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ABSTRACT

This guide helps teachers use the 15th season of the television program "Newton's Apple" in the classroom and lists show segments on asthma, car engines, glacier climbing, glass blowing, glaucoma, gliders, gold mine, greenhouse effect, kids on Mars, lightning, "Lost World" dinosaurs, mammoth dig, NASA robots, Novocain (TM), pack behavior, pet food, phases of the moon, proteins, robots, scuba diving, smiles, sunken slave ship, white-water rafting, wilderness training, wind blow, and zoo vet. Each topic features one main activity and several mini-activities related to the scientific concept it covers. Background information and additional resources are also listed. (WRM)

FREE educational materials

1 5TH SEASON

Developed in partnership with the National Science Teachers Association

PUBLIC TELEVISION'S FAMILY SCIENCE SHOW

NEWTON'S APPLE is a production of KTCA Twin Cities Public Television Saint Paul/Minneapolis and is made possible by a grant from 3M.

3M Innovation

GREETINGS FROM 3M AND NEWTON'S APPLE

Science and technology can be fascinating and fun—especially when presented with excitement, insight, and a strong understanding of the needs of today's students and teachers. That's why 3M is proud to continue as national sponsor of NEWTON'S APPLE, the television series that revolutionized science and technology programming. Now in its 15th season, NEWTON'S APPLE has successfully shown thousands of students how science can help enhance life, protect people, and preserve our resources.

We're also proud to work with KTCA-TV and the National Science Teachers Association to produce these special classroom materials. We hope these supplements will be a valuable addition to your curriculum. Our goal is to help your students approach the world with curiosity and a desire to understand what they can do to create their own future.

L.D. DeSimone
Chairman and Chief Executive Officer
3M

The NEWTON'S APPLE team shoots the rapids in Costa Rica, rubs elbows with the dinosaur celebrities from* The Lost World: Jurassic Park, *mines for gold in South Dakota, unravels the mysteries of fog in London, dives the wreck of a slave ship off the Florida Keys, and more.

David Heil

Ten years ago, in his debut segment on NEWTON'S APPLE, David Heil plummeted through the air in a tandem skydiving maneuver. Since then, David has shared hundreds of science experiences with viewers. This season, he continues his intrepid reporting with a white-water rafting trip down the Pecuare River in Costa Rica, a trip to the dentist's chair for a touch of painless dentistry, and a look at robots on Earth and in space.

SuChin Pak

A graduate from the University of California at Berkeley in political science and ethnic studies, SuChin Pak proves that you don't have to have a degree in science to be interested in how and why the world works. SuChin's science exploration continues in season 15 as she travels to South Dakota to find out what's so bad about the Badlands, how gold miners find the loot, and how wild mustangs are tamed.

Dave Huddleston

Award-winning television journalist Dave Huddleston really knows how to find the answers to viewers' science questions. On NEWTON'S APPLE, he has traveled the world to learn about sharks, tattoos, the postal service, and more. During Dave's third season, the adventures continue as he dives the wreck of a sunken slave ship, takes off in an engineless glider plane, digs for massive mammoth bones in Hot Springs, S.D., and more.

Eileen Galindo

With a background in musical theater, Eileen Galindo is not what people think of as the typical science scholar. But the newest member of the NEWTON'S APPLE team has learned that science is fun and interesting. In her second season with the show, Eileen gets up close and personal with the ferocious dinosaurs from **The Lost World: Jurassic Park** *ride at Universal Studios. She also finds the answers to questions about glassblowing, virtual reality, and chocolate.*

Brian Hackney

Brian Hackney became interested in science as a child while playing with a telescope in his back yard. After receiving degrees in electrical engineering and physics, he became an on-air meteorologist and science reporter. In his third NEWTON'S APPLE season, Brian ("Sherlock") travels to England to unravel the mysteries of London fog. Then he visits the Waltham Pet Center, where dog and cat foods are developed and tested in a completely humane way.

Educational materials developed with the National Science Teachers Association.

NEWTON'S APPLE is a production of KTCA Saint Paul/Minneapolis. Made possible by a grant from 3M.

How to use the NEWTON'S APPLE *Teacher's Guide*

This guide was developed to help you use the 15th season of NEWTON'S APPLE in your classroom. Follow these steps to get the most from the show and the guide in the classroom.

1. Check the season 15 index or the alphabetical Science Subject Index to find the show in which your desired segment appears.
2. The guide is organized in show number order. Flip to the show number to find your segment.
3. Use the Getting Started activity and questions to engage your students *before* you watch the segment.
4. Watch the segment. Look for opportunities to incorporate the Main Activity or the Try This activities into the viewing of the segment. Tailor the use of video, lecture, and activities according to your teaching and your students' learning styles.
5. Use the Overview section as background for your lecture.
6. Use the Resources section to find further information. We've listed books, magazine and newspaper articles, software, and Web sites that are not only helpful for you but also provide your students good sources for additional information.
7. Pose the Connections questions to your students to prompt discussion of extension subjects and to promote independent learning.
8. Use the Main Activity and Try This sections within the lesson in the classroom or as take-home activities.

Finding NEWTON'S APPLE

NEWTON'S APPLE allows three-year, off-air recording rights for educational purposes. Tape the show, or have your resource center tape it directly off the air and use it in the classroom as often as you like for three years.

The 15th season of NEWTON'S APPLE will air on most PBS stations beginning in October 1997 (check your local PBS listings for exact air dates and time). If you don't find NEWTON'S APPLE listed in your local TV or PBS viewer's guide, contact your PBS station to find out when the 15th season will air in your area. If you cannot tape it off the air, call 1-800-588-NEWTON to purchase a tape.

Public television stations depend on what they hear from viewers to help make their programming decisions, and as an educator, you are one of public television's most important constituents. If your public television station is not running NEWTON'S APPLE, you must let them know that it is important to you and your students. If your station is running the show, call them and let them know how much you depend on it in the classroom.

If you have any comments or questions, please write to:
Director of Outreach & Promotion
NEWTON'S APPLE
172 4th St. E
St. Paul, MN 55101
e-mail: napple@ktca.org
NEWTON'S APPLE Teacher's Guides also are available on the Web at http://www.ktca.org/newtons

INDEX TO THE 15TH SEASON LESSON PAGES

There are two ways to locate any of the 26 lessons in this guide: Check the alphabetically arranged subject index found on the inside back cover or look through the numerically arranged show index on this page.

Either way, once you've identified a topic you'd like to explore, look in the upper right corner of each lesson page for the NEWTON'S APPLE show number (e.g., 1501, 1502) that corresponds to that topic. We've also included the segment's approximate running time in the same corner.

In the center of this book, you will find a guide to the past four seasons of NEWTON'S APPLE. These episodes may be rebroadcast on your local PBS station throughout the year, or you may purchase them by calling 1-800-588-NEWTON. We hope you will continue to use them in your classroom.

SCIENCE SUBJECT INDEX

Here is an at-a-glance index of the science disciplines dealt with in the NEWTON'S APPLE lesson pages, incorporating the National Science Teachers Association's Scope, Sequence, and Coordination of Secondary School Science model.

We've also listed some extended concepts.

Segment	Biology	Chemistry	Physics	Earth/Space	Mathematics	Technology	Additional Applications
Asthma 1505	●						Medical Science Health
Car Engines 1511			●		●	●	Engineering
Glacier Climbing 1507	●	●	●	●			Geology
Glass Blowing 1508		●	●	●			Engineering
Glaucoma 1501	●		●				Medical Science
Gliders 1506			●	●	●	●	Engineering
Gold Mine 1503		●		●		●	Engineering Geology
Greenhouse Effect 1509		●		●		●	Environment Meteorology
Kids on Mars 1510			●	●	●	●	Geology • Computer Science Topography
Lightning 1513	●		●	●			Meteorology
Lost World Dinosaurs 1501	●	●	●			●	Paleontology • Engineering Computer Science
Mammoth Dig 1509	●	●	●				Paleontology
NASA Robots 1512			●	●	●	●	Computer Science Engineering

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Novocain 1506	●	●	●				Medical Science
Pack Behavior 1504	●						Zoology • Animal Psychology Genetics
Pet Food 1504	●	●				●	Zoology • Food Nutrition Veterinary Science
Phases of the Moon 1503			●	●			Astronomy
Proteins 1513	●	●	●		●	●	Microbiology
Robots 1512			●		●	●	Engineering Computer Science
Scuba Diving 1502	●		●	●		●	Oceanography
Smiles 1508	●	●					Psychology
Sunken Slave Ship 1502		●				●	Archaeology
White-water Rafting 1505			●	●		●	Fluid Dynamics Engineering
Wilderness Training 1507	●		●	●		●	Ecology • Environment Food/Nutrition
Wind Blow 1510			●	●	●		Ecology • Environment
Zoo Vet 1511	●	●				●	Veterinary Science

GLAUCOMA

What is glaucoma and how do people get it?

Brian takes a closer look into the eye of glaucoma.

http://www.ktca.org/newtons

[SHOW NUMBER] 1501

Segment Length: 6:40

Getting Started

Begin the lesson by asking students, "Do you know that everyone is a little bit blind?" Then instruct them to conduct the following experiment to find their normal blind spot.

On a piece of paper, draw two small stars about four inches apart. Cover your left eye and hold the paper at arm's length. With your right eye focused on the left star, move the paper slowly toward you. What happens? Switch eyes and do it again. Where did the star go? Why do you think this is happening?

Overview

Most of us have thought about how difficult daily life would be if we were blind, so we're careful to protect our eyes. Yet for a million Americans, there is a sneak thief at work, slowly and silently stealing their vision. The thief is so clever that the victims don't even know their eyesight is in danger.

The thief is a disease called glaucoma, a painless affliction that is the second leading cause of blindness in the United States. Glaucoma is a disease of the plumbing system of the eye, a system that most people don't even know they have. A normal eye is filled with a fluid, called aqueous humor, that constantly flows through the pupil (the dark, central part of the eye that lets in light) and over the iris (the colored ring of tissue around the pupil that gives our eyes their color). The fluid, produced inside the eye by the skin of the ciliary body (focusing muscle), nourishes the cornea (the clear front lens of the eye) as it flows out of the eye through a meshwork of tiny drainage openings at the base of the iris (where it joins the outside edge of the cornea).

There are several types of glaucoma, but the most common kind occurs when the drainage openings slowly become blocked over many years. Since there are no pain-sensing nerves in the region, the increasing pressure of the fluid is painless.

Even when the drainage openings are almost completely blocked, the ciliary tissues keep producing fluid. As a result, pressure from the backed-up fluid starts building inside the eye. This increased pressure pushes on the optic nerve at the back of the eye, distorting, compressing and, over time, destroying it, one nerve cell at a time, until blind spots form.

The loss is usually slow, with ever-increasing dimming of vision creeping in from the side, as if you were looking through a narrowing tunnel or the room lights were dimming. Many people don't notice this loss in their peripheral vision, even when 50 percent of the nerves are destroyed. When they go to an eye doctor and discover they have glaucoma, further loss of vision can be prevented, but nothing can be done to restore the eyesight already lost.

Glaucoma can't be cured, but doctors can prevent further damage by using drugs in the form of eyedrops or pills to lower the pressure in the eye. If drugs don't work, doctors can use laser surgery to open the drainage system and allow the fluid to pass out of the eye. If that fails, microsurgery is used to create new tubes to allow the fluid to drain out. The best way to deal with the disease of glaucoma, however, is to detect it early, before much vision is lost.

Connections

1. If you were blind, how do you think your life would be different? How would it be the same?
2. Do you get a glaucoma test when you visit the eye doctor? How do you think the test works?

Resources

Books

Bantam medical dictionary. (1996) New York: Bantam Books.

Barnes & Noble concise medical dictionary. (1995) New York: Barnes & Noble Books.

Computer software:

The Learning Company: *Mosby's Medical Encyclopedia.* CD-ROM for Macintosh or Windows.

Interactive Ventures Inc.: *Mayo Clinic Family Health.* CD-ROM for Macintosh or Windows.

Dorling Kindersley Multimedia: *The American Medical Association Family Medical Guide.* CD-ROM for Macintosh or Windows.

Organizations

The Glaucoma Research Foundation
490 Post Street, Suite 830
San Francisco, CA 94102
(800) 826-6693
http://www.glaucoma.org/grf/booklet.html

Prevent Blindness America
500 E. Remington Road
Schaumburg, IL 60173
(800) 331-2020
http://www.prevent-blindness.org

Web sites

American Academy of Ophthalmology
http://www.eyenet.org

Glaucoma Foundation
http://www.glaucoma-foundation.org

Ophthalmic Consultants of Boston
http://www.eyeboston.com/glaucoma.html

NEWTON'S APPLE video cassettes and educational materials provide further information about this and other topics. Call 1-800-588-NEWTON or check out our Web site at: http://www.ktca.org/newtons

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NEWTON'S APPLE

SHOW NUMBER

1501

Glaucoma

CATCH THE SNEAK THIEF OF SIGHT

GLAUCOMA: Student Activity

Conduct interviews to determine which older friends and family are at risk for glaucoma.

http://www.ktca.org/newtons

Try This

Glaucoma first steals sight by taking away peripheral vision. To get an idea of what that is like, take a black piece of construction paper about the size of regular notebook paper and roll it into a tube. When you hold it in your left hand and look through it with your left eye, it's like looking down a dark tunnel. That's how many people with advanced glaucoma see. Now hold your right palm midway along the tube in front of your right eye. What do you see in your palm?

Try This

On a dark evening, go outside and try to look at familiar objects. Can you see them better if you look straight at them or if you look just to the side of them? Why do you think that is?

Try This

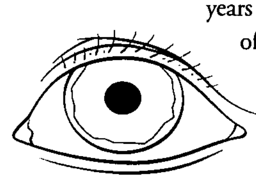
Look at one word on the page of a book. Without moving your eyes from that word, how much can you read?

Main Activity

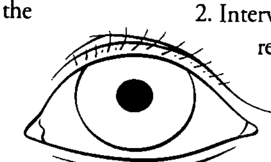
Between two and three million Americans have glaucoma, and worldwide it is the second leading cause of blindness. Glaucoma also is the leading cause of blindness in African Americans. Some people have a much higher risk of getting glaucoma than others. While glaucoma is rare in young people, some of the adults you know may be suffering from the "silent sneak-thief of sight."

In this activity, you will develop a "glaucoma risk" questionnaire, then interview at least three adults to determine if they should be extra vigilant about getting their eyes checked for the disease.

Materials



- pen or pencil
- notebook or other paper on which you can take notes
- list of questions (you will develop the questions) to ask the people you interview



1. Based on the facts listed below and other information you gather from the resource material on glaucoma, develop a list of questions designed to determine a person's risk of getting glaucoma.
   - A normal, healthy 65-year-old eye only sees 20 percent of the light that a teenager sees. Any loss in light sensitivity will further diminish night vision.
   - Glaucoma is seven times more likely to occur in blacks than in whites. People of Asian descent are also at a higher risk than those of European descent.
   - People over the age of 65 are seven times more likely to get glaucoma than those under 65.
   - Only 15 percent of people with glaucoma go blind.
   - Between 20 and 25 percent of people with a close relative who has glaucoma will get the disease themselves, especially if both are female.
   - Some people with normal pressure in their eyes can have glaucoma, and some people with high pressure in their eyes don't get glaucoma.
   - The risk of developing glaucoma if you have a family history of the disease is nearly 10 times greater than someone without a family history of glaucoma.
   - About 80 percent of people with glaucoma are over age 60; 31 percent are between 45 and 60 years old; less than one percent are under 45 years of age.
   - People who suffer from diabetes or who wear thick glasses for myopia are more likely to get glaucoma.
   - People who have had an eye injury are more likely to get glaucoma in that eye, even many years later.
2. Interview at least three adults, making sure to record their age, family history of disease, ethnic background, when they last had their eyes checked, and anything else that might put them at a higher risk for glaucoma.
3. Figure out a system to write down and keep track of each adult's risk factors. Determine which of them is most likely to develop the disease.

Questions

1. Is a person who wears glasses or contact lenses more or less likely to have an undetected case of glaucoma? Why?
2. Are there other eye diseases that are hard to detect, yet also damage vision?

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LOST WORLD DINOSAURS

How were realistic dinosaurs created for Jurassic Park: The Ride?

Eileen goes to Universal Studios to get a behind-the-scenes look at the famous ride.

http://www.ktca.org/newtons

[SHOW NUMBER] 1501

Segment Length: 7:10

Getting Started

Begin the lesson by asking these questions: Have you seen the movies *Jurassic Park* or *Lost World?* How real did the dinosaurs appear to you? What makes them seem real? Have you ever seen model creatures that didn't seem real? What was the difference? What were the moments in the movies that were most striking? Why?

How would you like to come face to face with a *T. rex* or *Ultrasaurus?* Of course, the dinosaurs in *Jurassic Park* aren't real. Despite *Jurassic Park's* science fiction about recreating dinosaurs through modern science, we are still left to imagine how dinosaurs really looked, sounded, and felt. So how did they build Jurassic Park: The Ride? How did they get the dinosaurs to move so realistically? How did they make an environment that replicates the one scientists believe the dinosaurs lived in? How do paleontologists know what environment would be the most realistic?

Overview

The Jurassic Park ride at Universal Studios Hollywood was in development even before the first frame of film was shot for the first movie, *Jurassic Park.* The creators spared no expense to make the park as lifelike and realistic as possible, right down to the scripted "disaster" that happens in the middle of the ride. The designers of the ride (who came from every area of the science and technology community) based the ride's environment on the most current knowledge about what the dinosaurs looked like and how they behaved.

For example, chemists made materials for the dinosaurs' skin that accurately duplicates skin imprints found with fossils. Botanists selected over 100 species of plants to be viewed from the ride. They based their choices in part on fossilized plants found in Wyoming. An attempt was made to accurately depict dinosaur behavior, too. Scientists now think that dinosaurs were at least somewhat warm-blooded, that some of them (like the *Velociraptor)* hunted in groups, and that some tended their hatchlings the way birds do today. Evidence for these ideas comes from a large fossil deposit in Montana, in which dinosaur eggs and babies were found in nestlike formations, and a group of *Velociraptors* was found entangled with the fossil of an enormous plant-eating dinosaur.

Scientists extrapolated dinosaur movements and posture by studying the size and shape of bones and connective tissue, and by observing the layout of fossils that had apparently died in action (running or fighting). Robotics experts at a defense contractor then modeled these movements with an advanced hydraulic technology first developed for the space program.

The hydraulics were particularly important because most of the moving models of living creatures (animatronics) up until then had been rather jerky. This new hydraulic system, however, used a fluid under pressure to allow very smooth and detailed movement called compliant reactivity. Combined with computerized instructions for even the smallest movement detail, such as shifting the shoulder slightly when moving an arm or moving the tail for balance when shifting weight from foot to foot, this compliant reactivity is startlingly realistic.

Connections

1. Why is realism so important to people in a ride like the Jurassic Park ride?
2. How do you think the ride designers are going to top themselves? How could the next ride be even better?

Resources

Books and articles

Allman, W.F. (1993, June 7) The dinosaur hunter. *U.S. News & World Report,* pp. 62-72.

Horner, J. & Dobb, E. (1996) *Dinosaur lives: Unearthing an evolutionary saga.* New York: Harper Collins.

Thro, E. (1993) Robotics: *The marriage of computers and machines.* New York: Facts on File.

Catalog

The Everything Dinosaur Catalogue (800) 346-6366.

Web sites

Dinosaur Society http://www.dinosociety.org

Universal Studios' Jurassic Park: The Ride http://jurassic.unicity.com/jurassic.html

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NEWTON'S APPLE.

SHOW NUMBER

1501

Lost World Dinosaurs

DINO-MITE: HOW DID THEY DO?

LOST WORLD DINOSAURS: Student Activity

Determine how accurate the dinosaur-makers were in creating realistic dinos.

http://www.ktca.org/newtons

Try This

Write a story line for an amusement park ride. What kind of action would you have? How would you draw the audience into your story?

Try This

An online Jurassic Park game is available on the Internet at the address below. Try this game out. What do you think of it? How would you improve it? http://jurassic.unicity.com/jurassic.html

Try This

Raise your arm or leg and notice what other parts of your body shift or move also. Is this movement consistent? Can you move a limb without moving any other part of your body?

Main Activity

The best models show that close attention was paid to small details. See if you can notice these details and suggest materials for models.

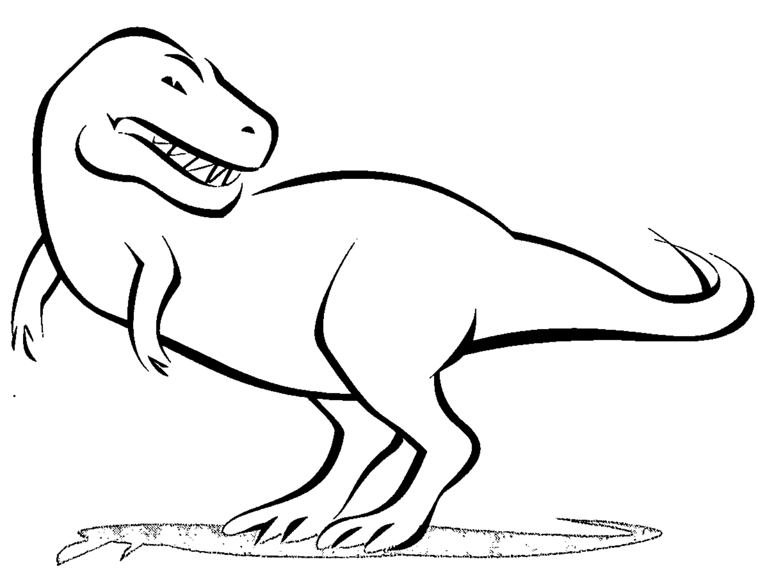
Materials

- video of a dinosaur movie (*Jurassic Park* or *Lost World*, for example, but also *Godzilla* or another science fiction movie) and the equipment to play it on, preferably with a stop-motion feature
- artists' depiction of reconstructed dinosaurs (in library books, magazine articles, or on the Web)
- natural objects (rocks, flowers) or a small animal such as a frog or fish

1. Choose a short portion of the video with a dinosaur exhibiting some close-up behavior.
2. Watch the video clip a couple of times, stopping it to study individual movements and materials. Can you identify any clay animation, models, humans in costumes, or computer-generated elements? Is there anything that isn't completely realistic?
3. Compare the video to the reconstruction of dinosaur fossils. Can you find mistakes or inaccuracies in your video clip?
4. Take a simple natural object such as a rock or a single flower, and think about how you would design a model for it. What materials would you use? What details would be particularly important to reproduce? If you wanted to design a model for a small animal such as a frog or fish, what additional details would you need? Why are moving models more difficult to make?

Questions

1. What areas of study are necessary to get a job modeling animals and natural elements for the movies or for museums?
2. A science has recently been created that involves creating faces on human (or human ancestor) skulls. What do scientists have to consider when reconstructing a face on a skull?



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SCUBA DIVING

What does it take to scuba dive?

NEWTON'S APPLE takes the plunge to explore scuba diving.

http://www.ktca.org/newtons

[SHOW NUMBER] 1502

Segment Length: 4:30

Getting Started

Scuba diving is more than a sport. It's a science that operationally integrates physics, chemistry, physiology, and oceanography. It's also pretty cool.

Begin the lesson by showing students a can of compressed air. "Air blasters" are often available as commercial dusting sprays at photographic supply stores. Explain that the can contains a large volume of air that has been compressed into a small space. Within this space, the gas is stored under considerable pressure. When the nozzle is pressed, some of the pressurized gas escapes from the can.

Attach a length of plastic tubing or a nozzle extension to the can. Press the nozzle to demonstrate the directional flow of air. Fill a fish bowl with water. Position the free end of the tubing beneath the water's surface. Press the nozzle and have students observe the rush of rising air bubbles.

Challenge the class to critically analyze their observations. What causes the rush of bubbles? What do the bubbles contain? Predict how much air is stored in the can. Can compressed air support living things that require oxygen?

Overview

Scuba—from the phrase "self-contained underwater breathing apparatus"—refers to a type of diving in which an individual carries his or her own supply of air. This air supply is stored within a steel or aluminum cylinder called a scuba tank. A device called a regulator "taps" the pressurized air and adjusts its flow for breathing.

Prior to the dive, a mechanical compressor fills the tank with a large volume of air. The pressure produced by this compressed air can exceed 200 times the standard atmospheric pressure! As a diver breathes, flow-adjusting devices called stages drop the flow pressure. Air that is exhaled does not return to the scuba tank. Instead, it is released and observed as the rush of rising bubbles. Sport divers can safely dive to a depth of about 39 meters (130 feet) or five atmospheres of pressure.

Although the first crude scuba apparatus was invented over 150 years ago, it was Jacques-Yves Cousteau and Emile Gagnan who perfected the modern day Aqua-Lung. Unlike the "hard-hat" divers that relied on a surface air hose, Cousteau (in the early 1940s) had attained untethered freedom.

Connections

1. Suppose a balloon filled with air was released from the sea bottom. How does the surrounding pressure change as the balloon rises? What is likely to happen to the balloon before it reaches the surface? Explain.
2. The bends is a life-threatening illness that results from too rapid a return to surface air pressure. During ascent, nitrogen dissolved in the blood stream comes out of solution as lung bubbles that can block the flow of blood to critical body organs. When construction of underwater foundations for the Brooklyn Bridge was underway, laborers worked in pressurized chambers. Upon a rapid return to the surface, many suffered from the bends. If you were in charge of this construction project, how might you protect these workers from decompression sickness?

Resources

Books and articles

Berg, C. (1993, Dec) Another look at the mysterious closed system. *Science Teacher*, pp. 44–48.

Frazier, R. (1995) *A philosophical toy.* Available at: http://www.ed.uiuc.edu/courses/CI241-scienceSp95/resources/philoToy/philoToy.html

Marx, R. (1990) *The history of underground exploration.* New York: Dover Publications, Inc.

Computer software

Chariot: *Eco-Adventures in the Oceans.* 3.5 disks for DOS or Macintosh. (619) 298-0202 or http://www.chariot.com

Edmark: *Destination: Ocean.* CD-ROM for Macintosh/Windows. (800) 320-8379 or http://www.edmark.com

The Learning Company: *Operation Neptune.* CD-ROM for Macintosh or Windows. (800) 852-2255

Web sites

Divers Alert Network (DAN) (800) 446-2671 http://www.dan.ycg.org/

Scuba! On-Line Interactive Magazine http://www.scubaon-line.com

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UPS AND DOWNS OF DIVING

SCUBA DIVING: Student Activity

Create a Cartesian diver and watch what happens when you put it under pressure.

http://www.ktca.org/newtons

Try This

Contact a local dive shop and invite one of the divers to visit the class. Ask the diver to bring and demonstrate the proper and safe use of scuba equipment.

Try This

Put on a pair of safety goggles. Then, pour a small amount of vinegar into a small beverage container. Place about a teaspoon of baking soda into a balloon. Slip the neck of the balloon over the neck of the bottle. Pick up the balloon so that the baking soda falls into the vinegar. Observe what happens to the balloon as the pressure within the container increases. Can this observation be applied to diving? If so, how?

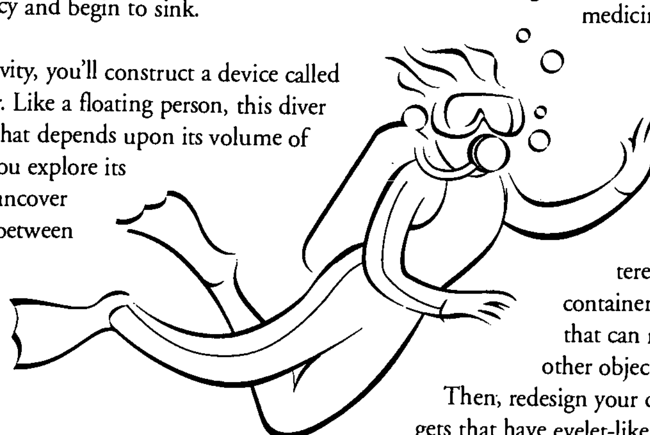
Try This

Research the depth limits associated with scuba diving. Why can't divers descend past a certain depth? How can dolphins and whales dive to incredible depths while scuba divers are restricted to the near surface waters?

