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ABSTRACT

This guide was developed to help teachers use the 14th season of NEWTON'S APPLE in their classrooms and contains lessons formatted to follow the National Science Education Standards. The "Overview," "Main Activity," and "Try-This" sections were created with inquiry-based learning in mind. Each lesson page begins with "Getting Started," which contains a simple activity and a series of open-ended, inquiry-based questions to engage students. These activities are designed to gauge what the students know about the subject and to initiate discussion. Lessons include background information, interdisciplinary connections, resources, and hands-on activities. Also included is a Guide to Enjoying NEWTON'S APPLE at Home that encourages family participation in science education. Topics are as follows: (1) Spelunking; (2) Human Eye; (3) Tahiti Special which includes Sharks and Black Pearls; (4) Riverboats; (5) Body Fat; (6) Hypercoaster; (7) Nicotine; (8) Avalanche Rescue; (9) Prosthetic Limbs; (10) Andes Special on Inca Engineering; (11) Ski Jumping; (12) Bee Stings; (13) Rain Forest Special which includes Rain Forest Plants and Rain Forest Animals; (14) Olympic Solar Energy; (15) Soccer; (16) Malaria Tracking; (17) Clocks; (18) Post Office; (19) Gems; (20) Ethanol; (21) Bones; and (22) Water Special that includes Wetlands and Drinking Water. (JRH)

● 14TH SEASON

DEVELOPED IN PARTNERSHIP WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION

NEWTON'S APPLE®

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

NEWTON'S APPLE continues to provide innovative, fun, and meaningful programming for young people. At 3M, we believe early exposure to science increases interest and appetite for learning, and helps foster appreciation for the importance of and opportunities in science. We're proud to sponsor the 14th season of NEWTON'S APPLE.

An important aspect of 3M's sponsorship is our work with KTCA-TV and the National Science Teachers Association to produce these NEWTON'S APPLE classroom materials. These materials help bring to life the wonder of science and can instill greater curiosity about science, our world, and our future.

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

The five-member NEWTON'S APPLE team travels the world over and explores our backyards to find out the answers to YOUR science questions. NEWTON'S team members climb into caves, swim with sharks, plunge down one of the country's largest roller coasters, learn the secrets of the rain forest and the Andes mountains, track mosquito infestation and malaria incidence, follow a letter through the postal service, and more.

Eileen Galindo

Actress and comedienne Eileen Galindo joins the NEWTON'S APPLE team in its 14th season. Eileen travels to Switzerland to investigate how rescuers find people buried in avalanches. She then goes to the Andes mountains in Peru to learn how the ancient Incas used special beads called quipus to communicate. In the Warehouse, Eileen learns the art of soccer from a physicist and she gets her hands on some very valuable gems.

Dave Huddleston

Dave once again dives (literally!) into sticky situations to help answer your science questions. In Tahiti, he straps on scuba gear and swims with sharks to find out how they breathe. In Peru, he explores the rain forest to discover some of its unique animals: leaf cutter ants, snakes, and frogs. Back home, Dave takes a thrilling ride with a letter to find out how the postal service handles so much mail!

Brian Hackney

Brian's curiosity leads him to New Orleans, where he takes the helm of a Mississippi River boat to find out how steam power keeps it moving. In Switzerland, he teams up with championship ski jumpers to show how they fly through the air. Back at the Warehouse, Brian explores why nicotine is so addictive.

David Heil

After nine years with NEWTON'S APPLE, David's adventures continue as he travels to the Andes mountains of Peru to investigate how the ancient Incas built those huge stone structures without wheels, machines, or iron tools. Then he catches up with some researchers in the Amazon to find out why tropical rain forests are so important to world climate and health.

SuChin Pak

In her second season with NEWTON'S APPLE, SuChin, now a college senior, investigates science in the world around us—she goes to Tahiti to dig up the story on black pearls. Then see if she STILL wants to get that tattoo after learning more about them from the Tahitian people, famed for their ornate body art. In the Warehouse, SuChin learns how popcorn gets its pop!

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3M Innovation

Welcome to the NEWTON'S APPLE TEACHER'S GUIDE

NEWTON'S APPLE®

This guide was developed to help you use the 14th season of NEWTON'S APPLE in your classroom.

New Features

The new NEWTON'S APPLE Teacher's Guide lessons are formatted to follow the National Science Education Standards. The "Overview," "Main Activity," and "Try-This" sections have been created with inquiry-based learning in mind.

Getting Started

Each lesson page begins with "Getting Started," which contains a simple activity and a series of open-ended, inquiry-based questions to engage your students before you conduct the lesson or show the segment. These activities are designed to gauge what your students know about the subject and to initiate discussion.

Key Concepts

The "Key Words" section, previously listed on each lesson page, has been consolidated in the center of the book, on durable cardstock. "Key Concepts" words are **highlighted** on each lesson page for easy reference.

Features You've Come To Depend On

•	An index to the 14th season lesson pages and an index to the past three seasons of NEWTON'S APPLE.
•	A science subject index that gives you a quick overview of the science concepts presented in each 14th season lesson.
•	Lessons, lessons, and more lessons (including background information, interdisciplinary connections, resources, and hands-on activities) focused on the major topics explored in the 14th season.
•	Hands-on "Science Try It" experiments and a "Street Smart" quiz.
•	A "Guide to Enjoying NEWTON'S APPLE at Home" that you can duplicate and send home with your students to encourage family participation in science education.
•	Our 14th season poster, with easy-to-photocopy activities for the classroom on the back.

Using NEWTON'S APPLE in the Classroom

NEWTON'S APPLE allows three-year, off-air record 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 14th season of NEWTON'S APPLE will air on most PBS stations beginning in October 1996 (check your local PBS listings for exact airdates and time). If you don't find NEWTON'S APPLE listed in your local TV guide or PBS viewer's guide, contact your local PBS station to find out when the 14th season will be airing in your area.

Public television stations depend on what they hear from viewers to help make their programming decisions, and you, as an educator, 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
SAINT PAUL MN 55101
e-mail: newtons.apple@umn.edu
NEWTON'S APPLE Teacher's Guides also are available on the web at: http://ericir.syr.edu

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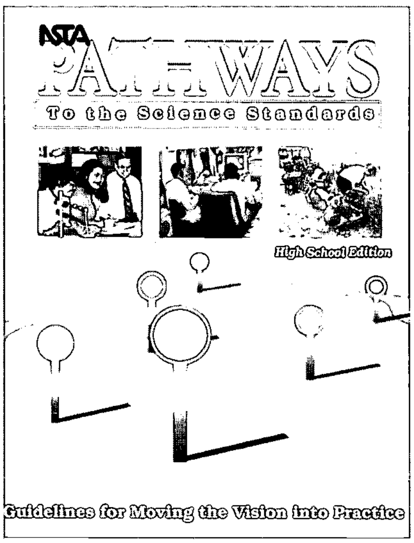
NEWTON'S APPLE®

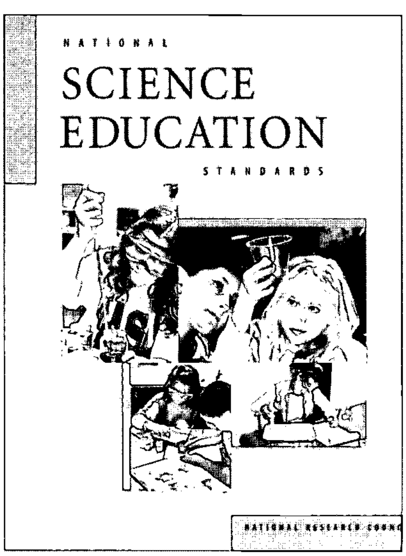
The NEWTON'S APPLE educational materials were developed to help teachers approach some of the goals of the new National Science Education Standards.



The *National Science Education Standards,* recently published by the National Research Council, presents criteria to help state and local school personnel make decisions about every area of science education. From teaching and the quality of what students know to assessment practices and the system that supports teachers and programs, national standards bring coordination, consistency, and coherence to the improvement of every aspect of science education.

The National Science Teachers Association (NSTA) applauds the release of the *National Science Education Standards,* and encourages science educators to put the Standards into practice in the classroom. The world's largest organization dedicated to science education, NSTA has led the way in promoting the Standards with teacher institutes, awareness kits, and a Standards discussion area via the Internet. NSTA also has developed many publications to keep educators informed about the latest issues in science education, including a variety of resources for implementing the Standards.

This year, NSTA presents its *Pathways to the Science Standards,* practical guidebooks for bringing the standards to life in any school or classroom. Written *by* teachers *for* teachers, these books include examples, discussions, and demonstrations on how you can carry the vision of the Standards—for teaching, professional development, assessment, content, program, and system—into the real world of the classroom and school. *Pathways* is also a tool for you to use in collaborating with administrators, school boards, and other stakeholders in science education. Separate editions treat elementary, middle, and high school levels.



NSTA's project on Scope, Sequence, and Coordination recently updated its *High School Framework for National Science Education Standards* to help teachers implement the Standards within the SS&C model. *A Framework for High School Science Education* demonstrates how the content standards can be sequenced and integrated over the four years of high school. Integral to this publication is a series of "micro-units" that corresponds to the elements of the *Framework's* learning sequence. These micro-units consist of lab activities, readings, and assessment items that will help you put the national standards to work in your classroom.

The *Standards;* elementary, middle level, and high school editions of *Pathways;* and the *SS&C High School Framework* are available from NSTA. For a catalog and sales information, contact the NSTA Science Store at (800) 722-NSTA (6782) between the hours of 8 a.m. and 6 p.m. (EST).

Index to the 14th Season Lesson Pages

There are two way to locate any of the 25 lessons in this guide: check out 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-hand corner of each lesson page for the NEWTON'S APPLE show number (e.g., 1401, 1402) that corresponds to that topic. We've also included in the same corner the segment's approximate running time.

On the back of this page, you will find a guide to the past three seasons of NEWTON'S APPLE. These episodes may be rebroadcast on your local PBS station throughout the year, and we hope you will continue to use them in your classroom.

Index of Past Seasons

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Science Subject Index

NEWTON'S APPLE

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
Avalanche Rescue 1405	●			●		●	Zoology
Bee Stings 1407	●	●					Zoology
Black Pearls 1402	●	●					Zoology
Body Fat 1403	●	●			●	●	Health; Medical Science; Food/Nutrition
Bones 1412	●	●			●		Health; Medical Science; Food/Nutrition
Clocks 1410			●	●	●	●	History
Drinking Water 1413	●	●		●		●	Ecology; Environment
Ethanol 1412	●	●		●	●	●	Ecology; Environment; Botany
Gems 1411		●	●	●		●	Geology
Human Eye 1401	●						Medical Science
Hypercoaster 1404	●		●			●	Engineering
Inca Engineering 1406			●	●		●	History; Engineering; Archaeology; Geology
Malaria Tracking 1410	●			●		●	Geography; Botany; Computer Science

Science Subject Index

NEWTON'S APPLE®

Segment	Biology	Chemistry	Physics	Earth/Space	Mathematics	Technology	Additional Applications
Nicotine 1404	🍎	🍎					Medical Science; Health; Social Studies
Olympic Solar Energy 1409		🍎	🍎	🍎		🍎	Engineering; Environment
Post Office 1411					🍎	🍎	Engineering; Computer Science
Prosthetic Limbs 1405	🍎		🍎			🍎	Engineering; Medical Science
Rain Forest Animals 1408	🍎	🍎		🍎			Zoology; Ecology; Environment
Rain Forest Plants 1408	🍎			🍎			Botany; Ecology; Food/Nutrition; Environment; Health
Riverboats 1403			🍎			🍎	Engineering
Sharks 1402	🍎			🍎			Zoology; Environment
Ski Jumping 1407	🍎		🍎			🍎	Engineering; Physical Education
Soccer 1409	🍎		🍎				Engineering; Physical education
Spelunking 1401		🍎	🍎	🍎		🍎	Engineering; Physical Education
Wetlands 1413	🍎	🍎		🍎			Ecology; Botany; Environmental

SPELUNKING

How are caves formed?

What are some characteristics of a cave environment?

NEWTON'S APPLE

SHOW NUMBER 1401

DAVID STRAPS ON THE SAFETY HARNESS TO GET THE LOWDOWN ON CAVES.

SEGMENT LENGTH: 8:00

Getting Started

http://www.mnonline.org/ktca/newtons

How can you "see" when the lights go out? Many animals in caves are blind because there is no light. How do they navigate? Set up your own "touch tunnel" to see if you can navigate a room obstacle course strictly by feel. Can your other senses help you find the way?

Have you ever been inside a cave? How deep was it? Could you see any light? What did it look like? What did it smell like? What did the walls feel like? Was there any life in the cave?

How do you think caves are formed? Do you think all caves are the same? How many different plants and animals do you think can live in caves? What are some differences between these plants and animals and those living outdoors?

Overview

Caves have long been regarded as places of mystery and intrigue. Prehistoric people used them for shelter and decorated them with some of the earliest-known works of art. Pirates used them to hide their ill-gotten booty. By definition, a cave is simply a natural open space found underground. Sometimes caves form when large rocks get stacked up after a landslide, but most often they're the result of the chemical **solution** of limestone by subsurface water.

In pure water, limestone is actually quite stable. However, when water gets a little acidic, the limestone dissolves. When water percolates through the soil, it picks up carbon dioxide from rotting plants. This forms carbonic **acid**, the same acid found in soda pop. As this acid water flows through the soil, it eats away at the underlying limestone rock and a cave is formed. Some larger caves are formed by sulfuric acid—the same acid found in battery acid. Sulfuric acid is created when the percolating water mixes with hydrogen sulfide from underground oil and gas and from acid rain.

Over time, small caves can grow to become elaborate systems of **caverns** containing large, needlelike structures that seem to grow down from the ceiling (**stalactites**) and up from the floor (**stalagmites**). These structures are formed by the slow, steady accumulation of calcium carbonate precipitating from the chemical-rich water dripping off the stones. Sometimes, these two "dripstones" meet, creating large **pillars** with spectacular colors.

Very few plants can grow in a cave because of the lack of light. Instead, fungi, algae, and even some simple mosses dominate caves. Insects, reptiles, and bats also are uniquely adapted to the cave environment. One of the most unusual cave dwellers is the "cave fish." Totally blind, this colorless creature navigates by touch, using tactile sensors on its body.

Sometimes, so much solution takes place inside a cave that the **caprock** can no longer support the weight of the surface above. The roof caves in and a feature known as a **sinkhole** forms. Each year, there are news stories about people returning home from work to find a large hole in the ground where their house once stood. By understanding the dynamics of what's happening inside a cave, scientists hope to minimize the risk of sinkholes in populated areas.

Connections

1. Since limestone dissolves in acidic water, how do you think increases in acid precipitation will affect the rate of sinkhole occurrences around the world? What can be done to offset this?
2. Areas of natural cave and sinkhole development are said to have **karst topography**. What special zoning and building codes have to be used in these areas to safeguard the structures?

Resources

Bush, L. (1994, Apr) Caving beneath the Tongass. *Bioscience*, pp. 215-218.

Coch, N. & Ludman, A. (1991) *Physical Geology* (2nd ed). New York: Macmillan Publishing Co.

Gurnee, R. (1980) *A Guide to American Caves*. Teaneck, NJ: Zephyrus Press.

Stone, W.C. (1995, Sept) Cave quest. *National Geographic*, pp. 78-93.

Reading Rainbow: *The Magic School Bus Inside the Earth*. GPN: (800) 228-4630.

U.S. Geological Survey 419 National Center Reston, VA 22092

The National Speleological Society operates "grottoes" (clubs) in many areas with caves: http://www.caves.org/~nss/nssabout/nssabout.html

The Potomac Speleological Club Web page: http://www.intr.net/dskouts/psc.htm

Newton's Apple video cassettes and educational materials provide further information about this and other topics. Call (612) 222-1717 or check out our Web site at: http://www.mnonline.org/ktca/newtons

NEWTON'S APPLE

SHOW NUMBER

1401

SPELUNKING

SOLUTION POLLUTION

SPELUNKING: Student Activity

Test the behavior of three samples in three chemical solutions.

Main Activity

http://www.mnonline.org/ktca/newtons

Many caves form because weakly acidic groundwater flows through cracks in limestone and slowly dissolves the rock. Caves form particularly well in areas where there is a resistant caprock like sandstone over the limestone below. In this activity, you will compare the solution rates of different minerals in liquids of differing pH to discover for yourself how some caves form. Note: It may take a week or longer to complete this activity.

Materials

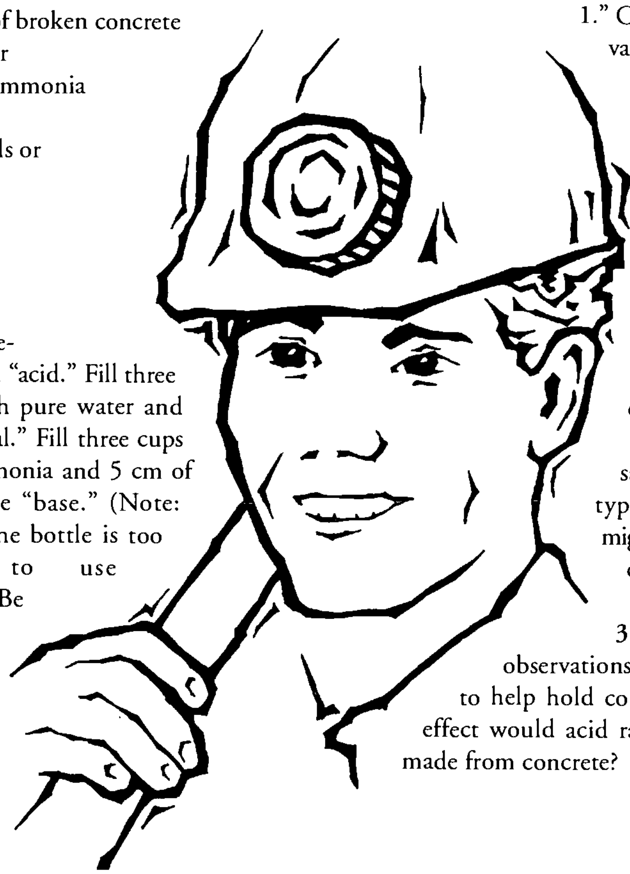
- 9 large disposable plastic cups (12 oz or larger)
- 3 pieces of chalk (limestone)
- 3 quartz pebbles
- 3 small pieces of broken concrete
- bottle of vinegar
- bottle of clear ammonia
- pure water
- 9 self-stick labels or masking tape
- marking pen
- pen and paper

1. Fill three cups half full with vinegar and label them "acid." Fill three cups half full with pure water and label them "neutral." Fill three cups with 1 cm of ammonia and 5 cm of water. Label these "base." (Note: Ammonia from the bottle is too concentrated to use without dilution. Be careful because even diluted, it can irritate skin and eyes.)

2. Examine and describe each of the rock samples in as much detail as possible. Set up a data sheet for each sample and record your first observations under the heading "time zero." Make sure to include things like color, texture, size, and shape.

3. Place one piece of chalk in a cup with vinegar, a second in a cup with water, and the last in a cup with ammonia. Add the word "chalk" to each label. Repeat the procedure with the concrete and quartz pebble so that each cup now has a rock sample in it.

4. Place all nine cups in a dark corner and observe them the next day. Record any changes you see for each sample under the heading "day 1." Continue to make observations for each day until a full week has passed.



Questions

1. Based on your observations, what can you say about the behavior of limestone in the three different chemical environments?

2. Did any of the other samples show the same type of behavior? How might these similarities and differences help to explain how caves are formed?

3. Based on your observations, what material is used to help hold concrete together? What effect would acid rain have on structures made from concrete?

Try This

Some of the best archaeological evidence comes from caves. Bones, pottery, and even food remains often are found in caves, some dating back more than 50,000 years. What aspects of a cave environment make it so good at preserving the past? Why were ancient hunters and gatherers drawn to caves?

Try This

Erosion by acid solutions is only one way that caves form. Other environments include empty lava tubes near volcanoes and ice caves in glaciers. What do these different cave types have in common? Use materials found around your home to model the development of different types of caves.

Try This

Write a story about what it would be like to live underground. How could you adapt to living in a cave environment? Where would you get your food? What about air and water sources? Is light critical to human life? How might you cope?

HUMAN EYE

How does the human eye see?

How does the eyeball work?

Getting Started

http://www.mnonline.org/ktca/newtons

You can draw your own simple stereogram. Draw two identical rectangles next to each other. Draw a small circle in the center of the one on the left. Draw an identical circle slightly to the left of center in the rectangle on the right. Hold the paper at arm's length or tape it to the wall and cross your eyes slightly so that the two squares exactly overlap. The circle will appear to float above the paper. See if you can construct more complex three-dimensional pictures.

How do your eyes work? Why do you have two of them and why are they placed where they are on your head?

Why do some people need glasses? Why do some people need them for distance and some need them for reading? How do optical illusions trick your eyes into seeing things you're not?

Overview

Look around. What do you see? Human beings can obtain a large amount of information about the surrounding environment through their sense of vision. But to see, we need light and the light-processing organs called eyeballs.

The outside of an eyeball is white, except for the clear, bulging **cornea** in front. Just behind the cornea is the **iris**, a colored area with a hole in the center called the **pupil**. Circular muscle tissue in the iris allows it to open and close the pupil to regulate the amount of light that gets inside the eyeball. Just behind the iris and pupil is the lens. The cornea and the lens work together to focus images on the **retina**, the light-sensitive layer that lines the inside of the eyeball.

Light moves in straight lines. Whenever a light ray encounters a surface of a different transparent medium, however, it bends (refracts) and heads off in another direction. The amount of bending depends on the nature of the transparent substance, the angle at which the light hits the surface, and the color of the light. On a curved surface such as a lens, parallel rays of light will hit the surface at different angles and will be bent differently. A greater curvature will lead to a greater difference in the amount of bending.

When your eye focuses on an object, all the light rays from a single point on that object are bent toward a single point on your retina. In the eyeball, light rays passing through the cornea are bent by its curvature toward the pupil. The lens flexes to change its curvature and finish the focusing process. Interestingly, the image projected on the retina is upside down because of the way the rays of light are bent by a double-convex lens.

On the retina are two kinds of cells that change light into nerve impulses. **Rod** cells do not see color but are best for night viewing because they react to very low light levels. **Cone** cells are for color viewing. They work best in good light and are found mostly in the center of the retina—an area called the macula, which provides the sharpest vision. Within each eye is a small blind spot with no rods or cones, where the optic nerve is attached to the eyeball. The **optic** nerve collects the nerve impulses and carries them to the brain, which interprets them as an image.

Connections

1. Many animals besides humans use vision. Are there any animals that do not have or use vision?
2. Two eyes are needed for "stereoscopic" or 3-D vision. Why do you think this is so? Do all animals that see have two eyes? Why are some animals' eyes on the side of the head rather than in the front?

NEWTON'S APPLE®

SHOW NUMBER 1401

SUCHIN TAKES A SNEAK PEEK AT HOW OUR EYEBALLS WORK.

SEGMENT LENGTH: 7:00

Resources

MINNAERT, M.G.J. (1993) *LIGHT AND COLOR IN THE OUTDOORS*. (TRANSLATED AND REVISED BY L. SEYMOUR.) NEW YORK: SPRINGER-VERLAG.

PARKER, S. (1989) *THE EYE AND SEEING*. IN THE *HUMAN BODY* SERIES. NEW YORK: FRANKLIN WATTS.

SIMON, H. (1983) *SIGHT AND SEEING: A WORLD OF LIGHT AND COLOR*. NEW YORK: PHILOMEL BOOKS.

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ALL ABOUT YOUR EYES:
http//www.ushc.com/health/3109.html

AN INDEX TO VISION SITES IS AVAILABLE AT "VISION SCIENCE":
http://vision.arc.nasa.gov/VisionScience/VisionScience.html

NEWTON'S APPLE VIDEO CASSETTES AND EDUCATIONAL MATERIALS PROVIDE FURTHER INFORMATION ABOUT THIS AND OTHER TOPICS. CALL (612) 222-1717 OR CHECK OUT OUR WEB SITE AT: http://www.mnonline.org/ktca/newtons

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NEWTON'S APPLE

SHOW NUMBER

1401

HUMAN EYE

IN AND OUT OF FOCUS

HUMAN EYE: Student Activity

Test different people to find out what makes an object look blurry in their eyes.

Main Activity

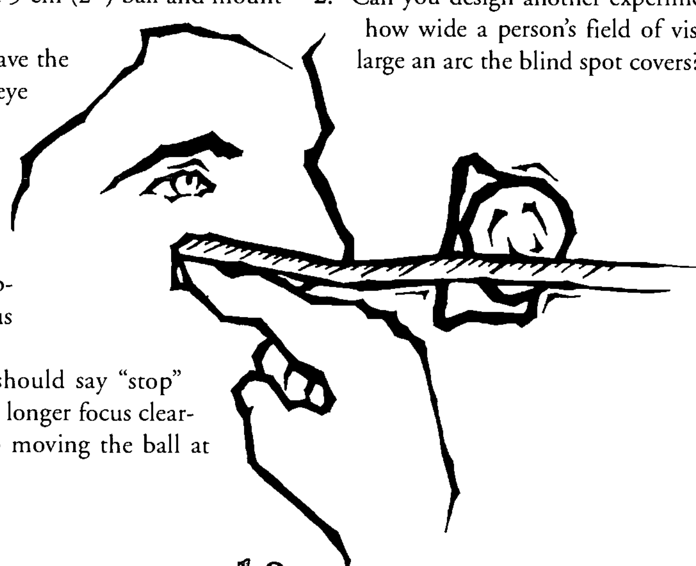
http://www.mnonline.org/ktca/newtons

As an object approaches, the human eye's lens flexes to focus on it. Eventually the object gets so close, however, that the lens can no longer focus on it. Then the object begins to blur. How close can you bring an object before it looks blurry? Does this distance vary for different people or age groups? Does the shape or color of the object make any difference? Does it matter how brightly the object is illuminated?

Materials

- a 2.5-cm x 5-cm (1″x 2″) swatch of printed words from a newspaper or magazine
- modeling clay or sculpting compound
- a 3″x 5″ index card
- a cloth or soft vinyl tape measure like those used in sewing (CAUTION: Do not use any sharp or pointed objects, including wooden or plastic rulers, since these materials will be held close to students' faces.)

1. Glue or paste the newspaper or magazine selection in the center of the 3″ x 5″ card.
2. Roll the clay into a 5-cm (2″) ball and mount the 3″ x 5″ card in it.
3. For the first test, have the test subject cover one eye with a hand.
4. Slowly bring the clay ball and words directly toward the test subject's uncovered eye. The test subject should try to focus on the words.
5. The test subject should say "stop" when she or he can no longer focus clearly on the words. Stop moving the ball at that point.
6. Have the test subject hold one end of the tape measure to her or his cheekbone just below the eye and measure the distance to the 3″x 5″ card. (NOTE: Having the test subjects measure the distances helps ensure that no eyes get poked.)
7. Write down the measurement. Be sure to include whether or not the test subject wears glasses or contact lenses.
8. Repeat the test several times, using different test subjects and testing different variables. For example, try the test with both eyes uncovered, with and without glasses, with different amounts of light, and so on. Just remember to change only one variable for each test and to repeat each test at least once. Average the results of repeated tests.



Questions

1. What is the average distance where the image begins to blur for all test subjects? Is the average distance larger or smaller for people who wear glasses? Is it larger or smaller for one eye or both eyes? Is the distance the same for both eyes of the same person?
2. Can you design another experiment that tests how wide a person's field of vision is? How large an arc the blind spot covers?

Try This

On a dark evening, go outside into your backyard 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 suppose that is?

Try This

Change the color scheme on a color television. Try different colors. Try black and white. Can you see as much detail on the black-and-white screen? (Ask your parents for permission to do this.)

Try This

One evening, stand in front of the mirror in the bathroom at home. Turn off the light for several minutes. When you turn it back on, observe the iris in your eye. How fast does it change shape to react to the light?

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.

3M Innovation

SHARKS

How do sharks find their prey?

If a shark sees you, will it bite? And if it bites, will it kill you?

Getting Started

http://www.mnonline.org/ktca/newtons

Do vibrations travel differently through different substances? Begin with a large, empty, plastic zip-lock bag. First, blow air into the bag and zip it shut. Place your ear on one side of the bag and have a helper make a noise or say something on the other side. Now fill the bag with water and try again. Does the sound travel differently in water than in air? How does this affect how ocean animals hear?

What animals do you think are dangerous to humans? Why? What are these animals' primary diets? Are humans included? Why would an animal attack a human? How are these animals important to the world environment?

How many different types of sharks can you name? What do they eat? How do they find their food? What do they all have in common? What makes them different from other ocean animals?

Overview

Unlike the ferocious star of *Jaws,* most sharks pose little danger to humans. The world's 370-plus species of sharks eat a variety of foods. Whale sharks gulp in water and filter it out through their gills, trapping tiny **plankton** for food. Cookie cutter sharks fasten onto prey, then twist and pull away flesh, leaving a hole like that made by a cookie cutter. Nurse sharks use thick lips to suck food from rocky crevices.

A keen sense of smell helps sharks find food. Through touch, hearing, and sight, they detect movement in the water. A special organ on the snouts of sharks, called the **ampullae of Lorenzini**, allows them to detect weak electrical voltages from living creatures or ocean currents.

Humans pose a greater danger to sharks than sharks do to humans. People kill about 100 million sharks each year, eating shark fin soup and shark meat, using shark oil cosmetics, wearing sharkskin boots and shark tooth jewelry, and using parts of the shark to make medicines.

Despite many differences, sharks have one thing in common—no bones! Most fish have bony skeletons, but sharks have skeletons made of **cartilage**. Also, throughout their lives, all sharks grow new teeth, with one set of teeth constantly growing in behind another. And instead of scales, sharks have a rough surface covered with **denticles** or skin-teeth.

Sharks come in many sizes. Whale sharks weigh up to about 13 metric tons (14 U.S. tons) and grow up to 18 meters (60 feet) long. The dwarf dog shark measures less than 20 centimeters (8 inches) long.

Some sharks lay eggs from which young sharks, called pups, hatch. Other species give birth to live pups. Pups fend for themselves from the first day, growing slowly to adult size over as long as 15 years.

Fossil records show that the earliest sharks lived nearly 400 million years ago. Despite their long history on earth, many mysteries about them remain.

Connections

1. The gray reef shark makes a "threat display" with specific posture and movements. How do other animals (including humans) use physical posture or gestures to show that they are threatened or about to attack?
2. What steps can be taken to minimize danger to sharks from humans?

NEWTON'S APPLE®

SHOW NUMBER 1402

DAVE SWIMS WITH THE SHARKS TO LEARN WHAT MAKES THEM UNIQUE.

SEGMENT LENGTH: 7:30

Resources

BULLOCK, D.K. (1991) *THE UNDERWATER NATURALIST*. NEW YORK: LYNN & BURFORD.

CONNIFF, R. (1993, MAY) FROM JAWS TO LAWS. *SMITHSONIAN*, PP. 32-43.

CURTSINGER, B. (1995, JAN) CLOSE ENCOUNTERS WITH THE GRAY REEF SHARK. *NATIONAL GEOGRAPHIC*, PP. 44-67.

MICHAEL, S.W. (1993) *REEF SHARKS AND RAYS OF THE WORLD*. MONTEREY, CA: SEA CHALLENGERS.

THE OCEAN PLANET. (1995, MAR) *POPULAR SCIENCE*, PP. 29-49.

PERRINE, D. (1995) *SHARKS*. STILLWATER, MN: VOYAGEUR PRESS.

SPRINGER, V.G. & GOLD, J.P. (1989) *SHARKS IN QUESTION*. WASHINGTON, DC: SMITHSONIAN INSTITUTION.

TAYLOR, L. (1993) *SHARKS OF HAWAII: THEIR BIOLOGY AND CULTURAL SIGNIFICANCE*. HONOLULU: UNIVERSITY OF HAWAII PRESS.

BEN S. ROESCH'S ULTIMATE SHARK PAGE: http://www.ncf.carleton.ca/%7Ebz050/HomePage/shark.html

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EDUCATIONAL MATERIALS DEVELOPED WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION.

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TAXONOMY

SHARKS: Student Activity

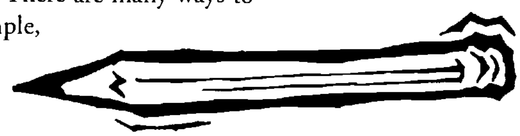
Try your skill at setting up a classification system for items in your room.

Main Activity

http://www.mnonline.org/ktca/newtons

Have you ever wondered how scientists classify animals? Why, for example, are some fish that lay eggs and some fish that give birth to live pups both classified as sharks? What is the common link between a 6″ shark and a 60′ shark?

The classification of living organisms into a system is called taxonomy. In this activity, you will try to establish a classification system for the world of your classroom. There are many ways to classify things. For example, sharks might be put in separate classes according to size, according to whether they are meat eaters and/or plant eaters, according to how they bear young, or according to where they live.



1. Working in groups of three or four, devise a system for classifying every object in your classroom. First, list all the objects that you will classify. Then decide on general categories and subcategories that make sense to your group.
2. Draw a chart showing the categories and subcategories that your group has chosen. List objects in the classroom in each category.
3. Each group should explain its classification system to the class. Display and compare the charts. Are there ways in which they are similar? How are they different?

