Glencoe Science

Culturally Responsive Teaching

Activities for the Science Classroom

Glencoe

New York, New York Columbus, Ohio Chicago, Illinois Peoria, Illinois Woodland Hills, California

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Send all inquiries to:
Glencoe/McGraw-Hill
8787 Orion Place
Columbus, OH 43240

ISBN-13: 978-0-07-875741-9
ISBN-10: 0-07-875741-X

Printed in the United States of America

1 2 3 4 5 045 09 08 07 06 05

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To the Teacher

The *Culturally Responsive Teaching* lessons are included to help you encourage students to understand and appreciate the cultural diversity within California, the United States, and throughout the world. American classrooms reflect this rich and diverse cultural heritage. Students come from different ethnic backgrounds with a wide variety of cultural experiences into a classroom where all must work and learn together.

Responding to Cultural Relevance

Responding to the needs of our culturally diverse classrooms and incorporating diversity into the science curriculum is challenging for any teacher. Science emphasizes understanding. This emphasis can be used to address the issues of diversity and global awareness. The *Culturally Responsive* component is designed to promote understanding of how people from different cultures approach and solve problems basic to all humans.

The Issue of Cultural Relevance

The *Culturally Responsive* activities address the issue of diversity by providing information about people and groups who traditionally have been misrepresented or omitted. Some of the lessons may include hands-on activities that give students a broader and more personal understanding of the people and achievement discussed in the lesson material. The information in *Culturally Responsive Teaching* also shows the continuous change and interaction of cultural groups, both in history and in the students' worlds today.

Name Date Class

Lewis Mehl Madrona—Pioneering Doctor

Activity 1

As a young person, Lewis Mehl-Madrona was fascinated by the work of his great-grandmother. She was a Native American healer who lived in rural Berea, Kentucky. She used her knowledge of plants and herbs to make medicines and relied on traditional Native American ceremonies to ease people's suffering. One of her most powerful tools, it seemed to her great-grandson, was the time she spent listening to her patients.

Blending Old and New

Mehl-Madrona took what he learned from his great-grandmother and combined it with conventional medicine to shape the path of his medical career. At 15, he graduated from high school and decided to pursue medicine at Indiana University. At 18, he entered medical school at Stanford University. His professors recognized his talent, and some called him "brilliant." However, Mehl-Madrona left residency training because he began to question conventional medical practices. It would be many years later before he completed the last part of his education and became a board-certified physician.

Mehl-Madrona believed that traditional approaches to healing, like those of his great-grandmother, and "modern" approaches, as practiced by conventional doctors, could be combined to administer more effective patient care. Unlike many doctors, Mehl-Madrona combined the resources of Native American healing and other alternative approaches with the Western medicine he learned during his university years.

Alternative Medicine

Alternative medicine is any treatment that's considered outside of "official" medicine being taught in medical schools across the country. Some of the alternative methods Mehl-Madrona uses include massage, acupuncture, yoga, and guided imagery.

Dr. Lewis Mehl-Madrona

Acupuncture is an ancient Chinese method of healing that involves placing tiny needles in key places on the body to relieve pain, treat disease, and improve overall health. Yoga uses a series of poses or postures to make the body strong and flexible. Guided imagery is a technique that assumes that the mind can influence the body. People who practice guided imagery create positive images in their minds in an attempt to control involuntary functions such as breathing and heart rate.

Gaining Acceptance

Using these and other techniques in the early years of his practice made Mehl-Madrona a medical pioneer, of sorts. However, at the time, many of his physician colleagues did not agree with his approach. Today, alternative treatments like those practiced by Mehl-Madrona have become more widely accepted.

Sometimes, Mehl-Madrona's patients are those that other doctors have referred to him

Activity 1 (continued)

after conventional treatments have not worked. And, unlike when Mehl-Madrona was a medical student, medical schools now offer some courses in alternative medicine.

Statistics show that in 1997, four out of ten Americans used alternative therapies. Yet in spite of all the changes in the last few decades, there's still controversy among doctors about alternative medicine. While physicians continue to debate the pros and cons of it, and Congress studies the effectiveness of it, Mehl-Madrona will continue using it.

Active Reading

1. Is there something that helps you feel better, such as holding onto a stuffed toy, having a back rub, or eating a certain food that has no accepted medical value? Why do you think it helps you feel better?
2. All patients bring not only their illness but also their culture with them to doctor's offices and hospitals. Some cultures, like Dr. Mehl-Madrona's believe that the entire family must be involved in helping the patient recover. Others don't. Some people believe only disposable items and items wrapped in plastic are really clean. Other cultures have dietary restrictions. How much should medical personnel and hospitals do to accommodate the cultural concerns of patients? Explain your reasons.
3. Why do you think that Dr. Mehl-Madrona's integrated medicine has been so controversial?

Alternate Assessment

Make a table with three columns. Using research, list four ailments and then conventional and alternative methods that might be used to treat each.

Japanese Cultured Pearls—Endangered Future

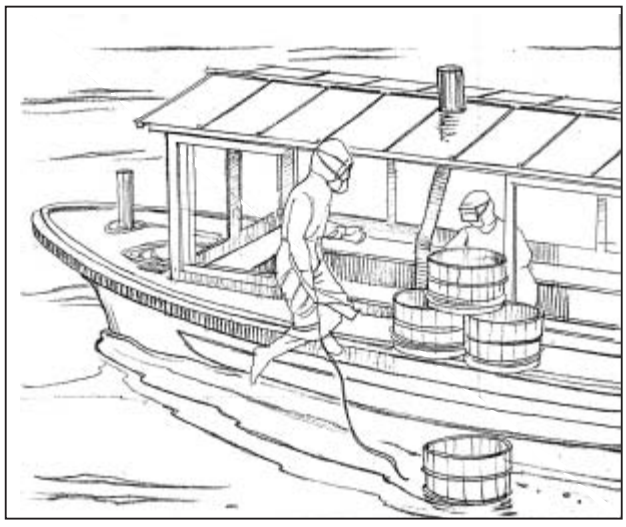
Activity 2

Natural pearls have been popular in many cultures throughout history. Pearls are mentioned in the literature and sacred writings of early India and were considered a sign of status in ancient China. Early Romans valued pearls more than any other gemstone. Wealthy Romans wove pearls into their gowns and used them to adorn their furniture. Native Americans gathered freshwater pearls in waters along the Atlantic Coast and around the Mississippi River. They used them for jewelry and wove them into clothing.

The round shape of pearls, their soft, lustrous colors, and their rarity have made them highly desirable in many cultures. Once considered financial assets, natural pearls were equal in value to real estate. Today, pearls are still popular. However, most pearls are cultured pearls, rather than natural.

The Pearl Crop

Like other crops, cultured pearls are cultivated and harvested. To make a cultured pearl, tiny mother-of-pearl beads are implanted in the ovary tissue of mother oysters. Mother-of-pearl is the lustrous coating inside oyster shells.



Mother oysters are placed deep on the ocean floor by pearl divers (traditionally, women dressed in white), who also bring the oysters back to the surface for cultivation.

The oysters then are placed in wire nets and hung from rafts in shallow, coastal seabeds. Their shells are cleaned twice a month. Removing seaweed and other attachments results in a larger, higher-quality pearl. It takes a year or more for each pearl to form. Pearl oysters thrive in calm, warm waters and mild temperatures help produce more pearls.

All cultivated pearls have a covering, called *nacre,* that's thinner than their natural counterparts. Nonetheless, there is still a demand for fine-quality, cultured pearls.

World Leader

For more than 100 years, Japan has led the world in the production of cultured pearls. Japan harvests two-thirds of the world's supply.

In the 1890s, Kokichi Mikimoto, the son of a Japanese noodle maker, perfected the commercial process of producing cultivated pearls. He developed the method of creating whole, cultured pearls using tiny mother-of-pearl beads.

Previous methods included inserting small pieces of mud, bone, or metal into freshwater mussel shells. Mikimoto's method not only took less time to cultivate a pearl, it resulted in a more lustrous pearl that closely resembled a natural pearl.

Pearls in Peril

In the 1990s, Japan's $400-million-a-year cultured pearl industry was considered to be at risk. In 1992, a red tide of poisonous plankton moved into Ago Bay off the small island of Masaki. Masaki, located in central Japan, once was called Treasure Island because of the great wealth the pearl industry brought to the area.

Red tides are caused by an overabundance of microscopic, plantlike cells called phytoplankton. Warm surface water temperatures, high-nutrient and low-saline content, help the plankton to thrive.

Activity 2 (continued)

They produce toxins in large amounts that can kill fish and cause respiratory problems in humans. Since 1992, the red tide has returned to Masaki almost every year, killing the oysters and putting pearl farmers out of business.

In 1996, a puzzling disease affected oysters in an area called the Ehime prefecture in northwestern Japan. Pearl farmers here typically raise 70 percent of Japan's mother oysters. The disease not only killed off many of the mother oysters, it also weakened the shells of other oysters, making them too fragile to clean. As a result, the cultivated pearls were smaller and of much lower quality. Only 20 percent of the pearls cultivated in this area are good enough to be used in jewelry. With healthy oysters, 80 percent of the pearls produced are usable.

Causes for Concern

Scientists and pearl farmers are investigating both the red tides and the mysterious disease. Some research suggests that a pesticide, known as formalin, might be contributing to the problem. Scientists also are investigating the El Niño weather system, the overcrowding and overfarming of oysters, and parasites as possible causes.

It may be that advances in cultivation techniques have created a pearl that's prone to disease. Unless a definite cause is identified and a solution is found, Japanese cultured pearls soon could become as rare as natural pearls.

Active Reading

1. Natural pearls are more expensive than cultured pearls, although they may be more irregular in shape. What makes a natural pearl more valuable than a cultured one?
2. What do you think will happen to the price of Japanese cultured pearls if the red tides and disease are not stopped? Why?
3. How might the weather affect production of cultured pearls?

Alternative Assessment

Investigate the process of producing cultured pearls. Show the process in a colorful flow chart, using photographs or drawings to illustrate each step.

Buffalo Jerky and Freeze-Dried Fish

Activity 3

What is one everyday kitchen appliance you and your family would rather not do without? No doubt, it's the refrigerator/freezer because without it, all your food would spoil. But refrigerator/freezers have not always existed. How do you suppose people preserved food before refrigeration? They did it by developing effective techniques such as salting, curing, and drying their food to preserve it for long periods of time.

Two Enemies of Food

Food spoilage takes two main forms. When an orange becomes moldy or chicken starts to smell, it's because microorganisms, such as bacteria, have spread through the food. To safely preserve and store food, harmful microorganisms must not be allowed to grow.

Food also can spoil through a process called oxidation. This occurs when extra oxygen molecules join with food molecules. Although oxidation of food won't make you sick, it will change the texture, flavor, aroma, and appearance. Oxidation is what makes a cut apple turn brown. An acidic liquid, such as lemon juice or vinegar, can help prevent oxidation.

Sun-Dried and Safe

The problem of food preservation was solved in many different ways by many different cultures. Drying is, perhaps, the oldest method of preserving food. With drying, most of the food's moisture is taken out so microorganisms cannot grow and spoil it.

Jerky has become a popular snack food. Some Native American cultures made jerky by drying buffalo meat. They sliced long strips of it and hung it over poles to dry in the sunlight and wind. Because harmful bacteria need water to survive, a dried food is much less likely to spoil. It also is much lighter in weight, "cleaner" to keep, and easier to carry, a great advantage to people who move around to survive. It often was taken on journeys because of its convenience.

Native Americans also developed pemmican, a mixture of dried venison pounded into a powder and combined with melted bone marrow fat (usually from a bear), dried berries, and dried vegetables. Pemmican could be stored for long periods of time. Jerky, dried fish, dried beans, nuts, grains, and pemmican provided useful foods for some Native Americans during cold winters when other foods were unavailable.

Salted and Pickled Preserves

Early Egyptians and Chinese dried fruit in the sunlight. The fruits shriveled as they dried, but recovered much of their original weight when soaked in water. The Egyptians and Chinese also dried fish and meat. They added plenty of salt, which drew water from the foods—and also from the cells of potentially harmful microorganisms. Without water in their cells, microorganisms either die or become inactive. Therefore, spoilage is delayed.

The Chinese and Babylonians used pickling, another ancient preservation method. With this technique, food is stored in salt solutions, sugar solutions, or vinegar solutions, which create a bacteria-hostile environment. Cucumbers, when pickled, become pickles. And cabbage, when pickled, is similar to sauerkraut.

Sauerkraut is, in fact, an ancient Chinese food. It is the product not only of pickling, but also of fermentation. Fermentation occurs when certain "good" yeasts and bacteria become active in a substance such as grape juice, milk, or cabbage. Over time, the bacteria and yeasts create ethyl alcohol in the grape juice, and lactic acid in the milk and in the cabbage. The alcohol and the acid preserve the resulting wine, buttermilk, and sauerkraut.

Fermentation creates many types of wine, beer, rum, cheese, and yogurt. In the Pacific Islands, poi, made from taro root, is a traditional food that is preserved through fermentation.

Activity 3 (continued)

Saved by Fire and Ice

Fire and ice are two more time-honored preservatives. The Chinese smoked pork, poultry, tea leaves, and other edible plants over wood or charcoal fires. The heat from the fires dried the food. Then, the smoke either killed or inhibited the growth of bacteria. Wood smoke contains traces of formaldehyde, tars, alcohols, and creosote. All of these agents are preservatives, and they also lend a special flavor to ham, bacon, salmon, and other smoked foods.

High in the snowy Andes mountains, the Inca freeze-dried meat, fish, potatoes, and yams. This method preserved foods indefinitely and, as with jerky, it made foods smaller and lighter for easy transport and storage. High temperatures during the day alternate with freezing nighttime temperatures. The extremes made it possible to freeze-dry foods without machines. To this day, descendants of the Inca spread out potatoes on the high ground. The potatoes freeze at night and thaw during the day, when excess moisture is pressed out by walking on the potatoes. This process makes *chuño,* a dried-potato product that can be stored for long periods of time.

Descendants of the Inca still make Chuño.

Sealed in Oil

Many ancient peoples, such as the Romans and the Maya, used olive oil to seal jars of fruit preserves or jugs of wine. The oil created a film on the surface of the fruit or liquid, thereby discouraging harmful organisms from entering the fruit or wine. Today, the oil seal has been replaced by paraffin and corks.

Active Reading

1. How does drying food help preserve it?
2. What is meant by the term *pickling?*
3. Compare and contrast three different techniques of food preservation.
4. How did the way people lived affect their food preservation techniques?

Alternate Assessment

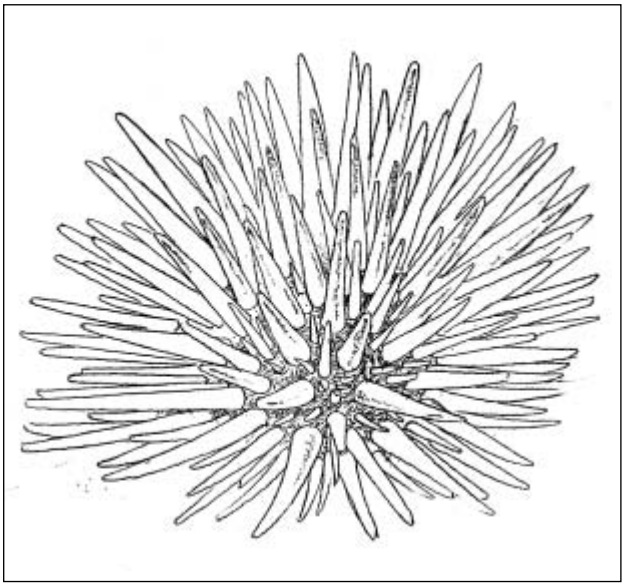
Today, many foods and beverages are preserved by adding chemicals. Choose various packaged foods from your kitchen shelf and research the chemicals listed on the labels by typing each chemical's name into a Web search engine. After identifying a chemical used as a preservative, investigate how it reacts with the food to prevent or delay spoilage. Draw a cause-and-effect concept map to illustrate your findings.

Coral Reefs at Risk

Activity 4

Kenyan Reefs

A coral reef is a complex ecosytem and usually is the home of many diverse species. Reefs serve as an important source of both food and medicine. They also protect the coastline from erosion. But along the coast of Kenya in the Indian Ocean, the beautiful coral reefs that once thrived and teemed with life are struggling to survive. The reefs in Kenya have caused the formation of a quiet lagoon near shore. This lagoon and its nearby beach are very important in bringing tourists to the area. In addition, fishing in the lagoon provides food and a livelihood for the residents.



The *Echinometra mathaei* sea urchins also are known as rock-boring urchins.

A Growing Menace

Starting in the 1970s, people began noticing that the sea urchin population in the Kenyan reef was on the rise. By the 1990s, scientists had estimated that it had grown five times in size. The sea urchin species that appears to be taking over is *Echinometra mathaei.* These are the smallest of the three species of sea urchins found here. They are short-spined sea urchins that normally burrow around the coral reef. They usually scrape the stony coral with their spines, feeding on algae and whatever else they scrape away.

Usually, when sea urchins scrape the coral, they help diversify life on the reef. The little nooks and crannies that they scrape onto the coral surface provide the habitat for some other tiny reef organisms. But with so many sea urchins scouring the corals, the reef is breaking down faster than the corals can rebuild it. The sea urchins are out of control.

Nyawira Muthiga is a Kikuyu woman from Kenya who is a marine biologist. She's interested in finding out why the corals are dying, and why the sea urchins are multiplying so rapidly. Muthiga is estimating the sea urchin population and examining specimens to find clues as to why their population has exploded.

Hypothesis: A Missing Predator

Muthiga has proposed a hypothesis, based on observation of the reefs, to explain the overpopulation of sea urchins. First, the lagoon is near a popular beach. The activity at the beach causes a certain amount of water pollution. Second, the area is one of the most heavily fished parts of the coast. In fact, in nearby Tanzania, some fishermen set dynamite to blast the reef and scare the fish into their nets. This practice has led to the sharp decline of some species of fish. Muthiga hypothesizes that the pollution of the water coupled with overfishing of some fish species has caused a natural predator of the sea urchin to die out. This could account for the explosion in the sea urchin population.

Sea urchin populations can increase at an amazing rate. A single sea urchin can release 20 million eggs at a time. Without any predator to eat them, many of the sea urchin eggs would develop into mature sea urchins, which would later reproduce, adding even more sea urchins to the population.

Activity 4 (continued)

Other Threats

Although sea urchins are a major concern for the coral reefs, they're not the only problem. Global warming, pollution, poorly regulated fishing, coral bleaching, and more, all threaten the coral reef with damage and destruction.

The overpopulation of another species has damaged coral in some places in the Pacific. The crown-of-thorns starfish, *Acanthaster planci,* feed directly on the living coral. In places, their natural predators, triggerfish and emperor fish, are being overfished. In other places, sediment from construction and fertilizers in farm runoff have caused surges in the starfish population. Sediments and chemicals such as nitrates and phosphates can cause algae to grow faster than normal. Accumulated dead algae eventually lower the oxygen levels in the water, damaging or even killing the coral.

Global warming causes increases in water temperature that can harm the coral. Coral do best in seas with a temperature no higher than 28°C. As Earth's climate has warmed, sea temperatures have risen to 31°C in some places. Because of this, the coral reefs—some of them hundreds and hundreds of years old—are dying.

In 1998, global warming and the calm conditions caused by El Niño and La Niña triggered an outbreak of coral bleaching in Kenya and around the world. Coral get their color and food from tiny algae called zooxanthellae. Coral bleaching occurs when the zooxanthellae decrease and the coral loses its color. When high water temperatures kill too many of these algae, they also kill the coral. About 27 percent of the world's reefs had died by the end of 2000, most due to coral bleaching.

What happens next?

Research and preservation efforts continue around the world. However, human activities and environmental changes endanger the complex relationships of species in and around the reefs. Scientists need to better understand these factors to help protect the oceans from pollution and human activities.

Active Reading

1. Why is a sea urchin invasion a problem to the coral reef and lagoon?
2. Why do scientists want to protect the coral reef?
3. What do you think would happen to the sea urchin population if the coral reef were destroyed?
4. How can overpopulation of crown-of-thorns starfish and algae harm the coral?

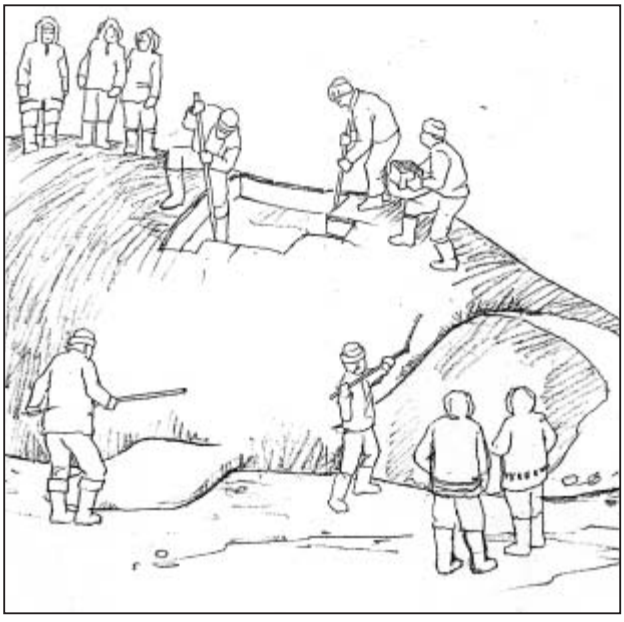
Alternate Assessment

Research a possible food chain in the coral reef. Include the sea urchin and describe what part of the food chain scientists such as Muthiga are looking for.

Whales—To Hunt or To Protect?

Activity 5

The Inupiat of northern Alaska have a long tradition of whaling, going back hundreds, perhaps thousands, of years. They use all parts of the whale: meat, oil, bone, and blubber. All of the activities surrounding the whale hunt are part of Inupiat culture and are established by tradition. Who joins the hunt, how the whale is butchered, how the parts of the whale are distributed—all of these are governed by cultural rules. Today, however, the Inupiat are coming into conflict with those who are concerned about preserving endangered species such as bowhead whales.



Members of an Inupiat community work together during a whale hunt.

A Return to the Past

Whale meat has long been one of the main foods of the Inupiat. Whale oil has been burned by the Inupiat to protect them from the bitter cold and to brighten the dark nights that last for months in the arctic. In times past, the Inupiat also used whalebone as the framework for their sod homes.

Today, many Inupiat live in frame homes and work for mining companies, fisheries, the timber industry, and other Alaskan employers. But money from these jobs often is used to finance subsistence hunting activities. Whaling is one of these.

In addition to providing food for Inupiat families, whaling is an important part of who they are historically and culturally. It also supports the Inupiat's identity of being a courageous people, since whaling (even in the modern day) can be extraordinarily daring.

Following tradition, captains of whaling expeditions also are community leaders. In fact, community business often must be set aside during whaling season because so many villagers are on the sea, hunting whales.

The whale captains' wives also are important. They help in the success of the hunt by paying respect to the whales' spirits. After a whale is caught, a captain's wife pours freshwater into its mouth to help it on its journey to the spirit world.

Traditional Hunting

The hunting of whales begins in the spring. Traditionally, the Inupiat headed out for the hunt on the half-frozen sea armed only with harpoons and lances. To kill the animal with these weapons, the crews in the boats had to approach dangerously close to the enormous whales. Once a whale was dead, the hunters dragged it across the ice to fellow villagers who cut up the animal and distributed its meat.

The whale hunt is an important event and traditionally was marked by religious rituals and feasts. The selection of the crew also was based on cultural rules. Some of these customs have been affected over time, and not all villagers follow them as carefully today.

It is more difficult to be a whaling captain as well. Technological advances such as dart guns and shoulder guns are expensive. These weapons cost $300–$400 per crew. Modern Inupiat whale-hunting captains must have enough income to purchase the weapons needed by the entire crew.

Activity 5 (continued)

Whales Become Endangered

Although many whales once thrived in the world's oceans, a number of whale species have been hunted to extinction or near extinction. In North America, the real threat to whales began with large-scale hunting during the 1600s.

During that period, whale oil and whalebone became two of the chief products exported by the American colonies to Spain and Portugal. By 1852, 220 whaling ships had headed north to Alaskan and arctic regions. Eventually, the profits to be made from whale products led fishing companies to outfit factory ships that could catch and process an entire whale in one day. These fleets of ships were aided by modern technology that included helicopters and radar for spotting whales.

By 1946, scientists realized that large-scale overhunting was threatening the world's whale population. In Antarctic waters, the population of blue whales, the largest animal ever to have lived on Earth, dropped from about 200,000 in the early days of whaling to only 2,000 in 1965. The number of bowhead whales in Alaskan waters fell from about 20,000 in the 1850s to between 6,900 and 9,200 in the 1990s.

In 1967, the International Whaling Commission (IWC) put many whale species on its protected list and asked nations not to hunt them. In 1970, the United States banned whale products. It also has outlawed all whaling within 322 km of its coasts.

Respect for Cultures

U.S. officials and the IWC recognize the significance of whale hunting for the Inupiat and permit limited hunting. For example, native whalers operating out of Barrow, Alaska, were permitted to take 68 bowhead whales during the 1995 spring migration and 65 whales during the 1998 season. Scientists set this limit based on the number of whales that they judge can be harvested without threatening the survival of the species.

Native groups from other countries, such as Russia, Canada, and Greenland, also would like to reinstate whale hunting. In spite of IWC controls, unsanctioned hunts are beginning to take place. Inuit groups around the world are placing an increased demand on the IWC to allow traditional whale hunting. Some whale populations, however, are still at a critically low number. In Canada, where the Inuit are allowed to hunt outside of IWC regulations, the bowhead whale population remains at 450 (from 11,000 at their peak).

