5 minutes]

DAY 2 Begin the Video and Do Activity I

4. Watch the video until instructed by the narrator to pause for Activity I: Rats and Armadillos in a Salt Marsh Habitat. [10 minutes]

5. Set the stage for this activity by telling the students a little about the natural history of each species (Teacher Instructions pages 15-16). [5 minutes]

6. Follow the procedure outlined in the Teacher Instructions (numbers 4-6) to clarify terms, review graphing skills and explain the activity. [15 minutes]

7. Have students work independently to complete the graph on page 20 and answer the Summary Questions. *(The questions may be assigned for homework, if time runs short.)* [20 minutes]

DAY 3 **Discuss Summary Questions to Activity I, Watch Video, and Begin Activity II**

8. Discuss the population growth patterns and the answers to the Activity I Summary Questions. [15 minutes]

9. Watch the video until instructed by the narrator to pause for Activity II: Beat Ya' To the Beads. [5 minutes]

10. Do Extension #1 (pages 12-13) to emphasize the finite nature of earth's resources. This may be done as a demonstration or as a teacher-guided group activity. [10 minutes]

11. Explain the procedure for the game, Beat Ya' to the Beads and play GAME 1.

12. Have the students complete the Summary Questions to GAME 1 for homework.

DAY 4 **Discuss Summary Questions to GAME 1 and Complete Activity II**

13. Discuss the Summary Questions for GAME 1. [10 minutes]

14. Introduce and play GAME 2. [15 minutes]

15. Allow time for the students to answer the Summary Questions. [10 minutes]

16. Discuss the Summary Questions. [10 minutes]

17. Assign each student a term from the Vocabulary section (pages 9-10). For homework, have them draw and color a scene that represents the term . [5 minutes]

DAY 5 **Continue the Video, Discuss Human Population Growth, Do Postviewing Questions**

18. Allow time for the students to show and explain their drawings depicting the vocabulary terms. Clarify any misconceptions regarding the meanings. [15 minutes]

19. Watch the remainder of the video. [10 minutes]

20. Using a transparency of the Human Population Growth Curve (page 29), explain reasons for the exponential growth of the human population since the beginning of the Industrial Revolution. *(Refer to the Background Information on pages 5-6.)* [10 minutes]

21. Have students work in small groups to answer the Postviewing Questions. [10 minutes]

22. Discuss answers to the Postviewing Questions. [15 minutes]

DAY 6 **Show and Discuss the Film *World Population***

23. [OPTION] Show the 4 minute film, *World Population (See Extension #5 on page 14.)* Discuss the need:

    - for becoming a sustainable society
    - to reduce waste and overconsumption
    - to reduce population growth

    [20 minutes]

24. At the teacher's discretion, the Evaluation section (pages 30-33) may be assigned or used to accompany the next unit test. There are additional activities in the Extension section (pages 13-14) that may be used for further study.

VOCABULARY

The following terms are used at various times throughout the module. The definitions should be adapted to suit the students' grade level.

Biogeochemical cycles: A repeating sequence of events occurring between organisms and the physical environment (soil, water, air) as elements and compounds move from the physical into the biological and back to the physical environment. For example, in the carbon cycle, plants use carbon dioxide from the air and water from the soil to produce food (glucose). When the plant dies and decomposes, the carbon dioxide and water are returned to the air and soil, and are available for reuse.

Birth rate: The annual number of births per 1000 individuals in a population.

Carnivores: Animals that eat other animals (meat-eating).

Carrying capacity: The point at which an ecosystem can no longer support additional members of a species with the food, water, shelter, and space they need to survive.

Community: All the organisms — plants, animals, fungi, and microbes — living in the same area during a particular time.

Consumers: Organisms — animals, fungi, and bacteria — that ingest other organisms to obtain food.

Death rate: The annual number of deaths per 1000 individuals in a population.

Deforestation: The removal of all or most of the trees in a forest or wooded area.

Demography: The study of populations, their characteristics, and what happens to them over time.

Detritivores: Organisms — scavengers and decomposers — that eat dead or decaying organic matter (dead leaves, roots, carcasses, and feces).

Dynamic equilibrium: Population size fluctuates but is in balance with the habitat's average carrying capacity.

Ecosystem: An area where living things interact with each other and with their nonliving surroundings. Substances essential for life such as oxygen, water, and nitrogen are cycled, and energy flows from producers through consumers.

Exotic species: Foreign plants, animals, or microbes that are introduced to a habitat.

Exponential growth: Rapid, uncontrolled growth in a population. The growth pattern produces a J-shaped curve, when graphed.

Finite resources: Substances such as water, soil, minerals and air that are in a fixed or limited supply. These resources can be recycled and reused, but none can be created.

Food chain: The organisms involved in a flow of energy from producer through consumers. (Producer — Herbivore — First Carnivore — Top Carnivore)

Food web: The complex, intertwining feeding relationships among the organisms in an ecosystem. It includes producers, herbivores, carnivores, and detritivores.

Habitat: The area where a particular species lives. It provides all the species' requirements for life — water, food, shelter, and space.

Herbivores: Animals that eat plants.

Industrialized (developed) countries: Nations with advanced economies and social structures that provide for most people's basic needs (clean water, food, shelter, space) and have available health and welfare services. (The U.S., Japan, Canada, Australia, New Zealand, and most European countries are examples.)

Limiting factors: Conditions in a habitat which control the rate at which population size changes. (Availability of food, pollution, adverse weather conditions, disease are examples.)

Migration: The movement of individuals into or out of an ecosystem.

Non-industrialized (developing) countries: Nations with agricultural and small manufacturing economies that are striving to provide for most people's basic needs (clean water, food, shelter, space). Health and welfare services are available only to a few at the top of the economic and social ladder. (South Africa, Kenya, Asia, Mexico, and many Latin American countries are examples.)

Overpopulation: When a population's size exceeds its habitat's ability to supply enough water, food, shelter, space, or other requirements for survival.

Population: All members of the same species living in particular area during a specific time.

Predator/prey relationships: One animal serves as food for another animal. The predator kills and eats the prey.

Producers: Organisms that make their own food (autotrophs).

Species: A group of similar organisms that interbreed in nature to produce fertile offspring.

Sustainable use: Using earth's renewable resources in a way that will neither alter nor reduce their availability for future generations.

Zero population growth: When growth stabilizes in a population because the number of births equals deaths.

PREVIEWING QUESTIONS AND ANSWERS

1. An ecosystem is an area where living things (plants, animals, microbes, etc.) interact with each other and with their nonliving environment (water, air, minerals, soil, etc.). All the members of a particular species living in an ecosystem at the same time make up a population. All the different populations in the ecosystem combine to form a community.

   a. Name ten different populations you would expect to find in a pond ecosystem of the Gulf Coast region. Be as specific [common names] as possible.

   Answers will vary. Encourage students to include producers, herbivores, carnivores, and detritivores. For example: *bald cypress trees, algae, duckweed, water lilies, snails, grass shrimp, dragonflies, mosquitoes, minnows, perch, catfish, bass, water moccasins, diamond-back water snakes, bullfrogs, salamanders, common egrets, great blue herons, wood ducks, nutria, muskrats, raccoons, crawfish, and bacteria.*

   b. Describe some interactions that might occur between these populations.