Main Activity

Imagine entering a freshwater pond or lake. Take a deep breath and you're likely to float. Exhale, and you'll probably find yourself sinking. These "ups and downs" depend upon the amount of air in your lungs. As the volume of this gas increases, you become more buoyant. As the gas volume drops, you lose buoyancy and begin to sink.

In this main activity, you'll construct a device called a Cartesian diver. Like a floating person, this diver has a buoyancy that depends upon its volume of trapped air. As you explore its behavior, you'll uncover the relationship between pressure and volume.



Materials

- plastic 1- or 2-liter soda container with a screw-on lid
- glass medicine dropper

1. Fill the container with tap water.
2. Lower the medicine dropper into the container. Squeeze the bulb slightly so that the glass tube becomes partially filled with water.
3. Set the dropper floating within the container. Add more water to the container so that the level of water rises to the brim.
4. Screw on the container lid. The seal should be tight enough to prevent the leakage of water.
5. Squeeze the center of the plastic container. What happens to the medicine dropper? Release your pressure. What happens now? Note: If the dropper remains afloat, you'll need to open the container and fill the dropper tube with more water.
6. Take a close look at the air bubble trapped within the medicine dropper. What happens to the bubble's volume as you squeeze the container?

Can you explain the connection between this change in volume and the behavior of the medicine dropper? What happens to the bubble's volume when you release your grip? How does a change in volume relate to the movement of the medicine dropper?

Extend the activity

Can you modify the design of your medicine dropper so that it can recover items that are scattered at the bottom of the container? First, design a diver that can retrieve paper clips and other objects attracted to magnets. Then, redesign your diver to "recover" targets that have eyelet-like handles.

Is it possible to make a Cartesian diver out of other materials, such as the plastic cap to a pen, weighted with a bit of clay? See what objects will work.

Questions

1. Does squeezing the bottle force more water into the air or compress the air, making the diver heavier and causing it to sink?
2. How do these demonstrations relate to scuba diving equipment? How do they explain free divers' use of stones for weight as they dive?

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SUNKEN SLAVE SHIP

How and what can we learn from a shipwreck?

Dave dives a wreck and learns how scientists investigate it.

http://www.ktca.org/newtons

[SHOW NUMBER] 1502

Segment Length: 10:30

Getting Started

Divide the class into teams. Give each team a photograph of an ocean floor or desert scene and a piece of graph paper. Ask them to imagine they are archaeologists who are looking for treasure under the sand or sea. Have them decide what the treasure is and how it ended up there. Then have them plot a map of exactly where they think the treasure might be located. Be sure to draw any landmarks that will serve as reference points. Ask one student from each group to explain their graph and what they hope to find.

Ask these questions: How is the work of marine archaeologists different from the work of dry land archaeologists? How do you think marine archaeologists preserve the integrity of a site and its contents during and after the initial discovery?

Overview

The *Henrietta Marie's* trip began in 1700 in London. The ship stopped in Africa to trade glass beads, guns, and pewter to tribal chiefs in exchange for a human cargo of 190 African slaves and continued on to Jamaica and sold the slaves to plantation owners, but never returned to London from there. It was overtaken by a violent storm and went down off the Florida coast.

We know the details of the *Henrietta Marie's* voyage as a direct result of a painstaking sleuthing of marine archaeologists and historians. Marine archaeologists unearthed the ship's artifacts in 1982. Using items such as the bell and shackles, historians pieced together the ship's saga, providing a rare look at how slave ships operated.

The first step for archaeologists was to establish a base line and grid on the ocean floor around the wreck to serve as reference points. Then they began mapping out where artifacts were discovered.

Some of the 7,500 artifacts were covered with layers of encrustation made up of the tiny skeletons of microorganisms. As one group of the organisms died, another would attach itself on top of the original layer. Other ship artifacts were preserved by layers of sand, creating an absence of oxygen that protected them from microorganisms that feed off organic matter, waves, and other forces of nature. Conditions such as the depth at which the wreck was found and the cold temperature of the ocean also helped to preserve the artifacts.

After carefully gridding, tagging, and excavating artifacts from the site, conservationists removed sand and small shell encrustations. Then, in a lab, they removed any rust from metal artifacts through a process of electrolytic reduction, where the oxidation (or rust) process is reversed. Some artifacts are beyond help for this method to work, but if the layers of encrustation are thick enough, they can be filled like a mold with an epoxy resin to create casts or replicas of the pieces.

What is finally preserved provides us with a time capsule, a glimpse into the past, particularly the conditions of the slave trade during that period. This glimpse may help us to understand our history and move more wisely into the future.

Connections

1. Archaeological discoveries like the *Henrietta Marie* change the way we view history. How do they affect our view of the present and future?
2. How do recent discoveries like those made by astronomers about the surface of Mars or by biologists working in Antarctica and the Amazon rain forest change our understanding of life on Earth?

Resources

Books and articles

Marx, R. (1990) *The history of underground exploration.* New York: Dover Publications, Inc.

Sullivan, G. (1994) *Slave ship: The story of the Henrietta Marie.* New York: Cobblehill Books.

Computer software

Clearvue: *African-American History: Heroism, Struggle, and Hope.* CD-ROM for Macintosh/Windows. Available through catalogs.

Scholastic: *Exploring the Titanic.* CD-ROM for Macintosh. (800) SCHOLASTIC or http://scholastic.com

Organizations

Mel Fisher Maritime Heritage Society
P.O. Box 511
Key West, FL 33041
(305) 294-2633

Web sites

Connections: A Culturally Historical Perspective of West African to African American
http://asu.alasu.edu/academic/advstudies/home.html

Marine Archaeology Home Page
http://www.marinearchaeology.com

The Mystery of the Pipe Wreck Home Page
http://copernicus.bbn.com/vq/pipewreck/index.html

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LOST AT SEA

SUNKEN SLAVE SHIP: Student Activity

Become underwater detectives as you investigate the site of a sunken ship.

http://www.ktca.org/newtons

SHOW NUMBER **1502**

Sunken Slave Ship

Try This

Dr. Madeleine Burnside, executive director of the Mel Fisher Maritime Heritage Society, asserts, "I really feel that [the discovery of the Henrietta Marie] is an important event historically. There's something about not just being able to hear stories, but to touch and feel the tangible objects, that allows you to close the book. It's over. You've brought it to consciousness and you can say, 'We'll never let anyone do this to anyone else again.'" Debate why you agree or disagree with this statement.

Try This

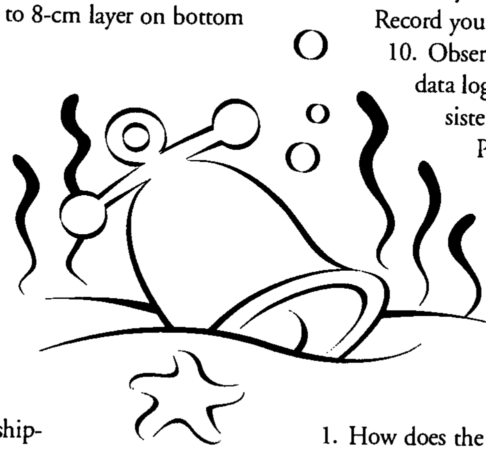
Gather several different metal items. Place each item in a numbered and covered glass or clear plastic container filled with saltwater. Record how much water and how much salt you placed in each container and which item is in each container. Check each container daily for a week and record your observations. Do you see signs of rust? On which metals? How can you explain your observations?

Main Activity

Work in teams to create the story and site of a shipwreck in a tub or aquarium filled with sand and water. Explore another team's site to grid, tag, and excavate the artifacts. Record information about each item as you excavate and analyze it, then present your findings to the other teams of marine archaeologists.

Materials for each team

- modeling clay
- a variety of small objects with different shapes, including marbles, safety pins, hairpins, Popsicle sticks, coins, metal and rubbers washers, screws, pencils stubs, wrapped hard candy, beads, cheap jewelry, etc.
- 40 x 80 cm plastic tub, disposable aluminum roasting pan, plastic shoe box, or aquarium
- sand to make a 5- to 8-cm layer on bottom of container
- water to fill container
- plastic knives, spoons, forks
- graph paper
- string
- toothpicks
- pencil/paper
- magnet



1. Work in teams to create a story of a shipwreck: What kind of ship was it? What was it carrying at the time it sank? How and when did it happen?
2. Gather a variety of objects that represent what might have been on the ship. Make a detailed list of your artifacts, including size, shape, and material.
3. Cover each one with clay to represent the encrustations on artifacts encountered by marine archaeologists.
4. Cover the bottom of your container with a layer of sand. Fill with water.
5. Arrange your artifacts in and under the sand.
6. Move to another team's site to explore and excavate their artifacts. (That team should keep the story it wrote secret for now—the new team examines only the artifacts.)
7. Use string tied to toothpicks to set up a grid in the sand around the site or main artifacts. Record the grid on graph paper, and then record the location where each artifact is discovered.
8. Use a data log to record a description of each item as you find it. Think about what information is important to include.
9. Use plastic utensils and water to carefully remove any encrustation found on the artifact. Record your findings.
10. Observe your artifacts and analyze your data log. Write a story that might be consistent with the artifacts you found. Present your findings and interpretations to the other teams of marine archaeologists. How closely does your story compare to the one devised by the team that created the site?

Questions

1. How does the process of discovery by excavation compare to the investigative process used by other scientists?
2. What "experts" could help marine archaeologists determine the nature and historical context of their discoveries?
3. How might a metal detector aid in the investigative process?

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GOLD MINE

How is gold found in the ground?

SuChin digs deep to explore how gold is panned and mined.

http://www.ktca.org/newtons

NEWTON'S APPLE. FIFTEEN YEARS OF HANDS-ON SCIENCE! 15

[SHOW NUMBER] 1503

Segment Length: 8:30

Getting Started

In a pie pan, mix a few small copper BBs (available in a sporting goods or discount store) with a handful of glass beads of about the same diameter (approximately 5 mm, available in an art supply store). Add two or three cups of water. Over a colander, swish the mixture in a circle, sloshing some over the side each time. Ask students: Do the glass beads or the copper BBs rinse out more easily with the water? Why is this happening?

Ask the following questions to prompt discussion before watching the segment: How do prospectors and geologists find gold? How is it mined? What are those small bits of yellow metal you sometimes see in rocks? Why are people so crazy about gold?

Overview

When you think of the gold rush days in the Old West, you probably picture the miner as a grizzled prospector with his mule and pickax. Gold mining today, however, is a scientific process that uses computers, geologic data, chemistry, microbiology, and sophisticated refining equipment to extract trace amounts of gold from rock blasted out from deep underground. If you look at a map of an underground mine, such as the one that the Homestake Mining Company operates in South Dakota, it looks like a very orderly ant farm, with rooms carved out of the solid rock for machine shops, laboratories, and other facilities.

Data from geological core samples goes into a computer that makes a drawing of an area (like a connect-the-dot map in three dimensions) and tells the miners where to find gold-bearing rock. The miners then drill a series of precision holes into the rock face, pack in explosives, clear everyone out, and blast. After checking for gas leaks, workers reinforce the walls and ceiling to prevent cave-ins and then hoist the ore out of the mine through the vertical shafts.

Gold, a pure element identified with the chemical symbol Au, exists in nature. (Fool's gold, a compound of iron and sulfur called a pyrite, looks a little like gold.) Tiny gold particles are encased in tons of rock, so the ore first goes to a mill where it is crushed very fine. The larger particles separate from the ground rock on a vibrating table that works on the same principle as panning, in which substances of different densities separate from each other.

The smallest particles of gold then are dissolved (leached) out of the ground rock with a weak cyanide solution. This still doesn't get all the gold, and it leaves some very toxic wastewater behind, but miners have some valuable new helpers for both of these problems: bacteria. Some bacteria chew up the cyanide in wastewater. Others chemically alter stubborn rocks so that the cyanide treatment can be more effective. This is called bioleaching. A side benefit of bioleaching is the fast production (and consequent treatment) of acids that would otherwise leak slowly from the sludge into the environment.

Connections

1. Mining can have significant environmental effects, particularly in developing countries without strict environmental monitoring. For example, cyanide and acid wastes from mines contaminate streams. How do you think we can help these developing countries, who may be rich in raw materials but poor in cash and education, protect their environment from being degraded by mining operations?
2. We use gold not only for jewelry, money, and high-tech products but also as a part of our language. How many ways do you use the word "gold"? How is this word used in the books you read and in products you buy?

Resources

15

Books and articles

Butterworth IV, W. (1995, Sept) Panning for gold. *Boy's Life*, p. 26.

Moffat, A. (1994, May 6) Microbial mining boosts the environment, bottom line. *Science*, p. 778.

Parker, W. (1966) *Gold in the Black Hills*. Lincoln, NE: University of Nebraska Press.

Sawa, T. (1996, Dec 30) Yukon alchemy: A mine raises environmental concerns. *Maclean's*, p. 92.

Computer software

MECC: *The Yukon Trail*. CD-ROM. (800) 685-6322 or (612) 569-1500

Nissen Ventures: *StripMiner* for Windows. (604) 436-5501

Web sites

Homestake Mining Company
http://199.170.0.164/

Info-Mine
http://www.info-mine.com/
Videos (free) on acid mine drainage are available on request from:
http://www.info-mine.com/technomine/enviromine/videos/vmain.html

O&K Gold Mining Game
http://www.oandk.com/game1.html
Requires Netscape 3.0 plug-in for Shockwave.

Recreational Gold Prospecting and Mining Page
http://www.dnai.com/~wfw
One link goes to a list of organizations (categorized by state) devoted to recreational gold prospecting.

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ON PBS

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3M Innovation

NEWTON'S APPLE.

SHOW NUMBER

1503

Gold Mine

UNDER PRESSURE

GOLD MINE: Student Activity

Design a reinforcement that will help your tunnel withstand collapse.

http://www.ktca.org/newtons

Try This

Find out what properties gold has that make it essential in some industries and medical procedures. Find five uses of gold in the world of high technology, two uses in art or architecture, and three uses in health care. Gold is sometimes used in food—do you know why?

Try This

The weight of an object divided by its volume will give you its density. How can you measure weight and volume? Find out if different metals have different densities and how metal densities differ from nonmetals such as glass.

Try This

Gold has been treasured by human beings since long before the Pharaohs and not just as money. Visit a museum and look for historical items made of gold. What did ancient people do with gold? How did they use it? How was it a part of their culture?

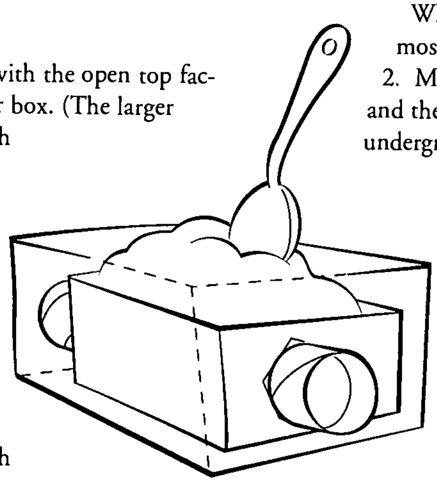
Main Activity

Cave-ins have always been a serious danger in mines. As the depth increases, the pressure on the walls and ceiling of the mine tunnel becomes enormous. Engineers have worked to design new methods of reinforcing tunnels so they will not collapse. Using just paper as a reinforcement material, can you design a good, safe tunnel? Try this as a contest among several groups of students.

Materials

- two cardboard boxes, one small enough to fit inside the other with considerable room to spare, but deep enough to hold several inches of sand. The small box should have a hole cut at the base in two opposite sides, large enough for the experimental tunnels to slide through (see diagram).
- several pounds of wet sand
- a big spoon, scoop, or measuring cup
- several sheets of regular white paper or construction paper
- tape

1. Place the smaller box, with the open top facing up, inside the larger box. (The larger box is just there to catch spilled sand.)
2. Design a tunnel, using only paper with enough tape to hold it together. Start with something simple like a long, narrow box or tube.
3. Place the tunnel through the holes in the small box. (The tunnel must be long enough to fit through both holes with an inch or so protruding from each side.)
4. Pour wet sand into the small box in measured quantities (scoops or cups), covering the tunnel. Record how much sand is required to make the tunnel collapse. (You will have to look through the tunnel from one end to determine when it collapses.)
5. Design some reinforcements or cross braces for your tunnel, still using just paper. You might try folding, twisting, tightly rolling, or braiding pieces of paper to obtain supports with different strength characteristics.
6. Repeat steps 3 and 4 to test your design again.



Questions

1. Which design best resisted collapse? Was any particular cross section—triangular, circular, rectangular—unusually good at withstanding pressure from all sides? Was any design better at withstanding pressure from the side than from the top or vice versa? What kind of cross braces were most effective?
2. Miners usually don't build tunnels and then bury them—they dig tunnels underground. Which tunnel reinforcement design would be easiest to install if you packed the small box firmly with sand and then dug a tunnel? Can you think of a way to dig and reinforce at the same time?

PHASES OF THE MOON

Why does the moon look different at different times of the month?

David examines how the moon looks from Earth.

http://www.ktca.org/newtons

[SHOW NUMBER] 1503

Segment Length: 7:30

Getting Started

Darken the classroom but turn on a single, incandescent light bulb in a corner. Choose someone to hold a ball in the center of the room. Students should then sketch what they see of the ball from wherever they are sitting. Include the light and shadow on the ball, and the location of their seat relative to the light and the ball. Turn the lights on, and compare the sketches. What differences are there? What caused the differences?

Why do most newspapers publish the upcoming dates for the phases of the moon and the times of each moonrise and moonset? What professions depend on knowing this information? Why? Can you think of any ways the moon's phases affect your life?

Overview

What you see when you look at the moon depends on its location in relationship to the sun and Earth. The moon never goes away or changes shape—we just see a different fraction of sunlight being reflected from the moon to Earth.

So how do you explain why this happens? Start with the facts: The moon is our planet's only natural satellite. Its diameter is about a quarter that of Earth's. The moon takes about 27.3 days (about a month) to revolve around Earth, traveling at an average distance of about 384,000 kilometers.

We divide the moon's orbital cycle into several segments, or phases. When the sun and the moon are on the same side of Earth, the sun illuminates the side of the moon that faces away from Earth. We don't see any reflected sunlight on its front face, so it looks like there is no moon. We call this the new moon phase. When the crescent moon begins to appear, if you look carefully you may see some faint illumination of the moon from earthshine

About two weeks later, when the moon and sun are on opposite sides of Earth and all are in a line, the sun shines past Earth directly onto the full face of the moon and we see a "full moon." What happens in between?

As the new moon phase ends, the moon waxes, or appears to grow larger, and we see more of the moon's face. The lighted area increases over time from right to left from our perspective on Earth. When the sun-earth-moon angle is very small, we see only a thin bright curve, called the waxing crescent. Over the next seven days the angle between the sun, Earth, and the moon grows to 90 degrees. We see the sunlight spread to cover the right half of the moon. This is called the first quarter. The visible part of the moon continues to wax through the gibbous phase over the next seven days until we see the full moon.

As the cycle continues, we say the moon is waning, or growing smaller. The amount of lighted area we see decreases, and the darkened area increases from right to left. You can tell if the moon is waxing or waning by whether the right side of the moon is dark or light.

Another 14 days pass as the moon moves through the waning gibbous phase, then the third quarter, then the waning crescent phase, and seems to finally disappear in the new moon phase. Now we're back to where we started about a month ago!

Connections

1. The full moon always rises about the same time as the sun sets. Why?
2 If the new moon is on the same side of the sun as Earth, why doesn't it block out the sun and create an eclipse?

Resources

Books and articles

Koppeschaar, C. (1995) *Moon handbook: A 21st-century travel guide.* Chico, CA: Moon Publications.

Taylor, I.J. (1996, Nov) Illuminating lunar phases. *The Science Teacher,* pp. 39–41.

Computer software

Sunburst: *Field Trip to the Sky.* CD-ROM for Macintosh and Windows. 800-321-7511 or http://nysunburst.com

Organizations

NASA Jet Propulsion Laboratory
Teacher Resource Outreach
4800 Oak Grove Drive
Mail Code CS-530
Pasadena, CA 91109
(818) 354-6916 (phone)
http://www.jpl.nasa.gov/

Web sites

NASA Lunar & Planetary Institute Home Page
http://cass.jsc.nasa.gov/lpi.html

National Space Science Data Center
http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html

Students for the Exploration and Development of Space (SEDS) presents The Nine Planets: A Multimedia Tour of the Solar System
http://www.seds.org
(click on Nine Planets)

Moon Phases
http://www.astro.wisc.edu/~dolan/java/MoonPhase.html

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3M Innovation

SHOW NUMBER

1503

Phases of the Moon

PHASE IN, PHASE OUT

PHASES OF THE MOON: Student Activity

Create models that show how and why the moon looks different as it revolves around Earth.

http://www.ktca.org/newtons

Try This

Keep a journal of lunar observations for two months. To create your journal pages, draw a 10-cm circle on a page to sketch what you see, then add a table to record the date, time, local weather conditions, your location, and general observations. Make 60 photocopies and bind them with a report cover. At the end of the observation period, read your notes. Can you create a calendar based on your observations?

Try This

Most newspapers and many Web sites post monthly lunar tables. Study a lunar table to become familiar with the vocabulary. Invite an astronomer to explain why lunar tables are important–and why they are published in newspapers.

Try This

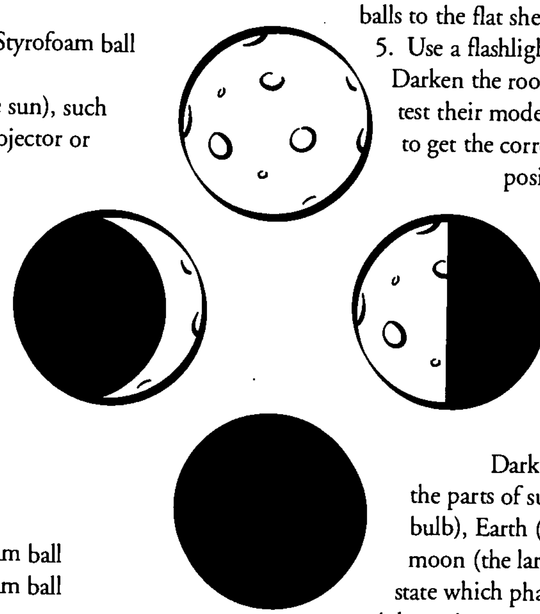
A light year is the distance light travels in one Earth year, ten trillion kilometers. Light travels at a speed of 300,000 kilometers per second. When you see the moon, it's really a snapshot of something that happened how long ago?

Main Activity

Work in teams to create 2D and 3D models of each phase of the moon. After creating, testing, and refining your models, you'll be able to demonstrate to your classmates what you've learned.

Materials

- one 5- to 10-cm Styrofoam ball (the moon)
- a light source (the sun), such as an overhead projector or lamp with a 400-watt bulb
- room that can be darkened



For each group of students, provide:

- chart paper
- markers
- rulers
- one 2-cm Styrofoam ball
- one 4-cm Styrofoam ball
- toothpicks
- large flat sheet of foam core or Styrofoam packing material
- flashlight

1. As an introduction to this activity, view the NEWTON'S APPLE video about the phases of the moon. Emphasize and review the direction of Earth's rotation and the moon's revolution.
2. Work in groups of three or four. Assign a phase of the moon to each group:

A. New	*E. Full*
B. Waxing crescent	*F. Waning gibbous*
C. First quarter	*G. Third quarter*
D. Waxing gibbous	*H. Waning crescent*

3. Use markers to draw a diagram on a piece of paper that shows the position of the moon, sun, and Earth during your assigned phase of the moon. Be sure to label the diagram to indicate the names of each of the bodies as well as the name of the phase.
4. Create a 3D model of your diagram. Use toothpicks to attach the Styrofoam earth and moon balls to the flat sheet of foam core.
5. Use a flashlight to provide the sunlight. Darken the room when everyone is ready to test their model. Move the balls as necessary to get the correct phase. Mark and label the positions of the flashlight, moon, and Earth on the foam base when the correct phase is attained.
6. Now for the real test: Explain to the class why we see your phase of the moon. Use your diagram and 3D model. Darken the room and role-play the parts of sun (overhead projector/light bulb), Earth (volunteer from class), and moon (the large Styrofoam ball). Do not state which phase you are demonstrating. Ask a volunteer to guess, based on what he or she sees on the "moon."

Questions

1. What do you think it would be like to have several moons revolving around Earth? Would it change your calendar? Poetry? Tides?
2. What views do you think astronauts have of Earth and moon as they orbit Earth?
3. Would the moon phases change if the moon revolved around Earth in the opposite direction? How?

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PACK BEHAVIOR

Why do dogs act the way they do?

Dave talks to the animals to learn more about dogs and wolves.

http://www.ktca.org/newtons

[SHOW NUMBER] 1504

Segment Length: 6:30

Getting Started

Begin the lesson by asking these questions: Do you or does someone you know have a dog? Have you ever observed how it reacts to you and treats you? What does it do when it is hungry? Angry? Frightened? Glad to see you? Do you know of a dog that has problem behaviors such as biting? Why does an animal behave that way? How do dogs fit into a family? Do dogs think of human family members as other dogs?

Overview

Genetic evidence confirms that dogs descended from wolves—they are still so close genetically that they can interbreed. Even though dogs were domesticated 12,000 to 14,000 years ago, they still retain many of the original behaviors of their wolf ancestors. Many new pet owners are astonished to find, for example, that puppies feel safer and more secure—and are easier to housebreak—if kept inside a cage part of the time rather than being allowed to run free. Dogs, like wolves, are den animals; in the wild they sequester their puppies safely in close, dark quarters.

Dogs also conform to a specific social structure, the pack, in which they cooperate to hunt, feed young, and defend themselves. There is a chain of command, with each dog dominant or submissive to other pack members. The most dominant or alpha male leads the pack and keeps everybody else in line with nips and other aggressive behavior. The alpha male is sometimes successfully challenged by another pack member, and then drops down in the hierarchy, but one dog is always in charge.

When dogs began to live with people, they simply transferred this structure—dominance behavior and all—to their human "pack." A dog instinctively defends its human family, but many also try to establish a rank within that family. (Not all dogs will compete for a higher rank.) The problems start if a dog tries to establish dominance over some or all of the human pack members, resulting in aggressive behaviors such as biting or growling.

Trainers and animal behaviorists concentrate on communicating to the dog that it is lower in the hierarchy than the people. Some ways of doing this include making the dog eat last, restricting its movements and sleep areas, refraining from showing fear, and encouraging everyone in the house to give the dog commands. This can't remedy all bad behavior, of course—some dogs have been abused or bred for aggressiveness and no amount of training can make them reliable pets. Often, however, the trainer can use instinctive pack behavior to send the dog the message that other family members outrank it. If this idea is established, the dog usually will accept it.

Connections

1 What value can you see to a hierarchical social structure? What are some difficulties with it? Do people exhibit similar traits?
2. The famed dog trainer Barbara Woodhouse frequently said that the problem was usually not the dog, but an inexperienced owner. Do you agree? Why?

Resources

Books and articles

American Kennel Club. (1991) *American Kennel Club dog care and training.* New York: Howell Book House.

Coren, S. (1995) *The intelligence of dogs.* New York: Bantam Books.

The call of the wild: After 70 years, gray wolves return to Yellowstone. (1997, Feb 7) *TIME For Kids,* pp. 4+.

Woodhouse, B. (1982) *No bad dogs the Woodhouse way.* New York: Summit Books.