Some scientists argue that it's too soon for even small-scale hunting. Still, many arctic cultures remain passionately committed to continuing the hunts that define their culture. They also work actively to preserve the whales' habitat for future generations, monitoring pollution levels and managing the populations of various arctic animals.

Active Reading

1. What are some items that the Inupiat take from whales for survival? What purpose does each item serve?
2. What caused many species of whales to become extinct? When did the problem begin?
3. Are modern Inupiat hunts today the same as traditional hunts?
4. Should the Inupiat and other arctic natives be allowed to hunt? Explain.

Alternate Assessment

Create a poster of whale species and their populations in different parts of the world. Include a list of causes other than hunting that threaten their survival.

El Puente—Bridge to Environmental Justice

Activity 6

Have you ever wondered what you could do to improve the environment? If you need help thinking of ideas, take a look at what teens are doing in the neighborhood of Williamsburg, in Brooklyn, N.Y. In this community, inner city students at *El Puente* Academy for Peace and Justice are actively involved in turning around one of the city's most polluted communities. The hundred or so students at this small theme-oriented public school consider working for the environment part of working for social justice. The school is a partnership between the City Board of Education and *El Puente,* a youth development group in the neighborhood.

Step in the Right Direction

El Puente, or "The Bridge," was founded as a place where young people could go after school to get actively involved in their community. Its founder, Luis Garden-Acosta, had been the associate director at the emergency room of the local hospital. From there, he saw a neighborhood with its health and environment in decline. So he organized parents, educators, and professionals to start a community center based on principles of helping oneself and the community. He envisioned *El Puente* as a place of growth and empowerment and a bridge between young people and adults who could act as role models.

Not long after the founding of *El Puente,* one group of teenagers became aware of some of the environmental contaminants that threatened the health of their community. This group of teens, known as the *Toxic Avengers,* could recite easily the names of all the possible harmful chemicals that might be coming from a nearby factory. This was the start of community action and environmental awareness that got many local residents involved.

A Toxic Neighborhood

According to the Community Environmental Health Center of Hunter College, the Williamsburg and Greenpoint sections of Brooklyn had almost 60 times more pollution than the national average for a residential neighborhood. How could this have happened? First, this neighborhood is bordered by the East River; the bridge that crosses it; and a major highway, the Brooklyn-Queens Expressway. This road cuts a wide path through the neighborhood, causing the exhaust fumes of cars and trucks to hang in the air. The riverfront, once home to the bustling Brooklyn Navy Yard, holds numerous functioning factories sandwiched between deteriorated vacant lots. The area has several dozen garbage transfer stations, so commercial waste is always being trucked in and out. In Greenpoint, the site of a massive underground oil spill, there is also a city sewage treatment plant and a small garbage incinerator. To make matters worse, the population of the neighborhood has swelled at least 10 percent since 1980. This has made for very crowded living conditions in already overburdened apartment buildings.

Citizens Take Control

To deal with these environmental crises, *El Puente* and other local citizen groups called for action. They led a march against a nearby storage facility that was emitting low-level radioactive waste. Soon the citizen groups had formed the Community Alliance For the Environment, or CAFE. The leadership organized the first environmental town meeting in 1992. The first act of the Alliance was to hold a march across the Williamsburg Bridge, which 1,500 people joined. Their goal was to protest the city's plan to build yet another huge garbage incinerator in the neighborhood.

Activity 6 (continued)

In 1995, groups in Williamsburg painted this mural to protest the building of a waste transfer station.

El Puente: A Thriving Community

Today, *El Puente* has grown into a center with a permanent staff carrying on many impressive projects. The center has programs for the arts, a health clinic, and youth environmentalist groups. "The miracle of *El Puente,*" says Garden-Acosta, "is the bridge we've built for people to come back home and, in a sense, raise the village that raised them." At the new board-certified high school, *El Puente* Academy, the curriculum echoes the after-school programs in health, the environment, and the arts. Students work on individual projects that combine these areas, producing murals and videotapes that document the positive changes in their environment. And after the first four years of *El Puente* Academy's existence, the percentage of students graduating was higher than the average in New York City.

A few blocks from the school, sunlight brightens small patches of green growing in what used to be an empty city lot. Bricks from demolished buildings now surround tidy flower beds. Trees planted by young people line streets that have been treeless for decades. A sign proclaims the work of *El Puente*. In the evening, an audience claps with approval as young people in costumes tell a story in dance about celebrating Earth—and that special piece of it that is their neighborhood. They tell of successes in converting their neighborhood into a greener, safer environment, one city lot at a time.

Active Reading

1. What are some of the specific factors that damaged the environment surrounding *El Puente*?
2. What are some of the steps community members are taking to improve their environment?
3. Are students at your school involved in projects to improve the community? Are there projects that could be started? What changes would you like to see in your area?

Alternate Assessment

Decide on a science-related project that could bring positive change to your neighborhood. Create a proposal stating the goal of the project and the steps necessary to achieve that goal. Share your proposal with the class. **Hint:** *Use a visual aid, such as a poster or overhead transparency, when presenting your proposal.*

Unraveling a Prehistoric Food Web

Activity 7

Have you ever seen a fossil of a dinosaur bone? Scientists learn a lot by studying the bones of a dinosaur, but how can they tell what a dinosaur ate? In addition to fossilized bones, they look at trace fossils, or fossils of things that dinosaurs left behind. Trace fossils include tracks, eggs, nests, and even dung.

The Search Begins

Karen Chin, a paleobiologist with the U.S. Geological Survey, is the world's first expert on fossilzed dinosaur dung. She began by studying animal feces when she worked as a naturalist for the National Park Service. Wild animals are very shy and prone to flight, which makes them hard to study. However, their dung is stationary and relatively easy to find. And, it contains a wealth of information. For example, by studying their dung, Chin could see how many bears were in an area, what direction they were traveling, and what they were eating.

When Chin started working for paleontologist Jack Horner, she brought along her interest in studying animal droppings. Horner had found what might be fossilized feces, known as coprolites, in Montana where he was digging up a duck-billed dinosaur, called a *Maiasaura.* Chin wanted to find out whether the fossils were actually dinosaur dung. If they were, she wanted to know what they might reveal about the dinosaurs.

A Closer Look

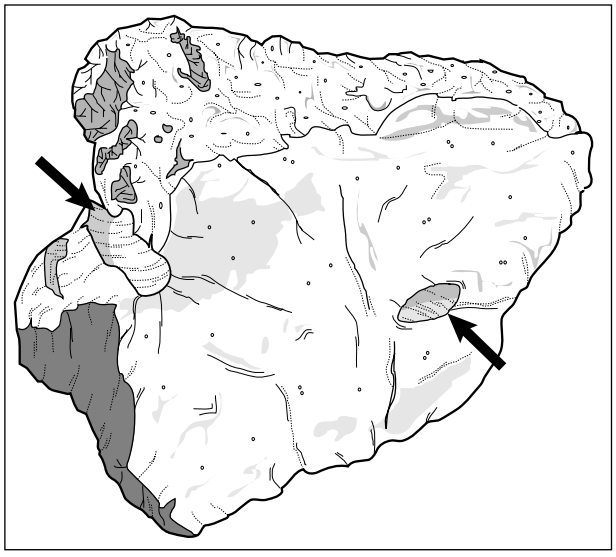
You might wonder how scientists can tell the difference between prehistoric droppings and rocks. Clearly, the task is tricky and inexact. In the past century, fossilized feces have been found in many distinctive shapes. Different species produced droppings in differing shapes and colors. The specimens that Horner had found were almost shapeless, blockier and larger than many other known coprolites—some measuring more than 33 cm by 33 cm by 22 cm. The blocks might have been produced by the 135- to 65-million-year-old dinosaurs whose bones were found nearby, but Chin needed to make certain.

To learn more, Chin cut extremely thin slices of the blocks and examined them under a microscope. She discovered that the blocks were composed primarily of tissue from the stems of evergreen plants. This tissue, all chopped up, resembled the chewed-up plants excreted by horses and elephants.

A Revealing Discovery

Taking a closer look, Chin saw small tunnels in many of the blocks and in the surrounding fossilized soil. Based on these observations, Chin hypothesized that the tunnels were made by dung-eating beetles. Consulting with other scientists, she learned that the tunnels indeed may have been made by dung beetles. These industrious insects are the only living organisms known to store plant matter in such tunnels.

Because dung beetles eat only dung, this supported the idea that the large Montana blocks were coprolites. They probably came from a *Maiasaura,* because they were too large to be produced by any other plant-eating animals of the period.



A block of *Maiasaura* dung with tunnels made by dung beetles.

Activity 7 (continued)

Interdependent Relationships

By solving the mystery of the Montana dinosaur dung, Chin helped shed light on dinosaur activity in North America. We now know that at least one species of dinosaur ate evergreen stems. We also know that at least one species contributed to the ecosystem: without huge droppings to dine on, the dung beetles might have starved. As it was, they had plenty to do. They strengthened the health of their environment by storing dinosaur dung in the soil. This fertilized the soil and encouraged plant growth. In turn, the dinosaurs ate the plants, and the cycle repeated itself.

Tyrannosaurus rex's Diet

Since then, Chin has helped other scientists analyze more samples of dinosaur dung, including that of a *Tyrannosaurus rex* fossil found in Saskatchewan, Canada. Its coprolite measures 44 cm by 16 cm by 13 cm, making it the largest coprolite of a carnivore, dinosaur or otherwise, ever found. The bones that Chin found within the coprolite came from a young dinosaur about the size of a cow. Chin's study of this dropping showed that *Tyrannosaurus rex* didn't swallow its food whole, as reptiles do. Rather, it crushed the animals with its mighty teeth.

Active Reading

1. Why did Chin begin studying animal dung?
2. How did Chin positively identify the fossilized blocks as coprolites, or feces?
3. What are some things scientists can learn about prehistoric animals by studying their dung?
4. What did Chin learn about *Tyrannosaurus rex*'s eating habits?

Alternate Assessment

Do research to find out what scientists think that some dinosaurs ate. Then, design a transparency of a likely food web involving some of the dinosaurs you studied. Show it to the class, explaining how the parts of the web are interrelated.

Acupuncture—Modern Uses for Traditional Medicine

Activity 8

A patient lies in a bed in a doctor's office with a dozen steel needles sticking out of her arms, legs, and ears. At first, this sight might look painful. Nevertheless, the patient is having the treatment performed in order to relieve the pain in her body. The procedure is known as acupuncture, and it is an ancient Chinese healing art that is increasing in popularity throughout Western countries. This technique is widely used to treat a number of ills, including backache, headache, arthritis, and substance abuse.

Where It Began

No one knows exactly how or when the practice of acupuncture developed. Historians do know that the strategic placement of needles in various parts of the body to treat health problems began at least 2,500 years ago in China. The ancient Chinese text called *Yellow Emperor's Classic of Internal Medicine* (or *Canon of Medicine*) is the first written source known to discuss the practice of acupuncture. The text only dates to 200 B.C., but attributes the principles of acupuncture to the Yellow Emperor, Huang Di, who lived around 2500 B.C. The text explores the philosophy behind traditional Chinese medical practices. The basis of this philosophy is the balance of opposing natural forces known as *yin* and *yang*.

Some historians estimate that the practice started closer to 4,000 years ago. Others cite evidence that such treatments began 10,000 years ago when people may have used stone needles, called *bian shi*, to press into one part of the body to stop pain in another part.

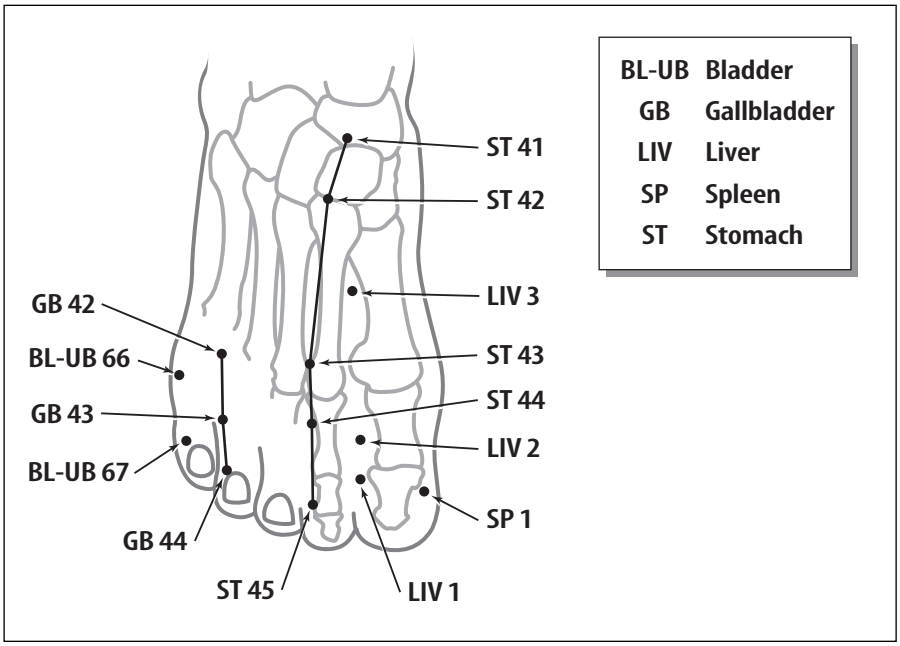
The tools for administering acupuncture have changed over time. The needles of stone gave way to needles of bronze, gold, and silver made in nine different shapes, each serving a specific purpose. Today, acupuncture practitioners use stainless steel needles and various surgical instruments.

The Flow of *Qi*

Qi energy is believed to flow to all parts of the body through 14 major pathways that run along the skin and into the body. When the *qi* is imbalanced or blocked, acupuncture treatment restores the proper flow of energy. Needles are inserted at one or more of the nearly 2,000 acupuncture points on the body.

Often, the desired acupuncture point may not be near the affected body part. A kidney problem, for example, might call for a few needles in the arms and ears. And sometimes, the needles aren't even inserted under the skin—they barely touch the surface.

Acupuncture may relieve pain by prompting the nervous system to release chemicals called endorphins and other natural pain relievers. Acupuncture also may prompt the pituitary gland in the brain to produce pain blockers and



Many acupuncture points on the foot are believed to affect internal organs.

Activity 8 (continued)

to trigger a process that releases anti-inflammatory agents into the bloodstream.

To put it another way, acupuncture seems to stimulate the body's own painkillers. And it succeeds so well that in China, Sri Lanka, and other Asian countries, minor surgery often is performed without anesthesia. Acupuncture has none of the adverse effects (such as nausea and, occasionally, death) brought on by conventional general anesthetics. Recently, it has been used this way in the United States, as well.

Integrating Two Approaches

In light of acupuncture's benefits, some U.S. physicians have overcome their suspicion of this alternative treatment and have embraced the ancient technique. Still, many U.S. physicians remain wary of acupuncture because how it works is unproven by Western medicine's standards. Today, at least 3,000 U.S. doctors use acupuncture to treat patients. In addition, 7,000 other practitioners use acupuncture for a broad range of health problems, sometimes together with herbs, massage, and other Eastern treatments.

Acupuncture may prove especially valuable in two areas where Western treatments have been challenged: chronic pain and substance abuse. In numerous cases of chronic pain, such as backache and arthritis, patients who undergo regular acupuncture treatments are able to reduce their use of medication and resume normal activities. As for substance addiction, acupuncture practitioners have enjoyed notable success in treating patients addicted to drugs such as cocaine and alcohol.

According to Dr. Michael O. Smith of Lincoln Hospital in the South Bronx neighborhood of New York, withdrawal symptoms and drug cravings disappear within minutes of the acupuncture treatment. Acupuncture also soothes patients who might otherwise panic or show hostility. If an addict is calm—that is, if his or her *qi* is in harmony—he or she is more likely to benefit from counseling.

Active Reading

1. What is the idea behind how acupuncture works?
2. How does the insertion of acupuncture needles cause the body to react?
3. How does the basis of acupuncture differ from the basis of Western medicine?
4. How does the Chinese theory of acupuncture differ from Western ideas on how it works?

Alternate Assessment

Find out more about one aspect of acupuncture. Focus on how it is used today to relieve pain or to treat a medical condition, or find out more about the major pathways and points of the system. Create a visual display to present your findings to the class.

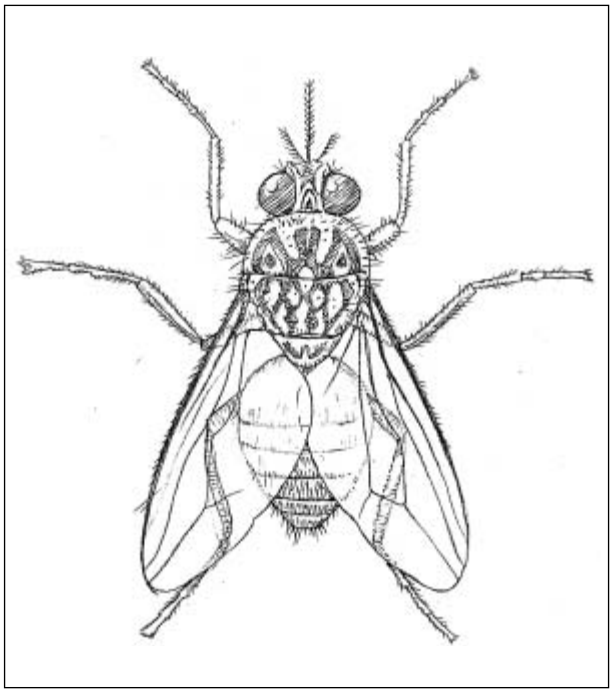
The Reawakening of Sleeping Sickness

Activity 9

In 1997, in a town called Ezo in southern Sudan, 40 percent of the residents were suffering from a terrible disease called sleeping sickness, or trypansomiasis (trih pan uh suh MI uh sus). This disease, which had been nearly wiped out more than ten years before, again had become a crisis. In the entire region south of the Sahara, 55 million people were at risk for contracting the disease.

Symptoms and Causes

Trypanosomiasis is fatal if left untreated and is difficult to control. People become infected with the disease when they are bitten by a tiny tsetse fly. Two versions of sleeping sickness occur—one in West Africa and one in East Africa. Both pass through two stages. In the first, less serious, stage, the tsetse bite can turn into a red, painful sore called a chancre (SHANG kur). After a couple of weeks, the victim can develop a fever, rash, and swollen lymph nodes, be irritable and extremely tired, and suffer from muscle and joint pain.



The tsetse fly, host to one-celled trypanosomes which cause sleeping sickness, is found only in Africa.

In the second stage of the disease, the victim will become more and more confused and irritable, have trouble walking and speaking, and may suffer seizures. A person at this stage may sleep all day and stay awake all night—hence the name sleeping sickness.

The tsetse fly itself doesn't cause the disease. The fly is host to trypanosomes, parasites that feed on a host's blood. Two varieties of this species cause West African and East African sleeping sickness in people. Another variety of the same species causes a potentially deadly disease called *nagana* in cattle, sheep, goats, and horses. Nagan is a kind of anemia in which the blood lacks sufficient red blood cells. Wild animals in Africa may have the parasite but do not become sick.

When the tsetse fly bites, piercing mouth parts inject some of the protists into the victim. The trypanosomes multiply in the blood. By destroying red blood cells, the tryponosomes cause symptoms such as tiredness, fever, and joint pain. Once they attack the fluids of the nervous system in the second stage, seizures, comas, and death result unless the victim receives treatment.

Dealing with the Problem

Africans have had to deal with this problem for centuries. The well-established range of the tsetse fly covers the central region of the entire African continent. It is an area that people have long avoided. They don't want to put themselves or their animals at risk. For example, the Masai people of Kenya are traditionally nomadic cattle herders who depend on their cattle for milk and for their livelihood. They usually graze their cattle on open land, staying away from the area of the tsetse fly.

Drugs effective against trypanosomes were discovered and developed during the first half of the 1990s. These drugs, combined with the use of pesticides, brought nagana and sleeping

Activity 9 (continued)

sickness under control—for a while. Then the parasites became resistant to these chemicals. A civil war in the region also forced healthcare workers to leave, causing the disease to be left virtually untreated for many years.

Developments in Treatment

Treatment during the second stage of trypanosomiasis is problematic. The drug used since 1949 for this stage contains arsenic, which is poisonous. Doctors and researchers from many African nations held a conference in the early 1990s in the Ivory Coast, looking for new treatments for sleeping sickness. Two years later, they found one from an unexpected source. A drug that was developed originally as a cancer drug was tested for its effect on people with sleeping sickness. Doctors tested the drug on hundreds of patients with second-stage sleeping sickness in hospitals in Nioki, Zaire. Scientists also conducted trials on some animals with nagana. They concluded that the drug could be a safe, effective treatment against East African trypanosomiasis. Unfortunately, it has not proven effective against West African trypanosomiasis, and often is unavailable or in short supply.

Toward the Future

Research on sleeping sickness continues. Some researchers in the United States have investigated why human blood can fight the protists that cause nagana, but not sleeping sickness. In 1995, they found a protein in human blood that destroys the trypanosomes that cause nagana. This discovery could lead to developing strains of cattle in Africa that will be resistant to the effects of trypanosomes.

Researchers in Zanzibar have found that by releasing male tsetse flies made infertile by radiation, they can effectively control nagana. This method might be used in the future on mainland Africa. In the meantime, international health organizations are fighting to help the 36 countries in the region. With more research and discoveries on the horizon, perhaps Africans will one day awake to a day free of sleeping sickness.

Active Reading

1. Why is sleeping sickness again on the rise in southern Sudan?
2. What is being done to save cattle from nagana in Zanzibar?
3. Besides finding a cure, what other things do you think need to happen in order for this disease to be eliminated?

Alternate Assessment

Create a drawing that shows how sleeping sickness infection occurs. Perform any necessary research to help you with the drawing. **HINT:** *The trypanosomes that cause sleeping sickness are flagellated protists.*

Biodiversity—Planting the Seeds for a Healthy Planet

Activity 10

One hundred years ago, over 7,000 varieties of apples were grown and sold in the United States. Today, four main varieties (Delicious, McIntosh, Winesap, and Jonathan) dominate grocery store shelves. This reduction in the variety of commercially grown crops has become common practice around the world. As a result, more and more people have become dependent upon fewer and fewer types of crops.

People around the world traditionally have grown many types of crops that are virtually unknown to major commercial growers and retailers. Today, many of these crops are naturally resistant to pests, and some do not require as much water as more common varieties. Now, there's growing interest in restoring crop diversity. Reasons for doing this include conservation of water and avoidance of pesticides.

Biodiversity is a form of genetic insurance that allows plants to adapt to an ever-changing environment. In some cases, indigenous communities (groups of people native to an area) are attempting to return to their traditional agricultural methods; especially since they are proving more productive than modern methods.

Blue Corn

Blue corn is a variety of corn grown for centuries by native agriculturalists of the southwestern part of the United States. The Hopi incorporated blue corn into their rituals, and it is still important today. Blue corn contains 30 percent more protein than the yellow corn that is more readily available commercially. Blue corn plants grow from 1 m to 2.5 m and perform well with the dryland farming techniques used by the Hopi. Blue corn is used to make tortillas, corn chips, pancake flour, cornbread, and cereal.

Amaranth

Amaranth (AM uh ranth) was highly valued by the Aztecs of Mexico. It was domesticated in Mexico at the same time as corn, beans, and squash, around 5000 B.C. Today, amaranth is popular in West Africa, particularly in Sierra Leone, and is experiencing new popularity in Peru. It is easy to care for, resisting heat and drought. Growing about 2 m high, amaranth is topped with large, heavy seed heads containing up to 500,000 seeds. These seeds can be popped like popcorn or ground into a nutritious flour. The leaves can be eaten as well and taste somewhat like spinach. Amaranth has the highest amount of protein of all grains and is rich in calcium, iron, potassium, fiber, and vitamins A and C.

Some crops that are receiving more attention include blue corn, amaranth, quinoa, and blue potatoes.

Quinoa

Quinoa (KEEN wah) is a weedy plant that's been grown in the Andes for at least 5,000 years. The Inca may have regarded quinoa as sacred. When the Spanish came, the popularity of quinoa fell as the Spanish encouraged the growing of European crops. In the 1940s, Peru began to import large quantities of wheat, lowering demand for quinoa even further. Now, quinoa is receiving renewed interest, as scientists search for alternative food crops. Each year, Americans consume about 1.4 million kg of quinoa.

Activity 10 (continued)

Quinoa contains higher levels of amino acids than other more popular grains. It also has three times the amount of calcium and twice the amount of phosphorus as wheat.

Almost all of the world's quinoa is grown in the Andes. Quinoa grows best at altitudes above 2,700 m and needs little water. Its seeds can be white, yellow, gray, light brown, pink, black, or red. They can be boiled, toasted, or popped and are used in many traditional dishes. The bitter seed coating, saponin, may repel pests. Saponin is removed before cooking and can be used as an ingredient in soap, fire extinguishers, and photo processing. Quinoa also may be a good food for extended space travel because it's such a good source of nutrition.

Blue Potatoes

Blue potatoes have come to U.S. supermarkets and restaurants. They can be cooked in the same way as regular potatoes, but they might be more nutritious with a higher mineral content. Blue potatoes are just one of the many varieties of lesser-known potatoes and other tubers gaining new recognition in Andean countries in South America, as well as around the world.

The International Potato Center in Lima, Peru, has made an initiative for Andean biodiversity. The Center attempts to rescue Andean food crops in danger of extinction. As part of this program, the Center has banked the genes of nine species of roots and tubers. These species grow well in high altitudes, are high in vitamins, and might have medicinal value.

The Value of Diversity

There are between 30,000 and 80,000 edible plants, but humans rely on only about 150 of them for food. Three crops (rice, corn, and wheat) make up one-half of the human diet. Without genetic diversity, whole fields of crops can be wiped out by diseases, fertilizers, pesticides, and fungicides.