Questions

1. How many different ways of classifying things did your class list?
2. What kinds of things were easier to classify?
3. Were there some things that were classified by one group but ignored by another?
4. What are the advantages and disadvantages of each system of classification?

Try This

How fast and how far do smells travel? Slice an onion at the front of the classroom. How far away can the onion be smelled? Wait 30 minutes. Now how far away can the onion be smelled? What has happened?

Try This

Make a model of a coral reef. Paint the inside of a large box blue and then cut and color cardboard, Styrofoam, or clay to resemble coral. Research accurate colors and shapes of fish and make them. Two-dimensional fish can be painted or three-dimensional models can be made from fabric or clay.

Try This

Fill one container with a liter (1 qt) of water and another container with a mixture of one liter of water and 30 grams (1 oz) of salt. Do objects float differently in the two containers?

BLACK PEARLS

How does the oyster make a pearl?

What do you know about pearls? How long do you think it takes to make one?

Getting Started

http://www.mnonline.org/ktca/newtons

What do you think the difference is between "natural" and "artificial"? Is a cultured pearl natural or artificial? Explain your reasoning.

Do you have any pearls? What do they feel like? What color are they? Where do they come from? Where are pearl molluscs found? How are pearls formed in nature and how are they made by humans? Is there some way humans can "help" nature make more beautiful pearls faster?

How do you think people discovered these beautiful things? Why are they so valuable?

Overview

For centuries, humans have treasured pearls. The lustrous play of light across the surfaces of good pearls is so attractive that people have paid fortunes for them, even though they have no human use except adornment.

Pearls actually come in many colors, sizes, and shapes, and are ranked in value according to these qualities. Perfectly round ones with a deep glowing luster, particularly in unusual colors that also show an iridescence (or **orient**), have always been the most prized and expensive; dull, irregular ones the least.

Pearls come from a group of water organisms called **pearl molluscs**, which includes oysters, mussels, and clams from both freshwater and saltwater. The pearl itself actually begins as an irritant. Sand, a pebble, or a pesky parasitic organism gets inside the oyster's shell. To reduce the irritation, the oyster coats the intruder with layers of a solid, slick material called **nacre**.

The oyster's **mantle** tissue secretes the two main components of nacre: thin layers of the mineral **aragonite** and a gluelike substance called **conchiolin**, which cements the layers together. Because the aragonite is translucent, light interacts with the overlapping layers to give the finished pearl its lustrous appearance. Pearl molluscs also coat the inside of their own shells with nacre, so some shells picked up at a seashore are shiny and iridescent inside.

Pearls used to be harvested by divers. However, it is a dangerous occupation and natural pearls of high quality are rare. People have now learned to farm pearl molluscs specifically to produce cultured pearls, small beads with layers of pearl material around them. Oyster larvae (called **spat**) are allowed to settle in sheltered locations underwater. Once they have attached themselves to ropes or rafts, the young oysters are grown for a few years. Then their shells are opened just wide enough to surgically insert a small pearl bead and a piece of mantle tissue from another mollusc into the soft tissue. This **nucleation** process provides the oyster with a spherical irritant to coat with nacre, increasing the likelihood of a symmetrical, round pearl. The farmer removes the cultured pearl from the oyster one to three years later. Cultured pearls, produced around the world, account for about 90 percent of all pearl sales.

Connections

1. Pearls are rated primarily for their beauty, based on the criteria of luster, color, shape, and size. What other objects around you do you rate in some way? How do you do it? What criteria do you use?
2. Why do you think people pay so much money for something as attractive but impractical as a pearl?

NEWTON'S APPLE

SHOW NUMBER 1402

SUCHIN GOES RIGHT TO THE SOURCE TO FIND OUT HOW PEARLS ARE FORMED.

SEGMENT LENGTH: 7:00

Resources

McClintock, J. (1994, May-June) Out of the oyster. *Sea Frontiers*, p. 18.

Mineral Gallery (choose aragonite from the list):
http://mineral.galleries.com/Minerals/by_name.htm

Gems and Gemology
University of Texas at Austin (many links to other gem pages):
http://www.lib.utexas.edu/Libs/GEO/GemBibl.html

Pearls and other organic gems:
http://geology.wisc.edu/~jill/Lecture17.html

What you should know about cultured pearls—from a jeweler's point of view:
http://www.jewelers.org/what/pearl/

Gemological Institute of America (GIA)
(800) 421-7250
(Ask for either the Library and Information Center or the bookstore. The bookstore has children's activity kits and books on pearls)

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3M Innovation

MOTHER OF PEARL

BLACK PEARLS: Student Activity

Examine the coating in an oyster shell to test the properties of nacre.

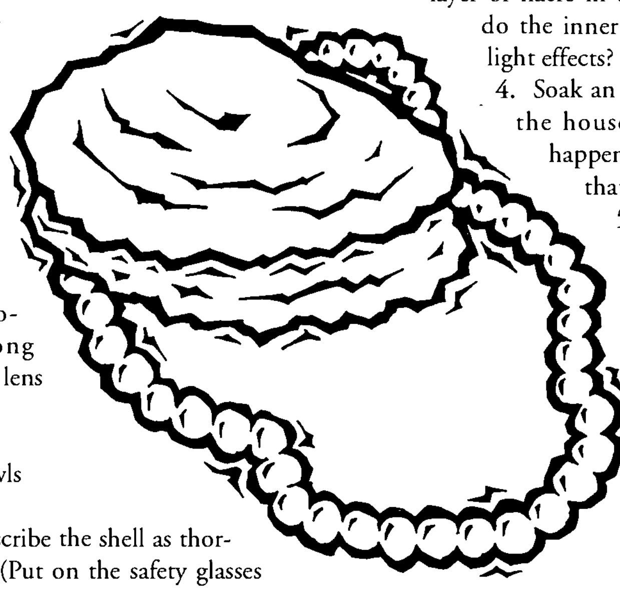
Main Activity

http://www.mnonline.org/ktca/newtons

Real pearls are too expensive to experiment on, but you can investigate their properties by studying oyster shells, which are coated with a layer of the same nacre, called mother-of-pearl.

Materials

- oyster shells, obtained from a fresh seafood store and scrubbed with a soft brush under water to remove the last bits of oyster (CAUTION: After handling raw seafood, always wash your hands thoroughly.)
- a piece of cloth or rag
- hammer
- sharp knife or chisel
- household liquids such as vinegar, lemon juice, ammonia, rubbing alcohol, and vegetable oil
- binocular dissecting microscope, or strong hand magnifying lens
- small flashlight
- safety glasses
- small cups or bowls



1. Observe and describe the shell as thoroughly as possible. (Put on the safety glasses and wrap the shell in cloth if you want to smash the shell with a hammer.) Put a shell chip (with nacre) under a magnifying lens or microscope and draw what you see. How many different characteristics can you notice? Do you need to make up new words to completely describe every characteristic?
2. Scratch the shell using your fingernail, a sharp knife or chisel, a stone, or the back of your pen. How hard and scratch-resistant is nacre? Which substances scratch the surface and which do not? Can you pry up the layers in thin sheets and then re-layer them?
3. How does light interact with nacre? Does the luster change depending on the angle at which a flashlight beam strikes the surface or how far away you hold the flashlight? Can you see any iridescence? If you chip or dissolve off the outer layer of nacre in the shell with vinegar, do the inner layers show different light effects?
4. Soak an oyster shell in each of the household liquids. What happens? Why do you think that happens?
5. Share your observations with other groups.

Questions

What other kinds of questions do you have about these shells? How could you investigate those questions?

Try This

Some freshwater clams (available in pet stores) do well in a simple aquarium with a light, filter, some gravel, and food. Make a home for a clam and take notes on its behavior. How and when does it move around? Can you determine how it eats and circulates water?

Try This

Place a layer of sand at the bottom of a partially full aquarium and bury various kinds of shells, stones, and other materials in it. With your eyes closed, can you tell the difference between the objects just by digging around in the sand with your hand?

Try This

Pearl is an example of "biomineralization," the process by which an organism makes hard materials from a combination of organic and inorganic compounds. Other examples include the formation of bones and teeth. Investigate these at the library. How do bone formation and teeth formation compare with pearl formation?

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.

3M Innovation

BODY FAT

Is all fat bad? What's the best way to lose fat?

What is fat? Why is it good for you? How does a fat cell function?

SHOW NUMBER 1403

DAVE INVESTIGATES WHY EVERYONE IS CONCERNED ABOUT DIETARY FAT.

SEGMENT LENGTH: 8:45

Getting Started

http://www.mnonline.org/ktca/newtons

Bring food labels to school representing as many of the five food groups as possible. Find the serving size and number of servings in each container or box. Since most fruits and vegetables do not come in containers, "guestimate" their size and check the serving size in a cookbook. Why is it important to know serving size? How does this information help in your daily menu planning?

Do you think you eat well? Why? Do you know anyone who has lost weight? How did they do it?

Do you pay attention to the nutritional value of the food you eat? Do you pay attention to how much fat is in your food? How does fat in your food relate to the fat in your body? Why is fat important to the human body? Why is too much fat bad?

Overview

To supply the calories our bodies need for energy, we must eat food. As food passes through our digestive systems, it is mechanically and chemically broken down into nutrients (amino acids, simple sugars, fatty acids, and monoglycerides) that our bodies use for growth, maintenance, and repair. When these simplified nutrients—especially the simple sugars and **fats**—reach the cells, they are metabolized as fuel. This releases heat, which is measured in calories.

With calories, the body works on a supply-and-demand system. If the daily calorie supply from food you've eaten meets the daily demand, all the calories from fats, **proteins**, and **carbohydrates** are converted to energy. If the daily supply exceeds the demand, the excess calories are stored in fat cells. These fat cells serve as energy warehouses for fat molecules, allowing your body to draw upon the stored fat when your demand for calories exceeds the daily supply from the food you consume.

Despite the recent negative publicity about fatty foods, we all need some fat in our diets. It's a good source of the calories we require to fuel our bodies and to keep us going when our energy demands suddenly increase. One gram of fat provides nine calories of energy, while one gram of protein or carbohydrate offers only four. Fat also gives texture and flavor to foods. It helps us feel full and satisfied after we eat. In addition, it protects our organs, aids in the development of cell membranes and hormones, and insulates our bodies.

However, we should eat fat sparingly—it should make up no more than 30 percent of our daily caloric intake. Excess fat in our bodies is linked to health problems such as hardening of the arteries and heart disease, to name just two.

Throughout a day, a month, a year, and even a lifetime, the body's supply of and demand for fat changes. Demand increases with activity and decreases in sedentary times. We can modify our caloric intake to meet these changing conditions. We can also manage the body's fat supply through exercise, which uses fat as fuel. So, to maintain a healthy balance in our bodies, we need to monitor our food intake and energy demands and add a daily dose of exercise.

Connections

1. What part do calories and exercise play in our daily lives?
2. What role does fat have in our diets? Where does it come from and go to?
3. Why do we gain or lose weight?
4. What would happen if we had no fat in our diets?
5. What diseases are associated with excess fat intake?

Resources

ARE YOU EATING RIGHT? (1992, OCT) *CONSUMER REPORTS*, PP. 644-655.

LAMBOURNE, M. (1992) *DOWN THE HATCH*. BROOKFIELD, CT: THE MILLBROOK PRESS, INC.

MUÑOZ, W. (1992) *NUTRITION: WHAT'S IN THE FOOD WE EAT?* NEW YORK: HOLIDAY HOUSE.

CHOOSE A DIET LOW IN FAT, SATURATED FAT, AND CHOLESTEROL: http://www.nalusda.gov/fnic/dga/dga95/lowfat.html

SURGEON GENERAL'S REPORT OF PHYSICAL ACTIVITY AND HEALTH. FOR A COPY, CALL (888) 232-4674, OR REQUEST A SUMMARY SHEET AT: http://www.cdc.gov

UNITED STATES DEPARTMENT OF AGRICULTURE NUTRIENT DATA LABORATORY 4700 RIVER RD RIVERDALE, MD 20737 (301) 734-8491 REQUEST HOME AND GARDEN BULLETIN #72: NUTRIENT VALUE OF FOOD.

COOPERATIVE EXTENSION SERVICE: FAT FACTS UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN: http://www.agen.ufl.edu/~foodsaf/il041.html

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NEWTON'S APPLE

SHOW NUMBER

1403

BODY FAT

CARRYING YOUR CALORIES

BODY FAT: Student Activity

Plan what you'd need to pack for a three-day hiking trip.

Main Activity

http://www.mnonline.org/ktca/newtons

Want to get away from it all? Go mountain hiking? Now's your opportunity. Plan a three-day backpacking trip to the Rocky Mountains in Colorado. Your trip will involve climbing, carrying, eating, cooking, and sleeping. All these activities will challenge your body's supply of and demand for calories. Plan what you'll pack for your trip as if your life depended on it.

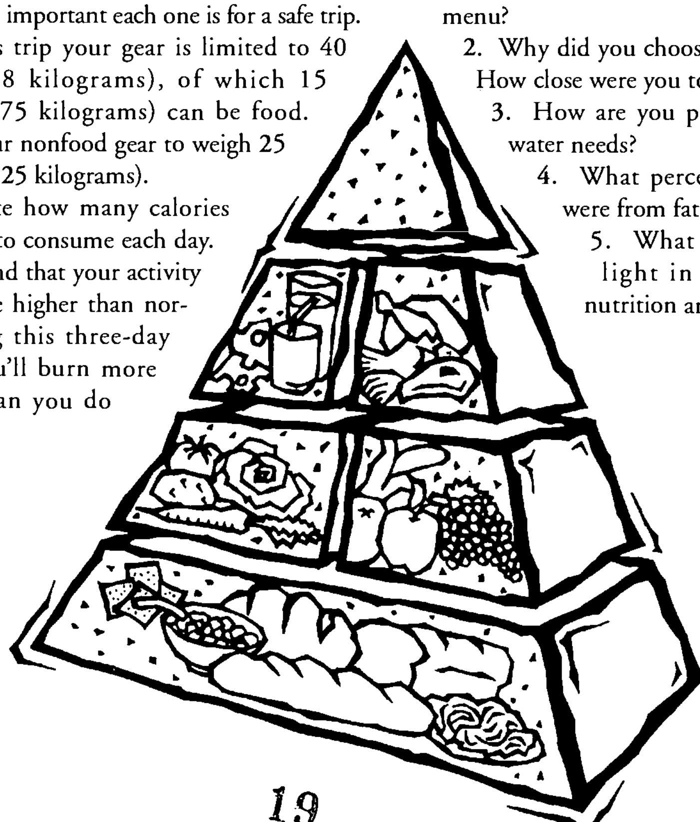
Materials

- scale
- food already in plastic bags
- metric conversion charts
- Food Guide Pyramid and servings chart

1. As a class, discuss what items you should include in your gear. Write these on the chalkboard. Discuss how important each one is for a safe trip.
2. For this trip your gear is limited to 40 pounds (18 kilograms), of which 15 pounds (6.75 kilograms) can be food. Plan for your nonfood gear to weigh 25 pounds (11.25 kilograms).
3. Estimate how many calories you'll need to consume each day. Keep in mind that your activity level will be higher than normal during this three-day hike so you'll burn more calories than you do normally.
4. Knowing your total calorie needs, figure how you can meet your daily nutritional needs in each of the five USDA food groups. What percentage of your total daily calories should come from each group?
5. Next, think of foods you can carry that will meet both your caloric and nutritional needs for three days, yet allow you to remain within your food weight limit. Discuss your food list with your classmates and your family.
6. Gather your food choices and weigh them. Add or subtract items as necessary, keeping in mind your daily food needs as well as water consumption needs.

Questions

1. What effect did vigorous activity have on your menu?
2. Why did you choose the foods you chose? How close were you to your weight limit?
3. How are you planning to meet your water needs?
4. What percentage of the calories were from fat?
5. What kinds of foods were light in weight but high in nutrition and calorie needs?



Try This

Go to your local grocery store and look for four or five products that have regular and light versions. An example would be yogurt. Read the labels of both the regular and light versions. How are they the same? How are they different? What ingredients are exchanged or lessened to get a light version? How do they compare in taste?

Try This

List all the things you usually order when you eat a meal at a fast-food restaurant. Do some research to find out what the calorie count is for each item. Add the total calories. If it exceeds 500 calories, what could you do to reduce the calories, but still eat the meal?

Try This

Fat is in almost everything you eat, especially those things that are on many people's "favorites" list, like pizza, doughnuts, and potato chips. Your challenge is to plan a lunch or dinner meal with no fat. Good luck!

RIVERBOATS

How does steam power big machinery?

Where does energy come from? Can you make energy?

Getting Started

http://www.mnonline.org/ktca/newtons

Fill a glass with ice and water. Place it in direct sunlight. Stir the mixture. Measure the temperature of the water and record it. Every five minutes, stir the mixture and measure the temperature again. Keep recording your results for 20 minutes after all of the ice has melted. Graph your results. What happened? How does your graph change after the ice melts?

What is energy? Name things you use in everyday life that need energy. How are these items powered? How do you think this power is made? What do you think is the best source of energy?

Do you think one form of energy can be converted into another? Give some examples. Make a list of the different kinds of energy and then what each kind can be converted to.

What happens to energy after you've "used" it? For instance, when you drive a car and then park it, where does the energy go? Have you exhausted the source? Does a parked car with a full tank of gas have energy?

Overview

We think of **energy** in many different ways. You need energy to go to school, play soccer, or carry groceries. People need energy to drive cars and cook food. But whatever you think of when you think of energy, it is really just the ability to do work.

Energy can change from one form to another. It can be stored (as potential **energy**) or it can be used in motion, heat, or electromagnetic radiation.

In a steam engine, fuel (such as oil, gas, coal, or wood) is burned to heat water. The unburned fuel has chemical potential energy. As it burns, the fuel's potential energy is released as thermal energy (heat). The thermal energy is absorbed by the liquid molecules in the heated water, exciting them enough so they can break away from the liquid pool. After breaking away, they shoot into the space above the liquid. When this happens, we say that the liquid has "vaporized," or **changed** its state, turning into steam.

The fast-moving **vapor** molecules can **hit** objects hard and often, causing a lot of **pressure** against whatever they hit. This pressure can be used to do work such as pushing on the blades of a **turbine**, or pushing on the base of a **piston**. The thermal energy has become mechanical energy, allowing the machine to do work.

One type of piston drives a steamboat. Steam pushes the piston one way. Then that steam is released and new steam enters the other side, pushing the piston in the other direction. The piston pushes a long arm, called a **pitman** arm, which turns the paddle wheel. The paddle wheel pushes against the water, moving the boat forward. The steam in the system is cooled, heated again, and reused.

Steam engines were the first engines. They changed the way we work. Since their invention, people have discovered other ways of converting energy and now steam engines are used less.

Connections

1. Many machines that used to be steam-powered now rely on other sources for energy. What examples can you think of? Why don't we use steam for those machines now?
2. Energy consumption (along with its side effects) and dwindling supplies of some energy sources are topics of concern today. How can we use available energy sources more efficiently?

NEWTON'S APPLE®

SHOW NUMBER 1403

BRIAN TAKES THE HELM TO LEARN WHAT MOVES A RIVERBOAT.

SEGMENT LENGTH: 7:15

Resources

Ardley, N. (1990) *Hands-on Science: Muscles to Machines.* New York: Gloucester Press.

Comstock, H.B. (1993) *An Illustrated Guide to Steam Locomotives.* Sykesville, MD: Greenberg Publishing.

Coy, P. (1993, Oct 18) A steam engine smaller than an ant's whisker. *Business Week,* p. 67.

Gardner, R. (1987) *Energy Projects for Young Scientists.* New York: F. Watts.

Peterson, R. (1995, June) Masters of invention: Men of power. *Boys' Life,* p. 20.

Rutland, J. & Nash, D. (1987) *The Age of Steam.* New York: Random House.

On-line renewable energy education module: http://solstice.crest.org

National Resource Energy Laboratory: http://www.nrel.gov

International Stationary Steam Engine Society
Box 311
Nescopeck, PA 18635
(717) 752-2279

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CHANGING MOTION

RIVERBOATS: Student Activity

Design a machine that turns the crank on a manual pencil sharpener.

Main Activity

http://www.mnonline.org/ktca/newtons

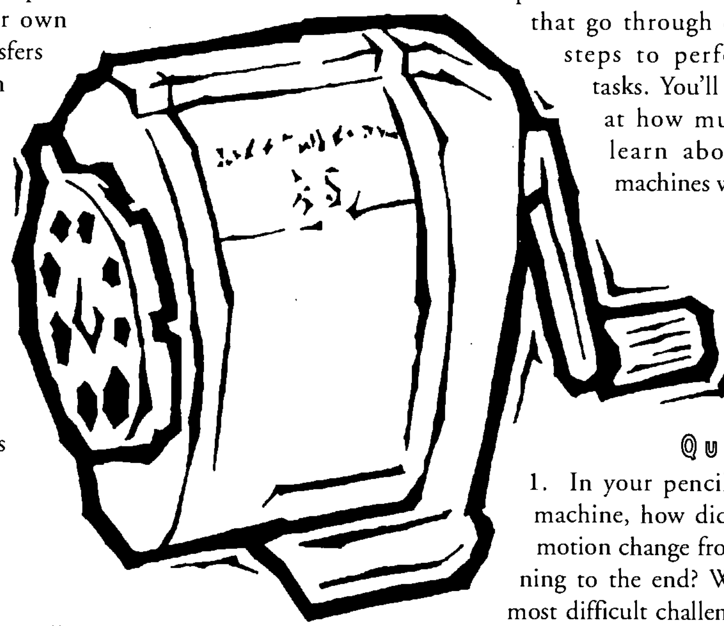
One big challenge engineers face when designing a machine is how to transfer one kind of motion to another. For instance, on a steamboat, the piston moves back and forth, but it drives a paddle wheel around in a circular motion.

First, think about what kinds of motion are needed to do different tasks. What kind of motion is needed to open and close a garage door? To turn the wheels on a car? To operate an elevator? Now, design your own machine that transfers one kind of motion to another.

Materials

(This is a partial list—use whatever you think will work to make this machine.)

- 3 mechanical pencil sharpeners
- meter sticks
- tape
- coathangers
- chairs



1. Break into three small groups. Your task is to design a machine that will operate a manual pencil sharpener. You can power your machine by tipping a chair back and forth but you can't use your hands to turn the pencil sharpener's crank. Your design also should include a way to keep the pencil in place while it is being sharpened.
2. Rube Goldberg was a cartoonist who invented fantastic machines (on paper) to do simple things. For instance, he might suggest that if you stepped on a cat's tail, the cat would jump up, knocking over a wastebasket, which would release a ball that would roll down a ramp, pushing down the lever on a toaster. People have taken up the challenge and actually built Rube Goldberg contraptions. Your pencil sharpener is the beginning of a Rube Goldberg contraption. Try to expand it or build other inventions that go through complicated steps to perform simple tasks. You'll be surprised at how much you can learn about the way machines work.

Questions

1. In your pencil-sharpening machine, how did the type of motion change from the beginning to the end? What was the most difficult challenge you faced when you actually put your machine together? How did you overcome the problems you encountered?
2. Which pencil-sharpening machine worked the best? Why? What conclusions can you draw from this experiment that might help you design a better machine in the future?

Try This

FILL A 2-LITER PLASTIC SODA BOTTLE ONE-QUARTER FULL OF HOT (NOT BOILING) WATER. SCREW THE CAP ON TIGHTLY. SUBMERGE THE BOTTLE IN ICE-COLD WATER. WATCH THE BOTTLE. WHAT HAPPENS? WHY? NOW SUBMERGE THE BOTTLE IN A BATH OF VERY WARM WATER. WHAT HAPPENS NOW? WHY?

Try This

FILL A SMALL BOTTLE (200 ML OR 3/4 CUP) THREE-QUARTERS FULL OF COOL WATER. STICK A DRINKING STRAW THROUGH THE TOP AND HOLD IT IN PLACE WITH MODELING CLAY. MAKE SURE NO AIR CAN GET OUT OF THE BOTTLE EXCEPT THROUGH THE STRAW. WARM UP THE BOTTLE WITH YOUR HANDS OR BY PLACING IT IN A TUB OF WARM WATER. WHAT HAPPENS? WHY?

Try This

FILL A MARGARINE TUB HALF FULL OF WATER. SNAP THE LID FIRMLY IN PLACE. PUT THE COVERED CONTAINER IN A MICROWAVE FOR ABOUT 3 MINUTES, UNTIL THE WATER BOILS. WHAT HAPPENED? WHY? USE HOT PADS TO TAKE IT OUT AND BE CAREFUL NOT TO GET BURNED!

EDUCATIONAL MATERIALS DEVELOPED WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION.
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HYPERCOASTER

How do you know a roller coaster is safe?

What makes a roller coaster ride exciting?

Getting Started

http://www.mnonline.org/ktca/newtons

Place a marble on a table and turn a round cake pan upside down over it. Move the cake pan around so you can hear the marble rolling around in a circle against the inside edges of the pan. When you have the marble traveling in a consistent circle, pick up the cake pan. Does the marble keep moving in a circle? Why?

Have you ever been on a roller coaster? How did it make you feel? Did you wonder how the car stayed on the track?

What is the highest roller coaster you've ever ridden? How big can a roller coaster be before it is unsafe? How do you think engineers figure out how to make a roller coaster safe?

Overview

Isaac Newton never had a chance to ride a **roller coaster**. The first one was built 75 years after his death. But the principles involved in roller coasters are right up Sir Isaac's alley.

Newton's laws of motion describe how forces determine the motion of objects. Designers rely on the **acceleration** caused by those forces to make a roller coaster ride both thrilling and safe. The trick is knowing how to use the forces properly. If the forces are too great in one direction, for instance, they'll throw the car off the track. If an upward force is too large (giving you a feeling of heaviness), your heart cannot pump enough blood to your head and you faint. On the other hand, the lack of supporting forces can create feelings of incredible lightness. This can provide an electrifying ride that delivers you safely to the end.

Hypercoasters are about twice as tall as regular roller coasters. This larger scale adds new design challenges. Going down a 200-foot hill, a car has more time to accelerate and gains more speed. If while going at this fast speed the car experiences a sudden change in direction or speed, the car's acceleration changes. A big or sudden change in speed or direction can make a bigger acceleration. Since the force acting on the car (and you) is equal to its mass times its acceleration, the bigger the change in direction or speed and the less time that change takes, the greater the acceleration and the bigger the force you'll feel.

To keep these forces at safe levels, the designer has to stretch out the time and the distance it takes to navigate the curve at the bottom of the hill. This spreads the change out over time, decreasing the force you feel. The top of the next hill has to be high enough to slow the coaster down, or stretched out to a gentler or banked curve, so the car doesn't fly off the track.

Space is a problem. Coasters go forward two feet for every foot they climb. If the highest hill is 100 feet, it takes about 200 horizontal feet to get the car that high. If the highest hill is 200 feet, it takes 400 feet. Since land is expensive, the designers have to be creative about the use of space. A track shaped into a curve takes up less space than one left in a straight line.

Connections

1. Creators of amusement park rides apply their knowledge of physics in their designs. What rides can you think of, and what principles of physics do they rely on?
2. Highway engineers use many of the same principles as roller coaster designers. How does road design affect the speed limit?

NEWTON'S APPLE

SHOW NUMBER 1404

DAVE TAKES A RIDE TO LEARN HOW HYPERCOASTERS ARE ENGINEERED.

SEGMENT LENGTH: 8:45

Resources

COLT, G. & RENTMEESTER, C. (1993, AUG) THE PHYSICS OF FEAR. *LIFE*, PP. 68-72.

FARRELL, K. (1993, OCT 22) HOLY BATMAN, THE RIDE. *SCIENCE WORLD*, P. 19.

SILVERSTEIN, H. (1996) *SCREAM MACHINES, ROLLER COASTERS—PAST, PRESENT, AND FUTURE*. NEW YORK: WALKER.

TIMNEY, M.C. (1996, JUNE) UPS AND DOWNS OF COASTER PHYSICS. *BOYS' LIFE*, P. 50.

ZUBROWSKI, B. (1985) *RACEWAYS—HAVING FUN WITH BALLS AND TRACKS*. NEW YORK: WILLIAM MORROW AND COMPANY.

SKYSCREAMER: http://www.rollercoaster.com/sfh/sky.html

WORLD OF COASTERS: http://www.rollercoaster.com/

3M LEARNING SOFTWARE: *WHAT'S THE SECRET?* (VOL 1). CD-ROM FOR MACINTOSH OR WINDOWS. (800) 219-9022.

AMERICAN COASTER ENTHUSIASTS
PO BOX 8226
CHICAGO, IL 60680
(410) 385-1222

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NEWTON'S APPLE

SHOW NUMBER
1404
HYPERCOASTER

THE WILDEST RIDE

HYPERCOASTER: Student Activity

Put physics to work by designing the ultimate in scary roller coaster rides.

Main Activity

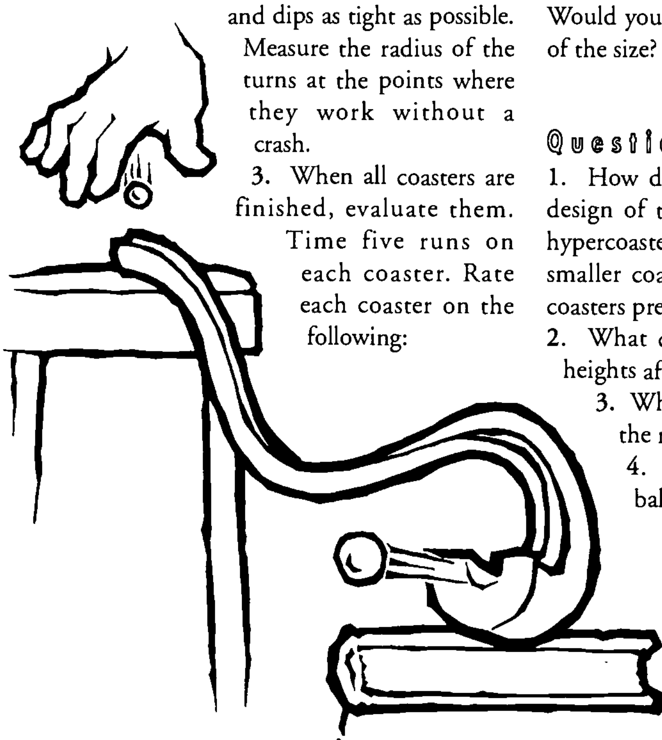
http://www.mnonline.org/ktca/newtons

Roller coaster design is a balance between a wild ride and safety. You try it.

Materials (for each group)

- 2 or more lengths of pipe insulation
- tape
- marbles (Be sure each team has one the same size and weight.)
- stopwatch
- steel ball
- scissors

1. Divide into groups.
2. Cut the pipe insulation in half lengthwise to make two long chutes. Using classroom furniture and materials as supports, each group should build a roller coaster. Use tape to hold the coaster in place. Start each ride at 1 meter (3.3′) high. Build the wildest ride you can that still delivers the marble to the end. Make the turns and dips as tight as possible. Measure the radius of the turns at the points where they work without a crash.
3. When all coasters are finished, evaluate them. Time five runs on each coaster. Rate each coaster on the following:



- Average speed (length of original "track" divided by time)
- Safety (Did it stay on the track?)
- Number of turns and hills (include loops)
- Originality

4. Test all the coaster tracks using a steel ball instead of a marble. Compare the times of the runs of this ball to the times for the marbles.
5. Work together as a class to design the "ultimate coaster" on the blackboard. Use the best qualities of each group coaster. Build and test your ultimate coaster. Decide what the best qualities for a ride are.
6. Build a hypercoaster. Start the first hill at 2 meters (6.6′). Make each hill twice as high as on your "ultimate coaster." Make the turns as tight as possible. Compare your hypercoaster to your ultimate coaster. Measure the radius of the turns at the point when they work without a crash. How do they compare between the two coasters? Evaluate the hypercoaster using the list of criteria. Would you change the design in any way because of the size?

Questions

1. How does the height of the ramp affect the design of the coaster ride? Would you design a hypercoaster using a different set of criteria than a smaller coaster? What new problems do hypercoasters present to the designers?
2. What constraints had to be set on the hill heights after the initial hill drop? Why?
3. What happened to the safe turn radius as the ride progressed downward? Why?
4. What effect did a heavier car (steel ball) have on the ride time?

Try This

Hold a marble against the side of a large mixing bowl or wok. If you let it go, will it roll all the way up the other side of the bowl? Will it fly out? Try it. What happened? What is affecting the way the marble behaves? Try it with different-sized marbles or other small balls. Are they any different?

Try This

Tie a nut to the end of a string and a toothpick to the string about 10 cm (4") above that. Put the nut and the toothpick in a clear, 2-liter plastic bottle so that the toothpick is horizontal and you can hold the bottle up by the string. Stand on a chair and let go of the string. Where is the nut during the fall? What happens when it hits?

Try This

Do this outside on a warm day. Put about 2 liters ($^1/_2$ gal) of water in a bucket. Swing it in a circle vertically so it goes from upright to upside down and back again. First try it as fast as you can and then slow down. What happens? Why?

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NICOTINE

Why is it so hard to quit smoking?

What is nicotine addiction? Can it be cured?

NEWTON'S APPLE®

SHOW NUMBER 1404

BRIAN DELVES INTO THE NATURE OF NICOTINE ADDICTION.