Web sites

American Dog Trainer's Network http://www.inch.com/~dogs/articles.html

5TOP Dog Behavior and Training site http://www.suite101.com/topics/cfm/156

International Wolf Center http://www.wolf.com

SeaThunder's Scratchpad of Wolves and Wolf-Dog Hybrids http://home.mem.net/%7Ewhisper/wolves.html

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NEWTON'S APPLE

SHOW NUMBER

1504

Pack Behavior

PACKING IT IN

PACK BEHAVIOR: Student Activity

Create a pack and see if you can live like a social canine.

http://www.ktca.org/newtons

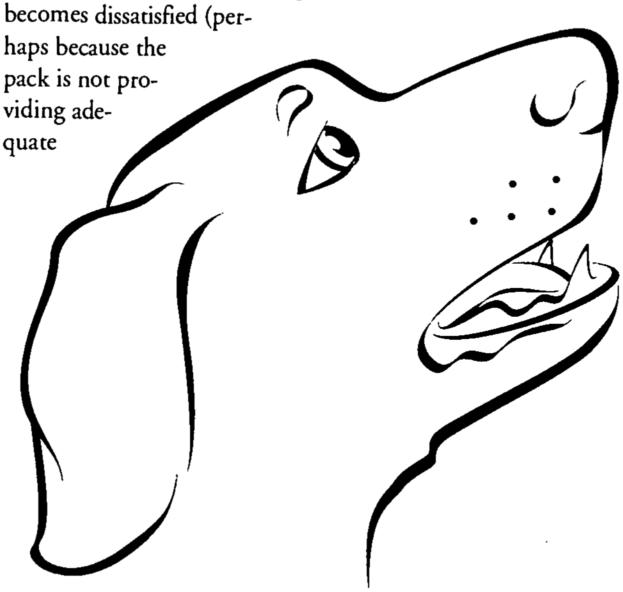
Main Activity

A good pack structure both benefits and restricts the individual—even the leader, who may have more rights, but also more responsibilities. Design a role-playing game based on a pack.

1. Divide the class up into "packs" of four or five people.
2. Write up a list of pack rules for each group. Be sure to include all the necessary elements: packs must find food, distribute it, and keep themselves warm and safe. Examples of specific behaviors might include how to successfully challenge the leader, special tasks only the leader can perform, how to warn of intruders from other packs, who gets first access to privileges, what tasks should be cooperative, what constitutes "food," who feeds the pups, and so on.
3. Establish an initial hierarchy in each pack by drawing numbers out of a hat, and then begin acting out the pack roles. If a pack member becomes dissatisfied (perhaps because the pack is not providing adequate food or protection), he or she may wish to challenge the leader.
4. After playing for a while, stop and discuss how well the pack worked. How effective was your pack at carrying out its responsibilities? Did everyone get enough food? Was everyone adequately protected? How effective was the leader? How many times did leadership change hands? If you played both leader and follower, which position did you like best? Why?

Questions

1. Do you think humans exhibit pack behavior? What situation can you think of where one person becomes the dominant member of a group and others follow his or her lead? How and when does leadership in this kind of pack change?
2. What kinds of behavior have you seen in pet dogs that might be explained by their pack tendencies? Have you ever had a dog consider you the "alpha" member of a pack? How did it treat you?



Try This

Observe other students in the cafeteria. Can you see any pack structure at work among other students? Can you see behaviors that are aggressive or submissive? Are there natural leaders? Followers? Methods that the leaders use to keep the followers in line? Challenges to the leaders?

Try This

Visit a dog training facility and watch how the trainers work. If you have a dog at home, try training it to sit up or exhibit a specific behavior. Is it easy or difficult? Why?

Try This

Find out more about the domestication of animals. How many kinds of domesticated animals are there? How do their relationships with people differ?

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PET FOOD

How do scientists create the perfect dining delights for my pet?

Brian investigates how researchers develop yummy, nutritious pet foods.

http://www.ktca.org/newtons

[SHOW NUMBER] 1504

Segment Length: 6:30

Getting Started

Begin the lesson by asking students the following question: How do you choose the right product for your pet from such a wide selection? Gather as many different print ads (newspapers, magazines, promotional advertising) for pet food as possible. Collect a variety of sample packages of pet food from your local pet superstore. Ask students: Which product is better for your pet? What would you want to know if you went to a place where scientists design the foods? Show the video to the class.

Overview

They're cute, most of them are smart, and they make great friends. No, not the kids in your class. Pets! An estimated 36 million homes in the United States have at least one canine. About 31.4 million U.S. homes have at least one feline. That's a lot of hungry pets to feed. And many pets (except for those finicky kitties) will eat pretty much anything we put in front of them. So how do the pet food companies determine what goes into their products to make sure your pet can and will eat it?

There are three basic ways to provide food for your pet: improvise food at home from table scraps, prepare pet food from regular food, or purchase commercial pet food. But different pets have different dietary needs—their food must provide the same nutrients found in foods their wild ancestors ate. Commercial pet foods deliver the nutrients and are convenient.

From a scientific perspective, pet food must contain the correct balance of ingredients for the pet's breed, age, size, physical condition, and lifestyle. It must be digestible to ensure that all the nutrition from the food is absorbed by the body rather than passed out as waste. Last but not least, it must be appealing and palatable enough to entice the pet to eat it.

To devise the perfect pet food, a great deal of scientific research takes place at facilities such as the Waltham Centre for Pet Nutrition (WCPN) in England. Over a thousand scientists in the Waltham network around the world conduct pet-friendly research in the areas of feeding behavior, dietary management, palatability, raw materials, product performances, and owner/animal expectations. The WCPN—home to 250 dogs, 450 cats, and 400 birds—generates more than 15,000 pieces of research daily. Many findings are shared with veterinarians and animal nutritionists worldwide.

In the United States, minimum standards for animals' nutritional requirements are established by the National Research Council, a federal agency. Based on research from organizations like the WCPN, the agency mandates, for example, that dog food include a balance of carbohydrates, fats, proteins, minerals, and vitamins. Even after 5,000 years as domestic pets, cats are still carnivores, so cat food must contain certain amounts of amino acids, taurine, arachidonic acids from animal fats, arginine, vitamin A, and niacin.

Next time you shop for food for Fluffy or Fido, compare the contents listed on the labels, and think about the research that went into putting together your pet's perfect meal. Bon appétit!

Connections

1. Many product labels now carry a statement indicating whether they use animals to test the product. Do you think animal testing is appropriate? Why? How could animals be protected against improper testing?
2. Pet ownership is a big responsibility. What are the advantages of owning a pet? Challenges?

Resources

Books and articles

Anderson, N. & Peiper, H. (1995) *Are you poisoning your pets: A guidebook to pet health and safety.* East Canaan, CT: Safe Goods. (800) 903-3837

Hanna, J. & Mundis, H. (1996) *Jack Hanna's ultimate pet guide.* New York: Putnam Publishing Group.

Roach, P. (1995) *The complete book of pet care: Birds, cats, fish, dogs, guinea pigs, hamsters, horses, mice, rabbits, reptiles.* Indianapolis: MacMillan General Reference.

Computer software

Dorling Kindersley: *Eyewitness Virtual Reality: Cat.* CD for Macintosh or Windows. Available at retail stores and in catalogs.

Dorling Kindersley: *Eyewitness Virtual Reality: Bird.* CD for Macintosh or Windows. Available at retail stores and catalogs.

Web sites

American Pet Products Manufacturers Association
http://www.appma.org

American Veterinary Medical Association
AVMA Care for Pets Home Page
http://www.avma.org/care4pets/

NetVet—The Electronic Zoo
http://netvet.wustl.edu/e-zoo.htm

Waltham Centre for Pet Nutrition
http://petsource.com/WALTHAM

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WHAT'S FOR DINNER?

PET FOOD: Student Activity

Analyze packaged pet food to find the best choice for your hungry animal friends.

http://www.ktca.org/newtons

Try This

Test your cat or dog (or a friend's pet) to determine whether it is overweight. Stand above the animal to find its waist. If it is overweight, you won't see the waist behind its ribs. Next, use your hands to try to feel the pet's ribs. If you can see the ribs, the pet is underweight. If you can't feel the ribs, it's overweight. Check with a vet to confirm your observations.

Try This

All pets need plenty of fresh water. A dog, for example, who weighs about 30 kg and eats moist dog food needs about four cups of water a day. The same dog would need eight cups if he eats dry food. Select a breed of dog and calculate how much water it would drink. Next figure out how much you would spend on food for this dog for one year. Hint: Check package labels and pet care books to get the basic information for your calculations.

Main Activity

Try being a product analyst, pet nutritionist, and package designer. Create a data log to compare the content analysis for several brands of dog or cat food. Include columns for serving size, target age, crude protein, etc. Examine the products themselves and record and compare your observations. Decide which one is actually best for your pet and which one your pet will most likely eat.

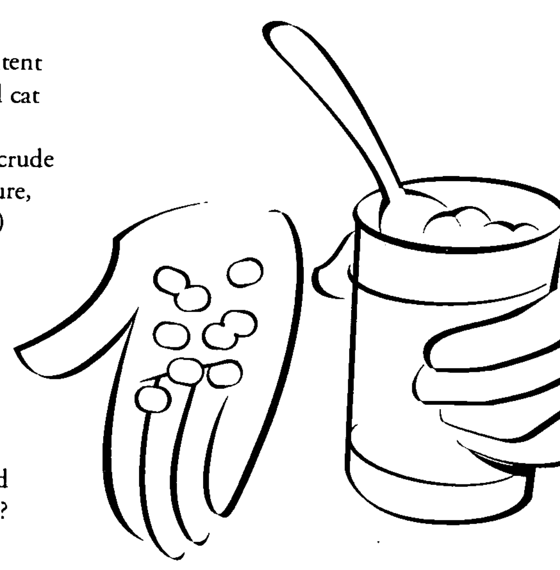
Materials

- variety of pet foods (at least three different types per group) of food for the pet chosen
- paper plates
- plastic forks, knives, spoons
- paper, cardboard, rulers, tape, glue, markers
- pens, pencils

1. Create work groups and select which kind of pet will be the focus of your product research and development.
2. Create a data log to compare the content analysis for several brands of dog and cat food. Include columns for price per gram/ounce, serving size, target age, crude protein, crude fat, crude fiber, moisture, calcium, phosphorus, main (first five) ingredients, as well as texture, smell, and appearance.
3. Record the data printed on the packages.
4. Open the packages and examine the products.
5. What differences and similarities do you observe? Compare volume and weight. Are the contents moist or dry? Do they seem greasy? What do they smell like?
6. Each work group should choose the food they think is the healthiest. Does it cost more than the others?
7. Relate the observations to what students in the class actually serve their pets.
8. Invite a veterinarian to comment on the work groups' choices.

Questions

If you owned a pet food company, how much would you budget for scientific research and development of new products? Raw materials? Would you use "only the best?" How much would go into marketing research and container costs? Explain your budget choices.



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ASTHMA

What makes it hard for people with asthma to breathe?

Brian explores what it's like to have asthma.

http://www.ktca.org/newtons

[SHOW NUMBER] 1505

Segment Length: 6:00

Getting Started

To begin the lesson, find out if any students in the class have asthma. Ask them what it feels like to have an asthma attack. To give students an idea, tell them to do the following: Pinch your nose closed, then breathe in and out through a straw. How hard is it to get fresh air into your lungs? How about getting the stale air out? Try to breathe fast, like you do when you are exercising. What does it feel like to have your body struggling for fresh air? How do you think your life would be different if you always had to worry that an asthma attack could happen, sometimes with little warning?

Overview

About 12 million Americans have asthma, which means someone you know probably has the disease. Even though it is so common, doctors don't know what causes asthma. They do know it isn't contagious. Asthma usually strikes during childhood. Half the children who get asthma outgrow it by adolescence. The other half spend their lives using medications and avoiding things that trigger attacks.

An attack happens when something irritates an asthma sufferer's respiratory system, triggering a series of events that make it difficult for the sophisticated structures within the lungs to get oxygen into the bloodstream. An asthma attack begins by striking the bronchi, the two large tubes that connect the windpipe to the lungs, and the bronchioles, the many little tubes that carry air from the bronchi deep into the lungs. In normal lungs, air from the bronchi moves into tiny air sacs called alveoli. Oxygen moves from these sacs into the bloodstream through tiny blood vessels called capillaries. At the same time, carbon dioxide is removed from the blood and exhaled from the body.

An asthma attack causes the muscles surrounding the lungs' airways to tighten. The airways can also become inflamed and swollen, making breathing much more difficult. Finally, the lungs increase production of mucus that clogs the airways even more. Asthma victims often make wheezing sounds and cough as they struggle to breathe and clear out the excess mucus. For someone with asthma, breathing out, or exhaling, is as hard as breathing in.

Scientists don't think asthma is inherited, but they suspect genes that make it easier for allergies and other environmental irritations to develop into asthma are passed on from parents to children. If neither parent has asthma, you have a 10 percent chance of developing it. If one parent has asthma, your odds increase to 25 percent. If they both have it, you have a 50 percent chance of developing the disease.

Many things bring on asthma attacks and these triggers vary from person to person. Cold winter air, cleaning solvents, dust, spicy food, aspirin, and cigarette smoke can all be triggers. Exercise and strong emotions also can cause attacks. So can viral and bacterial infections. With so many triggers, how can people with asthma live normal, active lives? Most do by inhaling medications that dilate, or open, constricted airways and stop inflammation. They also learn what their specific triggers are and try to avoid them. A cure isn't on the horizon, but people with asthma can control the disease and turn it into an inconvenience, not a barrier to a full life.

Connections

1. What other diseases affect the lungs and make it hard to breathe?
2. Would you tell your friends if you had asthma or some other disease that occasionally affected your ability to do things with them? Why?

Resources

Books

Harrington, G. (1992) *The asthma self-care book.* New York: Harper Perennial.

Rooklin, A. (1995) *Living with asthma.* New York: Plume.

Sander, N. (1994) *A parent's guide to asthma: How you can help your child control asthma at home, school, and play.* New York: Plume.

Organizations

American Lung Association
1740 Broadway
New York, NY 10019
(212) 315-8700
Free educational material about asthma.

Asthma Allergy Foundation of America
1125 15th Street NW
Washington, DC 20005
(800) 727-8462

Mothers of Asthmatics
10875 Main Street, # 210
Fairfax, VA 22030
(703) 385-4403

National Asthma Education and Prevention Program Information Center
4733 Bethesda Avenue
Bethesda, MD 20814

Web sites

Asthma support group
http://www.radix.net/~mwg/asthma-gen.html

National Jewish Center for Immunology and Respiratory Medicine
http://www.njc.org/MFhtml/RAS_MF.html

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NEWTON'S APPLE

SHOW NUMBER

1505

Asthma

BREATH TEST

ASTHMA: Student Activity

Experience what it might feel like to strain for air.

http://www.ktca.org/newtons

Try This

Ask a local doctor or school nurse to explain to your class what asthma is and demonstrate the inhalers asthma sufferers use to take their medicine. The doctor might also be able to let you try a peak-flow meter, a simple device asthmatics use to measure how well their lungs are working. If any students in your class have asthma, they can, if they want to, work with the doctor in the demonstration.

Try This

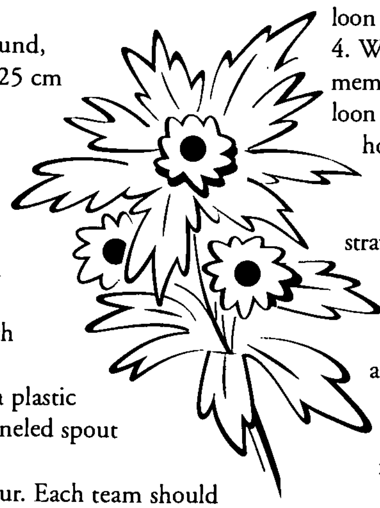
Do you suffer from allergies? Many people who don't have asthma are allergic to grass, different types of pollen, and even cat or dog hair. Go through magazines and cut out pictures of all of the things that cause you to sneeze, itch, or break out in a rash or that make it harder for you to breathe. Paste them in a notebook and compare your allergy triggers with those of your classmates. If these things caused more serious problems, like a full-blown asthma attack, how would you avoid them? Would you need to change your daily routine?

Main Activity

In this activity you will create a simple model of the respiratory system. Not only will you measure the effect of narrowed airway channels, you will experience it as well.

Materials

- notebook, pen, and ruler
- construction paper, scissors, and tape
- balloons—large and round, that blow up to about 25 cm (10") in diameter
- plastic drinking straws .6 cm (1/4") in diameter, cut to 15 cm (6") lengths
- rubber bands 2.5–5 cm (1"–2") in length
- stopwatch or watch with sweep second hand
- honey dispensed from a plastic squeeze bottle with funneled spout



1. Divide into teams of four. Each team should use an inch-wide strip of construction paper and tape to make a ring 25 cm (10") in diameter. Each team member will need three balloons. Two of the balloons will be modified by inserting a 15 cm (6") length of drinking straw about 2.5 cm (1") into the opening and securing it with a small rubber band. (About eight twists will make the connection airtight and still not crimp the plastic straw.)
2. Each team member takes a turn at blowing up a plain balloon. Inflate the balloon until it just fills the paper ring, which is held by another team member. The third team member measures the time needed to inflate the balloon to the nearest second, while the fourth team member records the data. When inflation is complete, pinch the balloon shut. Reset the watch, then release the air from the balloon. Record the time it takes for the balloon to deflate completely.
3. When each team member has performed the trial with a plain balloon, repeat the entire process with one of the modified balloons. Record the times needed to inflate the balloon to 25 cm and to deflate it completely.
4. When this trial is finished, each team member takes the remaining modified balloon and squirts about 2 teaspoons of honey into the balloon through the straw. Gently squeeze the balloon so that the entire length of the straw is filled with honey. Inflate the balloon to 25 cm as before. Record the inflation and deflation times.
5. Calculate the average inflation and deflation times for the three trials performed by your team. Compare the results with those from the other teams.

Questions

1. In our model, the three balloons represent different conditions in the human respiratory system. What are they?
2. How did narrowing the passageway and adding a thick, sticky substance affect your ability to blow up the balloon?
3. How do medicines treat an asthma attack?

WHITE-WATER RAFTING

How do white-water rafters navigate the rapids?

David shoots the rapids to learn the physics behind river rafting.

http://www.ktca.org/newtons

[SHOW NUMBER] 1505

Segment Length: 9:15

Getting Started

Begin the lesson by showing students how complicated currents can be. Mix one quart of white Ivory dishwashing liquid with five drops of food coloring. Place several small rocks in a shallow baking pan, then tilt the pan up at one end. Pour the liquid in and watch the pattern of currents flowing around the rocks. The more swirls, the more turbulent the water.

Which currents would push your raft back upstream? Where are the calm areas? How hard would it be to paddle a raft through the currents without hitting any rocks?

Overview

Few sights reveal nature's power as clearly as rapids in a fast-flowing river. Water pounds against rocks, sprays into the sky, and boils into white froth. The thought of rafting through such turbulence is scary—unless you are an experienced river runner.

Rapids look chaotic, but they are predictable. The volume of water, the steepness (or gradient) of the river, the width of the channel, and the obstacles in the water all have understandable effects on the rapids. Experts can read a stretch of rapids, spotting the hazards and seeing the safest way through.

Knowing the amount of water flowing in a river is important because the river's speed increases as more water flows through it. Double the water means double the speed, so a mild rapid becomes a dangerous one during the rainy season. Rafters also must know the flow because water is heavy, weighing 1,000 kilograms per cubic meter (62 pounds per cubic foot), and in rapids it exerts tremendous pressure on a raft.

Three basic states of flowing water exist: laminar, turbulent, and chaotic. Laminar describes the smooth-flowing currents in an unobstructed river. Even these currents can be complicated, for their speeds vary. Surface water is slowed by wind, while deep currents are slowed by friction with the riverbed. Water in the middle, a few feet below the surface, usually runs the fastest.

Turbulence occurs when obstacles, such as rocks or a sudden narrowing of the river channel, obstruct the current's flow. Obstacles force too much water into too little space, so the water runs faster and laminar sheets break into individual ribbons of current. Then things get really complicated. If water runs into a boulder, a turbulent zone is created where the water and rock collide. The current runs faster around the boulder's edges, but behind the rock, it forms an area of backward-flowing water called an eddy. Shear zones between the eddy and the fast water can be strong enough to keep a raft from reaching the calm water.

Water crashing over a submerged ledge or rock becomes chaotic and creates a hole. A hole creates a horizontal vortex underwater that actually rotates in an upstream direction. A rafter who falls into a hole is pushed back upstream against the ledge that created the hole, then driven down underwater. Often the only way out of a vortex is to dive to the bottom of the river, where some of the water crashing into the hole flows under the vortex. A rafter who gets into that deep current can follow it out of the hole and then resurface.

Connections

White-water rafters must understand fluid dynamics and physics to accurately "read" a rapids. How much and what kind of science must race car drivers know? What about other sports?

Resources

Books

Bangs, R. (1989) *Riding the dragon's back: The race to raft the Upper Yangtze.* New York: Laurel Expedition.

Bennett, J. (1992) *Class five chronicles: Things Mother never told you 'bout whitewater.* Portland, OR: Swiftwater Publishing Co.

Bennett, J. (1996) *The complete whitewater rafter.* Camden, ME: Ragged Mountain Press.

Organizations

American Whitewater Affiliation
P.O. Box 85
Phoenicia, NY 12464
http://www.awa.org/

Periodicals

Canoe & Kayak
10526 NE 68th, Suite 3
Kirkland, WA 98033

Currents
P.O. Box 6847
Colorado Springs, CO 80934
Publication of the National Organization for River Sports

Web sites

Cyberwest Magazine
http://www.cyberwest.com

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NEWTON'S APPLE

SHOW NUMBER

1505

White-water Rafting

SHOOTING THE RAPIDS

WHITE-WATER RAFTING: Student Activity

Float a boat down a model river.

http://www.ktca.org/newtons

Try This

Plan an imaginary white-water trip on a river you'd like to challenge. How would you find out the water level of the river? What kind of equipment would you need? Where would you go for training? How much would it cost?

Try This

Call a local outfitting store that equips people for outdoor adventures. Ask if they can bring a small white-water raft to your class and demonstrate how it works. Ask if they can provide a white-water rafter or kayaker who could talk to your class about the joys and dangers of the sport.

Try This

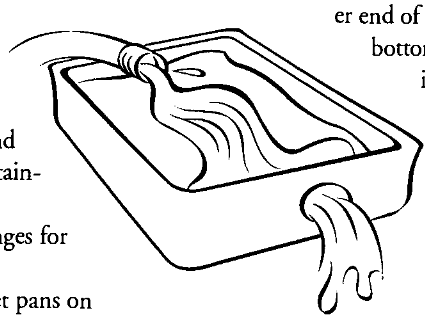
If you live near a lake, organize a field trip with an expert canoeist who can show you the different techniques in paddling that are needed to control a canoe. How much teamwork is needed to quickly turn, back and otherwise maneuver a canoe? How much harder would it be if it was a bulky raft running in rapids?

Main Activity

Materials (For each station)

- large aluminum baking pans or plastic storage boxes, approximately 2' long and 1' wide or larger
- diatomaceous earth (can be found in a swimming pool supply store)
- fine sand
- food-service gloves
- dust mask
- tiny scraps of notebook paper or cardboard (enough to fill pan to a depth of approximately 3")
- pitcher
- bucket or other container to mix sand
- bucket or other container to catch water
- paper towels or sponges for cleanup
- blocks of wood to set pans on

(Note that these supplies may be available as part of earth-science activities that explore river erosion, or you can use a stream table apparatus.)



1. (May be done ahead of time) In a large bucket, mix approximately 3 parts diatomaceous earth with 1 part fine sand and enough water to make a firm mixture. It will take a few minutes of mixing for the material to absorb the water. If you have sensitive skin, wear disposable food-service gloves as you make this mixture. Also, pour the diatomacieous earth carefully, to avoid raising clouds of dust, as it may irritate your eyes and throat.
2. In one end of the plastic or aluminum pan, carefully cut a hole so water can drain out. Tilt the pan and position the drain hole over a bucket or other container to catch the water.
3. In the bottom of the pan, mold a river bed that is about 10 cm (4") wide at the higher end and then narrows to approximately 2 cm (1") at the bottom. You can also explore a curving river bed or a river that is deeper in some places than others, or place a pebble in the river bed so you can observe eddies forming around it. Draw a sketch of your riverbed in your journal.
4. Then, shoot the rapids! Begin with a small amount of water. Pour it carefully into the higher end of your river and watch it flow to the bottom. Make sure all of the water flows into your catch bucket. Then gradually add more water.
5. To see the effect on a raft, sprinkle some fine bits of paper or confetti on the water. Increase the amount of water to make your river run even faster. To see more detail of the turbulence in the water, add a few drops of food coloring into the water as you pour it. Try other materials as well, such as sawdust, and see how they travel.
6. Observe and note in your journal how fast your model "rafts" move at different points in your river.

Questions

1. What's the relationship between speed and the features of your river?
2. How much does the speed change when you pour more water? How do different kinds of model rafts behave in the water? What happens when the channel gets deeper? When it gets shallower?

[Adapted from activities from "Landforms and River Cutters," developed by the Lawrence Hall of Science, University of California, Berkeley]

GLIDERS

How do engineless planes stay aloft?

Dave takes a flight in a glider to see how it stays aloft.

http://www.ktca.org/newtons

NEWTON'S APPLE

[SHOW NUMBER] 1506

Segment Length: 8:20

Getting Started

Begin the lesson by asking students how they think wings help birds fly. Then instruct each of them to take a piece of paper and roll it into a ball. Let it go and watch how it falls. Then take the same paper and smooth it out. Let it go and watch how it falls.

Ask the following questions: Based on your observations, does the weight of the paper have any effect on whether the paper falls or floats? How about surface area? Explain that the greater the amount of air hitting the bottom of the paper, the more "lift" the air can give it. The wings of birds are similar to those of gliders. Not only do they have a large surface area, but they also have a special shape that helps keep them afloat.

Overview

Flying a sailplane is probably the closest thing any human will come to feeling like a bird. Powered only by gravity and air currents, these gliders move silently through the sky, often for hours at a time. Because they have no engines, gliders or sailplanes can be thought of as pure flying vehicles, staying aloft by balancing the forces of gravity, lift, drag, and thrust.

As you might suspect, if you want to stay airborne for a long time, the most important force to conquer is gravity. Lift, the force that directly opposes gravity, comes from the force of the air on the underside of the wing. In wings, lift is controlled by three factors: surface area, shape, and angle of attack

To see how surface area works, roll a piece of paper into a ball. Drop it and the paper falls. Spread the paper out and drop it, and it will float. The greater the surface area, the greater the amount of air pushing up on the wing.

The shape of the wing works because of something called Bernoulli's principle. Most wings are curved on the top and flat on the bottom. As the wing pushes through the air, the air on top of the wing must move a little faster than the air on the bottom. This creates slightly lower pressure on the top, which allows the greater air pressure beneath the wing to push the plane up.

The angle of attack is the orientation of the wing as it faces into the wind. Increasing the angle of attack means increasing the amount of air hitting directly on the bottom, which gives the wing more lift. Of course, if you make the angle of attack too big, the wing will blow backwards, and the plane will come crashing down!

In a sense, a sailplane is very similar to a roller coaster. Both are towed up high and released. They begin to fall and the force of gravity gets them going. Unlike a roller coaster, which continuously loses height, a sailplane can also gain elevation by riding rising currents of air. Known as thermals, these localized updrafts are caused by air being heated by the warm ground below. When the sun shines down on a sandy beach, for example, the sand heats up faster than the water. As the air in contact with the sand begins to heat up, it expands and rises. This differential heating is what causes thermals and when a glider hits one, it can fly for hours at a time.

Connections

1. How is the flight of a bird similar to the flight of a sailplane?
2. How do birds get their thrust and how do they control their direction of flight?