Active Reading

1. Which crops make up most of the human diet? How does this compare with the potential number of food crops?
2. Why is biodiversity in food crops important?
3. Why do you think that crop varieties have become so limited?
4. How might individuals help establish plant diversity on a small scale?

Alternate Assessment

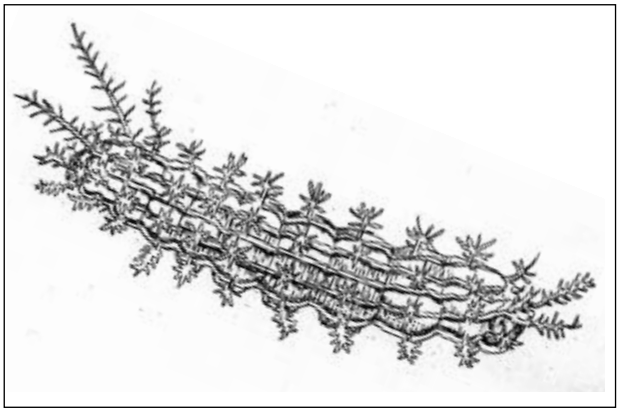
Create a graph showing crop diversity and how it has changed in your area. First, find out how many varieties of fruits and vegetables are at your local supermarket. Then, pick one fruit or vegetable (for example, apples or cucumbers) and find out how many varieties are grown in (a) your area, (b) your state, and (c) nationwide. How has the number of varieties changed over the last 25 years? You might choose to create a pie chart showing the number of varieties sold compared to the number of existing varieties.

The Fight Against Killer Caterpillars

Activity 11

In the south of Brazil, a frightening scene presents itself approximately 400 times a year. A farmer makes a late evening round to check one of his soybean fields. As he does, he passes near some fruit trees, and a caterpillar lands on his arm, stinging him. In other parts of the world, a catepillar attack might be no big deal, but the Brazilian farmer is now facing a life-and-death situation.

The attacking caterpillar is known scientifically as *Lonomia obliqua*. This stinging killer caterpillar injects powerful venom, more powerful than that of many snakes, into its victims. That is why Brazilian scientists at the Butantan Institute in Sao Paulo, Brazil, have been working on a serum to treat people who have been attacked by these killer caterpillars.



The poisonous chemicals of *Lonomia obliqua* come out of the green, spiny bristles that cover its body like armor.

Pesticides Kill a Natural Predator

According to Butantan Institute researchers, the caterpillar is expanding its territory because of land development. Until about 30 years ago, the caterpillar lived only in the dense rain forests in many different parts of South America. But now, much of the land, especially on the outskirts of cities, has been cleared. Large soybean plantations spread out where rain forests once grew.

Farmers use pesticides on the crops to get rid of insect pests. In doing so, the pesticides kill wasps, the main enemies of the caterpillars. The result has been a boom in the caterpillar population. The spread of the caterpillars has put them in contact with people in more populated areas.

The caterpillars are nocturnal, doing their feeding at night. If people happen to be near the trees they feed in, they might attack, just as they would attack an animal in the rain forest that might be a natural enemy. During the day, the caterpillars sleep in the trunks of trees. Sometimes, they may be found in clusters of up to 60 caterpillars.

Causes and Effects of the Venom

The caterpillar *Lonomia obliqua* is the larval stage of a large moth related to the giant silkworm moth. Like all caterpillars, it spends this part of its life cycle eating many times its weight in leaves each day.

In the incredible diversity of rain forest life, there are many insect-eating animals that prey on caterpillars. To defend themselves, it is quite common for rain forest caterpillars to have some kind of defense, such as a poison. When the *Lonomia obliqua* caterpillar is threatened, it may pierce the skin of an animal or a person with its spiny bristles. Then, its venom enters the bloodstream.

According to one Butantan Institute researcher, within an hour of an attack the venom begins to interfere with the normal clotting of blood. If people are attacked and do not get treated right away, they might begin to experience kidney failure or to bleed internally. This kind of severe bleeding, called hemorrhaging, can lead to death.

Of all the reported cases since the early 1990s, over 20 of the caterpillar attacks have caused death. Butantan Institute director Isaias Raw says that the venom is "very, very powerful," although no one knows what makes this particular caterpillar so dangerous.

Activity 11 (continued)

Finding the Antidote

With so many reports of deadly caterpillar attacks, the research scientists at the Butantan Institute began work on a treatment. They are known all over the world for their anti-venom research. Today, a staff of around 200 people maintains a snake farm where some 50,000 poisonous snakes are bred so that serums can be developed to treat their bites. The institute also has developed an effective anti-venom for spider bites.

For the caterpillar venom, scientists used similar techniques. They injected venom from the caterpillars into horses. The horses then produced blood chemicals called antibodies to fight the venom. The scientists drew blood containing the antibodies from the horses and made it into a serum. A patient that has been attacked by a caterpillar can get a shot of the serum. People treated with the serum make a good recovery. The venom itself someday might be useful in treating blood clots, which occur when blood gets too thick.

Active Reading

1. Why do the caterpillars sting?
2. What did scientists have to know about the poisonous caterpillar in order to analyze why the caterpillar population was increasing?
3. What is the chain of causes and effects that led to the spread of the killer caterpillar?
4. What are some tactics that the Brazilian government might try in order to control the caterpillars without causing further environmental damage?

Alternate Assessment

Draw a life cycle of an insect that undergoes complete metamorphosis. Label the stage in which *Lonomia obliqua* is poisonous.

Cancer—Uncovering the Culture Connection

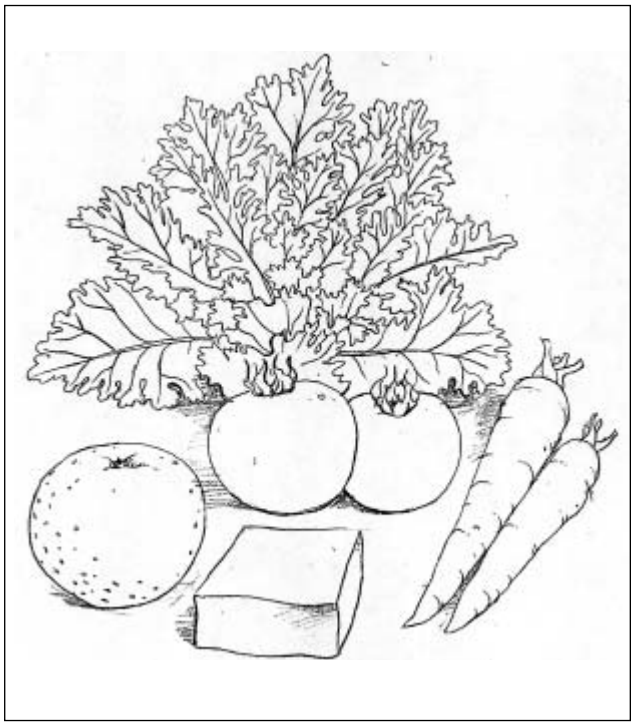
Activity 12

On the other side of the globe from the United States, breast cancer affects five times fewer women in Japan and China. The rates of colon cancer and, until a few years ago, lung cancer, also are lower in Japan and China than in the United States. On the other hand, the occurrence of stomach cancer in both China and Japan is astonishingly high. In China, for instance, the rate is 90.9 cases in 100,000 people, compared to a rate of 6.5 in the United States. Scientists are exploring answers to the question "why?" They began to ask themselves whether the tendency to get—or not to get—cancer was an inherited trait. Their observations, however, took them in a different direction.

A Change of Direction

If protection against cancer—or the tendency to get it—were largely genetic, then it shouldn't matter where a person lived. Yet, environment does seem to play an important role. Studies have shown that cancer incidence often changes as people migrate from one place to another. As with breast cancer, the rate of colon cancer is lower in Japan than in the United States. But when Japanese people move to the United States, their risk of developing colon cancer increases. On the other hand, their rates of stomach cancer decrease. What causes the rates to change?

As scientists started hunting for changes in lifestyle that could account for differences in cancer rates among people of different cultures, they began looking at dietary habits. For instance, the Japanese have long eaten a diet low in fat. For example, in 1955, only nine percent of a typical Japanese woman's diet consisted of fat—about a third of that typical for American women. Researchers began looking at fat intake, as well as estrogen levels, in order to find potential causes of breast cancer. (Fatty food and substances such as alcohol increase estrogen levels in women.)



Studies have shown that eating a diet containing such foods as carrots, tomatoes, kale, soy, and oranges can lower a person's risk of certain cancers.

In a press release from November of 1999, the Harvard School of Public Health (HSPH) reported that the cause of the cancer might not be directly related to high levels of estrogen, as researchers had begun to think. In fact, the rates of breast cancer in Japan and China remain lower, even among women with estrogen levels similar to those of women in the United States. The cause instead might be related to a protein, called a receptor estrogen, that causes estrogen to be absorbed by cells. American women have higher levels of the protein. If this research continues to prove that the protein is a factor in causing breast cancer, rates of it might be controlled through both diet and drugs.

And what about stomach cancer? Does diet play a role in its incidence, too? A clue to the answer was unearthed in the city of Linxian in China.

Activity 12 (continued)

The people of Linxian have very high rates of stomach cancer. And unlike Americans, they have a diet high in preserved vegetables, and low in fresh fruits and vegetables. Their salted, pickled, low-fat diet helps prevent colon cancer, but may be contributing to higher incidences of stomach cancer.

Other studies have revealed that stomach cancer also is common in places such as Japan, Korea, Chile, and India. In these places, the people have a diet high in salted, pickled, smoked, and cured foods, and low in fresh fruits and vegetables containing vitamins A and E. In a recent long-term experiment, people likely to get stomach cancer were given vitamin supplements to increase their levels of vitamins A and E. Their cancer rates decreased by 13 percent.

An Infamous Culprit

Habits other than diet also can decrease the risk of getting certain cancers. Before the 1960s, relatively few Japanese people living in Japan developed lung cancer. In 1960, for example, lung cancer accounted for only two percent of deaths among middle-aged Japanese men. By 1995, however, that figure had soared to an alarming 18 percent, and it's still rising.

What had protected the Japanese men from getting lung cancer that no longer protected them? Cigarette smoking had not been common in Japan prior to the middle of the 1900s. Then, as the decades passed, cigarette smoking became more popular. A lifestyle that had protected the people of Japan against lung cancer began to vanish.

Clearly, lifestyle choices, including those related to diet and tobacco use, have an impact on cancer rates. Looking at and comparing the different lifestyles of cultures around the world can help scientists unravel the mystery of what causes cancer, a complex group of more than 100 different diseases.

By borrowing the most healthful practices from countries around the world and avoiding harmful practices, people can lower their cancer risk. Because this is a field where research is continuous, individuals periodically should check reliable sources of information for updates.

Active Reading

1. What are some of the risk factors for cancer?
2. What might contribute to the high rates of stomach cancer in China and Japan? What nutrients are missing from the diet of the people in those countries?
3. What choices can you make that could help reduce your risk of cancer?
4. Studying other cultures can provide clues to preventing cancer. What other health benefits might be gained from the study of other cultures?

Alternate Assessment

Some causes of cancer are directly related to a choice of foods and other substances. Create a poster showing which foods and substances may help protect the body from cancer and which may expose it to increased cancer risk. **Hint:** *Visit science.glencoe.com to start your research on this topic.*

Ellen Ochoa— Space Delivery

Activity 13

Ellen Ochoa scanned her packing list. It included water, sleeping bags, clothing, and medical supplies. The items on the list were common enough; it was her destination that was unusual. Ochoa was preparing for a trip into space. She and six other astronauts would be crew members on the *Discovery* space shuttle, launched in May 1999. One goal of the *Discovery* mission STS-96 would be to deliver supplies to the International Space Station (ISS), which was nearing completion.

Astronaut Ellen Ochoa

Living and Working in Space

Although this was not the first shuttle trip into space, it would be the first time the shuttle would dock with the ISS. The ISS was being built in space, piece by piece. It is a large orbiting space station where scientists and engineers are able to live and work for long periods of time. Sixteen countries, including the United States and Russia, have worked together building and operating the station.

The first piece of the ISS was hauled into space in 1998. It took at least 40 more space flights to transport all the materials to complete the station. Completed, the ISS is as long as a football field and has 1300 m^3 of space. It has a module where crew members live, and at least six laboratories where engineers and scientists can conduct research.

Part of the *Discovery* crew's mission was to deliver supplies for the scientists and engineers who would be living and working on the ISS. Ellen Ochoa, a mission specialist on the voyage, was responsible for coordinating the transfer of about 1,800 kg of materials from the *Discovery* to the ISS. Some items, such as water, medical supplies, and computers, had to be stored inside the ISS. Other hardware and equipment had to be mounted on the outside of the station. Ochoa operated a robotic arm to help unload and move items into and out of the cargo bays. She also used the arm to assist two other astronauts in an eight-hour space walk. The two astronauts attached equipment to the outside of the ship and made repairs to the ISS modules.

The Strength of Experience

Space travel is nothing new to Ochoa. In 1991, she was 1 of 23 people selected from a group of 2,000 by NASA to enter its astronaut-training program. In 1993, she became the first female Hispanic astronaut to travel in space. Since then she has logged more than 700 hours and traveled millions of miles in space on several different shuttle flights.

On her first flight, in 1993, Ochoa was a mission specialist aboard the *Discovery*. The nine-day mission was to gather data on the Sun's effects on Earth's atmosphere and the loss of ozone in the atmosphere. On this flight, Ochoa operated a robotic arm to help deploy and retrieve a satellite. In 1994, as payload commander on the space shuttle *Atlantis, s*he was again called upon to use her skills with the robotic arm to retrieve instruments from a satellite.

Activity 13 (continued)

Originally from California, Ochoa has college degrees in science, physics, and electrical engineering. She was a good candidate for the NASA space program because of her achievements in optical and computer research. As a graduate student and later, working at Sandia National Laboratories in California, she received patents on three different optical systems that she had co-invented. The systems use light to convey information about objects to a computer. The devices can identify objects and pinpoint flaws in objects. Before joining NASA as an astronaut, Ochoa worked at the NASA Ames Research Center in California. There, she managed a research team of 35 scientists working on space-related computer systems.

Into the Future

Today, Ochoa continues to work with NASA specialists to help them plan and develop the ISS. When she is not in flight training as a shuttle crew member, she works at the Johnson Space Center in Houston. Her duties have included spacecraft communications and monitoring audio from other shuttle missions.

Ochoa has received many awards for her work and her contributions to science, including the NASA Exceptional Service Medal and Outstanding Leadership Medal. In 1995, she was honored with The Albert V. Baez Award for Outstanding Technical Contribution to Humanity.

Active Reading

1. What skills made Ochoa a good candidate for NASA's astronaut program?
2. What was the purpose of Ochoa's last mission in space?
3. What are some of the advantages of having an international space station?

Alternate Assessment

Do research to create a time line showing the progress of the construction of the ISS. Begin your timeline in 1998, when the first piece of the space station was carried into space. Provide brief descriptions on the time line of what was accomplished at each stage.

Activity 14

Dawn Wright— Deep-Sea Explorer

Dawn Wright is a geologist and geographer. Her focus is not on land above water but on land underwater. Wright researches and maps the ocean floor.

The Mid-Ocean Ridge

Much of Wright's underwater research is centered around the volcanic mountain ranges and other structures along the mid-ocean ridge. The mid-ocean ridge is a 70,000 km-long range of underwater mountains that circle the Earth. The structures along this seamlike ridge have formed and reformed over millions of years because of volcanic activity and earthquakes.

Wright studies the volcanoes, earthquakes, and hydrothermal vents found along this ridge. Hydrothermal vents are like underwater geysers. They are formed when ocean water seeps into cracks in the seafloor called fissures. The water is heated by magma beneath the surface of the Earth, and then is forced back out into the ocean. Recent discoveries reveal that hydrothermal vents are surrounded by thriving and diverse ecosystems.

Searching for Answers

One of Wright's goals in her marine research is to determine what causes these seafloor fissures. Fissures that have formed near the mid-ocean ridge cause the seafloor to spread an average of 1 cm to 17 cm per year. These fissures might be a result of the movement of tectonic plates or they could be caused by magma under pressure that erupts through the ocean floor.

Wright has traveled the world, from the East Pacific Rise, to the Northern Indian Ocean, to Antarctica to do research. During expeditions, she explores the ocean bottom in a small research submarine to examine and photograph fissures. She also studies seafloor photos, videos, and sonar images taken by a remote-controlled vehicle.

Oceanographer Dawn Wright

As a geologist, Wright is interested in the relationships between volcanic, hydrothermal, and tectonic processes. As a geographer, she tries to find new and better ways to analyze, interpret, and map the data she and other oceanographers collect from the seafloor. She says scientists know more about mapping the planets than mapping the ocean floor. She's been given the nickname "Deep-sea Dawn."

Mapping the Seafloor

Wright is an expert on geographic information systems (GIS), software programs that help scientists convert information gathered by satellites into maps. Today, GIS is used for everything from mapping endangered species to identifying the best location for new housing developments. However, GIS is somewhat new to the field of oceanography.

Wright was introduced to GIS in the early 1990s while studying for her doctorate degree. In those early years, marine GIS primarily was used to locate objects lost on the ocean floor. In 1991, she took a set of data collected by a deep-sea vehicle and successfully applied GIS, making her one of the first scientists in North America to do that. Wright also was the first to complete a book on marine GIS.

Activity 14 (continued)

As an authority on GIS, Wright continues to research how to apply GIS to deep-sea data. GIS maps can show oceanographers where geological occurrences, such as hydrothermal vents and fissures occur. These maps also can show temperature, ocean currents, and chemistry changes in the water.

One drawback to using GIS underwater it that it is expensive. The process also is not very good at interpreting three-dimensional data. Wright continues to work with computers to develop software that can convert data for use with the GIS system.

Active Reading

1. What particular challenge does GIS pose to oceanographers?
2. Why do oceanographers such as Wright study fissures?
3. What might cause the seafloor to change?

Alternate Assessment

Using research to find a map of the ocean floor, make a three-dimensional model, putting in the fissures. You could use papier-mâché, plaster of paris, or come up with your own way to show your map in three dimensions.

The Maya—Keepers of Time

Activity 15

Wrist watches, wall clocks, digital radio alarms, school schedules, and bus schedules fill our world. Our daily lives revolve around our methods of keeping track of time. But time is not a physical object that can be weighed or measured with a ruler. Measuring it is a complex matter, and it was a major concern of people such as the Maya.

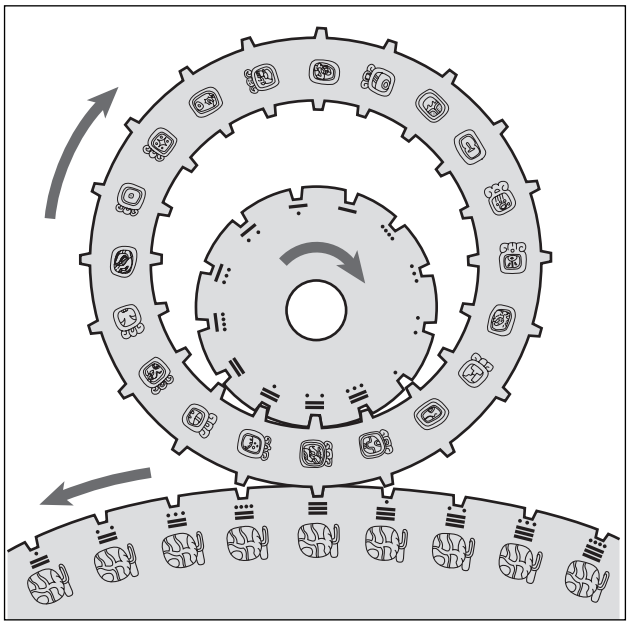
Approximately 1,750 years ago in Central America, the Maya measured time by observing the cycles of the Sun and Moon. They developed calendars (different ones for different purposes) and became expert astronomers. The Maya were one of the first cultures to develop an annual calendar that was 365 days long. But the Maya also had a 104-year almanac based on the cycles of the planet Venus, and a 260-day calendar based on the apparent movement of the Sun to different points in the sky. The 260-day calendar and the 365-day calender were later adopted by other civilizations, such as the Aztecs.

Careful Observation

The Maya learned about the stars, Moon, and Sun through direct, unaided observation. The movements of the stars look different to observers in different latitudes on Earth. Near the poles, the stars seem to move in circles. At the equator, the stars rise and set at a 90º angle from the horizon. The Maya lived near the equator, so to them, the stars appeared to rise and set at about a 70º angle.

The exact point where each star, including the Sun, appears to rise and set varies depending on the time of the year. An observer can see this by watching a star at night, noting how close the star is to a particular landmark, such as a tree or a mountain, on different dates throughout the year.

The Maya designed observatories used to observe particular astronomical events. Some observatories had holes in their ceilings that could be used to look at particular constellations.



The Mayan calendars interlock with the Mayan almanac like sprockets. Each day the wheels are turned by one place, and the symbols for the month and the day line up.

The Maya added vertical sight tubes to their observatories. This way, they could determine the exact date when the Sun reached its highest point in the sky. Then, the Sun's light would shine directly through the tube into the room below.

What time is it?

The Maya used their knowledge of astronomy to keep track of the time of day and to develop calendars. Two of the Mayan calendars reflect their observation of the Sun. The Sun appears to move in two different ways—it always rises in the east and sets in the west, but the exact spot on the horizon where the Sun rises and sets varies from season to season.

In the latitudes of the northern hemisphere in which the Maya lived, the Sun appears exactly to the east and disappears exactly to the west only at the spring and autumn equinoxes, when night and day are the same length. At the summer solstice, when the Sun is at its highest northern point, it appears in the northeast and disappears in the northwest.

Activity 15 (continued)

At the winter solstice, when the Sun is at its most southern point, it appears in the southeast and disappears in the southwest.

Venus Rising and Setting

The Maya also developed an almanac based on the movements of the planet Venus. Venus is so bright that sometimes it can be seen even in daylight. For this reason, Venus sometimes is called the morning star.

During the time of the year when Venus is a morning star, it appears just before dawn. The first time that Venus appears this way, it rises directly above the Sun. Gradually, Venus appears earlier and farther away from the Sun, then it moves back toward the Sun again. For eight weeks, Venus disappears because the light of the Sun hides the light of Venus.

Next, Venus reappears as an evening star, just before dark. Gradually, it appears later and farther away from the Sun, then it moves back toward the Sun. Venus disappears for a week before it once again begins its predawn appearances.

Venus was important to the Maya because its rising and setting was so closely connected with the Sun. The Venus almanac included 65 cycles of Venus.

The Maya also used their knowledge of astronomy to create interesting visual effects in their architecture. The Mayan pyramid at Chichén Itzá was positioned so that twice a year, at the sunset of the spring and fall equinoxes, viewers could see the illusion of the body of a snake descending the north stairs.

Active Reading

1. How did the Maya use astronomy to tell time?
2. Why might early people have been so concerned with telling time?
3. How do you think the Maya decided that a solar year is about 365 days long?
4. The Maya had no telescopes to assist with their observations. How do you think their direct, unaided astronomical observations were made easier with the use of an observatory?

Alternate Assessment

Create a star chart with naked-eye astronomy, using the same techniques as the Maya. Choose a particular star, planet, or the Moon. Chart the apparent rising and setting of your star, planet, or the Moon everyday for a least a month, by observing how close it rises or sets to a feature on the horizon, such as a mountain, tree or building. **Hint:** *If you live in the city, stars will be hard to see. In this case, choose a bright object such as the Moon*

Adriana Ocampo—Making an Impact

Activity 16

A discovery made in 1988 is lending credibility to a convincing theory of what might have caused the extinction of dinosaurs. Adriana Ocampo Uria, a well-known and respected scientist, was the first to recognize a ring of sinkholes, or *cenotes,* surrounding a large impact crater in the Yucatan area. This exceptional scientist is known for her work in geology, both in space and on Earth, as well as for her participation in teaching conferences, professional boards, and science outreach programs.

Her Interests Started Early

Ocampo is a planetary geologist at NASA's Jet Propulsion Laboratory in Pasadena, California. Planetary geologists study the geology of planets, stars, moons, comets, and asteroids, as well as objects such as meteorites that have come to Earth from space.

Ocampo was born in Colombia and raised in Argentina, and came to the United States with her family when she was 15 years old. After her junior year in high school, she got a summer job at the Jet Propulsion Laboratory (JPL) in Pasadena, California. She has worked there through college and ever since, pursuing her interests in space science. Ocampo has always wanted to be an astronaut, so she has applied in the past to become a mission specialist on the space shuttle.

Exploring Surfaces in Space

Ocampo has worked on a number of important projects at the JPL. They include the Viking space missions to explore Mars and the outer planets, the Hermes mission to explore Mercury, and the Galileo mission to explore Jupiter. She used remote sensing techniques—methods to gather information at a distance—to make a photo atlas of Phobos, one of the moons of Mars. This atlas was used in planning a Russian mission to that moon.

Scientist Adriana Ocampo

Models of Earth's Past

Ocampo also gathered evidence to prove that a comet or asteroid struck Earth. The scientists working on the theory developed computer models to see what such an impact would do. The model projected enormous earthquakes and huge, destructive tsunamis. The impact would have released so much energy that fires could have covered entire continents. Soot, dust, and gases would have shot into the atmosphere, blocking light from the Sun. As a result, temperatures on Earth would fall so low that photosynthesis would halt. The final outcome would be extinctions all across the globe. It was a convincing theory. To confirm it, scientists needed to find evidence that such an impact really occurred. They were hunting for the crater of an asteroid impact.

Traces of the Crater

In 1988, Ocampo was the first person to recognize that a ring of sinkholes in the Yucatán Peninsula in Mexico might be a sign of an asteroid impact. The crater is now called Chic-xulub, after a Mayan village built there.