   - *Food interactions — Snails eat algae, perch eat snails, raccoons eat perch, bacteria decompose all of these organisms after they die.*
   - *Competition — Members of the same species compete with each other for food, hiding and nesting spaces, and mates. Sometimes members of different species compete for the same food, space, and shelter — egrets and blue herons both eat fish, frogs, snakes and crawfish.*
   - *Cooperation —Some species provide shelter for other species — wood ducks nest in cypress trees.*

c. Name some ways that the nonliving environment (soil, water, air, climate) and the living environment interact.

Answers will vary. Encourage students to think back to previous *Project Tellus* modules for answers.

- *Plants and algae use carbon dioxide, water and minerals from the pond to make food (photosynthesis).*
- *Most organisms take in (breathe) oxygen from the air or water.*
- *Plants release oxygen into the water and atmosphere during photosynthesis.*
- *Solar energy provides light for photosynthesis and infrared radiation to warm the earth.*

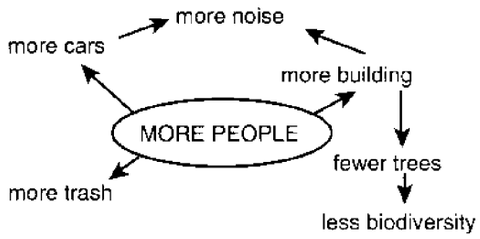
2. Name at least four resources or conditions that a habitat must supply for plants and animals to survive. What would happen if any one of these resources or conditions became depleted through overuse or degraded through pollution?

Answers should include some of the following: *food, water, space, oxygen, places for shelter and hiding (for animals), light and soil minerals (for plants), suitable climate.*

If a condition required for survival was depleted, fewer individuals could survive. If the resource (air, water, soil) was degraded, the species would either die out, become weak, or if mobile, migrate to a new location where conditions were better.

3. Consider the following scenario. A large ship-building company plans to build a factory on some land along the river just outside your town. A thousand new families will be moving into the area. How will these changes negatively affect your community? (Consider social, economic, and environmental effects.)

Write "more people" on the chalkboard then have students offer ideas about how life in the town would change. Use arrows pointing away from the central theme "more people" to list the ideas on the board. If one effect is an outgrowth of another, link the two with an arrow as shown:



Answers are numerous some suggestions are:

- more noise
- more trash
- more traffic
- more pollution
- less available housing
- fewer trees
- less animal habitat
- more crime
- dirtier water
- crowded schools in the fall
- more building
- crowded recreational sites

4. List 10 things you would like to have, to be, or to have done by the time you are 30 years old.

Answers will vary. List some of the student responses on the board. Tell students that they will have a chance to add to or take away from the list at the end of the module.

Collect the previewing questions and answers; question # 4 will be the basis for a class discussion at the end of the module.

POSTVIEWING QUESTIONS AND ANSWERS

1. Ground level ozone is emitted from industries and vehicles that burn fossil fuels. This type of pollution interferes with photosynthesis in plants — when ozone levels are high, plant growth decreases. How would a reduction in plant growth affect other parts of a food web?

Fewer plants would be available for herbivores, therefore there would be less prey for predators (carnivores). All populations in the habitat would decline because all are directly or indirectly dependent on the energy stored in the food that plants make.

2. Name some ways that the human population has negatively altered earth's environment.

Responses will vary. The following are a few suggestions.

- *Habitats have been degraded and lost due to industrial, residential and agricultural development in areas that were previously forest, wetlands, meadows, etc.*

- *Exotic species have been introduced that outcompete native species for food, space, and shelter, thus weakening the established ecosystems. (Argentine fire ants, nutria, zebra mussels, kudzu, and water hyacinths)*

- *Water pollution from industrial, residential, and agricultural runoff has led to the decline of many aquatic and marine species.*

- *Overconsumption of groundwater for irrigating crops, industrial uses, and residential purposes has led to water shortages and depleted aquifers in some areas of the world.*

- *The excessive emission of greenhouse gases is possibly causing the current worldwide warming trend.*

3. How have industrialization and human population growth caused the environmental problems mentioned in question #2?

   - *As the human population grows, people require more of the earth's supply of water, food, space, and shelter. This reduces the amount available for other species and, therefore, leads to declining biodiversity.*

   - *Because transportation between continents is common, exotic species find their way into foreign habitats more easily.*

   - *The amount of pollution from industry, agriculture, and residential areas increases as the population grows.*

   - *More people means more burning of fossil fuels to supply energy for transportation, manufacturing, and agriculture. This increases greenhouse gases in the atmosphere.*

4. Discuss question #4 from the Previewing Questions.

   - *Return the Previewing Questions and Answers to the students and allow a few minutes for students to revise their aspirations (add or take away).*

- *Draw 3 columns on the board.*

- *List the student responses in the first column and tally the results for each suggestion in the second (the number that want a car, VCR, stereo, TV, boat, home, children, wealth, health, a degree from college, to eat dinner out every night, travel to foreign countries, etc.)*

- *Have the class decide whether each response is a "want" or a "need." Write the consensus in the third column.*

- *Have each student identify three "wants" from the list that s(he) would be willing to do without in order to become less consumptive. Encourage them to refrain from those three consumptive behaviors during the coming week.*

EXTENSIONS

1. **"Earth: the Apple of Our Eye" — modeling the earth's finite land resources:**

   - Show your students a globe or a poster of the earth in space. Emphasize that the earth is a closed system *(with the exception of solar energy, everything is contained within the boundary of earth's atmosphere)* with finite resources (water, soil, minerals, and air are in a limited supply).

   - Tell the students to think of the earth as an apple.

   - Using a kitchen knife, cut a large apple into quarters. Set aside three of the quarters and ask, "What do you think the three quarters represent?" *(Oceans cover three-fourths of the earth's surface.)*

   - The fourth quarter represents all the land area of the earth. Cut this "land" in half and set aside one of the pieces. The part set aside represents all the land on earth that is inhospitable to humans — polar areas, deserts, very high or rocky mountains. Ask, "What fraction of the whole apple (earth) is left?" *(1/8)*

     This 1/8 portion represents the land where people can live, but only part of the land can be used to grow food.

- Cut the 1/8 piece into four sections. Set aside three of these pieces and ask, "What fraction of the apple (earth) is left?" *(1/32)*

  Ask students to suggest what the other 3 pieces represent. *(They represent areas that are too rocky, wet, cold, steep or with too poor soil to produce food. They also represent the cities, highways, shopping centers, schools, parks, factories, parking lots, and other places where people live but do not grow food.)*

- Carefully peel the 1/32 slice of apple. Show the students the very small, thin peeling. It represents the thin layer of earth — less than five feet deep — upon which humans depend for growing food.

  Agricultural advancements — fertilizer, pesticides, machinery — have enabled the world to feed many of its people. But, with a fixed land resource and an ever-increasing number of people to feed from that land base, each person's portion becomes smaller and smaller as the population grows. Additionally, the land can be made unusable through pollution and erosion. Because earth's land, water, and air are finite, it is essential to protect them from pollution and overconsumption.