Resources

Books

Hixson, B. (1991) *Bernoulli's book.* Salt Lake City: The Wild Goose Company.

Hosking, W. (1990) *Flights of imagination: An introduction to aerodynamics.* Washington, DC: National Science Teachers Association.

Vogt, G. (1996) *The space shuttle glider kit.* NASA Johnson Space Flight Center—Educational Publication 349 8-96.

Computer software

Casady and Greene (1991): *Glider* 4.0 for Macintosh. (408) 484-9228

Organizations

Virginia Air and Space Center
NASA Langley Research Center
600 Settlers Landing Road
Hampton, VA 23669-4033
(804) 727-0900, ext. 757

Web sites

Sailplane Construction and Cost
http://www.wiltonct.com/soaringadv/gliderbook5.html/

Learning to Fly Sailplanes
http://www.wiltonct.com/soaringadv/gliderbook3.html

Sky Sailing: Frequently Asked Questions
http://www.skysailing.com

Soaring Information
http://groupgenesis.com/soar.html

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NEWTON'S APPLE

SHOW NUMBER

1506

Gliders

THE RIGHT FLIGHT

GLIDERS: Student Activity

Design a glider to achieve maximum glider efficiency.

http://www.ktca.org/newtons

Try This

Research how engineers use wind tunnels to test the design of a wing, and then try building and testing one yourself. Start by building an experimental wind tunnel, using an ordinary house fan blowing through an empty cardboard box to focus the airflow. Try putting different-sized cardboard inserts in the box to deflect and focus the flow and see how it affects the lift on a standard paper glider.

Try This

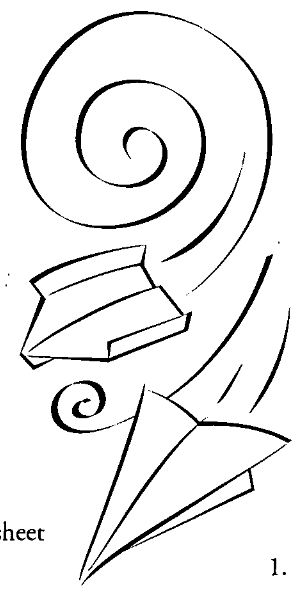
Build a kite from a kit or from plans in a reference book. Try flying the kite on days with different weather conditions. (Watch out for thunderstorms!) You'll discover how wind, thermals, and changing barometric pressure have an effect on how gliders fly.

Try This

Ultralights are planes that combine many of the design features of a glider with a small motor to provide continuous thrust. Research these ultracool flying machines and see how they compare to both sailplanes and conventional aircraft.

Main Activity

If you could build your own sailplane, what would it look like? Since sailplanes are pure flying vehicles, they have no engines to power them. Instead, they depend on their wing structure and stability to maintain lift. See what kind of aeronautical engineer you are by designing and building your own glider. Try to set your own personal best for maximum flight time with your plane.



Materials

- standard 8 1/2" x 11" sheet of copy paper
- paper airplane book (can be found in most hobby or bookstores)
- stopwatch

1. Discuss how the forces of lift, drag, gravity, and thrust all work together to keep a glider in flight. Look at one of the basic glider designs pictured above (or get a paper airplane book with other designs) and construct the one you think will have the longest timed flight, based on wing shape and structure.
2. Have each team member take a turn flying the plane and record all the flight times. Gently throw each plane from the same place. (It's essential to launch each trial the same way.) Compare your flight times with those of the other groups and discuss how the size and the shape of the wings may have affected the flight.
3. After you have evaluated the performance of your plane, try modifying the design to maximize your time aloft. Test your plane again to see if you improved on your flight time.

Extend the activity

How does your plane behave under different atmospheric conditions? Once you have perfected your glider, see how it will work when the air is in motion. Try flying it over a fan or maybe even a hot plate. Can your plane take advantage of thermal updrafts? Test it out and see.

Questions

1. What were some of the common features of the planes with the longest flight times?
2. How did the size and shape of the wings affect the way the planes flew?
3. What other materials besides paper might you use in constructing your plane to get an even longer flight time?
4. Gliders are often towed by airplanes and released at a relatively high horizontal speed. How could you perform this experiment to measure the effects of thrust on the glider's flight?

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NOVOCAIN™

How can the dentist drill my teeth without hurting me?

David explores painless dentistry from the dentist's chair.

http://www.ktca.org/newtons

[SHOW NUMBER] 1506

Segment Length: 7:00

Getting Started

Begin the lesson by bringing in a few samples of nonprescription products for mouth pain. Make sure the students are not allergic to local anesthetics such as procaine, benzocaine, or any of the other "-caine" drugs. Let the students use a cotton swab to apply a small amount of the preparation to a quarter-sized area of the inner wrist. Ask how it feels. In groups, have the students read the labels on different preparations, write down the active ingredients, and try to find descriptions of those chemicals in reference books.

Ask students the following questions: What does your dentist use to numb your mouth when you have a cavity filled? What is the benefit of these preparations? What are some potential problems with them? Why do teeth need so many nerves and blood vessels? How does anesthesia work? Why do we need to feel pain anyway?

Overview

Pain is an important safety feature of the human body because without it, no one would have any warning of injury. Nerves transmit pain messages by a combination of chemistry and electricity. When a nerve receives a pain stimulus over a certain intensity, it "fires" by changing the arrangement of positive and negative charges across its cell membrane. When the message reaches the end of the nerve cell, chemicals known as neurotransmitters spill out into a space (synapse) and stimulate the receiving areas (receptors) on the next nerve cell. The signal passes from nerve to nerve very quickly until it reaches the brain, where the message registers as pain (and you say "Ouch!").

Because nerves send messages by a combination of chemistry and electricity, interference in either area can relieve pain. Traditionally, dentists have used a shot of lidocaine (a substitute for Novocain) to numb the tooth so the patient can't feel the drill. This is a little alarming in itself when the cavity is in a lower jaw tooth; the only available nerve to numb is way in the back of the mouth, so the needle is several inches long. The numbing effects of lidocaine last a while, too, which can be embarrassing. Ever try to talk when your mouth is numb?

One nonchemical procedure, which dates back to the 18th century, avoids needles altogether by stimulating the tooth's nerve with electricity to numb it. Although it can't be used for everything, this electronic anesthesia has proven useful for some simple dental procedures. There are generally two electrodes, placed inside or outside the mouth (sometimes one in and one out). The patient controls the degree of stimulation by turning a knob on a small switch box. When the stimulation is turned off, the numbness goes away immediately.

Anesthesia works in a number of ways. Some anesthetic drugs block certain receptors. Others inhibit biochemicals that increase the nerve's likelihood of firing. Scientists disagree on how electrical stimulation works, although some think it somehow results in the release of natural painkilling substances in the brain called "endorphins."

Connections

1. Are you a little nervous about going to the dentist? Do you think nervousness makes pain worse? How can you calm yourself?
2. Some anesthetics have side effects. How should these drugs be regulated?

Resources

Books

Clayman, C. (Ed.) (1994) *American Medical Association family medical guide* (3rd ed.), "Teeth and gums," pp. 469–482. New York: Random House.

Computer software

Softkey: *Bodyworks, Classic Edition.* CD ROM for Windows. To order: http://cdrom.softkey.com/products/bdc3344ae-front.html

Web sites

American Dental Association, Consumer Information Page
http://www.ada.org/co-menu.html

Dental Breakthroughs and You
http://www.soluna.com/dds/cedata.html

Electronic Dental Anesthesia
http://weber.u.washington.edu/~quarn/eda.html

Pain Lecture Slide Show
http://pain.roxane.com/index2.html

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THE PAINLESS GAME

NOVOCAIN: Student Activity

Test different methods to numb your sense of touch.

http://www.ktca.org/newtons

Try This

The next time you brush your teeth, look carefully inside your mouth. What do you see? Are there parts that are more sensitive than others? What does brushing have to do with gum sensitivity?

Try This

Interview a doctor at a pain management clinic. Are there different kinds of pain? How are they classified? How are they managed?

Try This

Write a story about an alien visiting Earth. This alien has no understanding of "pain" and wonders what it is for. How will you explain what it feels like?

Main Activity

Because pain and touch receptors on nerves are closely related, an area of skin more sensitive to touch will often be more sensitive to pain. You can investigate some phenomena that cause changes to the sense of touch; whatever numbs the sense of touch may also be a potential anesthetic.

A classic experiment on the sense of touch is called the "two-point discrimination test," which means noticing whether one or two objects are pressed against your skin. More sensitive areas of skin will be able to tell one from two, even when the two are very close together. Less sensitive areas will require that the objects be widely spaced. A numbed area should become less sensitive.

Materials

- several toothpicks
- blindfolds (one for each person—be careful not to share blindfolds)
- rulers
- tape
- ice or ice water
- a source of fairly strong vibration (personal massager works well)
- pen and paper for keeping records

1. Tape two toothpicks to a ruler (in the same direction as the markings). Measure the distance between them.
2. Touch either a single toothpick or the two side-by-side toothpicks to a blindfolded subject's inside forearm. Record whether the subject can distinguish between the two.
3. Touch with toothpicks that are different distances apart until you can conclude the minimum distance for distinguishing one toothpick from two.
4. Try to alter the sense of touch by applying ice or vibration to the same skin area. What do you notice? What is the shortest distance between toothpicks that can be distinguished? Does the ice make the skin more or less sensitive? Does the vibration make the skin more or less sensitive?
5. Design a similar test for the first finger. Is the first finger more or less sensitive than the forearm? Does the ice or vibration have more or less of an effect on the finger than on the forearm? Repeat the test with loud music or static sounds. Does this alter the sense of touch in any way?

Questions

1. Why do you think the ice or vibration works to numb your sense of touch?
2. Why are some areas of your body more sensitive to pain than others?

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GLACIER CLIMBING

What is a glacier and how does one move?

Four Oregon teenagers climb to the summit of a glacier.

http://www.ktca.org/newtons

NEWTON'S APPLE

OAG Outside Adventure Giants

[SHOW NUMBER] 1507

Segment Length: 6:30

Getting Started

Begin the lesson with the following question: Where is most of the freshwater on Earth currently found—in rivers, lakes, or glacial ice?

Explain that glaciers not only are found in polar regions like Antarctica and Greenland, but mountain glaciers exist even at the equator. Glaciers can have an enormous effect on sea level around the world. Toward the end of the last ice age, 12,000 years ago, sea level was almost 300 feet lower than it is today. If global warming occurs, some scientists theorize that melting glaciers in the next century could cause a rise in the sea level worldwide.

Overview

Over the last 25,000 years glaciers have had an even greater effect on our global landscape than earthquakes, volcanoes, hurricanes, or floods. But because they flow so slowly, they are often overlooked as a significant agent of change.

A glacier is a large mass of ice that acts like a river, flowing downhill under the influence of gravity. Glaciers are "born" at high elevations where snow builds up over many years without significant melting. In these "accumulation zones," snow at the bottom of the pile gets compacted by the weight of new snow above, causing it to turn into dense glacial ice. Once the depth of the ice reaches 20 to 30 meters (66 to 98 feet), there is enough pressure from above to cause the ice pack to slowly "creep" or flow downhill. As long as new snow is added at the top, a glacier will continue to move forward.

As the front of a flowing glacier moves downhill, it scours the land surface, picking up rock and soil and trapping it in the ice. If snow keeps falling and temperatures stay cold enough, glaciers will continue to move downhill, eventually reaching a point of dynamic equilibrium. Here, the rate of melting at the front of the glacier is exactly balanced by the flow rate of the glacier from the back. While it may look like the glacier has stopped, the flow of ice is continuous, so large piles of glacially derived sediment begin to build up at the foot of the glacier. When the glacier retreats, the deposits become terminal moraines These telltale signs of past glacial action often reach several hundred meters in thickness.

In polar regions like Antarctica and Greenland, so much snow accumulates that individual glaciers flowing down valleys begin to merge together, forming large-scale continental ice sheets. In some cases, these massive glaciers are more than 1,000 meters (3,300 feet) thick and, while they may look static, they too are in continuous motion.

Data seems to suggest that over the course of the last two decades, global warming may be causing glaciers all over the world to retreat. The fear is that large-scale melting of glaciers will create a devastating rise in sea level. Only time will tell if this is a long-term trend or simply a natural "blip" in the worldwide glacial cycle.

Connections

1. What is the current distribution of glaciers around the Earth? Are there any major trends where glaciers appear to be either growing or shrinking at abnormally high rates? What can changes in glacial distribution tell us about changes in climate?
2. A retreating glacier can leave rich soil behind. What areas of the world benefited from this glacial activity?

Resources

Books and articles:

Hambrey, M. (1992) *Glaciers.* New York: Cambridge University Press.

Hostetler, S. (1997, Jan) Near to the edge of an ice sheet. *Nature*, p. 393–394.

Kimber, R. (1993, May) The glacier's gift. *Audubon*, pp. 52–53.

Lee, L. (1994, June) Summer's here: Chill out! *National Geographic World*, pp. 10–14.

Pfeiffenberger, J. (1997, April) Ice age journey. *Earth*, pp. 76–79.

Walker, S. (1990) *Glaciers: Ice on the move.* Minneapolis: Carolrhoda Books.

Organizations

The World Glacier Monitoring Service
Wilfried Haeberli and Martin Hoelzle
Department of Geography
University of Zurich
Winterthurerstrasse 190
CH-8057 Zurich, Switzerland
http://www.nercbas.ac.uk/public/icd/icsi/WGMS.html

Web sites

Alaska SAR Facility—Great Glacial Images
http://www.asf.alaska.edu/

Glacier Page
http://168.99.215.253/earth/glacier.html

USGS Cascades Volcano Observatory
http://vulcan.wr.usgs.gov/Glossary/Glaciers/framework.html

Whistler Networks—How to Make a Glacier
http://www.whistler.net/glacier/howgl.html

Whistler Networks—What Is a Glacier?
http://www.whistler.net/glacier/whatgl.html

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NEWTON'S APPLE

SHOW NUMBER

1507

Glacier Climbing

THE SLOW FLOW

GLACIER CLIMBING: Student Activity

Discover how a valley glacier flows by using a superthick, viscous fluid as your model glacier.

http://www.ktca.org/newtons

Try This

Although scientists have been monitoring the movement of glaciers for over 100 years, there is a renewed interest because of the fear that global warming may be causing a widespread melt-back. Does the data fit this model? Collect data on several different glaciers and chart their progress over the last 50 years. A good place to start is with the glaciers in Alaska or on Mt. Rainier in Washington State. Data can be obtained from the Internet (see resources) or from a regional U.S. Geological Survey Office.

Try This

Make dirty ice cubes by mixing different amounts of dirt and debris in the water before freezing it. Identify which ice cube has the least mass and which has the greatest. Place these two ice cubes, plus a third whose mass is some where in between, on an inclined ramp and allow them to melt. What do you observe? How is this similar to what happens when a glacier melts?

Main Activity

Because it takes an enormous amount of mass to make a real glacier creep downhill, scientists often rely on substitute materials to make a model of fluid flow in glaciers. In this activity, you'll make a highly viscous suspension of cornstarch and water to simulate a glacier, and track the way that it flows down a "valley."

Materials per group of four students

- plastic shoe box
- one 16-oz box of cornstarch
- one to two cups of water
- one 2-qt mixing bowl
- 5 wooden toothpicks
- 5–6 large pebbles
- one 5" x 7" inch index card
- pencil

1. Mix the cornstarch and water together in the bowl to form a suspension with the consistency of toothpaste. (It should not be runny or wet.)
2. Lay the pencil flat on the table and place one end of the shoe box on top of it to give the box a slight tilt. Begin pouring the cornstarch mixture into the box at the raised end and observe what happens.
3. After the mixture has flowed through the entire box, scrape it up with your hand and pile it in the raised end of the box. Use the index cards to make a "dam" across the shoe box valley to hold the mixture back. Lay the five toothpicks across the front of the mixture so that they are one inch apart and parallel to each other. Remove the dam and observe the way the toothpicks move as the glacier flows.
4. After you have tracked the flow of the glacier with the toothpicks, repeat the experiment, but this time place a few large pebbles on the bottom of the shoe box to make obstructions in the valley. Allow the glacier to flow again and observe what happens when it interacts with the obstructions.

Questions

1. When the cornstarch mixture initially flowed through the box, what shape did the front take? How does this relate to valley glaciers?
2. When you released the mixture from behind the index card "dam," what pattern did the toothpick markers make? What do you think caused this?
3. What happens to the flow of the glacier when it hits the obstructions in the valley? Do you notice anything different in the top of the glacier as it flows over the rocks?

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WILDERNESS TRAINING

How do adventurers prepare for a long wilderness journey?

Four Oregon teenagers explore what you need to climb a glacier.

http://www.ktca.org/newtons

NEWTON'S APPLE

OAG OUTSIDE ADVENTURE GRANTS

[SHOW NUMBER] 1507

Segment Length: 5:30

Getting Started

Begin the lesson by asking these questions: Do you like hiking in the woods? What equipment do you take on a camping trip? Most camping areas have at least some comforts, such as trash removal, trails, and rest rooms, but real wilderness has none of those things. How would you plan for wilderness travel, such as climbing a mountain? How much and what kinds of food would you take? How would you find shelter, build a fire, and stay warm? How would you navigate with no trails or constructed landmarks? How would you avoid falling on a steep slope? What specialized equipment would you need?

Overview

In 1997, four teenagers from Oregon won the Outside Adventure Grant for their proposal to climb Mt. Sir Sanford, a remote peak in the Canadian Rockies. To get there, these wilderness enthusiasts had to kayak and hike to the base of the mountain and then climb up a glacier to the peak. The group's winning proposal included tracking and documenting the habits of an endangered species of caribou along the way. The grant outfitted them for their expedition.

As these outdoor adventurers could tell you, alpine climbing and snow travel require particular skills and knowledge. Climbers must have good strength and endurance. They must work effectively in the thin air at high altitude.

Because climbing in the cold uses up calories rapidly, these mountaineers need to consume foods that provide them with the right ratios of protein to fat to carbohydrate, but they mustn't carry food that's too heavy or perishable.

Successful climbers also must know how to avoid frostbite and other cold-related problems. The right choice of fabrics and the right layering techniques allow them to stay warm and dry throughout the journey.

Finally, the adventurers need to be skilled at anticipating, preventing, and stopping falls before anyone is hurt. Even on a flat glacier, falls are a danger because of the deep trenches called crevasses (sometimes hidden by snow) in the glacial ice.

How do climbers manage to stay on steep slopes? The idea is to keep three of the four limbs solidly fixed to the surface at all times. Spiked boot clamps called crampons allow solid footholds, even on vertical surfaces. In addition, climbers can secure their handholds with special ice axes.

Mountain climbing safety depends on climbers belaying (securing) each other with ropes. The National Outdoor Leadership School identifies four elements of a belay: friction, anchors, each climber's position relative to the others, and communication among climbers. The terrain to be climbed is often rated according to its difficulty (rather like the degree of difficulty rank in the sport of diving), so each belay will be a different combination of the four elements.

Connections

1. There are many different kinds of wilderness. How many can you name? How would you expect exploration equipment and supplies to differ for various kinds of wilderness?
2. When a wilderness area is opened to people, the environment often degrades because people leave behind trash, pick endangered plants, or trample sensitive ecosystems. What is the best way to allow access to wild places without damaging them?

Resources

Books and articles:

Angier, B. (1973) *Wilderness gear you can make yourself.* Harrisburg, PA: Stackpole Books.

Boga, S. (1997) *Orienteering: The sport of navigating with map and compass.* Mechanicsburg, PA: Stackpole Books.

Dash, J. (1995, Mar 19) The active traveler: The adventure guide's hard reality. *Newsday,* p. 8.

McManners, H. (1996) *The backpacker's handbook.* New York: Dorling Kindersley Publishing, Inc.

Tilton, B. (1995, April 14) Wilderness U. *Backpacker,* p. 70.

Web sites

Outside Online
Outside Adventure Grants
http://www.starwave.com

Princeton University Outdoor Action Program
http://www.princeton.edu/~oa/oa.html

National Outdoor Leadership School
http://www.nols.edu

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NEEDLE POINT

WILDERNESS TRAINING: Student Activity

Construct your own navigational tool with some common household items.

Main Activity

Almost a thousand years ago, the Chinese writer Shen Kua first described the use of a magnetic compass in navigation. At the time, this "orienting" technique was practiced almost exclusively by seafarers. It wasn't until the 1500s that the compass became popular as a land-based navigational tool. Its rapid and widespread acceptance among landlubbers was probably due to its "double duty" as an inexpensive pocket sundial.

The first compasses were most likely made of a naturally-occurring magnetic rock called lodestone. If allowed to rotate freely, this magnetic material comes to rest aligned with Earth's magnetic field. Another valued characteristic of lodestone is its ability to transfer magnetic properties to iron and other metals.

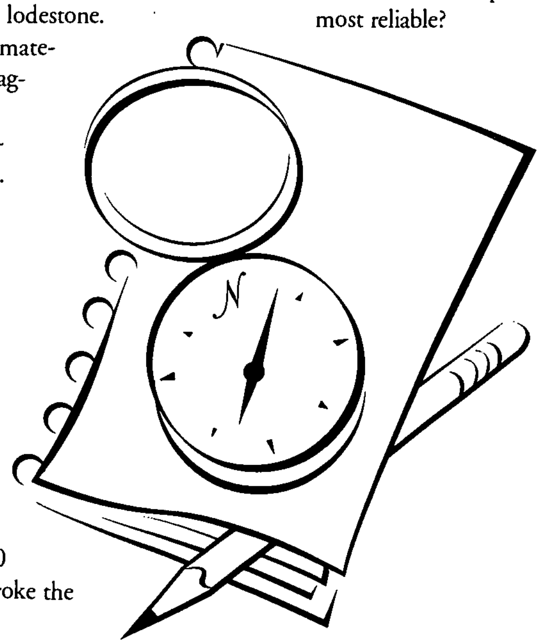
Materials

- permanent magnet
- straight sewing needle
- small bowl
- plastic foam chip or flattened noodle

1. Fill a small bowl with tap water.
2. Magnetize the needle by stroking it 50 times with the permanent magnet. Stroke the needle in only one direction.
3. Position the needle lengthwise in the center of the foam chip (or noodle).
4. Carefully lower the chip and needle into the center of the water-filled bowl.
5. Observe the movement of the chip.
6. Move the bowl-compass to different locations, near walls, large metal objects, etc. Note in your journal what happens in each location.

Questions

1. What causes the chip to move?
2. Can you tell which is the north-seeking end of the needle? Explain.
3. Suppose the needle had been stroked in the opposite direction. Would that affect its pointing direction? Suppose the needle was stroked back and forth. Would that affect its use as a navigational tool? Explain.
4. In what locations is a compass most reliable?



Try This

Design a wilderness training ground on the playground of your school. What would be a good training exercise for hiking? Climbing? Endurance?

Try This

Stage a mock-up camping or climbing accident and practice first-aid procedures on pretend "victims." What are good first-aid procedures? What are some dangerous first-aid procedures to avoid?

Try This

Write your own adventure grant. It must be "wild, original, and meaningful." It should explain what you want to do, what equipment you need, your plans for training, and how you will accomplish your goals.

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INDEX TO PAST SEASONS

How to Get Your Hands on NEWTON'S APPLE

As an educator, you may tape NEWTON'S APPLE off the air and use it as many times as you wish for three years. Check with your local PBS station for their schedule. When they are finished airing the current season (Season 15), they often rerun shows from past seasons.

If you prefer, you can purchase tapes from any of the seasons listed on these two pages by calling 1-800-588-NEWTON.

10th Season

Show 1001
Behind-the-Scenes Special
•How TV Works
•Studio Tour
•Control Room/Editing
•Satellite Technology

Show 1002
Hollywood Stunts
Household Chemistry
Cream in Coffee
Musk Ox

Show 1003
Election Polls and Surveys
Electric Car
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Cougar

Show 1004
Monster Makeup
Ozone
Car Mirror
Artificial Sweeteners

Show 1005
Oil Spills
Diet and Nutrition
Crystal Gayle
Caribou

Show 1006
Antarctic Special
•Journey
•Penguins
•Palmer Station
•Krill
•Seals

Show 1007
HIV/AIDS
Glass Recycling
Cement
Science Challenge
Wolverine

Show 1008
Cockroaches
Broken Bones
Dentist Chair
Rhinoceros

Show 1009
Omnimax Technology
Archery
Light Bulbs
Condor

Show 1010
Aurora Borealis
Air Pressure
Al Gore
Piranha

Show 1011
Traffic Control
Cryogenics
Static Electricity
Russian Kids Visit

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Blood Typing
Moles
Penguin

Show 1013
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Dweezil Zappa
Ostrich

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Rock Climbing
Taste Test
Monty Hall
Baby Bobcats

Show 1102
Emergency Rescue
Black Holes
Pizza
Reindeer

Show 1103
Memory
In vitro Fertilization
Goose Bumps
Hummingbird

Show 1104
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Echoes
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Meteors
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Otters

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Dead Fingernails
Chile Peppers

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Michael York
Wolves

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Infrared
Shelley Duvall
Polar Bears

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Candles
Chimpanzees

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Brain
Carrier Life

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Garlic
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Hubble Telescope
Inventor's Fair
Komodo Dragon

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Skipping Stones
Snakes

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Red Fox

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•Water Towers

GLASS BLOWING

How do they make glass into different shapes?

Eileen learns about the art and chemistry of glass blowing.

http://www.ktca.org/newtons

[SHOW NUMBER] 1508

Segment Length: 6:30

Getting Started

Begin the lesson by having students dip a chopstick into a small cup of honey at room temperature. Tell them to try to keep the largest gob possible of honey on the tip of the stick as they pull it out of the cup. They are simulating how a glass blower works with gravity to keep a gob of molten glass on the end of the blowpipe.

Ask: Is all glass the same? Compare and contrast different type of glass (based on properties such as heat resistance, shatter resistance, and color).

Overview

Glass is an amazing substance—hard, transparent, capable of beautiful colors and sparkles, strong yet brittle. Where does this material come from?

A crude version of the material we know as glass was most likely first produced about 4,500 years ago. Around 1500 B.C., artisans learned how to press glass in open molds, producing a variety of shapes and containers. The process, however, was slow, labor intensive, and expensive. Pressed glass was considered as valuable as precious metals.

More than a thousand years passed before people discovered how to shape intricate and delicate objects through glass-blowing techniques.

Today there are a variety of glasses. These materials have ingredients and structures that produce distinct characteristics. Automobile glass (also called safety glass) is actually two layers of glass that "sandwich" a layer of plastic. If the glass layers shatter, the pieces don't go flying off. Instead, they are held together by the plastic. Laboratory glassware contains a large amount of silica and boric oxide. These components produce a material that can withstand sudden temperature changes.

Perhaps the most common type of glass is called soda-lime glass. The basic ingredients include sand (a source of silica), soda (sodium oxide), and lime (calcium oxide). These materials are mixed together and then heated in furnaces. As the materials melt, they combine to form a syrupy liquid. This molten glass is then withdrawn from the furnace and processed in different ways.

Although it is brittle, hardened glass is not a solid. It exists in a slow-flowing state known as a supercooled liquid. When molten glass cools, there is no "solidifying temperature" at which the batch suddenly transforms from liquid to solid. Instead, the molten material undergoes a gradual change from a free-flowing to a more viscous material. The more it cools, the less it flows. At room temperature, the minuscule flow goes unnoticed.

There are several ways to shape glass. It can be pressed into a mold. This technique produces objects such as bowls and optical lenses. It can be drawn through rollers or holes to produce fibers, tubes, and plates. It can also be blown, with or without a mold.

Connections

1. Consider the differences you might find between glass created by hand and glass shaped by machine. When might a plastic product be preferable?
2. The use of fiber optics for telecommunications has become a reality. How many different objects can you think of that are made of glass?

Resources

Books and articles

Carbery, E. (1993) *Glassblowing: An introduction to artistic and scientific flameworking.* Marshall, MN: MGLS.