Activity 16 (continued)

Now, together with an international group of scientists, Ocampo is studying the crater, which stretches more than 200 km across. In or around the crater, scientists have found debris made up of rocks formed by a huge impact. They include fractured quartz crystals, round glass droplets, and deposits from huge tsunamis. Scientists also have found a layer of melted rock hundreds of meters thick. Tests have shown that the debris is about 65 million years old, placing its arrival at around the time that dinosaurs became extinct.

Most of Chicxulub crater lies beneath layers of sediments up to 1,000 m thick. Ocampo discovered an area that could be studied more easily. This area is part of the "ejecta blanket"—a layer of matter around the surface of the crater that was ejected, or "splashed" out, when the comet or asteroid hit. By studying these rocks, scientists can learn more about the impact and how it may have affected living things long ago.

Ocampo also has been involved in efforts to bring people together to learn about science. She helped organize the Space Conference of the Americas, held in Central and South America. This conference encouraged countries to learn more about the planetary sciences and to cooperate in the peaceful use of space. In addition, she also works with international student exchange programs and mentoring programs in order to involve others in science.

Active Reading

1. What kinds of evidence support the theory that a comet or asteroid hit Earth 65 million years ago?
2. Explain how a large comet or asteroid hitting Earth could cause extinctions.
3. How might studying the geology of a planet other than Earth help scientists on Earth?
4. Why do you think international cooperation is necessary for the exploration and peaceful use of space?

Alternate Assessment

Research the Chicxulub crater. Create a drawing showing the different geological features of the crater. **Hint:** *Include geographic features such as cities and oceans to show the size of the crater.*

Name Date Class

The Ancient, Rising Nile

Activity 17

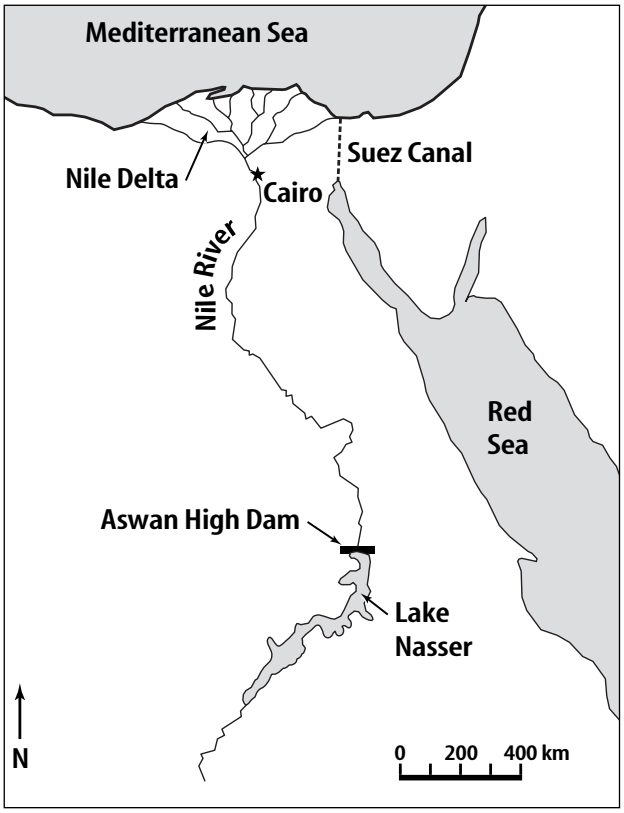
Would you consider living next to a river famous for its yearly flooding? Many people might instinctively say "no," but this is exactly what the ancient Egyptians did. In fact, the rising waters might have led to the rise of this great culture.

The ancient Egyptians called this land Kemet, meaning the black land, a fitting name for the narrow strip of rich, dark soil on either side of the Nile River. Without the soil that the Nile deposited during its yearly flood, the people of ancient Egypt would have been swallowed up by the desert sands of Deshret, the red land that loomed beyond their fields. The river irrigated their farmlands and helped them carry their crops to market. Early historians did not exaggerate when they called Egypt "the gift of the Nile."

A Fertile Foundation

As was the case with the Tigris and Euphrates rivers in Mesopotamia and the Indus River in India and Pakistan, the Nile gave rise to a highly advanced ancient culture. The fertile land, which yielded tremendous supplies of food, encouraged people to settle in communities. Supported by the wealth of their fields, the early Egyptians developed a national government, a written language, and a religion that emphasized life after death. Their culture expressed itself through stunning pyramids, temples, and sculptures.

The Nile has its source in central Africa and flows over 6,400 km north to the Mediterranean Sea. About 960 km of the river flows through Egypt. North of the great pyramids, the Nile splits into several streams to form a fan-shaped delta of rich soil. Most of the early Egyptians lived in the narrow Nile River Valley and on the delta. Every year about June, the rainy season far south in Africa caused the Nile to rise and overflow its banks. To forecast the flooding, the Egyptians watched for the rising of the star Sothis, which we call Sirius. When this star first reappeared in the eastern sky, the people knew that floods would come soon.



The Nile River flows north into the Mediterranean Sea.

The Three Seasons

The Egyptians began their calendar of 365 days at this point and divided it into three seasons. First was Inundation, or the season of flooding. Next came Going Forth, the time for sowing seeds. This season began about September, when the water drained away and left behind a strip of fertile silt. Here, the farmers grew large crops of barley and wheat, possibly two crops a year. They also grew lettuce, onions, beans, grapes, and melons, as well as flax, the source of linen—the cool, white fabric people used for clothing. During Deficiency, the last season of the year, the river water was low and harvesting took place.

For thousands of years after ancient Egyptian civilization had fallen into ruins, the Nile repeated its cycles of flooding and receding. People continued to depend on it for food and transportation.

Activity 17 (continued)

Stopping the Flood Cycle

Then, in 1968, the Aswan High Dam went into operation and stopped the Nile's floods that some considered damaging to Egyptian farms. The 111-m-high dam blocks off the Nile about 680 km south of Cairo. Extending south behind the dam is Lake Nasser, a 4,030 km^2 reservoir.

Creating the Aswan High Dam was a monumental task and caused controversy. Whole villages of people had to be moved from their ancestral homes, because their land would be submerged under the waters of Lake Nasser once the dam was complete.

The water of Lake Nasser is now used to generate electricity and irrigate fields year round. Farmers can plant as many as three crops a year without fear of losing them to flooding, and Egypt has doubled its agricultural output. In times of drought, the waters stored by the dam are used for irrigation to prevent crop failures.

Damming the Nile has proven a mixed blessing, however. The silt that for thousands of years enriched fields is no longer deposited at the Nile's mouth, so farmers must use expensive fertilizers on their lands. The fertilizers increase the amount of salt in the soil. When these fertilizers wash into the river, they kill fish.

The Mediterranean shoreline at the delta of the Nile is eroding away because it is no longer replenished by silt deposits. Also, growing cities cover precious soil with concrete. A disease caused by snail-infesting worms has increased among Egyptians, probably because the irrigation canals, where the snails thrive, are full of water all year round.

While breaking the chain of flooding and drought is in some ways a great benefit, it may take years before people know whether the benefits truly outweigh the problems the dam has created.

Active Reading

1. What is the connection between rivers, agriculture, and civilization?
2. Why did the ancient Egyptians develop a calendar?
3. What are some advantages to placing a dam in the Nile? What are some disadvantages?
4. Do you think that building the Aswan High Dam was a good thing? Explain.

Alternate Assessment

Make a model with which you can demonstrate to your class the yearly flooding of the Nile River in ancient times. Then, modify your model to show the effect of the Aswan High Dam on the flooding.

The Ancient African Art of Metalworking

Activity 18

No one knows exactly when or where the change happened, but it was enormous. Gradually, in places all over the world, communities of people began learning that metals were plentiful in Earth's crust, mixed with minerals in rock formations called ore. The ore, they discovered, could be mined, separated, and shaped into tools, weapons, and art. They experimented, refined their methods, and became experts at metalworking, using only the simple materials they had available. The metal was plentiful. Turning it into a useful form, however, involved a complex technology called smelting.

Finding Evidence

About 2,500 years ago, people living in East Africa near what is today known as Lake Victoria had mastered this technology. They used iron to make tools and weapons. In the early 1950s, the Bahunde people of southern Zaire unearthed clay bricks that had been used by these early Iron Age people to build smelting furnaces. Not far away, in Rwanda, the remains of 23 tall, round furnaces made from sun-dried clay bricks were discovered. In figuring out how early Africans made iron, archaeologists turned to modern Africans for help. A few of them remembered the revival of ancient smelting techniques used during World War II when iron imports were scarce.

Hot Enough to Smelt

The smelting process removes metallic iron from ore and requires extremely high temperatures. The first step, called reduction, removes the oxygen from the compound iron oxide that makes up much of the ore. This happens at around 800°C. The second step purifies the iron further by removing unwanted minerals. These impurities melt and begin to run off as a liquid at about 1,150°C. Since iron itself melts at about 1,540°C, smelters must control their furnaces carefully to keep the temperature within a relatively narrow range.

This Yoruban bronze sculpture of an Ife king was made between A.D. 1100 and A.D.1300 and stands 47 cm high.

Early iron smelters had everything they needed for smelting close at hand. Iron ore came from the surrounding hillsides. Hot-burning charcoal, made from local trees, fueled the smelting furnaces. The furnaces consisted of tall shafts of sun-dried bricks built over pits. Inside, layers of ore alternated with layers of charcoal. Holes around the bottom of the furnace were fitted with clay pipes so air could be forced inside, raising the temperature of the charcoal. When the necessary temperature was reached, smelters removed iron from the furnace.

Activity 18 (continued)

Bronze Sculptures

Iron was not the only metal that early Africans were skilled at working. Hundreds of years ago in West Africa, artists used bronze—copper alloyed with other metals—to make stunning sculptures. In Ife, the sacred city of the Yoruba people of Nigeria, wonderful figures, probably of royal leaders, and handsome, naturalistic heads were produced sometime between A.D. 1100 and A.D. 1450. The heads may have played a part in funeral or other religious ceremonies.

Not far from Ife was the city of Benin, the capital of a powerful kingdom. In the 16th century, Benin artists also produced superb bronze sculptures, including full figures and heads. The heads were memorials honoring dead Benin rulers.

Lost-Wax Method

In both Ife and Benin, bronze sculptures were made by casting—pouring molten metal into a mold. The technique they used, the lost-wax method, took great skill. The artist made a core sculpture from clay. This core sculpture was then coated with about a centimeter of beeswax. The artist sculpted details on the wax layer and then covered the wax with another layer of clay. The wax was "lost" by roasting the head, which burned away the wax but not the clay. Melted bronze was then poured into the space where the wax had been. When the bronze cooled, the clay was removed to reveal a timeless tribute to the artistic and metal-working skill of Africa.

Active Reading

1. How did early iron smelters control the temperature in the furnaces?
2. Why do you think furnaces were made from clay?
3. What kinds of iron tools and weapons do you think were made in Africa 2,500 years ago?
4. What do you think are some properties of metal that would make it a good material for tools, weapons, and sculptures?

Alternate Assessment

Use the information presented above and some additional research to make an exhibit about bronze sculptures from West Africa. Be sure to include diagrams showing the process of lost-wax casting. Artists today still use this method of producing bronze sculpture.

Like Salt in the Bank

Activity 19

One substance on Earth, almost as plentiful as water from the ocean, has played an important role in both the diets and economies of people throughout the world. From thousands of years ago up to the present time, people have used salt to improve the flavor of foods and to preserve foods for the winter. Salt also aids the digestion of food. In fact, our bodies actually need salt. The sodium and the chloride that it contains carry electrical impulses that tell our nerves and muscles what to do. Salt helps maintain the water content of the cells in our bodies—without it, our cells would burst.

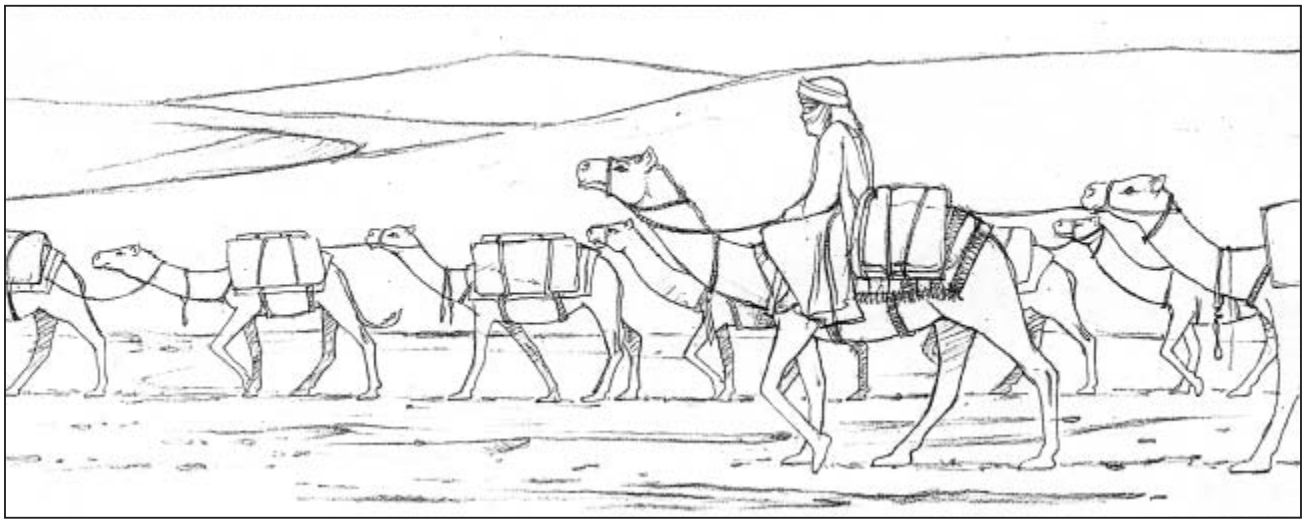
Where's the Salt?

Solar evaporation of seawater is the oldest known method of obtaining salt. Seawater is about 3.5 percent salt. In many places around the world, seawater is let into shallow ponds and allowed to evaporate, leaving the salt behind. Although water slowly evaporates in a hot, dry climate without assistance from humans, the Maya and the Chinese had a method for speeding up the process. They boiled the seawater in thick bowls, causing it to turn into vapor. Also, throughout history, when oceans dried up, they left beds of rock salt. These beds of salt have been found both underground and above ground. In parts of Saharan Africa, there is so much rock salt that people used to make houses out of it. Lakes can be a source of rock salt as well. In Spain, a lake called the Mata fills with seawater in the winter and dries up in the summer, leaving salt beds behind.

The Business of Salt

In ancient times, salt was once so valuable that it was traded for gold. The ancient Chinese even made their coins out of salt, and the Roman soldiers who built roads were often paid their wages in salt. This practice was so common that the English word for wages, *salary,* comes from the Latin word for salt, *sal.*

Since there has always been so much salt in the world, why was it once as precious as gold? The main reason is that people who lived in coastal areas had plenty of salt, but people who lived in most inland areas had to trade for it. History is filled with examples of the importance of the salt trade. Historic records suggest that one of the reasons the Romans built so many roads was their need to transport salt to Rome.



In Saharan Africa, salt is still carried from salt mines to cities by camel caravans. However, faster trucks carrying larger loads are beginning to replace the salt-carrying animals.

Activity 19 (continued)

Spain, Italy, Greece, and Egypt traded salt throughout Europe and the Middle East. In sub-Saharan Africa, the trade city of Timbuktu became extremely wealthy from the salt trade. The Italian cities of Genoa, Pisa, and Venice also became centers of the trade. Areas that were formed by the evaporation of oceans, such as the Danakil Plain in Ethiopia, had a natural business advantage. Residents of the Danakil Plain cut salt from the plain into bars, loaded it into packs, and traveled the country by mule selling it. In Central America, the Maya traded salt from the coastal areas of Belize to inland parts of southeastern Belize between the years A.D. 250 and A.D. 900. In return for salt, inland communities traded ceramic pots and whistles.

Because salt was valuable and everyone needed it, governments considered salt to be an ideal substance for tax. The governments of Rome, Syria, Egypt, and China all regulated the salt trade for profit. The Chin Dynasty in China began to tax salt in about 200 B.C., probably becoming the first government to do so. By the A.D. 800s, salt had become the T'ang Dynasty's most important source of money. The T'ang Dynasty also sent unemployed people to labor in its saltworks.

Most European governments began taxing salt much later. France began to tax salt in the 1600s. The French government required every person over the age of eight to buy a certain amount of salt every week at a fixed price—and to pay a tax on it. This rule was hard to enforce, and some historians think it added to tensions in France, contributing to the French Revolution of 1789.

Most governments were not able to tax salt very successfully. People living near the coast could make their own salt, and people inland bought salt from smugglers. In France, guards regularly searched people entering the city of Angers to see if they were bringing in salt. In 1494, Spain decreed that anyone caught smuggling salt could be shot to death with arrows. But smugglers were rarely caught, and governments were unable to stop the smuggling.

Active Reading

1. Why did the salt trade begin?
2. Why did governments become involved in taxing and regulating the salt trade?
3. Why do you think that salt is no longer as valuable as gold?
4. Do you suppose that Earth could ever run out of salt?

Alternate Assessment

Solar evaporation still is used today to produce salt for the salt trade. Make your own salt water by dissolving 10 mL of salt in 50 mL of water, then produce your own salt through slow salt evaporation or by boiling the salt water until the water boils away. Write a lab report analyzing your production process. Note the percentage of salt in the salt water, and the amount of water you must use to obtain a teaspoon of salt. **Hint:** *Be sure to measure the amount of water you start with and the amount of salt you end up with to help you find the percentage of salt in the water.*

Jade—Gemstone of Kings

Activity 20

Sealed away in the burial tombs of Mayan kings lie clues as to what objects the early Maya must have held dear. How valued must an object have been for it to be considered worthy of getting buried respectfully along with the dead? One such object is the gemstone jade, which was painstakingly carved (without the use of metal tools) into detailed, decorative objects.

The Art of Carving

Mayan jade carvers were masters of a difficult craft. Besides being beautiful, jade, known to scientists as the mineral jadeite, is extremely hard. If you could examine the structure of jadeite, you would see that it is made up of tiny, interlocking needles. This means that it is strong enough to carve into complex, delicate shapes without breaking.

This jade figure of a Mayan god stands about 10 cm tall.

Although the Maya used copper and gold to make many objects, they did not have access to the ores commonly used for making tools. Archaeologists (scientists who study past cultures by looking at artifacts) have found only tools made of stone, bone, and wood.

A Mayan artist would sit patiently rubbing a cord back and forth across a chunk of green stone. The cord would be wet with a paste of gritty sand and water. Gradually, the action of the cord and sand would wear a groove in the hard mineral, cutting off a piece. The artist would then use the same method to shape the piece, rubbing sand into it with cords or with drills made of wood or bone. Next, the stone would be polished to a glassy smoothness. The work must have seemed endless, but the artist could take pride in the fact that someday, a powerful king might wear the carving on a cord. The king might even be buried with the carving.

The Cultural Scene

The early Maya lived hundreds of years ago in cities in present-day southern Mexico and Central America. The early Maya developed a great civilization that reached its high point between the years A.D. 250 and A.D. 900. In addition to being expert carvers, they knew a great deal about mathematics. They were great astronomical observers and learned to predict the exact movements of the stars and planets. Their writing system helped them keep records of their rulers' lives and important events in their history. They built great stone pyramids topped with temples to their many gods. Mayan farmers grew tomatoes, beans, squash, and above all, corn, their main food.

Layers of Society

Mayan society includes slaves, peasants, nobles, warriors, and priests. People were grouped by profession, such as craftspeople, merchants, and civil servants. Almost all Maya were born into their positions or classes in society. Slaves did most of the manual labor. They were important in farming because the Maya did not have animals capable of plowing or hauling. Peasants also worked very hard and had the "privilege" of paying large taxes. A slave

Activity 20 (continued)

or a peasant would never own jade or any other valuable object that symbolized status. Nobles made up the upper classes and warriors were a special, well-respected class of their own. The warriors protected the Maya from their enemies. And, Mayan priests—the most cherished of all people—were in charge of religion, government, and trade.

The Value of Jade

To the Maya, the most precious of all substances was not gold or silver, but jade. Although the rare gemstone comes in a variety of colors, such as pale green or light purple, the Maya most prized jade stones that were a translucent emerald green. Translucent means that some light passes through the stone, giving it a deep, mysterious glow. Translucent green jade resembles the quetzal bird, whose feathers were used as currency.

Mayan carvers fashioned jade into many forms of jewelry, such as strings of beads, earrings, and pendants. Pendants are little carvings that hang from strings or chains worn as necklaces. Sometimes the Maya made larger sculptures out of jade, such as a 15-cm head of the Sun god found in the Central American country Belize. The Maya gave some of their finest jade objects to the gods as offerings. Some of the best-quality stones, however, are the ones found in graves, alongside the bodies of rulers and other nobles.

The value of jade to the early Maya was based on more than its beauty and rarity. The rich green gemstone stood for life itself. Jade's typical green color is the same as that of the husks on growing ears of corn. According to the Mayan story of Earth's creation, the Popol Vuh, humans are created from corn. Some think that jade's color also reminded the Maya of deep pools of life-giving water.

Active Reading

1. What might jade have symbolized to the Maya?
2. What color is jadeite?
3. Why was it so difficult for Mayan workers to carve jade into jewelry and other objects?
4. Why do you think that the early Maya thought it was important to bury their dead with objects carved from jade?

Alternate Assessment

People often have given special meaning to rare and beautiful minerals and gemstones. Find out more about some of these minerals and gemstones and what they have meant to different civilizations. Make an illustrated wall chart or poster displaying their meanings. **Hint:** *You may want to use pictures of minerals and gems cut from old magazines and catalogs?*

Harnessing Sunshine

Activity 21

Harnessing solar power and building solar-powered homes might seem like a modern topic, but for thousands of years, people have used the power of the Sun. In ancient times, the Greeks built their houses facing south so that they would be warmed by the Sun's rays in winter. Such planning helped the Greeks reduce their use of more costly fuels, such as wood and charcoal. The Romans later added their own methods to those of the Greeks—using glass windows to increase the effectiveness of solar heating to warm their homes, baths, and greenhouses. Solar energy was so important to the Romans that access to sunlight was guaranteed by law.

Catching Some Rays

Centuries later, during the 1970s, high oil prices and gasoline shortages helped revive interest in solar energy. One solar design, pioneered in Israel, uses parabolic (curved) mirrored dishes to concentrate the Sun's energy and to heat steam. The steam then powers a turbine that produces electricity. Electronic tracking devices allow the solar collectors to follow the Sun across the sky, creating a very efficient system, which can turn 23 percent of the energy in sunlight into electricity.

Solar Panels

A simpler type of solar collector is the solar panel. A solar panel is made up of many solar, or photovoltaic, cells, such as the ones used in solar-powered calculators. These cells convert energy from sunlight into moving electrons—electric current. A solar panel is tilted toward the Sun to collect the Sun's energy. One solar panel can generate from 30 to 60 watts of power when the Sun is at its peak. Unused energy can be stored in batteries that can hold enough power to last up to five sunless days. Continued improvements in solar technology have led to lower costs and greater efficiency, making solar energy a more attractive option around the world, especially in less industrialized nations.

This woman in India fills a pot with water from a solar pump.

Solar Power Around the World

By the early 1990s, more than 200,000 homes in Mexico, Indonesia, South America, Sri Lanka, and other developing nations were using rooftop-mounted solar systems to generate electricity.

Solar energy can play an important role in bringing power to the more than 2 billion people who are still without electricity. Many of these people live in remote rural areas where there are no power plants or access to power lines. Instead, people in these isolated communities generally use diesel generators, kerosene lamps, and batteries for light and power.

A simple solar energy system can change all that. For example, in farming villages in the Dominican Republic, small solar panels (1-m^2) have been installed on the roofs of houses. The solar panels turn the Sun's rays into electric current for household use. At the end of the day, the extra electrical power can be stored in a battery for later use.

Activity 21 (continued)

Solar Power in India

Solar energy also has transformed lives in remote Himalayan villages in northern India. Before the arrival of solar power, villagers had to use diesel generators to produce electricity. But diesel fuel was costly and hard to transport into these mountain villages, and it polluted the environment. Villagers now have solar panels that provide the electricity they need—a renewable, low-cost, and nonpolluting source of energy.

Solar power can do more than just light and heat homes. In other areas of India, engineers have put solar power to use in agriculture. There are more than 90 million small farms in India, where farmers often cannot access water during the dry summer months. Although water exists from the ground that could be used for irrigation, farmers need power in order to pump it from the ground to the fields. Villagers and solar technicians have found a solar solution for this.

As part of an ambitious solar energy program, many farming communities install solar-powered water pumps. With the newly available water, farmers can produce more food to feed their families and to sell at market.

A Sunny Future

The future of solar energy looks bright as well. The United Nations declared 1996–2005 the "World Solar Programme" in an effort to promote the use of Sun power worldwide. Through this program, the United Nations planned to create an international network of centers for solar education and research. In addition, American scientists say solar-powered satellites may become a major source of energy in the next few decades. Transmitting solar energy from space to Earth could reduce this country's reliance on fossil fuels.

Active Reading

1. How is solar power collected?
2. What are some of the possible drawbacks of relying on solar power?
3. Why do you think people all over the world have tried to harness solar power?
4. People in many less-industrialized countries use kerosene lanterns for light. Kerosene is a petroleum oil product. What reasons might there be for these people to use solar power instead?

Alternate Assessment

One way that solar energy is used in many parts of the world is to heat water. Using simple materials and working in a small group, design and test a solar water heater of your own. Share your design with your classmates.

Name Date Class

Pioneers of the Surf

Activity 22

The scene must have been too tantalizing to resist. Foaming ocean waves rumbling in the distance and crashing near the shore must have called to people throughout the centuries, tempting them to find a way to ride along with the water. It might be surprising to think of people riding on surfboards in the ocean before modern times, but that's just what some of them did.