[Adapted and reprinted with permission from *For Earth's Sake: Lessons in Population and the Environment*, Zero Population Growth, Inc., c 1989. 1400 Sixteenth Street, NW Suite 32, Washington, DC 20036]

2. **Compare developed (industrialized) and developing (non-industrialized) countries:** Network with social studies teachers to have student groups research and compare two different countries — one industrialized the other non-industrialized.

   - Divide the class into groups.

   - Have each group research and write a report comparing the resources and living conditions (availability of food, clean water, housing, clothes, medicine, education, and employment) in two countries — one a developing (third-world) country and the other a developed (industrialized) country. (See Vocabulary definitions for examples in each category.)

   - Have them conclude the report by suggesting ways that developed countries can help developing countries advance their standard of living.

   - Have each group present their findings to the class.

   - Allow time for the class to discuss the pros and cons associated with the suggestions for helping developing countries — money, technology, tax breaks on their exports, services provided by government (Peace Corps), religious, or private agencies.

3. **Ways to "reuse:"** Many household items, which are usually thrown away, can be reused. Reusing these items helps decrease overconsumption by reducing the demand for newly manufactured items.

   - Have the class brainstorm ways to reuse each of the items below. Encourage them to be creative — no suggestion is too absurd. Ask them to suggest other items for the list.

     plastic containers and lids from foods such as yogurt and margarine
     coffee cans and lids
     baby food jars and lids
     35mm film canisters and lids
     toilet paper rolls
     paper towel rolls
     paper bags
     plastic shopping bags
     shoe boxes
     small boxes with covers
     popsicle sticks
     ribbon, yarn, string
     rug scraps
     cardboard oatmeal boxes
     clay or plastic flowerpots

   - Encourage the students to begin a reduce, reuse, recycle, repair campaign in their homes.

4. **Math:** If the world's human population is 5.7 billion (1996), and it is growing at an annual rate of 1.7%, by how many will the population increase next year?

(5,700,000,000 people x 0.017 = 96,900,000 = 96.9 million additional people)

5. Population explosion: It took from the beginning of human history until 1960 for the world population to reach three billion. In less than 40 years that number has almost doubled to 5.7 billion. The human population is growing exponentially (increasing at an accelerated rate from year to year). The 4 minute video entitled *World Population* powerfully illustrates the human population's growth and distribution from 1 A.D. to the year 2020.

   After watching the film, have the students discuss ways to reduce the growth rate of the human population to attain zero population growth. (The *Project Tellus* team is **NOT** advocating the following measures, but merely preparing the teacher for ideas that students may mention — pros and cons should be discussed for any suggestion.)

   - medical means
   - adjusting religious doctrines concerning family planning
   - government restrictions on the number of births allowed per family
   - adoption as an alternative to childbearing

   [The 16 mm film or 1/2" VHS video can be obtained by contacting Zero Population Growth (ZPG), 1400 16th Street NW #320, Washington, DC 20036. The cost is $29.95 plus $3.00 for postage and handling. The film is often available through county, parish, or regional school board libraries.]

6. **Prepare a newsletter:** Have students work in groups to compile a newsletter reporting on the effects of human population growth on natural resources in your state (or the Gulf of Mexico region). Each student in the group will be responsible for researching and writing an article reporting on one of the following:

   - water shortages
   - water pollution
   - habitat loss
   - declining biodiversity
   - climatic change
   - air pollution
   - deforestation

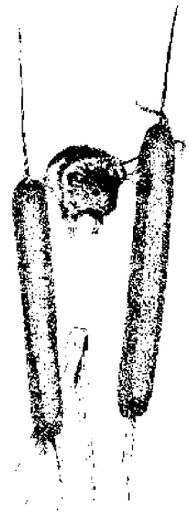
   The newsletter may also include advertisements, cartoons, an editorial, diagrams, and graphs.

   If your school has a computer lab and access to a desktop publishing program, network with the computer teacher to have the students format the newsletter in the computer lab.

   Display the newsletters in a prominent place *(school library, front hall, cafeteria, etc.)* so the entire student body, faculty, and administration will be impacted by the news.

ACTIVITY I

RATS AND ARMADILLOS IN A SALT MARSH HABITAT
(Teacher Instructions)



Objectives

- To plot and interpret graphs of two animal populations.
- To compare a population changing in dynamic equilibrium with one growing exponentially.
- To describe factors that may limit population growth.

Description

This activity is based upon a hypothetical but believable situation in a Gulf Coast salt marsh habitat. The purpose of the activity is to demonstrate that populations living in the same geographical area during the same 10-year period may show different growth patterns due to differing sets of limiting factors. Students will plot population data on two species — marsh rice rats and nine-banded armadillos. The graph of the rat population will show a population in dynamic equilibrium (changing but balanced) while the armadillo graph will show a population growing exponentially. Students will use the graphed results, background information in their instructions, and teacher input, to answer questions and make inferences concerning the two populations.

The following information on the two species will be helpful in guiding students toward logical inferences.

Background Information

The Gulf Coast's salt marsh ecosystems provide valuable habitat for numerous species. Among the inhabitants of this grassy, wet environment are populations of marsh rice rats *(Oryzomys palustris)* and nine-banded armadillos *(Dasypus novemcinctus)*.

The marsh rice rat is a small-sized rodent with populations well established throughout the Gulf Coast states. As their common name implies, they prefer grassy, wet areas such as marshes, ditches, fields with damp soil, and edges of lakes and streams. They feed on aquatic plants, seeds, insects, and crustaceans such as small crabs.

As with most rodents, these rats are reproductively aggressive. A female reaches sexual maturity approximately 50 days after her birth. After that time, she may have up to seven litters per year, averaging four to five babies per litter. Although prolific, rice rat populations are generally kept in check by their numerous predators — owls, hawks, and water snakes. Because of the high rate of predation, the average life span for a rice rat is approximately one year.

Compared to the well-established marsh rice rats, armadillos are newcomers to the Gulf Coast states. The nine-banded armadillo (the only species of armadillo in the United States) migrated into Texas from Mexico about 100 years ago. By the 1940s, the species had expanded its range eastward to the Mississippi River, and today has spread into Florida.

The body of an armadillo is protected by hard, bony plates arranged in bands that slide against each other. Armadillos are primarily nocturnal, and when seen, appear to be completely preoccupied, nosing through leaves and debris in search of favorite foods — spiders, beetles, ants, snails, slugs, and earthworms. (Armadillos are also known to kill and eat poisonous snakes.)

Unlike many other exotic species, armadillos fill a very beneficial niche in their

habitat. Besides devouring huge quantities of noxious insects, their burrows provide a retreat for rabbits, skunks and other forms of wildlife.

Armadillos suffer high mortality due to predation by bobcats, wolves, coyotes, dogs, and from being struck by automobiles. Nevertheless, they have been successful in extending their range and growing in population size. Generally, female armadillos produce a litter of quadruplets (four offspring of the same sex and genetically identical) once a year, usually in February. The average life span of each offspring is four years.