Whitehouse, D. (1993) *A pocket dictionary of terms commonly used to describe glass and glassmaking.* Corning, NY: The Corning Museum of Glass.

Organizations

Corning Museum of Glass
One Museum Way
Corning, NY 14830-2253
(607) 974-8257

National Glass Association
8200 Greensboro Drive
McLean, VA 22102
(703) 442-4890
http://ourworld.compuserve.com/homepages/nga

Print and AV materials:

Video: *Beginning Glass Sculpturing by Bill Rasmussen* (103 min.). Available from Arrow Springs, (916) 677-9482.
http://www.innercite.com/~flameon/

Glass Line magazine
120 S. Kroeger Street
Anaheim, CA 92805-4011
(714) 520-0121
http://www.hotglass.com/

Web sites

Kosta Boda
http://www.kostaboda.se/en/2.html

Scientific Glassblowing Lab Tour
http://www.cem.msu.edu/~kenney/outreach/glasblow/tour/

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NEWTON'S APPLE

15 YEARS OF HANDS-ON SCIENCE

SHOW NUMBER

1508

Glass Blowing

SUPERCOOL!

GLASS BLOWING: Student Activity

Change the temperature of butter and check out the properties of a supercooled liquid.

http://www.ktca.org/newtons

Try This

Observe variations in the viscosity of honey, syrup, liquid soap, hand lotion, and milk. Gather about half a cup of each. Dip a wooden stick into each to pull out a sample. Record your observations. Pour each liquid into another cup; record observations, including temperature, flow rate, and color. Change the temperatures of each and observe changes. What happens to the viscosity of each as the temperature changes?

Try This

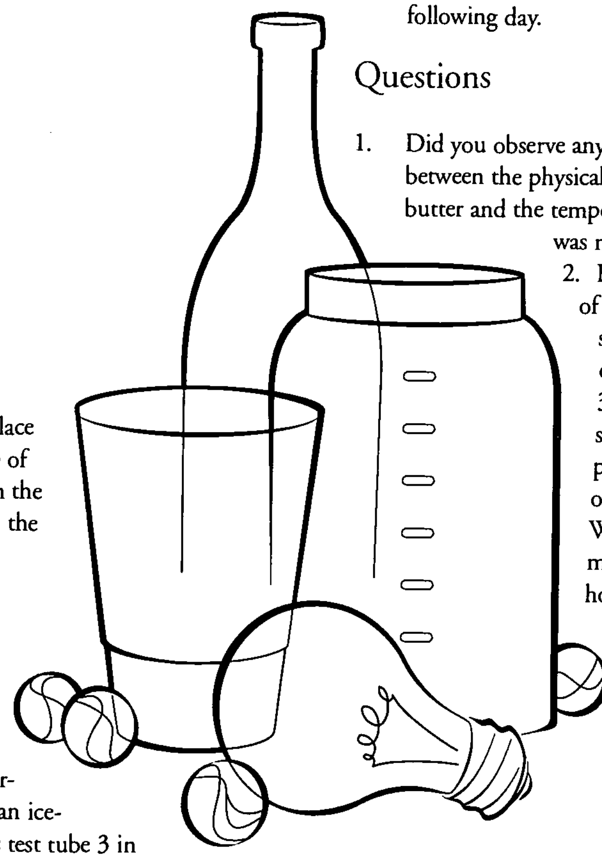
Make two batches of any candy requiring that the sugar reach a specific temperature and candy stage in cooking. For one batch, follow the recipe exactly. For the second batch, heat the sugar to a different candy stage—cook either too little or too much. What differences do you observe in the candy?

Main Activity

Like glass, butter is an example of a supercooled liquid. Although it appears solid, butter's hardness depends on its temperature. As its temperature increases, butter becomes less viscous. Eventually the butter flows like more traditional liquids. If liquid butter is cooled, it takes on the hardened characteristics we associate with solids. The colder the temperature, the more solid the butter becomes.

Materials

- butter
- two 250-ml beakers
- five small test tubes
- test tube rack
- test tube holder
- spatula
- ice
- water



1. Use the spatula to place a marble-sized lump of refrigerated butter in the five test tubes. Label the test tubes 1–5.
2. Place test tube 1 in a freezer.
3. Place test tube 2 in the refrigerator.
4. Fill a beaker halfway with cold water. Add several ice cubes to form an ice-water solution. Place test tube 3 in this solution.
5. Fill the other beaker halfway with hot water. (Be careful not to burn yourself.) Place test tube 4 in this solution.
6. Keep test tube 5 in the rack at room temperature.
7. At the end of the period, examine the butter sample in each of the test tubes. Note and record any differences in shape and appearance and relative hardness.
8. Discard samples 3 and 4. Replace samples 1, 2, and 5 in the freezer, refrigerator, and test tube rack, respectively.
9. Observe samples 1, 2, and 5 on the following day.

Questions

1. Did you observe any relationship between the physical properties of the butter and the temperature at which it was maintained? Explain.
2. How is the viscosity of butter and glass similar? How is it different?
3. Predict how the shape of a windowpane might change over many years. Would this change be more dramatic in a hot climate or a cold climate? Explain.

SMILES

Why do humans smile?

Dave Huddleston learns how smiling helps us communicate.

http://www.ktca.org/newtons

NEWTON'S APPLE

[SHOW NUMBER] 1508

Segment Length: 7:45

Getting Started

Begin the lesson by having the class make six emotion charts labeled as follows: happiness, fear, disgust, sadness, surprise, and anger. On a pad of sticky notes, have pairs of students write down as many other emotions as they can think of, one per sticky, in three minutes. Have the students put each sticky note on the chart that most closely matches the emotion. As a group, discuss each chart.

Ask the following questions of the group: As you were thinking about different categories of emotions, did your facial expressions change for each? Did you notice changes in your partner's expressions?

Overview

Have you ever been asked to "wipe that expression off your face" or to "smile for the camera"? Were you able to? Our facial expressions tell others what we're thinking and feeling—and usually it's easy to tell when someone is faking an expression. In addition, our facial muscles send messages to our brains so that when we make a facial expression, our emotions grow stronger.

You have 80 muscles that control what happens on your face. Those muscles communicate at least 40 different groups of expressions—the six primary emotions and their blends. Using the Facial Action Coding System (FACS), scientists have observed and analyzed nearly 10,000 facial expressions by determining which muscular actions produce each expression. By studying the mechanics of smiles, frowns, and the thousands of other "faces" we make, scientists are beginning to understand how people use facial expressions.

Why is it important to study facial expressions and who cares about them? Actors study expressions to seem more realistic. Police detectives look at the faces of suspects and witnesses to help determine if they are telling the truth. Airport security people study faces of travelers to look for clues about danger in the skies. Medical professionals observe facial reactions during physical exams. Interpreters closely watch the faces of the speakers to determine accurately the message to translate. Reading faces is an important survival skill.

Researchers at the Massachusetts Institute of Technology's Media Lab are working on many projects that involve computers learning to imitate human movement, actions, and even emotions. One project involves developing ways for computer-generated models to interact with each other, using speech with appropriate intonations, hand gestures, and facial movements. In another, scientists use algorithms to generate facial animations from speech and are studying how the face, hands, and speech complement each other in our communication. The focus of another project looks at how people might communicate with computers using speech, gesture, and gaze—the same things humans use to communicate with each other.

So next time you meet someone, take a few seconds to think about what that person's face is communicating before either of you says a word. Chances are you'll be able to tell what the person is feeling. But remember—he or she might be doing the same thing to you!

Connections

1. How do gestures differ from facial expressions or emotions?
2. How do animals communicate with each other?

Resources

Books and articles
Ekman, P. & Friesen, W. (1984) *Unmasking the face: A guide to recognizing emotions from facial expressions.* Palo Alto, CA: Consulting Psychologists Press.

Computer software
Mindscape: *How your body works.* CD-ROM for Macintosh or MPC. (888) 808-4311 or http://www.mindscape.com

Organizations
American Psychological Association
750 First Street NE
Washington, DC 20002-4242
(202) 336-5500
http://www.apa.org

MIT Media Lab
MIT Building #E15, The Wiesner Building
20 Ames Street
Cambridge, MA 02139
(617) 253-0338
http://www.mit.edu/Media Lab/Research.html

Print and AV materials
Mandler, G. (1989) "Notes on emotion," written for the Rotating Faces Exhibit in the Traveling Psychology Exhibition of the American Psychological Association.

The "Rotating Faces" and related activities are part of the exhibition entitled *"Psychology: Understanding Ourselves, Understanding Each Other."* The exhibition was developed and produced by the American Psychology Association and the Ontario Science Centre in cooperation with the Association of Science-Technology Centers, the Exploratorium, and The Children's Museum, Boston. Additional support for the exhibition was provided by the National Science Foundation, the William T. Grant and Alfred P. Sloan Foundations, Harvard University, the National Institute of Mental Health, and the Annenberg/CPB Project.

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IT ON PBS

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3M Innovation

NEWTON'S APPLE

SHOW NUMBER

1508

Smiles

FACE TO FACE

SMILES: Student Activity

Find out how the parts of the face work together to express emotions.

http://www.ktca.org/newtons

Try This

Walk for several minutes with your eyes looking down, taking short, shuffling steps. Now walk for several minutes with your eyes straight ahead, taking long strides and swinging your arms. Does your mood change?

Try This

Human faces are asymmetrical, and usually the facial muscles on one side convey more tension. Ask someone to take a picture of your face looking straight into the camera. When you develop the film, ask for two copies—one from each side of the negative. Cut each picture in half vertically. Glue the left side of one to the right side of the other. Repeat with the remaining halves to make two pictures of yourself. What differences do you notice? Which side of your face is more expressive?

Try This

Communication via email or in online chat areas requires creativity to express not only your ideas but how you feel. Emoticons are symbols that express feelings. For example, :-(is a frown and :-} is an embarrassed smile. Look at the symbols on a keyboard and create your own set of emoticons. If you have a keypal, share your "faces" and have fun communicating!

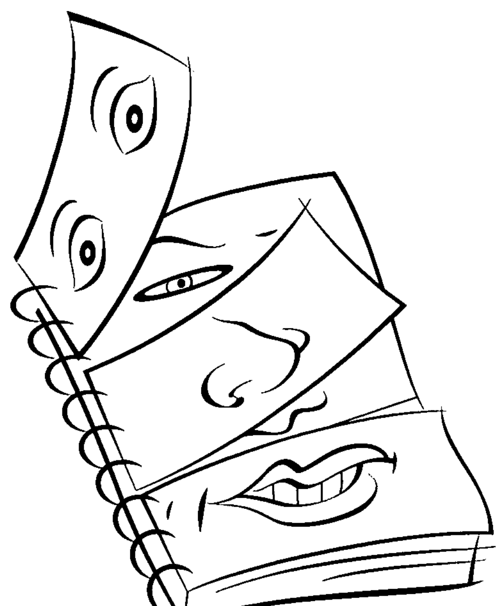
Main Activity

Does a smile only happen on one part of your face? Create a face book to find out. By combining different faces, you can identify what emotions other people see on each face you create. You'll learn which parts or combination of parts of the face communicate most accurately.

Materials

- magazines you can cut up
- scissors
- glue
- construction paper or other heavy paper
- markers and pens
- three 1" metal rings or spiral binding machine and binding material

1. Working with two or three partners, collect large (8.5" x 11") pictures of faces from magazines.
2. Glue each face to a page of paper. You should have at least 10 pages of faces. Punch holes in each page and use metal rings or a spiral binding machine to make a booklet.
3. Make two horizontal cuts through each page, dividing the faces into these parts: brow/forehead/eyes; nose; and lower face (mouth, chin). Identify each part of each face on the back of each section. Example: Face 1a (eyes), Face 1b (nose), Face 1c (lower face).
4. Create a table/log to record the face combinations and the emotions your classmates think each face communicates. Remember that there are many more emotions than sad, angry, and happy. Encourage your viewers to think of more complicated emotions, such as satisfied, disgusted, desperate, compassionate, scornful, excited, dull, egotistical, and fawning. Look in a dictionary or thesaurus for some other unusual or detailed emotions.
5. Flip through the booklet to create facial composites. Be sure to note in your log which combination of parts was used for each face and each person's response to that face. Ask your viewers how and why they came to their conclusions.



Questions

1. What do your findings demonstrate about how we "read" faces? Share your ideas with the class.
2. What features change the expression the most? The eyes? The mouth?
3. Does everyone tend to focus on the same features? Where do you look first?

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GREENHOUSE EFFECT

How does the loss of ozone affect our climate?

David investigates why the greenhouse effect is bad for our environment.

http://www.ktca.org/newtons

NEWTON'S APPLE

[SHOW NUMBER] 1509

Segment Length: 7:30

Getting Started

To begin the lesson, pose the following situation: On a bright, sunny day, you park your car in the sun and lock it. When you come back later, what has happened? Have you ever been inside a greenhouse when the sun was out? How did it feel? This phenomenon is called the greenhouse effect.

Before showing the video, ask the following: Is Earth enclosed by something? In what ways is Earth like a greenhouse? What effects will changes in Earth's average temperature have? How do human activities contribute to this change in temperature? Are we making Earth too hot to live on? How can we cool off?

Overview

Climate—that is, the weather over a long period—depends on Earth's average temperature. This temperature stays relatively constant because Earth's surface absorbs energy from sunlight, changing it to heat (infrared radiation). Greenhouse gases, particularly water vapor, absorb the resulting heat energy and hold it in the atmosphere instead of allowing it to radiate out into space. (In an actual greenhouse, the glass windows block the heat's exit.) This greenhouse effect keeps us warm, but scientists are concerned that humans may be creating problems by adding certain greenhouse gases to the atmosphere, such as carbon dioxide (from carbon-based fuels), chlorofluorocarbons (from aerosol cans), and methane (from cow digestion).

The accumulation of greenhouse gases could result in global warming—an increase in the average temperature that would probably lead to climate change. If the worst predictions come true, we may have to deal with melting polar ice caps; rising sea levels; uninhabitable coastal areas (where half the world's population now lives); and wild, unpredictable storms. Agricultural areas might turn to desert, while barren areas might become fertile.

Researchers have analyzed air that was trapped in glacial ice 160,000 years ago. By comparing that air to the air in our current atmosphere, they have discovered an increase in carbon dioxide as the use of fossil fuels has increased.

Some scientists aren't convinced that excess greenhouse gases will actually cause global warming. They point out that cooling effects also are taking place. For instance, the oceans absorb much of the carbon dioxide that human activity contributes to the atmosphere. Higher temperatures cause more water to evaporate into clouds, which shade Earth from sunlight, cooling it. Particulate matter from volcanic eruptions and other pollutants deflects sunlight and also contributes to cooling.

The greenhouse effect is a very complex issue. Much of the information we have about global warming comes from computer models that estimate climate change. These estimates may be inexact because the atmosphere is so huge. In addition, an observed temperature increase may be caused by something else. Some measurements suggest that variations in the sun's light output cause temperature changes far more significant than those caused by greenhouse gases.

Connections

1. Sometimes a waste product or pollutant can be recycled for another use. Can you think of some other uses for the greenhouse gases?
2. How can we determine if human activity is really contributing to global warming? And if it is, what should we do about it?

Resources

Books and articles

Botkin, D. & Keller, E. (1995) *Environmental science: Earth as a living planet* (chapter 21 on climate). New York: John Wiley & Sons, Inc.

Rawls, R. (1996, Nov 4) Ironing the ocean: Iron, a micronutrient for marine plants, may be critical to global carbon balance. *Chemical and Engineering News*, p. 40.

Roleff, T. (Ed.) (1997) *Global warming: Opposing viewpoints*. San Diego: Greenhaven Press.

Sarmiento, J. & Le Quere, C. (1996, Nov) Oceanic carbon dioxide uptake in a model of century-scale global warming. *Science*, p. 1346.

Computer software

KIDWare: *Weather Tracker* (ver. 3.0). Shareware, downloadable from http://www.hotfiles.com, $15 to register.

Web sites

CIESIN (Consortium for International Earth Science Information Network) http://www.ciesin.org/

Environmental Defense Fund http://www.edf.org/pubs/Brochures/GlobalWarming/a_gwexhibition.html

Environmental Protection Agency http://www.epa.gov

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NEWTON'S APPLE

SHOW NUMBER

1509

Greenhouse Effect

BUBBLE

GREENHOUSE EFFECT: Student Activity

Use vinegar to identify carbonate-containing materials.

http://www.ktca.org/newtons

Try This

Fill a 1-liter beaker with water. Add 7 drops of red food coloring. This makes a solution approximately 350 parts per million (the same as the carbon dioxide concentration in the atmosphere). Can you still see the red color? What if you double the concentration?

Try This

Carbon dioxide is not a pollutant in the traditional sense. All green plants need it to grow. Make a list of other things that have this good-in-small-amounts/bad-in-large-amounts behavior.

Try This

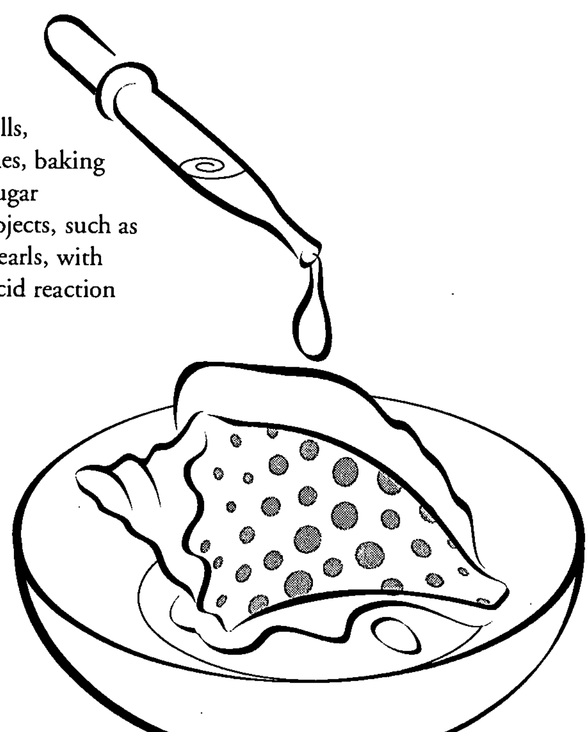
Record the temperature outside several times a day for a week, at approximately the same times each day. Note whether the sun is out. Plot temperature versus time on a graph. What's the relationship between temperature and sunlight? What's influencing your temperature readings?

Main Activity

Carbon dioxide doesn't just take up space in the atmosphere. It's part of the global "carbon cycle," in which carbon travels through the living environment to nonliving things and back again. You can also find carbon in some rocks and minerals, generally combined with oxygen and a metal in a compound called a carbonate. You can identify carbonate-containing materials because they react with acid to give off bubbles of carbon dioxide. The chemical sentence (equation) that describes this process is:
$Na_2CO_3 + 2HC_2H_3O_2 \longrightarrow CO_2 + H_2O + 2NaC_2H_3O_2$

Materials

- white vinegar (a solution of acetic acid and water)
- various materials, such as eggshells, chalk, rocks, sand, seashells, bones, baking soda, salt, baking powder, and sugar (Caution: Do *not* test favorite objects, such as prized seashells or your mom's pearls, with vinegar or any other acid. The acid reaction will damage them.)
- eyedropper
- shallow glass or ceramic dish for testing



1. Weigh the material to be tested on a balance.
2. Put the material in the dish and place several drops of white vinegar on it.
3. Observe whether bubbles form. If bubbles do form, keep adding vinegar until they stop.
4. When bubbles stop forming, dry and weigh the material (if there is any left).

Questions

1. Which materials gave a positive test for carbonate? How can you be certain that any bubbles you saw were carbon dioxide and not some other gas? What percentage of the material was carbonate?
2. How else could you measure the amount of gas given off?
3. Does it seem likely that carbonate-containing rock is a source of atmospheric carbon dioxide?

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MAMMOTH DIG

Why are there mammoth "burial grounds"?

Dave checks out a huge mammoth dig.

http://www.ktca.org/newtons

NEWTON'S APPLE. 15 YEARS OF HANDS-ON SCIENCE

[SHOW NUMBER] 1509

Segment Length: 8:00

Getting Started

Begin the lesson by getting students to make a list of as many mammals as they can think of that live in your area. Cats and dogs are easy, but what animals live in the woods, in an abandoned dwelling, near wetlands, or on the prairies? Are there mice, raccoons, or bears near you? Which are biggest? Have students research mammals that lived during the most recent ice age. Ask: How were these animals different from the ones today? What happened to them? Are any types of mammals still around that also lived during an ice age? How did they survive when so many others didn't?

Overview

On a windblown steppe some 11,000 years ago, a herd of mammoths stampeded up a hill as a vast fire set by Paleo-Indians burned toward them across the grasslands. The panicked giants, elephant-like creatures standing 11 to 13 feet (3.3 to 4 meters) high at the shoulder, reached the top of the rise, then fell 50 feet down into a ravine. Out of the drifting smoke appeared a dozen of the Paleo-Indians, carrying spears tipped with sharp Clovis points to finish off the mammoths that had survived the fall. Starting fires to stampede large animals over cliffs was one of the ways humans used to hunt. Mammoths, with large tusks and abundant meat, were highly prized.

Mammoths were members of the genus *Mammuthus*, a group of several species of prehistoric elephants that roamed the North American continent from about two million years ago until becoming extinct here about 11,000 years ago. Many scientists believe human hunting and climate change combined to kill off the mammoths.

Before human hunters arrived and the climate changed, mammoths thrived on the plentiful grasses and other vegetation of the tundra and steppe. There were several species of the creatures, including the Columbian mammoth, Jefferson's mammoth, the imperial mammoth, and the woolly mammoth. The Columbian, Jefferson's, and imperial mammoths were similar to modern elephants in that they had two large, curved tusks; a long trunk; and little hair. The adults stood about 9 to 15 feet (2.7 to 4.6 meters) tall and had a life span of about 50 years. The woolly mammoth, which lived in the colder arctic tundra, was covered with thick curls of wool overlaid with long, coarse protective hair.

Mammoths differed from mastodons, another elephant-like creature that roamed North America from about 4.5 million to 10,000 years ago. Mastodons were smaller, standing 8 to 10 feet (2.4–3 meters) tall at the shoulder and weighing four to six tons. The key difference between mastodons and mammoths was their teeth. Mammoths had flat teeth designed to grind grasses, while mastodons had cones on their teeth that enabled them to feed off shrubs and trees. As a result, mastodons lived in the tropical rain forest and spread into South America.

Mammoths have ancestral roots going back about 35 million years to a swamp-dwelling creature that resembled a small hippopotamus. During eons of evolution, an assortment of strange-looking creatures came and went—animals with two or four tusks, curved up or down, some shaped like flat shovels or corkscrews. Mammoths evolved from this group about four million years ago, but elephants are the only modern survivors.

Connections

1. How could changes in the climate at the end of the last ice age push a species toward extinction?
2. What is the biggest threat to modern elephants—hunting or climate change? Why?

Resources

Books

Bahn, P. (1996) *The Cambridge illustrated history of archaeology.* Cambridge, England: Cambridge University Press.

Fagan, B. (1987) *The great journey: The peopling of ancient America.* New York: Thames and Hudson.

Organizations

The Mammoth Site of Hot Springs, South Dakota, Inc.
1800 Highway 18 By-Pass
P.O. Box 606
Hot Springs, SD 57747-0606
(605) 745-6017
Publishers of booklet entitled *Mammoth graveyard: A treasure trove of clues to the past* by R.A. Border (1994).

Web sites

Illinois State Museum
http://www.museum.state.il.us/exhibits/larson/ice_age_animals.html

Swedish Museum of Natural History: Mammoths in Europe
http://www.nrm.se/virtexhi/mammsaga/mammut.html.en

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NEWTON'S APPLE

15 YEARS OF HANDS-ON SCIENCE

SHOW NUMBER

1509

Mammoth Dig

SURVIVAL OR EXTINCTION?

MAMMOTH DIG: Student Activity

Graph what might have happened when humans met mammoths.

http://www.ktca.org/newtons

Try This

Invite a geologist, archaeologist or paleontologist from a local college or state geological survey office to talk to the class about what the ice ages were like, why they happened, and if another one could happen. Read some books about the last ice age and try to find some geological evidence of an ice age in your local landscape.

Try This

Copy a picture of a mammoth onto a sheet of overhead transparency plastic. Then project this image onto a wall so that the mammoth appears 3m (10') tall. Trace the image onto strips of butcher paper. When the drawing is complete, cut out the animal's outline and assemble the strips into a complete life-size representation.

Try This

Use modeling clay to construct an assortment of tooth shapes. These shapes should include distinct teeth that are adapted for grinding, cutting, and tearing. How can these teeth be used to explain the spread of mastodons, but not mammoths, into South America?

Main Activity

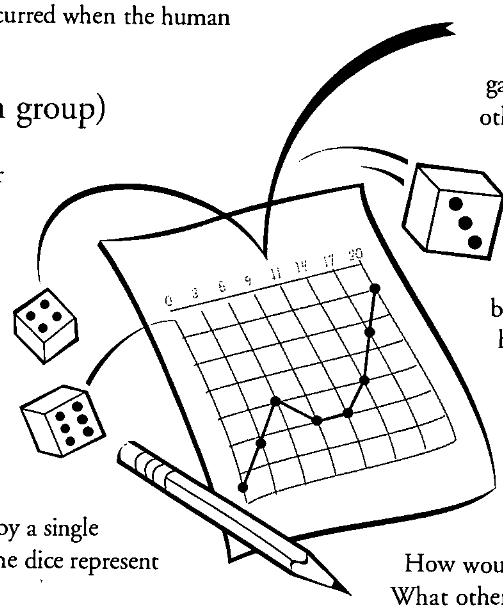
Vast herds of mammoths roamed the North American continent for more than a million years, surviving several ice ages. At the end of the last ice age, about 11,000 years ago, just after the arrival of human hunters, mammoths became extinct. While the changing climate certainly made life more difficult for mammoths, the added threat of human hunters may have been enough to cause the extinction.

In this activity students divide into small groups and play two games of survival to see how extinction might have occurred when the human hunters arrived.

Materials (for each group)

- 2 sheets of graph paper
- 20 dice for each group (Have students bring in a couple of regular dice from a game at home.)

1. Each team begins with a herd of 20 mammoths, each animal being represented by a single die. The numbers on the dice represent the following events:
   - ***1 = Death by starvation***
   - ***2 = Birth of a calf***
   - ***3 = Falls into an ice crevasse of the permafrost***
   - ***4 = Lives well for one year***
   - ***5 = Killed by giant bears***
   - ***6 = Lives well for one year***
2. Each roll of all of the dice represents one year. For each 1, 3, or 5 rolled, subtract one mammoth from the herd. For each 2 rolled, add a mammoth. For each 4 or 6, don't change the number.
3. Roll the dice for 20 turns, representing 20 years. Keep track of the births and deaths for each year, then graph the growth or shrinkage of the herd over time. Did any of the teams have a herd go extinct? Did the number of mammoths go up, down, or stay about the same?
4. Play the game again, but this time change the meaning of number 4 on the die to "Killed by Paleo-Indian hunter." Compare your graphs from both rounds of the game with those of the other teams.



Questions

1. Based on your results, would mammoths have become extinct if humans had not come to North America? Explain.
2. Suppose you replaced the meaning of both the "4" and the "1" with "Killed by Paleo-Indian hunter." How would that affect the herd? What other factors might affect the survival of the mammoths?
3. Are there any modern animals that are being threatened by changes to their ecosystem? Is the threat caused by nature, human hunting, or some other human activity?

Educational materials developed with the National Science Teachers Association.

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KIDS ON MARS

How do scientists design probes for distant planets?

Kids recreate the surface of Mars and design a planetary rover.

http://www.ktca.org/newtons

NEWTON'S APPLE. 15 YEARS OF HANDS-ON SCIENCE!