SEGMENT LENGTH: 8:40

Getting Started

http://www.mnonline.org/ktca/newtons

Calculate the price of the cigarette habit. Say, for example, a smoker "burns up" a pack a day: $________ (price per pack) x 365 days/year = $________ per year. What could you buy or use that money for that would not harm your health?

Why do you think people smoke? Do you think they know that it's bad for them? Do you think it would be easy to quit and that everyone should?

Why is smoking bad for you? Can you name other things that are unhealthy that people do anyway? Name some similarities between these things and smoking. If you had a friend or family member who smoked, what would you suggest to help that person quit?

Overview

Researchers continue to release shocking statistics about smoking. One estimate puts the total number of deaths due to smoking-related illnesses (such as cardiovascular illness, lung cancer, and emphysema) at 400,000 in 1990 alone, almost a quarter of the total deaths for that year. Smokers know that cigarettes are unhealthy—even cigarette packages display dire health warnings—yet many still have difficulty quitting. Part of the reason for that became official in 1988, when the U.S. Surgeon General announced that **nicotine**, a chemical found in virtually all tobacco products, was an addictive drug.

When someone smokes a cigarette, nicotine molecules are inhaled into the lungs. From there they are absorbed into the bloodstream. About 10 seconds later, the nicotine reaches the brain, where it locks onto specific **receptor** areas. When that happens, a chemical called **dopamine** is released into the brain, which causes the smoker to experience pleasurable, positive feelings. People who smoke have difficulty quitting because they come to depend on the good feeling they get from nicotine and want to experience it repeatedly. This dependence is a sign of **addiction**.

Nicotine is both physically and psychologically addictive. Physical addiction is biochemical. A person who tries to quit smoking experiences **withdrawal** symptoms such as depression because the brain expects nicotine and becomes physically distressed without it. Smokers also tend to associate cigarettes with other pleasurable activities such as relaxing with friends or reading the newspaper at breakfast. This psychological addiction is hard to break because the smoker resists changing these daily routines.

Ironically, tobacco-related illnesses are not directly linked to nicotine itself, but result from exposure to the several hundred other chemical substances inhaled in tobacco smoke or absorbed from chewing tobacco or snuff. Some of these chemicals come directly from the tobacco plant, while some are produced in chemical reactions as the cigarette burns. Because nicotine in small doses is probably not too harmful, doctors sometimes administer nicotine alone, usually in the form of gum or a skin patch. This nicotine **replacement therapy** helps reduce the physical craving for nicotine, so the smoker can more easily quit smoking.

Connections

1. There is a urine test that can determine if a person has been smoking. Because smoking is illegal for individuals under 21 years of age, someone has proposed that anyone under 21 who fails this test should lose or be denied a driver's license. What do you think of this proposal?
2. Nicotine may have some medicinal value in addition to its addictive properties. What do you think is the best way for society to handle a drug that can be both good and bad for people?

Resources

BARTECCHI, C.E., MACKENZIE, T.D., & SCHRIER, R.W. (1995, MAY) THE GLOBAL TOBACCO EPIDEMIC. *SCIENTIFIC AMERICAN*. PP. 44-51.

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SWISHER, K.L. (ED.) (1995) AT ISSUE: SMOKING. IN THE *OPPOSING VIEWPOINTS* SERIES. SAN DIEGO: GREENHAVEN PRESS.

TOBIAS, A. (1991) *KIDS SAY: DON'T SMOKE*. NEW YORK: WORKMAN PUBLISHING. (REPRODUCES DOZENS OF ANTISMOKING POSTERS CREATED BY CHILDREN)

ACTION ON SMOKING AND HEALTH: http://ash.org/ash/links.html

SMOKING: FACTS AND TIPS FOR QUITTING: http://www.winternet.com/~terrym/quitsmoke.html

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NEWTON'S APPLE

SHOW NUMBER

1404

NICOTINE

CLEARING THE AIR

NICOTINE: Student Activity

Interview smokers and nonsmokers to compare their points of view.

Main Activity

http://www.mnonline.org/ktca/newtons

Smoking is a hotly debated topic. Many people express very strong views on the subject. What do smokers and nonsmokers have to say about smoking? Conduct some interviews to find out.

1. Find two smokers and two nonsmokers to interview. These might be family members, teachers, or friends.
2. Make a list of questions you want to ask, such as: Why did you start (or not start) smoking? When did you start smoking? Do you want to quit? How do you feel if you can't have a cigarette? Do you tell others they ought to quit or refuse to associate with smokers?
3. Take notes as you listen to the answers.
4. When you get back to your classroom, compare notes with the other students. Make bar graphs of some of your data. For example, you could record the number of people on the Y-axis and the age they started smoking on the X-axis.

Questions

1. Can you find some common themes? For example, do smokers seem to have started smoking at about the same age or for the same reasons?
2. When we have problems to solve in society, why is it important to listen to many different opinions? How might the information you obtained help establish better ways to deal with the smoking debate?

Try This

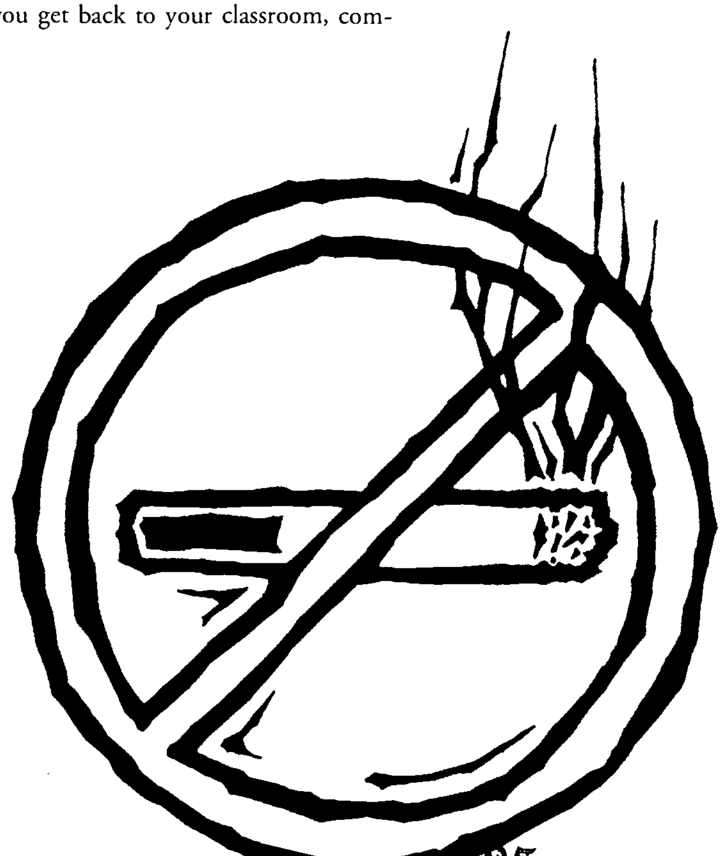
THE BLOODSTREAM CARRIES ALL SORTS OF CHEMICALS TO VARIOUS PARTS OF THE BODY. WHAT DOES BLOOD CONSIST OF? WHY IS IT SO GOOD AT CARRYING NICOTINE AS WELL AS OXYGEN AND CARBON DIOXIDE?

Try This

ACTIVISTS OFTEN COMPLAIN THAT CIGARETTE ADVERTISING TARGETS YOUNG PEOPLE. COLLECT SOME CIGARETTE ADS FROM MAGAZINES AND ANALYZE THEM. WHAT DO THE ADS SAY? WHAT DO THEY SEEM TO SUGGEST WITHOUT STATING OUTRIGHT?

Try This

MAKE A LIST OF HABITS YOU HAVE. WHICH ONES ARE GOOD FOR YOU? WHICH ONES ARE BAD FOR YOU? IF YOU HAVE A BAD HABIT LIKE CHEWING YOUR FINGERNAILS, WHAT STRATEGY COULD YOU USE TO QUIT?



AVALANCHE RESCUE

How do dogs find people buried in an avalanche?

Why do some animals have a better sense of smell than others?

Getting Started

http://www.mnonline.org/ktca/newtons

Put familiar substances with various odors into containers labeled with numbers. Herbs, spices, oils, and any other nontoxic substances that give off a distinctive odor will work. Smell each one. Write down what you think the odor is and how strong it is. Describe what each odor smells like (sweet, sour, like a flower or an old dishrag). Test your friends to see what smells they recognize. How good are you at identifying the substances? Does everyone describe odors the same way?

When an occupied building collapses, what is the first thing emergency crews do? How do they do it? What is the best way to find survivors in such a disaster? Would you use the same method if someone was buried under several feet of snow?

What kind of animal would be best for rescuing people who are lost or buried? What makes your choice ideal for such work?

Overview

Imagine you're skiing the deep snow of a mountain pass when you hear a low rumble. The snow beneath you suddenly gives way. In a terrifying instant you realize you've been caught in an avalanche.

A roaring sea of snow envelops you and you are buried under snow compacted as hard as concrete. Rescue must come fast. After only 30 minutes your chances of survival are 50 percent. If you are not equipped with an avalanche rescue beacon, your next best hope is a search-and-rescue (SAR) team working with avalanche rescue dogs.

How can a dog pick up your scent through densely packed snow, recognize the scent as the important one, and then hone in on it? Part of the answer is the dog's **olfactory system**, which is 10,000 to 10 million times more sensitive than a human's. Dogs have about 220 million scent cells, compared to about 5 million in humans.

Scent cells, or cilia, react to odor-carrying molecules that flow into noses. In dogs, these cells line the canine mucosa, a membrane at the rear of the snout which is folded so many times that, if smoothed out, it would be larger than the dog's body. When the hairlike cilia encounter an odor-carrying molecule, they trigger **nerve** cells that signal the dog's brain.

It takes three to six years to teach a dog to track a human scent, for the dog must learn to pick up and follow an individual scent it hasn't smelled before, and do it in rough terrain amid distractions. The task is made more difficult when the victim is buried under an avalanche and has left no scent trail.

Dogs can smell a buried person because our bodies constantly shed skin cells and give off odors in the form of gases. A person walking across the ground leaves these cells and odors in a scent trail the dog can follow. A person buried under snow leaves no such trail, but dogs use **air scenting** to smell the human odors, or gases, rising up through the snow.

A dog searches an area until it finds the spot where the odors are strongest, then alerts rescuers by barking or digging. For dogs, tracking and searching is just a game. For the buried victim, it's a matter of life and death.

Connections

1. Do all dogs have the same sense of smell, or do dogs with bigger noses smell better than those with little noses?
2. People have used dogs to find things for centuries, but scientists still don't completely understand why dogs are so good at using their noses. Why is this difficult to understand?

SHOW NUMBER 1405

EILEEN BUNDLES UP TO SEE HOW RESCUE DOGS FIND PEOPLE.

SEGMENT LENGTH: 8:00

Resources

BULANDA, S. (1994) *READY! A STEP-BY-STEP GUIDE FOR TRAINING THE SEARCH AND RESCUE DOG.* PORTLAND: DORAL PUBLISHING.

MCCLUNG, D. (1993) *THE AVALANCHE HANDBOOK.* SEATTLE: MOUNTAINEERS.

RING, E. (1991) *SEARCH AND RESCUE DOGS: EXPERT TRACKERS AND TRAILERS.* BROOKFIELD, CT: MILLBROOK PRESS.

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WHITTEMORE, H. (1995) *SO THAT OTHERS MAY LIVE: CAROLINE HEBARD AND HER SEARCH AND RESCUE DOGS.* NEW YORK: BANTAM BOOKS.

AVALANCHE RESCUE DOGS: http://weber.u.washington.edu/%7Edanc/avalanche.html

THE SEARCH AND RESCUE SOCIETY OF BRITISH COLUMBIA: http://www.sarbc.org/sarbc/sar-sar.html

CALIFORNIA RESCUE DOG ASSOCIATION: http://www.crc.ricoh.com/people/jamey/public/carda/carda.html

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SHOW NUMBER
1405
AVALANCHE RESCUE

CATCH A WHIFF OF THIS

AVALANCHE RESCUE: Student Activity

Smell different dilutions of vinegar to measure your odor sensitivity.

Main Activity

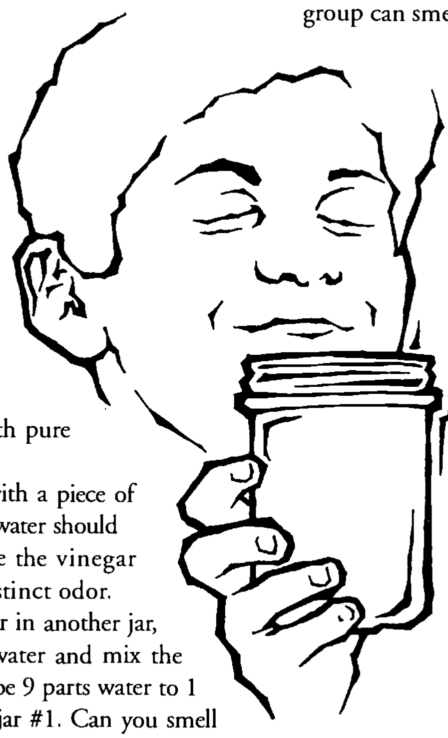
http://www.mnonline.org/ktca/newtons

Many people believe dogs are the top smellers of the animal kingdom, although that has never been proven. Scientists do know that dogs smell much better than most animals, including humans. Researchers have also found that some dogs can smell better than others, even if they are of the same breed.

How sensitive is your nose? Can you smell better than some other people? And how does your nose stack up against a dog's? To find out, try this smell sensitivity test.

Materials

- glass measuring cup like those used for cooking
- bottle of white vinegar
- distilled water
- several clean, medium-sized glass jars
- masking tape
- markers



1. Fill one glass jar with pure water and another with vinegar. Label the jars with a piece of tape and a marker. The water should not have an odor, while the vinegar will have its typical, distinct odor.
2. Put $\frac{1}{4}$ cup of vinegar in another jar, then add $2\frac{1}{4}$ cups of water and mix the solution. The ratio will be 9 parts water to 1 part vinegar. Label this jar #1. Can you smell the vinegar?
3. Pour $\frac{1}{4}$ cup of that 9:1 water/vinegar solution from jar #1 into a jar labeled #2. Add another $2\frac{1}{4}$ cups of water. You've just reduced the concentration of vinegar by an order of magnitude, making it ten times weaker. Can you still smell the vinegar?
4. Repeat step 3, this time pouring $\frac{1}{4}$ cup of the diluted solution from jar #2 into a jar labeled #3. Add $2\frac{1}{4}$ cups of water to jar #3 and mix. You've reduced the concentration of vinegar by another order of magnitude. Can you smell the vinegar?
5. Continue the process until no one in the group can smell the vinegar.

Questions

1. At what dilution could you no longer smell the vinegar? Dogs can smell the vinegar down to about 10 dilutions, six or seven orders of magnitude weaker than humans. Why?
2. Did anyone with a cold or allergies have a harder time smelling the vinegar? Why?
3. There are some odors that some people can't smell at all, a condition called human specific anosmia. Is there anyone in your group who can't smell vinegar at all?

Try This

MANY SEARCH-AND-RESCUE OPERATIONS DON'T INVOLVE DOGS. TALK TO LOCAL POLICE AND VOLUNTEER SEARCH ORGANIZATIONS ABOUT WHAT SKILLS PEOPLE MUST USE AND WHAT CLUES THEY LOOK FOR WHEN SEARCHING FOR SOMEONE.

Try This

INTERVIEW SEVERAL DOG TRAINERS OR POLICE K-9 OFFICERS AND FIND OUT WHAT BREEDS THEY THINK MAKE THE BEST SEARCH DOGS. ARE DIFFERENT BREEDS BETTER AT FINDING CERTAIN THINGS? WHAT FACTORS OTHER THAN SENSE OF SMELL DO DOG TRAINERS LOOK FOR?

Try This

BUY A SMALL, SOLID AIR FRESHENER AND HIDE IT IN A ROOM. WAIT ABOUT A HALF HOUR, THEN BRING A FEW FRIENDS IN AND ASK THEM TO FIND IT, USING ONLY THEIR NOSES. DOES ONE PERSON HAVE A BETTER SENSE OF SMELL THAN THE OTHERS? DO PEOPLE BECOME LESS SENSITIVE TO THE SMELL AS TIME PASSES?

PROSTHETIC LIMBS

How does a person control a prosthetic hand?

How does an artificial arm or leg work? What kinds of artificial limbs are there?

Getting Started

http://www.mnonline.org/ktca/newtons

Try to use a clothespin to substitute for fine motor hand functions like picking up coins or counting and moving sheets of paper. Could you unzip a zipper or tie a shoelace? Try using chopsticks. Both tools can be viewed as kinds of prostheses—not too different from the look of a prosthetic claw hand.

If you were born without your hands or lost them in an accident, how would you pick up things? If you lost a foot in an accident, how would you walk? What characteristics would the ideal artificial hand have—what would you need to be able to do with it to live normally? What about a foot?

What would your ideal prosthesis look like? How would it work? What kinds of prostheses do you think exist right now? Is it possible that you've seen someone with a prosthetic limb and haven't even noticed it? Why?

Overview

What would it be like to lose a hand, a foot, or even an entire arm or leg? Scary, that's for sure. How can **amputees** pick up things or walk or play soccer or write a letter? Although nothing is as good as the original flesh and bone, doctors can provide artificial replacements, called **prostheses**, for some damaged body parts. In addition to replacing lost functions, prostheses can result in cosmetic improvements for the patient and build self-confidence.

Simple prostheses like peg legs have been around for centuries. If they do not use sophisticated electronics, these artificial limbs are called static prostheses. One kind of artificial arm, for example, ends in a pair of hooks rather than a hand. The other end is attached to the remaining portion of the patient's arm, and then to a harness that straps over the shoulders. By moving the shoulder, the patient can pull on the harness, which in turn pulls on flexible cables to open and close the hooks, allowing the person to grasp objects. There is no sense of touch in this type of prosthesis, so the user has to watch closely what he or she is doing.

Dynamic prostheses, on the other hand, use sophisticated electronics. They can do this because the nerve and muscle systems in the human body are electrical. For example, an amputee with a **myoelectric** arm tenses his or her remaining arm muscle. Sensors detect this muscle electricity (myoelectricity) and transmit the signal to the artificial hand, powered by batteries, which then opens or closes.

Signals also can go from the environment to the patient, allowing an approximation of the sense of touch. For example, some prosthetic hands have sensors that can detect heat or cold and transmit that information to electrodes on the patient's skin.

Researchers are still improving prostheses. New materials allow artificial feet to press and spring on the ground very much like a real foot. One type of artificial foot transmits electronic information about pressure to amputees, allowing them to balance because they can tell whether their weight is on the toes, heels, or sides of the feet.

Connections

1. Artificial limbs are very expensive. What do you think would be the fairest way for everyone, rich or poor, to have access to the prostheses they need?
2. Make a list of some of the movies you have seen recently. Are there any amputees in them? How are they portrayed? Why do you think this is?

NEWTON'S APPLE®

SHOW NUMBER 1405

DAVE CHECKS OUT HOW NERVES AND MUSCLES MOVE PROSTHETIC LIMBS.

SEGMENT LENGTH: 6:45

Resources

ARTIFICIAL LIMBS: THEY LOOK AND WORK MORE LIKE THE REAL THING. (1995, NOV) *MAYO CLINIC HEALTH LETTER*, P. 6.

BUILDER OF HOPES. (1995, APR 17) *SPORTS ILLUSTRATED*, P. 5.

FIELD, R. (1993, OCT 15) TWO BIG STEPS FORWARD: WITH NEW PROSTHESES, THE PARALYZED WALK AND AMPUTEES WALK WITH FEELING. *MEDICAL WORLD NEWS*, P. 32.

KELLY, A. (1991, FEB-MAR) ADVANCEMENT IN PROSTHETICS: NEW MATERIALS, HIGH TECHNOLOGY, AND PERSONAL SERVICE BENEFIT PROSTHETIC PATIENTS. *INDEPENDENT LIVING*, P. 42.

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RIDLEY, K. (1994, OCT) ARTIFICIAL SENSATIONS. *TECHNOLOGY REVIEW*, P. 11.

ORTHOTICS AND PROSTHETICS ONLINE: http://www.oandp.com/index.htm

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NEWTON'S APPLE.

SHOW NUMBER
1405
PROSTHETIC LIMBS

MUSCLE MOTION

PROSTHETIC LIMBS: Student Activity

Work as a group to imitate the cooperative movements of your muscles.

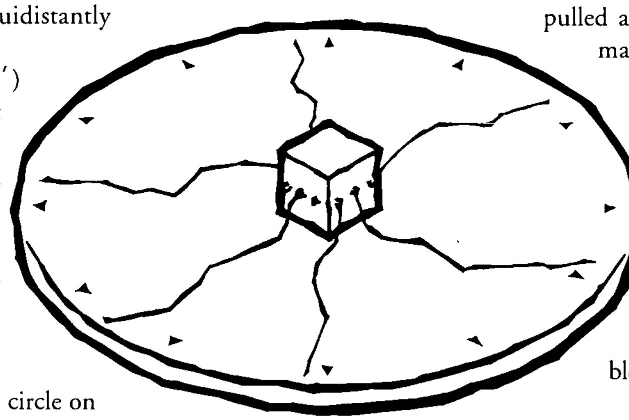
Main Activity

http://www.mnonline.org/ktca/newtons

Think of all the movements your hands make. These movements require sets of muscles that put opposing stress on the jointed bones in your fingers and palms. If one muscle in the set pulls harder, the hand opens. If another pulls harder, the hand closes. The muscles must work together to give you control over your movements. You can make a simple model of this process in your classroom.

Materials

- large, square block of wood with 12 hooks spaced equidistantly around the sides
- six 1.5-meter (5′) lengths of light rope or clothesline
- masking tape and a marker
- large round table
- clock faces drawn on paper for recording data



1. Mark off a large circle on a table with the masking tape (1.5 meters in diameter, maximum) and mark numbers on it from 1 to 12 to make a clock face.
2. Have six students sit around the table and place the block in the center of the circle.
3. Each time you want to add the ability to pull the block from a new direction, tie another length of rope onto a hook and hand the end to someone sitting around the circle. If you decide to use all six lengths of rope, you will end up with what looks like a wheel with spokes, with the block at the center.
4. Pass a clock face paper to each observer, who will write the data and results on the clock face with lines and arrows.
5. Figure out how much combined tension from different directions it takes to perform more and more complicated movements of the block. (The ropes are models of individual muscles and the block is a model of a finger.) Try moving steadily in straight lines at first; then starting and stopping; then starting, stopping, and reversing direction; then moving in a half circle, a full circle, and so on. Each participant may only pull the rope toward her or him, or allow it to be pulled away, in order to help make the block move in a desired way. No fair extending arms, grabbing anyone else's rope, starting a tug-of-war, or interfering with the block's movement. Work together to make the block move.

Questions

1. What is the fewest number of ropes required to make the block start *and* stop quickly and reliably?
2. Can you make the block travel in a circular arc with only two ropes attached to it?
3. What is the fewest number of ropes required to make a complete circle around the numbers on the clock?
4. When moving the block in a complete circle, who must pull the hardest on his or her rope and when?

Try This

Ask a prosthetist to come by and show several different types of prostheses—lower extremity, upper extremity, etc.

Try This

A thermometer is a sensor. Your eyes and skin are highly sophisticated sensors. How many other sensors can you list, both natural and invented?

Try This

Marionettes are related to prostheses, since you work their hands and feet from a distance. Construct a simple marionette out of paper, string, and paper fasteners. How easy is it to make working arms and legs?

Educational materials developed with the National Science Teachers Association.
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NEWTON'S APPLE

INCA ENGINEERING

How did the Incas build without mortar or wheels?

How would you move a huge stone up a mountain without animals or machines?

SHOW NUMBER 1406

DAVID GOES TO PERU TO DISCOVER THE ANCIENT INCAS' BUILDING SECRETS.

SEGMENT LENGTH: 8:15

Getting Started

http://www.mnonline.org/ktca/newtons

Have you ever tried to build miniature stone buildings with the rocks in your yard? How did you keep the rocks from tumbling down? What characteristics were important when you chose which rocks to use?

Imagine having to build a full-size building without using materials such as mortar or pre-cut stones or any machines like cranes or saws. What if you couldn't move the stones on vehicles with wheels? What would you use to move large stones?

Overview

About 90 years after Spaniards conquered the Inca Empire, Shakespeare wrote that "our life ... finds books in the running brooks and sermons in stones." Stone structures, road systems, agricultural terraces, and irrigation systems built in 1450–1540 A.D. by Incan engineers speak eloquently of a highly developed culture. Without machines, metal tools, or wheels, the Incas built structures that harmonize with natural outcroppings of stones found on the mountain tops. The precisely carved, carefully fitted stones required no mortar, yet have withstood 500 years of weather and earthquakes.

The Incas used simple, labor-intensive technology to help carve and move the stones harvested from nearby rockfalls. Many weighed more than 100 metric tons. **Stonemasons** shaped the blocks using a simple, effective method called **flaking** and a neolithic tool called a **hammer stone**. Made of granite, quartzite, or olivine basalt, hammer stones have a hardness of at least 5.5 on the **Mohs scale**, about the same hardness as the larger stones. Striking at a 15- to 20-degree angle, stonemasons could chip off pieces of the rock; alterations in the angle and force of the blow determined the size of the chips. Twenty quarry workers took about two weeks to **dress** four sides of one stone measuring 4.5 by 3.2 by 1.7 meters (14.8 by 10.5 by 5.6 feet).

Inclined planes, rope fashioned from the **four-croya andina** plant, and gravity helped transportation crews move the stones. They moved the massive blocks across several kilometers of valley, through a shallow river, and up the mountain face to 2,400 meters (7,875 feet) above sea level, where their buildings still stand. In his account, Garcilaso de la Vega reported that "they moved them, dragging them with muscle power using thick ropes; nor were the roads along which they hauled them level, but very rough mountains with steep slopes over which they were moved up and down with sheer human strength."

Excellent organization and management were required to accomplish this. Labor rather than money served to pay taxes, so a large labor force was seasonally available. Researchers estimate that 1,800 laborers were required to drag one 100-metric-ton block. This is equivalent to each laborer pulling approximately 54 kilograms (120 pounds). Evidence on or near the ramps suggests that the Incas may have used wet clay or gravel to reduce **friction**, which could have decreased the number of laborers needed to pull each stone.

Incan engineers worked with their environment, economy, and people to fashion "sermons in stones" that have withstood centuries. Today's challenge is to withstand the thousands of visitors that come to marvel at their accomplishments.

Connections

1. Why would you spend several months moving lots of hundred-ton stones up a mountain, and how would you convince several thousand friends to help?
2. Describe similarities and differences between Incan and Egyptian structures. What can you conclude about these cultures' concepts of science and engineering?

Resources

BAQUEDANO, E. (1993) *AZTEC, INCA AND MAYA*. NEW YORK: ALFRED A. KNOPF.

MOSELY, M. (1992) *THE INCAS AND THEIR ANCESTORS*. LONDON: THAMES & HUDSON.

PETERS, D. (1991) *THE INCAS*. NEW YORK: RANDOM HOUSE.

PROTZEN, J. (1993) *INCA ARCHITECTURE AND CONSTRUCTION AT OLLANTAYTAMBO*. NEW YORK: OXFORD UNIVERSITY PRESS.

LEARN MORE ABOUT THE INCAS:
http://www.webwise.com/incatour/learn.htm

LINKS TO ANTHROPOLOGICAL SITES:
http://www.unm.edu/~anthro/links.html

LORDS OF THE EARTH: MAYA/AZTEC/INCA EXCHANGE:
http://www.realtime.net/maya/

MAYAQUEST HOME PAGE:
http://www.mecc.com/mayaquest.html

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EASY SLIDER

INCA ENGINEERING: Student Activity

Test different methods for reducing friction.

Main Activity

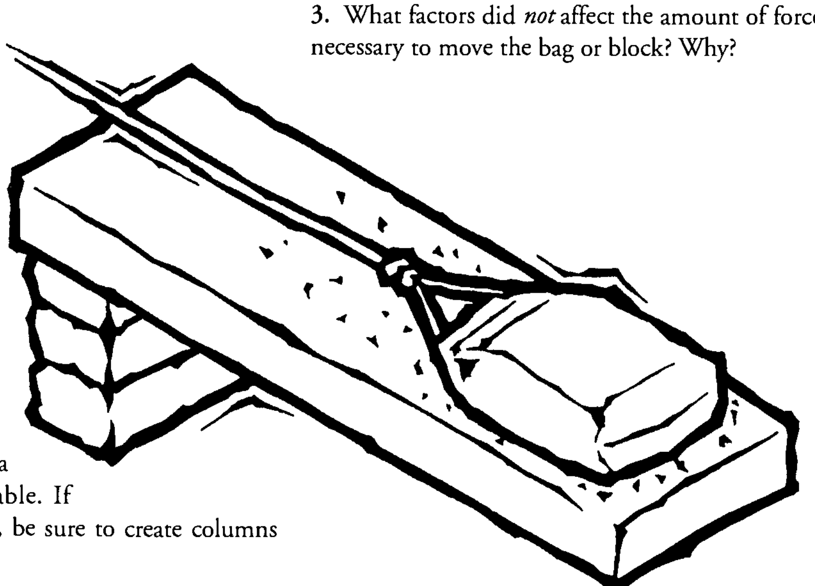
http://www.mnonline.org/ktca/newtons

The Incas realized that by using wet clay or gravel on their roads, they needed fewer people to move huge stones. Do differences in the surface really reduce the friction? What effect do rollers or skids have on friction? Predict which method will work best, then try all of them.

Materials

- one 10-lb bag of flour, wrapped in a plastic bag
- one 4′-long, two-by-six board
- 5 bricks
- gravel
- fine sand
- mud
- spring scale
- four 8″ dowels, 1/2″ in diameter
- four 8″ dowels, 1″ in diameter
- two 4″ dowels, 1/2″ in diameter
- two 4″ dowels, 1″ in diameter
- paper
- pencils
- concrete block
- 2 pieces of twine, 2 meters each (6 1/2′)

1. Make a stack of bricks about 5 bricks tall.
2. Lean the board on the stack to create a ramp.
3. On paper, create a table to keep track of which variable you alter each time you move the bag down the inclined plane. Alter only one variable at a time. Include a column for each variable. If you try other variables, be sure to create columns for them. Include rows for predictions, observations, and conclusions about what happens on each ramp.
4. Decide who will record your predictions and observations, who will move the bag or block on the ramp, and who will time each run.
5. Tie a piece of twine around the bag of flour and attach the other end to the hook on the spring scale.
6. Release the bag down the board. Record the force it takes to first lower, then raise the bag at a constant speed. Try replacing the flour bag with the concrete block. Spread sand, gravel, or mud on the ramp, and then try using skids and dowels. Each time you change the variable, first lower, then raise the block or bag at *constant* speed, carefully measuring the force necessary to do so.



Questions

1. What conclusions can you draw about the best way to reduce friction?
2. What kinds of companies or professions might be interested in finding ways to reduce friction to move things?
3. What factors did *not* affect the amount of force necessary to move the bag or block? Why?

Try This

To navigate across rivers and through the rain forest, Incan engineers constructed several types of levees and bridges. Find pictures of different levees and bridges, and draw conclusions about why each is best suited for its environment. What materials are best for each kind of bridge?

Try This

Find pictures of the ruins of ancient empires in Mexico, Guatemala, Peru, England, Egypt, and Greece. Now choose your favorite and write about what your life would be like if you lived in that time.

Try This

Find your own hammer stone and try to change the shape of a rock. Use safety glasses and let the hammer stone fall on and bounce off the rock. Is that more or less effective than using force to hit the rock? What kind of progress do you make in five minutes? How long do you predict it would take to smooth the surface of the rock?

Educational materials developed with the National Science Teachers Association.
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3M Innovation

SKI JUMPING

How do ski jumpers go so far?

How do jumpers use physics to get the most out of their flight?

Getting Started

http://www.mnonline.org/ktca/newtons

How do the shapes of objects affect the flow of a fluid? Mix one quart of white Ivory dishwashing liquid with five drops of food coloring and place in a shallow baking pan. Try dragging different-shaped objects through the liquid and observe the flow patterns they create. The more swirls, the more turbulence and the less aerodynamic the shape. Based on this experiment, why do you think manufacturers don't make skis with square fronts?

Have you ever skied over a large bump and become airborne? Why do you think that happens? Do you watch the ski jumpers during the Winter Olympics? How far do the jumpers go before landing? Why do they hold their skis and their bodies a certain way?

Overview

There are few feats as breathtaking as a perfect ski jump. Hurtling down a snow-covered ramp at speeds in excess of 100 kilometers (60 miles) per hour, the skier literally dives off a cliff, soars through the air, and finally descends back to earth some 100 meters (328 feet) from takeoff.

To a novice, the steps in a ski jump look deceptively simple. In reality, each involves a complex balance of forces where only slight changes in equipment or body position can mean the difference between a gold medal and disaster.

Like a roller coaster, all the energy for a jump comes from **gravitational potential energy** acquired by going to the top of a hill—in this case, the **inrun**. Coming down the inrun, jumpers try to build up as much speed as possible while maintaining control. To minimize air resistance, they get in a low crouch, point their arms forward, and bend their heads slightly downward like a diver entering the water.