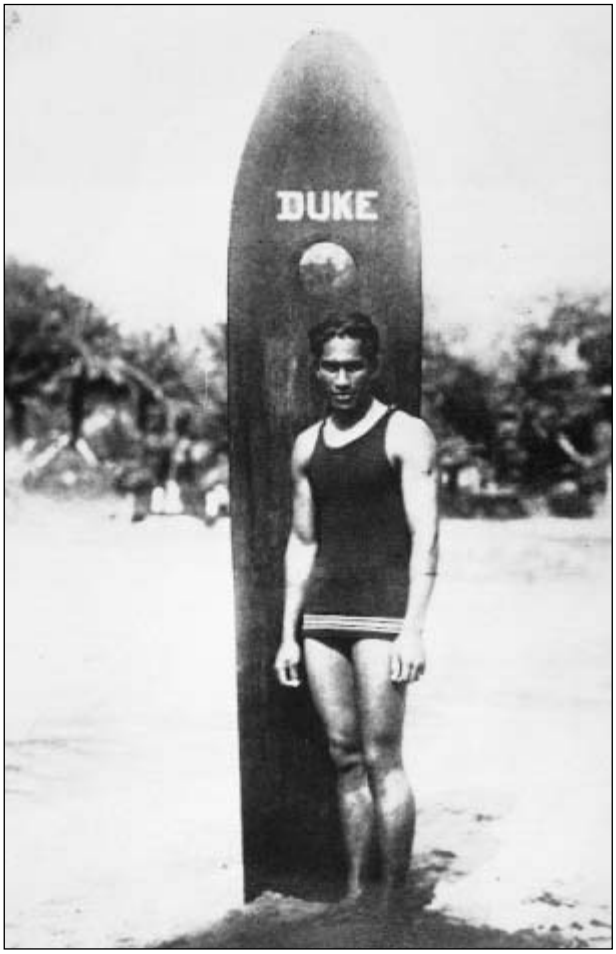
Work Before Play

The art of riding the waves probably began in early times in Polynesia, islands in the western Pacific. The Polynesians likely brought the sport with them when they first migrated from the Marquesas Islands to Hawaii around a.d. 400. The early days of surfing probably had more to do with working—catching fish—than playing. Island fishermen used the waves to propel their canoes over the offshore coral reefs and back to the beach to bring in the day's catch. As these early surfers developed their skills, riding the waves, naturally, became a sport. Surfing for recreation flourished in Hawaii. When European and American explorers and missionaries reached the islands in the 1700s, they remarked on the popularity of the sport.

Surfing's Decline

During the 1800s, European ways of life took over Hawaiian customs. As a result, Hawaiian traditions, such as surfing , were abandoned. The death of Hawaii's King Kamehameha in 1819 also contributed to the delcine in pre-European surfing habits. When the king's eldest son took the throne, he put an end to Hawaiian traditions by publicly going agianst Hawaiian society's rules and regulations, which were called the kapu.

That's when everything changed. Even a three-month celebration of surfing and other sporting tournaments were abandoned. With the festival, the king, and the Kapu all dead, the islanders soon followed the ways of the Europeans in everything from religion to sports.



Bishop Museum

Hawaiian Duke Kahanamoku helped to revive interest in surfing.

Some of the Hawaiian people were attracted to the new European culture and the Europeans were happy to have their customs embraced by the islanders. European missionaries, in particular, discouraged surfing. They did this, in part, because they thought leisure time could be better spent. Wearing European clothing also limited surfing activities.

Brief Revival

A new king, David Kalakaua, was elected in 1874. The king wanted to reintroduce Hawaiian traditions, such as music, the hula dance, and surfing. During his 17-year reign, surfing was reborn. However, when he died in 1891, surfing's popularity declined again.

Activity 22 (continued)

Duke Kahanamoku

Early Hawaiian surfboards were long, narrow, and carved from solid wood. Some boards were as long as 5.5 m and weighed as much as 68 kg. By the early 1900s, only a few surfers were riding the waves, mostly in the Waikiki area of Oahu.

Then, in 1910, a Hawaiian swimmer named Duke Kahanamoku introduced a 3-m-long board on the beach at Waikiki and helped revive interest in surfing. Besides being a first-class surfer, Kahanamoku was one of the world's fastest swimmers. He won a gold medal in swimming at the 1912 Olympics.

On his way to the games, Kahanamoku stopped in southern California and displayed his surfing skill before delighted crowds along the beaches. As a result, people in the mainland United States began to take up surfing. In 1915, Kahanamoku inspired people in Australia to begin surfing.

Since then, the sport has spread and today, people surf along the coasts of Hawaii, North America, Australia, Peru, and South Africa. Modern surfboards are generally short, made of molded plastic reinforced with fiberglass and resin, and weigh just 11 kg.

Waves for Surfing

The best conditions for surfing occur when large, smooth ocean waves meet reefs or sandbars 90 m to 900 m offshore. The longest rides are usually found where the ocean bottom is gently sloping. Surfing waves originate thousands of kilometers out in the ocean. Winds blowing across the surface of the ocean create most ocean waves. As a wave nears the shore, the bottom of the wave is slowed by the friction of the ocean floor, while the top of the wave continues to move forward at its original speed. Eventually, the top of the wave "breaks" or spills over the bottom of the wave, creating surf. These are the types of waves that lured early surfers off the beach and into the water.

Active Reading

1. How did surfing get started?
2. What caused surfing to spread throughout the world?
3. How could knowledge of the ocean floor help surfers?
4. Hawaii has some of the best surfing beaches in the world. What conditions do you think make Hawaiian beaches so perfect for surfing?

Alternate Assessment

In a large, flat-bottomed plastic container, build a model of a section of ocean floor and seashore that would be a good location for surfing. Add water to your model and use a flat board, such as a ruler, to create waves. If a plastic container is not available to you, make a drawing of a cross section of ocean floor that would be ideal for surfing.

Name Date Class

Oil—Mexico's Primary Export

Activity 23

One resource has shaped the course of the Mexican national economy over the past 100 years. That product, petroleum, makes up about 70 percent of the nation's foreign-exchange currency. For Mexicans, flowing oil wells mean more than low-cost gas. They also mean more schools, more hospitals, and more jobs. In the 1970s and again in the late 1990s, oil and its products, such as gasoline, brought a great deal of money into the Mexican economy. They brought in even more money than did visitors from other countries.

A National Concern

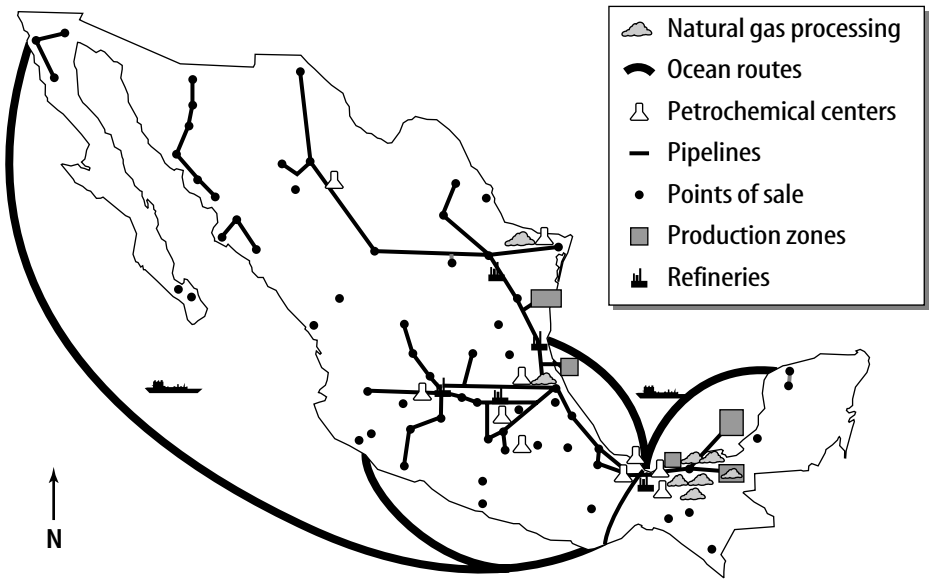
In most countries, private businesses own oil wells and oil companies. In Mexico, however, the oil business is controlled by the government. The government's oil company produces Mexico's oil, natural gas, and oil-based products. The profits help pay for schools, hospitals, and roads. Mexico is the fifth largest oil producer in the world.

Mexico began producing oil in 1901 and nationalized its oil production in 1938. Today, Mexico is the ninth largest exporter of oil and the largest supplier of crude oil to the United States. Oil and gas pipelines move these products to Mexico City, one of the largest cities in the world, and other cities in central Mexico. Pipelines also join up with pipelines in the United States. Mexico exports about half of its crude oil to other countries.

In the early 1900s, most of Mexico's oil wells were found on the coast along the Gulf of Mexico. Since then, oil has been discovered in the southern part of the country. In the 1970s and early 1980s, new oil was discovered near the Guatemalan border and in the Gulf of Mexico off the Yucatán [yoo kuh TAN] Peninsula. Most geologists believe there is much more oil and natural gas to be found in Mexico. They estimate that Mexico has produced only one-fifth of its total oil and owns enough to last well through this century.

The Need To Diversify

In the past, Mexico relied on its strength as an oil-producer to take out international loans. The loans were based on the price of oil and were used to supply almost 40 percent of the money for schools, hospitals, and other programs. When the price of oil fell in the mid-1970s, Mexico was burdened with foregin debt and domestic inflation, and the government had less money for important social programs. That's when the Mexican government decided to diversify. Mexico wants to develop other industries so that it won't be dependent on just oil and oil products. Marine resources are plentiful and there's talk of expanding Mexico's natural gas market.



Activity 23 (continued)

Oil Pollutes

Besides financial problems, the oil business has caused environmental problems for Mexico. Searching for oil and pumping it out of the ground has spoiled huge areas of land and marshes. Oil wells can leak. Oil tankers can accidentally spill millions of gallons of oil into nearby waters. Improper waste disposal can damage the land and the drinking water. Production of chemicals that use oil as an ingredient can harm rain forests.

Mexico and its trading partners, particularly the United States and Canada, recently have started many programs to protect Mexico's environment. For example, the North American Commission for Environmental Cooperation oversees programs to protect the environment from chemical pollution. It also provides funds to communities to help them carry out local environmental programs.

The government of Mexico has launched environmental prevention and cleanup programs, and has increased its monitoring and inspection efforts.

Economic Solutions

Some things about Mexico's state-run oil company are changing. It will continue its efforts to find more oil and dig wells to bring it to the surface. However, leaders in the government who took office in 2000 are making efforts to end the government's monopoly on petroleum. In addition, Mexico plans to increase its use and development of natural gas to reduce its reliance on oil. This move stemmed primarily from the need to use cleaner fuel in order to improve the environment. Natural gas likely will become the primary fuel for producing electricity in Mexico.

Active Reading

1. Where has oil been found in Mexico?
2. Based on geologists' predictions, what will happen to Mexico's oil economy?
3. Explain why Mexico's state-run oil company is an important part of life in Mexico.
4. How is the oil industry a problem for Mexico?

Alternate Assessment

Products that are made from petroleum oil are called petrochemicals. The most familiar ones are gasoline and motor oil, but there are many others. Research petrochemicals to find out the many everyday products that are made from them. Create a chart of your findings to share with the class.

Name Date Class

A Day of Destruction

Activity 24

On the morning of November 1, 1755, thousands of people in the Lisbon, Portugal, area were in church because it was All Saints' Day, a religious holiday. Others, however, were at home or near the docks. Then, at 9:40 A.M., an earthquake began, and church chandeliers began swinging to and fro—not just in Lisbon, but in places 2,240 km away. Spain, North Africa, and the south of France all were shaken violently for ten minutes.

A Modern Disaster

There were no seismographs in Lisbon in 1755. But if there had been any, seismologists think the earthquake would have registered at 8.8 on the Richter scale. An estimated 70,000 people died because of the Lisbon quake and its aftereffects. That would make the Lisbon earthquake one of the most devastating earthquakes of modern times—more terrible than the 1964 earthquake in Anchorage, Alaska, which measured 8.5, and more frightening than the 1906 earthquake in Valparaiso, Chile, which measured 8.6 and killed 20,000 people. Only the 1920 earthquake in Kansu, China, killed more people than the Lisbon earthquake—the Kansu earthquake measured 8.5 and killed 180,000.

Far-Reaching Effects

People felt the Lisbon earthquake even in areas which were not shaken violently. In Italy, Switzerland, Ireland, Scotland, the Netherlands, Germany, and Scandinavia, the water in lakes and bays was set into motion, like water in a bowl that is rocked back and forth. This phenomenon is called a seiche (SAYSH) and usually happens in areas far from the epicenter of an earthquake. During the Lisbon earthquake, every lake and bay from Italy to Finland experienced seiches. At the ports of Amsterdam, Rotterdam, and Dartmouth, seiches cause ships in dock to break their moorings. In all, the earthquake was felt in an area of 2.6 million km2.

More than 60 people were killed in St. Paul's Church in Lisbon by an earthquake and the fire that followed. The front entrance was blocked by rubble.

A Wall of Water

Not long after the Lisbon earthquake began, a tsunami (tsew NAH mee) hit. Tsunamis are caused by sudden earthquakes on the ocean floor. The water reacts as if it were being churned by a giant paddle and produces powerful waves at surface level. These waves move out from the area of the earthquake and keep going until they reach a coastline.

If you ever have been to the beach, you can understand what happens next. When a normal wave comes in, the water level is reduced momentarily, because the tide pulls water out and then crashes back in. When a tsunami comes in to a coast, water is sucked much farther out, sometimes leaving fish stranded on the beach. The wave can reach a height of 9, 18, or even 30 m. (So a tsunami is between 6 and 20 times as tall as a 1.5-m tall person.) Then it curls over and crashes upon the shore—exactly like a normal wave does, only it is much, much bigger. A tsunami coming in is often described as a "wall of water."

Activity 24 (continued)

Tsunamis often are more destructive than the earthquakes that cause them, and this also was true in Lisbon. In fear of the earthquake, many people crowded along the seashore, where they drowned. In some places, the tsunami caused the sea to rise 15 m above its normal level.

After the first shock at Lisbon there were two more earthquakes. One happened at 10 A.M., 20 min after the first earthquake, and the next occurred at noon. Both were very violent. Those parts of Lisbon built on rock were able to survive the shock to some extent, but the rest of the city was nearly destroyed.

The Final Act

After the noon earthquake, a fire broke out, completing the day's demolition. The 1755 Lisbon earthquake prompted the first modern scientific studies of earthquakes.

Active Reading

1. What is the difference between a seiche and a tsunami?
2. Why do you think that earthquakes are felt so far away from their epicenters?
3. What do you think are the main dangers in an earthquake? If you were in an earthquake, what safety precautions could you take?
4. In Lisbon, houses built on rock survived better than houses built on soil. What other features do you think would help a building survive an earthquake?

Alternate Assessment

Why do you think a seiche would occur far from the epicenter of an earthquake, but not at the epicenter itself? To help you answer this question, fill a cup with water. Then, move the cup up and down. Does a seiche form? Move the cup to the left and right. Does a seiche form? Research the formation of seiches and create a diagram or small model landscape to show the results of your experiment and your answer to the question.

Philip Emeagwali— Breaking All the Records

Activity 25

Philip Emeagwali has been called "one of the world's fastest humans." His title doesn't come from his performance on a racetrack but from his unique understanding of computers. In 1989, Emeagwali stunned computer specialists when he performed the world's fastest computer calculation to date—3.1 billion calculations per second.

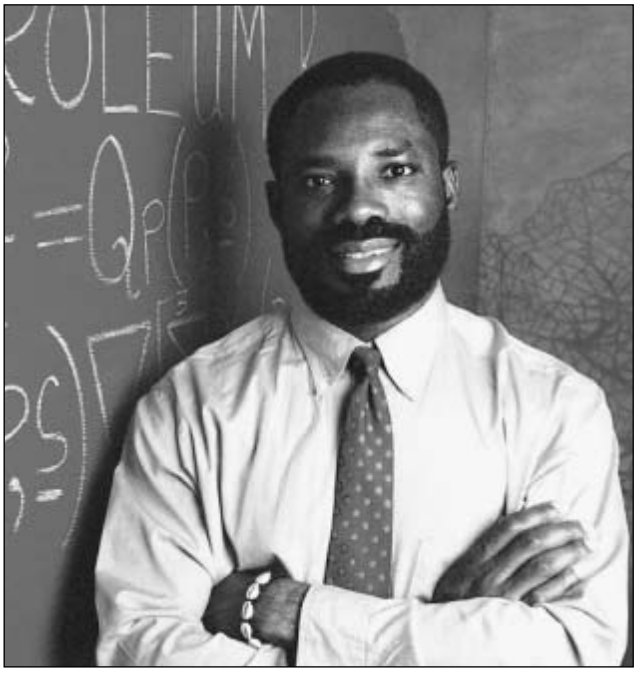
Math Whiz

Emeagwali, who now lives in the United States, was born and raised in Nigeria. The oldest of nine children, Emeagwali was forced to quit school at age 14. When he learned all the math that his father could teach him, he spent hours at a public library teaching himself higher-level mathematics, chemistry, physics, and English. When a civil war began in Nigeria, Emeagwali and his family fled to eastern Nigeria, living as refugees. Having to sleep in refugee camps, abandoned school buildings, and bombed houses was difficult but only increased his determination and dreams.

At 17, Emeagwali was awarded a scholarship to Oregon State University and moved to the United States. He majored in mathematics and would later earn four more degrees in scientific computing, ocean and marine engineering, civil and environmental engineering, and applied mathematics. While working on a doctorate degree, Emeagwali tapped into a list created by the U.S. government. The list included the 20 greatest challenges in science and engineering facing the United States. The list inspired Emeagwali to tackle the problem of how to recover oil more efficiently from underground reserves.

Cracking the Code

Most petroleum exists underground, trapped in the pores of rocks. Oil companies pump a substance such as gas or water into the ground to flush the oil out of the rocks. The oil then flows toward wells that pump it to the surface.



Philip Emeagwali performed the world's fastest computer calculation.

Oil companies use supercomputers that cost millions of dollars to help them figure out how oil will flow underground and what path it will take. In most cases, companies are able to pump out only about 10 percent of the oil flushed from the rocks. If the flow is cut off or if it shifts to another area, the company has to put in another well and tap into the reserve again. Engineers rely on the models they build with supercomputers to be able to predict where and how to extract the oil most efficiently.

Emeagwali combined his training in math, science, engineering, and computer science to devise a formula to tackle this problem in a different way. He used an existing computer called "The Connection Machine." The difference was that he connected this main computer to 65,536 small computers in order to speed up the oil-mapping process, which takes millions of calculations to complete. By doing so, he tripled the speed at which calculations could be made. As a result of Emeagwali's achievement, oil companies are now able to retrieve a larger percentage of oil from each reserve in a shorter period of time.

Activity 25 (continued)

For his work, Emeagwali was awarded the 1989 Gordon Bell Prize. The award is considered by most to be the "Nobel Prize" of computer science and is given by the American Institute for Electrical and Electronics Engineers. Usually, the award is given to teams of researchers, who use computers to solve an important problem. Emeagwali's award was unique because he developed this process working alone.

A Natural Approach

Emeagwali uses nature as a model for much of his thinking about computers. Many of his designs for computer operations are based on patterns in nature. "Being born and raised in a low-tech African environment enabled me to have a greater appreciation of the usefulness of drawing design inspirations and ideas from natural analogies," he said.

When studying the flow of oil underground, Emeagwali compared it to the flow patterns of water in oceans and air in the atmosphere. He used the geometric structure of a bee's honeycomb as a model to program computers to make them work more efficiently. He said, "The trial-and-error approach of nature yields more solutions than the logical approach used by humans . . . . However, after designing from nature, I use advanced mathematical methods to analyze my inventions."

Moving Forward

Today, Emeagwali continues to apply his research to solving problems. His computer systems are being used by many to help forecast the world's weather, to monitor the effects of global warming, and to track the spread of AIDS.

Active Reading

1. How is oil extracted from under the ground?
2. Why was Emeagwali's achievement important?
3. What hypothesis did Emeagwali come up with before he began his research?

Alternate Assessment

Emeagwali uses nature as a model for many of his designs. Find a human-made object that was patterned after something natural. Share the object or a picture of the object with the class and describe the characteristics that are similar. Then, explain the advantages or possible disadvantages of this design.

ALMA—World's Strongest Telescope Array

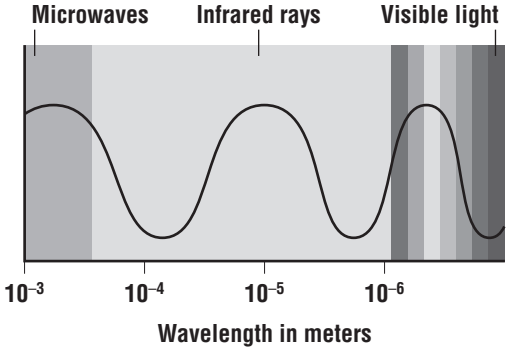
Activity 26

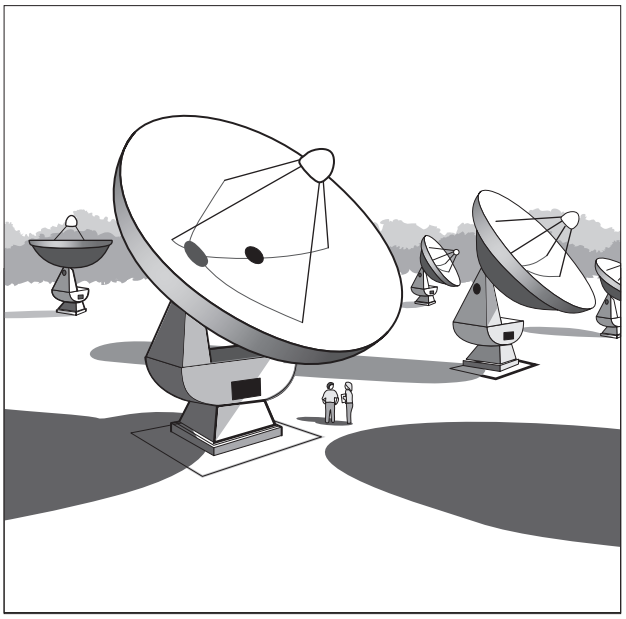
Imagine looking at the formation of the earliest and most distant galaxies, seeing images from space that even the powerful Hubble Space Telescope cannot capture. Thanks to ALMA, astronomers will get never-before-seen views of our solar system. ALMA, the Atacama Large Millimeter Array, is the world's first multinational observatory. It also is the largest of its kind, the strongest telescope ever, and the highest, sitting on the Atacama desert plateau nearly 4,900 m above sea level in the Andes Mountains of Chile. ALMA ultimately will cost $400 million to build and is due to be completed in 2009.

ALMA truly is an international partnership. The United States, Japan, and several European nations have joined together to build ALMA. The ALMA project has been called "the most ambitious and expensive ever built on Earth." It is a major step in the field of astronomy, since ALMA will allow scientists to study the origin of stars, planets, and galaxies.

A New Band

ALMA will use millimeter and submillimeter wavelength astronomy, a relatively new field. On the electromagnetic spectrum, the band for millimeter and submillimeter waves lies between the far infrared and high-frequency radio bands. These waves can help scientists tell how stars, galaxies, and planets were formed. By studying astronomical objects at these wavelengths, scientists can get a clear idea of how stars and galaxies were born.





ALMA will be an array of 64 giant telescopes.

Astronomers also will use millimeter and submillimeter waves to identify molecules in comets, dust clouds, and far-away galaxies. Millimeter and submillimeter waves are longer than light waves collected by regular telescopes. Therefore, astronomers would need an extremely large antenna to detect them. However, it's impossible to build a single antenna that can do what astronomers need it to do. Instead, an array of antennas will be used. In fact, ALMA will be an array of 64 giant telescopes, acting as one.

Astronomical First

One of the most exciting things about ALMA is that with it, scientists will be able to look back to a time when the universe was one-tenth its current age. Not even the infrared Hubble Space Telescope can do that. Hubble goes back only to a time when the universe was one-half its current age. With ALMA, scientists will be able to see what they call the early universe's "Dark Ages," a time when dust filled space. ALMA will locate early galaxies that can be mapped by astronomers over cosmic time.

Activity 26 (continued)

ALMA will detect and image thermal dust emissions of galaxies and stars, tracing their formation. In other words, it will image the universe in a way that's never before been done and with incredible sharpness and clarity. In addition, ALMA will make it easier for scientists to study other planets. Because the array is so powerful and can detect submillimeter waves, it will find other solar systems that scientists think exist but have never seen.

Clear and Dry

In the past, Earth's atmosphere has blocked the millimeter and submillimeter band so that astronomers could not see it. ALMA will be an extremely sensitive telescope array and will able to detect these hard-to-see waves. But in order to see them, the atmosphere above the telescope must be clear. Water vapor soaks up these kinds of waves, so scientists have to look above the atmosphere's vapor layers. By placing ALMA in a very high, very dry place, astronomers will be able to observe the waves. That's the reason Chile's Atacama Desert—one of the driest places on Earth—is a good place for it. Another reason why the Atacama Desert is ideal is that the peak where ALMA will be located is large enough to hold the huge observatory.

Working as One

Together, ALMA's 64 antennas will be positioned over an area that's larger than a soccer field. The antennas will move together, following a single object in the sky. All of ALMA's antenna signals will be combined by a large central computer called the Collator, making ALMA work as though it's a single antenna. Because ALMA will be so powerful, it will be able to create extremely clear images of what it sees. The fact that ALMA can cover such a large area with a high degree of accuracy means that it is a highly sensitive telescopic array. It will be able to pick up even the faintest cosmic signals.