Procedure

1. Have the students read the introduction in their instructions.

2. Spend a few minutes explaining the concepts that are the focus of the activity: limiting factors, carrying capacity, dynamic equilibrium, and exponential growth. *(Refer to pages 3-5 in the Background Information.)*

3. Review graphing skills. *(Refer to pages 3-4 in the Background Information of module 1 — "TELLUS About Science.")*

   - Distinguishing the independent (manipulated) variable from the dependent (responding) variable.
   - Labeling the x- and y-axes.
   - Labeling the grid with appropriate scale numbers.
   - Plotting data.

4. Have students follow the procedure in their instructions to complete the graphing activity and answer the Summary Questions.

5. Discuss the results and the answers to the Summary Questions. *(The answer key follows.)*

6. Continue the video.

Summary Questions

1. How are the two graphed lines similar?

   Both are changing from year-to-year.

2. How are the graphed lines of the two populations different?

   The graph of the rat population is fluctuating up and down within a predictable range, while the graph of the armadillo population is only curving upward.

3. Which population appears to be in balance (dynamic equilibrium) with the environment?

   The rat population appears to be in balance with the environment because there are no extreme changes in population size.

4. Draw a line to represent the average carrying capacity of the rat population over the ten year period.

   What is the approximate carrying capacity for marsh rice rats?

   The carrying capacity is about 470 rats.

5. What type of growth pattern is shown by the changes in the armadillo population?

   The armadillos are showing exponential growth.

6. Based on its current pattern of growth, estimate the size of the armadillo population for year 10.

   The armadillo population appears to be doubling each year, so there should be about 800 individuals present in year 10.

7. Suppose the armadillo population decreased to 300 in year 10. Name some possible reasons for the decline.

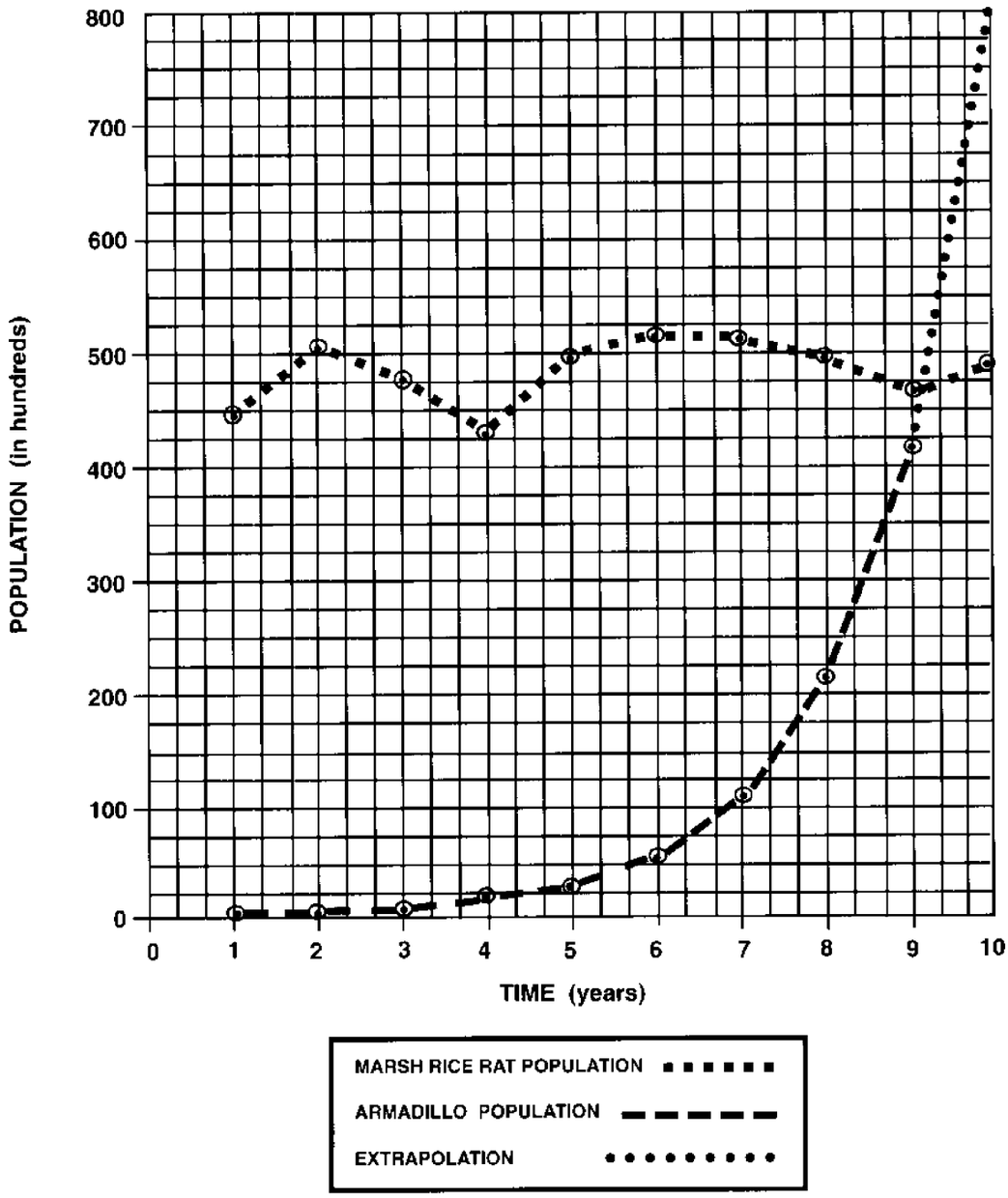
   The armadillos may have reached the carrying capacity of the salt marsh ecosystem. If that was the case:

   - *A shortage of food may have caused some to starve.*

- *A shortage of places to dig burrows may have lead to increased predation as the armadillos roamed or slept in open view of predators.*

Other reasons for a decline may be an incidence of disease, adverse weather conditions (hurricanes and tropical storms), or changes to the habitat caused by human activity such as pollution and development.

GROWTH PATTERNS IN TWO SALT MARSH POPULATIONS



ACTIVITY I

RATS AND ARMADILLOS IN A SALT MARSH HABITAT

(Student Instructions)

SALT MARSH ECOSYSTEM

Introduction

Salt marsh ecosystems line the Gulf Coast. These grassy areas are places where inland freshwater streams and rivers merge with the salt water of the Gulf or where the Gulf waters simply merge with the land. Diverse communities of plants, animals, and microbes depend on the habitat components — food, water, shelter and space — in these areas.

Sediment deposited by the rivers and streams provide a rich bottom in which many plants grow. The tall grasses and shrubs of the marsh provide cover as well as food for animals like crabs, shrimp, and clams that live in the shallow water and eat the decaying matter (detritus) trapped at the base of the plants. Birds nest on the stems of the plants, and insects eat the leaves. Long legged birds wade the muddy flats hunting for insects and crustaceans. Other water birds — ducks, gulls and pelicans — scoop fish from the water for food. Small marsh rodents — mice and rats — scurry beneath the tall grasses and shrubs, eating aquatic plants, seeds, insects, and small shrimp and crabs. They, in turn, are hunted by hawks, owls and snakes. Lizards stalk insects in the grass, and terrapins chase fish in the shallow waters.