Halfway down the inrun, jumpers begin to reposition their bodies in preparation for leaping off. Near the end, where the inrun begins to curve upward, they raise their hips slightly while pressing the chest tight against the knees. This makes their legs act like a coiled spring storing additional energy for the takeoff. About three meters (10 feet) from the end of the inrun, jumpers begin their final adjustments before takeoff, bringing their arms perpendicular to the ground and rising up slightly.

The most important part of the jump occurs at takeoff. Within a tenth of a second, jumpers must combine two motions at once, leaping both forward and upward at the same time. The timing of the takeoff leap is what makes or breaks a jump. If jumpers spring before they reach the exact end of the **takeoff table**, their skis will point down, causing extra wind resistance which results in a short jump. If they spring too late, their skis are pointed too high, resulting in a serious loss of control.

In the air, jumpers become flying projectiles, using their bodies and skis like a giant **airfoil**. They lean forward, producing a positive **angle of attack** on the wind. Traditionally, jumpers always kept their skis straight in line with their bodies to lessen air resistance and reduce **drag**. In 1989, a jumper revolutionized jumping by holding his skis in a large V with the open end pointed forward. This positioning increases the surface area below the body, providing more lift toward the end of the flight. It extends the time in the air and the distance of the jump.

Connections

1. How is a ski jump like a roller coaster ride? How are the same forces used in different ways?
2. How do jumping skis act like the wings of an airplane? How would changing their shape affect the flight?

NEWTON'S APPLE

SHOW NUMBER 1407

BRIAN HITS THE SLOPES TO LEARN HOW SKI JUMPERS GO SO HIGH AND FAR.

SEGMENT LENGTH: 7:30

Resources

Botterill, S. (1994, Feb) V for victory. *Life*, p. 94.

Finkel, M. (1994, Jan) Leap of faith. *Skiing*, p. 26.

Friedman, J. (1994, Feb) This joint is jumping. *Skiing*, p. 22.

Roessing, W. (1995, Jan) Ramp champ. *Boys' Life*, p. 18.

Rosenberg, D. (1995, Jan 16) High-tech skiing. *Newsweek*, p. 63.

Ulmer, K. (1996, Feb) To air is human. *Skiing*, p. 70.

Wolff, A. (1994, Feb 7) Flight of the Finns. *Sports Illustrated*, p. 82.

Wolff, A. (1994, Feb 28) Jens Weissflog, ski jumper. *Sports Illustrated*, p. 55.

Giving jumpers a lift: http://www.oslo.sintef.no/gemini/1993-dec/11.html

Jump: The homepage dedicated to ski jumping: http://www.consport.ca/jump/

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NEWTON'S APPLE®

SHOW NUMBER

1407

SKI JUMPING

Try This

THE LIFT PRODUCED BY SKI JUMPERS IS AFFECTED BY THE ANGLE AT WHICH ONCOMING AIR HITS THEIR SKIS. POSITION A FLAT CARDBOARD EDGE IN FRONT OF THE FLOW OF AIR FROM A HAIR DRYER. TILT THE CARDBOARD PROGRESSIVELY HIGHER. WHICH ANGLE PRODUCES THE MOST LIFT? CAN THE ANGLE OF ATTACK EVER BE TOO STEEP?

Try This

TO DECREASE FRICTION, SKIERS USE WAXES ON THEIR SKIS. USING TWO BLOCKS OF WOOD, TEST DIFFERENT SUBSTANCES ON THEIR SURFACES TO SEE WHICH OFFERS THE LEAST RESISTANCE WHEN YOU SLIDE THE TWO BLOCKS PAST EACH OTHER. TRY OIL, WAX, AND ICE.

Try This

SKI JUMPERS ARE ALWAYS CHANGING THE POSITION OF THEIR BODIES DURING THE JUMP TO MINIMIZE AIR RESISTANCE. TO SEE HOW THIS WORKS FOR YOURSELF, GO FOR A BIKE RIDE AND FEEL THE WIND BLOW. HOW DO YOU HAVE TO RIDE TO GET THE LEAST RESISTANCE? WHAT SIMILARITIES AND DIFFERENCES ARE THERE BETWEEN BIKE RIDERS AND SKI JUMPERS?

LAUNCH CONTROL

SKI JUMPING: Student Activity

Vary the angle of a ramp and chart your flight path.

Main Activity

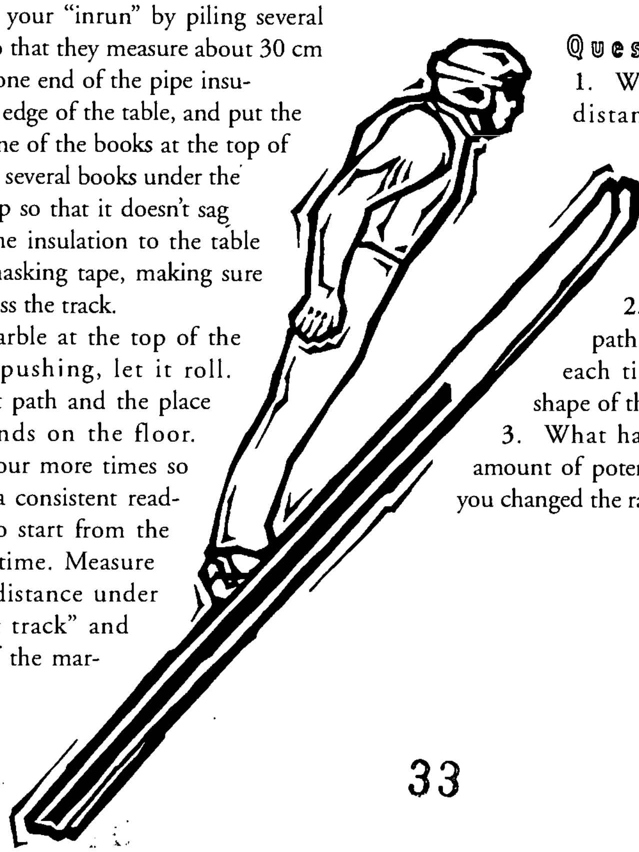
http://www.mnonline.org/ktca/newtons

Ski jumping converts gravitational potential energy to kinetic energy. The objective is to launch a human projectile as far as possible. By manipulating a track, you can discover how changing the launch angle will change the direction and duration of flight.

Materials

- 1 meter (3.3′) of Styrofoam pipe insulation, cut lengthwise
- marble or small steel ball
- 8 to 10 thick books or bricks or a chair
- masking tape
- tape measure
- table
- paper and pencil

1. Start building your "inrun" by piling several books on a table so that they measure about 30 cm (12″) high. Place one end of the pipe insulation right on the edge of the table, and put the other end under one of the books at the top of the stack. Build up several books under the middle of the ramp so that it doesn't sag or bend. Secure the insulation to the table and books with masking tape, making sure you don't tape across the track.
2. Place your marble at the top of the ramp. Without pushing, let it roll. Observe the flight path and the place where it first lands on the floor. Repeat this step four more times so that you can get a consistent reading. Remember to start from the same place each time. Measure and record this distance under the heading "flat track" and draw the shape of the marble's flight path.
3. Remove the books holding the middle of the ramp and adjust it so that it curves down to the table and runs flat along the table for about 20 cm (8″) before it reaches the end. Make sure that the end of the ramp still lines up exactly with the edge of the table and once again secure it with masking tape.
4. Using the same marble as before, test the ramp again. Remember to start from the same place. Record the distance under the heading "curved track" and again draw the flight path of the marble.
5. Repeat step 4 but this time add a book to the end of the ramp so that instead of lying flat on the table, the ramp curves down and back up a bit. Record your measurements under the heading "U-shaped/one book" and draw this flight path.



Questions

1. What happened to the distance traveled by the marble each time you changed the launch angle of the ramp? Why did this happen?
2. How did the flight path of the marble change each time you changed the shape of the track?
3. What happened to the total amount of potential energy each time you changed the ramp?

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3M Innovation

BEE STINGS

Why do bees sting?

How are bee societies organized? What actually happens when a bee stings you?

Getting Started

http://www.mnonline.org/ktca/newtons

Have you ever been stung by a bee? What were you doing at the time? Make a list of situations in which bees might sting. How can you avoid being stung by a bee? What should you do if you are stung by a bee? Do bees always die after they've stung someone?

If you were the bee "in charge" of a hive, how would you organize the society? What jobs would need to be done and how would you equip the different bees you've assigned to those jobs?

Overview

Ouch! A bee sting is a painfully memorable experience, but do you know what actually happens (to the bee and to you) when a bee stings? Not all bees have stingers—only those whose job it is to protect the hive. But there are other kinds of bees in a hive, whose jobs are as important as those of the stinging bees.

Bees belong to an ancient species that has continually adapted to the many challenges posed by the environment. As a result, a highly organized society has evolved. The development of a community lifestyle to ensure survival is but one example of the species' evolutionary adaptations.

The hive of the honeybee provides a delectable prize for many predators. Insects such as ants, wasps, and other bees are common intruders, as well as many mammals—bears, skunks, badgers, raccoons, opossums, humans, anteaters, and even mice. Through generations of evolution, the attack behavior of bees developed as a defense to certain stimuli that signal the hive is in danger from an intruder. The bee's stinger has a flexible design. It allows bees to defend themselves against less threatening insects and survive, but forces them to forfeit their lives when facing the bigger dangers posed by a mammal. This costly act of sacrifice activates an alarm system that calls other bees into battle and enables the colony to take advantage of strength in numbers.

Because the success of a beehive is dependent on collaborative efforts, bees have developed an extensive communication system, including the use of chemical odors known as **pheromones**. For example, when a bee stings, it releases one type of pheromone that alerts other bees to join the attack. Other pheromones are used to transmit different information, including membership in the colony, the location of a good food source or a new nesting site, or when to tend to the needs of the **queen**.

Rock paintings from 6000 B.C. provide evidence that humans have been collecting and eating honey for thousands of years. Throughout the centuries, people have developed a working relationship with bees based on an understanding of their remarkable behaviors. This information has allowed us to design adequate protection from bee stings and to identify what behaviors will stimulate an attack. Still, each year, more than 50 persons in the United States die of allergic reactions to bee stings. While a bee sting is not a pleasant occurrence, the very survival of our agricultural production is dependent on the busy bee's pollinating activities. Therefore, it is best that we accept the bee as a friend instead of a foe.

Connections

1. What are some myths about avoiding bees and treating stings? How do these myths compare with the information presented in the segment and through your discussions?
2. What are Africanized bees? Where in North America are Africanized bees now? What effects have they had on agriculture?

NEWTON'S APPLE®

SHOW NUMBER 1407

DAVID GETS A CLOSE LOOK AT A BEE HIVE WITHOUT GETTING STUNG.

SEGMENT LENGTH: 8:00

Resources

GRAHAM, J. (ED.) (1992) *THE HIVE AND THE HONEYBEE*. HAMILTON, IL: DADANT & SONS.

HAINES, J.W. (1993, APR) BEE-LIEVE IT OR NOT: YOU CAN TAKE THE STING OUT OF YOUR NEXT TRIP. *BACKPACKER*, P. 26.

KIRCHNER, W.H. & TOWNE, W.F. (1994, JUNE) THE SENSORY BASIS OF THE HONEYBEE'S DANCE LANGUAGE. *SCIENTIFIC AMERICAN*, P. 74.

MORSE, R. (1995, JUNE) INSECTS THAT STING. *CONSERVATIONIST*, P. 22.

WATANABE, M.E. (1994, AUG 26) POLLINATION WORRIES RISE AS HONEY BEES DECLINE. *SCIENCE*, P. 1170.

ZAHRADNIK, J. (1991) *BEES, WASPS AND ANTS*. LONDON: HAMLYN PUBLISHING GROUP.

BEEKEEPING HOME PAGE: http://weber.u.washington.edu/~jlks/bee.html

INTERNATIONAL BEE RESEARCH ASSOCIATION: http://www.cardiff.ac.us/ibra/index.html

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NEWTON'S APPLE

SHOW NUMBER **1407**

BEE STINGS

HONEY NUT

BEE STINGS: Student Activity

Follow scent clues to learn how bees communicate using pheromones.

Main Activity

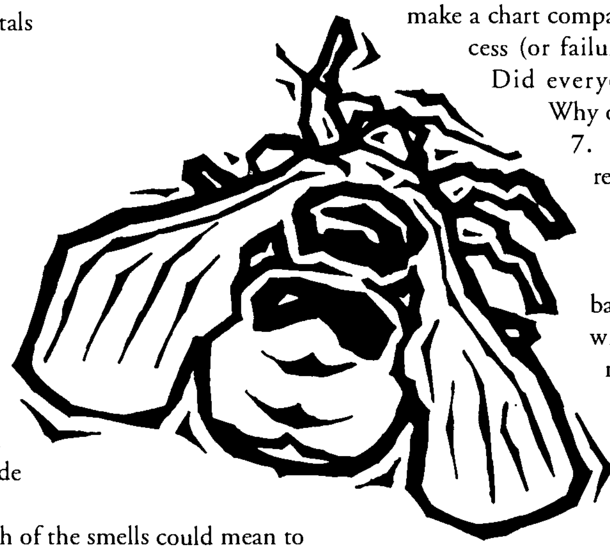
http://www.mnonline.org/ktca/newtons

Bees communicate with each other through pheromones, which are chemicals they emit in certain situations. For instance, when a bee stings, it releases a type of pheromone that tells the other bees there is a threat to the hive. This will make them sting, too. In this exercise, see if you can find your way through the maze to the honey just by smells. Because you are a bee, you will know what to do next just by the smell.

Materials

- blindfolds
- aromatic flower petals
- pinecone
- orange
- vinegar
- banana
- lemon
- jars for each smell
- honey samples

1. Make a maze in your classroom using desks, chairs, and moveable blackboards. Hide the honey inside one of the desks.
2. Discuss what each of the smells could mean to a bee. For instance, one could mean "Go right." Another could mean "Danger, go back!" or "The honey is here." Participants should take careful notes, or they won't be successful bees.
3. Place the jars along the maze route, where they would lead a bee to the honey.
4. Students should split up into teams of three or four. Each team represents a colony of bees. One bee is blindfolded and goes through the maze, using only the scent "cues" to find the honey. The other members of the colony should guide the bee so he or she doesn't get hurt in the maze, but only the scents can tell the bee where to go next. Record what happens with each bee.
5. Try moving the jars around and changing the maze so that a bee following the cues would not be able to find the honey.
6. Discuss the results of the honey hunt and make a chart comparing each colony's success (or failure) to find the honey. Did everyone find the honey? Why or why not?
7. Discuss some of the real scents that bees use to help them find food, sense danger, and find their way back to the hive. Discuss what these real scents mean to a bee.



Questions

1. Was it easy to find the honey using the scent cues? Why or why not?
2. Do humans use their sense of smell as a communication tool? What do some smells mean to you?

Try This

Invite a beekeeper from a local bee society to show the class a bee suit and smoker and possibly a sample hive. Or, visit a local apiary where you can watch bees and beekeepers in action.

Try This

Use straightened-out fishhooks and straight pins to mimic the difference between barbed and straight stingers. Use a piece of leather (or suede) to represent a mammalian predator's flesh and oranges, apples, and bananas to represent other insects. Try sticking these items with the two "stingers." How do the straight hook and the barbed hook compare?

Try This

Make a model of a bee using household or classroom materials. Choose any type of bee (drone, worker, or queen). Be sure to include all of the parts: the head, antennae, wings, thorax, legs, and abdomen. Which parts have special functions for the bee you chose?

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And watch Show 1411 to see finalists and winners from last year's contest.

For complete rules and prizes, write to us at:

America's Most Scientific Home Videos Contest
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TWIN CITIES PUBLIC TELEVISION
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SAINT PAUL MN 55101-9851

Key Concepts

NEWTON'S APPLE

AVALANCHE RESCUE

air scenting finding odors that are drifting through the air without having an odor trail to follow on the ground
cilia minute hairs that move when stimulated and trigger nerve impulses that send signals to the brain
nerve cell the cell that transmits electrical signals to the brain and other parts of the body; also called a neuron
olfactory system the combination of mucus, cilia, nerve cells, and other structures that allow animals, including humans, to smell odors
SAR the "search and rescue" acronym commonly used by rescue groups and a good search word on the Internet

BEE STINGS

apiary a group of human-made beehives placed together to make beekeeping easier
defensive zone the area around the hive
defensive behavior an aggressive action taken against any disturbance in the defensive zone
drones male bees, few in number, that mate with the queen bee
pheromone a chemical odor used for communication
queen the only female in the hive who can reproduce by laying eggs
worker bees female bees who perform most of the tasks; the majority of the bees in a colony

BLACK PEARLS

aragonite one mineral form of calcium carbonate, laid down in overlapping layers as the principal constituent of a pearl
conchiolin the organic, gluelike substance that cements the layers of aragonite together in a pearl
epithelial cells the outer layer of mantle cells in a pearl mollusc; they produce the aragonite and conchiolin necessary to make nacre
mantle the outer membrane of a mollusc, just inside the shell and covering the soft tissue
nacre the solid, shiny coating that a pearl mollusc secretes over the inside of its shell and any irritants or foreign objects
nucleation the process of infecting the pearl mollusc with an irritant to initiate the production of nacre for pearl culture
orient an iridescent sheen exhibited by some of the best pearls
pearl mollusc any shelled sea or freshwater creature that produces a nacreous coating on objects
spat newborn oyster larvae, which eventually attach themselves to an object

BODY FAT

calipers a tool that can be used to measure body fat
carbohydrates a food group that includes sugars, starches, and cellulose
fat adipose tissue; a group of storage cells that store fat molecules
enzymes substances that help speed up chemical changes; in digestive processes, these are called organic catalysts and are usually proteins
metabolic rate the rate at which our bodies use up energy, or "burn" calories
muscle a group of cells that work together to enable movement; they weigh more than an equal amount of fat cells
protein a nutrient used for growth and repair of our muscles and organs

BONES

calcium a mineral that is vital to bone development
growth plate a disk of cartilage along which bones extend their length or size
lacunae a small space, cavity, or depression; a hollow
mineral an essential element that helps keep our organs working smoothly
osteoblast a cell that builds or produces bone
osteoclast a cell that absorbs bone under certain conditions such as fractures
osteoporosis a thinning of bone that occurs with aging or inactivity
rickets a bone disease of infants or juveniles in which vitamin D deficiency causes skeletal deformities
vitamin D a vitamin needed for development of healthy bones and teeth

CLOCKS

atomic clock a very accurate clock that keeps time by measuring the natural oscillations of a cesium atom
horology the science of measuring time
obelisk an upright, four-sided pillar that tapers to a pyramid at its top
oscillate to swing back and forth; with electricity, to switch between a high and a low charge
quartz crystal when placed in an electric field, a quartz crystal vibrates and generates a regular electric signal that is a good resonator for running clocks and watches
spring-driven clocks a tightly wound spring provides the energy for these clocks, but they slow down as the spring unwinds
weight-driven clocks old mechanical clocks that used the pull of a heavy weight to provide energy to run the clock

DRINKING WATER

alum a colorless aluminum salt used as a flocculating agent in water treatment
filtration mechanically separating out particles from a liquid such as water
flocculant a chemical which causes tiny suspended particles to clump together into loosely packed flakes
ion a charged atom
microbe a microscopic organism such as a bacterium or a protozoan
osmosis the process where a solvent moves across a semipermeable membrane to an area of higher concentration
protozoan a microscopic organism such as an amoeba which is made of a single cell
sediment sand, silt, clay, and organic material that can be suspended in water and filtered out

ETHANOL

carbon dioxide a gas with molecules made up of one carbon atom and two oxygen atoms; part of the air that is released when living things respire
carbon monoxide a poisonous gas with molecules made up of one carbon atom and one oxygen atom
fossil fuel fuel derived from fossil matter of a previous geologic age, such as petroleum, natural gas, and coal
gasohol gasoline mixed with a smaller amount of ethanol, such as a mixture of 90 percent gasoline and 10 percent ethanol
methanol often called wood alcohol; formed from synthesis gas and by distillation of wood, coal, or farm wastes
photosynthesis process by which plants turn carbon dioxide and water into glucose, using the sun's energy to drive the reaction
volatile organic compounds (VOC) hydrocarbon compounds released by the incomplete combustion of gasoline and other fuels, which contribute to air pollution

GEMS

cabochon a gemstone that has been polished into a dome shape
carat a unit of measurement for weighing gemstones; 5,000 carats (cts) equal 1 kilogram
crystal a mineral that has a regular geometric internal structure, which is reflected in its external shape
gemstone a mineral that has a high market value because of its rarity, beauty, hardness, and durability
inclusion a small amount of gas, liquid, or mineral matter trapped in a gemstone when it was forming
lapidary a person who cuts, polishes, and sets gemstones
refraction the bending of light as it passes from one medium to another

HUMAN EYE

cornea the clear, curved portion of the eyeball directly over the iris and pupil
iris the colored portion of the eye that opens and closes the pupil in response to light intensity
lens the flexible, clear, lentil-shaped object just behind the pupil
optic nerve the nerve in the back of the eyeball that carries impulses from the retina to the brain for interpretation
pupil the hole in the center of the iris
retina the light-sensitive layer of the eye that registers the image entering through the pupil; the sharpest vision comes from the macula portion of the retina
rods and cones vision cells; rods see only black and white and are most useful for night vision; cones see only color and do best in good light
sclera the white, outer part of the eyeball

HYPERCOASTER

acceleration the rate of change in speed or direction
gravitation the force of attraction that every object in the universe has on every other object
hypercoaster a giant roller coaster twice as high as and 40 percent faster than most roller coasters
inertia the tendency of an object to resist changes in its motion—that is, to stay still or keep moving with constant speed unless some force acts on it
mass the amount of material an object contains
momentum mass of an object times its velocity
Isaac Newton the English mathematician and scientist who published three laws of motion in 1687
roller coaster a high-speed, elevated railway that has steep and sharply curving sections

INCA ENGINEERING

archaeologist scientist who studies artifacts, buildings, and other relics to learn about ancient cultures
dress to smooth or polish a stone or wood
flaking chipping small, usually broad pieces from the larger core block
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Mohs scale used to indicate relative hardness of minerals, ranging from 1 (talc) to 10 (diamond)
stonemason person who cuts and shapes stones

MALARIA TRACKING

Anopheles the genus of mosquito that includes species which transmit the parasite that causes malaria in humans
Geographic Information Systems (GIS) a computer informational system designed for storing, updating, analyzing, displaying, and manipulating spatial data in various ways
infrared a form of heat radiation similar to light
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rain forest a dense, evergreen forest occupying a tropical region with an annual rainfall of at least 2.5 meters (100 inches)
remote sensing techniques for acquiring information about an object without being in direct contact with that object, as through aerial cameras and satellites
satellite imaging tech-

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.

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carbohydrates a food group that includes sugars, starches, and cellulose
fat adipose tissue; a group of storage cells that store fat molecules
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microbe a microscopic organism such as a bacterium or a protozoan
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protozoan a microscopic organism such as an amoeba which is made of a single cell
sediment sand, silt, clay, and organic material that can be suspended in water and filtered out

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carbon monoxide a poisonous gas with molecules made up of one carbon atom and one oxygen atom
fossil fuel fuel derived from fossil matter of a previous geologic age, such as petroleum, natural gas, and coal
gasohol gasoline mixed with a smaller amount of ethanol, such as a mixture of 90 percent gasoline and 10 percent ethanol
methanol often called wood alcohol; formed from synthesis gas and by distillation of wood, coal, or farm wastes
photosynthesis process by which plants turn carbon dioxide and water into glucose, using the sun's energy to drive the reaction
volatile organic compounds (VOC) hydrocarbon compounds released by the incomplete combustion of gasoline and other fuels, which contribute to air pollution

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dress to smooth or polish a stone or wood
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remote sensing techniques for acquiring information about an object without being in direct contact with that object, as through aerial cameras and satellites
satellite imaging tech-

RAIN FOREST PLANTS

What's unique about plant life in the rain forest?

What are rain forests? Why are tropical forests important to everyone?

NEWTON'S APPLE®

SHOW NUMBER 1408

DAVID CLIMBS TO NEW HEIGHTS TO TALK TO RAIN FOREST EXPERTS.

SEGMENT LENGTH: 9:15

Getting Started

http://www.mnonline.org/ktca/newtons

Openings called stomata on plant leaves allow the leaves to receive carbon dioxide and give off oxygen. Where are stomata located? Coat the bottom of two leaves on a healthy plant with a heavy layer of petroleum jelly. Coat the tops of two other leaves. Let the rest of the leaves remain uncoated. Observe the leaves daily for a week. Is there any difference between them? Explain.

What makes a rain forest tropical? Why do more than half the world's plant and animal species live in rain forests? How do rain forest organisms depend on one another?

Overview

From the oxygen we breathe to the food we eat, we owe our lives to plants. Plant variety is essential to life, and rain forests shelter more than half of all plant and animal species on earth. Rain forests straddle the equator in a belt called the tropics. The tropics receive more direct sun than the rest of the earth. That means more solar energy for photosynthesis—the process plants use to make food. This supports more plants, which in turn support more animals in the food chain.

Rain forest plants compete with one another for scarce nutrients and for light and space to grow. Trees reach heights of 76 meters (250 feet). Many develop **buttresses**—roots that grow above ground from the trunk to create a wide, stable base for the tree. These are necessary due to the shallow depth of the roots. Shallow roots are present because there is fierce competition for nutrients among species at the surface of the soil. Leaves the size of dinner plates and high-climbing vines help some plants compete for light.

No species can exist without the help of others. Orchids and **bromeliads** can grow as **epiphytes**—plants that grow with their roots anchored to surfaces of other plants. Bromeliads use other plants for support while they collect rain and water runoff from the foliage above. The pool in a bromeliad's center can hold a host of life, from insect larvae to tadpoles, lizards, and more.

Indigenous people have always found many uses for the chemical substances that rain forest plants make to repel predators and diseases or to attract animals for pollination and seed dispersal. Chemists use these compounds as the basis of insect repellents, insecticides, flavorings, dyes, other industrial raw materials, and medicines. (The use of plants to help people is called **ethnobotany**.) Although some compounds are now reproduced synthetically, many others can be obtained only from the plants themselves.

At least one-fourth of all prescription drugs have their origin in the rain forest. No one knows how many plants with powerful uses are still hidden away among vast numbers of unknown species. The most valuable thing about rain forests may not be what we know about them, but what we don't yet know.

Connections

1. How are rain forests different from the forests in the area where you live?
2. How have plants in your area adapted to their surroundings?

Resources

AMAZON CENTER FOR ENVIRONMENTAL EDUCATION AND RESEARCH FOUNDATION
TEN ENVIRONS PARK
HELENA, AL 35080
(800) 255-8206
(BILINGUAL TEACHER MATERIALS AND "ADOPT A SCHOOL" INFORMATION)

AMAZON ADVENTURE: SEVENTH-GRADERS IN THE AMAZON. (1993, JAN 15) *SCHOLASTIC SCOPE.*, PP. 12-16.

LOFTY LESSONS OF THE RAIN FOREST: A TREETOP CLASSROOM IN THE AMAZON. (1993, MAR 23) *USA TODAY*, P.1.

A.C.E.E.R.: *AMAZON RAIN FOREST FLORA AND FAUNA.* SLIDE SET. (800) 255-8206.

A WALK IN THE RAINFOREST WITH DR. JIM DUKE. VIDEOTAPE (1994) TRADITIONAL USES OF MEDICINAL PLANTS. (800) 255-8206.

NATIONAL GARDENING ASSOCIATION
180 FLYNN AVE
BURLINGTON, VT 05401
(800) 538-7476
NGA@together.org
(RESOURCE BOOKS FOR CREATING MINI-ECOSYSTEMS)

NEWTON'S APPLE VIDEO CASSETTES AND EDUCATIONAL MATERIALS PROVIDE FURTHER INFORMATION ABOUT THIS AND OTHER TOPICS. CALL (612) 222-1717 OR CHECK OUT OUR WEB SITE AT: http://www.mnonline.org/ktca/newtons

OUR FEATURED CONTRIBUTOR IS INTERNATIONAL EXPEDITIONS, INC., SPONSOR OF RAINFOREST WORKSHOPS FOR EDUCATORS AND STUDENTS. FOR MORE INFORMATION CALL (800) 633-4734 OR E-MAIL intlexp@aol.com

EDUCATIONAL MATERIALS DEVELOPED WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION.
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NEWTON'S APPLE

SHOW NUMBER
1408
RAIN FOREST PLANTS

STANDING UP FOR TREES

RAIN FOREST PLANTS: Student Activity

Find out how tall rain forest trees manage to stand up in thin soils and high winds.

Main Activity

http://www.mnonline.org/ktca/newtons

Imagine life as an **emergent** rain forest tree. These trees grow very tall and often have many species living on them and in them. They need to stand up against high winds and soaking rains, yet they are anchored in a foundation of soil that's shallow and thin. How do they do it? Many grow buttressed roots. Buttresses come in different shapes, sizes, and thickness. Some are thin and flat. Others are twisted and branching. One scientist described a tree with such enormous buttresses and surface roots that it took a full five minutes to walk around it. Work in small groups to investigate how buttresses work.

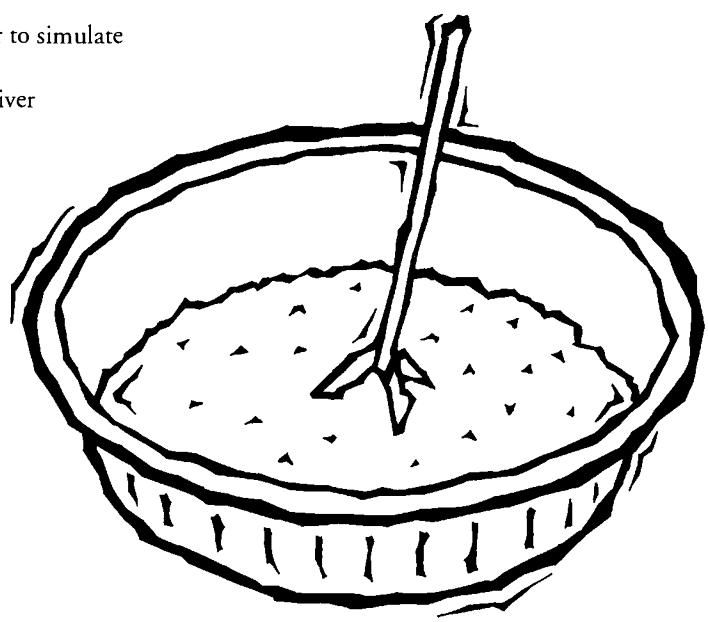
Materials (per group)

- several sections, 15 to 30 cm (6″ to 12″) long, cut from ends of tree branches
- shallow container such as a pie tin or deep paper plate, filled with 2.5 cm (1″) of sand
- cardboard, clay, small sticks, and other items to make buttresses
- tape
- fan or hair dryer to simulate wind
- water can to deliver rain

1. Place the branches upright in the sand to represent an emergent rain forest tree. What happens when your "tree" is subjected to winds and rains? Make predictions and put them to a test.
2. What adaptations can you create with available materials to help your tree withstand wind and rain in the shallow soil? Test out your designs.
3. Which adaptations were most successful? Why?

Questions

1. How have buttresses in nature been "adopted" in humanmade structures you have seen?
2. How do climate and physical environments in different parts of the country affect the structure of plants?



Try This

Slip a plastic bag over the leafy end of a branch. Pick one that is not exposed to full sunlight or wait for a partly cloudy day. Seal the open end of the bag tightly shut with a twist tie. After three hours, check it before removing it from the branch. Where did the moisture inside the bag come from?

Try This

Observe a variety of leaves for characteristics that may help the plants survive in particular environments. For example, how might leaf thickness, texture, shape, coating, or size help a plant survive?

Try This

Take an up-close look at two different mini-ecosystems or habitats near your school. Examples are a rotten log, a tree, a woodland park, or a square foot of yard. Identify and compare the living things and their interactions. Measure, describe, and compare physical factors such as moisture, light, and soil type.

Our featured contributor is International Expeditions, Inc., sponsor of Rainforest Workshops for Educators and Students. For more information call (800) 633-4734 or go to: http://www.infomedia.net/intlexp/ieworks.html

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.

3M Innovation

RAIN FOREST ANIMALS

How are animals in the rain forest unique?

In what ways are rain forests important to your survival?

Getting Started

http://www.mnonline.org/ktca/newtons

Create a book about animal species found only in the Amazon rain forest. Find one species to represent each letter of the alphabet, and write each name on a different piece of paper. Illustrate with your original drawings or cut out pictures of each species. Use the book to speak to classmates, friends, or other groups about why it's important to protect animals' habitat and what is happening to the rain forest animals and plants.

Why do you think rain forests exist where they do in the world? How do they affect the environment where you live? Why are they so important?

Overview

Imagine a vast, unexplored kingdom, inhabited by more than 30 million different species ranging in size from microscopic to gigantic. A land where cooperation is just as vital to survival as competition. A land untamed by humans. This is a rain forest.

Now travel along the 6,275 kilometers (3,900 miles) of the Amazon River. Two-thirds of the world's fresh water is found in the river and its 1,000 tributaries. Investigate territory covering more than 6 million square kilometers (2.3 million square miles) in Brazil, Peru, Ecuador, Bolivia, and Venezuela. You'll meet up to three-fourths of all known species of plants and animals—and thousands of unnamed species as well.