The design and development of ALMA creates a partnership that allows many countries to share not only the financial responsibilities of such a large-scale project, but also a wide-range of knowledge and expertise. This new frontier of submillimeter waves has scientists from all over the world excited about the possibility of many new discoveries.

Active Reading

1. Why are millimeter and submillimeter wavelengths hard for astronomers to study?
2. Why do you think ALMA needed to be a multinational project?
3. Where will ALMA be located? How is this location significant to the project?
4. Explain the following statement: ALMA is an array of antennas that will be controlled by the Collator.

Alternate Assessment

Using colored pencils or crayons, begin with visible light and draw a spectrum that shows where infrared, high-frequency radio, and submillimeter wavelengths fall on the spectrum.

Biomass—Renewable Energy from Everyday Things

Activity 27

France, Belgium, Britain, Italy, Spain, and the United States all experienced a major energy crisis at the turn of the twenty-first century. This was unlike anything since the 1970s. Shortages in energy not only affected transportation and gasoline prices, but also electrical power. Looking at ways to get around the high price of oil and the limited availability of coal, oil, and gas (fossil fuels) has moved to the top of priority lists around the globe.

One potential source of non-fossil fuel energy is biomass. Biomass is any organic material that can be turned into energy to gas up our cars, heat our homes, power our computers, and more. Biomass is converted to energy either by burning it, fermenting it, or treating it with chemicals or bacteria.

A Plentiful Source

There's plenty of biomass to be used for energy. Because we can get more of it, biomass is called a renewable energy source. Most of our energy now comes from non-renewable sources such as coal, oil, and natural gas. These energy sources are called non-renewable because their supplies are limited; there's only so much coal or oil that can be mined. Burning fossil fuels has been shown to harm the environment. Fossil fuels release a lot of sulfur and other pollutants into the air. This causes environmental problems such as global warming and smog. Biomass, on the other hand, does not harm the environment. It does release carbon dioxide into the air, but plants and soil are able to absorb all of it. This means that biomass produces no pollution.

A New Industry?

Biomass is a source of energy that's of interest to the United States because it's reliable, renewable, and environmentally friendly. Biomass is becoming a kind of industry in this country. In fact, energy experts say the need for biomass could create new opportunities for farmers and others in the rural part of the United States.

The government is taking a big interest in biomass, too. The U.S. Department of Energy (DOE) is looking to reduce the nation's need for petroleum products imported from other countries. That's why it is providing grant money for several research projects. The DOE is looking into a method developed by pipeline researchers that compacts yard waste into logs that can be burned in ordinary coal-fired power plants. The DOE is also testing other kinds of technology, including one that magnetically separates mercury from coal, one that recycles the

Total Projected Biomass Supplies for Energy for the Year 2000 (exajoules per year)

Region	Forests	Residues	Energy crops	Total
Africa	2.43	6.81	18.94	28.18
Latin America	1.59	10.92	23.30	44.81
Asia	4.34	18.35	5.00	27.69
Australia and New Zealand	0.02	1.14	—	1.16
United States	0.61	5.86	9.60	16.07
Canada	0.04	1.43	4.20	2.67
Europe	0.89	10.13	13.00	24.02
Middle East	0.02	0.18	—	0.20
Total	9.94	54.82	80.04	144.80

unburned carbon in fly ash, and one that makes fuel from coal and sewage sludge.

In addition, combining biomass with fossil fuels, called cofiring, is one way to extend the use of fossil fuels. Already this is being done with gasoline for automobiles. Some gasoline contains up to ten percent ethanol, an alcohol product that results from the fermenting of biomass.

Brazil's Sugarcane

Brazil is another country that's looking at cofiring. Since Brazil is the world's largest producer of sugar from cane, Brazilian scientists are finding ways to use sugarcane. Sugarcane produces alcohol, which is added to gasoline or used alone to fuel cars. Some Brazilians believe that sugarcane pulp and the alcohol by-product could be used to supply ten percent of Brazil's electricity each year. Unfortunately, the growing period for sugarcane in Brazil is only six months each year. So, even though it's a renewable source of energy, it's not always available. Brazil also is researching ways to use waste from processing grain and forest products such as paper and cellulose as other sources of energy.

British Chicken and Straw

In Britain, a private utility company owns and operates two power stations, each of which uses biomass to produce power. One, in Fife, Scotland, uses approximately 100,000 metric tons of chicken droppings to produce 79,000 megawatt hours of power each year. The other is in Cambridgeshire, England. It's the world's largest straw-fired power station and uses about 180,000 metric tons of local straw to produce 283,000 megawatt hours of power each year. (One megawatt of power is enough to power 1,000 homes.)

Increasing Efforts

For now, the United States produces just three percent of its primary energy from biomass. The United States plans to triple that amount by the year 2010. Other countries, too, are looking to increase significantly their use of biomass. In fact, in the summer of 2000, 72 countries met in Seville, Spain, for the First World Biomass Conference. This historic gathering proved that international understanding and the use of biomass fuels could make a positive impact on the world.

Active Reading

1. How is biomass turned into energy?
2. Why do you think the United States and other countries already aren't using biomass as a primary source of energy?
3. Compare and contrast the use of fossil fuels with biomass.

Alternate Assessment

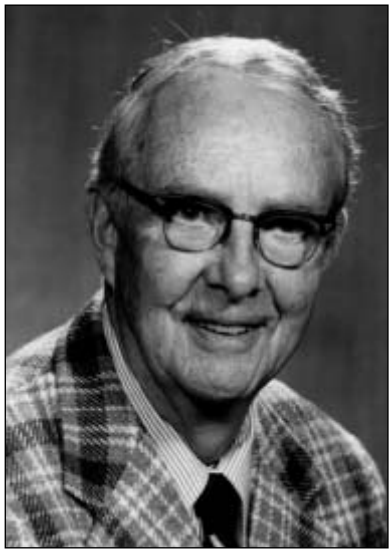
Find out what types of biomass are being used in your city or state. Make a collage showing the kinds of organic materials used in your area as renewable energy sources.

Luis W. Alvarez—Idea Man

Activity 28

Luis W. Alvarez was one of those rare thinkers whose questions led him into a wide variety of fields of study. His developments affected the fields of archaeology, optics (the properties of lenses), particle physics (the study of the structure and particles in atoms), and applied physics. During his lifetime, Alvarez was sometimes called "the wild idea man of physics" because of the wide range of his scientific discoveries and inventions.

What inspired him? Alvarez's father once advised him to take time regularly to put other matters aside and think of what new problems he could solve. Alvarez later was glad that he took his father's advice.



Inventor and scientist Luis W. Alvarez

Isotopes and Submarines

In 1938, when Alvarez was 27, he discovered that some radioactive elements undergo what is called the beta-decay process. The nucleus "captures" an electron but doesn't create a new element. Instead, he realized that it produces a new version, or isotope, of the atom.

When World War II began, Alvarez moved to the Massachusetts Institute of Technology (MIT) Radiation Laboratory. There, he began to develop the use of radar to detect submarines. At that time, airplanes hunting submarines already used radar. However, submarines could detect an airplane's radar signals as the airplane neared. This warning enabled the submarine's crew to take action, and the submarine would get away.

In response to this problem, Alvarez invented a new radar system called VIXEN. As a plane moved closer to a submarine, VIXEN produced a signal that got weaker and weaker, thus fooling the sub's radar-detection system. Alvarez also invented a type of radar that helps pilots land at night and in daytime when there is heavy fog or rain.

Exploring Atoms

After the war, one of Alvarez's first projects was to build a machine called a proton linear accelerator. This is a machine that smashes atoms. Atoms are sped up to incredible speeds, then smashed into each other, breaking the atoms apart. Much of what scientists know about the structure of matter comes from accelerators.

The Path to a Nobel Prize

Despite the fact that Alvarez invented many useful devices, his primary interest was in theories about physics. Some of the work that he is most famous for has to do with the particles of atoms. In 1939, he and a colleague were the first to measure the strength and direction of the magnetic field of a neutron, one of the particles in the nucleus of an atom.

In 1953, Alvarez decided to improve another scientist's invention, called a bubble chamber detector. This work led to major changes in the field of nuclear science, as well as to the discovery of over 70 elementary particles. Many particles (cosmic rays, for example) are so small and move so fast that the human eye can't detect them. The chamber, which contained a type of gas called diethyl ether, was designed to detect such particles and slow their pathways through the ether. The original model was very small—only about 2.5 cm across—and could be applied to only a few tasks. Alvarez decided to build one that would be more useful in particle physics.

Activity 28 (continued)

Alvarez's version of the chamber measured 183 cm across and contained liquid hydrogen instead of ether. He included computerized equipment that automatically scanned and measured the tracks of a particle. Alvarez also used a computer to store and analyze data.

With these innovations, Alvarez and his team discovered a large number of subatomic particles. They are the smallest particles of matter—smaller even than atoms—and exist independently for only a short time before they combine with other particles. Today, these particles are called *quarks.* For this work, Luis Alvarez was awarded the 1968 Nobel Prize for Physics.

Geological Discoveries

In the 1980s, Alvarez began working with his son, Walter, a geologist. In the 1970s, when Walter was excavating a site at Gubbio, Italy, he discovered an unusual layer of clay. Luis suggested that it be analyzed.

Walter already knew that it was about 65 million years old. But the analysis also showed that the clay contained high levels of a rare metal called iridium. There was only one problem. Levels this high are normally not found on Earth. However, they are common in asteroids. When the father-son team announced their findings, other geologists began to look for iridium. They found it on land and even beneath the ocean floor.

As people collected more and more data, Luis and Walter came up with a revolutionary idea. Perhaps, they said, an asteroid crashed on Earth about 65 million years ago. Perhaps the impact caused that extinction of dinosaurs. They estimated that such an asteroid may have been about 10 km in diameter, weighed one quadrillion metric tons, and moved at several hundreds of thousands of km per hour.

The Alvarezes' idea that an asteroid struck Earth 65 million years ago is strongly supported today. However, their hypothesis about the impact being the cause of extinction is still a hotly debated issue.

Ahead of His Time

Alvarez held patents for more than 40 of his inventions. Often he was far ahead of his time. For example, in 1963, Alvarez invented an optical system that held the lenses steady in cameras or binoculars. Someone finally used his system in the zoom lenses of video cameras—in the early 1980s.

Luis Alvarez always was quick to investigate a new idea or adventure. Having learned to fly when he was 23 years old, he flew his own planes until he was 73. That same spirit of determination left a legacy of important contributions.

Active Reading

1. Name three of Luis Alvarez's inventions that are used by people other than physicists.
2. Which of Alvarez's projects led scientists to a better understanding of atoms?
3. How did Alvarez's work lead to a better understanding of geology?

Alternate Assessment

Do research in order to create a diagram of the known structure of atoms and their particles.

The Camera—A Snapshot of Its History

Activity 29

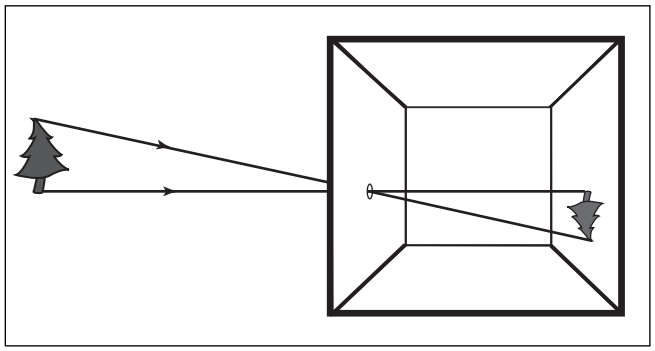
Discoveries that led to modern-day photography began much earlier than you might expect. Around 400 B.C., the Chinese made an important discovery when they realized that light entering a dark room through a tiny hole projected a fuzzy, upside-down image of the outside world onto the opposite wall of the room. The Chinese used such rooms to observe and record information about solar eclipses. The word *camera* actually comes from a Latin phrase meaning "darkened room."

The Camera Obscura

Later, during the A.D. 900s, Arabian scholar Hassan ibn Hassan, whose Latin name was Alhazen, laid the groundwork for camera lenses in the first major book on optics. It was called *The Optical Thesaurus* and described how light is reflected by mirrors or glass and even how the lens of the human eye works. Alhazen developed a mathematical formula that could predict angles of reflection between a light source and a spherical mirror. He also developed the camera obscura, which was a darkened box with a pin-sized hole. A lens was attached to the hole to focus the light onto the opposite wall of the box.

Chinese darkrooms left their mark on Europe, where many artists in the 1500s were working with the idea of the darkened room. However, in 1609, Johannes Kepler added a lens to the hole to focus light, just as in Alhazen's invention. By moving a sheet of paper back and forth, an artist could form a sharp image from the sunny outside world on the paper. The artist could then trace the image with a pen and color it to produce an accurate drawing of what was outside.

By the 1600s, Alhazen's camera obscura became more common. Kepler, as well as other scientists, used the camera obscura to study astronomy. In 1611, Kepler developed a portable version of the camera obscura. In contrast to a darkroom, an artist could carry one around.



As light enters through the hole of a pinhole camera, an image of the outside appears on the opposite wall of the camera.

In the box, lenses and mirrors could produce sharp, right-side-up images. Artists used this technique to trace life-sized portraits and landscape scenes in miniature. The camera obscura even was used by an English company to trace sketches onto its well-known china. In 1637, Rene Descartes compared the eye to a camera obscura—the retina at the back of the eye works like a wall opposite the pinhole.

The Earliest Film

In the 1600s and 1700s, several Europeans discovered that light turns certain silver salts and other chemicals dark. Objects were placed onto sheets of paper coated with silver nitrate solution. Then, the paper was exposed to sunlight. After a while, when the object was removed, a silhouette of the object could be seen on the paper. However, since the entire sheet of paper was sensitive to light, the entire paper eventually turned black unless it was kept in a completely darkened room.

Finally, in the 1800s, people found a way to make the images imprint themselves permanently on the paper. The paper was soaked in a weak solution of sodium chloride (table salt). Then, the paper was coated with silver nitrate. A reaction between the two chemicals caused the formation of silver sulfide. The paper was still light sensitive, but once it had been darkened, the images could be preserved by soaking the paper in a concentrated table salt solution.

Activity 29 (continued)

Photography for Sale

In 1827, Joseph Niepce produced the first photograph on pewter plates that had been covered with light-sensitive varnishes. Then, in 1839, William Talbot and Louis Daguerre each discovered the first light-sensitive daguerreotype (duh GAYR uh tipe). It was a photographic plate on which a camera obscura image could be held and permanently fixed. The exposure time was cut from hours to minutes.

Not until the introduction of another camera in 1888 did dramatic changes in the world of photography come about. The camera, developed by George Eastman, was preloaded at the factory with enough film for 100 exposures. Eastman's easy-to-use camera brought photography to the average person.

In 1900, a $1 camera was marketed to the public. Fourteen years later, the first 35-mm camera was developed, and in 1932, the invention of Technicolor brought color to the previously black-and-white motion picture industry. The art and science of photography continued to develop throughout the 1940s, 1950s, and 1960s with the introduction of better, faster film and improvements in film processing. The 1970s brought the first point-and-shoot camera and the 1980s ushered in the era of the disposable camera.

Modern Photography

The age of computers brought digital technology to photography. Instead of recording images on light-sensitive film, a digital camera acts like a kind of optical scanner that copies images onto the hard drive of a computer. In digital photography, changes in the intensity or color of light produce tiny patterns that can be translated into precise digital signals. The signals can be stored in the memory of the camera or on the hard drive of a computer and be called up at any time.

In 1984, Japanese news reporters gave digital cameras the first real-world test by using them to cover the Olympic games in Los Angeles. Then, in 1996, a Japanese manufacturer introduced a new model of digital camera for professional photographers. It allowed the user all of the technical control found on the most sophisticated film cameras, and had a built-in color, liquid crystal viewfinder, making framing a picture easy. It also allowed the photographer to review stored images on the viewfinder as soon as they were taken to find out whether another shot was necessary.

It's been a long way from the Chinese darkrooms of 400 B.C. to the twenty-first century digital cameras of Japanese manufacturers, but the journey is far from over. Improvements in camera technology are likely to continue.

Active Reading

1. What were the Chinese studying when they discovered how to use darkened rooms?
2. What was Alhazen's major contribution to photography?
3. What factors do you think influenced photography's spread to the masses?
4. How do you think the development of cameras and photography has influenced people around the world?

Alternate Assessment

Create your own pinhole camera. Create a simple design that you can build from household objects. Make sure you have adult supervision when making the pinhole itself.

Lise Meitner— The Test of Time

Activity 30

Lise Meitner has been called "the mother of the atomic bomb." While she didn't create the bomb and was publicly against its development, she did make a profound discovery that eventually would lead to its making.

Meitner was the co-discoverer of nuclear fission—the splitting of the nuclei of atoms. In her life she experienced gender discrimination, fled from Nazi Germany, and became history's often forgotten, famous physicist.

An Impressive Beginning

Born in Vienna, Austria, in 1878, Meitner was the third of eight children. In her family, all the Meitner children, including the five girls, received advanced educations. At the time, this was extraordinary because until the end of the nineteenth century, women were excluded from Austrian universities by law. She entered the University of Vienna in 1901, where she studied physics, calculus, chemistry, and botany and became interested in radioactivity.

She received her doctorate in physics in 1906, only the second woman to do so at the University of Vienna. In 1907, Meitner moved to Berlin, Germany. At the most important center for the study of theoretical physics, Professor Emil Fischer's chemistry institute, she met Otto Hahn.

Because she was a woman, Meitner was not allowed in the institute, so she conducted her experiments in the institute's basement. Two years later, she was allowed in, but many well-respected scientists still did not give her credit for her work. Meitner and Hahn eventually moved to the Kaiser Wilhelm Institute where Meitner oversaw the physics department and Hahn the chemistry department.

Discrimination and War

Early in her career, Meitner published several articles on radioactivity, but used only her first initial and last name. When the editors of a German encyclopedia contacted Meitner to submit an article on radioactivity, she responded and included her first name as well. Finding out that she was a woman, the editors suddenly were no longer interested.

During World War I, Meitner worked as an X-ray technician in the Austrian army, where she was assigned to a field hospital. At the same time, Marie Curie was doing similar work for France. Meitner and Hahn often coordinated their army leaves so they could return to their laboratory to continue their research. After the war, they were able to announce their discovery of the 91st element—protactinium.

In 1934, Meitner convinced Hahn to join with her to investigate the atomic nucleus and to seek elements beyond uranium, then the heaviest known atom. By bombarding uranium with neutrons, the researchers found a mix of radioactive particles that couldn't be identified easily. Meitner's job was to explain the nuclear processes that were occurring.

Escaping Persecution

Nuclear physics was on the brink of a major discovery when Hitler came to power in Germany. When the Nazis took over, Meitner was dismissed from her teaching position because she was Jewish by birth. Fearing for her life, Meitner escaped from Germany in 1938. Fellow physicists helped her escape to Sweden, and one arranged an appointment for her at the Nobel Institute for Experimental Physics in Stockholm.

A breakthrough in Meitner and Hahn's work came in late 1938. Meitner continued to correspond with Hahn, and she directed him to analyze more closely the by-products of their nuclear bombardment experiments. They were amazed to find that their experiments had resulted in the production of elements that were much lighter than uranium, rather than heavier.

Hahn asked Meitner to check his experimental methods for errors because he couldn't believe

Activity 30 (continued)

the results. When she did, she realized that the uranium atoms had split. Meitner explained that the uranium nucleus must have captured the neutrons, causing enough instability for the nucleus to split in two. Since there was an observed loss of mass, energy must have been released. She made the necessary calculations and predicted that Hahn's experiment should yield barium, krypton, and energy. She also predicted the existence of the chain reaction. She reported her findings in *Nature* in 1938. It was here that she first used the phrase *nuclear fission.*

However, Hahn published the chemical evidence for fission without listing Meitner as a co-author. That omission resulted in Hahn alone being awarded the 1944 Nobel Prize for Chemistry.

After the Discovery

Because of World War II, the discovery of fission led to the development of the nuclear bomb. Meitner, however, refused to work on the development of the bomb during the war. After the war, she was careful to make this fact known.

Meitner returned to her work on subatomic particles, especially concerning beta radiation. She became the recipient of numerous awards and accolades in the late stages of her life. She retired to Cambridge, England, where she died in 1968, shortly before her 90th birthday. Although she never received the Nobel Prize many people think she deserved, she will be remembered. In 1966, she, Hahn, and a colleague named Strassman were given credit by the scientific community in the form of the U.S. Fermi Prize.

A Newfound Respect

More recently, in 1994, the International Union for Pure and Applied Chemistry agreed that element 109, artificially created by slamming bismuth with iron ions, would be named meitnerium in her honor. Since 1996, a new biography of this important physicist has led to even greater recognition of her in the scientific community.

Active Reading

1. What obstacles did Lise Meitner have to overcome in order to pursue her work in nuclear physics?
2. What contributions did Meitner make to the field of nuclear physics?
3. How did Hitler's rise to power affect Meitner's (and others') research?

Alternate Assessment

Create a diagram showing the process of nuclear fission, along with an explanation of how it works.

A Universal Language

Activity 31

Melody, rhythm, and harmony each are a part of the universal language of music. The who, what, when, and where of music, however, can be as diverse as the many people that populate the planet. Yet, the sound of music—the how of it—always is rooted in science.

Musical instruments produce sound vibrations that can be detected by the human ear. Sometimes it is a solid substance that vibrates; sometimes it is a taut membrane or column of air; and sometimes it is a string stretched taut. Different geographical areas and cultures have developed a wide array of musical instruments, each creating a sound uniquely their own.

When different areas of a Caribbean steel drum are hit, different notes sound.

Catch the Beat

Most drums produce sounds by the vibration of membranes. Some of the most interesting of these membrane-vibrating instruments are found in Africa. The majority can play only one note in varying rhythms. However, in Nigeria, there is a drum shaped like an hourglass that has two heads laced together by leather thongs. When the middle of the drum is squeezed, the thongs tighten the membranes at each end, which changes the drum's pitch. A skilled player can imitate the tonal patterns of an African language with this kind of drum. These drums are called talking drums and can be used to communicate over distances.

Related to drums, xylophones are widespread in Africa. The Fang people of Cameroon and the Chopi people of Mozambique make xylophones with hollow gourds hanging beneath each key. The gourds pick up the vibrations of the keys and make a larger, more resonant sound.

Shaken Up

Sometimes instruments are shaken, hit, moved, or rubbed to produce music. Such instruments are known as idiophones. They can be made of ceramic, glass, wood, or metal. Two stones being hit together to create sound were the first idiophones. Idiophones don't require a membrane, column of air, or string like other instruments. The natural vibrations of the instrument body cause the notes and sounds.

Several of these instruments are used in the traditional music of South America and the Caribbean. Maracas were originally, and sometimes still are, hollow gourds containing seeds. They look like rattles and often are played as a pair. When each is held in one hand and shaken, together they produce a soft, hissing sound. Maracas probably originated in Puerto Rico. Now they sometimes are made of wood or clay and contain steel beads instead of seeds.

The *cabaça* is an instrument made from a gourd that looks like a rattle and has a cylindrical, drumlike head with steel beads strung around it and rattling pieces inside. When the cabaça is held in the air and twisted, or hit against the palm, the beads vibrate, making a scraping sound. It is the movement of the beads and the rattling pieces inside the resonating chamber of the gourd that produces a sound unique to Latin American dance music.

Activity 31 (continued)

Winds of Change

All wind instruments operate by the vibration of trapped columns of air. The *shantu*, played by the Hausa of Nigeria, is made of different-sized gourds fastened with cow skin. When air is blown through the gourds, a hypnotic buzzing sound is produced.

One of the oldest wind instruments is the panpipe, which is a set of tubes of varying lengths fastened together. Air blown through the tubes vibrates to create a clear sound. Some of the earliest panpipes found are from the Nazca culture of southern Peru, made around 200 B.C. Throughout the centuries, panpipes have been made of stone, baked clay, bone, wood, or hollow reeds. They were used in places as diverse as Greece, China, Romania, South America, and Southeast Asia.

Pipes that use vibrating reeds produce the nasal sound that we associate with clarinets, oboes, and bagpipes. A bagpipe is one or two reed pipes that receive air from an attached windbag. The windbag is inflated by blowing into it or by pumping bellows held under the arm. Changes in pitch are caused by covering and uncovering finger holes. You may associate bagpipes with Scotland and Ireland, but the first bagpipes originated in Asia.

Strumming a Tune

Instruments producing sounds by the vibration of stretched strings vary from one-stringed instruments, to complicated instruments with many strings of differing lengths. The Russian *balalaika* is a guitarlike instrument with three strings, a triangular body, and a long, wooden neck. Pressing the strings against the neck at different points shortens the strings to produce different pitches. Zithers are made by stretching strings over a flat board or box. The strings are picked and strummed. The Turkish *ganon* is a board zither that dates from the A.D. 900s but is still used today in folk music. The Japanese *koto* is a type of zither. Its 13 strings are made of silk.

Keyboards

Keyboard instruments have keys that are struck with the fingers. Each key plucks or hits a string or forces air through a pipe. The pipe organ began as a wind instrument around 300 B.C. and developed into a keyboard instrument around A.D. 1500. Each pipe produces a particular note and sound as a key is pressed on a keyboard. The harpsichord was perfected in the 1500s. Because its keys pluck strings, neither its tone nor the duration of a note played can be varied. The keys of a pianoforte, or piano, hit strings. Therefore, the piano also is a percussion instrument. This allows musicians to vary and hold a tone.

In 1761, electricity was combined with instruments to create music. Abbe Delaborde created an electric harpsichord in France. Throughout the 1800s, electricity was combined with mechanical elements to create musical sounds. These early inventions, along with advances in electronics during WWII, paved the way for electronic music synthesizers in the second half of the 1900s.