Each population in the salt marsh is connected to others through competition, predator/prey relationships, or other interdependent links. These relationships with each other coupled with other **limiting factors** such as disease and harsh weather serve to prevent each population from growing beyond what the habitat can support.

The number in a population that can be supported by the habitat's available resources is the **carrying capacity** for the particular species. As a population nears the carrying capacity, limiting factors — lack of food, shortage of hiding places, increased predation — begin to affect population size, bringing the number back within the range that can be supported.

A population number that is rising and falling from year-to-year around the carrying capacity of the habitat is said to be in **dynamic equilibrium** (changing but balanced) with the environment. Populations that are well established in their habitat generally show this type of growth pattern. However, when a species first moves into a habitat, limiting factors may not be in place to curb population growth. In that case, the population experiences exponential growth (it increases at an accelerated rate) until some limiting factor begins to define the number that can survive.

The following activity will help you to understand the effect of limiting factors on a populations' growth pattern.

Procedure

1. The data table that follows gives annual population counts for two different species — marsh rice rats and nine-banded armadillos — living in the same salt marsh habitat over a ten year period.

2. Graph the data on the grid provided.

   - Label the x-axis (horizontal) with the name of the independent variable and the y-axis (vertical) with the name of the dependent variable.

   - Label appropriate scale numbers on each axis.

     a. Determine the range of data for the axis.

     b. Divide by the number of grid marks on the axis

     c. Round up to an easily manipulated number.

   - Using two different colors of ink or the line patterns given in the key, plot both sets of data on the grid.

3. Based on the information in the introduction, your teacher's description of the animals, and the graphed results, answer the Summary Questions that follow.

Summary Questions

1. How are the two graphed lines similar?

2. How are the graphed lines of the two populations different?

3. Which population appears to be in balance (dynamic equilibrium) with the environment?

4. Draw a line to represent the average carrying capacity of the rat population over the ten year period.

   What is the approximate carrying capacity for marsh rice rats?

5. What type of growth pattern is shown by the changes in the armadillo population?

6. Based on its current pattern of growth, estimate the size of the armadillo population for year 10.

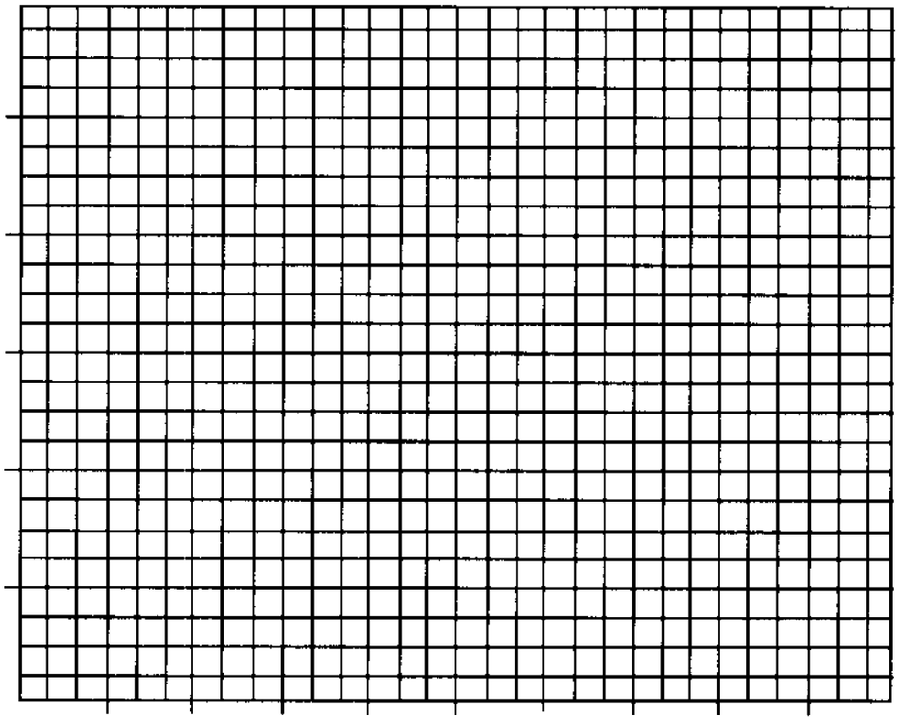
7. Suppose the armadillo population decreased to 300 in year 10. Name some possible reasons for the decline.

STUDENT DATA SHEET

TEN YEAR POPULATION STUDY ON MARSH RICE RATS AND NINE BANDED ARMADILLOS IN A FLORIDA SALT MARSH

Year	Marsh Rice Rats	Armadillos
1	437	2
2	502	5
3	478	9
4	425	13
5	493	27
6	514	51
7	511	105
8	498	213
9	467	409
10	488	?

GROWTH PATTERNS IN TWO SALT MARSH POPULATIONS



MARSH RICE RAT POPULATION

ARMADILLO POPULATION

EXTRAPOLATION

ACTIVITY II

BEAT YA' TO THE BEADS
(Teacher Instructions)

Introduction

The concepts of **finite** resources and interconnectedness among species are essential in understanding the impact of **overpopulation** on an ecosystem. When more resources are used by one group, less are available for other organisms. Since everything is interconnected, if one part of the environment is depleted, weakened, or missing, balance is lost and the entire ecosystem suffers.

Because earth's resources are limited (finite), every ecosystem has a carrying capacity — a point at which it can no longer support additional members of a species with the food, water, shelter, and space they need to survive.

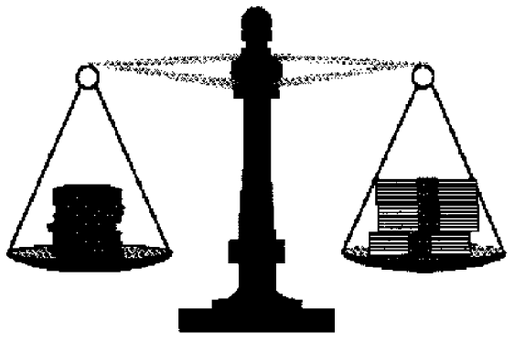
This activity will help students to understand the finite nature of an ecosystem's food supply and will demonstrate the effect of overpopulation on available food in an area. Students will be able to correlate what happens in the game with what could happen to any population that exceeds the limits of its carrying capacity.

Objectives

- To understand the finite nature of an ecosystem's food supply.
- To demonstrate the effect of overpopulation on food resources in a designated area.

Description

The teacher will introduce the activity by explaining the finite nature of earth's resources. Then, working in small groups, students will simulate a growing population competing for a finite supply of food. They will collect data, graph the data, determine the carrying capacity for the environment, and answer Summary Questions that will help them identify the effects of overpopulation on the environment. The second part of the



activity — GAME 2 — will demonstrate the effect of competition from an exotic species. The extension activity — GAME 3 — may be used to demonstrate the effect of toxins in the environment on the population.