Survival here depends on a highly complex system of interdependence and **adaptation**. In the equatorial **ecosystem**, birds eat insects and plants. Snakes eat birds and frogs. Frogs eat insects and each other. Plants provide homes for insects and animals and depend on those animals to disperse their seeds.

Leaf cutter ants provide an excellent example of a **symbiotic** relationship. Leaf cutters are herbivores that can't digest **cellulose**. To survive, they collect plant leaves, cut or chew them, and "feed them" to the fungus in their enormous subterranean gardens. Fecal fluid from worker ants contains amino acids and enzymes that fertilize the fungus and break down the leaf proteins into smaller protein molecules that ants can digest.

Adaptation is another key factor in survival. Pink dolphins, about twice as large as the other species of river dolphins that inhabit the Amazon, are adapted to their environment in some interesting ways. The murky water has diminished their eyesight but sharpened their **echolocation** abilities, while the water's warmth has eliminated the need for body fat.

Superstition has also contributed to the pink dolphins' survival. Their unusual color (caused by blood flowing through capillaries beneath their translucent skin) has prompted locals to spin tales about them. Local lore has it that anyone who hunts or harms them can become ill or die, so everyone leaves them alone.

What external factors threaten survival? The number of people living in or near the rain forests is increasing. This puts many additional pressures on the ecosystem. Changes such as highway and dam construction, urbanization, commercial exploitation of animals, pollution, diseases, parasites, and the introduction of predators can all result in the destruction of habitat. Many experts believe that if current practices continue, the rain forests will soon be gone. And with them will go the millions of species that call the rain forest home.

Connections

1. Who and what is at risk if humans don't learn to protect rather than destroy rain forests? Why?
2. What can you do to help the rain forests survive?

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NEWTON'S APPLE

SHOW NUMBER 1408

DAVID AND DAVE SEARCH THE RAIN FOREST FOR UNUSUAL ANIMALS.

SEGMENT LENGTH: 14:00

Resources

INTERNATIONAL EXPEDITIONS
ONE ENVIRONS PARK
HELENA, AL 35080
(800) 633-4734
(RAIN FOREST WORKSHOPS AND EDUCATIONAL MATERIALS)

ADVENTURE IN THE AMAZON RAINFOREST. (JUNE 1993) *NATIONAL GEOGRAPHIC WORLD*. PP. 19-21.

ECOTOUR, HOLD THE ECO. (1995, MAY 29) *U.S. NEWS AND WORLD REPORT*, PP. 61-63.

GOODMAN, S. (1995) *BUGS, BATS, AND BIODIVERSITY*. NEW YORK: ATHENEUM BOOKS FOR YOUNG READERS, AN IMPRINT OF SIMON & SCHUSTER CHILDREN'S PUBLISHING DIVISION.

PINK DOLPHIN PAGE:
http://www.arrakis.com.au/~zan/pinkdolphin.html

SOUNDS OF LEAF CUTTING ANTS:
http://www.efn.org/~dharmika/

WORKSHOPS, BOOKS, SLIDES, VIDEOS: AMAZON CENTER FOR ENVIRONMENTAL EDUCATION AND RESEARCH:
http://www.infomedia.net/intexp/ieworks.html

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SHOW NUMBER

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RAIN FOREST ANIMALS

A FOREST OF LIFE!

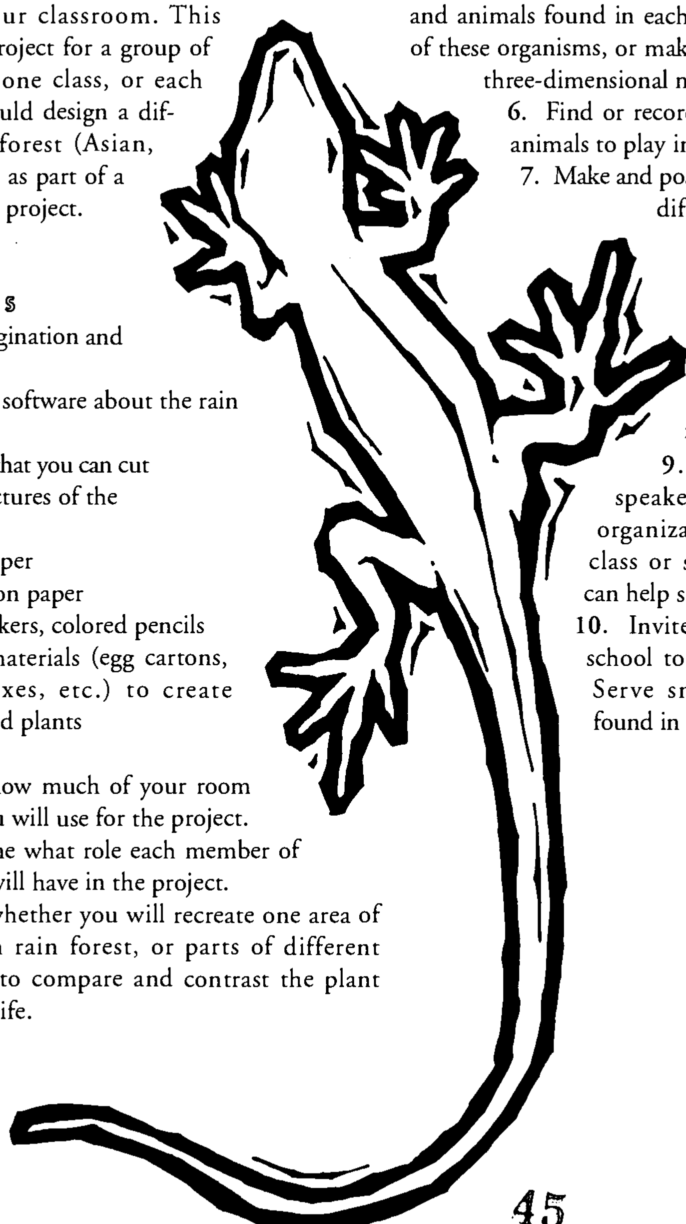
RAIN FOREST ANIMALS: Student Activity

Turn your classroom into a tropical rain forest.

Main Activity

http://www.mnonline.org/ktca/newtons

The best way to learn about the Amazon rain forest is to go there. (See "Resources" for more information.) You can also create a corner of the rain forest in your classroom. This could be a project for a group of students in one class, or each classroom could design a different rain forest (Asian, African, etc.) as part of a whole school project.



Materials

- lots of imagination and creativity
- books and software about the rain forest
- magazines that you can cut up with pictures of the rain forest
- butcher paper
- construction paper
- paint, markers, colored pencils
- recycled materials (egg cartons, cereal boxes, etc.) to create animals and plants

1. Decide how much of your room or school you will use for the project.
2. Determine what role each member of your group will have in the project.
3. Decide whether you will recreate one area of the Amazon rain forest, or parts of different rain forests to compare and contrast the plant and animal life.
4. Think about how to best represent the different layers of the rain forest.
5. Do research to learn more about the plants and animals found in each layer. Collect pictures of these organisms, or make your own pictures or three-dimensional models of them.
6. Find or record sounds of rain forest animals to play in the room.
7. Make and post signs that describe the different plants and animals in your rain forest.
8. Create an area or poster that describes threats to the survival of the species that live in your rain forest.
9. Write to or invite speakers from conservation organizations to talk to your class or school about how we can help save the rain forest.
10. Invite other classes in your school to visit your rain forest. Serve snacks that might be found in the rain forest.

Try This

IMAGINE YOU LIVE IN THE AMAZON RAIN FOREST. WRITE A DIARY DESCRIBING ONE WEEK OF YOUR LIFE, INCLUDING WHERE YOU LIVE, WHAT YOU EAT, WHAT YOU WEAR, WHAT SOUNDS YOU HEAR AS YOU WAKE UP AND FALL ASLEEP, AND WHO YOUR FRIENDS ARE. HOW DOES IT FEEL TO KNOW THAT MILLIONS OF ACRES OF YOUR HOME (THE RAIN FOREST) ARE DESTROYED EVERY YEAR?

Try This

ABOUT 10 YEARS AGO, BRAZIL BEGAN TO RESTRICT EFFORTS TO DEVELOP THE AMAZON IN ORDER TO PROTECT THEIR FOREST RESOURCES. FIND OUT WHAT YOUR LOCAL CITY OR COUNTY GOVERNMENT HAS DONE TO PROTECT THE NATURAL RESOURCES WHERE YOU LIVE. IF PROTECTIVE LAWS WERE PASSED, ARE THEY BEING ENFORCED? WHY OR WHY NOT?

Try This

DESIGN AN ANIMAL AND AN ENVIRONMENT IN WHICH IT CAN LIVE. FIGURE OUT HOW EACH WILL SUPPORT THE OTHER. ADD PLANTS AND INSECTS THAT CAN COEXIST. WHAT DOES EACH CREATURE EAT? HOW DOES EACH CREATURE OBTAIN ITS FOOD? HOW DO THE LIVING THINGS INTERACT?

OUR FEATURED CONTRIBUTOR IS INTERNATIONAL EXPEDITIONS, INC., SPONSOR OF RAINFOREST WORKSHOPS FOR EDUCATORS AND STUDENTS. FOR MORE INFORMATION CALL (800) 633-4734 OR GO TO: http://www.infomedia.net/intexp/ieworks.html

EDUCATIONAL MATERIALS DEVELOPED WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION.

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3M Innovation

OLYMPIC SOLAR ENERGY

How is the sun used for power?

How does the sun's heat get to the earth through millions of miles of cold space?

Getting Started

http://www.mnonline.org/ktca/newtons

Build a small "greenhouse" out of a plastic, cardboard, or wood box that has a clear cover on the top (glass or clear plastic). Put the tip of a thermometer in a container of black dirt inside the greenhouse, then place the house in the sun or under a floodlight. Check the temperature every 15 minutes to see how much hotter it is inside the greenhouse. Open the top or sides of the box and see what effect that has. Why does heat build up inside of a greenhouse? Can you maintain a constant temperature below the maximum temperature by opening and closing holes, or vents, in your greenhouse?

Overview

Olympic officials stand with a magnifying lens in the ancient temple of Zeus in Olympia, Greece, the site of the first Olympic Games 2,772 years ago. They focus rays of the sun on dry grass. The grass catches fire, and from that "Mother Flame" the Olympic torch is lit, just as it was by the original Olympians.

As the lighting of the Olympic flame shows, the solar energy that strikes the earth is tremendous, despite traveling 93 million miles across space to get here. The total annual energy consumption in the United States is only about two-hundredths of a percent of the solar energy falling on this country each year.

People harness solar energy in many different ways, but the most common methods use solar collectors to heat water and photovoltaic cells to convert sunlight directly into electricity.

Photovoltaic cells, thin wafers usually made of silicon crystals, were first used in 1958 to power satellites in space. Now the cells are used for everything from running lighting systems to powering water pumps.

When photons (the tiny, individual packets of light energy that come from the sun) strike a cell, some are absorbed and transfer their energy to an electron in an atom. The electron, gaining energy from the photon, breaks free of its atom. The cells are made so that one layer of each cell is more highly charged than the other layer. The negative charges move toward the positive ones. The moving charges are an electric current, or electricity. This type of current production is called the photovoltaic effect.

At the 1996 Olympics in Atlanta, 2,856 photovoltaic cells covering 40,000 square feet provided 340 kilowatts of electricity to power the lights in the swimming complex. The water in the swimming pool—one million gallons of it—was heated by a solar thermal heating system. Such systems work by aiming large, black metal solar collectors at the sun. Black and other dark colors absorb more sunlight than light colors. Solar energy makes the collectors very hot, much like the surface of a blacktop road on a bright, sunny day. Water pumped through the collectors is heated naturally and then can be pumped back into the pool. Temperature sensors automatically turn on pumps to use the solar-heated water when the pool becomes too cool.

Solar thermal heaters for swimming pools typically reduce water heating costs by about 50 percent. Many big pools with solar heat also use natural gas heating as a backup for cloudy days when the sun isn't shining.

Connections

1. What are the advantages of producing energy directly from the sun instead of burning coal or natural gas?
2. Photovoltaic cells, solar thermal heaters, and other solar systems have been around for a couple of decades. Why weren't they more widely used?

NEWTON'S APPLE®

SHOW NUMBER **1409**

SUCHIN CATCHES SOME RAYS TO FIND OUT ABOUT SOLAR POWER.

SEGMENT LENGTH: 8:00

Resources

BROOKE, B. (1992) *SOLAR ENERGY*. NEW YORK: CHELSEA HOUSE.

HUFBAUER, K. (1991) *EXPLORING THE SUN: SOLAR SCIENCE SINCE GALILEO*. BALTIMORE: JOHNS HOPKINS UNIVERSITY PRESS.

SPENCE, M. (1993) *SOLAR POWER*. NEW YORK: GLOUCESTER PRESS.

GENERAL SOLAR INFORMATION: http://www.eren.doe.gov/RE/solar.html

OLYMPIC SWIMMING POOL SOLAR SITE: http://www.heliocol.com/olym.html

THE CENTER FOR RENEWABLE ENERGY AND SUSTAINABLE TECHNOLOGY: *THE SUN'S JOULES*. CD-ROM MULTIMEDIA ENCYCLOPEDIA ABOUT SOLAR ENERGY. ORDERING INFORMATION: (800) 842-5505.

U.S. DEPARTMENT OF ENERGY: ENERGY EFFICIENCY AND RENEWABLE ENERGY CLEARINGHOUSE P.O. BOX 3048 MERRIFIELD, VA 22116 (800) DOE-EREC (ASSORTED BOOKLETS ON RENEWABLE ENERGY)

NEWTON'S APPLE VIDEO CASSETTES AND EDUCATIONAL MATERIALS PROVIDE FURTHER INFORMATION ABOUT THIS AND OTHER TOPICS. CALL (612) 222-1717 OR CHECK OUT OUR WEB SITE AT: http://www.mnonline.org/ktca/newtons

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NEWTON'S APPLE

SHOW NUMBER

1409

OLYMPIC SOLAR ENERGY

SOLAR COOKOUT

OLYMPIC SOLAR ENERGY: Student Activity

Harness the energy from the sun to power a parabolic oven.

Main Activity

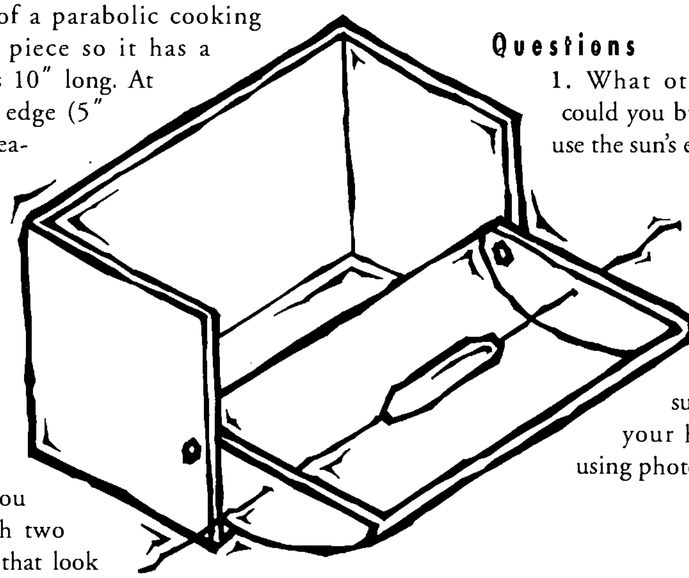
http://www.mnonline.org/ktca/newtons

Solar thermal collectors work because they not only gather solar energy, but concentrate it in a small space. In this activity, you'll build a solar oven that, by concentrating sunlight, will gather so much heat you can cook a hot dog.

Materials

- aluminum foil
- poster board
- unpainted coat hanger
- a cardboard box, about 10 1/2" on one side
- a medium-sized piece of cardboard
- glue
- scissors
- marker
- tape
- two nuts and bolts
- hot dogs

1. Cut two sections out of the piece of cardboard to form the ends of a parabolic cooking trough. Cut each piece so it has a straight edge that is 10" long. At the middle of this edge (5" from each end), measure a point 4 1/2" back onto the cardboard and make a mark. Draw an arc from one corner of your straight edge, through the point, then down to the other corner. Cut along the arc and you should end up with two pieces of cardboard that look roughly like half circles.
2. Cut a piece of poster board so that it is 11 1/2" by 14". Cut a piece of aluminum foil the same size and glue it, shiny side up, to the poster board.
3. Curve the poster board around the two end pieces, with the aluminum foil facing in, and tape it in place.
4. Cut the top and front side off of your cardboard box and slide the back of your trough a couple of inches into the box. Secure the trough to the box by putting a bolt through each side of the trough and the sides of the box. Make sure the bolts are toward the rear of the trough. Fasten the two bolts with the nuts. The trough should be able to tilt up and down.
5. Straighten out the coat hanger and push it through the trough, from one side to the other, so it sits like a spit for cooking. It should sit about two inches back from the open front of the trough.
6. Put a hot dog lengthwise on the coat hanger and point the trough at the sun. How long does it take the hot dog to get warm? Does it cook faster if you move the coat hanger a little deeper into the trough?



Questions

1. What other machines could you build that would use the sun's energy?
2. What can the sun's energy do around your house? Draw plans that would maximize sunlight energy in your house without using photovoltaic cells.

Try This

USE A MAGNIFYING GLASS TO FOCUS SUNLIGHT ON A PIECE OF BLACK CONSTRUCTION PAPER. HOW LONG DOES IT TAKE BEFORE THE PAPER STARTS TO SMOKE? REPEAT THE PROCEDURE USING WHITE CONSTRUCTION PAPER. DOES IT TAKE MORE OR LESS TIME TO START SMOKING? WHY?

Try This

PURCHASE A PHOTOVOLTAIC CELL AND AN ELECTRIC ANALOG CLOCK. WIRE THE CELLS TO THE CLOCK, SET THE CLOCK AT 12, AND THEN PUT THE WHOLE APPARATUS OUTSIDE. AT THE END OF THE DAY YOU WILL KNOW EXACTLY HOW MUCH TIME THE SUN WAS SHINING AND HOW MUCH TIME IT SPENT BEHIND THE CLOUDS.

Try This

FILL SOME ICE CUBE TRAYS WITH WATER TO THE SAME DEPTH. ADD DIFFERENT COLORS AND CONCENTRATIONS OF FOOD COLORING TO DIFFERENT CUBES. STIR WELL. WHEN THE ICE CUBES FREEZE, YOU SHOULD HAVE A COLLECTION OF CUBES IN A VARIETY OF COLORS. SET THEM OUT IN THE SUN AND SEE WHICH ONES MELT THE FASTEST. WHY DON'T THEY ALL MELT AT THE SAME RATE?

SOCCER

How can I control the soccer ball?

How can physics help your team win the next soccer game?

Getting Started

http://www.mnonline.org/ktca/newtons

What science is involved in learning to play sports? Think about specific games and how your knowledge of science can help you play them.

When you play soccer, what must you do to make the ball move? What can you do with your foot to change the path, speed, and rotation of the ball? With what other parts of the body do soccer players hit the ball? How is the contact different from contact with the foot?

Overview

The score is tied, with only three minutes left in the game. To win, you need to think and move fast to control the ball, get it down the field, and shoot it past the goalie. Can science help?

Soccer (or football, as the game is known outside the United States) requires lots of training and practice. But while training books may not mention anything about **momentum**, collisions, or **Newton's third law of motion**, every move a soccer player makes involves physics.

How? When your foot, thigh, knee, chest, or forehead acts on the soccer ball, the ball reacts. Players need to know when to best use **heading**, **dribbling**, passing or power kicking, **feinting**, **trapping**, **swerving**, or shooting.

For example, a passing kick uses the inside of the foot and provides the largest surface area to contact the ball. This gives you better control of where the ball goes, but with your leg turned out, you can't swing it with maximum force. The ball won't go as far as it would with a power kick, where your knee points in the same direction the ball goes. That's why you need the force of a power kick to drive the ball down the field. And remember that to have more control, use the laces of your shoe rather than your toes to get a bit more surface area. It won't do much good to get the ball down the field if it doesn't go where it's supposed to!

How big you are and how fast you're moving when you make contact with the ball is an important factor, too. Why? Your momentum—whether you're running toward the ball when you kick it or toward the goal when someone passes it to you—can move that ball down the field at very high speeds. Your mass (which is related to your body weight) multiplied by your **velocity**, or motion in a particular direction, equals a lot of momentum. When your body collides with the ball, you share your momentum with it. The more momentum the ball gets from you, the faster and farther it will move. The bigger you are and the faster you're moving, the greater your momentum will be, and the more momentum you will have to share with the ball.

Of course, this all looks very different to the defending goalie. The goalie must be ready to absorb all the momentum of the ball you just kicked when it collides with her or his body. But if you do your job right, that person won't feel a thing—the net will.

Connections

1. How do you think a baseball player uses physics to hit a home run? What about golf, tennis, or basketball? Think about the science *you* use in your favorite sport.
2. How do you think sports have changed in the past 100 years? Think about the effects of changes in shoes and equipment, rules, playing fields, teams, and even advertising. Has the science of sports changed?

NEWTON'S APPLE

SHOW NUMBER 1409

EILEEN GETS HER KICKS LEARNING THE PHYSICS BEHIND SOCCER.

SEGMENT LENGTH: 8:00

Resources

DITCHFIELD, M. & BAHR, W. (1988) *COACHING SOCCER THE PROGRESSIVE WAY*. ENGLEWOOD CLIFFS, NJ: PRENTICE-HALL.

GONICK, L. & HUFFMAN, A. (1991) *THE CARTOON GUIDE TO PHYSICS*. NEW YORK: HARPER COLLINS.

YEAGLEY, J. (1994) *WINNING SOCCER*. INDIANAPOLIS: MASTERS PRESS.

THE CENTER OF EXCELLENCE FOR SCIENCE AND MATHEMATICS EDUCATION: http://192.239.146.18

SOCCERCITY: 2000+ LINKS TO SOCCER SITES: http://nettvik.no/sportsholmen/soccercity/

SOCCER–THE INTERNATIONAL SOCCER CYBERTOUR: http://www.cybergoal.com/soccer

3M LEARNING SOFTWARE: *WHAT'S THE SECRET?* (VOL 3). CD-ROM FOR MACINTOSH OR WINDOWS. (800) 219-9022.

AMERICAN YOUTH SOCCER ORGANIZATION (AYSO) 5403 WEST 138TH ST HAWTHORNE, CA 90250 (800) USA-AYSO http://www.ayso.org

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3M Innovation

NEWTON'S APPLE

SHOW NUMBER

1409

SOCCER

SOCCER KICKOFF

SOCCER: Student Activity

Conduct a kicking contest to figure out what makes the ball travel the farthest.

Main Activity

http://www.mnonline.org/ktca/newtons

What factors determine how high or how far a ball goes when kicked? To find out, gather some friends to kick a soccer ball and take measurements.

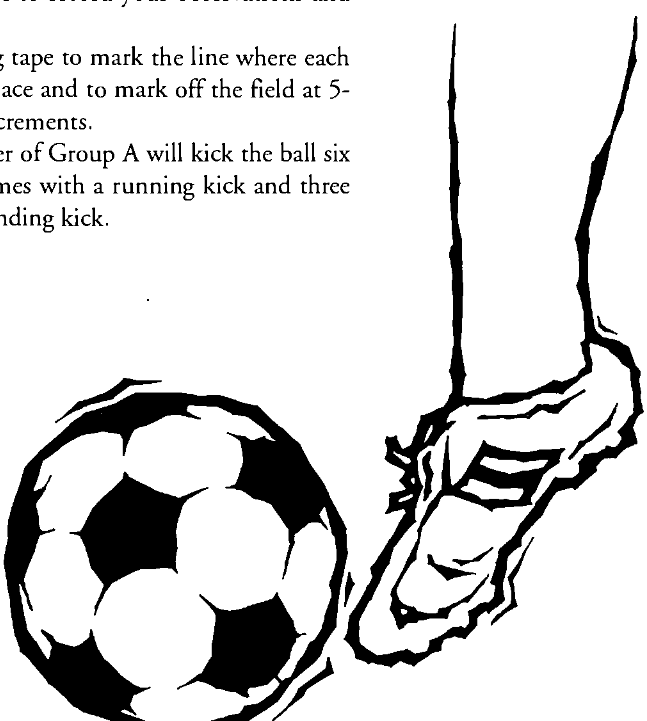
Materials

- school athletic field or park
- paper
- pencils or pens
- masking tape
- soccer ball
- tape measure

1. Divide into two groups. Group A will kick the ball; Group B will observe the kicks and measure the distance the ball travels.
2. Create a table to record your observations and conclusions.
3. Use masking tape to mark the line where each kick will take place and to mark off the field at 5-meter (16′) increments.
4. Each member of Group A will kick the ball six times—three times with a running kick and three times with a standing kick.
5. A member of Group B should write down how far the ball traveled in the air (that is, where it landed, not where it stopped rolling). Members of Group B can also estimate the angle at which the ball was kicked and note that in the table.
6. Switch group roles and repeat steps 4–5.
7. Average the running kick distances and the standing kick distances for all the kickers.

Questions

1. What effect does the condition of the playing field (dry, muddy, natural, or plastic) have on the momentum of the kickers and the ball? What effect do cleats have on the kickers' momentum?
2. How does a kicker's weight affect the results?
3. Based on the results recorded in your table, can you determine the kick angle that produces the longest distances?



Try This

USE A BILLIARD BALL AND CUE STICK TO EXPLORE WHAT HAPPENS WHEN YOU APPLY FORCE TO DIFFERENT HORIZONTAL (LEFT, RIGHT, CENTER) AND VERTICAL (TOP, BOTTOM, CENTER) POSITIONS ON THE BALL. WHAT HAPPENS IF YOU TAPE A COTTON BALL TO THE END OF THE CUE STICK?

Try This

ACCORDING TO THE SOCCER INDUSTRY COUNCIL OF AMERICA, DURING THE MID-1990S ABOUT 12 MILLION AMERICANS UNDER THE AGE OF 19 WERE PLAYING ORGANIZED SOCCER. FOR PEOPLE UNDER 13, SOCCER PARTICIPATION RANKED SECOND AFTER BASKETBALL. CREATE A SURVEY TO FIND OUT WHAT SPORTS THE BOYS AND GIRLS IN YOUR SCHOOL PLAY. SHOW YOUR RESULTS IN A TABLE OR CHART.

Try This

MILLIONS OF PEOPLE IN AT LEAST 140 COUNTRIES PLAY SOCCER. FIND OUT WHICH COUNTRIES THEY ARE BY USING THE INTERNET OR LIBRARY. MAKE A WORLD MAP AND INDICATE WHICH COUNTRIES PLAY, WHICH SEND TEAMS TO THE OLYMPIC GAMES, AND WHICH COMPETE FOR THE WORLD CUP.

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MALARIA TRACKING

How can you locate disease-carrying mosquitoes?

When are mosquitoes dangerous? Why do female mosquitoes suck blood?

NEWTON'S APPLE

SHOW NUMBER 1410

DAVID DISCOVERS HOW SATELLITE TECHNOLOGY HELPS PREVENT DISEASE.

SEGMENT LENGTH: 7:30

Getting Started

http://www.mnonline.org/ktca/newtons

Why do mosquitoes bite? Do all mosquitoes bite? How can mosquitoes spread disease? What diseases can mosquitoes carry?

How can we prevent mosquito-borne diseases? How can we use technology to control mosquitoes?

Overview

Mosquitoes aren't just irritating. They can carry diseases like **malaria**, a huge problem for people who live in the tropics where mosquitoes breed year-round. Malaria endangers the lives of millions worldwide, and the numbers are increasing.

Malaria is caused by a **parasite** that infects mosquitoes in the genus ***Anopheles.*** Both male and female mosquitoes feed on plant nectar, but females of most kinds of mosquitoes need a blood meal for protein so their bodies can make eggs. Anyone bitten by an infected female anopheles can also be infected with the malaria parasite.

One way to stop malaria and other diseases carried by mosquitoes is to eliminate the mosquitoes themselves. But many kinds of mosquitoes have become resistant to chemicals that have been used to get rid of them. New techniques are needed. For example, scientists have stocked mosquito fish in storm water ponds along highways as a biological control. This small, minnow-type fish consumes hundreds of mosquito larvae per day.

Eliminating the places where mosquitoes breed works well when it is possible. But it's tough for people to locate anopheles mosquito breeding sites in deep, dense **rain forests**. That's where using satellites can help. Satellites that gather information through a technique called **remote sensing** help track the breeding sites of anopheles mosquitoes.

Things on the ground, such as vegetation cover, standing pools of water, or human settlements, emit electromagnetic radiation. This radiation shows up as certain colors when picked up by **infrared** cameras aboard satellites. When fed into a computerized information base called a **Geographic Information System (GIS)**, these remotely sensed images can be useful in interpreting what is happening on the ground. Infrared cameras are used because they reveal more information than can be obtained from images taken with visible light. Heat characteristics of objects can be observed during night and day with infrared cameras.

A GIS uses the power of the computer to help answer geographic questions by arranging and displaying useful information about places in maps, charts, or tables. When ground events or situations can be correlated with data sent from remote satellites, experts will be able to predict ground conditions from satellite data. This correlation is done though a process called ground truthing, or finding out through field studies how satellite images correspond to what is actually happening on the ground. When experts know the kind of vegetation anopheles mosquitoes prefer to feed on, and if they can see from satellite images where it is growing, they can plan and monitor long-term campaigns for the control of malaria.

Connections

1. What are some ways public health, industry, government, city planners, or business planners might use GIS—maps merged with other data?
2. What are some benefits of remote sensing? Some challenges?
3. Why is it difficult to stop malaria and other diseases carried by mosquitoes?

Resources

AMERICAN MOSQUITO CONTROL ASSOCIATION, INC.
2200 EAST PRIEN LAKE ROAD
LAKE CHARLES, LA 70601
(318) 474-2723

CAROLINA BIOLOGICAL SUPPLY COMPANY
2700 YORK ROAD
BURLINGTON, NC 27215
(800) 334-5551
(MOSQUITO LIFE-CYCLE KIT OR MOSQUITO LARVAE)

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE, INC.
380 YORK ST
REDLANDS, CA 92373-8100
(909) 793-2849

METROPOLITAN MOSQUITO CONTROL DISTRICT
2099 UNIVERSITY AVE W.
ST. PAUL, MN 55104-3431
(612) 645-9149

NATIONAL CENTER FOR GEOGRAPHIC INFORMATION AND ANALYSIS (NCGIA)
U.C. AT SANTA BARBARA
SANTA BARBARA, CA 93106-4060
(805) 893-4305

NASA CLASSROOM OF THE FUTURE:
http://www.cotf.edu/ETE/scen/rainforest/RemoteSensing.html

REMOTE SENSING:
http://www.rsgis.do.usbr.gov/rsgis.html

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MOSQUITO PATROL

MALARIA TRACKING: Student Activity

Devise a plan to help prevent mosquito-borne diseases.

Main Activity

http://www.mnonline.org/ktca/newtons

Malaria is not the problem it once was in the United States, but container-type mosquitoes—those that lay eggs anyplace they find still or slow-moving water—are a national problem. For example, the tree hole mosquito carries LaCrosse encephalitis, a viral disease that can affect children under age 18. Tree hole mosquitoes breed and develop in water-holding tree holes and artificial containers such as old tires, cans, buckets, and children's toys. This differs from the pest mosquitoes that use temporary pools of water (marshes and land depressions) for a breeding habitat. Very few tree hole mosquitoes in any area actually carry the virus, but children can become ill if they are bitten by one that does. If tree hole mosquito breeding sites are modified or removed from an area, then no adult tree hole mosquitoes are produced, and the LaCrosse virus cannot be transmitted to children.

Note: This activity is best suited for spring, summer, or early fall.

1. Brainstorm a list of places where mosquitoes breed.
2. Go on a mosquito patrol at home and school to identify and eliminate possible mosquito breeding sites. Report what you did to eliminate the site for breeding.
3. Create a leaflet to distribute in your neighborhood or community and spread the word: "Don't raise mosquitoes!"

Questions

1. What did you learn about how mosquitoes develop? What other questions do you have?
2. How can knowing their breeding habits and life cycle help efforts to control mosquitoes?
3. What are some ways you can prevent mosquitoes from breeding where you live?

Try This

Order disease-free mosquito larvae (see Resources) and watch the life cycle of the mosquito unfold in your classroom. How does knowing the life cycle help in efforts to control the mosquito and the diseases it carries to people and pets?

Try This

Imagine you are preparing to travel to a tropical country. The Centers for Disease Control and Prevention provide up-to-date information about health concerns in other nations. List your questions and call (404) 332-4559 or (404) 332-4555 for answers.

Try This

Find out what attracts mosquitoes to people. Combine those facts with what you know about mosquito breeding sites to design an imaginary product to repel mosquitoes. Prepare an "infomercial" to promote your product and to help people avoid mosquito bites. Perform your infomercial complete with sound effects.

CLOCKS

How do clocks keep time?

What was the world like without clocks? How did people keep appointments?

Getting Started

http://www.mnonline.org/ktca/newtons

Without looking at the clock or your watch, look out the window and guess what time it is. How close were you to the "correct" time? What clues did you use to tell what time it was? Are there other things you could use? How do you know it's lunchtime without looking at a clock?