Active Reading

1. Why do you think that instruments around the world often have much in common?
2. What do you think might have been the first kinds of musical instruments made? Explain.

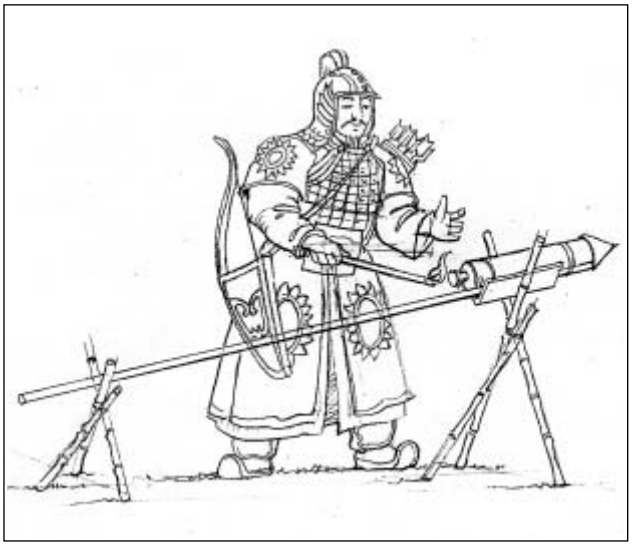
Alternate Assessment

With a partner, design and make a musical instrument. Your instrument can be a wind or stringed instrument, or a drum. Be creative in your design and decoration of the instrument. When your instrument is complete, demonstrate how it is played to the class.

Rocketry Starts with a Bang

Activity 32

Ancient warriors shoot flaming arrows across the battlefield to ward off an attack. Fireworks are launched into the night sky, to the delight of onlookers. The space shuttle is hurtled into the universe for exploration. The scientific principle at work in all three cases is the same—Newton's third law of motion. The law states that for every action or force in nature, there is an equal and opposite reaction.



A Chinese soldier launches a fire arrow.

The Law in Action

To visualize this law of motion, think about what happens to a gas such as air when it is heated. The molecules in the gas speed up, and the gas expands. Now, imagine that the air is inside a tightly sealed metal can. Inside the can, millions of molecules are moving in all directions, pressing against all sides of the can with equal force. When you view the can from the outside, nothing seems to be happening.

What happens if you poke a large hole in the bottom of the can? The millions of fast-moving molecules pushing against the top of the can continue to do so, but the millions of fast-moving molecules pushing downward escape from the hole in the bottom of the can. Then the can is propelled upward. The same process happens with fireworks and rockets.

A Startling New Tactic

No one knows exactly when rockets were invented. But they probably weren't built until the first explosive, a powder, was invented. This explosive powder also was the first gunpowder. When it is burned, it produces 60 percent solid residues and 40 percent by-products in the form of gas. When it is burned in a space with a limited air supply, such as a tube, the gas builds up.

The Chinese developed explosive powder as early as A.D. 100. The mixture probably was used first for fireworks and firecrackers, which were an important part of Chinese religious festivals and other celebrations. Early rockets most likely containing this powder were thrown onto fires to create explosions and lots of noise.

At some point, the Chinese began to attach rockets to arrows and then use bows to shoot the "fire arrows" into the air. Soon, they discovered that the power of the escaping gases alone could launch the rockets.

A Successful Trial

Historians think that the Chinese began to use rockets in battle starting around A.D. 1000. The first recorded incident was in A.D. 1232, during a war between the Chinese and the Mongols. During the battle of Kai-Keng, the Chinese filled tubes, capped one end of each tube, and attached them to long sticks to add stability during flight. When the rockets were lit, they produced fire and smoke. The gases pushed out the tube's open end, launching the rockets into the air.

By launching barrages of rockets at the Mongol troops, the Chinese won the battle. The Mongols, afterward, produced their own rockets and may have been responsible for the introduction of rockets in Europe.

Activity 32 (continued)

Lighting up the Sky

Today, many different flammable substances are used as propellants in most fireworks. The lit fuse rapidly burns into the core of the rocket and ignites the powder. The hot, expanding gases escape through a heat-resistant clay nozzle, providing thrust.

Additional chemicals in the rocket's nose cone create the firework's colors, sounds, and sparks. Just before the rocket reaches its highest point, when all of its propellant has been used up, a fuse in the nose cone produces a small explosion. This propels a spray of colored sparks. This spray is what you see as fireworks in the sky.

The Call of the Skies

The dream of soaring through space must be as ancient as humankind. One traditional legend tells of a Chinese official named Wan-Hu, who wanted to fly to the Moon. He ordered his assistants to build a large wicker chair fastened to two large kites and 47 large rockets. On the day of the flight, Wan-Hu seated himself in the chair, and 47 servants rushed to light the fuses. A tremendous roar followed and the air filled with billowing clouds of smoke. When the smoke finally cleared, the chair and Wan Hu were gone.

Active Reading

1. How does Newton's third law of motion work in the case of rockets?
2. What two major factors contributed to the development of rocketry?
3. At lift-off, the space shuttle, together with its fuel tanks, rocket boosters, and payload, can weigh over 12 million kg. How is it able to get off the ground?
4. A specially designed maneuvering unit allows a shuttle astronaut on a space walk to move about using small nitrogen thrusters that are controlled by the astronaut's hands. Based on the law of action and reaction you have read about, how might the thrusters work?

Alternate Assessment

Create a time line of major breakthroughs in rocketry, from the early Chinese rockets to the space shuttle.

Desalination—Solving a Middle Eastern Shortage

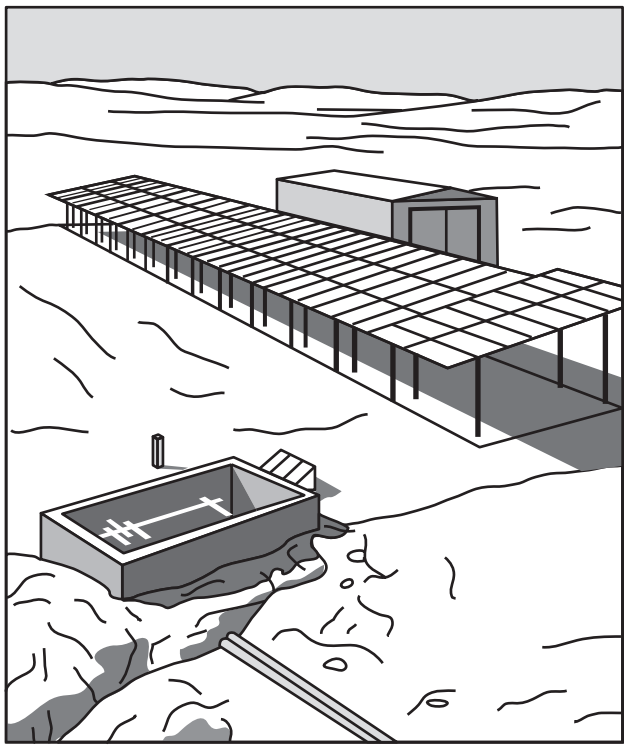
Activity 33

Although three-fourths of Earth is made up of water, only two percent of it is freshwater, and two-thirds of that is frozen. With the exception of drought conditions, Earth's water supply pretty much stays the same. The world's population, however, is growing, which means there's less water to go around. Seawater offers a plentiful supply. That's why so many drought-prone areas, such as the Middle East which only gets a few inches of rain each year, are looking for ways to tap into it.

Getting the Salt Out

Unfortunately, seawater is not drinkable because of its high saline, or salt, content. Removing the salt to make the water drinkable is done through a process called desalination. Although desalination is not a new process, technologies are making it more affordable than ever. In the late 1990s, desalinated water cost just one-tenth of what it had cost almost 20 years before. In the 1980s, desalinated water cost $5.28 per 1,000 liters, so it was said to be only for the very rich and the very desperate. Thanks to scientific advances, desalinated water dropped to just $0.53 per 1,000 liters in the late 1990s. In spite of that, the Middle East, which now produces 75 percent of the world's desalinated water, still has the highest average cost of water supply and sanitation in the world.

First used by Greek sailors in the fourth century B.C., desalination made its way to England in the 1860s, and to the island of Aruba in the 1930s. The Middle East has been using the process since the 1950s. During the 1970s and 1980s, the standard of living improved for the oil-rich countries in the Middle East. Population growth was running at three percent per year and the need for more water increased. So even though desalination then was a very expensive process, Middle Eastern countries needed the water they got through desalination and, more importantly, they had the money to pay for it.



A solar desalination system in the Saudi Arabian desert

More than 7.9 billion liters of freshwater continue to be made each day by more than 11,000 desalination plants located worldwide. The world's largest desalination plants are located in the Arabian Peninsula. Israel remains a global leader in water conservation techniques. But water has been so limited in the Middle East that at one time Middle Eastern business people even explored the idea of towing Antarctic icebergs to the Persian Gulf and the Red Sea.

Still, desalination continues to offer the most promise for providing necessary drinking water. There are two principal methods of desalination: distillation-based desalination and reverse osmosis. With the distillation-based method, salt water essentially is boiled. The boiled water produces a clean steam that then is condensed. In reverse osmosis, water is forced at high pressure through filters that take the salt out.

Activity 33 (continued)

Middle Eastern countries are more likely to use distillation-based desalination because gulf water contains more sediment and other things that are not easily filtered. In addition, there's much more salt found in the warm gulf waters surrounding that area than in Earth's oceans.

The lack of water has caused political conflicts in the Middle East. With a fast-growing population and limited water supplies, tensions can be high. Middle Eastern countries such as Iraq, Syria, and Turkey fight over the rivers they share. In the year 2000, Israel controlled approximately 80 percent of the West Bank's water sources, making water one of the contested resources between Israel and Palestine.

A Pipeline for Peace

Cooperation between countries is needed and has been talked about for many years. In the 1980s, Turkey's president suggested building a "peace pipeline." The pipeline would have begun at the Ceyhan and Seyhan Rivers in Turkey where water is plentiful. Water would have run through the pipeline and been delivered to the water-deprived nations in the Middle East. The project is still only an idea because of its high cost—somewhere between $5 and $20 billion—and the political differences among Turkey and Syria and other Arab countries.

Active Reading

1. Explain how the two primary methods of desalination work.
2. Why might a shortage of water also cause disease?
3. What impact on political tensions do you think the peace pipeline would have if it were built in the Middle East? Explain.

Alternate Assessment

Is seawater really undrinkable? Fill a cup with water. Add one tablespoon of salt to the cup and stir. Take a very small sip of the water. Then, write a report on seawater that explains salinity and includes information on which elements make up seawater. Include observations about your experience.

Aslihan Yener—Archaeological Detective

Activity 34

Aslihan Yener had been searching for the cave for a long time. Years of study indicated that answers to her unresolved questions lay close in the area. She tied a rope around her waist and peered into the dark, rock-lined opening in the side of a Turkish hill. Excited and frightened at the same time, she had a fellow archaeologist lower her down. "It was one of the scariest things I have ever done in my life," she said later. There, in an abandoned tunnel, Yener discovered what she had been searching for—Kestel Mine, a major source of tin for Bronze Age tools in the Near East.

Bronze Age Tin Mines

Between 3000 B.C. and 1100 B.C., a period named the Bronze Age, people made most metal objects out of bronze alloy, a mixture of tin- and copper-bearing metals. Swords, maces, bowls, hairpins, and blades for daggers or for kitchen use all were crafted from bronze. Before this time, tools had been fashioned from stone, so this was a great change.

Archaeologists had wondered for decades where people got the tin to make the bronze. Ancient records of the Assyrians, from an area consisting of present-day Syria and northern Iraq, claimed that they had brought it from tin mines thousands of kilometers to the east, in today's Afghanistan.

But Yener's discovery disproved all these claims. Much of the tin had come from the Kestel Mine and had been refined in the nearby town of Göltepe.

In a nearby area, Yener and her fellow researchers also discovered bones of those who had toiled in the mines nearly five thousand years ago—children. Twelve- to fifteen-year-olds had trudged up the mountain each morning, squeezed through narrow tunnels, and begun their day's work. They lit fires to soften the ore embedded in the tunnel's walls. Once the metal-bearing material had melted slightly, the child miners hit the walls with stone tools to loosen the ore. Other workers loaded the ore in baskets and dragged it through the tunnels to Göltepe, located on a hill 2 km away.

Separating Tin from Rock

In Göltepe, the ore was refined into tin. First, the workers washed the ore with water to separate relatively pure nuggets of tin. After pounding the nuggets to a powder, they emptied the crushed ore into heat-resistant bowls and poured burning charcoal over it. The bowls were made out of clay so that they could resist the shock of high temperatures. As the powder melted, the tin formed small droplets. These gradually cooled to form nuggets. Clay nozzels also were found near the site. After performing experiments to test the techniques, Yener and her colleagues determined that people blew air through the nozzles into covered containers to raise the heat of the fire enough for the smelting process. Yener and her crew uncovered an entire metal-working tool kit, including a movable pan to hold the hot coals, clay nozzles, heating bowls with a stone cover, ore crushers, ore powder, and ore nodules.

Activity 34 (continued)

A Change of Direction

As a professional archaeologist, Yener thinks of her discoveries at Kestel and Göltepe as a major step in understanding Bronze Age tool-making and trade in the Near East. In a more personal way, Yener's work has led her back to her family's roots.

Yener was born in 1946 in Istanbul, Turkey, a 15-hour drive from her most famous discovery. The following year, her parents moved to the United States. Yener showed an early interest in science, and when she went to college, she decided to study chemistry. But soon the lure of Turkey tugged at her, and she transferred to a university in Istanbul. There, she planned to study art history. However, she became more and more interested in ancient cultures buried under the classical ruins, so she switched to archaeology. Archaeologists study relics, artifacts, and monuments of past human life and activities. When she graduated from the Turkish university, Yener moved back to the United States to study for her Ph.D.

After Yener finished her degree, she returned to Turkey. She began to teach at Bosphorus University and to search for a Bronze Age source of tin in the Near East. In 1987, another scientist told Yener that he had found cassiterite, a kind of tin ore, in the foothills of the Taurus Mountains. There, Yener found the mine she had been searching for.

Yener has been working on this discovery ever since. In 1993, she joined the Oriental Institute of the University of Chicago and has directed a number of expeditions to Göltepe and Kestel. In 1994, scientists from this program conducted the experiment with the clay nozzles. She and her colleagues continue to explore the questions raised by her discovery. Was tin refining in Göltepe a cottage industry, with individuals or families working at home with their own equipment, or was it part of a more complex system? Were there specialists in each part of the process? How did the tin and bronze from this region find their way to other parts of the Near East? For Yener, finding the Kestel Mine was a groundbreaking experience in both senses of the word.

Active Reading

1. How was tin taken from the cave?
2. What was the clue that led Yener to Kestel Mine?
3. Why do you think tools made of bronze might be better than tools made of stone?
4. Why were children used to mine the tin ore rather than adults?

Alternate Assessment

Create a diagram of the tin-smelting process, based on further research. Include drawings of how the Bronze Age metalworking tools were used in the process.

Dr. Chien-Shiung Wu— Changing the World of Physics

Activity 35

A brilliant young woman arrived to study in a new country. Two decades later her work had turned the world of physics on its head. That young woman was the famous experimental physicist, Dr. Chien-Shiung Wu. She is most remembered for her influential experiments in nuclear beta decay.

The Science of the Atom

Ancient alchemists dreamed of turning one chemical element into another, thus producing gold from less valuable elements. But as atomic theory developed, their dream was shattered. Scientific observation revealed that an atom was a stable, indivisible unit of matter. Scientists believed that an atom could not change into something else.

The study of radioactivity in the early 1900s, however, brought about the realization that atoms do change during nuclear events. For example, the nuclei of uranium and some other elements are unstable. They gradually decay, or break apart into the nuclei of elements with smaller atomic masses. Such a process is a change in the chemical nature of the element itself. Marie and Pierre Curie gave this decay the name radioactivity.

As nuclei decay, they release particles and rays called radiation. Radiation consists of alpha particles, beta particles, and gamma rays. Alpha particles are positively charged nuclear particles made up of two protons bound to two neutrons. Beta particles are either electrons or positive particles that are equivalent to electrons and are known as positrons. Gamma rays are electromagnetic rays. Wu's lifetime of study was based on beta decay, the emission of electrons from radioactive nuclei.

Wu's Early Career

Wu, spent most of her career studying nuclear forces and structure. She was born in Liu Ho, China, in 1912. She studied physics at the National Central University in Nanking in the 1930s, graduating in 1936.

Physicist Dr. Chien-Shiung Wu

At that time, China was fighting a war against Japan. After earning her degree, Wu decided to emigrate to the United States. Once arriving there, she began studying at the University of California at Berkeley.

When Wu had finished her doctorate, she taught at Smith College and later at Princeton University. Then, in 1944, the Division of War Research at Columbia University in New York City hired her to work on the detection of radiation. Her new job gave her a chance to study the process of radioactive decay.

Challenging the Law of Parity

At Columbia University, Wu became well known for her experimental work in nuclear beta decay. Meanwhile, two scientists working with her, Dr. Tsung Dao Lee of Columbia and Dr. Chen Ning Yang of Princeton University, were already noted for their work in quantum theory physics.

One of the laws of quantum theory is the law of parity, a basic law of physics that compares

Activity 35 (continued)

the behavior of a subatomic particle with that of its mirror image. Basically, the law of parity holds that some objects are the mirror images of other objects. This would mean that the same basic principles that apply to one object would have to apply as well (in every detail) to an object that was its mirror image.

Wu's Famous Experiments

Up until this time, scientists had assumed that nuclear decay obeyed the law of parity. Lee and Yang, however, pointed out that the parity law had never been proven in nuclear reactions. To find out whether such reactions obeyed or broke the law, they asked Wu to perform some experiments. Although her experiments later won Wu great praise, Lee and Yang first doubted her results. Wu focused her work on the decay of cobalt-60, a radioactive form of the element cobalt. When cobalt-60 decays, it produces intense gamma radiation.

Wu wanted to examine the beta particles that were released during this process in order to see whether they obeyed the laws of parity. She performed the experiment in a cryogenics lab, where the cold temperatures required for the observation were possible. She then placed the cobalt-60 in a strong magnetic field and aligned the north and south magnetic poles in the atoms. Finally, Wu supercooled the nuclei and carefully watched the movement of the electrons emitted by the decaying nuclei. The electrons moved primarily in one direction. If the parity theory were true with nuclear reactions, the electrons would have moved from both the left and right sides in a symmetrical way. Her observations shattered this law of quantum theory. A few days later, fellow researchers at Columbia duplicated her results. Today, most scientists agree that this seems to be the case for all subatomic particles.

A Lifetime of Achievement

Wu's experiments confirmed her colleaques' hypothesis. In 1957, Lee and Young won the Nobel Prize for Physics. Although Wu did not win a share in the Nobel Prize, news about the experiments gave her world-wide attention. For her contributions, she was awarded the Research Corporation Award. Wu was elected to the National Academy of Sciences in 1958. Afterward, she continued to prove herself to be a tireless researcher. She continued her studies of nuclear beta decay, and in 1963 produced more evidence against the law of parity. In 1978, she became the first woman to receive the Wolfe Prize, as well as the first living scientist to have an asteroid named after her. These are just a few of the awards from a long list of those she received. Wu retired from Columbia in 1980 and died in 1997.

Active Reading

1. What did Wu's famous experiments reveal?
2. Do you think that Wu should have shared in the Nobel Prize for Physics? Why or why not?
3. What caused Lee and Yang to question the law of parity? Why is it important to test theories in many different situations?

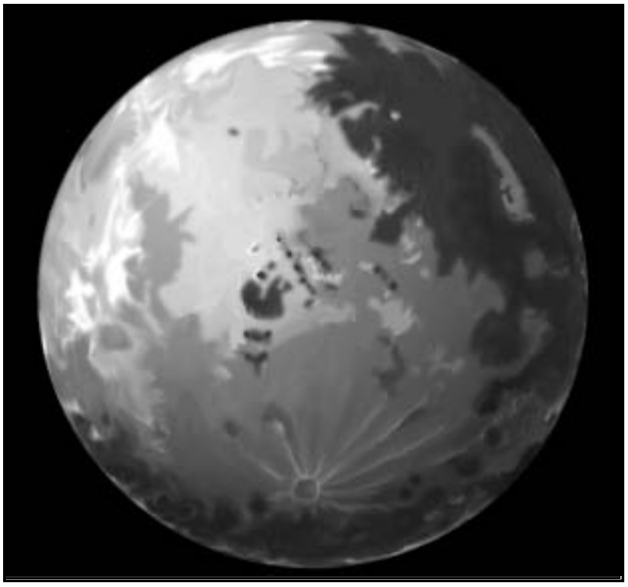
Alternate Assessment

Radiation cannot be seen, heard, or felt, but it can be detected. Find out how electroscopes, cloud chambers, bubble chambers, nuclear emulsions, and Geiger counters are used to detect radiation. Make a chart that explains how each device indicates the presence of radiation.

Watching Moon Cycles—Tradition and Science

Activity 36

For as long as humans have gazed up at the night sky, the changing Moon has filled them with questions. Over the millennia of human cultures, people have searched for ways to explain the changes in the appearance of the Moon as it moves through its cycles. Observation of the Moon and its cycles has inspired many myths and stories that give symbolic meaning to this natural phenomenon. Watching the Moon also has given people a way to mark time.



The Moon has been a source of wonder for thousands of years.

Because the Moon's motion around Earth is so regular, for thousands of years people have used the lunar month (28 days) to create calendars. They subdivided the solar year (the time it takes Earth to revolve around the Sun) into smaller periods of time. One solar year, however, is longer than 12 lunar months. Today, most cultures use calendars that adjust for this difference, so they are solar calendars, not lunar ones.

There are exceptions, however. The Jewish calendar begins in autumn. Its 12 months alternate between 30 and 29 days. It maintains a solar year by adding a certain number of days and inserting a leap year every so often. In a leap year, an extra day is inserted into the calendar.

The lunar Muslim calendar makes no adjustments for the solar year. As a result, as years go by, Muslim holidays such as Ramadan rotate through the seasons.

Myths About the Moon's Motion

Some cultures tell stories about the path the Moon takes every month. One Menominee (Native American) tale is about the Sun, Ke'so, and his sister the Moon, Tipä'ke'so. They lived in a wigwam in the east, and every month, at the New Moon, Ke'so would take his bow and arrows and leave to go on a hunt. Just as the Moon would begin to wax, the story goes, Tipä'ke'so would become worried because her brother had been gone so long. So she would leave and travel across the sky for 20 days until she found him. This reflected the 20 days during which the Moon was visible. The brother and sister then returned to the wigwam until Ke'so left for the next hunt.

Heng-o is the ancient Chinese mother of the Moon. Myths tell about her 12 children who were the 12 Moons of the year. One by one, Heng-o bathed her Moon children on the western half of the world, then for the 20 days of the lighted Moon, each child would travel across the sky to the eastern half of the world.

Using Lunar Months to Plan Holy Days

Lunar phases mark social, political, and religious events. Based in part on the lunar calendar, Thailand's Songkran Festival celebrates the end of one year and the beginning of a new one. The festival occurs during the month before farmers plant their crops. Today, Buddhists continue to rely on the phases of the Moon to indicate the holy days of each month.

Koreans also base their holidays on the lunar calendar. The first day of the First Moon is New Year's Day. The fifteenth day of the First Moon is also important because it is the first full Moon of the year. This night, under the light of the Moon,

people play traditional games and celebrate by cracking nuts and lighting firecrackers.

Some Native American cultures name specific full Moons according to the seasonal events. March's full Moon is the Full Sap Moon, because this is when the maple trees are tapped for their sweet sap. May is the Full Flower Moon, August is the Green Corn Moon, and October is Leaf-Falling Moon. Other Native American names relate more to events that take place during the entire month. For example, the Cherokee call January the "month of the cold Moon," and call March the "month of the windy Moon." The Lakota call April the "Moon of tender grass."

A Scientific Look at the Phases of the Moon

At various times during the Moon's revolution, the Moon might be between Earth and the Sun, on the far side of the Earth from the Sun, or any point in between. Because the Moon rotates at a particular speed about its axis, the same side of the Moon always faces the Sun. When we observe the Moon, we actually are observing the reflected light of the Sun bouncing off the Moon's surface. When the Moon is closest to the Sun, its lighted side faces away from Earth, so we see only a thin crescent called the New Moon.

During the next several days, the visible portion of the Moon increases. During this time, the Moon is said to be "waxing." When the Sun, Earth, and Moon are aligned in the right angle, half of the side that faces Earth, or one quarter of the total Moon surface, is visible. This is called the First Quarter. As the Moon continues its revolution at the midpoint, the entire near side (about one-half of the Moon's surface) is lit by the Sun. At this time we see the Full Moon phase. As the Moon's revolution continues, the visible portion decreases, or wanes, until the Moon is again at the New Moon.

The Dark Side of the Moon

Sometimes, during the New Moon, we can faintly see the dark side of the Moon as it faces Earth. This is because Earth reflects Sunlight, just like the Moon does. During the New Moon, that light reflects off Earth and illuminates the dark side of the Moon.

The relationship of Earth's daily rotation and revolution around the Sun with the Moon's motions means that the Moon moves eastward, relative to an observer, and appears to rise later each day. After the Last Quarter, the Moon is visible only in the morning sky.

Active Reading

1. What factors affect the changing phases of the Moon?
2. How do the Moon's phases help people regulate their lives?

Alternate Assessment

Create a model of the Moon as it moves through its five major phases. Show the Sun and Earth in relation to the Moon. You might choose to build five small stationary models instead.