Materials (per group)

Large rectangular cake pan
1 lb. box of corn meal
2-3 packages of yellow or clear seed beads
2-3 packages of red seed beads
4-6 small paper cups (numbered 1 through 6)
4-6 extra cups for GAME 2

Teacher Preparation

On the day of the activity, mix both packages of beads with the 1 pound box of corn meal and pour the mixture into the cake pan. (Do this for as many groups as will be participating.)

[NOTE: Upon completion of the activity, the corn meal and beads can be stored in airtight plastic containers and reused for several years.]

Procedure

A. Explain the finite nature of earth's resources (Refer to Background Information on page 3.)

   Extension #1 (Earth: the Apple of Our Eye) on pages 12-13 is an excellent way to convey the finite nature of earth's land resource.

B. Divide the class into cooperative learning groups of 4 to 6 students.

C. Give each group a pan of the corn meal/beads mixture and a number of cups equal to the number of group members. (The number of group members determines the number of rounds played during the game.)

D. Explain the following:

- An ecosystem can only support a certain number of individuals. Once the carrying capacity has been exceeded, the ecosystem and the species begin to suffer.
- In nature, a wide variety of food is available, but different species are adapted to eat different things; not all possible food sources are available to a particular species.
- The pan of corn meal/bead mixture represents an ecosystem, and the beads are food. Everyone in the group is of the same species and can "eat" only the yellow or clear beads. The red beads are a source of food, but not for their particular species, so they are to ignore the red beads.
- At the teacher's signal to start, ONE student is allowed 30 seconds to "graze" through the cornmeal to look for food. When time is called, the student must stop and count the number of beads collected, then put the beads in cup #1.
- For the second round, TWO students will be given 30 seconds to look for food. At the end of the 30 seconds, they are to stop, count the total number of beads collected, divide by 2 to get an average number, and place the beads into cup #2.
- Repeat the procedure adding one person for each round of play. Play as many rounds as there are people in the group. (During the last round, all students in the group are competing for food at the same time.)

E. When each group is ready, give the signal to begin. Play as many rounds as are required to complete the game, then allow time for the students to complete the chart for GAME 1, graph their results, and answer the Summary Questions.

F. Discuss the results and answers to the Summary Questions. (The answer key is on pages 23-24.)

G. Repeat the game but vary it by adding a population of exotic species to the ecosystem. Relate the following information:

- The climate of the states bordering the Gulf of Mexico is generally mild. Thus, conditions are favorable for many species not native to the area to survive, thrive, and extend the range of their populations. In doing so, they often take over habitats and crowd out the native species. These non-natives are called exotic species.
- One student in each group will play the role of an exotic species. As an exotic species, the student is able to "eat" all colors of beads. The student who represents the exotic species will keep his/her beads separated from the beads collected by the native species.
- Have the students number the second set of cups 2-6 (these will hold the beads of the exotic species).

H. When each group is ready, give the signal to begin GAME 2. Play as many rounds as are required to complete the game (4 to 6 rounds), then allow time for the students to complete the chart and answer the Summary Questions.

I. Discuss the results and answers to the Summary Questions.

J. Watch the remainder of the video program.

Extension

GAME 3: Dealing With Toxins In The Environment

- Repeat the game. This time, all the students represent a native species, and pollution has made the red beads toxic. If a student accidentally picks up a red bead in getting to the yellow or clear colored bead, they have been poisoned and become ill. When counting the number of beads they successfully "ate," they must give up two beads for each red one handled. If they

handled five or more red beads during the 30 second period, they must consider themselves "killed," and the activity proceeds without them.

- Play as many rounds as are required to complete the game, then allow time for the students to complete the chart for GAME 3, and answer the Summary Questions.

- Discuss the results and answers to the Summary Questions.

ANSWER KEY - ACTIVITY II
Summary Questions

GAME 1: Competition For Food

1. What happened to the number of beads you were able to collect as the number of individuals looking for beads increased?

   The number decreased as more people competed for food.

2. Was it easier or harder to find beads during the last round when the entire group was searching at the same time and the "ecosystem" was experiencing over-population? Explain.

   Answers will vary. Some may say that it was easier because the corn meal was agitated more, exposing the beads; others will say that it was harder because everyone was crowded around the pan and aggressively hunting the beads.

3. Suppose that in order to meet your energy requirements for survival, health, and growth, you require 10 beads per round. Would you have been able to survive through all the rounds? If not, how many rounds would you have survived?

   Answers will vary based on the results.

4. Suppose you could survive on only 5 beads. Would you have survived all rounds?

   Answers will vary based on the results.

   If not, how many would you have survived?

   Answers will vary based on the results.

   What would be the condition of your health?

   Health would be in jeopardy. Hunger and disease would likely become problems.

5. How do you think animals in the wild would be affected, if they had to compete for food in this manner? How did it make you feel?

   Answers will vary. Typically, animals become aggressive and hostile (more fighting) when others enter their territory. Competition causes stress. Smaller animals would get less food and would therefore have less chance of survival.

6. Animals need more than food to survive and be healthy. What are some of their other needs?

   They need fresh water to drink and places to hide and nest (shelter and space).

   What would happen to a population if there was not enough food or other essential needs to go around?

   The population would decline, fewer would survive. Eventually, the population size would fall within the carrying capacity of the ecosystem and population size would stabilize.

7. Carrying capacity is the average number of individuals in a population that an ecosystem can support with its available resources.

   - Graph the data from your chart and determine the average carrying capacity of the ecosystem for the 4 to 6 rounds of play.

   Graphs will vary depending on the results and the number of players. The carrying capacity will be the average quantity.

8. Apply the above situation to people. How might competition for resources in an overpopulated area affect the health of the human population?

   Answers will vary. Generally it causes stress which may present itself as greed, anger, and violent behavior. Among some people it can cause cooperative behavior — combining efforts as in communal living.

As long as food, water, shelter, and space are available, the health of the human population will not be in jeopardy. However, as competition for higher standards of living increase, the results of stress may become more apparent.

How does this competition affect the environment?

As the human population grows, humans consume more and more of the earth's finite resources — water, vegetation, minerals, and animals — leaving less for other organisms, less for the physical environment, and ultimately less for humans themselves. In the end, as the environment is altered to take care of human needs, the quality of life for all organisms decreases. This is evidenced by environmental problems such as a reduction in biodiversity, deforestation, and declining water and air quality.

GAME 2: Invasion of an Exotic Species

1. How does the feeding success of the exotic species compare to the success of the ecosystem's native species? (For each round, compare the number collected by the exotic species to the average collected by the others.)

   At first there may be little difference, but as competition and overcrowding occur, the exotic species should be able to collect more beads than the native species.

2. Do you think that the results of this activity are similar to the consequences of exotic species invading an ecosystem in the wild? Explain.

   Yes, if an exotic species can eat a greater variety of food than the native species, their chances of survival and reproduction are much better. Eventually, they may take over much of the habitat, causing the decline of native species (as has occurred with the Argentine fire ants and nutria in some areas of the Gulf Coast region).