How does a clock measure time? What would happen if a minute were 100 seconds and an hour were 100 minutes? How would that change the way you schedule your day? How long would this class last? What about your school day?

Overview

The alarm clock rings in the morning and, even in your drowsy fog, you look to see what time it is. As you get dressed, you check the clock again and again to make sure you're not late for school.

We look at clocks all the time because these devices help us regulate our lives, telling us not only when to get up, but when to eat, sleep, play, and work. They are so much a part of our lives that we rarely think about what clocks really do.

Whether they are highly accurate **atomic clocks** or slightly less accurate quartz watches, electric alarm clocks or grandfather clocks with slowly swinging pendulums, all clocks have one thing in common—they consistently count precise units of time. Those units could be anything we want them to be, but for the world to function in harmony, we have a timekeeping standard based upon three units of time—seconds, minutes, and hours.

To measure these units, all clocks must have two things: a regular, repetitive resonator, or oscillator, to mark off equal units of time; and a way of displaying those units in an understandable form.

Most clocks and watches today keep time by applying electric energy to a **quartz crystal**, a system developed in the 1930s. The energy makes the crystal vibrate or **oscillate** at a constant frequency and produce regular electric pulses that regulate a motor. The motor advances the watch hands or, in a digital watch, the number display, by one-second increments.

Mechanical watches use a coiled mainspring for power. The mainspring drives gears that cause a hairspring to oscillate, rocking a lever to and fro. The lever drives other gears that move the clock hands.

Atomic clocks, the world's most accurate timekeepers, use the natural vibration, or oscillation, of the cesium atom as their resonator. Cesium atoms vibrate exactly 9,192,631,770 times a second, driving a clock that is accurate to within a millionth of a second per year.

In ancient times, people used the rising and setting sun to keep track of time. The first devices to measure time, invented in about 3500 B.C., were small towers called **obelisks**. The changing length and position of their shadows divided the day into morning and afternoon. Then came sundials, which split the day into hours; water clocks, which measured even smaller units of time; **weight-driven mechanical clocks** that were much more accurate; and finally, in about 1510, **spring-driven clocks** that led the way to clocks and watches accurate to within a minute or two a day.

Connections

1. How would your day be different if nobody had clocks or watches? What other ways could you tell time?
2. Why is it that time seems to pass quickly when you're doing something interesting or fun, and slowly when you're bored?

NEWTON'S APPLE®

SHOW NUMBER 1410

EILEEN GOES TO SWITZERLAND TO FIND OUT WHAT MAKES CLOCKS TICK.

SEGMENT LENGTH: 6:45

Resources

DOHRN-VAN ROSSUM, G. (1996) *HISTORY OF THE HOUR: CLOCKS AND MODERN TEMPORAL ORDERS*. CHICAGO: UNIVERSITY OF CHICAGO PRESS.

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TAIT, H. (1983) *CLOCKS AND WATCHES—AN ILLUSTRATED HISTORY OF CLOCKS SINCE THE MIDDLE AGES*. CAMBRIDGE: BRITISH MUSEUM PUBLICATIONS/HARVARD UNIVERSITY PRESS.

INDEX OF HOROLOGY: http://www.horology.com/horology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY: http://physics.nist.gov/lab.html (CLICK ON GENERAL INTEREST IN MAIN MENU, THEN CLICK ON A WALK THROUGH TIME)

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EDUCATIONAL MATERIALS DEVELOPED WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION.

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3M Innovation

NEWTON'S APPLE.

SHOW NUMBER

1410

CLOCKS

WATER CLOCK

CLOCKS: Student Activity

Build a clock that uses dripping water to measure how much time has passed.

Main Activity

http://www.mnonline.org/ktca/newtons

Try This

LOOK AT THE SWEEP HAND OF A CLOCK AND NOTE EXACTLY WHEN A MINUTE BEGINS. WITHOUT LOOKING AT THE CLOCK AGAIN, TRY TO SILENTLY COUNT OFF 60 SECONDS IN YOUR HEAD. HOW CLOSE DID YOU COME? TRY AGAIN, BUT THIS TIME HAVE SOMEONE TALK TO YOU AND INTERRUPT YOUR CONCENTRATION.

Try This

BUILD YOUR OWN SUNDIAL WITH A MEDIUM-SIZED FLOWERPOT FILLED WITH SAND. PUT A 30-CM (12") STICK IN THE CENTER OF THE POT AND SET IT IN THE SUN. EVERY HOUR, MARK WHERE THE SHADOW OF THE STICK FALLS ON THE EDGE OF THE POT WITH A PIECE OF MASKING TAPE. IF YOU DON'T MOVE THE POT, YOU CAN KEEP TRACK OF TIME ON SUNNY DAYS.

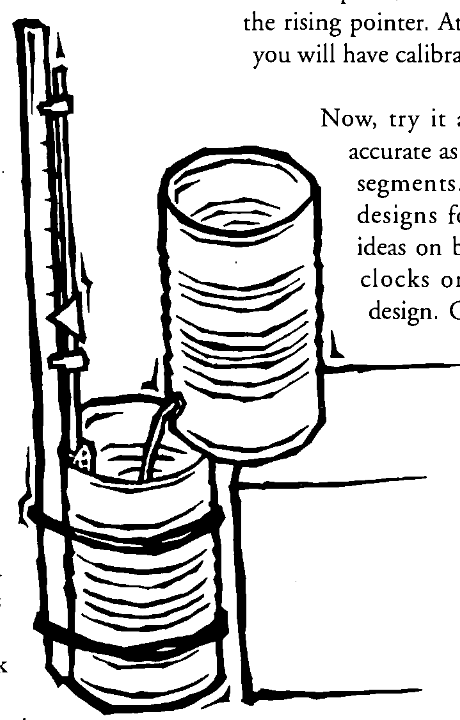
Try This

GALILEO REALIZED THAT A PENDULUM OSCILLATES, OR SWINGS, BACK AND FORTH FOR THE SAME UNIT OF TIME, EVEN AS THE ARC OF EACH SWING DECREASES. TIE A WEIGHT TO ONE END OF A STRING AND TIE THE OTHER END TO A STICK. LAY THE STICK DOWN ON A TABLE SO THE STRING IS HANGING FREE. THEN SWING THE STRING LIKE A PENDULUM. WAS GALILEO RIGHT?

For many centuries, the best technology available for keeping time was the water clock. While these clocks weren't very reliable, they worked indoors, at night, and on cloudy days, so they were much more useful than the sundial, the only other clock in use at the time. Over time, many styles of water clocks were invented. Here's an activity that lets you find out just how accurate an "inflow" water clock is.

Materials

- 2 big eye screws
- a sturdy, wooden stick, 30 cm (12″) long and 2.5 to 5 cm (1″ to 2″) square
- a thin, round stick or dowel, 20 to 25 cm (8″ to 10″) long, that fits through the eye screws
- 2 rubber bands
- a marker
- glue and a small piece of sturdy paper or cardboard
- a cork
- 2 empty cans—medium sized, about 28 oz
- can opener



1. Screw the eye screws into the 30-cm stick, the first an inch or so above the level of the cans, the other an inch or so below the top of the stick.
2. Run the thin, round stick through the openings in the eye screws and insert the lower end of the stick into a cork.
3. Fasten the large stick to the outside of one of the cans with the two rubber bands. Make sure the cork at the bottom of the thin stick doesn't rub against the inside of the can.
4. Glue a small paper or cardboard pointer to the thin stick so that it points at, but doesn't touch, the large stick.
5. Use the can opener to make a tiny hole in the side of your second can as close to the bottom as possible. You want the hole small enough so the water only drips out.
6. Fill the second can with water and set it on a platform so water drips from it into the first can. As the water slowly fills the first can, the cork will rise and push the thin stick and the pointer upward. Mark the starting level for the pointer on the large stick. Then every five minutes, as the water drips in, make another mark across from the rising pointer. At the end of the class period, you will have calibrated your clock.

Now, try it again and see if it remains accurate as it counts off the five-minute segments. There are many different designs for water clocks. Look for ideas on building other types of water clocks or come up with your own design. Compare the accuracy of different designs.

Questions

1. Does the clock run slower or faster if you use very cold water? Why?
2. Can you build two water clocks that measure time at the same rate? If not, why not?
3. What disadvantages are there to using this type of clock?

POST OFFICE

What happens to a letter dropped in a mailbox?

Why does some mail have a bar code on it? What happens to undeliverable mail?

NEWTON'S APPLE®

SHOW NUMBER 1411

DAVE RIDES ALONG WITH A LETTER TO SEE HOW THE POST OFFICE WORKS.

SEGMENT LENGTH: 8:15

Getting Started

http://www.mnonline.org/ktca/newtons

How many pieces of mail (letters and packages) do you think actually go through the postal system every day? How do you think the postal service keeps track of all that mail? If you look at a map of zip codes, can you see trends in the numbers? Why do you think we now use nine-digit zip codes?

Name all the ways (kinds of vehicles, people, etc.) the postal service gets mail from the mailbox to its destination. How do you think someone living on an island would get his or her mail? How about someone living in the tundra near the North Pole?

Overview

The U.S. Postal Service handles half a billion letters a day. How big is half a billion? If you started counting right now and did nothing else, it would take you 16 years to reach half a billion. How does the postal service get so much mail to us so fast?

The answer is the bar codes you see on your mail and computerized mail processing machines called **optical character readers** (OCRs) and **bar code sorters** (BCSs). These machines, located in post offices across the country, are programmed to "read" and sort up to 36,000 pieces of mail per hour. The size and the shape of the envelope and the way it's addressed are important.

Machinable mail needs to be the right size and shape to pass easily through the equipment. Readable mail must be quickly and accurately read, coded, and sorted by the equipment. That means the address should be typed, computer generated, or neatly printed in the recommended format with a minimum of three lines, aligned at the left. The OCR best reads plain-style, capital letters on white envelopes.

Speedy conveyor belts move each piece of mail by the OCR's scanner, which reads the delivery address. Then the OCR's printer sprays on a **bar code** for that address or reads the bar code applied by a business customer before the envelope was mailed. The bar code can represent a five-digit **zip code**, a nine-digit **zip+4** code, or an eleven-digit **delivery point bar code**. Next, the piece of mail zooms to one of the OCR's sorting channels reserved for its proper delivery area. From there, bar-coded mail is fed to BCSs for fast and final separations—and with the delivery point bar code, it is placed in the order in which the letter carrier delivers the mail on the route.

The postal service is currently perfecting automated equipment for reading handwriting. But for now, an address not neatly printed or readable by the machine has to be handled by a human. Mail that can neither be delivered nor returned to the sender usually winds up in a mail recovery center in Atlanta, New York, Philadelphia, St. Paul, or San Francisco. This includes letters and packages that don't have an address, mail with illegible addresses, or items from packages that have fallen apart, separating the contents from the address. All undeliverable mail is recorded on a computer so people can call to see if a lost item has been recovered. Every three months, the postal service holds an auction to sell any unclaimed items.

Connections

1. Electronic technology is making communications faster, easier, and cheaper than ever. People are now paying bills and banking online and using the Internet to send messages and documents, read newspapers and magazines, and order merchandise. How will this affect the postal service? Can you see any ways this technology will increase mail volume?
2. How can you help your mail get delivered quickly and accurately?

Resources

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ANNUAL REPORT OF THE POSTMASTER GENERAL
U.S. POSTAL SERVICE
CORPORATE RELATIONS
475 L'ENFANT PLAZA SW
ROOM 10431
WASHINGTON, DC 20260-3100
ELECTRONIC VERSION:
http://www.usps.gov

STAMP UNIVERSE:
http://www.stampworld.com

U.S. POSTAL SERVICE:
http://www.usps.gov/fyi/fyi.html

YOUR POST OFFICE:
http://www.usps.gov/postofc/pstoffc.html

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SHOW NUMBER

1411

POST OFFICE

SPECIAL DELIVERY

POST OFFICE: Student Activity

Conduct an experiment to see how the address format affects a letter's delivery.

Main Activity

http://www.mnonline.org/ktca/newtons

What kind of writing can postal automation machines read? Design an experiment to find out.

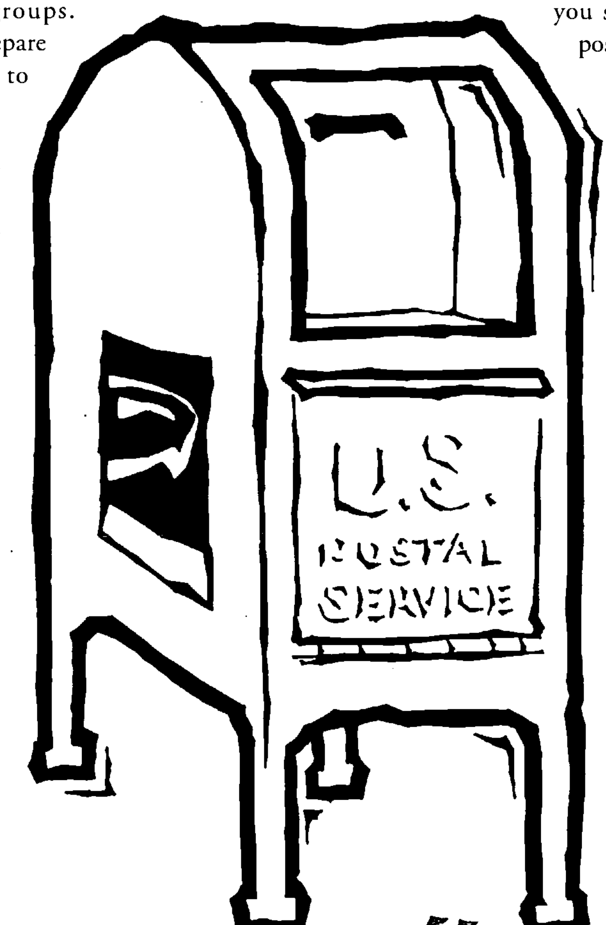
Materials

- envelopes of readable size for machinable mail
- stamps

1. What is the best way to address a piece of mail to have it delivered on time? What might happen with different address formats? What if the address isn't perfect? List some ways in which you could write the address.
2. Divide into groups. Group A should prepare envelopes addressed to the school in exactly the same way with block type neatly printed. Mail the envelopes at different boxes with similar pickup times. Group B should prepare envelopes addressed to the school using variations on Group A's address format. Try varying the handwriting. Mail the envelopes from different boxes with similar pickup times. Keep a list of where everything was mailed.
3. Decide how you will keep track of the results so you can draw some conclusions.

Questions

1. What do you think affects how quickly mail gets delivered? Which is the most important factor?
2. What did you learn to ensure that the letters you send receive the best possible service from the U.S. Postal Service's new automated technology?
3. Get a copy of the postal service's recommended format and see who came closest.



Try This

Set up your school just like a town. Name the town, name each hallway and each large room, and give each classroom an address. Write letters to students in other classrooms. Figure out the most helpful way to address the envelopes so they can be quickly delivered.

Try This

Approximately 232,000 city carriers and 43,000 rural carriers cover routes that stretch 2.6 million miles (4.2 million km). How many miles does each carrier cover on average? These workers each deliver an average of 550 pieces of mail each day. How much mail is that?

Try This

The postal service prints over 40 billion postage stamps a year. Stamps are produced on a huge variety of topics—geography, history, technology, art, and dozens more. Divide chart paper into vertical columns and label each column with one of the topics. Bring in stamps you receive on mail at home and place stamps in the various columns. Look into collecting stamps as a hobby.

Educational materials developed with the National Science Teachers Association.
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GEMS

How do gemstones get their colors?

What different factors control how a gemstone is colored?

Getting Started

http://www.mnonline.org/ktca/newtons

How do the natural shapes of gemstone crystals control what the final cut gem will look like? Visit a local jewelry store or gem shop and see what you can find out from the experts on how gemstones are cut.

Where do gemstones come from? Do you own any jewelry with gems in it? What makes the gems sparkle? What shape are they? What color are they? What do you think affects the color of a gemstone?

Overview

There's nothing as eye-catching as a piece of fine jewelry covered with beautifully colored **gemstones**. Natural gemstones, however, are simply mineral **crystals** whose chemistry and structure make them look special. Of the 2,000 minerals identified in the world, only about 16 yield important gemstones. To be a gemstone, a mineral has to be beautifully colored, hard, quite durable, and, most of all, rare!

Color is the most obvious and attractive feature of gemstones. The color of any material is due to the nature of light itself. Sunlight, often called white light, is actually a mixture of different colors of light. When light passes through a material, some of the light may be absorbed, while the rest passes through. The part that isn't absorbed reaches our eyes as white light minus the absorbed colors. A ruby appears red because it absorbs all the other colors of white light—blue, yellow, green, etc.—and reflects the red light to the viewer. A colorless stone absorbs none of the light, and so it allows the white light to emerge unchanged.

Some minerals are idiochromatic, or "self-colored." Their colors are part of the chemical and physical makeup of the minerals themselves. Other minerals are allochromatic, or have some color added due to contamination by other chemicals.

Most raw gems (including diamonds) have a rough shape and a dull color. Only after they have been cut and polished do they take on that special glow that people have come to expect. A person who cuts gems is called a **lapidary**, but actually that person does very little cutting. Instead, a lapidary uses a variety of grinding wheels and grits to shape and polish the colored gems or stones.

Gems are usually cut to highlight their internal color or natural crystal shape. The two main cutting techniques produce either **cabochons** or faceted gemstones. Cabochons are stones that have been cut, ground into the shape of a dome, and then polished on the outer surface. This technique is used primarily for opaque stones like opals that don't let the light shine through.

Faceting is generally used with gems that are transparent. By grinding regular, flat surfaces in a predetermined geometric pattern on the outside of the gem, a lapidary turns a rough diamond stone into a brilliantly-sparkling gem.

When light enters a faceted gemstone, it is bent to a different angle. This is called **refraction**. The facets on the outside of the gemstone are positioned so that the light enters the stone from the top, is bent, and eventually is reflected back to the viewer, displaying the brilliance within the gem. Nature provides the gemstones, but it's human ingenuity that turns them into dazzling jewels.

Connections

1. Gemstones have been collected and traded for thousands of years. Has the process of mining and polishing changed much over time?
2. What industries depend on natural gemstones for high-tech applications? How have synthetic substitutes helped them expand and grow?

NEWTON'S APPLE

SHOW NUMBER 1411

EILEEN FINDS OUT WHAT GIVES FINE GEMSTONES THEIR BRILLIANCE.

SEGMENT LENGTH: 7:00

Resources

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MERCER, I. (1987) *GEMSTONES*. NEW YORK: GLOUCESTER PRESS.

EARTH MAGAZINE. PUBLISHED BIMONTHLY BY KALMBACH PUBLISHING CO. LISTS REGIONAL MINERAL AND GEM SHOWS: (800) 533-6644.

LAPIDARY JOURNAL. PUBLISHED MONTHLY BY LAPIDARY JOURNAL, 60 CHESTNUT AVE, SUITE 201, DEVON, PA 19333-1312.

3-2-1 CLASSROOM CONTACT: *CRYSTALS—THEY'RE HABIT-FORMING*. AVAILABLE FROM GPN: (800) 228-4630.

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NEWTON'S APPLE

SHOW NUMBER

1411

GEMS

CRYSTAL CLEAR

GEMS: Student Activity

Try growing your own "synthetic gemstones" to see the shapes they form.

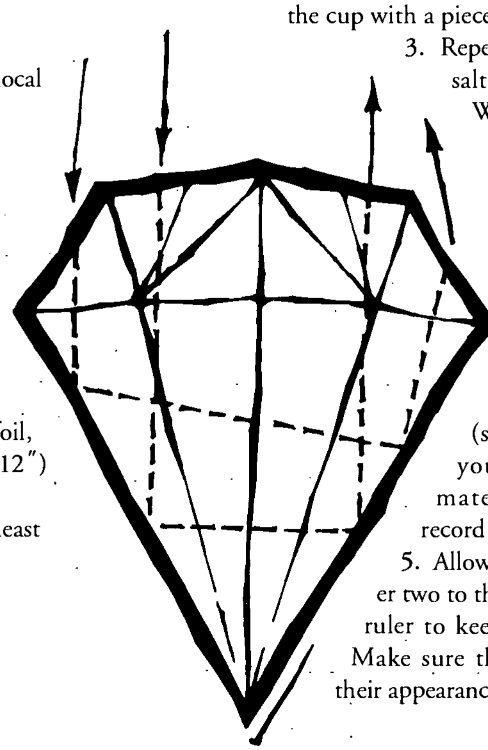
Main Activity

http://www.mnonline.org/ktca/newtons

One of the things that makes gemstones look so spectacular is the way the light bends and bounces inside them. This light show is mainly due to the internal arrangement of atoms within the crystal's structure. As the chemistry of the mineral changes, so does the crystal shape, or "habit." In this activity, you'll see for yourself how different chemical compounds produce different-shaped crystals when you cook up your own "gems."

Materials

- 200 grams (7 oz) alum powder (available in a local pharmacy)
- 200 grams table salt
- 200 grams Epsom salt (available in a local pharmacy)
- 3 pieces of string, each about 15 cm (6″) long
- 3 paper clips or washers
- 3 sheets of aluminum foil, approximately 30 cm (12″) square
- 3 large plastic cups, at least 12 oz each
- hot tap water
- 3 plastic teaspoons
- roll of masking tape
- marking pen
- pocket magnifier



1. Fill each plastic cup about half full of hot tap water. In the first cup, begin stirring in spoonfuls of table salt until you can dissolve no more (usually about 68 spoons). Use a piece of masking tape and the marking pen to label this first cup NaCl. With a clean spoon repeat the procedure with the second cup, only this time use the Epsom salt. Label this cup $MgSO_4$. In the third cup, stir in the alum powder and label it $KAl(SO_4)_2$.

2. Tie a paper clip on the end of each string. Wet one string with water and rub some salt crystals on it. Take a piece of aluminum foil and poke a small hole in the middle of it. Thread the free end of the salted string through the hole in the foil, and then cover the cup marked NaCl with the foil. Pull up on the string so that the paper clip is just touching the bottom of the cup and then secure the free end of the string to the top of the cup with a piece of tape.

3. Repeat step 2 first with the Epsom salt and then the alum powder. When all three solutions have been set up, place them in a safe location away from any direct heat or sunlight. In about one week, visible crystals should start to develop on the end of each string.

4. Using a magnifier, observe each crystal and draw a picture of its habit (shape). Compare the crystals you are growing to the three materials you started with and record your observations.

5. Allow the crystals to grow for another two to three weeks and use a millimeter ruler to keep track of their growth rate. Make sure that you note any changes in their appearance over time.

Questions

1. What similarities and differences did you notice among the three crystals? How might their chemical formulas help to explain this?
2. Why was it important to cover each of the glasses and keep them out of the sunlight?
3. What might you do to reduce the amount of time needed to grow the crystals?

Try This

GEMSTONES ARE NOT FOUND EVERYWHERE ON EARTH. RESEARCH THE CONNECTION BETWEEN GEOGRAPHY AND GEMSTONES AND SEE IF YOU CAN FIND OUT THE GEOLOGICAL REASONS SOME AREAS ARE NATURAL TREASURE CHESTS.

Try This

CHECK WITH A LOCAL ROCK CLUB OR LOOK IN A LAPIDARY JOURNAL TO FIND OUT IF THERE ARE PLACES NEAR YOUR HOME TO DO MINERAL COLLECTING. WHILE THEY MAY NOT BE GEM QUALITY, YOU CAN PERHAPS FIND YOUR OWN GEMS IN THE ROUGH AS YOU BUILD YOUR COLLECTION.

Try This

SINCE DIAMOND IS THE HARDEST SUBSTANCE KNOWN ON EARTH, IT OCCUPIES THE TOP SPOT (#10) ON THE MOHS SCALE. ON THE OTHER END OF THE SCALE IS THE MINERAL TALC (#1), WHICH IS SO SOFT IT'S USED FOR BABY POWDER. RESEARCH THE MOHS SCALE AND SEE WHERE OTHER GEMSTONES RANK. ALSO, SEE WHERE MATERIALS LIKE A PENNY, GLASS, AND YOUR FINGERNAIL FIT IN.

ETHANOL

What is ethanol and how does it make a car run?

What are renewable resources and why are they important?

SHOW NUMBER 1412

DAVID EXPLORES HOW WE CAN FUEL CARS WITH CORN.

SEGMENT LENGTH: 7:15

Getting Started

http://www.mnonline.org/ktca/newtons

Research fuel consumption figures for city or school buses. Compare the bus efficiency to a Ford Taurus with a 31 mile-per-gallon rating. If the Ford Taurus carries four passengers, then it gets 124 passenger-miles per gallon. If it carries just one passenger, it gets only 31 passenger-miles per gallon. How many passengers does a bus have to carry to become more efficient than using individual cars for transportation?

What kind of gasoline does your family put in your car? Does it contains any additives? Do you think the additives make a difference in how the car runs? Do they make a difference in the amount of pollution cars produce?

Overview

As the number of people in the world keeps growing, so does our need for energy. Some energy sources, specifically **fossil fuels** like coal and oil, are in limited supply. Once we use up what's in the ground, they will be gone forever. Other energy sources, such as wind, water power, and solar energy, are called renewable energy, because they will regenerate over and over again as we use them.

Ethanol is one form of renewable energy that is becoming widely used. Ethanol is a form of alcohol that can be burned in engines just like gasoline. But unlike gasoline, which is made by distilling crude oil, ethanol is made from the starchy parts of plants. Most ethanol in this country is created through fermentation of corn. Microscopic yeast cells break down the starch and water, creating ethanol and carbon dioxide gas.

In addition to being a renewable fuel, ethanol helps to reduce air pollution. When anything burns in air, molecules of that substance combine with oxygen. Gasoline is a substance made of carbon and hydrogen. When it burns, some, but not all, of the carbon atoms combine with oxygen to make **carbon dioxide** (CO_2). Hydrogen in the gasoline combines with more of the air's oxygen to make water (H_2O). There isn't enough oxygen left to combine with the remaining carbon atoms. Deadly **carbon monoxide** gas (CO) is the result. Like gasoline, ethanol is made of carbon and hydrogen, but in addition it contains its own supply of oxygen. When ethanol burns with gasoline, its "extra" oxygen atoms combine with the "extra" carbon atoms to reduce or even eliminate CO in the exhaust gases.

In some parts of the U.S., ethanol is mixed with gasoline at 1 part ethanol to 9 parts gasoline to help reduce air pollution. No adjustment is needed for a car's engine to burn this mixture. Some new cars are designed to burn fuel blends of up to 80 percent ethanol.

Ethanol costs more to make than gasoline. New production technologies may bring the price of ethanol down in the coming years.

Another disadvantage is that a gallon of ethanol doesn't hold as much chemical energy as a gallon of gasoline. So even though ethanol burns more cleanly than gasoline, a car won't go as many miles per gallon.

Connections

1. Half the oil we use in the U.S. comes from foreign countries. The plants we use to make ethanol are all grown inside this country. How would producing more ethanol affect the U.S. economy?
2. Much of the corn grown here is used to feed cattle. What might happen to meat and milk prices if more corn is used to make ethanol?

Resources

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MORRIS, D. & LORENZ, D. *HOW MUCH ENERGY DOES IT TAKE TO MAKE A GALLON OF ETHANOL?* (REV 1995) MINNEAPOLIS: INSTITUTE FOR LOCAL SELF RELIANCE WEB SITE: http://www.ilsr.org

ALTERNATIVE FUEL VEHICLES: http://www.energy.ca.gov/energy/cectext/AlterVehicle.html

BIOFUELS INFORMATION NETWORK: http://www.esd.ornl.gov/BFDP/BFDPMOSAIC/binmenu.html

BIOMASS: http://www.nrel.gov/research/industrial_tech/biomass.html

BIOMASS ENERGY ALLIANCE: http://www2.biomass.org/

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STIRRING UP A STORM

ETHANOL: Student Activity

Discover the best food to ferment.

Main Activity

http://www.mnonline.org/ktca/newtons

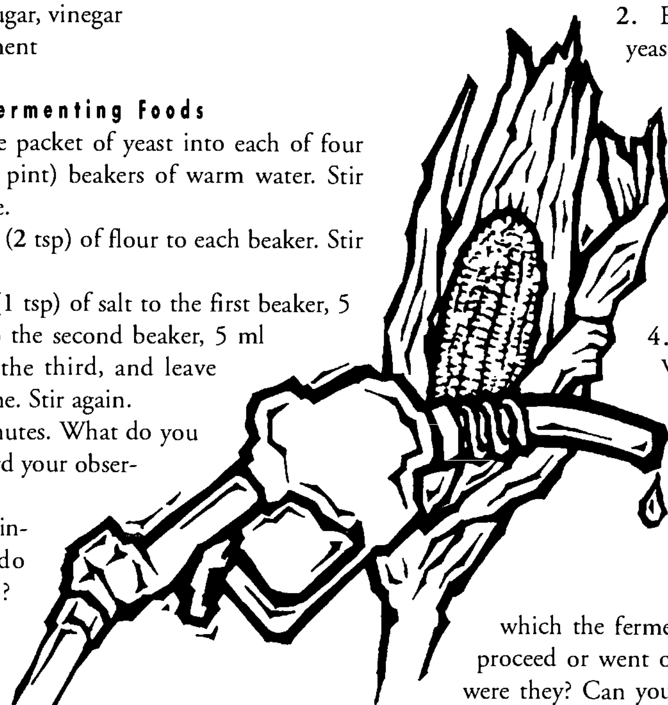
What kinds of foods are easiest to ferment for fuel? Ethanol is made from a variety of plant substances—corn, sugar cane, even some kinds of wood. In this activity, you will test different substances to see what you can learn about fermentation.

Materials

- 8 (or more) packets of yeast
- 4 clear glass, half-liter containers
- stirrers
- measuring spoons
- flour, salt, sugar, vinegar
- heating element

Part One–Fermenting Foods

1. Empty one packet of yeast into each of four half-liter (one pint) beakers of warm water. Stir for one minute.
2. Add 10 ml (2 tsp) of flour to each beaker. Stir again.
3. Add 5 ml (1 tsp) of salt to the first beaker, 5 ml of sugar to the second beaker, 5 ml of vinegar to the third, and leave the fourth alone. Stir again.
4. Wait 5 minutes. What do you observe? Record your observations.
5. Wait 15 minutes. What do you observe? Record your observations.
6. Let the solutions sit overnight. What do you observe? Record your observations.



Questions

1. What is the evidence that reactions are going on in any of the containers? How are these observations related to fermentation?
2. Can you draw any conclusions about which of the substances tested was most helpful to yeast fermentation?

Part Two–Changing Temperatures

1. In this part of the activity, you will observe the effect of different temperatures of water on fermentation. The teacher will prepare boiling water for the first beaker. Fill the second beaker with warm water—just a little warmer than skin temperature. Fill the third beaker with cold tap water. Fill the fourth beaker with ice water.
2. Empty one packet of yeast into each beaker. Stir to dissolve. Add 10 ml of flour and 5 ml of sugar to each jar. Stir again.
3. Wait 5 minutes. What do you observe? Record your observations.
4. Wait 15 minutes. What do you observe? Record your observations.

Questions

1. Were there any conditions under which the fermentation didn't seem to proceed or went only very slowly? What were they? Can you think of explanations for these results?
2. Can you draw any conclusions about what temperature is best for yeast-flour-sugar fermentation? Try many different combinations of yeast and food and temperatures. What is the optimum mixture for fermentation?

Try This

LIST ALL OF THE OBJECTS IN YOUR HOME (OR SCHOOL) THAT USE PURCHASED ENERGY INPUTS. REMEMBER APPLIANCES THAT YOU MAY NOT SEE, SUCH AS WATER HEATERS. HOW IS EACH OBJECT POWERED? WHAT FUEL IS BURNED TO PRODUCE THE POWER?

Try This

COLLECT NEW CAR BROCHURES. COMPARE EPA MILEAGE FIGURES AND PRICES FOR EACH. USE THE PRICE OF GASOLINE TO FIGURE OUT WHICH CAR WILL COST MORE OVER A FIVE-YEAR PERIOD, BASED ONLY ON THE PURCHASE PRICE OF THE CAR AND COST OF GASOLINE TO DRIVE IT 15,000 MILES PER YEAR.

Try This

ASSUME THAT A 1995 FORD TAURUS GETS 30.9 MILES PER GALLON ON A MIXTURE OF 10 PERCENT ETHANOL AND 90 PERCENT GASOLINE, AND ONLY 23.1 MILES PER GALLON WITH A MIX OF 85 PERCENT ETHANOL TO 15 PERCENT GASOLINE. IF PURE GASOLINE COSTS $1.25 PER GALLON, HOW CHEAP MUST ETHANOL BE TO MAKE THE COST PER MILE THE SAME FOR BOTH MIXTURES?

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3M Innovation

BONES

How do bones get so strong?

How are the human body and a house alike? What does our skeletal system do?

Getting Started

http://www.mnonline.org/ktca/newtons

What keeps us from flopping to the floor like a rag doll? What functions do our bones perform besides protecting our organs. Why are some of our bones big while others are very small and delicate?

Do you know how many bones we have? Name some functions of these different bones. What is our largest bone and what is our smallest? What do you think is the most important bone we have? Why?

Overview

Like a house, the human body has a framework. But instead of wood, the body's framework is made of all the bones in our skeletal system. There are long bones (arms and legs), short bones (fingers and toes), flat bones (skull and sternum), and even tiny bones (in the middle ear). Some bones, like the ribs, permit respiration and protect vital organs such as the heart from harm. Others, like the spinal vertebrae, form the framework to keep us upright as well as surround and protect the spinal cord.