Answer Key

Activity 1 _____ page 1

Lewis Mehl-Madrona—Pioneering Doctor

1. Answers will vary. Students should provide an example of something that makes them feel better when they are sick and explain why it helps.
2. Answers will vary. Students should give an opinion on how much medical personnel and hospitals should accommodate patients' cultural concerns. Students also should offer reasons to support the opinion given.
3. because he's doing some things differently than the way they have always been done; also, because some of his methods aren't medically proven as treatments

Alternative Assessment

Students' tables should have three column heads: "ailments," "traditional treatments," and "alternative treatments." Traditional treatments might include surgery, medication, chemotherapy, and physical therapy. Alternative treatments might include relaxation techniques, talk therapy, herbal therapies, and therapeutic touch.

Activity 2 _____ page 3

Japanese Cultured Pearls—Endangered Future

1. Natural pearls are more rare, making them more valuable. It takes longer to produce a natural pearl. Also, natural pearls have a thicker layer of nacre than cultivated pearls.
2. The price of pearls will skyrocket if scientists and farmers cannot solve these problems. Once pearl inventories run low or are gone, supply will no longer exceed demand. Prices rise when demand is high and supply is low. Prices also may rise because pearls will have to be imported from other countries such as Australia and China.
3. Abnormal weather conditions caused by an El Niño weather pattern could cause Japanese waters to be too cold. Cold water temperatures can kill the oysters and also cause changes in the ecosystem.

Alternative Assessment

Students' flow charts should be visually interesting and easily understandable, and should demonstrate careful research.

Activity 3 _____ page 5

Buffalo Jerky and Freeze-Dried Fish

1. Drying preserves meat by removing water. Bacteria cannot survive without water. Salt can be added to help draw water from food.
2. Pickling means that food has been placed in a salt, sugar, or vinegar solution. These solutions discourage bacteria from growing.
3. Some modern techniques, such as canning, refrigeration, and freezing, often use electrically powered devices and factory-produced materials. Traditional techniques instead rely on the Sun, wind, smoke, or additives such as salt and vinegar.
4. Food preservation allows for large amounts of food to be stored easily for large groups of people and improves nutrition during winter and times of scarcity for many people. Over time, people spent less and less time growing and preserving food for themselves and their families, instead purchasing much of their food in markets.

Alternative Assessment

See students' concept maps. Verify that the chemicals that they have chosen are, in fact, preservatives and not sweeteners, flavor enhancers, or vitamins.

Activity 4 _____ page 7

Coral Reefs at Risk

1. With an excess number of sea urchins scouring the corals for food, the reef is being destroyed faster than the corals can rebuild it.
2. The reef is an important ecosystem where many different species live. The reef also provides an important source of food and medicine and helps protect the coastline. The reefs also indicate the overall health of the surrounding ocean.
3. If the entire reef died, the sea urchins would lose their food source and eventually would die out as well.
4. Crown-of-thorns starfish feed directly on coral; thus, when overpopulated, they can damage coral. An overpopulation of algae causes oxygen levels in seawater to drop, starving coral of necessary oxygen.

Alternative Assessment

Students' food chains should demonstrate their research on coral reef ecosystems. Some species that students might mention include spiny lobster, grouper, giant clams, and sea cucumber.

Activity 5 _____ page 9

Whales—To Hunt or To Protect?

1. They use meat for food, oil for light and heat, and bone as framework for their homes.
2. Whales became extinct because they were over-hunted for commercial purposes. The problem began in the 1600s, when large-scale hunting with colonial whaling ships began.
3. Modern hunts are different today because the Inupiat now use technological advances such as dart guns and shoulder guns, rather than harpoons and lances. The structure of the crew no longer follows traditional guidelines, and whaling captains today must have enough money to purchase guns for their crew.
4. Students' answers will vary. Students should provide reasons for their opinions based on the reading or background knowledge of the subject.

Alternative Assessment

Students' posters should clearly show where several whale species live and how many of each are living. Posters can feature a drawing of the globe or a chart. Students should be able to answer questions about threats to the whales' survival.

Activity 6 _____ page 11

El Puente—Bridge to Environmental Justice

1. Vehicles on the roadways, garbage incineration, and factory emissions contributed to air pollution; underground oil spills contributed to ground and water pollution; garbage sites contaminated the ground and were unsightly.
2. Young people are being informed of environmental issues and are working to improve the environment.
3. Students' answers will vary. Students should mention at least one specific change they would like to see that could be carried out by a student group working on a project and give one idea for a community project that could be started. This answer will help them with the research activity.

Alternative Assessment

Students' proposals should deal with a community issue and reflect a science-related goal for addressing the issue. The goal and necessary steps should be clearly stated and organized.

Activity 7 _____ page 13

Unraveling a Prehistoric Food Web

1. She found that while wild animals tend to be shy and flee when approached, dung remains and can be studied for information about the animal that left it.
2. She found evidence of dung beetle activity in the blocks. Dung beetles eat only dung.
3. Students' answers might vary. Scientists can learn about animals' diets and the creatures that depended on this waste material. They also might learn about an animal's migratory behavior and whether it preferred to be solitary or live in groups. They also can learn about the interdependent relationships among different creatures.
4. Chin learned that *T. rex* didn't eat its food whole; rather, it crushed the animals it ate with it's mighty teeth.

Alternative Assessment

Students' food webs should be clear and based on careful research.

Activity 8 _____ page 15

Acupuncture—Modern Uses for Traditional Medicine

1. The idea behind how acupuncture works is that opposing natural forces must be balanced, and the flow of energy should not be blocked.
2. Acupuncture prompts the nervous system to produce endorphins, which are natural painkillers. It also may trigger the release of the body's own anti-inflammatory agents.
3. Acupuncture is based on the philosophy of *yin* and *yang*, while Western medicine is based on treatments proven by science.
4. The Chinese explain acupuncture's effectiveness as a result of restoring the proper flow of energy that's believed to flow to all parts of the body. Westerners can't explain how it works scientifically, but some have experienced its benefits.

Alternative Assessment

Students should demonstrate that they have used reliable sources of information and provide a clearly organized visual to the class.

Activity 9 _____ page 17

The Reawakening of Sleeping Sickness

1. The disease was left untreated for several years and had become resistant to traditional medications used to treat it.
2. Researchers are releasing infertile male tsetse flies.
3. access to early treatment, availability of medication, protection from infection, and control of the tsetse fly population

Alternative Assessment

Students' drawings should include accurate representations of the infection process. Students should be able to answer questions about the process.

Activity 10 _____ page 19

Biodiversity—Planting the Seeds for a Healthy Planet

1. rice, corn and wheat; three crops out of a possible 30,000–80,000
2. Biodiversity in food crops is a form of insurance that allows plants to adapt to a constantly changing environment. Biodiversity gives people access to highly nutritious foods that might not be as widely available.
3. Commercial growers want to save time by cultivating fewer main crops. They grow and market the ones with the widest commercial appeal.
4. Individuals and families can grow some of the non-commercial varieties in their own gardens.

Alternative Assessment

Students' graphs of charts should be clearly labeled, easy to read, and supported by research. Students should be able to answer questions based on their research.

Activity 11 _____ page 21

The Fight Against Killer Caterpillars

1. They sting to protect themselves from predators. They might sting if a person approaches their food supply.
2. Scientists had to know where the caterpillar originally lived (the rain forest) and what its natural enemies are (wasps). Then, by knowing that its habitat was changing and its natural predators had been eliminated, scientists could determine why the population was increasing.
3. Rain forest was turned into farmland. Then, crops were grown on the land and farmers applied pesticides to protect the crops. As a result, the pesticides killed the caterpillars' natural predators, wasps, so the caterpillars spread.
4. It might try to discourage the use of pesticides, develop crops that are naturally resistant to pests, reintroduce the wasps to the ecosystem, or provide a border between fields and forest where pesticide spraying is not allowed.

Alternative Assessment

Students' drawings should be clearly labeled and accurate. Students should be able to answer questions about the life cycle and stages of the caterpillar.

Activity 12 _____ page 23

Cancer—Uncovering the Culture Connection

1. Risk factors include diet, smoking, exposure to cancer-causing substances such as chemical pollution, lack of access to health care, and family medical history.
2. The heavy use of pickled, salted, and cured foods might cause stomach cancer. Fresh fruits and vegetables, which provide vitamins A and E, are rarely consumed.
3. avoiding preserved foods, eating fresh produce, consuming all necessary vitamins, avoiding tobacco, and staying informed about new research on the subject
4. Studying other cultures can provide information about natural treatments, traditional health care techniques, and habits that lead to improved overall health, such as lowering the rate of heart disease caused by stress.

Alternative Assessment

Students' posters should be based on research from reliable sources.

Activity 13 _____ page 25

Ellen Ochoa—Space Delivery

1. She had degrees in science, physics, and electrical engineering and had conducted extensive research involving optical and computer systems.
2. to deliver supplies to the ISS
3. Answers will vary, but students should recognize that an international space program fosters cooperation among nations and provides an opportunity to pool knowledge.

Alternative Assessment

Time lines should track the progress of the construction of the ISS, beginning in 1998, and include brief descriptions of what was accomplished at each stage.

Activity 14 _____ page 27

Dawn Wright —Deep-Sea Explorer

1. GIS does not interpret three-dimensional data well. The ocean is three-dimensional because it also includes depth.
2. Fissures provide oceanographers with important clues about the nature of volcanic eruptions and the formation of hydrothermal vents.
3. Students' answers might vary; heat, pressure, movement of the tectonic plates, chemical interactions.

Alternative Assessment

Students' models should clearly and accurately represent a portion of the ocean floor identified in their research.

Activity 15 _____ page 29

The Maya—Keepers of Time

1. They told time by keeping track of the movements of the Sun and Moon and by observing their rising and setting times in relation to objects on the horizon.
2. They need to know when to plant crops and when to prepare for different types of seasons.
3. Students' answers might vary. Students should deduce that the Maya calculated the length of the solar year based on their observations of spring equinox, summer solstice, fall equinox, and winter solstice.
4. Students' answers might vary. Students may mention that an observatory's sighting holes make it easier for a person to focus on one particular star or constellation, and that the exact date the Sun reaches its highest point can be determined precisely using the observatory's vertical sighting tube.

Alternative Assessment

Students' charts should be clearly organized and show daily rising and setting times and positions for at least one month. If students observed a star, encourage them to find out the name of the star by looking in astronomy guides.

Activity 16 _____ page 31

Adriana Ocampo—Making an Impact

1. The Chicxulub crater in Mexico provides evidence of a major impact. The crater is huge, and the rocks in and around it are the types of rocks that form when an impact occurs.
2. Organisms could be killed directly by earthquakes, tsunamis, or fires. Also, the soot, dust, and gases that block out sunlight would make photosynthesis impossible. This would cause plants to die and become extinct, along with the animals that depend on the plants for food.
3. Studying the surface of other planets reveals how those planets might have formed and how they respond to events such as asteroid impacts. These discoveries can help scientists learn more about the history of this planet.
4. If countries don't work together, exploration becomes competitive and scientific information is not shared openly. This slows learning and can create conflict over discoveries and areas of space.

Alternative Assessment

Students' drawings should clearly and accurately show known geological features of the crater. The students should be able to answer questions about the crater's impact, based on their research.

Activity 17 _____ page 33

The Ancient, Rising Nile

1. Students' answers might vary. Students may mention that rivers such as the Nile provide water and soil for growing crops successfully. Growing crops requires that people live a settled life in one place. When they do this, they may be more likely to develop skills associated with civilization, such as those needed to build permanent shelters and to keep track of crops and animals.
2. They needed the calendar so they would know when to expect the floods, when to plant, and when to harvest.
3. Some advantages are a longer growing season and a constant water supply to generate electricity and to save for times of drought. Disadvantages are the need to use expensive fertilizers, the pollution of the river, the erosion of the soil line, and the infection caused by snail worms.
4. Students' answers might vary. Students should explain why they think the advantages outweigh the disadvantages or vice versa.

Alternative Assessment

The models should show flooding of the Nile and show how the Aswan High Dam works and where the water is reserved. Consider allowing students to work in small groups in order to complete the model.

Activity 18 _____ page 35

The Ancient African Art of Metalworking

1. They controlled the temperature by controlling the amount of air forced into the pipes.
2. Clay is able to withstand the high temperatures of smelting.
3. Students' answers might vary. Students may list weapons such as spear and arrow points and swords; for tools they might mention ax blades, knives, and cutting tools—maybe drills, hammers, and possibly agricultural tools.
4. Students' answers might vary. Students may mention its hardness. They may realize that it can have sharp edges that make it good for cutting. Because it is malleable, it can be made into a variety of shapes. It is strong and durable and, therefore, suited to things that are meant to last, such as memorials and religious objects. Its luster adds to its beauty.

Alternative Assessment

Ask students to present their exhibits to the class. Consider asking students to prepare the exhibits in small groups. If possible, invite a sculptor who uses the lost-wax method to class.

Activity 19 _____ page 37

Like Salt in the Bank

1. The trade began because many people did not live near the sea, where salt was easy to obtain.
2. Because everyone needed salt, the governments could make a lot of money from regulating it.
3. Students' answers might vary. Students may suggest that salt is more easily available throughout the world because of advances in technology and transportation.
4. Students' answers might vary. Students may note that sodium and chloride are elements that are present in many naturally occurring substances. Students may suggest that sodium and chloride can't leave Earth, but instead they appear in different forms depending on the circumstances. Also, Earth's oceans are a major source of salt.

Alternative Assessment

Students should provide a percentage of salt in the water and be able to answer the questions about the solar evaporation process.

Activity 20 _____ page 39

Jade—Gemstone of Kings

1. The green might have been a symbol of green ears of corn or pools of water. The stone probably symbolized wealth and status since rulers wore it and were buried with it.
2. Jadeite ranges in color from pale green to light purple.
3. Carving jade was difficult because the Maya didn't have metal tools. They had to slowly wear down the jade with water and sand. The molecular structure of jade also makes it an especially hard substance.
4. They might have thought that the rulers needed the objects for the afterlife, or they might have been showing respect by burying along with the dead such a valued substance that had been so carefully crafted.

Alternative Assessment

Students' charts should show several different minerals and gemstones and show their meanings in different cultures. They should be illustrated in an interesting, clear, and accurate manner. Ask students to provide a list of sources they based their charts on.

Activity 21 _____ page 41

Harnessing Sunshine

1. Solar power sometimes is collected with curved mirrors that concentrate the Sun's energy to produce heat and steam. This energy is used to heat steam, which in turn, produces electricity. Solar panels also are used. They have cells that store energy and convert it into electrical current. It can be stored in batteries for up to five days.
2. Some drawbacks of solar power are the expensive equipment it requires and the fact that it is hard to store. Also, if the Sun is blocked for a long period of time due to events such as wildfires or volcanic eruptions, the power supply also is blocked.
3. Students' answers might vary. Students may suggest that solar power is attractive because solar energy is available everywhere and because sunshine is a free, renewable, and nonpolluting source of energy.
4. Students' answers might vary. Students may suggest the following reasons: the high cost of kerosene, pollution caused by burning kerosene, the difficulty of getting kerosene, and the nonrenewable nature of petroleum products.

Alternative Assessment

Students may use glass, pieces of hard plastic, lenses, or mirrors to make their heaters. They should take the temperature of the water at different time intervals and note how much the temperature rises each time. How long does it take to heat the water 5°C? How long does it take to heat it 20°C? Does the amount of water to be heated affect the time it takes?

Activity 22 _____ page 43

Pioneers of the Surf

1. Surfing probably started as a way to help people catch fish for food.
2. Duke Kahanamoku introduced the sport to mainland United States and to Australia, and the sport then spread from those places.
3. Students' answers might vary. Students may suggest that by knowing whether the ocean floor is steep or gradual, or whether there is a reef or a sandbar offshore, a surfer could determine the best places for surfing.
4. Students' answers might vary. Students may mention the warm, coastal waters, sunshine, sandy beaches, offshore reefs or sandbars, and gently sloping ocean bottoms of Hawaii's coasts.

Alternative Assessment

Models should show sandbars offshore and have a gently sloping ocean bottom. Drawings should show these same features.

Activity 23 _____ page 45

Oil—Mexico's Primary Export

1. Oil has been found along the Gulf Coast and in the southern part of the country, near the Guatemalan border, and off the Yucatán Peninsula.
2. Geologists think that most of the oil in Mexico (four-fifths) has not been discovered and that the oil economy will be healthy for a good part of this century.
3. Its profits help pay for many important social programs in the country, such as schools and hospitals.
4. When an economy is based on one industry, it has little to fall back on if that industry falls on hard times. Also, the oil industry can cause pollution of the air and water.

Alternative Assessment

Students should illustrate several industrial as well as household products. Consider expanding the project by asking students to study the environmental effects of the petroleum industry, the need for alternative energy sources, and the possible alternatives to petroleum products.

Activity 24 _____ page 47

A Day of Destruction

1. A seiche occurs in lakes and ponds far from the epicenter. A tsunami produces ocean waves that move from the area of the earthquake and keep going until reaching land.
2. The ground moves so forcefully that it sends out vibrations in the ground for hundreds of kilometers. The quake will be felt throughout the continental plates that are moving and causing the phenomena.
3. Students' answers might vary. Students may mention that the danger comes from the shaking of the ground, which can cause objects to fall and structures to collapse; water disturbances such as seiches and tsunamis; and fires. Students may suggest safety precautions such as remaining calm, getting under a table, staying inside if you are inside and staying outside if you are outside, and not using candles, matches, or any kind of open flame.
4. Students' answers might vary. Students may suggest building with strong materials, reinforcing the structure, or building more flexible structures.

Alternative Assessment

If students build a model, they should use a material such as bubble wrap, foam, or batting to demonstrate how the movement travels through the ground.

Activity 25 _____ page 49

Philip Emeagwali—Breaking All the Records

1. Oil is trapped in the pores of rocks, so gas or water is used to flush the oil out of the rocks. The oil flows to nearby wells that pump the oil to the surface.
2. It enabled oil companies to extract oil more efficiently.
3. Students' answers might vary, but hypotheses should include reference to his use of a network of smaller computers.

Alternative Assessment

Each student should identify at least one example of a manufactured object that uses nature as its model, and explain the similarities to the class.

Activity 26 _____ page 51

ALMA—World's Strongest Telescope Array

1. Millimeter and submillimeter wavelengths are longer than other waves of light. Scientists haven't been able to see them previously. ALMA will be a powerful telescope located high enough so that they can see the waves above the atmospheric vapor layers and study them.
2. ALMA needed to be a multinational project because it's going to be very expensive. Having money and knowledge from many countries is the only way ALMA could be built.
3. ALMA will be located 4,900 m above sea level on the Atacama desert plateau, in the Andean Mountains of Chile. This location's atmosphere is very clear and dry, making it possible for ALMA to detect millimeter and submillimeter waves.
4. An array is a group of many telescopes or antennas. The Collator is a large, central computer that will control the telescopes, allowing them to work as though they were one very large antenna.

Alternative Assessment

Students should draw a spectrum that shows purple, blue, green, yellow, orange, and red waves of visible light. Infrared wavelengths should be just after visible light on the spectrum and high-frequency radio waves on the opposite end. Submillimeter waves should fall somewhere between the infrared and radio waves.

Activity 27 _____ page 53

Biomass—Renewable Energy from Everyday Things

1. Biomass can be turned into energy by burning it, fermenting it, or treating it with chemicals or bacteria.
2. Biomass must be processed before it can be used. Collecting, transporting, and storing biomass can be expensive.
3. Fossil fuels, such as coal, oil, and gas, are non-renewable sources of energy while biomass is a renewable source. Supplies of fossil fuels are limited and supplies of biomass are not. Burning fossil fuels harms the environment by releasing pollutants into the air, but biomass does not harm the environment; it releases only carbon dioxide, which is absorbed by plants and soil.

Alternative Assessment

Students should use pictures, drawings, and actual organic material in their collages to demonstrate biomass use in their community. Examples include corn, trees, garbage, paper pulp, wood, straw, and seaweed.

Activity 28 _____ page 55

Luis W. Alvarez—Idea Man

1. a radar system that helps airplane pilots land at night and in other conditions of poor visibility; the proton linear accelerator, which helps scientists understand the structure of matter; the optic stabilizer used in zoom lenses for shoulder-held video cameras
2. The proton linear accelerator and his work on the bubble chamber led to a better understanding of atoms.
3. His idea to study the strange rock layer at his son's geological site led to the discovery that asteroids landed on Earth about the time dinosaurs became extinct. This theory led other scientists to search for and find crater sinkholes that indicate that asteroids large enough to cause mass extinction crashed into Earth around that time.

Alternative Assessment

Students' diagrams should be accurate and clearly labeled. Students should be able to answer questions about how particles act and how Alvarez's work helped make discoveries about them.

Activity 29 _____ page 57

The Camera—A Snapshot of Its History

1. They were studying solar eclipses.
2. He developed the first camera lens by studying how light is reflected, and he developed a formula to predict angles of reflection.
3. George Eastman's camera for the everyday person; the continued availability of inexpensive cameras
4. Students' answers will vary. Students might mention that both photographs and movies have expanded people's worlds and imaginations, taking them from their backyards to places around the globe, and even to outer space. Cameras and photography also have increased our ability to communicate and record history.

Alternative Assessment

Students' cameras should be black inside and have a place to load and remove a film sheet. The pinhole should have a cover over it to act as a shutter. A darkroom is necessary for loading and unloading film (only one shot before reloading), so if a school darkroom is not available, arrangements might be made with a local developer.

Activity 30 _____ page 59

Lise Meitner—The Test of Time

1. She had to overcome prejudice against women in order to obtain an education and find work and recognition. She also had to overcome prejudice against Jews in Nazi Germany.
2. She discovered element 91 (protactinium), discovered and named nuclear fission, and explained the nuclear processes that occur in nuclear fission. She also predicted the existence of the chain reaction.
3. They were on the brink of a major discovery in nuclear physics when Hitler rose to power, so their work was delayed. In addition, many were fearful that their work would lead to the development of the atomic bomb.

Alternative Assessment

Students' diagrams should be accurate and clearly labeled. Students should be able to answer questions about the process of nuclear fission.

Activity 31 _____ page 61

A Universal Language

1. Students' answers might vary. The idea for a particular instrument, such as a bagpipe, may have traveled through trade from one part of the world to another. Also, there only are a few basic ways of producing sound vibrations, and all instruments must rely upon these methods.
2. Students' answers might vary, but students should be able to support their answers with logical explanations. Students might suggest that percussion instruments, such as drums, might have been made from animal skins stretched over a hollow log or animal bones or horns that were hit together.

Alternative Assessment

Students should be able to explain what family the instrument belongs to and explain how it works.

Activity 32 _____ page 63

Rocketry Starts with a Bang

1. Air is heated in a closed container and its molecules expand. If the surface is punctured, air rushes out of the bottom while the molecules at the top are still pushing forward. The object is propelled forward.
2. defense and space exploration
3. Upon ignition, billions upon billions of high-speed gas molecules are all pushing down on the ground at the same time, producing enough thrust to propel the shuttle off the ground and into space.
4. The maneuvering unit depends on action and reaction forces for motion. By firing the nitrogen thrusters in one direction, an astronaut can move in the opposite direction.

Alternative Assessment

Students should show events such as the battle of Kai-Keng, the approximate date fireworks were introduced in Europe, and at least one or two major developments there, including early attempts at rocket-propelled flight, the launching of Sputnik several other major space events, and I. Students should provide sources for their research.

Activity 33 _____ page 65

Desalination—Solving a Middle Eastern Shortage

1. Distillation-based desalination is the process in which seawater is boiled until it produces clean steam. The steam then can be condensed and used for drinking water. Reverse osmosis is the process in which water is forced at high pressure through filters to remove the salt.
2. If there were a shortage of clean water, untreated water would be used in agriculture. Untreated water can cause disease. Using it on crops would contaminate them and cause disease among those who eat the crops.
3. Students' answers might vary. Students may state that the peace pipeline would create agreement and cooperation between warring nations—a first step in the peace process.

Alternative Assessment

Students should write a report that explains that salinity is the salt content in seawater. The most common elements found in salt water are chloride, sodium, sulfate, magnesium, calcium, and potassium. Students should include a first-hand account of how undrinkable they found salt water to be.

Activity 34 _____ page 67

Aslihan Yener—Archaeological Detective

1. Workers lit fires to partially melt the rock with tin in it. When it melted, the workers broke it off and removed the rock chunks from the cave.
2. Another scientist had found casiterite—a tin ore—near the area.
3. Bronze can be sharpened more easily and is lighter than stone. It also is easier to shape and decorate.
4. Children can fit into narrow mine shafts more easily than adults, and it would take less effort to use children than to widen the mine shafts. Also, mining requires less skill than processing the ore; children would not need much training to dig out the ore.

Alternative Assessment

Students should show how tin is separated from its ore, purified, and worked into shape. They should be able to answer questions about the process.

Activity 35 _____ page 69

Dr. Chien-Shiung Wu— Changing the World of Physics

1. Nuclear reactions do not obey the law of parity.

2. Students' answers might vary, but students should be able to support their answers with logical explanations.

3. Lee and Yang questioned the fact that the law had never been officially proven in nuclear reactions. It was assumed to hold true. It is important to test theories in as many situations as possible to best determine whether they are true.

Alternative Assessment

Students may narrow the focus of the project by selecting one of the tools listed. If they choose this option, ask them to provide a few detailed notes with the chart, explaining how the device works, in what way it is used, how is was developed, and important discoveries it has been used for.

Activity 36 _____ page 71

Watching Moon Cycles—Tradition and Science

1. The alignment of the Sun, Moon, and Earth determines how much of the Moon's lighted surface is visible to observers. The factors affecting this angle are Earth's revolution around the Sun and the Moon's revolution around Earth.
2. The phases help people mark the passage of time in greater detail than by following the solar year. By counting moons, for example, Native Americans knew when the time was approaching for them to plant their crops. They also could set regular schedules for celebrating holidays.

Alternative Assessment

Students' models should show the waxing crescent, first quarter, full, last quarter, and waning crescent. Students can use dark cloth or paper to cover part of the model and represent the different moons.