SHOW NUMBER 1510

Segment Length: 8:00

Getting Started

Begin the lesson with the following comments: This past summer, NASA landed the Pathfinder space probe on the surface of Mars. What did scientists do before they even attempted such a mission? What are the difficulties they might have faced designing and constructing a vehicle to navigate a foreign landscape by remote control? Watch the video to see how one group of science students undertook their own "mission to Mars," following the same procedures as the NASA space scientists.

Overview

From that fateful day back in 1877 when Giovanni Schiaparelli trained his telescope on the surface of Mars and identified long, sinuous "canali," people have wanted to get a close-up look at the "red planet." It wasn't until July 1965 that earthlings finally got that first look, with the help of a remote probe called Mariner 4. Then in 1971, Mariner 9 produced pictures confirming that there were no signs of advanced life on the planet but strongly suggesting that running water and volcanoes had significantly reworked the surface.

In the summer of 1976, the Viking 1 and 2 spacecraft actually landed on the planet, taking the first color pictures and analyzing the soil for life. These two probes set the stage for the present round of exploration that culminated in the Mars Pathfinder and Global Surveyor missions in 1997.

Mars is geologically similar to Earth. Large amounts of water once flowed over its surface, carving out deep channels and possibly forming seas in which primitive life existed. Mars also is home to Olympus Mons, the largest known volcano in the solar system (three times as tall as Mount Everest). Eruptions from this giant ended millions of years ago, but the findings suggest that Mars was once a warmer, tectonically active place.

Even though the atmosphere on Mars is only about one percent as dense as Earth's, it still produces weather patterns. If all goes well, the Global Surveyor will provide us with detailed weather readings over the course of one Martian year (which is actually two Earth years).

In the coming years, NASA plans to send a number of additional unmanned probes to Mars to collect data on the ice caps and soil chemistry. Sending a spacecraft to analyze a planet that's 34 to 240 million miles away is a complex task, requiring an enormous amount of planning and teamwork.

To get a taste of what it's like to be a Mars mission scientist, students from the Marcy Open School in Minneapolis created their own "mission to Mars." The first step in the planning process was to create a model of the planet's surface. The next step was to design a vehicle that could successfully traverse the landscape without getting stuck or, worse yet, falling over. The students tried rovers with different numbers of wheels, rovers of varying heights and widths, and rovers with different kinds of traction. After each test, design changes were made until the final working model was built. The last step was to create a computer program to actually make the system run. Once the program was "debugged," the class ran its model trip to Mars.

Connections

1. How are photos of Earth from space used to determine changes in our global environment?
2. Recent advances in computer logic have made it possible for certain robots to "think." How might this be used in a space probe exploring the surface of a distant planet?

Resources

Books and articles

Burgess, E. (1990) *Return to the red planet.* New York: Columbia University Press.

Fortier, E. (1995, Dec) The Mars that never was. *Astronomy,* pp. 37–43.

McKay, C. (1997, Aug) Looking for life on Mars. *Astronomy,* pp. 39–43.

Naeye, R. (1996, Nov) Was there life on Mars? *Astronomy,* pp. 33–37.

Organizations

Lunar and Planetary Institute
3600 Bay Area Blvd.
Houston, TX 77058

NASA Central Operation of Resources for Educators
NASA CORE
Lorain County JVS
15181 Route 58 South
Oberlin, OH 44074
(216) 774-1051, ext. 249/293

Web sites

Lunar and Planetary Institute
http://cass.jsc.nasa.gov/lpi.html

Mars Global Surveyor: NASA/JPL
http://mgs-www.jpl.nasa.gov/

Mars Pathfinder: NASA/JPL
http://mpfwww.jpl.nasa.gov/

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NEWTON'S APPLE

SHOW NUMBER

1510

Kids on Mars

MAP YOUR OWN WORLD

KIDS ON MARS: Student Activity

Discover how changing the scale of a map can either increase or decrease the level of detail you see.

http://www.ktca.org/newtons

Try This

Using a topographic map of the moon or Mars, try building a 3D model of that area's landscape. First figure out how big you want your model to be, then decide on the scale of the contour interval. Using either foam core board or corrugated cardboard, build the terrain and discover how a model landscape can be constructed.

Try This

In recent years, the Galileo probe of Jupiter and the Magellan probe of Venus have sent back enormous amounts of information. Conduct a little research on what these probes discovered to find out the latest scoop on our neighbors in the solar system.

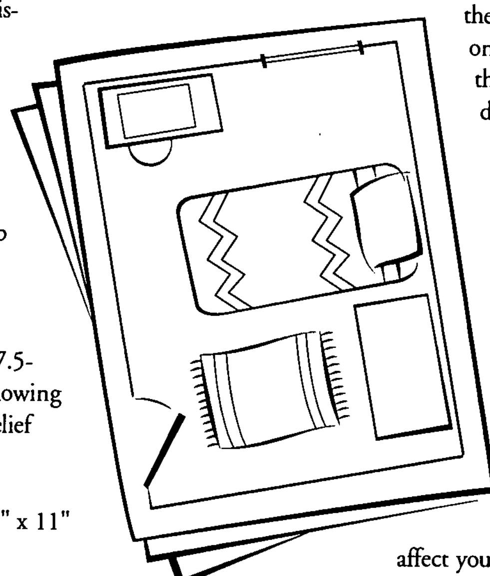
Try This

So you want to drive a space probe but you don't have the budget for it? Try your hand at building your own "Sojourner" using any commercially available, motorized building kit (LEGO, Capsella, etc.). Try testing your vehicle on different landscapes to see if it "makes the grade" and if it has enough traction to stay in action!

Main Activity

Maps are really models of a place in space. A topographic map uses special lines called "contours" to show how the ground surface changes in elevation from one place to another. In most cases, when contour maps are made, the scale that is selected for the contour interval is proportional to the scale used to show distance across the map.

In this activity, you'll discover what happens when you change the map scale but try to keep the contour interval the same.



Materials (per group of two students)

- any U.S. Geological Survey topographic 7.5-minute quad map showing at least 300 feet of relief
- millimeter ruler
- pencil
- sheets of blank 8 1/2" x 11" paper

1. Discuss how topographic maps are used to show land surface features and how the scale for the elevation (contour interval) is usually proportional to the map scale. Note the scale used to calculate distance (1: 24,000) and the contour interval (usually either 10 or 20 feet).
2. Use your ruler and pencil to mark off a 20-cm square on the topographic map. Take the first piece of paper and draw a 10-cm square. The object is to recreate all of the same contour lines that appear in the square on the topographic map by drawing them in the square on the paper. Since the square on the paper is half the size, your will have to "scale down" the space between the lines to half the distance. To do this, use your ruler to measure the distance between lines in millimeters and divide by two.
3. Once you have completed drawing your half scale map, draw a 5-cm square on the second piece of paper. Follow the same procedures as in step 2, only this time, take the data off the 10-cm square. Make sure you draw in every contour line.

Questions

1. Make a detailed contour map of your room or your classroom and do the activity again. Is it harder or easier to change the scale?
2. What has happened to the spacing between the contour lines as you reduced the scale of the map? How did this affect your ability to read changes in elevations?
3. When the scale is reduced on a map, what should be done to the contour interval? How does this affect the accuracy of the elevation readings?
4. If you wanted to make a detailed map showing 1-foot elevation change on the surface of a planet, what type of scale would you need?

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WIND BLOW

What causes wind? Where do air masses come from and where do they go?

Eileen gets blown away to investigate the wind.

http://www.ktca.org/newtons

[SHOW NUMBER] 1510

Segment Length: 6:30

Getting Started

Begin the lesson by asking: What is wind? What do you think makes it blow? Where does the energy come from to power the wind?

Explain that wind is moving air, and the energy to drive it comes from the sun. To illustrate, conduct the following experiment: Place an empty balloon over the top of an empty, clean, 2-liter soda bottle. Ask the class: What do you think will happen to the balloon if we begin to heat the bottle with a hair dryer? Heat the bottle until the balloon inflates. Explain that when air is heated, it expands and becomes less dense. As a result, hot air rises. In the real world, the sun heats Earth's surface, which in turn heats the air.

Rising air is only part of the story of what makes the wind blow. Watch the NEWTON'S APPLE video so you can see the "big picture."

Overview

Anyone who has ever lived through the fury of a hurricane or witnessed the destructive power of a twister knows just how much punch the wind can pack! What many people don't realize is that when they see the wind blow, they're really watching the power of the sun!

On Earth, our surface is surrounded by an ocean of air called the atmosphere, which, like water, is quite fluid. Just like there are currents in the ocean, our atmosphere has wind currents controlled by many of the same factors, including temperature differences, density differences, and the spin of the planet. Most winds get started because of local changes in the density of air. As with most matter, when air is heated, it expands, causing it to become less dense. Just like in a hot-air balloon, warm air is buoyant. Cool air, which is more dense, moves in and literally pushes the warmer air up, or, in common terms, the warm air rises. We sense the motion as wind.

All of the energy to heat the air comes from the sun, but in general the sun heats the air indirectly. Solar radiation in the form of visible light penetrates our atmosphere and strikes Earth's surface, where it's converted into heat and, as described above, begins to rise. Since the surface of the Earth is quite variable in its makeup (rock, tree, water, and pavement), the air is not heated evenly. Instead, separate pockets of rising warm air masses called thermals are formed, ultimately driving the local wind directions.

While small variations in Earth's surface help to cause localized wind conditions, differential heating and cooling of the atmosphere generates global-scale winds as well. Hot air rising over the equator pushes northward and southward. Upper atmosphere cooling causes the hot air masses to become more dense and sink. Once near the warm Earth, the air heats up and rises again. A vertically circling flow of air, called convection cells, results. The cyclic motion of these air masses is further modified by Earth's own rotation, deflecting them to the east and west. Known as the Coriolis effect, this rotation deflection is what gives rise to the global wind belts including the polar easterlies, mid-latitude westerlies, and tropical trade winds.

Connections

How did the global wind belts control the routes of early explorers and traders who depended on the wind to move them around? Besides sailboats, how else was the wind used to power civilizations of the past?

Resources

Books and articles

Demillo, R. (1994) *How weather works.* Emeryville, CA: Ziff-David Press.

Gipe, P. (1995) *Wind energy comes of age.* New York: John Wiley & Sons, Inc.

Greeley, R. (1994, Jan 21) Wind streaks on Venus: Clues to atmospheric circulation. *Science,* p. 358.

Onish, L (1995) *Wind and weather.* New York: Scholastic Voyages of Discovery.

Rennicke, J. (1995, Nov) Why the wind blows. *Reader's Digest,* p. 82.

Schaefer, V. & Day, J. (1981) *A field guide to the atmosphere* (a Peterson field guide). Boston: Houghton Mifflin.

Organizations

National Oceanic and Atmospheric Administration
NOAA Environmental and Information Services
1315 East West Highway, Room 15400
Silver Spring, MD 20910
(301) 713-0575

Web sites

National Weather Service
http://www.nws.noaa.gov/

The Wind: Our Fierce Friend
http://sln.fi.edu.tfi/units/energy/wind.html

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THE HEAT IS ON

WIND BLOW: Student Activity

See how heat from the sun creates wind and how Earth's rotation changes its path.

http://www.ktca.org/newtons

Try This

How fast does the wind blow in your neighborhood? Try your hand at designing and building your own wind vane and anemometer to measure the direction and speed of the wind. (You could use a bicycle wheel for your anemometer.) Set up a mini-weather station and record the data for a month. Are there any local wind patterns?

Try This

How does Earth's surface control the wind? Set up an experiment using two identical cups. Fill one with water and leave the second empty. Place each under a light bulb for 15 minutes. Use a thermometer to see which heats faster and then turn off the light to see how fast they cool. How does your experiment help explain offshore winds ?

Try This

Long before there were fossil fuels to power our vehicles, people used the wind. Design and build a tabletop wind racer that goes with the flow. Using a fan, challenge your friends to see who wins the race.

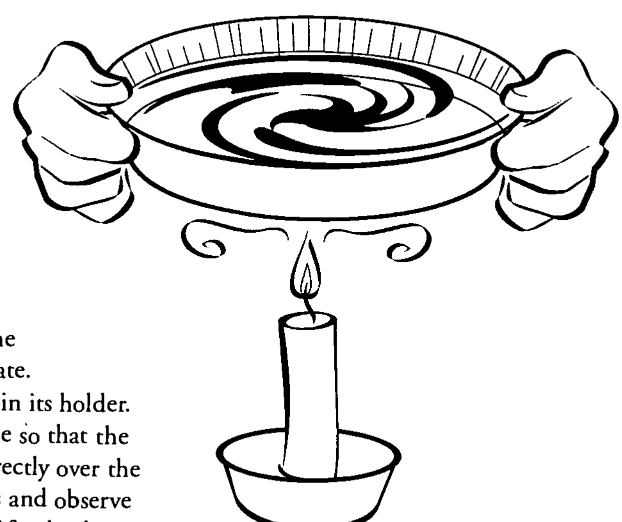
Main Activity

Convection cells are circular currents of air that result when hot air rises into the upper atmosphere, cools and contracts, sinks down near the Earth's surface, heats up and expands, and then rises again. The rotation of Earth causes these air masses to move in the form of wind. In this activity, you'll create small convection cells and watch their patterns as you put the spin on them.

Materials

- 2 aluminum pie pans
- opaque, white dishwashing liquid
- red or green food coloring with a dropper
- candle in a holder and matches
- watch with second hand

1. Fill one of the aluminum pie plates with a half inch of dishwashing liquid. Fill the other plate with a half inch of water.
2. Using the plate with the dishwashing liquid, place several drops of food coloring about halfway between the center and the edge of the plate.
3. Light the candle and place it in its holder. Hold the plate over the candle so that the drops of food coloring are directly over the flame. Wait about 45 seconds and observe what happens to the drops of food coloring. Describe how they look and how they move.
4. When heated, your drops of food coloring act like convection cells that form near Earth's surface. To see how the Earth's rotation might affect these cells, place the first pie plate into the pie plate containing water and spin it for about 30 seconds. Describe the patterns that are formed.



Questions

1. How did the shape of the convection cells change as you heated the plate?
2. The patterns that formed when you spun the plate can be compared to the wind patterns in Earth's atmosphere. Do you think wind patterns flow the same around other planets? Why or why not?

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CAR ENGINES

How do car engines work?

SuChin looks under the hood to examine the workings of an engine.

http://www.ktca.org/newtons

SHOW NUMBER **1511**

Segment Length: 7:00

Getting Started

Begin the lesson by having small groups of students do the following activity: Place two teaspoons of baking soda in a gallon-size, zipper-type storage bag. Put a cup containing three ounces of vinegar inside the bag, being careful not to spill any vinegar from the cup. Zip the bag closed. Hold the bag out away from you over a sink or garbage container. Pour the vinegar onto the baking soda.

Ask the students the following questions: What happens to the bag? What happened inside the bag to cause this reaction? How is this type of reaction, where chemical energy is transformed into mechanical energy, similar to what happens inside a car engine? How are they different?

Overview

It's hard to imagine living in a world where there are no cars, buses, or trucks. When it comes to important inventions, the internal combustion engine has to be near the top of the list. Unlike most steam engines that preceded them, internal combustion engines are small enough to fit in personal vehicles, such as cars. Unlike electric motors, these little powerhouses can travel a long distance on a compact fuel source.

As with most inventions, the internal combustion engine is really the product of many individuals working over a long period of time. Early experiments with engines that burned liquid fuel started back in 1838, but it wasn't until 1876 that a German engineer named Nikolaus Otto created one that actually worked.

Little has changed in the Otto-cycle engine over the last 120 years. The key element behind its power involves igniting a small amount of gasoline inside a confined space called the cylinder. As the fuel explodes, it produces a great deal of hot gas, which presses against the face of a piston, pushing it down in the cylinder. The other end of the piston is connected to a piston rod that turns a rotating crankshaft, which in turn is linked to the car wheels. The up-and-down motion of the piston makes the crankshaft turn, just as the up-and-down pedaling turns the crank of a bike. It is this rotary motion of the crankshaft that runs the car's engine.

For all this motion to take place smoothly, four distinct actions or strokes occur in the engine. During the intake stroke, the piston moves down in the cylinder and a mixture of air and fuel enters the cylinder through a valve in the top. In the compression stroke, the valve closes and the piston begins to move back up the cylinder, compressing the mixture.

Once the piston reaches the top of the cylinder, the spark plug ignites the fuel, which drives the piston back down. This is called the power stroke because it's where the power comes from. In the final exhaust stroke, the piston moves back up again and a second valve opens to allow the spent gas to escape. Then the cycle starts all over again.

Typical car engines have either four, six, or eight cylinders. It is important that all of the piston movements are timed to move in an orderly way. Otherwise, the engine won't run smoothly.

Connections

1. How did the development of the internal combustion engine change the settlement pattern of people over the last 100 years?
2. What are some of the disadvantages associated with the internal combustion engine and how might they be corrected?

Resources

Books

Heywood, J. (1988) *Internal combustion engine fundamentals.* New York: McGraw-Hill.

Macaulay, D. (1988) *The way things work.* Boston: Houghton Mifflin Company.

Computer software

Microsoft Home Essentials: *Microsoft Encarta 97 Encyclopedia.* (800) 454-9497

Organizations

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001
(412) 776-4841

Web sites

Society of Automotive Engineers
http://www.sae.org

University of Michigan Automotive Research Center
http://arc.engin.umich.edu

Woman Motorist Magazine On-Line
http://www.womanmotorist.com

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NEWTON'S APPLE

SHOW NUMBER

1511

Car Engines

YOU'VE GOT THE STROKE

CAR ENGINES: Student Activity

Build a piston system to convert linear to rotary motion.

http://www.ktca.org/newtons

Try This

For an engine to run efficiently, the motor has to keep cool. Otherwise, the metal parts will begin to expand and eventually lock up or "seize." See if you can design a "radical radiator" that dissipates the heat from a cup of hot water. Try using flexible plastic tubing for the core and aluminum foil fins.

Try This

Car transmissions use gears to speed up the rate at which the wheels turn. You can see how they work by checking out the gear cluster on a 10-speed bike. Turn the bike upside down. As you turn the pedals, switch gears on the rear wheel. See how the speed of the tire changes relative to the speed of the crank and size of the gear. Come up with a mathematical relationship to predict these speed changes?

Try This

What role does oil play in an engine and how do different types of oil behave? Check out samples of a 30-weight, 50-weight, and multi-weight oil. How do their properties compare.

Main Activity

For a car to move, the wheels have to turn in a rotary motion. Internal combustion engines are powered by pistons which move in a back-and-forth or linear motion. By building and testing a model piston/crankshaft system, you'll discover how this energy transfer takes place and learn why there is an upper limit to how fast an engine can run.

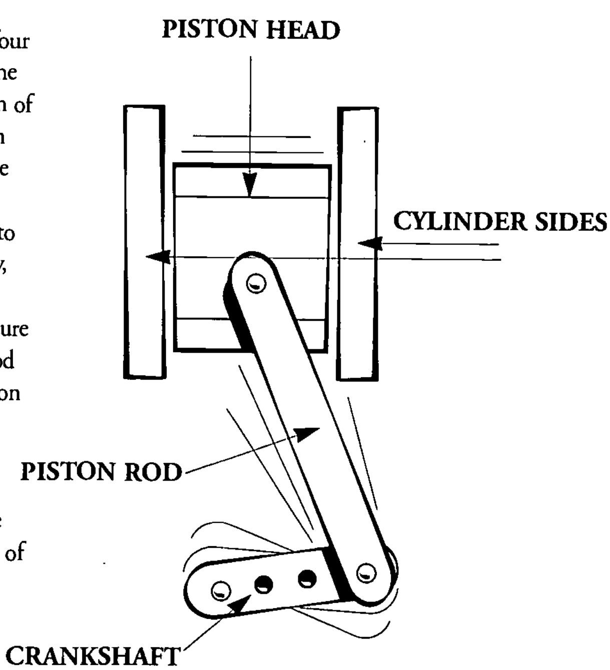
Materials

- two 11" x 17" pieces of cardboard or chipboard
- strong pair of scissors and glue
- three 2" brass paper fasteners
- 2" roofing nail
- metric ruler and stopwatch

1. Create a piston by copying and enlarging the illustration below. Cut the parts (piston head, piston rod, crankshaft, and cylinder sides) out of one of the pieces of cardboard or chipboard. You will mount the parts on the other piece.
2. Using the point of the nail, carefully punch out four holes in the crankshaft, one hole at each end of the piston rod, and one hole midcenter at the bottom of the piston head. Assemble the piston head, piston rod, and crankshaft using the brass fasteners. Glue the cylinder sides to your base board, allowing enough room between them for the piston head to move up and down without getting stuck. Finally, punch a hole in the base board so that you can attach the free end of the crankshaft to it. Make sure you've allowed enough room so that the piston rod can turn the crankshaft completely when the piston head moves up and down.
3. Gently push the piston up and down in the cylinder.
4. Using the ruler, measure the length of the stroke that the piston makes during one complete turn of the crankshaft. The stroke distance *(D)* is the difference between the highest and lowest point in the piston's head during one rotation of the crankshaft.
5. Determine the maximum number of complete cycles the piston can make in 15 seconds. To do this, carefully slide the piston up and down as quickly as you can without bending the apparatus.
6. Now connect the piston rod to the next hole toward the center of the crankshaft and repeat steps 4 and 5, recording your results. Repeat this for all the holes in the crankshaft.

Questions

1. What happened when you attached the piston rod closer to the center of the crankshaft?
2. Was it easier or harder to make the crankshaft turn quickly?
3. Did the crankshaft get stuck in any part of its motion? In a real engine, would this happen, too? Why or why not?



ZOO VET

How is a zoo vet different from my puppy's vet?

NEWTON'S APPLE looks at a day in the life of a zoo vet.

http://www.ktca.org/newtons

[SHOW NUMBER] 1511

Segment Length: 7:45

Getting Started

Begin the lesson by dividing the blackboard in half, labeling one half "Animals" and the other "Needs." Have the students come up with a list of all the animals that might be found in a zoo. Instruct them to think of all the things that a zoo needs to do and provide for each animal. Next to each "Needs," write students' suggestions of who could take care of each task you listed. Ask the students: What do you think the role of a zoo is or should be?

Overview

One of the most important people at any zoo is the veterinarian. Though zoo vets and domestic animal vets go to school for the same amount of time, zoo vets must be familiar with the anatomy and physiology of many more species of animals—thousands in some cases. A zoo vet must know how to take and read x-rays of a giraffe's neck or a crocodile's tail, whether a snake's vertebrae is developing correctly, where the best place is to give a shot to an elephant, and much more.

Zoo vets make regular visits to every animal enclosure and discuss potential health concerns with zookeepers, who are usually the first to notice if an animal is sick or injured. Wild animals in captivity need periodic checkups and vaccinations. The vet must carefully examine each animal's coat or skin, teeth, ears, eyes, heart, and lungs.

Different animals need different preventive care. For example, unlike humans, whose teeth stop growing when they reach a certain size, some animals (like rabbits) have teeth that keep growing but are naturally ground down in the wild by what the animal chews. Zoo vets must grind these animals' teeth down or make certain that they have appropriate items to chew.

Because the wild animals in zoos and aquariums are so exotic, their diseases can be, too. Sometimes an animal may suffer from a disease never before seen in its species. And sometimes one species of animal may transmit a "treatable" disease to another species in whom that disease is incurable.

A zoo is a collection of ecosystems and wild animal species. To ensure healthy animals, all aspects of their living space must be just right. Zoo vets are instrumental in exhibit design because they can detect health problems linked to the anxiety level of an animal in a too-small or crowded space.

Zoos and aquariums throughout the world share information on breeding of captive animals. In an effort to eliminate the capture of wild animals for zoos, these institutions plan their breeding programs for the good of wild animals everywhere. Family trees are kept to ensure that animals from different ancestry breed together (in-breeding can pass genetic diseases down through the generations). Vets determine when a female is ready to breed, monitor the pregnancy, and, when necessary, help deliver the young.

Often veterinarians specialize. Some specialty areas include cardiology, epidemiology, neurology, surgery, dentistry, ophthalmology, and radiology. Specialists in these and other fields are helping captive animals live healthier and longer lives.

Connections

Zoos have a serious mission: animal conservation. What relationship might zoo vets have with organizations that seek to protect endangered species?

Resources

Books and articles

Irvine, G. (1991) *The work of zoo doctors at the San Diego Zoo.* New York: Simon & Schuster. (out of print)

Computer software

Scholastic: *Operation Frog.* CD-ROM for Macintosh, or 3.5 diskettes for DOS and Macintosh. Available from Scholastic, (800) SCHOLASTIC or http://scholastic.com

Organizations

American Association of Zoo Veterinarians
6 North Pennel Road
Media, PA 19063
(610) 892-4812
http://www.worldzoo.org/aazv/aazv.htm

National Wildlife Federation
1400 Sixteenth Street, NW
Washington, DC 20036
(800) 588-1650
http://www.nwf.org/natlwild/1997/tableas7.html

Web sites

The Electronic Zoo
http://netvet.wustl.edu/e-zoo.htm

ZooNet—All About Zoos
http://mindspring.com/~zoonet/

Animal Omnibus
http://www.birminghamzoo.com/ao/

The University of Michigan Museum of Zoology's Animal Diversity Web
http://www.oit.itd.umich.edu/projects/ADW/

NEWTON'S APPLE video cassettes and educational materials provide further information about this and other topics. Call 1-800-588-NEWTON or check out our Web site at: http://www.ktca.org/newtons

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NEWTON'S APPLE

15 YEARS OF HANDS-ON SCIENCE

SHOW NUMBER

1511

Zoo Vet

THIS PLACE IS A ZOO!

ZOO VET: Student Activity

Design an environment that keeps wild animals safe and healthy in captivity.

http://www.ktca.org/newtons

Try This

Imagine yourself to be your favorite zoo animal. Write a story about how you spend 24 hours. What does your area look like? Who visits you? Do you like them? What do you eat and do? What would life be like if you were living in your natural environment rather than the zoo?

Try This

Visit your local zoo. Record your observations of how the animals are presented to the public. What do they eat? What ecosystems are displayed? What do you learn from the exhibit signage?

Try This

Many animal conservation and protection organizations encourage students to adopt an animal and learn more about its situation. Explore possibilities for your class to adopt an animal. Some of the organizations are listed in the Resource section on the reverse side.

Main Activity

Zoo vets work closely with zoo planners and other zoo staff to determine the healthiest environment for each species. Study two animals to determine how to provide the best ecosystem for them. Design an area of the zoo for them to live in. Plan each ecosystem design to a common scale so that the final product combines the work of each group to create a classroom zoo.

Use any resources available (text, software, Web sites, zoo staff, etc.) as you gather information for data logs.

If time allows, each group will use recycling supplies (cardboard, cans, etc.) and other supplies (clay, feathers, sticks) to create the animals and habitats for the zoo.

Materials

- paper and pencils to create data logs and record data
- variety of information resources (books, magazines, local zoo, Web sites, software)
- chart paper
- ruler
- markers
- recycling and other art supplies

1. Identify and assign the species that each group will study. (You may want to call a local zoo or check the many zoos on the Web to determine which animals are found in each ecosystem.) Alternately, assign an ecosystem to each group, and allow the group to select the animals they will include.
2. Research how to provide the best ecosystem, including the optimum number of animals of each species; the space required for each species; and temperature, light, water, plant, food, and medical requirement for each species.
3. On chart paper, design the section of your classroom zoo that will house your animals. Be sure to use rulers to make your design to scale. (Note: Before you start, make a class decision regarding the scale to use.)
4. Connect the ecosystems designed by all the groups to create the classroom zoo. Present your group's zoo ecosystem and its inhabitants to the larger group, and answer any questions others have about your animals or your design.

Questions

1. What fields of science do zoo staff members, including zoo vets, need to understand?
2 What other areas of expertise are required to manage a successful zoo?