Unlike a house's framework, however, the body's framework is alive—bones are living tissue. From birth until mid- to late-adolescence, bones grow as we do. They reshape themselves throughout our lives. Some of the bone cells that carry on this growth and "remodeling" work are called **osteoblasts** and **osteoclasts**. Bones grow at special areas called **growth plates**.

The outer layer of hard "compact" bone (the cortex) consists of a system of tunnels that looks like a miniature collection of hollow pipes. These tunnels keep bones lightweight, yet provide the strength necessary to support the body. The tunnels also allow for the exchange of nutrients and waste products. Collagen, a protein, gives bones their elasticity while calcium salts make them hard. Bone marrow, located in the center of our long bones, makes blood cells.

To develop properly and grow strong, our bones need **calcium**, **vitamin** D, and regular exercise. Sources of calcium such as milk, yogurt, ice cream, and broccoli provide the nutrients for continuous bone building and remodeling. Vitamin D helps our bodies absorb this calcium through the gut. Vitamin D comes either from a chemical action of sunlight on our skin or from fortified milk. Finally, regular exercise makes bones stronger by stressing them. When bones are stressed, they respond by fortifying themselves. This cycle of stress and response to stress promotes strengthening.

When we don't get enough calcium, vitamin D, and exercise, our bones deteriorate. For example, young children who are deprived of calcium and vitamin D may develop a type of bone weakness called **rickets**. Older people, particularly women, may develop a form of weak bones called **osteoporosis**.

Prevention of bone weakness is crucial—once weakness occurs, it may not be reversible. So to have healthy bones and keep our body's living framework strong and supple, we must eat foods containing calcium every day, exercise on a regular basis, and get either a moderate amount of exposure to sunlight or drink milk fortified with vitamin D.

Connections

1. What contributes to making and keeping bones strong?
2. What would happen if bones didn't grow or stopped growing too soon? What are some ways to help with this problem?

NEWTON'S APPLE®

SHOW NUMBER 1412

EILEEN REVEALS HOW AND WHY OUR BODIES MAKE OUR BONES.

SEGMENT LENGTH: 10:15

Resources

BALDWIN, D. & LISTER, C. (1984) *YOU AND YOUR BODY: THE STRUCTURE OF YOUR BODY*. NEW YORK: BOOKWRIGHT PRESS.

DINEEN, J. (1988) *HOW OUR BODIES WORK: THE SKELETON AND MOVEMENT*. ENGLEWOOD CLIFFS, NJ: SCHOOLHOUSE PRESS, INC.

GETTING CALCIUM WITHOUT THE FAT. (1996, MAY) *CONSUMER REPORTS*, PP. 48–49.

PARKER, S. (1994) *HOW THE BODY WORKS*. PLEASANTVILLE, NY: THE READER'S DIGEST ASSOCIATION, INC.

OPTIMAL CALCIUM INTAKE: http://isis.nlm.nih.gov/nih/cdc/www/97txt.html

NATION DAIRY COUNCIL
10255 WEST HIGGINS RD
SUITE 900
ROSEMONT, IL 60018-5616
(800) 426-8271

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3M Innovation

SHOW NUMBER 1412

BONES

BONE UP ON YOUR BODY

BONES: Student Activity

Make an articulated skeleton using yourself as a model.

Main Activity

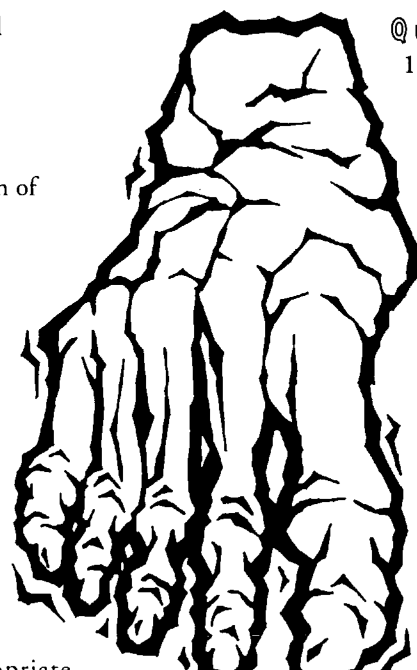
http://www.mnonline.org/ktca/newtons

Scary. Creepy. Weird. Cool. That's what you may say about skeletons on Halloween. Now you can easily make one in your classroom. Close your eyes and think of yourself as a skeleton. Imagine all your bones from the top of your head down to your toes. Did you know that when fully grown, you will have 206 bones in your body?

Materials

- poster board
- brads, medium and small
- glue
- scissors
- tape measures
- metric conversion charts
- anatomy book illustration of skeletal system
- chalkboard and chalk
- string

1. On the chalkboard, list the names of all the bones you want to include when you make your skeleton. Copy the list on paper.
2. Next, take measurements of all the bones on your list, using yourself as a model. Write measurements next to the appropriate bone on the list.
3. Either working in a small group or individually, start drawing your bone pieces on your poster board, using your measurements. Label all your pieces so you will know which are which. Then, cut out the pieces. Finally, connect the various bones using brads or glue.
4. When you have completed your skeleton, insert a string near the top of its head and hang your masterpiece in the classroom.



Questions

1. What things did you notice about your skeleton that are different from the real you? How could this skeleton move?
2. What did you notice about the bone sizes? Where are big bones? Little ones? Why?
3. What do the brad connectors and your joints have in common? Why is it necessary to use brads for joining some bone but not others?

Try This

Bring clean, dry chicken bones to class. Place half the bones in a bowl with a lid and cover them with vinegar. Place the remaining bones in a similar bowl and cover them with water. Cover the bowls. Check the bones daily for ten days. What effect did the different solutions have on the bones? Why?

Try This

Ask a radiologist or orthopedic surgeon from a local hospital to bring in some bones or portions of a skeleton as well as some X-rays used to examine bones. X-rays of broken bones would be especially interesting.

Try This

Discuss the daily calcium needs of a 16-year-old athlete in training. Design a one-day diet that would meet her or his daily calcium requirements as well as all other nutritional needs. What are all the things you have to consider in planning this diet? What percentage of calcium is needed in it? What types of foods provide calcium?

WETLANDS

What are wetlands and why are they so important?

What type of wildlife lives in wetlands? Why do people drain or fill them in?

Getting Started

http://www.mnonline.org/ktca/newtons

Collect about 1/4 liter (1 cup) each of several different soil types. Try sand, clay soil, forest soil, and any others you can find. Air-dry them. Put each soil sample in its own coffee filter and fit the filter into the neck of a jar. Tape it in place. Pour 1/2 liter (2 cups) of water into each jar, very slowly. The water that goes into the jar is water that the soil couldn't hold. How do they differ?

Do you live near a wetland? How is it unique from other areas? What kinds of wildlife live in the wetland? How does the wetland change from season to season? Which soil do you think would be best in a wetland? Why?

Overview

Heated controversy has surrounded attempts to preserve **wetlands**. For decades, many thought wetlands were mucky, mosquito-infested places and drained them to use as farmland, industrial sites, or residential areas. Fewer than half as many acres of wetlands remain in the continental United States compared with when the first European settlers arrived about 500 years ago. Now, wetlands are recognized as important wildlife refuges and water purification systems.

Wetlands are areas that have standing water for at least part of the year. Marshes, swamps, tidal flats and associated pools, bayous, and bogs are the most common. Marshes are water-saturated, poorly drained areas with both aquatic and grasslike plants. Swamps, unlike marshes, have trees and bushes. Water flows into swamps and marshes from streams, or even an ocean. Bogs are waterlogged, spongy ground in former lakes now filled with living and dead mosses, which eventually become peat.

Wetlands are important for many reasons. They support a large volume of plants, which in turn supply cover and food for animals. Wetlands retain water like a giant sponge—flowing water is slowed as it passes through and is absorbed by plants and soils. By soaking up the water, wetlands not only prevent **floods** but make water available during a drought. They also help reduce the threat of low salinities in coastal waters.

Wetlands can also clean up contaminated water. Organisms and soils in a wetland act as a filter for **fertilizers** and other pollutants. **Algae** and bacteria break down mineral and organic matter, which can then be used as food for plant life. Some municipalities use wetlands as the final stage in treating waste from **sewage treatment plants**. Other communities are actually constructing wetlands for this purpose. However, wetlands can't perform miracles. They can be ruined by too much waste.

Because the economic and health benefits of wetlands are now well known, Congress has passed several laws protecting them. However, in many areas developers want to build on the land, farmers want to cultivate it, and oil companies want to remove the oil under the ground. As long as our population keeps growing, the struggle over what will become of the wetlands will continue.

Connections

1. Flooding has always been a problem in many parts of the world, but it appears to be a growing problem. Why? What can we do to prevent it?
2. Imagine that you own property designated as a wetland. Should you be able to do whatever you want with that land?

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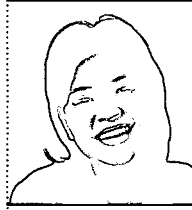

SHOW NUMBER 1413

SUCHIN SLOSHES THROUGH WETLANDS TO DISCOVER THEIR ECOLOGICAL ROLE.

SEGMENT LENGTH: 7:00

Resources

LEVANTINES. L. (1995. JULY-AUG) SCIENCE GETS SWAMPED. *AUDUBON*, P. 112.

LEWIS. W.M., JR. (1996, JULY) WETLANDS ON THE LINE. *GEOTIMES*, P. 5. (THIS ISSUE INCLUDES OTHER ARTICLES ON WETLANDS)

MANKS. M. (1996, JUNE-JULY) THE BEAUTY OF WETLANDS. *NATIONAL WILDLIFE*, P. 20.

NIERING. W.A. (1985) *WETLANDS: THE AUDUBON SOCIETY GUIDES*. NEW YORK: ALFRED A. KNOPF, INC.

ROOD. R. (1994) *WETLANDS*. NEW YORK: HARPER COLLINS.

RYBOLT, T.R. & MEBANE, R.C. (1993) *ENVIRONMENTAL EXPERIMENTS ABOUT LIFE*. HILLSIDE. NJ: ENSLOW PUBLISHERS, INC.

U.S. FISH AND WILDLIFE SERVICE—NATIONAL WETLANDS INVENTORY: http://www.nwi.fws.gov/

WETNET (INCLUDES VIRTUAL BIRD TOUR): http://www.wetlands.ca//

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NEWTON'S APPLE

SHOW NUMBER
1413
WETLANDS

INSECT INVENTORY

WETLANDS: Student Activity

Examine the insects that live in a nearby pond or stream.

Main Activity

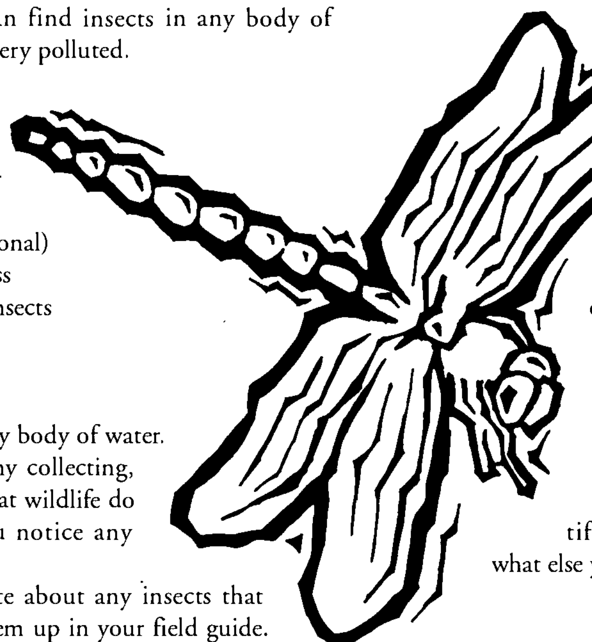
http://www.mnonline.org/ktca/newtons

(Note: This activity should be done before the first frost of fall or after spring thaw.)

Wetlands are important habitats for animals. One kind of animal that you might not think to look for there is insects. Yet there are more species of insects than of all the other animal species combined, and they live in almost all known habitats on earth. You can find insects in any body of water, unless it's very polluted.

Materials

- kitchen strainer
- jars
- insect net (optional)
- magnifying glass
- field guide to insects
- notebook
- pencil



1. Go to a nearby body of water. Before you do any collecting, look around. What wildlife do you see? Do you notice any insects?
2. Draw or write about any insects that you see. Look them up in your field guide. Can you identify them?
3. See if you can catch any insects. Put them in a jar to take back to the classroom.
4. Now look in the water. What wildlife do you see? Do you notice any insects?
5. Pull your strainer through the water and look at what animals you catch. If it isn't a fish or polliwog, chances are it's an insect. Put any insects you catch in a jar with some water.
6. Draw or write about the insects you caught. Were there any you could see that you couldn't catch? Look them up in your field guide. Can you identify them?
7. Chances are that many of the insects you see in the water are larval stages of the insects you see on land and in the air. Many insects start their lives in water and then move out of the water as they mature. Can you figure out which of the insects you caught in the water are an earlier stage of the same insects you saw on land?
8. Take the insects you caught back to the classroom and try to identify them more clearly. See what else you can learn about them.

Questions

1. How would the food chain change if many insects didn't have aquatic life-history stages?
2. What roles do insects have in nature?

Try This

RESEARCH A WETLANDS CONTROVERSY IN YOUR COUNTY OR STATE. FIND A SITUATION WHERE SOMEONE WANTED TO DEVELOP A WETLAND SOMEHOW. WERE THERE PEOPLE WHO WERE AGAINST THAT? WHO WERE THEY? WHAT WERE THE ARGUMENTS FOR EACH SIDE? HOW WAS IT RESOLVED? WHAT DO YOU THINK?

Try This

GO TO A WETLAND AND MEASURE AN AREA 1 METER X 1 METER (3.3' X 3.3'). COUNT HOW MANY DIFFERENT SPECIES OF PLANTS YOU FIND IN THAT AREA. SEE IF YOU CAN IDENTIFY ANY OF THEM. THEN MEASURE THE SAME AREA IN A FIELD OR FOREST. HOW MANY DIFFERENT SPECIES OF PLANTS DO YOU FIND THERE?

Try This

PREDICT PUDDLES. BEFORE A RAIN, LOOK AT YOUR YARD OR THE SCHOOL GROUNDS. WHERE DO YOU THINK PUDDLES WILL FORM? PUT MARKERS WHERE YOU THINK WATER WILL GATHER. DO YOU THINK IT WILL STAY LONGER IN ONE PLACE THAN ANOTHER? WHY? AFTER THE RAIN, GO CHECK OUT YOUR HYPOTHESES. WERE YOU RIGHT? ARE ANY ANIMALS USING THE PUDDLES?

DRINKING WATER

How do we get the impurities out of drinking water?

Where does drinking water come from?

Getting Started

http://www.mnonline.org/ktca/newtons

Water has been called the universal solvent because it can dissolve just about anything over time. How does the solubility of water change with temperature? See how much salt you can dissolve in equal volumes of water at different temperatures. How can you use your test results to make predictions about water solubility around the world?

Overview

Each day, millions of Americans use billions of gallons of water without knowing where it comes from or what might be in it. As populations grow, the combination of increased demand and increased pollution means many of us are using sources of water that are less than pristine. Contamination from **sediment**, bacteria, **protozoans**, heavy metals, and synthetic organic compounds shows up with alarming frequency. As a result, many municipalities are having to pre-treat drinking water.

The first step in most municipal treatment systems involves gravity. If you've ever let a glass of chocolate milk stand for any length of time, you've probably noticed that much of the chocolate settles to the bottom of the glass. The same is true of sediment in water. When the water is allowed to stand in large pools, many of these suspended particles simply settle to the bottom where they are collected and disposed of.

Next comes **flocculation**. Here, a chemical is added to the water that causes tiny suspended particles to clump together. Usually, these flocs settle out just like large-sized sediment. But if they escape, they are caught by filters farther down the line.

To kill unwanted **microbes**, protozoans, and other living organisms, many municipalities chlorinate the water. Chlorine is a chemical that kills microorganisms. In drinking water, the concentrations are low enough that often you can't even taste it.

The final stage in most municipal treatments is **filtration** and aeration. Water is pumped through large tanks filled with fine sand, called rapid sand filters. As the water flows through the spaces between the sand grains, suspended particles and dead microbes get trapped. Sometimes, crushed anthracite coal is used in addition to sand. Because the coal grains carry a charge on their surface, they act like tiny magnets attracting other charged contaminants. Aeration is exactly what it sounds like—adding air to water. When sprayed through large, fountainlike devices, water not only gains a great deal of oxygen, but any volatile compounds that may have been in the water escape into the atmosphere.

In the end, all the water we use doesn't just go down the drain and disappear. It gets recycled by the evaporative power of the sun. When water evaporates, most of the contaminants stay behind, which in theory means it rains pure water back on the land. Unfortunately, because of gases in the air, much of the water that falls from the sky is coming down prepolluted, so municipalities are going to have to work even harder in the future to treat the water we drink.

Connections

1. Before municipal water treatment became common, wetlands, streams, and grasslands provided much of the same cleansing action. How do these "natural" systems compare with municipal treatment methods? Would it be worth going "back to nature" to help get the job done?
2. Many municipalities are looking for solutions to water shortage problems. How do processes like ocean water distillation, water recycling, and deep aquifer recharge measure up?

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SHOW NUMBER 1413

DAVID DIVES IN TO SEE HOW WE MAKE WATER SAFE TO DRINK.

SEGMENT LENGTH: 6:30

Resources

HUGGLER, T.E. (1994, APR) AND NOT A DROP TO DRINK: WATER TREATMENT ON A WILDERNESS TRIP. *OUTDOOR LIFE*, P. 48.

KOTZ, D. (1995, NOV) HOW SAFE IS YOUR DRINKING WATER? *GOOD HOUSEKEEPING*, P. 128.

POWLEDGE, F. (1982) *WATER*. NEW YORK: FARRAR STRAUS GIROUX PUBLISHING.

SODA BOTTLE HYDROLOGY. U.S. DEPARTMENT OF ENERGY PUBLICATION DOE/EM-0215. (301) 903-4000.

STUDENT ACTIVITY SHEETS FOR DRINKING WATER PROJECTS. (1992, JULY) U.S. ENVIRONMENTAL PROTECTION AGENCY PUBLICATION 810/F-92-003. (202) 260-2090.

3-2-1 CONTACT EXTRA: *DOWN THE DRAIN*. AVAILABLE THROUGH WINGS FOR LEARNING. (800) 321-7511.

HYDROLOGIC INFORMATION UNIT
U.S. GEOLOGICAL SURVEY
419 NATIONAL CENTER
RESTON, VA 22092

SOIL AND WATER CONSERVATION SOCIETY
7515 NE ANKENY RD
ANKENY, IA 50021-9764

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STILL WATERS

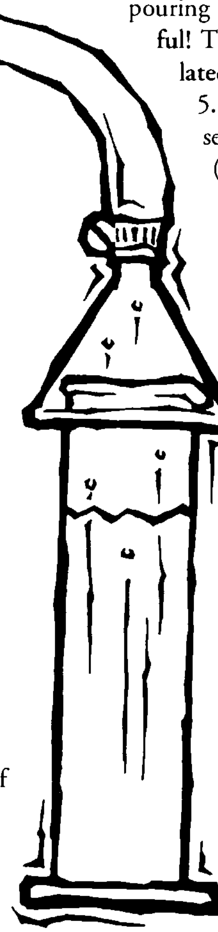
DRINKING WATER: Student Activity

Calculate how much energy it takes to distill drinking water.

Main Activity

http://www.mnonline.org/ktca/newtons

Since new sources of freshwater are hard to come by, some people have suggested using distilled seawater as a source of drinking water. In this activity, you will build a still and discover some of the costs associated with producing freshwater from the sea.



Materials

- 1 liter clean tap water
- 25 ml table salt
- clean 1000-ml beaker
- clean 1000-ml flask
- clean 500-ml beaker
- clean glass funnel with narrow (½″ O.D.) opening
- clean 1-meter length of ½″ I.D. high temperature plastic tubing that will fit snugly on the funnel
- electric hot plate
- graduated cylinder
- ring stand with test-tube clamp
- watch with second hand
- pot holder or oven mitt
- stirring rod
- paper and pencil
- goggles

1. Pour 25 ml table salt into 1 liter of clean tap water in the larger beaker to make your simulated seawater. Pour the seawater into the flask.
2. Place one end of the plastic tubing over the narrow end of the funnel. It should fit snugly. If not, secure with a hose clamp or rubber bands.
3. Place the flask on the hot plate and invert the funnel so that the wide end sits over the top of the flask. Use a test-tube clamp on the ring stand to hold the funnel in place and run the other end of the tubing into the empty 500-ml beaker.
4. Record your start time and turn on the hot plate to its highest setting for 15 minutes. The water will begin to heat up and boil. After 15 minutes, turn off the hot plate. Allow the system to cool down for 10 minutes and then record how much water has collected in the beaker by pouring it into the graduated cylinder. **Be careful! This water will still be hot. Use an insulated glove!**
5. Check the bottom of the hot plate to see how many watts of electricity it uses. (If there is no power indication, use 1000 watts, which is average.) Calculate the total amount of energy used to distill your sample by multiplying the wattage by .25 hours (15 minutes). Convert this number to kilowatt hours by dividing it by 1000. Example: 1000 watts x .25/1000 = .25 kW hrs.
6. Based on your experiment, calculate how much electricity would be required to distill one full liter of seawater. To do this, take 1000 ml and divide it by the volume you collected, then multiply by the amount of power you used in kW hrs. Example: If you collected 100 ml of fresh water: 1000 ml/100 ml = 10 x .25 kW hrs = 2.5 kW hrs of electricity/liter. Then use your electric company's current rate per kilowatt hour to discover the cost.

Questions

1. Based on your observations, what can you conclude about making "freshwater" from seawater?
2. Using the average billing rate for electricity in your community, how much would it cost you to make one liter of freshwater from seawater?
3. Are there any changes that you could make in the design of your still that would make this more efficient?

Try This

MANY PEOPLE ARE SERVICED BY MUNICIPAL SYSTEMS THAT GET WATER FROM EITHER SURFACE OR UNDERGROUND SOURCES. MANY RURAL HOME OWNERS HAVE THEIR OWN WELLS. DISCOVER THE SOURCE OF YOUR DRINKING WATER AND MAKE A MAP OF ITS PATH TO YOUR TAP.

Try This

DESIGN YOUR OWN SOLAR STILL. REMEMBER, THE WATER CYCLE WORKS BECAUSE FRESHWATER IS EVAPORATED FROM THE LAND AND SEA SURFACE BY THE SUN'S HEAT. SEE IF YOU CAN DESIGN AND BUILD YOUR OWN SOLAR SYSTEM TO TRANSFORM SALTWATER TO FRESH.

Try This

WHY IS THE OCEAN SALTY IF IT IS FED BY RIVERS CARRYING FRESHWATER? WITH THE EXCEPTION OF DISTILLED WATER, ALL FRESHWATER HAS SOME DISSOLVED MINERALS (SALTS) IN IT. TO SEE HOW SALTY YOUR WATER IS, PUT ONE LITER OF WATER IN A CLEAN SAUCEPAN AND ALLOW THE ENTIRE VOLUME TO EVAPORATE. THE MATERIALS LEFT BEHIND ARE THE FORMER MINERALS THAT WERE IN SOLUTION.

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Science Try-Its

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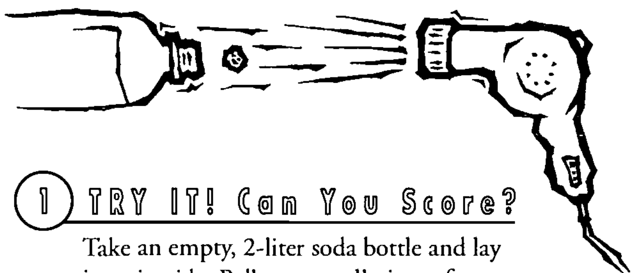
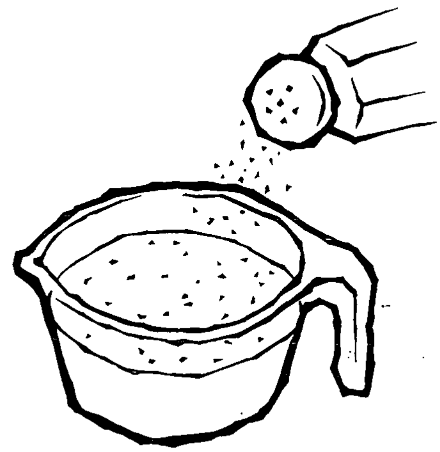


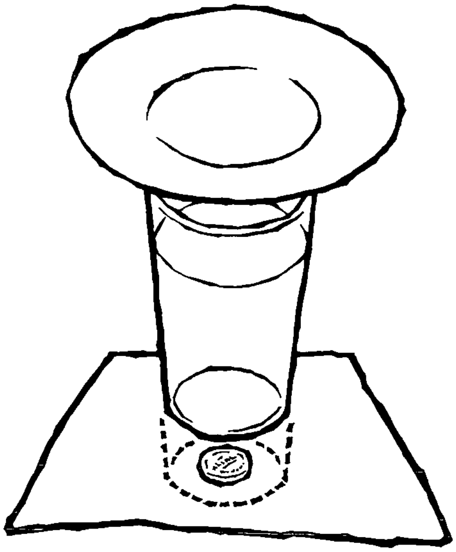
1 TRY IT! Can You Score?

Take an empty, 2-liter soda bottle and lay it on its side. Ball up a small piece of paper so that it will fit through the mouth of the bottle. Hold a hair dryer so it blows directly on the mouth of the bottle. Try to push the paper into the bottle using the air stream from the hair dryer. What do you think will happen to the paper? You'll have to try it!



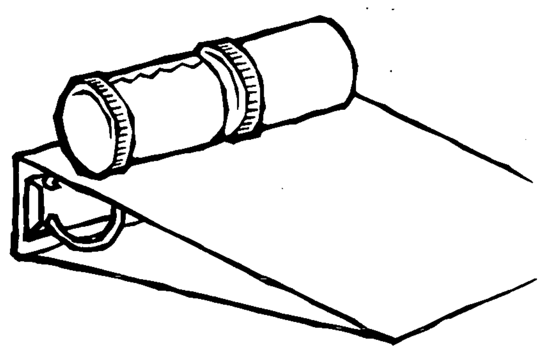
3 TRY IT! Pepper It Up!

Fill a dish with water. Sprinkle pepper all over the top of the water. Put several drops of dish detergent into the center of the dish. What happens to the pepper? Is the same thing happening over the whole surface of the water, or just in the middle? You'll have to try it!



2 TRY IT! Outta Sight!

Place a penny on a white piece of paper. Put a clear glass filled with water on top of the penny. Can you see the penny? Where is the best place to see it? Now place a saucer on top of the water glass. Try to find the penny without looking straight down through the water glass. Can you do it? You'll have to try it!



4 TRY IT! Racing Jars

Take two identical clear-glass jars, leave one empty, and fill one with water. Put the lids on both jars and tighten. Place a large, three-ring binder on a level floor, and start the jars from the top of the "ramp" the binder forms. Release them and watch what happens. Which one gets to the bottom of the ramp first? Which one rolls the farthest? You'll have to try it!

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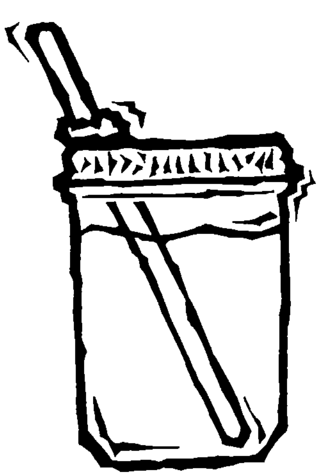
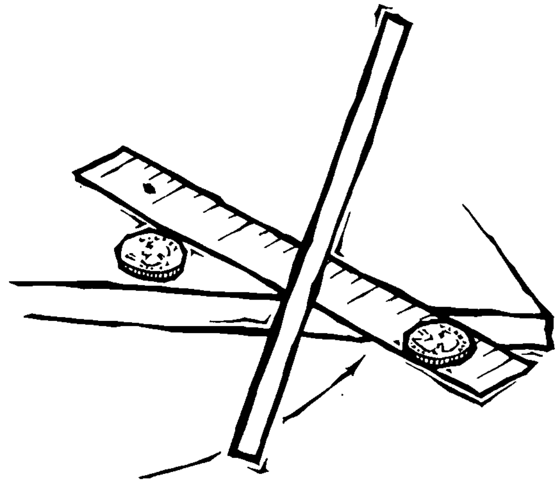
Science Try-Its





5 TRY IT! A Sucker's Bet

Fill a small jar with water. Poke a hole in the lid big enough for a straw. Put a straw into the water through the hole in the lid and seal up the space around the straw with modelling clay. Now try to suck water through the straw. Be sure there are no leaks. What happens? You'll have to try it!

6 TRY IT! Projectiles and Satellites

Put a quarter at the edge of a table. Put the edge of a ruler behind the quarter, with the rest of the ruler extending out over the table edge at an angle. Put another quarter on the end of the ruler that extends beyond the table edge. Take a second ruler and hit the first ruler (on the edge sticking out beyond the table edge) so that the first quarter is thrown off the edge of the table and the second drops off the ruler. You have to listen for the results so you want to do this over a hard floor. Listen carefully: Which quarter hits the ground first? You'll have to try it!

The science behind Science Try-Its

1. Why won't the paper go into the bottle?

In trying to push the paper into the bottle, you are aiming the air stream at the mouth of the soda bottle. The hair dryer pushes air into the bottle, filling it with air. In fact, the bottle is so full of air that there is room for nothing else—not even a little ball of paper. If you turn off the hair dryer or aim it away, the air can escape the bottle and there is room for the paper.

2. How did the penny disappear?

We see objects because light rays reflect off them and into our eyes. But light bends each time it hits a substance of a different density. The light reflecting off the penny must pass through air, glass, and water (all with different densities) to get to your eye but the light bends so many times that by the time it gets to your eye, it looks like it's someplace it's not!

3. Why did the pepper "run away"?

The pepper sprinkled on the water stays in place because the water is pulling on the pepper evenly in all directions. When the detergent comes into contact with the water in the center, it reduces the water's pulling action on the pepper and the pepper appears to run away from the detergent. But the water around the edges (untouched by the detergent) still has its pulling strength.

4. Why did the empty jar win?

Initially, the water-filled jar moves down the ramp faster than the empty one. This happens because its weight is evenly distributed throughout its volume, thanks to the water inside it. The empty jar's weight is all in the glass perimeter so it doesn't roll quite as fast. But as the jars begin rolling on the flat surface, the greater weight of the full jar causes friction between the jar and the floor as well as friction between the water and the inside of the jar. The full jar slows down, allowing the lighter, empty jar to take the lead!

5. Why couldn't I get any water from the jar?

When you drink from an open glass of water, air pressure allows the water to travel up the straw. When you reduce the pressure inside your mouth (by sucking on the straw), the surrounding air pressure pushes down on the water and forces the liquid up the straw. But when air pressure on the water is blocked (when you seal the jar lid), there is no air pressure to help push the water up your straw. The air can't get to the water to push on it, so it doesn't go up the straw. Regardless of how hard you suck, the water stays where it is!

6. Why did the quarters land at the same time?

The quarters start from the same height off the ground and are the same mass and shape, so gravity and air resistance worked on them in exactly the same way. Even if an object is thrown straight out, it will fall to the ground in exactly the same amount of time as an identical object that is dropped—the acceleration toward the ground that the objects experience as a result of gravity causes them to hit at the same time.

NEWTON'S APPLE®

HOW STREET SMART ARE YOU?

STREET SMART

1. What's the easiest way to catch a cold?

A. Sneezing
B. Sharing toothbrushes
C. Shaking hands
D. Going outside without a coat

2. What animal has the longest tail?

A. Armadillo
B. Giraffe
C. Anteater
D. Horse

3. What mammal gets the most sleep?

A. European hedgehog
B. Human being
C. Sperm whale
D. Kodiak bear

4. What's the largest reptile in the world?

A. Python
B. Alligator
C. Komodo dragon
D. Crocodile

5. In a day, how many minutes are your eyes closed from blinking?

A. 216 minutes
B. 30 minutes
C. 120 minutes
D. 3 hours

6. If all you had was beans to eat, what would be the most nutritious?

A. Lima beans
B. Soybeans
C. Kidney beans
D. Kazuke

Street Smart ANSWERS

1. Not so glad to meet you!

Going outside without a coat can make you more susceptible to colds, but the easiest way to catch a cold is by **shaking hands** with someone. A cold is a virus and your body causes you to sneeze and cough in an immune response to the virus—your immune system is trying to destroy the virus. All that sneezing and coughing causes some of the viral cells to be expelled in the mucous that comes from your nose and mouth. And some of that can get on your hands. The virus can remain infectious on your hands for up to three hours. And if you meet someone and shake hands, you've given them an unwelcome gift!

2. Now that's a tall tail!

The animal with the longest tail also has a pretty long neck—*Giraffa camelopardalis,* also called the camel-leopard by the ancient Romans. It's the **male giraffe.** This skinny guy's tail can grow up to eight feet. The female giraffe's tail may not be as long, but like the male, she has blunt, skin-covered horns on her head. And no wonder the Romans called them camels—giraffes can go up to one month without a drink of water!