3. Suppose the exotic species ate ONLY the red beads. Would the effects on the available food supply for the native species be the same? Explain.

   No, there would be no competition ***for food*** *between the two species.*

4. What are some ways that exotic species compete with native species besides vying for food?

   They compete for space, shelter, and water.

Extension

GAME 3: Dealing With Toxins In The Environment

1. What did the introduction of a "poisonous" food source do to your attitude during eating?

   Answers will vary. They may mention attitudes such as fear and caution.

2. Was the amount of food that you were able to collect affected by the presence of the poisonous food? Explain.

   Yes, because of caution, the search was slower and fewer beads were collected.

3. Were you able to survive as easily as in GAME 1? Explain. (Remember, it takes 10 beads to thrive, and 5 beads to survive.)

   Answers will vary based on results. Generally, the answer will be no, because fewer beads were collected.

4. Was your health affected by the presence of this poisonous food? Explain.

   Answers will vary. Generally, yes for fewer beads were collected.

5. How might wildlife in an ecosystem be affected by toxins in their environment?

   There would be a decrease in population size due to illness, death, and migration from the polluted ecosystem.

ACTIVITY II

BEAT YA' TO THE BEADS

(Student Data Sheet and Summary Questions)

GAME 1: Competition For Food

Average the number of beads collected during each round for your group. Do this by adding the total number of beads collected and dividing by the number of people participating during the round. Record the average in the chart below.

	Round					
	1	2	3	4	5	6
Average # of beads						

Summary Questions

1. What happened to the number of beads you were able to collect as the number of people looking for beads increased?

2. Was it easier or harder to find beads during the last round when the entire group was searching at the same time and the "ecosystem" was overpopulated? Explain.

3. Suppose that in order to meet your energy requirements for survival, health, and ideal growth and life-span, you require 10 beads per round. Would you have been able to survive through all the rounds? If not, how many rounds would you have survived?

4. Suppose, if necessary, you could survive on only 5 beads. Would you have survived all rounds?

   If not, how many would you have survived?

   What would be the condition of your health?

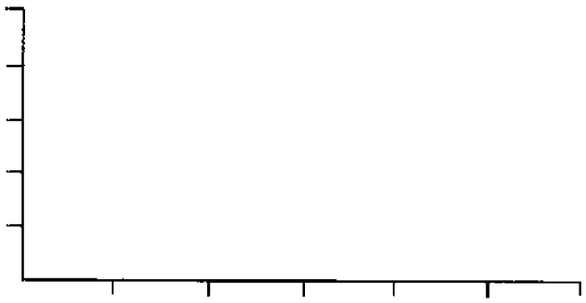
5. How do you think animals in the wild would be affected, if they had to compete for food in this manner? How did it make you feel?

6. Animals need more than food to survive and be healthy. What are some of their other needs?

   What would happen to a population if there was not enough food or space to go around? Consider each possibility.

7. Carrying capacity is the average number of individuals in a population that an ecosystem can support with its available resources.

   - Graph the data from your chart and determine the average carrying capacity of the ecosystem for the 4 to 6 rounds of play.



8. Apply the above situation to people. How might competition for resources in an overpopulated area affect the health of the human population?

   How might this competition affect the environment?

GAME 2: Invasion of an Exotic Species

During this game, one person is an exotic species and can eat all colors of beads. The exotic will begin playing in Round 2 and must keep his/her beads separate from the native

species. The native species will average the number of beads collected during each round as in the previous game. Record the results of each round in the following chart.

	Round					
Average # of beads	1	2	3	4	5	6
Native species						
Exotic species						

Summary Questions

1. How does the feeding success of the exotic species compare to the success of the ecosystem's native species? (For each round, compare the number collected by the exotic species to the average collected by the others.)

2. Do you think that the results of this activity are similar to the consequences of exotic species invading an ecosystem in the wild? Explain.

3. Suppose the exotic species ate ONLY the red beads. Would the effects on the available food supply for the native species be the same? Explain.

4. What are some ways that exotic species compete with native species besides vying for food?

Extension

GAME 3: Dealing With Toxins In The Environment

During this game, each player must try to avoid handling red beads because they are toxic (poisonous). Play as in GAME 1, but at the end of each round, each player must:

- Give up two beads for each red bead handled.

- If five red beads were handled, the person is considered "killed" and the activity continues without him or her.

Add the total number of beads collected, and divide by the number of people participating during the round. Record the averages in the chart below.

	Round					
	1	2	3	4	5	6
Average # of beads						

Summary Questions

1. What did the introduction of a "poisonous" food source do to your attitude during eating?

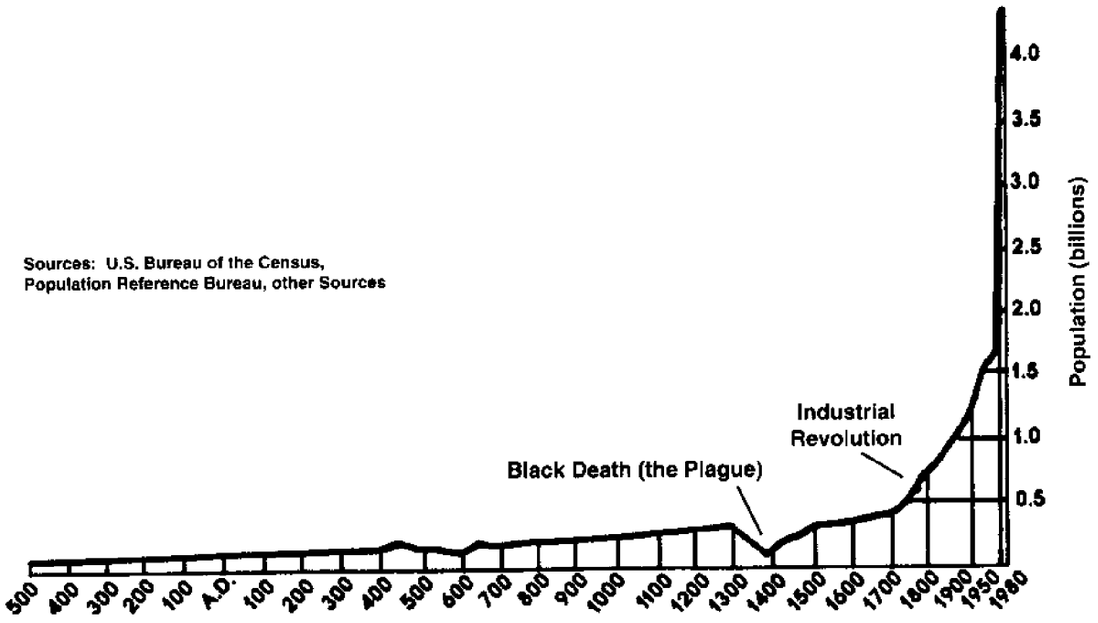
2. Was the amount of food that you were able to collect affected by the presence of the poisonous food? Explain.

3. Were you able to survive as easily as in GAME 1? Explain. (Remember, it takes 10 beads to thrive, and 5 beads to survive.)