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NASA ROBOTS

What are robots? How are they used in space?

David takes a journey to space with exploration robots.

http://www.ktca.org/newtons

NEWTON'S APPLE

[SHOW NUMBER] 1512

Segment Length: 7:15

Getting Started

Begin the lesson by asking students to imagine they are robots in Earth's orbit with a simple task to perform: Tie the safety tether of an astronaut to a metal ring in the open cargo bay of the space shuttle. Easy for a high-tech robot, right?

Have students put on blindfolds and tie their shoes. Ask them to try it again, this time wearing the blindfolds and heavy gloves. Repeat the task a third time, but this time tape Popsicle sticks or tongue depressors to the fingers of the gloves.

Ask students the following questions: Why is it so hard to tie your shoes? What are the many different kinds of signals your brain receives from your body to do this seemingly simple task? What would be involved in building a machine to tie your shoes?

Overview

Sometime during your life, maybe about 20 years from now, you will see the first images of a human walking on Mars. Long before a human undertakes the dangerous task of going to Mars, however, the planet will be explored by an army of large and small robots.

A robot is an electronically controlled device programmed to conduct tasks that could normally be done by human workers. In hostile environments everywhere, particularly in space, modern explorers are turning to robots to undertake dangerous missions—missions that cannot yet be undertaken by humans. In July 1997, a small robotic rover called Sojourner drove around on the cold surface of Mars, the first of many robots being designed by NASA to explore other planets. On Earth, smart robots are being developed to venture into active volcanoes, dive deep into the oceans, search for land mines left from wars, and help police disarm terrorist bombs.

Much robot development is spurred by NASA. The space agency plans to use robots in three basic ways: on-orbit assembly, science payload tending, and planetary surface exploration. Assembly robots will help build Space Station Alpha during the next few years. The robots will be the eyes and hands of human controllers who will use something called virtual reality telepresence to see what the robot sees.

Science payload robots will help astronauts inside the space station and will run science experiments when people aren't around. Exploration robots will land on and survey distant planets, moons, and asteroids. These robots must be able to "think" for themselves. If a robot comes to a cliff on Mars, for example, it has to stop without a controller back on Earth telling it to do so. Thinking robots are important because it takes many minutes to communicate between Earth and other planets, so human controllers can't respond fast enough to help a robot avoid a dangerous situation.

Earth-bound industries are adapting much of NASA's robotic technology for everything from tiny microsurgery tools to giant steam shovels. While a robot may never actually tie your shoes, the machines are increasingly becoming creatures not just of science fiction, but of the real world.

Connections

1. Robots have been used in manufacturing for more than a decade. What products do you use that were made with the help of a robot? How and why was a robot used?
2. Do you think a smart robot could be your friend? How would that be different from having a human friend or even a pet? What responsibilities would you have toward the robot?
3. What activities or problems can you think of that a robot could solve or at least help with?

Resources

Books and articles

Brown, L. (1996) *Robotix Mars mission activity guide* (for grades 3–12). Chicago: Carnegie Science Center and Learning Curve Toys Educational Division. To obtain, call (800) 704-8697 or e-mail: education@learningtoys.com

Haddrill, M. (1997, June) The incredible shrinking robot. *Final Frontier*, p. 26.

Web sites

Learning Curve Toys (Robotix Construction System) fact sheet
http://learningtoys.com/WORKSHOP/quickfaq.html

Long Range Science Rover Task (NASA robots for planetary exploration)
http://robotics.jpl.nasa.gov/tasks/scirover/homepage.html

NASA Space Telerobotics Program
http://ranier.oact.hq.nasa.gov/telerobotics_page/programdesc.html

Robotics Engineering Consortium (NASA-inspired robots at work on Earth)
http://rec.ri.cmu.edu/REC/brochure/broch2.html

Robotics Related Periodicals and Publications
http://www.frc.ri.cmu.edu/robotics-faq/4.html#4.2.1

Updates on NASA's Mars Missions
http://quest.arc.nasa.gov/mars

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NEWTON'S APPLE

SHOW NUMBER

1512

NASA Robots

PROGRAM YOUR PARTNER

NASA ROBOTS: Student Activity

Try your hand at guiding a robot to do a simple task.

http://www.ktca.org/newtons

Try This

Before there were robots, craftsmen built "automated men" using gears, motors, pulleys, and levers. These devices, which range from piano-playing people to bell ringers, are not true robots because they are not programmable. Research the history of automated systems. Do they use feedback?

Try This

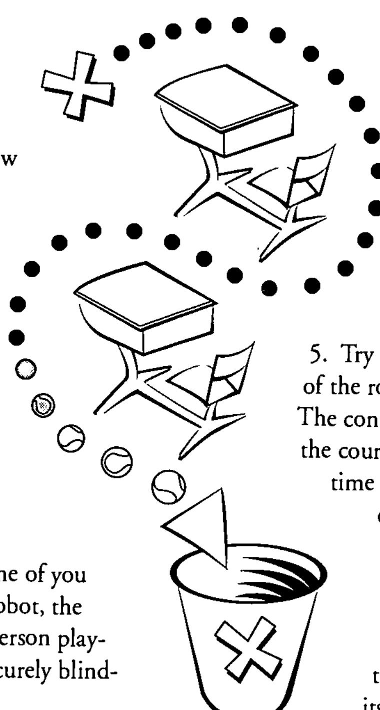
Robots have long been associated with outer space. From Voyager 2 to Viking to Sojourner, robot probes have collected an enormous amount of information from areas where "no one has gone before." Where are robots going in the 21st century?

Try This

Craters form on planets and moons when meteors hit. The shape of a crater reveals a lot about the power of the impact. Drop a metal ball bearing into a dishpan filled with flour. Remove the ball with a magnet and measure the width and depth of the crater. Try different-sized balls dropped from different heights. Why are the craters different?

Main Activity

Until robots become true "thinking" machines, able to understand their environment and make decisions about what to do to accomplish their mission, they will depend on controllers to guide them. In this activity you will work with a partner to find out how hard it is to accurately guide a robot through even simple tasks.



Materials

- blindfold
- notebook
- shoe box (or some other container that size)
- baseball or tennis ball

1. Working with a partner, one of you will take on the role of a robot, the other the controller. The person playing the robot should be securely blindfolded and given the ball.
2. The robot, following verbal instructions from the controller, must move along a prescribed course (down an aisle and around a desk, for example) and then deposit the ball in the container. The robot can't talk during the first attempt and must follow the directions given to it *exactly* ("turn right" doesn't necessarily mean all parts of the body or 90° right). After the robot has successfully put the ball in the container, the robot and controller should switch roles and try it again.
3. When you have both completed the task, figure out what the most difficult part in communicating instructions was, then develop a written glossary of commands to make maneuvering easier. Define a specific length for a step (the length of a piece of notebook paper, for example) and instead of saying "turn right" or "turn left," work out specific angles for the size of turns ("turn 20 degrees to the right," for example).
4. Repeat the mission again using a different route, taking a turn in each role. Did the glossary make things easier for both the robot and the controller? Was there less misunderstanding?
5. Try it again, but this time draw a map of the route the robot is supposed to take. The controller must sit facing away from the course the robot must follow, but this time the controller will use the robot's eyes (which in a real robot would be a TV camera). The controller must use the map to keep track of the robot's location and is allowed to ask "yes" and "no" questions so the robot can give feedback about its surroundings. The robot must still await the controller's instructions before moving.

Questions

1. What problems might you face if the robot wasn't as smart as you or your partner?
2. The minimum round-time for a signal between Earth and Mars is 8.8 minutes; the maximum time is 41.9 minutes. How would you change your commands if they took 20 or 30 minutes to reach your robot? What dangers would that delay cause?
3. What sensory devices could you add to the robot to make controlling it more precise?

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3M Innovation

ROBOTS

What are robots and how do they differ from other machines?

David and Eileen examine what makes a robot what it is.

http://www.ktca.org/newtons

NEWTON'S APPLE. FIFTEEN YEARS OF HANDS-ON SCIENCE

SHOW NUMBER 1512

Segment Length: 7:30

Getting Started

Begin the lesson by asking students: What does the word "robot" mean to you? How do real robots compare with the humanlike creatures found in science fiction movies and books?

Robots are often used to work in environments that are either inaccessible or too dangerous for humans. Have students think of some places where robots are used today. Ask them what guidelines they can use to determine if something is truly a robot. Then have them watch the video segment and play "Bot or Not?"!

Overview

When people hear the word "robot," the first thing that usually comes to mind are the shiny metal androids featured in classic science fiction movies. While machines resembling C-3PO and R2-D2 have been built, they are more the exception than the rule in today's robot community. More often than not, modern robots look nothing like humans. Their forms are usually the result of the functions they have been created to perform.

By definition, a robot is an electronically controlled device programmed to conduct a series of tasks that would normally be carried out by humans. Like computers, robots follow only those commands that have been placed in their microprocessor brains. Without proper programming, robots would not be able to carry out even the simplest function. While robots are not capable of thought in the traditional sense, their programming often allows them to make decisions through a process known as feedback.

Simply stated, feedback is the process where information is taken in, analyzed, and then used to make an adjustment in a system. All feedback systems, whether living or mechanical, have three main components. Sensors, which can be as sophisticated as the human eye or as simple as a photo cell, collect information and send it to a comparer, which analyzes the data by comparing it to some set standard. In living things, the comparer is usually the brain, while in robots, it's a microprocessor.

If the sensory data shows that the system is not working according to the standard, the comparer sends a message to an adjuster that changes the way the system is operating. In a human eye, the adjuster may be the iris, which controls how much light strikes the eye sensor, the retina. In the case of a robot, the adjuster might be a set of gears, hydraulic valves, or pulleys that control how much pressure is exerted or in which direction the robot moves.

As computers get more powerful and programs get more sophisticated, simple feedback systems in robots are being replaced by artificial intelligence. As the name suggests, artificial intelligence (AI) is an attempt at mimicking true thought processes used by humans and other sophisticated creatures. While full-fledged reasoning is still many miles down the technological highway, new advances in AI have given robots the ability to learn from their mistakes, recognize patterns, make simple decisions, and even comprehend spoken words. With continued advances in AI, it's only a matter of time before we all have our own robots to take care of the housework, walk the dog, and do the shopping!

Connections

How is the feedback system in a human eye comparable to the one found in an auto-focus camera? How might this technique be used in a robotic space probe designed to take pictures of a distant planet?

Resources

Books and articles

Brooks, R. (1991, Sept) New approaches to robotics. *Science*, pp. 1227-1232.

Rosheim, M. (1994) *Robot evolution: The development of anthropomorphics.* New York: John Wiley & Sons.

Suplee, C. (1997, July) Robot revolution. *National Geographic*, pp. 76-95.

Computer software

Microsoft: *Isaac Asimov's The Ultimate Robot.* Available in catalogs.

Organizations

Robotics Society of America
P.O. Box 1205
Danville, CA 94526-1205
(415) 550-0588

Web sites

Mobile Robot Laboratory Research Projects
http://www.cc.gatech.edu/aimosaic/robot-lab/research/aaai94.html

The Robot Group
http://www.robotgroup.org/

Robotics Internet Resource Page
http://piglet.cs.umass.edu:4321/robotics.html

Learning Curve Toys (Robotix Construction System) fact sheet
http://learningtoys.com/WORKSHOP/quickfax.html

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3M Innovation

NEWTON'S APPLE.

SHOW NUMBER

1512

Robots

GETTING SENSE-IBLE

ROBOTS: Student Activity

Discover the limitations of mechanical sensors used by robots.

http://www.ktca.org/newtons

Try This

Even the simplest task must be programmed into the robot's memory in a sequence that the machine can follow. Write a simple flow chart/program that commands someone else to perform a specific function—shoot a basketball, move a desk, etc. Account for every action in the proper sequence and leave nothing open-ended. Have someone follow your programming to get the job done.

Try This

While many science fiction movies have been based on robots resembling humans, building a robot that can walk like a person has proven to be an exceptionally difficult task. Research the Pathfinder's rover Sojourner to find out how scientists built it to move across the surface of Mars. How might you design a robot?

Try This

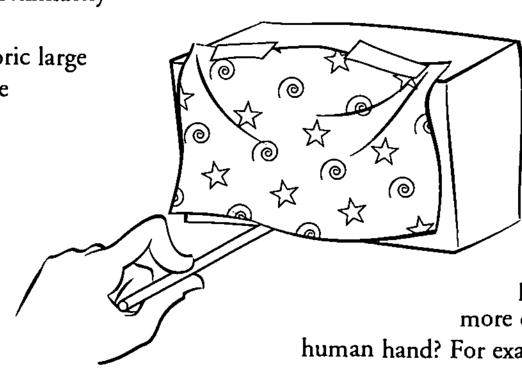
Feedback systems in robots closely resemble those that keep our own bodies in balance. To see a simple feedback system at work, get a small flashlight and stare into a mirror. Shine the light into your eye and see what happens. How fast does this reaction occur? What controls it?

Main Activity

How difficult is it for mechanical sensors to collect information in robotic systems? Because the human sense of touch is so well developed, it's hard to imagine what type of information a mechanical hand might obtain. See how "sense-ible" you can be when you try to gather information about the size and shape of an object using nothing but a mechanical sensor.

Materials

- large, open cardboard box approximately 40 by 30 by 20 cm (16" by 12" by 8") (The kind that copier paper comes in works great.)
- wooden dowel approximately 30 cm long
- piece of opaque fabric large enough to cover the box opening
- masking tape



1. Discuss how the sense of touch allows you to determine the size and shape of an object, and then imagine what it would be like if the only way you could "feel" something would be through the use of a mechanical probe.

2. Set up the sensory box by using the masking tape to drape the fabric over the opening of the box. Turn the box on its side and set it up in the middle of the table. Each person in the group should select one mystery object for placement in the box, making sure the other members of the group do not see it.
3. Place the first object in the box and have each member of the group try to collect as much information as possible on the size and shape of the object by slipping the wooden dowel under the drape and using it to "probe" the object. After all team members have collected their data using the stick, they should draw a picture of what they think the object looks like. Repeat the procedure with the other mystery objects. After all the individuals have finished, compare the drawings to the actual objects.

Extend the activity:
How does your sense of touch improve when you use your own hand? Once you have completed the activity using the wooden sensory probe, try repeating it with a different set of objects—only this time, use your hand to collect the data. How might you design a probe or set of probes that more closely resembles the human hand? For example, how would applying wax or soft clay to the end of the dowel affect how the object feels?

Questions

1. How did using a probe limit the amount of information you could gather?
2. How might changing the diameter of the dowel help change the "resolution" of the data collected?
3. Would changing the material that the probe is made from help you collect more useful data?

NEWTON'S APPLE.

LIGHTNING

How is lightning formed?

Brian becomes well-grounded in the physics of lightning.

http://www.ktca.org/newtons

[SHOW NUMBER] **1513**

Segment Length: 6:50

Getting Started

Begin the lesson by explaining that lightning is an extreme example of the same static electricity that shocks your fingers when you touch a metal door knob after rubbing your feet on a thick carpet.

The powerful bolts from the sky are proof of the old saying, "Opposites attract." To demonstrate, blow up a balloon, draw a face on it with a permanent marker, and then hang it on a string about head high for the students in your class. Have volunteers rub the face vigorously with a piece of wool. Does the face turn toward that person? Why? Ask the volunteer to step away from the balloon, then move toward it. Have other students try this same exercise. Ask: How close to the balloon do you have to be before it reacts to you? What do you think is happening?

Overview

Scientists know that lightning results from a complicated interplay of positive and negative electrical charges occurring in the 2,000 or so thunderstorms taking place on Earth at any given moment.

To learn about what causes lightning, scientists had to learn about the interaction of electrons and positive ions. Electrons, tiny particles orbiting the outside of atoms, carry a negative charge. Positive ions are atoms or molecules that have lost an electron. Atoms and molecules normally have equal positive and negative charges, making them neutral.

When different materials come in contact, electrons are transferred and one of the materials gains an excess of electrons and becomes negatively charged. When an object with a lot of positive or negative charges gets close to an object carrying the opposite charge, a spark jumps across the space between them to neutralize the charges.

In a thunderstorm, that spark is a lightning bolt. It's only a couple of inches wide, but it leaps between the clouds and the earth at a remarkable 90,000 miles per second. The power in the stroke is three million megawatts, comparable to all the power generated in the United States at any one instant.

The separation of positive and negative charges necessary for lightning begins during a thunderstorm, when rising water droplets collide with falling hailstones in the middle of the cloud. The hail strips electrons from the droplets and the top of the cloud becomes positively charged, while the bottom becomes negatively charged. What we see as lightning happens in a two-step process. Static electricity builds up between the earth and the cloud and a spark in the form of an invisible lightning bolt comes down from the cloud.

Just before this bolt reaches the ground, it is met with an upward moving, positively charged spark. When the two collide, an explosion occurs as the return stroke travels up the bolt—the result: a visible flash called lightning.

Connections

1 Why do most people hit by lightning survive? How do airliners, which are each hit by lightning about once a year, manage to keep flying?
2. Florida has some of the strongest lightning activity in the country, while there is very little in Oregon and Washington state. Why?
3. While the initial charge of most bolts of lightning travels from the cloud down to the ground, the flash we see actually travels from the ground up to the cloud. Why does the flash look like it is traveling down?

Resources

Books and articles

Burroughs, W. (1996) *The Nature Company guides to weather.* New York: Time-Life Books.

Day, J. (1991) *Peterson first guides, clouds and weather: A simplified field guide to the atmosphere.* Boston: Houghton Mifflin Company.

Newcott, W. R. (1993, July) Lightning: Nature's high-voltage spectacle. *National Geographic*, p. 80.

Web sites

Automated Weather Source Online
http://aws.com/index.html

Boston Museum of Science
http://www.mos.org
(Click on the electricity exhibit)

Lightning Retardant Cable
http://207.158.219.249/links.htm#11

National Weather Service, Newport, NC, Home Page
http://www.eastnc.coastalnet.com/weather/nwsmhx/lightng.htm

NOVA Online: Lightning!
http://www.pbs.org/wgbh/pages/nova/teachersguide/lightning/
The first of a series of linked pages that explore lightning and include several activities for the classroom.

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NEWTON'S APPLE

15 YEARS OF HANDS-ON SCIENCE

SHOW NUMBER

1513

Lightning

STATIC ATTACK

LIGHTNING: Student Activity

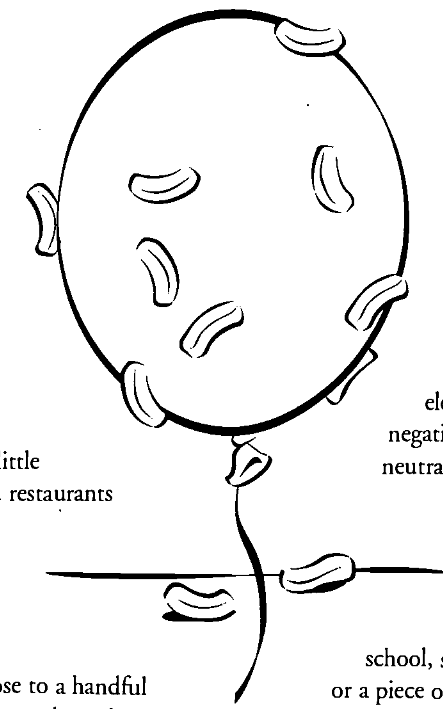
Charge up a balloon and watch the reactions.

http://www.ktca.org/newtons

Main Activity

Only scientists with sophisticated equipment can actually study lightning, but the same forces of static electricity that drive lightning can be studied on a much smaller and safer scale.

In this activity you'll play with electrons, creating negative and positive charges like those that form in thunderstorms. Instead of creating bolts of lightning that can fry trees, you'll use the charges to attract and repel objects.



Materials

- balloons
- Styrofoam packing pellets or puffed rice cereal
- strips of wool cloth
- salt and pepper (The little packets from fast food restaurants work well.)

1. Inflate a balloon and rub it with a wool cloth.
2. Bring your balloon close to a handful of the Styrofoam pellets and watch what happens.
3. Many of the pellets will cling to the balloon. Wait for several minutes and observe what happens to the pellets.
4. Try to explain what forces were involved in the pellets being attracted to the balloon, then explain the odd behavior of the pellets that followed.
5 Mix together a small pile of salt and pepper, recharge the balloon with the cloth, then hold the balloon very close to the salt and pepper. What happens? Is it what you expected?
6. Go back through the experiments and chart, in writing, the positive and negative forces involved in each step and how they caused the motions you observe.

Questions

1. Based on what you've seen, can you explain why rubbing your feet on a carpet and then touching another person or something metal causes a shock? Why does static electricity seem to build up more in dry air than in moist air?
2. Some materials, such as wool and human hair, give up electrons very easily and produce a negative charge in an otherwise neutral object. Other materials, such as rubber, don't. Why?
3. After you've explored the charges on the balloon, experiment with other objects available in your school, such as a rubber rod, a glass rod, or a piece of PVC plumbing pipe. Rub these objects with silk, fur, or wool, and see what happens when you bring them near your balloon. Do the objects attract or repel the balloon? Why?

[Adapted from an activity from the Boston Museum of Science]

Try This

Ask a meteorologist from a local TV station, your regional National Weather Service office, or a local college or university to come to your class and talk about lightning. How do weather forecasters predict lightning? Are there different types of lightning?

Try This

Research the dangers of lightning and develop a safety quiz for your school. Find the safest place to be in a lightning storm. What do you do if you're caught outdoors? Is it really safe to be in a car? Is it dangerous to take a shower or talk on the phone in a lightning storm? Why?

Try This

Cut out small squares of paper and put them on a table. Put the top of a clear plastic, take-out container over the pieces of paper and rub the top vigorously with a wool cloth for 2 or 3 minutes. What happens if you stop rubbing and wait 15 minutes? What happens if you rub the plastic again?

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PROTEINS

What are proteins and why are they important?

Dave takes a spin with proteins to see how they move.

http://www.ktca.org/newtons

NEWTON'S APPLE

15 YEARS OF HANDS-ON SCIENCE

[SHOW NUMBER] 1513

Segment Length: 8:15

Getting Started

To begin the lesson, set a Koosh ball (available at a toy store) on a table. Blow on it lightly and ask the class to describe the effect of the moving air on the Koosh ball's strands. Then give it a quick, hard puff and ask, "How did the strands behave differently when hit by the stronger current of air? How was the overall shape of the Koosh ball affected?" Stick a small bit of clay on one of the strands. Ask students to describe how changes in the form of one of the strands affects the arrangement of the others.

Explain that the Koosh ball's movements resemble those of a protein molecule, though the two don't look like each other. In the case of proteins, external factors like water molecules, not air, can affect surface projections of the protein and change its overall shape.

Ask the following questions: What are proteins? Why are they important to us? Why would altering a protein's shape be important?

Overview

Proteins run our show. Muscles, organs, hair, bone, and skin either contain or are made of proteins. They are a major component in all of our cells. Enzymes that run the chemical reactions in our bodies are proteins. Proteins help us move, send messages (hormones and nerve receptors), fight off disease (antibodies), and transport other molecules and atoms around our bodies.

A protein is a molecule that consists of a chain of amino acids. There are 20 different amino acids to choose from, and the genetic information in our DNA determines how they're put together. A single protein consists of hundreds of amino acids, all folding into a structure with a specific shape.

What job a protein does in the body is determined by its structure (its conformation) and the way it moves (its dynamics). Hemoglobin, for example, is an important red blood cell protein that delivers oxygen to tissues and hauls carbon dioxide to the lungs for removal. In the lungs, oxygen binds to the iron atoms inside a hemoglobin molecule and any attached carbon dioxide is released.

In the tissues, the molecules of oxygen are released and more carbon dioxide is picked up. As illustrated in the video segment, it is the motions of parts of the hemoglobin molecule that makes this binding and release action work.

Scientists can investigate these motions or dynamics as well as the protein's structure using a technique called NMR (nuclear magnetic resonance) spectroscopy. The nuclei of some atoms are like little magnets; they align within a magnetic field. If disturbed by a very quick blast of radio waves, this alignment is disrupted and these little magnets gradually relax back into alignment with the field. Researchers can interpret this NMR relaxation to get very detailed information about molecular motion and how proteins do their many different tasks in the body.

Connections

1. A protein's structure and activity allow it to accomplish its function. How do you use your own shape and movement to accomplish tasks?
2. You need to eat protein to survive. What foods contain protein? Do you think you get enough protein in what you eat? How can you find out?

Resources

Books and articles

Borman, S. (1996, May 27) Scientists refine understanding of protein folding and design. *Chemical and Engineering News*, p. 29.

Clore, G. & Gronenborn, A. (1993) *NMR of proteins*. Boca Raton, FL: CRC Press.

McCammon, J. & Harvey, S. (1987) *Dynamics of proteins and nucleic acids*. England: Cambridge University Press.

Schulz, G. & Schirmer, R. (1985) *Principles of protein structure*. New York: Springer-Verlag.

Web sites

Hemoglobin Allostery
http://cherubino.med.jhu.edu/~raj/Research/Hemo/hemo.html

Hemoglobin and Cooperativity
http://www.psc.edu/MetaCenter/MetaScience/Articles/Ho/Ho-hemoglobin.html

Protein Structure: A Beginner's Guide to Molecular Biology
http://www.res.bbsrc.ac.uk/molbio/guide/prot.html

NEWTON'S APPLE video cassettes and educational materials provide further information about this and other topics. Call 1-800-588-NEWTON or check out our Web site at: http://www.ktca.org/newtons

Educational materials developed with the National Science Teachers Association.
NEWTON'S APPLE is a production of KTCA Saint Paul/Minneapolis. Made possible by a grant from 3M.

IT ON PBS

3M Innovation

SHAPE SHIFTING

PROTEINS: Student Activity

Build a small protein and alter it to form new proteins.

Try This

Design your own protein out of a building set, gumdrops and toothpicks, or a rope or thick string. What do you want your protein to do? How will its shape have to be altered to perform that function?

Try This

Demonstrate NMR relaxation with a gyroscope. Set a gyroscope in motion. How does the motion resemble the motion of a protein nucleus inside an NMR? What happens to the gyroscope after it's been spinning for a while?

Try This

Vegetarian diets are often protein deficient. Why is that? Research vegetarian diets and find out which vegetarian foods can supply humans with an adequate amount of protein. Create a vegetarian menu for one day that would provide you with your daily protein requirements.

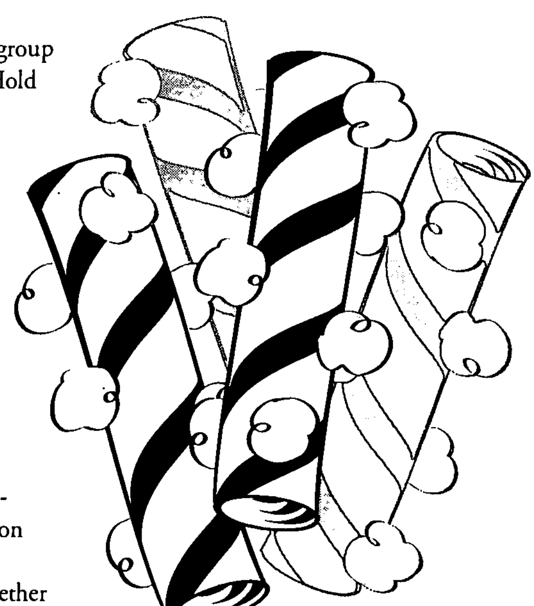
Main Activity

Scientists describe the structure of proteins several different ways, from the sequence of amino acids—the basic building blocks of protein—to how proteins interact. Some of the basic structures of proteins are recognizable; one is the alpha-helix, which looks like an open spiral staircase. Another is the beta-sheet, which resembles a picket fence. In this activity, you'll build a model of a protein with four helix units.

