EXOTIC SPECIES

Project TELLUS: Interactive Science Videos on Global Change Issues
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 activities 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 flotation.

- 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 light 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 pavilion. To sweltering southern exposition attendees, kudzu seemed so effective in shading the pavilion 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 produceing 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.

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-- 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 long-lasting 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.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Requirements</th>
</tr>
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<tbody>
<tr>
<td>Temperature</td>
<td>6 - 28°C (spawn at 12 - 23°C and die above 31°C)</td>
</tr>
<tr>
<td>Salinity</td>
<td>&lt; 5 parts per thousand (ppt)</td>
</tr>
<tr>
<td>pH</td>
<td>7.4 - 9.4 (slightly alkaline)</td>
</tr>
<tr>
<td>Magnesium and Calcium</td>
<td>&gt; 20 parts per million (ppm)</td>
</tr>
</tbody>
</table>

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 mussels 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 mimicking 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 several 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 numbs 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 sugarcane 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 1 — 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 teacher's 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 asexual 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.

**Velig:** 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.
**Argentina 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 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)

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)
- Scalpel 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:
   - Grassland Meadow: 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 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?

### 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?
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

American Toad  Cotton-tail Rabbit

Meadow Flowers  Red Fox

Green Grasshopper  Meadow Vole

Hawk  Barred Owl

Banded King Snake
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 very 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 coralla 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 mixes 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 squirrels, bluebirds, and wood ducks.
- The gopher tortoise digs tunnels in the soil. These tunnels are then used for hiding and protection by other wildlife.
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 needle rush. 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 plants, 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 other, 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.
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 your 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."
MULTIPLE CHOICE:

1. C  7. D
2. A  8. D
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 soybeans 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:


KUDZU:


NUTRIA:


LeBlanc, Dwight J., Nutria, USDA-APHIS-ADC, Port Allen, LA 70767.


ZEBRA MUSSELS:


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Coon, Thomas G., Safe Use of Zebra Mussels in the Classroom and Laboratories, Michigan Sea Grant, MICHU-SG-93-703.

Doll, Barbara, Mid-Atlantic Zebra Mussel Fact Sheet, North Carolina Sea Grant. UNC-SG-FS-93-01.


The Mussels Are Coming, MIT Sea Grant College Program. E38-300.

ARGENTINE FIRE ANTS:


**Africanized Honey Bees:**


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 unashingly. 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 by 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](image)

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 dyes 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 non-point 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 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]

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: Porous, 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.
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
- Colorado River
- Brazos River
- Trinity River
- Sabine River
- Toledo Bend Lake
- Red River
- Atchafalaya River
- Vermilion Bay
- Terrebonne Bay
- Barataria Bay
- Mississippi River
- The Everglades
- Pearl River
- Mexico
- Galveston Bay
- Tombigbee River
- Alabama River
- Coosa River
- Tennessee River
- Mississippi Sound
- Mobile Bay
- Pensacola Bay
- Apalachicola River
- Suwannee River
- Tampa Bay
- Lake Okeechobee
- Rio Grande River
- Yucatan Peninsula
- Gulf of Mexico
- Cuba
- 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.
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 and 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 CEEED, University of New Orleans College of Education, 1993.]

**ANSWER KEY FOR ACTIVITY I**

1. Complete this chart based on the serial dilution activity.

<table>
<thead>
<tr>
<th>Cup #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color of solution (blue, red, or green)</td>
<td>dark</td>
<td>The color becomes progressively lighter until it is invisible.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration of food dye</td>
<td>1:10</td>
<td>1:100</td>
<td>1:1,000</td>
<td>1:10,000</td>
<td>1:100,000</td>
<td>1:1,000,000</td>
<td>1:10,000,000</td>
<td>1:100,000,000</td>
<td>1:1,000,000,000</td>
</tr>
<tr>
<td>Color seen? (yes or no)</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

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 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?
FIRST YOU SEE IT .... NOW YOU DON'T!

(Student Data Sheet)

1. Complete this chart based on the serial dilution activity.

<table>
<thead>
<tr>
<th>Cup #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color of solution (blue, red, or green)</td>
<td>dark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration of food dye</td>
<td>1:10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color seen? (yes or no)</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 solution 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.

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.)

<table>
<thead>
<tr>
<th>Bucket</th>
<th>Amount (cups)</th>
<th>Name</th>
<th>Approximate Turbidity Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2 1/4</td>
<td>Muskrat Bay</td>
<td>4 cm</td>
</tr>
<tr>
<td>B</td>
<td>4 1/2</td>
<td>(students will name)</td>
<td>2 cm</td>
</tr>
<tr>
<td>C</td>
<td>3/4</td>
<td>Lily Pad Pond</td>
<td>9 cm</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>(students will name)</td>
<td>7 cm</td>
</tr>
<tr>
<td>E</td>
<td>1 1/2</td>
<td>(students will name)</td>
<td>5 cm</td>
</tr>
</tbody>
</table>

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.

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?
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
## Log of Water Use

<table>
<thead>
<tr>
<th>DATE</th>
<th>TIME</th>
<th>WATER USE ACTIVITY</th>
<th>GALLONS USED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USE</td>
<td>AVERAGE GALLONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>-----------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothes washing</td>
<td>35-50 gallons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flushing toilet</td>
<td>6 gallons/flush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dish washing (by hand)</td>
<td>10 gallons/meal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric dishwasher</td>
<td>60 gallons/load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooking</td>
<td>10 gallons/meal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinking</td>
<td>6-8 ounces/ glass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathing</td>
<td>36-45 gallons/bath</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Showering</td>
<td>5-6 gallons/minute</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing hands</td>
<td>0.25 gallons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brushing teeth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(with water running)</td>
<td>2-4 gallons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(without water running)</td>
<td>1 gallon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car washing</td>
<td>20-30 gallons/car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yard watering</td>
<td>8 gallons/minute</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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) ___________

3. Name two types of pollutants and describe at least one cause for each.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>CAUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>a.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>b.</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td></td>
</tr>
</tbody>
</table>

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.

1. _______________________
2. _______________________
3. _______________________
4. _______________________
5. _______________________
6. _______________________
EVALUATION ANSWERS

MULTIPLE CHOICE:

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


Lyons, Sue Ellen, and Mary M. Banbury, Ph.D., Urban Stormwater Runoff: How to Stem the Toxic Tide, Project CEED, University of New Orleans. 1993.


The Florida Yardstick, Tampa Bay National Estuary Program. (813) 839-2765.


Water A Splash In Class, National Association of Conservation Districts. 1995. 408 east Main, League City, TX 77573.