4. Was your health affected by the presence of this poisonous food? Explain.

5. How might wildlife in an ecosystem be affected by toxins in their environment?

GROWTH CURVE FOR THE HUMAN POPULATION



[Adapted from For Earth's Sake: Lessons in Population and the Environment, by permission from Zero Population Growth, Inc., © 1989.]

EVALUATION QUESTIONS

MATCHING: Match each definition or example in the left column with the correct term in the right column. Place the letter of the correct term in the space provided.

_____ 1. Members of the same species in an area

_____ 2. Organisms that make their own food

_____ 3. The maximum number of individuals a habitat can support with its resources

_____ 4. Current growth pattern in the human population

_____ 5. Eat dead or decaying organic matter

_____ 6. Spiders, fish, and birds

_____ 7. Conditions in the environment that control the rate of population growth

_____ 8. More individuals are living than the ecosystem can support

_____ 9. All the different species in an ecosystem

_____ 10. Animals entering or leaving an area

A. Community

B. Food chain

C. Consumers

D. Population

E. Detritivores

F. Overpopulation

G. Migration

H. Carrying capacity

I. Dynamic equilibrium

J. Exponential growth

K. Producers

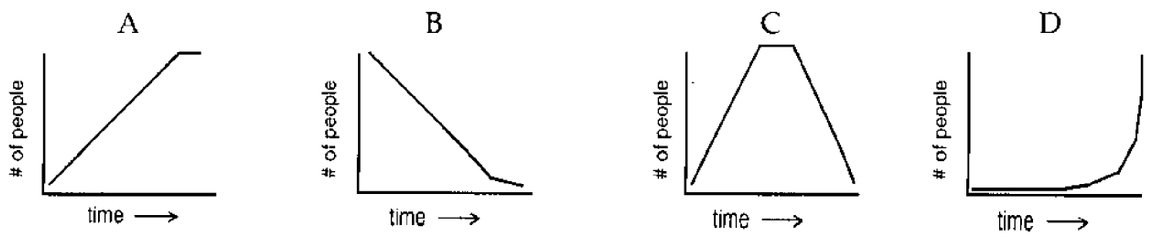
L. Limiting factors

MULTIPLE CHOICE: Select the BEST answer for each statement.

1. Today's worldwide population of humans is approximately _?_.

   A. 5.6 billion
   B. 10.6 billion
   C. 100 million
   D. 12 billion

2. Which of the following graphs represents the growth curve for the human population?



3. A coyote hunting and killing a rabbit for food is an example of a _?_ relationship.

   A. symbiotic
   B. predator/prey
   C. competition
   D. mutualistic

4. Which of the following would NOT be considered a limiting factor for bullfrogs living in a freshwater pond ecosystem?

   A. The amount of available food.
   B. The introduction of an exotic species that eats large fish.
   C. Toxic chemicals that enter the pond in runoff.
   D. Clearing the land surrounding the pond to develop a residential area.

5. Which of the following countries consumes the most resources and energy per person?

   A. China
   B. Peru
   C. The United States
   D. India

6. Which of the following situations does NOT produce competition in an ecosystem.

   A. Both nutria and muskrats build burrows in the banks of Gulf Coast rivers, ponds, and lakes.
   B. Seventy different Gulf Coast species need decaying trees for shelter and nesting sites.
   C. Snakes, hawks, and and foxes all eat field mice.
   D. Birds eat ladybug beetles, ladybug beetles eat aphids, and aphids eat plant juices.

7. The birthrate in the United States is decreasing, but population growth is still increasing. The reason for this is that

   A. the death rate is decreasing — people are living longer lives.
   B. people continue to migrate into the United States.
   C. couples are having more children today than they did forty years ago.
   D. All of the above are correct.
   E. A and B are correct.

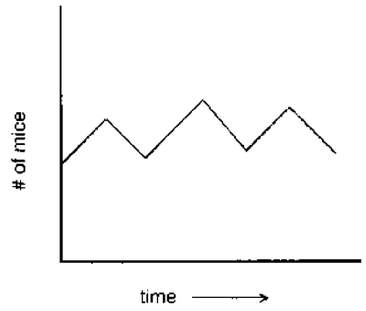
8. An area where living things react with each other and with their nonliving surroundings to recycle substances essential for life and to channel energy from the sun through producers to consumers is called a(n) _?_.

   A. ecosystem
   B. burrow
   C. nest
   D. niche

DISCUSSION: Use your best writing skills — spelling, punctuation, and grammar — in responding to the following statements.

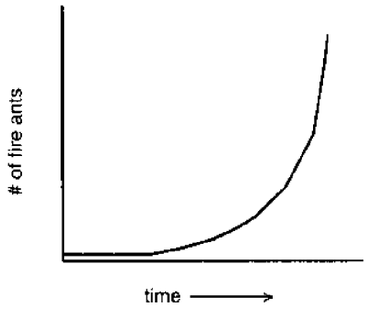
1. The following graphs show the population growth of two different species living in a Gulf Coast meadow. For each population, describe the growth pattern and give reasons for the its changes.

a.



Field Mouse Population

b.



Fire Ant Population

a.

b.

2. Explain the connection between the rapidly increasing human population and declining water quality in the Gulf Coast rivers, streams, and lakes.

3. List three actions that you can take to reduce waste and overconsumption of earth's resources.

a.

b.

c.

EVALUATION — ANSWERS

MATCHING:

1. D	6. C
2. K	7. L
3. H	8. F
4. J	9. A
5. E	10. G

MULTIPLE CHOICE:

1. A	5. C
2. D	6. D
3. B	7. E
4. B	8. A

DISCUSSION:

1. *a. The field mouse population shows a pattern of dynamic equilibrium — it is rising and falling around an average carrying capacity (the maximum number of mice the ecosystem can support with its available resources). This balanced change is likely occurring because predators — hawks, snakes, coyotes, etc. — keep the mice from overpopulating and essential habitat components of water, food, space, and shelter are available as long as the population stays close to or below the carrying capacity.*

   b. The fire ant population is growing exponentially — rapid, uncontrolled growth. The lack of dips or flat places in the curve (pattern) indicate that no limiting factors are hindering population growth. For this type of growth to occur, the ant's essential habitat needs of food, water, shelter, and space must be in ample supply and its predators must be few.

2. *Some explanations include:*

   - *People use water for bathing, drinking, cleaning, cooking, watering yards, and recreation.*
   - *Industry uses water in manufacturing goods.*
   - *Agriculture uses water to irrigate crops.*
   - *Water is a solvent used to spray fertilizer and pesticides.*
   - *Excessive fertilizer, pesticides, and toxic chemicals (such as the residue from petroleum products on streets and parking lots) flow into lakes, streams, and rivers in runoff after rains.*

   As the human population increases, the use of water also increases. All these uses add to the decline in the quantity and quality of water in the Gulf Coast's lakes, streams, and rivers.

3. *Answers will vary. Refer to suggestions listed in the Background Information on page 7. Accept all reasonable responses.*

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The following books, pamphlets, and journal articles were used in producing the "Overpopulation" module. Some of the resources are available to educators upon request or at a low cost; addresses of those resources are given in the reference citation.

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