Materials (per group of four)

- four 10"–12" cardboard tubes (from plastic wrap or aluminum foil)
- four 30"-long pieces of Velcro (with peel-off sticky back)
- cotton balls
- Ping-Pong or golf ball

1. Each member of the group will make one helix: Hold one of the tubes vertically and wrap the Velcro strip around the tube in a spiral pattern. Attach the cotton balls to the Velcro an inch apart from each other. Can you see how this resembles a helix structure of a protein? What do the cotton balls represent?



2. Position four tubes together so that the cotton balls of one tube touch the Velcro strip of another. They should be able to hold together this way. What happens if you combine yours with another group's?
3. Now take the Ping-Pong or golf ball and try to get it into the middle of your four helices. What do you have to do to get it to fit inside? How is this similar to what a protein does to accommodate a smaller molecule? What kinds of molecules change their conformation like this to do their job?

Questions

Why is it important for researchers to know the shapes of different proteins? How do you think they are able to alter a protein's shape?

Educational materials developed with the National Science Teachers Association.
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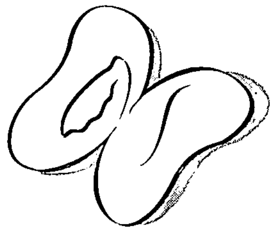
SCIENCE TRY-ITS



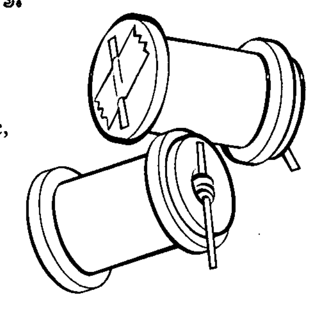
[1] TRY IT! Cuddle up to a baby plant!

Fill a glass half full with water. Put six hard-shell dry beans (pinto, kidney, or lima) in the glass of water to soften their outer casings. Set the glass of beans in a refrigerator overnight. (Keeping the beans cool prevents bacteria from growing and making the beans sour.) Remove the beans from the water and place them on a paper towel to dry. With your fingernail, scratch off the outer covering of one of the beans. Holding the bean in your hands, pry the two parts of the bean apart with your fingers. Using a flashlight, shine a beam on the split bean as you observe the inside with a magnifying lens. Do you see a small plant in one side of the split bean? What is that tiny structure? What does it look like? To find out, you'll have to try it!

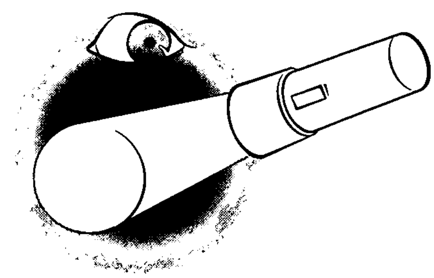
[3] TRY IT! The ink of many colors

Cut a paper towel into six-inch-wide strips. Using a black or blue (not permanent) felt-tip pen, make a large solid dot about two inches from the short edge of one of the strips. Put water, about one inch deep, into a glass and put the edge of the towel nearest the dot into the water—be sure the dot is not submerged. What happens? You'll have to try it!

[2] TRY IT! Go Spool Racers!



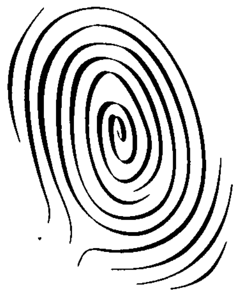
Materials you'll need: empty thread spool, rubber band, two round toothpicks, masking tape, metal washer (diameter must be smaller than that of the spool). Insert the rubber band through the hole in the empty thread spool. Put one toothpick through the loop formed by the rubber band at one end of the spool. Center the toothpick on the end of the spool and attach with the tape. At the other end of the spool, thread the rubber band through the hole in the washer. Put the second toothpick through the loop in the rubber band. Do not attach it to the spool. Hold the spool steady with one hand, and with the index finger of your other hand turn the unattached toothpick around and around in a clockwise direction to wind the rubber band tightly. Place the spool on a flat, smooth surface, such as a counter or the floor, and let go. Observe that as the rubber band unwinds, the spool turns, turning the toothpick taped to the spool. How does the spool move? You'll have to try it!

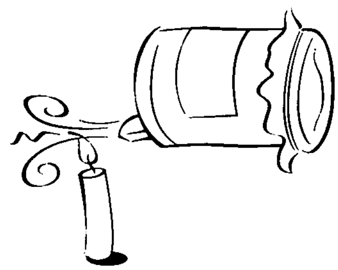


[4] TRY IT! Night Vision

In a dark room (not totally dark, but the light should be extremely low), let your eyes adjust for 10 minutes. Cover your right eye tightly with your hand so that no light can get through. Have a friend turn on a small flashlight and point it at your stomach. (Don't let them point it directly into your eyes!) Stare at the flashlight for 30 seconds with your left eye. Turn off the light and look around the room. Now cover your left eye and look around with your right. Is there a difference? You'll have to try it!

SCIENCE TRY-ITS





[5] TRY IT! Fingerprint Fun

Rub the sharpened end of a pencil across a sheet of paper 15 to 20 times to collect a layer of graphite on the paper. Rub your left index finger across the graphite on the paper. Tear off about one inch (2.5 cm) of tape and stick it across the darkened tip of your finger. Remove the tape and stick in on a sheet of white paper. Repeat the process using the tips of other fingers. Observe the patterns produced by each finger with a magnifying lens. Are the patterns different or the same? Why? To find out, you'll have to try it!

[6] TRY IT! Blowout!

Take an empty salt container and cut out the bottom. Place plastic wrap around the bottom of the container and secure with a rubber band. Have an adult light a candle and hold the container sideways about six to eight inches from the candle, the spout facing towards the candle's flame. Gently tap the plastic bottom of the container with your finger. What happens to the candle? You'll have to try it!

THE SCIENCE BEHIND SCIENCE TRY-ITS

[1] Baby Plant
Beans are a smooth, hard seed. When split open, each seed has a tiny, colorless, plantlike structure with two leaves stuck to one of the bean parts. When observed under the magnifying glass, this structure looks like a "baby" plant. This tiny baby plant is called the embryo, and is the part that ultimately develops into a plant. The two parts of the bean that are pried apart are the seed leaves or cotyledons, and they contain the food for growing the embryo. Plants with two seed leaves, such as beans, are called dicots, short for dicotyledons. Plants with only one seed leaf, such as corn, are called monocots, short for monocotyledons.

[2] Spool Racers
There are two basic forms of energy: kinetic (energy of motion) and potential (stored energy). It took energy stored in the muscles of your body to wind the rubber band. As long as you prevented the rubber band from turning by holding the toothpick, the energy was stored (potential). Releasing the toothpick allowed the rubber band to unwind and thus the stored energy in the twisted rubber band was transformed into kinetic energy.

[3] Ink
Black and blue inks are actually made up of many colors, not just black and blue. The different colors you see on the paper towel are the colors that make up the ink in the pen—each is a different substance, which means each color of ink has different-sized molecules. When the water is absorbed by the paper towel, it carries the different inks along with it. The water carries the lighter ink molecules farther than the heavier ones, separating the various colors in the ink. So the heavier ink molecules stop moving first, then the lighter ones—that's why different colors end up in different places.

[4] Night Vision
No one can see in total darkness, but when there is low light, your eyes produce a chemical called rhodopsin, which helps you see better in low light. It takes about 10 minutes in the dark for the rhodopsin to form. When your eyes are then again exposed to light, the rhodopsin is "burned off" of your eyes. When you wake up to someone turning on a bright light in your room, it makes your eyes hurt because the rhodopsin is burning off your eyes.

As you can see from this Try It, you can't see very well in the dark without your rhodopsin!

[5] Fingerprints
The inner layer of skin called the dermis has projections. The outer skin layer, the epidermis, fits over these projections, thus taking the same pattern. Each person has a fingerprint unique to that individual. These personal signatures form five months before birth and never change.

[6] Blowout
Inside the salt container, waves of air pile on top of each other and create a tremendous force that can only escape one way—through the spout. This focused rush of air is much stronger that the diffused rush of air that would come out of the container if the whole top were missing. When the salt container is tapped, air rushes out, forming a whirling mass of air shaped like a ring. The flow of air in the center of the ring is quite strong—strong enough to blow out the candle several inches away.

Street Smarts

NEWTON'S APPLE
15 YEARS OF HANDS-ON SCIENCE

QUESTIONS

[1] What is house dust made of?

A. Pet dander
B. Spent exhaust fumes
C. Dirt particles
D. Human skin particles

[2] What animal is the most poisonous?

A. Australian hedgehog
B. Cobra
C. Poison dart frog
D. Scorpion

[3] What makes a mosquito bite itch?

A. A portion of the mosquito's stinger left behind in the skin
B. Secretions ftom the mosquito's wings
C. A chemical reaction to certain types of skin oils and odors
D. The mosquito's saliva

[4] How long does it take light from the sun to reach Earth?

A. 12 hours, 17 minutes
B. 1.5 light years
C. 8 minutes, 20 seconds
D.13 minutes, 30 seconds

[5] What happens to cats if they don't eat meat?

A. They shed hair continually.
B. They lose their sight.
C. They sleep 18-20 hours per day.
D. They become vegetarians.

[6] Which reptile is the fastest swimmer?

A. Sting ray
B. Eel
C. Water snake
D. Leatherback turtle

[7] What's the strongest animal?

A. Elephant
B. Gorilla
C. Beetle
D. Camel

[8] What makes your stomach growl?

A. Acid reacting with stomach gases
B. Shifts and stretches in the stomach lining
C. Signals from the brain telling the stomach it's empty
D. Air moving through tissues

Educational materials developed with the National Science Teachers Association.
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Street Smarts

[1] A POUND OF FLESH

Your pets aren't the only ones that shed! **Human skin particles** make up 80 to 90 percent of all house dust, with each of us shedding about a billion skin scales every day. That's about a pound of skin per year! The average house has about 40 pounds of dust. Dust particles help form rain clouds and rainbows—something to remember the next time you dust!

[2] ONE DANGEROUS FROG

No it doesn't slither, it hops! The **poison dart frog** of South and Central America has powerful toxins in its skin and secretes some of the most deadly biological toxins ever discovered. This deadly poison can cause paralysis and even death to predators that eat the frog. The poison dart frog got its name from certain tribes in South America that use the frog's poison for hunting animals by wiping their arrow heads across the skin of the frog.

[3] THAT PESKY MOSQUITO SPIT

The mosquito's **saliva** acts as a lubricant and an anesthetic. It's also the saliva, not the bite itself, that causes an allergic reaction or the itchy bump. The female mosquito feeds off the blood of warm-blooded animals, including humans. When she bites, she injects some of her salivary fluid into the wound, causing swelling and irritation. Many mosquitoes inject infectious microorganisms and can transmit diseases such as encephalitis, malaria, and yellow fever.

[4] NOW THAT'S FAST!

Sunlight takes about **8 minutes and 20 seconds** to reach Earth, traveling at 186,282 miles per second. Light can be visible or invisible, depending on its wavelength, and is really an interplay between electric and magnetic fields. Light is just one portion of the electromagnetic spectrum, which also includes radio waves, x-rays, infrared waves, ultraviolet rays, and gamma rays.

[5] CATS NEED MEAT!

Unlike humans and dogs, **cats will go blind** if they don't eat meat. Cats need taurine, an amino acid found in meat, to keep their eyes in good shape. Many animals can synthesize taurine from vegetable proteins. Cats can't. Cats need their vision for hunting and have excellent night vision and extensive peripheral vision.

[6] THIS TURTLE CAN REALLY MOVE!

They may not move very quickly on land, but look out in the water! The **leatherback sea turtle** has been clocked at an amazing 22 miles per hour, swimming with speed and grace. The leatherback gets its name from its shell, which is like a thick, leathery skin, with the texture of hard rubber. These turtles live in almost all of the world's oceans, but require warm tropical beaches to nest. The leatherback sea turtle is an endangered species, with an estimated 100,000 leatherbacks remaining in the world today.

[7] THE MIGHTY BEETLE

Heave! They may be small, but they certainly can pull their weight. **Beetles** are the strongest animal in proportion to their size. A rhinoceros beetle can support up to 850 times its own weight on its back. This feat is comparable to a 150-pound man walking with a Cadillac on his head without tiring. Rhinoceros beetles don't actually carry heavy loads on their backs in nature, but they do engage in such strenuous tasks as plowing through forest litter for food and locking horns with rivals. Scientists have proposed that the beetles' tough exoskeleton and efficient muscles make them so strong.

[8] YOUR NOISY, AIRY STOMACH

While your stomach may sound like a monster with a mind of its own-sometimes, those growling sounds coming from it are actually just **air resonating** through your tissues. Muscle contractions increase the growling when you're hungry. Your body actually begins the digestive process by producing gastric juices before you eat, triggered by the sight, smell, or taste of food. If the stomach isn't filled, these gastric juices begin eroding the stomach lining itself, so fill 'er up!

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3M SCIENCE ENCOURAGEMENT

Discovery is a way of life at 3M.

Questioning, probing, and problem solving happen every day in 3M laboratories and result in innovative solutions like Post-it® Notes. However, 3M recognizes that innovation doesn't happen by accident. At 3M, the wonder of discovery is a universal experience that makes science come alive for students of all ages.

Over the past 40 years, this philosophy has evolved into a series of Science Encouragement Programs that embody our endeavors to spread enthusiasm for science. 3M engages in a wide variety of activities designed to raise the level of student learning. Our efforts are maximized through employee and retiree volunteers, who serve as tutors, mentors, and hosts. Our programs impact students from kindergarten through college and include special programs for teachers.

Many of our Science Encouragement Programs have received regional and national awards over the years. In 1996, 3M was awarded the Industrial Research Institute (IRI) Pre-College Education Award for our STEP and TWIST programs (detailed below).

As NEWTON'S APPLE demonstrates in its weekly, award-winning programs, the power of science is limited only by the imagination. As many 3M Science Encouragement students will attest, the wonders of science can take the imagination by storm and create a lifelong passion for discovery.

3M Visiting Wizards

3M volunteer scientists become "wizards" to elementary and middle school students as they present exciting science principles in hands-on classroom demonstrations. Since 1985, 3M Visiting Wizards have spread enthusiasm for learning science to millions of children in communities where 3M is located.

TECH (Technical Teams Encouraging Career Horizons)

Teams of women and men scientists visit middle and junior high school classrooms to discuss real-world opportunities in science and engineering, as well as how they apply their technical backgrounds to their current professions. The volunteer 3M scientists encourage students to maximize their career options by staying in challenging math and science classes.

Richard Drew Creativity Award Program

The program, which honors students for their creative instincts in science and math, captures the spirit of 3M scientist Richard Drew, who is remembered for his innovation and for encouraging the wonder of discovery in others. High school juniors from Minnesota and Wisconsin schools are invited to interact with 3M scientists and engineers in a day of science and career activities at 3M Center.

SSRD (Science Student Recognition Day)

The first and longest-running 3M Science Encouragement program, SSRD invites Upper Midwest high school seniors and their teachers to spend a day in our St. Paul laboratories with 3M scientists and engineers. Students see the link between academic training and real-world science careers.

STEP (Science Training Encouragement Program)

Minority and at-risk students in this academic mentoring and technical experience program explore their interests in scientific careers. High school students attend classroom training on-site at 3M's corporate headquarters to augment their regular high school curriculum. Students are given the opportunity of being introduced to "modern-day heroes." STEP participants also develop work environment relationships with culturally diverse technical mentors, while holding full-time summer jobs in 3M laboratories. A continuation of this program is currently underway with STEP II, providing summer employment for students in college who successfully completed the STEP I program.

TWIST (Teachers Working in Science & Technology)

Science and math teachers learn real-world research applications while working alongside 3M scientists. The six-week summer internship gives teachers a practical understanding of science and math concepts through first-hand technical experience in an industrial laboratory.

Teacher Workshops

Teaching science concepts can be challenging and intimidating for some school teachers, especially in the elementary grades. 3M sponsors several resource fairs for teachers, which provide non-threatening opportunities to explore exciting ways to teach science. Teachers acquire "recipes" for hands-on science activities that complement their current teaching methods, thereby enhancing teachers' confidence and resources.

Educational Outreach

3M supports local and national organizations that promote science and technology education and awareness. Commitment and support are demonstrated through grants, educational materials, and volunteerism. Currently, 3M supports events and organizations including: National Science and Technology Week, National Engineers Week, Industrial Research Institute (IRI) Pre-College Education, MATHCOUNTS, WIZKIDS, National Action Council for Minorities in Engineering (NACME), the National Science Teachers Association (NSTA), and the Minnesota Science Teachers Association (MSTA).

NEWTON'S APPLE

3M began full sponsorship of this Emmy Award-winning family science show in 1991. Currently, 3M volunteers serve as consultants on programming and related educational materials. When it comes to science education, 3M and NEWTON'S APPLE staff often find themselves working together at NSTA meetings or sharing ideas and hands-on activities with teachers.

If you would like additional information on any of 3M's Science Encouragement Programs, please write to:

3M Center
Technical Liaison Department
Science Encouragement Office
Bldg. 225-3N-09
St. Paul, MN 55144-1000

KEY WORDS

NEWTON'S APPLE

15 YEARS OF HANDS-ON SCIENCE

ASTHMA

capillaries smallest blood vessels in the body; capillaries take oxygen into the bloodstream from the air sacs and get rid of carbon dioxide, which is exhaled from the lungs
dilate to expand or open wide; many asthma drugs open constricted airways
mucus the thick, slippery secretion that comes from cells lining the nose, mouth, trachea, and lung airways
peak-flow meter a tube asthmatics use to monitor the rate at which air enters and leaves the lungs
respiratory system lungs and other organs that enable animals to breathe

CAR ENGINES

exhaust valve opening in the top of the cylinder that lets waste gas out after combustion has occurred
intake valve opening at the top of the cylinder that allows the air/fuel mixture to enter the combustion chamber

GLACIER CLIMBING

crevasse large, deep crack on the surface of a glacier
drumlin an elongated, smooth hill made of glacially derived sediment
erratic large, isolated boulder deposited by a glacier
esker long, sinuous ridge of glacially revived sediment
glacier large flowing mass of ice
ice sheet large ice field composed on several glaciers that have flowed together
iceberg large block of floating ice
kettle pond isolated pond formed from glacial deposits
moraine unsorted glacially derived sediment

GLASS BLOWING

annealing cooling a glass object at a fixed temperature
blowing pipe iron or steel tube with a mouthpiece at one end and a metal ring to hold the molten glass on the other
gather gob (mass) of molten glass
viscosity a liquid's resistance to flow

GLAUCOMA

aqueous humor fluid that fills the space between the eye's cornea and lens
ciliary body muscle around the lens that focuses the eye closer than arm's length
cornea lens that forms the front of the eye and does most of the eye's focusing
iris colored ring of muscular tissue lying between the cornea and the lens
lens transparent structure behind the iris that focuses light onto light-sensitive cells in the retina at the back of the eye
optic nerve bundle of nerve fibers that connect each light-sensitive cell to the brain
pupil the "hole" in the center of the iris through which light enters the eye
retina the light-sensitive membrane that lines the interior of the eye

GLIDERS

ailerons flaps on the wings of a plane that help the pilot steer and bank
angle of attack angle at which the leading edge of a wing is tilted while facing into the wind
Bernoulli's principle effect that a fast-moving fluid has on changing the pressure above and below the surface of an object
control surface one of the moving flaps on a plane that allows the pilot steer and change altitude
drag the force of air resistance against a plane as it flies
elevator horizontal flaps on the tail that cause the plane to rise and fall
gravity force that brings a plane back down to Earth
lift force that causes a plane to rise
rudder vertical flap on the tail of a plane that allows a pilot to steer right or left
thermal an updraft of air caused by the unequal heating of the Earth below
thrust force that pushes a plane forward through the air

GOLD MINE

density ratio of a material's weight to its volume; gold has an unusually high density
gold metallic element revered for its beauty and workability; like all metals, gold is shiny and conducts electricity
ingot a finished, refined bar of gold
mining digging in the ground to find usable metals and minerals
ore the raw material that contains the mineral or metal of interest, often mixed with rock and soil
panning agitating a shallow tray of sediment and water to gradually wash out unwanted soil and gravel, leaving any gold behind
prospecting searching for metals and minerals in nature
refining the process used to remove impurities from a metal

GREENHOUSE EFFECT

carbon dioxide CO_2; natural component of the atmosphere but also a greenhouse gas capable of absorbing infrared radiation and warming the atmosphere
global warming the observed increase in Earth's average temperature
greenhouse gas any component of the atmosphere that can absorb infrared radiation and potentially contribute to global warming
infrared radiation portion of the electromagnetic spectrum that we can sense as heat and that is radiated by a warmed surface

KIDS ON MARS

canali the Italian word for "channel"; used to describe surface features on Mars
contour line line of equal elevation on a topographic map
quadrant section of a map or area photo
topographic map a map that shows lines of equal elevation
torque force that produces rotation in a gear or wheel

LIGHTNING

ampere (amp) the standard technical measure for electricity
current a measure of how much electricity passes a given point in a fixed amount of time; measured in amps
electron an elementary particle that always carries a negative charge and orbits around the nucleus of an atom
microsecond one millionth of a second
static electricity electric charges that are not moving very much; the electricity is "static" compared to the other form of electrical phenomena called "current"
voltage measure of the force of an electrical charge; one volt is the force required to produce an electrical current of one ampere

LOST WORLD DINOSAURS

animatronics art form that designs and builds moving models to resemble actual creatures
compliant reactivity detailed, linked model movements possible with new technology
hydraulics using fluid under pressure to operate machines
paleobotany study of prehistoric plants
paleontology study and reconstruction of the prehistoric world through the excavation of fossils and other evidence from the geologic record

MAMMOTH DIG

Clovis point a spear point carefully hewn from larger stones found over much of North America starting about 12,000 years ago
genus level or group used in classifying organisms that are closely related
ice age interval of geologic history when considerable portions of land were covered by glacial ice
Paleo-Indians first people to populate North America
species a level or group used in classifying organisms that can reproduce to create fertile offspring
steppe semiarid region characterized by short clumps of grass and a lack of trees
tundra a cold region with few, if any, trees; gentle rolling plains covered mostly by mosses, lichens, and grasses

NASA ROBOTS

on-orbit assembly building large structures like the space station in Earth's orbit
robotic payload tending using robots to handle day-to-day upkeep, certain scientific experiment procedures, and other projects contained within a spacecraft or space station
robotic rover any one of a series of small, wheeled vehicles NASA is using to explore objects in space

KEY WORDS

NEWTON'S APPLE. 15 YEARS OF HANDS-ON SCIENCE

sensors devices on a robot that function like a human's eyes, ears, and nose; some robots have sensors that are able to pick up traces of chemicals or determine accurate distances to objects
smart robots robots capable of working autonomously
virtual reality telepresence by using special goggles or television screens connected to sensors on a distant robot, a controller can see the robot's surroundings as the robot sees them

NOVOCAIN

anesthesia loss of sensation or feeling; if the anesthetic is applied only to an area of the body, it is called a local anesthetic; if the entire patient is anesthetized, it is called a general anesthetic
electrode the point of electrical contact for electronic anesthesia
electronic anesthesia a form of anesthesia that uses electricity, rather than chemicals, to numb an area
lidocaine a common local anesthetic in dental offices, administered directly to the nerve through a needle
nerve fibers (made from specialized cells called neurons) in animals that transmit sensory information, including pain, to the brain
pain the discomfort felt when an injury or illness damages some part of the human body
receptor receiving area for neurotransmitter chemicals that connect one neuron to another

PACK BEHAVIOR

aggressive attempting to establish dominance by growling, biting, and otherwise intimidating pack members
domestication the process by which animals are tamed and begin to live and interact with human beings
dominance the establishment of authority of one animal over another in a pack structure
submissive accepting of dominance by other pack members

PET FOOD

amino acids organic compounds essential to human and animal metabolisms
animal husbandry care and management of domesticated animals
carnivore flesh- (meat-) eating animal
palatability feature of food that includes aroma, food temperature, texture, and how the food feels in the mouth
taurine a sulfonic amino acid cats need to maintain health

PHASES OF THE MOON

earthshine sunlight that is reflected off Earth onto the moon, and then reflected off of the moon back towards Earth
gibbous somewhat oval in appearance; more than half a circle, but less than a full circle
limb the edge of the disk of the moon
revolution the time it takes for one celestial body to complete its orbit around another
satellite a smaller object, such as a planet or moon, that revolves around a larger object, such as a star or planet
synchronous rotation period of a satellite's rotation about its axis and the period of its orbit around the primary body are the same so that the satellite always presents the same face to the primary body
terminator line between light and dark areas on the side of the moon we see; divides night and day on the moon.

PROTEINS

amino acid any one of 20 small molecules of similar structure that can link together in chains to form proteins
conformation the specific shape of a protein at any given time
helix conformation of a protein that looks like a spiral staircase
heme molecule that holds an iron atom inside the hemoglobin protein
hemoglobin blood protein responsible for transporting oxygen to the tissues and carbon dioxide to the lungs
nuclear magnetic resonance (NMR) technique for determining molecular structure and movement using magnetic fields and radiowaves
peptide bond specific type of chemical bond between the amino acids in a protein chain
protein fold the conformation of the animo acid sequence into secondary structured elements
sheet conformation of a protein that looks like a number of picket fences next to each other
side chains parts of an animo acid that make each one unique

ROBOTS

automation automatic operation of equipment or systems without human operator
electromechanical operating by means of both mechanical elements (rods, gears, etc.) and electrical elements (wiring, switches, etc.)
microprocessor a computer that controls a robotic system
photo cell a device whose electrical characteristics vary when light hits it

SCUBA DIVING

buoyancy the tendency to float in water or air
oceanography the scientific study of oceans, including waters, animals, plants, and depths

SMILES

algorithm special method or series of steps or calculations for solving a specific problem
asymmetrical not the same on the two sides of a dividing line or plane
gesture culturally learned movement of the hand, arm, face, or body that expresses an idea, opinion, or feeling

SUNKEN SLAVE SHIP

archaeologist a scientist who studies the life of ancient peoples by excavating artifacts, relics, and even entire ships or cities
electrolyte a substance that in liquid form conducts an electric current
encrustation a crust, coating, or hard layer
excavate to uncover or dig out
integrity complete, whole, not broken or damaged
maritime having to do with the sea, such as shipping or navigation
oxidation-reduction a chemical reaction in which one reactant is reduced, or gains one or more electrons, and the other is oxidized, or loses an electron
rust a reddish-brown or reddish-yellow coating on iron or steel caused by oxidation due to exposure to air or moisture

WHITE-WATER RAFTING

boils ascending currents that rise above the surface level
eddy pocket of water downstream of an obstacle that flows upstream or back against the main current
gradient measurement of a river's descent in feet per mile or meters per kilometer
hole vortex of water where the river pours over an obstacle and drops toward the river bottom, leaving a pocket behind the obstacle into which an upstream surface current flows
rapid a fast-moving section of a river or stream
reading a river studying the various hydraulic features of a section of a river, usually a rapids, to spot dangers and find a safe path through
vortex a mass of fluid with a whirling or circular motion that tends to form a cavity

WILDERNESS TRAINING

anchor any of a number of tools to fix a rope to the climbing surface
friction the fundamental physical principle that climbers rely on to stop falls—any two surfaces, rubbed together, will result in a dragging force that slows the movement

WIND BLOW

air mass a large mass of the atmosphere that has similar temperature, pressure, and moisture characteristics
convection cells circling fluid flow patterns
density a measure of how much mass occupies how much space (density equals mass divided by volume)
radiation energy emitted from a "hot" object that travels out in rays

ZOO VET

anesthesia a drug or gas given to block the sense of pain
diagnosis careful examination and analysis of a disease
ecosystem the environment that houses a community of animals, plants, and bacteria
euthanize to cause a painless death in order to end suffering
preventive medicine procedures, such as physical and dental exams, that keep a disease from occurring
ultrasound medical diagnosis that uses high-frequency ultrasonic waves

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