3. Yawn! Dig this bedtime story!

The sleepiest animal in the world is the **European hedgehog.** This prickly animal couldn't work a nine to five—it sleeps 18 hours a day in the summer, and all winter through. And it still has time for a family—in July or August, female European hedgehogs give birth to four to eight young. Because the European hedgehog has a coat of long pointed spines, it looks like a porcupine. But it's really closely related to the mole and the shrew.

4. Bigger than Jaws!

Just when you thought it was safe to go back in the water, beware; the largest reptile is the carnivorous **saltwater crocodile**, found in the coastal waters of India, southern China, and Malaysia. It can grow up to 26 feet, which, by the way, is longer than a great white shark. Like all members of the crocodile family, which evolved 200 million years ago, this amphibious creature differs from a lizard in two ways: it has bony plates on its back that make a kind of body armor and it has its teeth set into its jaw (like people do). It also can either walk upright or on all fours.

5. Open your eyes to this fact!

If you add up all those flickers, your eyes are closed for an average **30 minutes** a day. Blinking is like a quick shower for your eyes. By bathing them with tears, blinking keeps your eyes from drying out and washes away dust that gets in your eyes. But how do your eyelids stay healthy? On the edges of the eyelids are a number of small glands that produce a fatty secretion that lubricates your eyelids and the eyelashes to keep them in tip-top shape!

6. Now that's a healthy bean!

Let's hear it for the **soybean**! It's loaded with lots of protein, vitamins, potassium, magnesium, and iron. Soybeans have ten times the calcium of meat and twice that of eggs, and soybeans are low in fat. Soybeans were first grown in eastern China and brought to the United States in the 1800s. Today, it's the third leading crop, behind corn and wheat, in this country. Soybean products are protein meal, which is used as a dietary supplement in livestock feed, and oil, which is used in margarine, mayonnaise, salad oil, and other edibles. But this will surprise you: that same edible soy oil is used in industrial products such as paint, varnish, linoleum, and rubber fabrics. Versatile, wouldn't you say?

NEWTON'S APPLE is pleased that many of our viewers watch our show at school in their classes and at home as a family. Regardless of whom you are watching with, we encourage you to talk about the adventures you see on NEWTON'S APPLE and think about how science is all around you.

NEWTON'S APPLE's "Science Try-Its," "Street Smarts," "Most Scientific Home Videos," and regular demonstrations on the show allow home viewers to be part of the science action. Fun and easy to try at home, these activities help everyone learn together!

Do you have a science question about the world around you? Write us at:

NEWTON'S APPLE
Box 1500
172 4TH ST E
SAINT PAUL MN 55101

We may answer your question on the show!

NEWTON'S APPLE 14th Season

This special guide to our 14th season will let you know what topics are coming up in each new show. Check with your local PBS station for the exact dates and times that NEWTON'S APPLE airs in your area.

1401
Spelunking
Human Eye
Betty White
Elks

1402
Tahiti Special
Sharks
Tattoos
Black Pearls
Coconuts

1403
Riverboats
Body Fat
Motorcycle Scientists
Parrots

1404
Hypercoaster
Nicotine
Erasers
Dance Scientists

1405
Avalanche Rescue
Prosthetic Limbs
Football Scientist
Popcorn

1406
Andes Special
Inca Engineering
Quipus
Potatoes
Alpacas

1407
Ski Jumping
Bee Stings
Fear
Ruminants

1408
Rain Forest Special
Rain Forest Researchers
Snakes
Frogs
Leaf Cutter Ants

1409
Olympic Solar Energy
Soccer
Trumpets
Earthquake Scientist

1410
Malaria Tracking
Clocks
Inventor's Fair
Deformed Frogs

1411
Post Office
Gems
Science Home Videos

1412
Ethanol
Bones
Coyotes

1413
H_2O Special
Wetlands
Eco-Filtration Pond
Drinking Water
Water Towers

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.

3M Science Encouragement Programs (K-12)

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, and science doesn't begin in our labs. At 3M, we believe that 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, both on a local and national level, that are designed to raise the level of student learning. Our efforts are maximized through employee and retiree volunteers, who serve as tutors, mentors, and hosts, helping us support science education around the globe for kindergartners on up to high school students.

As NEWTON'S APPLE demonstrates in its weekly, award-winning programs, the power of science is limited only by the imagination. And as many 3M Science Encouragement students will attest, the wonders of science once unveiled 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 more than a quarter of a million children. On Super Science Saturday, more than 500 Wizards host a day-long science fair for their families, the 3M community, and other local community groups.

Elementary Teacher Workshop

Elementary school teachers gain ideas on how to incorporate fun in science lessons at this 3M-sponsored resource fair. About 600 teachers annually participate in the hands-on activities of this regional event.

TWIST (Teachers Working in Science and Technology)

Twenty-five science and math teachers learn real-world research applications while working alongside 3M scientists in this summer program. The six-week internship gives teachers practical understanding of science and math concepts through firsthand technical experience in an industrial laboratory.

TECH (Technical Teams Encouraging Career Horizons)

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

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STEP (Science Training Encouragement Program)

Academic mentoring and technical experience are cornerstones of this program, which lets minority and at-risk students explore their interests in scientific careers. High school students from St. Paul, MN develop relationships with "modern-day heroes" and culturally diverse 3M technical mentors, while holding full-time summer jobs in 3M laboratories.

Richard Drew Creativity Award Program

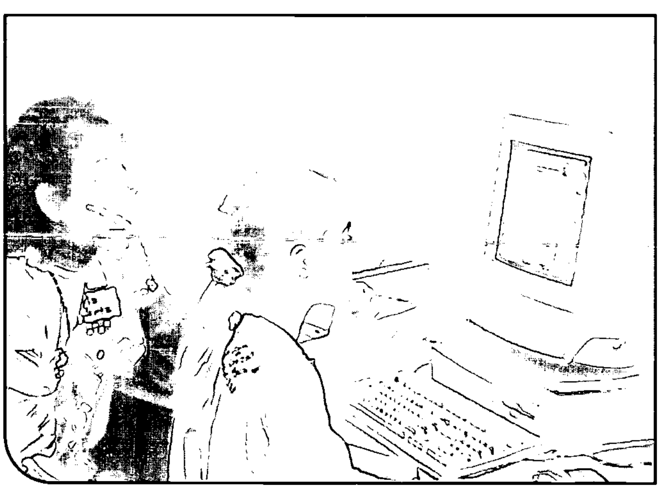
Honoring students for their creative instincts in science and math is the emphasis of this award program. The program captures the spirit of 3M scientist Richard Drew, who is remembered for his creative nature and for encouraging creativity in others. High school juniors from more than 200 Minnesota and Wisconsin schools are invited to 3M Center to celebrate the joy of creativity in science. The event includes tours of 3M laboratories, a careers-in-science panel discussion, and an evening program with parent participation.

Science Student Recognition Day (SSRD)

The first and longest-running 3M Science Encouragement program, SSRD invites 100 Upper Midwest high school seniors and their teachers to spend a day in our laboratories with 3M scientists and engineers. The program helps students see the link between academic training and real-world science careers.

Hillside Elementary Internet Project

A collaborative effort between Hillside Elementary School, the University of Minnesota College of Education, and 3M is bringing the world into classrooms via the Internet. Through this project, a seven-year-old student researched a report by contacting a science museum in Philadelphia and exchanging information with an eight-year-old in New Zealand. This dynamic program represents a benchmark for education in adopting the Internet as a learning tool.



Educational Outreach

3M supports local and national organizations that promote science and technology education and awareness. 3M shows its commitment through grants, educational materials, and volunteerism. Currently, 3M supports events and organizations including: MATHCOUNTS, National Engineers Week, National Science and Technology Week, 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. For example, 3M employees and their families volunteered to demonstrate the science activities on the NEWTON'S APPLE poster in this packet.

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

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

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Key Concepts

NEWTON'S APPLE

AVALANCHE RESCUE

air scenting finding odors that are drifting through the air without having an odor trail to follow on the ground
cilia minute hairs that move when stimulated and trigger nerve impulses that send signals to the brain
nerve cell the cell that transmits electrical signals to the brain and other parts of the body; also called a neuron
olfactory system the combination of mucus, cilia, nerve cells, and other structures that allow animals, including humans, to smell odors
SAR the "search and rescue" acronym commonly used by rescue groups and a good search word on the Internet

BEE STINGS

apiary a group of human-made beehives placed together to make beekeeping easier
defensive zone the area around the hive
defensive behavior an aggressive action taken against any disturbance in the defensive zone
drones male bees, few in number, that mate with the queen bee
pheromone a chemical odor used for communication
queen the only female in the hive who can reproduce by laying eggs
worker bees female bees who perform most of the tasks; the majority of the bees in a colony

BLACK PEARLS

aragonite one mineral form of calcium carbonate, laid down in overlapping layers as the principal constituent of a pearl
conchiolin the organic, gluelike substance that cements the layers of aragonite together in a pearl
epithelial cells the outer layer of mantle cells in a pearl mollusc; they produce the aragonite and conchiolin necessary to make nacre
mantle the outer membrane of a mollusc, just inside the shell and covering the soft tissue
nacre the solid, shiny coating that a pearl mollusc secretes over the inside of its shell and any irritants or foreign objects
nucleation the process of infecting the pearl mollusc with an irritant to initiate the production of nacre for pearl culture
orient an iridescent sheen exhibited by some of the best pearls
pearl mollusc any shelled sea or freshwater creature that produces a nacreous coating on objects
spat newborn oyster larvae, which eventually attach themselves to an object

BODY FAT

calipers a tool that can be used to measure body fat
carbohydrates a food group that includes sugars, starches, and cellulose
fat adipose tissue; a group of storage cells that store fat molecules
enzymes substances that help speed up chemical changes; in digestive processes, these are called organic catalysts and are usually proteins
metabolic rate the rate at which our bodies use up energy, or "burn" calories
muscle a group of cells that work together to enable movement; they weigh more than an equal amount of fat cells
protein a nutrient used for growth and repair of our muscles and organs

BONES

calcium a mineral that is vital to bone development
growth plate a disk of cartilage along which bones extend their length or size
lacunae a small space, cavity, or depression; a hollow
mineral an essential element that helps keep our organs working smoothly
osteoblast a cell that builds or produces bone
osteoclast a cell that absorbs bone under certain conditions such as fractures
osteoporosis a thinning of bone that occurs with aging or inactivity
rickets a bone disease of infants or juveniles in which vitamin D deficiency causes skeletal deformities
vitamin D a vitamin needed for development of healthy bones and teeth

CLOCKS

atomic clock a very accurate clock that keeps time by measuring the natural oscillations of a cesium atom
horology the science of measuring time
obelisk an upright, four-sided pillar that tapers to a pyramid at its top
oscillate to swing back and forth; with electricity, to switch between a high and a low charge
quartz crystal when placed in an electric field, a quartz crystal vibrates and generates a regular electric signal that is a good resonator for running clocks and watches
spring-driven clocks a tightly wound spring provides the energy for these clocks, but they slow down as the spring unwinds
weight-driven clocks old mechanical clocks that used the pull of a heavy weight to provide energy to run the clock

DRINKING WATER

alum a colorless aluminum salt used as a flocculating agent in water treatment
filtration mechanically separating out particles from a liquid such as water
flocculant a chemical which causes tiny suspended particles to clump together into loosely packed flakes
ion a charged atom
microbe a microscopic organism such as a bacterium or a protozoan
osmosis the process where a solvent moves across a semipermeable membrane to an area of higher concentration
protozoan a microscopic organism such as an amoeba which is made of a single cell
sediment sand, silt, clay, and organic material that can be suspended in water and filtered out

ETHANOL

carbon dioxide a gas with molecules made up of one carbon atom and two oxygen atoms; part of the air that is released when living things respire
carbon monoxide a poisonous gas with molecules made up of one carbon atom and one oxygen atom
fossil fuel fuel derived from fossil matter of a previous geologic age, such as petroleum, natural gas, and coal
gasohol gasoline mixed with a smaller amount of ethanol, such as a mixture of 90 percent gasoline and 10 percent ethanol
methanol often called wood alcohol; formed from synthesis gas and by distillation of wood, coal, or farm wastes
photosynthesis process by which plants turn carbon dioxide and water into glucose, using the sun's energy to drive the reaction
volatile organic compounds (VOC) hydrocarbon compounds released by the incomplete combustion of gasoline and other fuels, which contribute to air pollution

GEMS

cabochon a gemstone that has been polished into a dome shape
carat a unit of measurement for weighing gemstones; 5,000 carats (cts) equal 1 kilogram
crystal a mineral that has a regular geometric internal structure, which is reflected in its external shape
gemstone a mineral that has a high market value because of its rarity, beauty, hardness, and durability
inclusion a small amount of gas, liquid, or mineral matter trapped in a gemstone when it was forming
lapidary a person who cuts, polishes, and sets gemstones
refraction the bending of light as it passes from one medium to another

HUMAN EYE

cornea the clear, curved portion of the eyeball directly over the iris and pupil
iris the colored portion of the eye that opens and closes the pupil in response to light intensity
lens the flexible, clear, lentil-shaped object just behind the pupil
optic nerve the nerve in the back of the eyeball that carries impulses from the retina to the brain for interpretation
pupil the hole in the center of the iris
retina the light-sensitive layer of the eye that registers the image entering through the pupil; the sharpest vision comes from the macula portion of the retina
rods and cones vision cells; rods see only black and white and are most useful for night vision; cones see only color and do best in good light
sclera the white, outer part of the eyeball

HYPERCOASTER

acceleration the rate of change in speed or direction
gravitation the force of attraction that every object in the universe has on every other object
hypercoaster a giant roller coaster twice as high as and 40 percent faster than most roller coasters
inertia the tendency of an object to resist changes in its motion—that is, to stay still or keep moving with constant speed unless some force acts on it
mass the amount of material an object contains
momentum mass of an object times its velocity
Isaac Newton the English mathematician and scientist who published three laws of motion in 1687
roller coaster a high-speed, elevated railway that has steep and sharply curving sections

INCA ENGINEERING

archaeologist scientist who studies artifacts, buildings, and other relics to learn about ancient cultures
dress to smooth or polish a stone or wood
flaking chipping small, usually broad pieces from the larger core block
fourcroya andina the fibers from this plant's stringy leaves were used by the Inca for sandals, cloth, and rope
friction resistance to motion of two moving surfaces that are touching each other
gravity the force that tends to pull all bodies within the earth's atmosphere toward the center of the earth
hammer stones small ,neolithic pounding tools made of granite, quartzite, or olivine basalt
joint the content surface between two bodies
Mohs scale used to indicate relative hardness of minerals, ranging from 1 (talc) to 10 (diamond)
stonemason person who cuts and shapes stones

MALARIA TRACKING

Anopheles the genus of mosquito that includes species which transmit the parasite that causes malaria in humans
Geographic Information Systems (GIS) a computer informational system designed for storing, updating, analyzing, displaying, and manipulating spatial data in various ways
infrared a form of heat radiation similar to light
malaria a mosquito-borne disease caused by any one of four different blood parasites
parasite an organism that grows, feeds, and is sheltered on or in a different organism while contributing nothing to the survival of its host
rain forest a dense, evergreen forest occupying a tropical region with an annual rainfall of at least 2.5 meters (100 inches)
remote sensing techniques for acquiring information about an object without being in direct contact with that object, as through aerial cameras and satellites
satellite imaging tech-

nique of gathering geographic images using infrared cameras aboard satellites
vector an organism that carries disease-causing microorganisms from one host to another

NICOTINE

addiction the physical or psychological dependence on a chemical (such as cocaine) or action (such as gambling)
dopamine brain chemical that appears to produce feelings of reward or pleasure
nicotine an addictive drug found in tobacco products; when pure, it looks like a clear, liquid oil, but exposed to air, it turns brown
receptor in the brain, an area that binds to a particular kind of molecule; after a receptor "receives" the molecule, some other physiological change usually happens
replacement therapy the process of trying to quit smoking by ingesting small amounts of nicotine to reduce the craving for cigarettes
tar the mixture of chemicals formed when tobacco is burned
tolerance the increasing need for larger doses of an addictive substance
withdrawal symptoms an addicted person experiences when the supply of an addictive substance is removed

OLYMPIC SOLAR ENERGY

electromagnetic radiation the form of energy that comes from the sun, most of it as visible light
electron a subatomic particle with a negative charge that orbits the positively charged atomic nucleus
photon a packet of electromagnetic energy that behaves both as a particle and a wave
photovoltaic cells devices designed to convert sunlight into electricity
sensors any of a variety of devices, usually electronic, that detect, measure, or record physical phenomenon such as temperature or pressure
solar collector a device that gathers solar radiation to produce heat

POST OFFICE

bar code patterns of black lines that can be read by machine
bar code sorter (BCS) a computer-controlled machine that sorts letters with imprinted bar codes at speeds of 32,000 pieces an hour
delivery bar code sorter (DBCS) a small, high-speed bar code sorter that finalizes letter sorting down to the carrier's sequence of mail delivery
delivery point bar code (DPBC) a zip+4 bar code containing two additional digits that designate a specific delivery point
machinable mail the right size and shape to pass easily through automation equipment
optical character reader (OCR) a computer-controlled automated machine that interprets address information on a piece of mail, sprays a bar code on it, and then sorts it
remote bar coding system (RBCS) a system that uses image data of handwritten and other machinable mail that cannot be read by an OCR
zip code a five-digit numeric code that identifies areas within the United States and its territories
zip+4 a nine-digit numeric code incorporating the original five-digit zip code, a hyphen, and four additional digits; the four-digit add-on identifies a specific delivery segment such as a floor of a building or a group of post office boxes

PROSTHETICS

amputee a person who has lost part or all of a limb
dynamic able to move and respond to certain environmental influences
myoelectric muscle electricity; a myoelectric prosthesis has sensors that respond to the minute quantities of electricity produced by human muscle movements
prosthesis an artificial body part, usually a replacement for a damaged or amputated body part

RAIN FOREST ANIMALS

adaptation various functions or structures of a plant or animal that provide the organism with a better chance of surviving in a particular environment
cellulose a carbohydrate that forms the cell walls of plants
echolocation bouncing sound off objects to provide information about size, location, and movement of those objects
ecosystem the complex interactions among living and nonliving things and their physical environments
myrmecologist an entomologist who specializes in the study of ants
symbiosis two species that live together in harmony, each contributing to the survival of the other

RAIN FOREST PLANTS

bromeliads tropical plants in the pineapple family that often grow on the trunks and branches of trees
buttresses woody, finlike supports that radiate from the bases of some tall tropical forest trees
canopy the layer of a forest formed by the crowns of trees that are often about 23 to 76 meters (75 to 250 feet) tall. Most rain forest life is concentrated here, where 90 percent of the rain forest's photosynthesis occurs.
emergent a tree that grows taller than the canopy trees around it
epiphyte plants that grow on other plants and send no roots to the ground
ethnobotany the study of how people use plants
evapotranspiration the process by which water from inside a plant evaporates over the forest, providing vapor that can form clouds
indigenous occurring naturally in a certain area; "indigenous people" are native people
understory the forest layer beneath the canopy that includes small trees, young canopy trees, shrubs, and herbs

RIVERBOATS

change of state what happens when matter changes from a solid, liquid, or gas to another phase
energy the ability to do work
piston a cylinder or disk that fits tightly into a larger cylinder and moves under pressure from a liquid or gas; the piston takes the energy from the liquid or gas and turns it into a back-and-forth motion
pitman arm a connecting rod that links one moving part to another, such as the piston to the paddle wheel in a steamboat
potential energy stored energy; an object that can fall has potential energy and fossil fuels (oil, gas, and coal) have potential energy that they stored when they were formed of decaying organic matter millions of years ago
pressure the amount of push, or force, on a surface
turbine machine that is turned by a gas or liquid with the use of vanes or blades
vapor a state of matter in which the molecules of a substance are completely separated from each other and are energetic enough to spread into all available space

SHARKS

ampullae of Lorenzini jelly-filled canals connected to pores in the shark's snout, which detect low-voltage electrical charges
atoll a coral reef or island around a lagoon
cartilage tough connective tissue found in parts of the human body such as the nose, joints, or outer ear
coral reef ridge of coral rising to or near the surface of a body of water
denticle hard, tooth-like points covering the shark's skin
dorsal near the back or upper surface
pectoral near the breast or chest
plankton microscopic organisms that float or drift in water
ventral situated on or close to the lower surface or abdomen

SKI JUMPING

airfoil an elongated teardrop shape with one side flattened that experiences a net lifting force when moving through air or a liquid
angle of attack the tilt at which an airfoil or wing hits the onrushing air
drag the resistance of a fluid (air, water, etc.) against a moving object
gravitational potential energy the energy or ability to do work that an object has because of its position above ground level
inrun the ramp or hill a ski jumper travels down
lift the upward push of air against a surface like a wing or airfoil
outrun the hill or landing that a ski jumper lands on
takeoff table the actual point at which a ski jumper lifts off the bottom of the ramp
transition curve the point at the end of the inrun where the ski jump ramp curves back up to the takeoff table

SOCCER

dribbling advancing the ball by giving it a series of short kicks
feinting moving your body in a way that deceives your opponent about your intended path
heading hitting the ball with your forehead
momentum when an object is moving, its tendency to continue to move; an object's momentum is the product of its mass and its velocity
Newton's third law of motion every action (or force) exerted by one body on a second body gives rise to a reaction (or opposing force) of equal strength but opposite direction by the second body on the first
physics the science that deals with the properties, changes, and interactions of matter and energy
swerving rolling the ball across your body to make it spin
trapping using your chest, head, foot, or thigh to stop the ball
velocity the speed and direction of an object

SPELUNKING

acid a solution having a pH lower than 7 with an excess of hydrogen cations
caprock ceiling of a near-surface cave
cave a natural underground cavity
cavern a large cave system
karst topography ground that is characterized by limestone, numerous sinkholes, and underground drainage
pillar a column formed when a stalactite and stalagmite join
sinkhole a hole in the land surface formed in a limestone cavity by the collapse of the top of a cave
solution the process by which a material is dissolved by water
stalactite a rock needle that hangs from the roof of a cave; formed by the precipitation of calcium carbonate
stalagmite a geological feature formed on the floor of a cave by the precipitation of calcium carbonate solutions dripping from the ceiling

WETLANDS

algae aquatic plants with no true roots or leaves
fertilizer a natural or synthetic material used to increase plant growth
flood overflowing of water onto land normally dry
organic substance containing carbon, hydrogen, and other elements; all living things are made of organic molecules
sewage treatment plant a place where wastewater is broken down and filtered, the water returning to its natural, uncontaminated condition
wetland a low area on land that is saturated with moisture for most of the year

NEWTON'S APPLE.

THE 14TH SEASON SUBJECT INDEX

3M Innovation

START YOUR ENGINES

PROGRAM NUMBER

902

You can build your own solar powered cars and race them just like in the GM Solar Car Sunrayce!

NEWTON'S APPLE.

Build a custom-designed vehicle propelled by photovoltaic cells.

Materials

- four small solar cells
- small 1 1/2 volt motor
- propeller
- toy car or parts

1. Place the solar cells side by side.

2. Connect them in a series by twisting the negative and the positive wire of one cell to the next cell.

3. Attach the motor to the remaining positive and negative wires.

4. Attach the propeller to the motor. Place the cells in bright light. Observe how fast the propeller turns. Move the light and the cells and note in your journal how the speed of the propeller changes.

5. Design a custom body for the car that can hold the propeller and the cells. Compare yours with your classmates.

6. Try a few time trials to see whose car is the fastest. How can you modify your car to make it go faster?

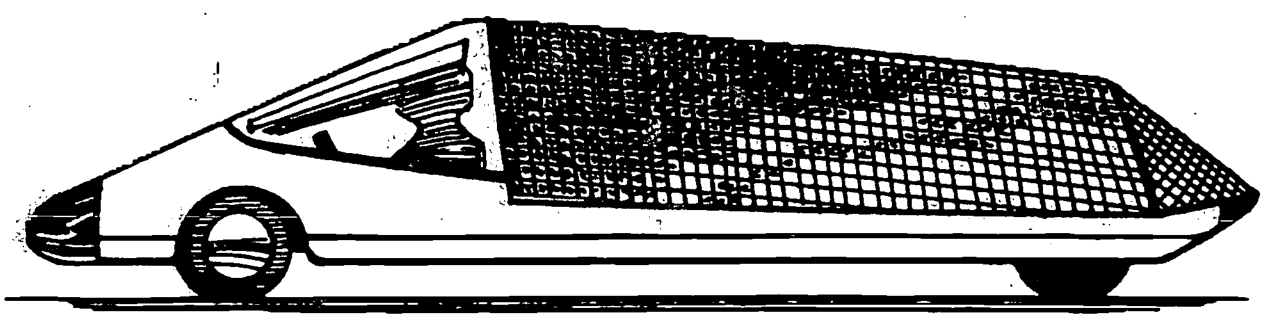
Questions

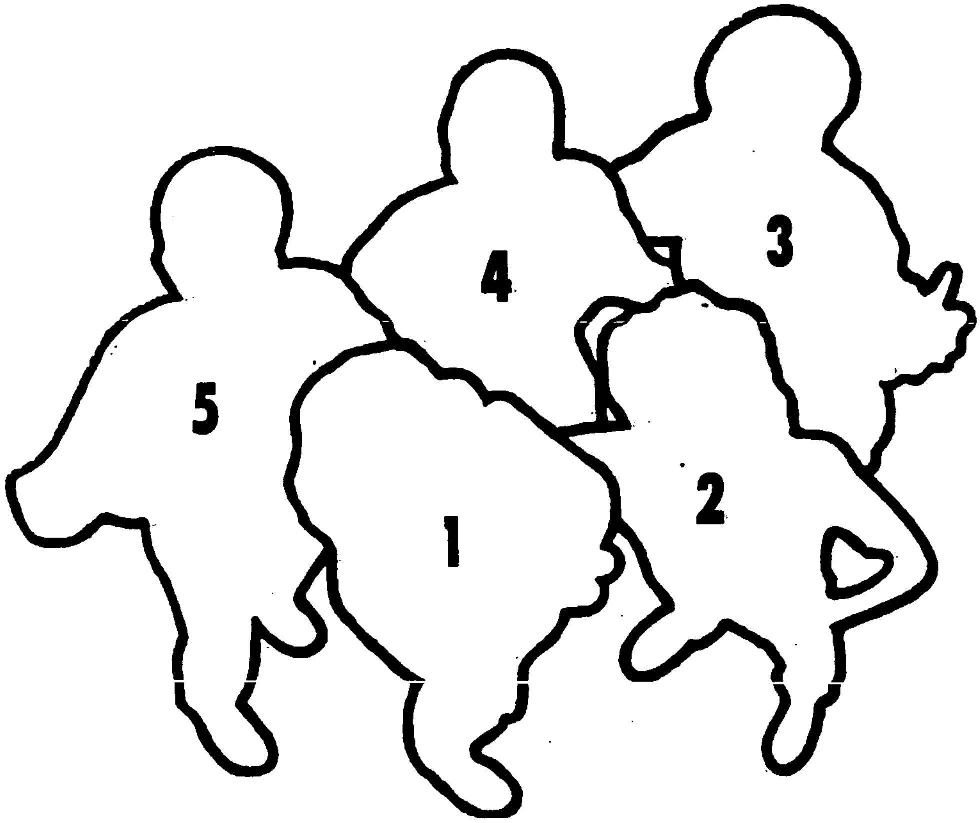
1. What would happen if you used more cells? Does placement of the cells affect the power of the motor?

2. Does the arrangement of the cells affect the design of your car? How could you arrange the cells to make the car more efficient?

3. Do you have any solar-powered items at home? Where else could solar cells be used at home? At school?

* Adapted with the permission from materials of the *Science Weekly.*





① EILEEN GALINDO

② SUCHIN PAK

③ BRIAN HACKNEY

④ DAVE HUDDLESTON

⑤ DAVID HEIL

CALLING ALL BIRDS

PROGRAM NUMBER 1312

Examine why anatomy helps determine the sounds we make.

NEWTON'S APPLE.

When you talk, you use your voice box. A bird makes sounds with a vocal organ called the syrinx. The vibration of thin muscles in the syrinx creates its song. Investigate and compare the vocal organ of a bird with that of a human.

Materials
- sheets of standard paper (8 1/2" x 11"), two per student
- pencils
- overhead transparency of a drawing of a bird's anatomy, showing trachea, lungs, air sacs, and syrinx
- overhead transparency of the head, throat and chest regions of a person's anatomy, showing trachea, bronchus, lungs, and larynx

Note: Make an overhead transparency by photocopying the artwork on this page, cutting out the illustrations, and transferring them to a transparency. Make sure the names of the parts do not appear on the transparency.

1. Give each student two sheets of paper.

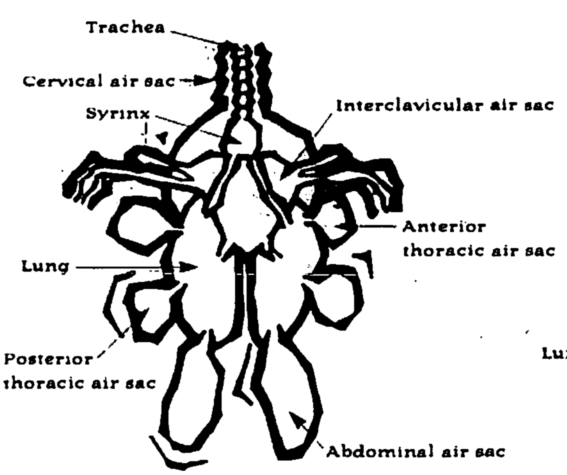
2. Show the transparency with an overhead projector. Have everyone draw an outline of the bird's chest, neck, and head. As you explain the different parts of a bird's anatomy that help make its songs, have each student add those parts and label them.

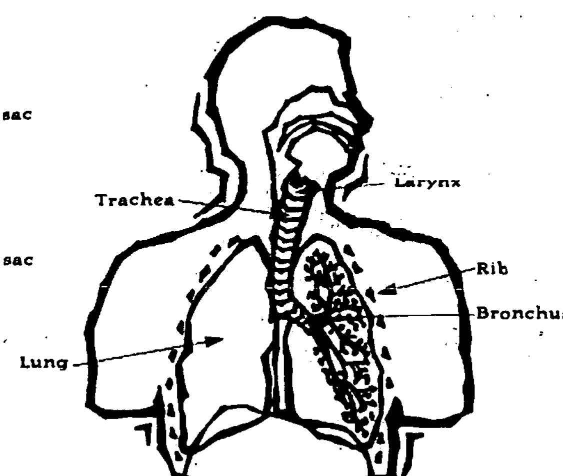
3. Show the transparency of a person's vocal cords and anatomy. Have each student then draw an outline of the person. Explain the different parts of the body that a person uses to speak. As a part is discussed, have each student draw the additional part in its normal location on the outline, labeling each part.

4. Place the two outlines beside one another. Discuss differences and similarities that exist between a bird and a person. What effect would these differences have in determining the sounds a person makes compared to a bird's sound?

Questions
1. Besides sound, in what other ways do birds and humans communicate?

2. How is bird behavior different or similar to that of people (hair vs. feathers, gestures vs. wing positions)? Why does your voice become scratchy and deep when you have a sore throat?





NEWTON'S APPLE IS A PRODUCTION OF TWIN CITIES PUBLIC TELEVISION. MADE POSSIBLE BY A GRANT FROM 3M.

EDUCATIONAL MATERIALS DEVELOPED WITH THE NATIONAL SCIENCE TEACHERS ASSOCIATION.

FOR MORE INFORMATION ABOUT NEWTON'S APPLE'S EDUCATIONAL RESOURCES, CALL 612-222-1717. CHECK OUT THE NEWTON'S APPLE WEB SITE AT...
http://www.mnonline.org/ktca/newtons

3M Innovation

WHAT IS NEWTON'S APPLE?

NEWTON'S APPLE, public television's family science show, is a fast-paced magazine format television program designed to excite viewers' curiosity. It is now in its 14th season on PBS and is carried on more than 250 public television stations nationwide. Starting from a viewer question, each program segment involves viewers in fascinating discoveries about science in the world around us.

Asking questions of NEWTON'S APPLE is a great classroom activity. Send your questions to: NEWTON'S APPLE, 172 4th Street E, Saint Paul MN 55101, or e-mail to <newtons.apple@umn.edu>.

NEWTON'S APPLE allows three-year, off-air record rights for educational purposes. If you miss a show or would like to obtain a segment from past seasons, call 800-228-4630.

NEWTON'S APPLE®

EDUCATIONAL RESOURCES

extensive Teacher's Guide, developed with the National Science Teachers Association for use in the classroom, accompanies the series and includes background, keywords, resources, and multiple classroom activities for each major segment.

NEWTON'S APPLE offers many other educational resources through partnerships with educational materials developers and distributors:

* Hands-on science kits: a series of laboratory activity kits, including *Newton's Greatest Hits* (Newton's Laws of Physics kit), *Newton on Slime,* (Colloidal Chemistry kit), *Newton on the Earth* (Solar System and Geology kit) and *Oh, Mr. Newton* (Science Overview kit). Each includes complete guides and all the equipment for experimenting at home or school.
* *What's the Secret?* CD-ROMs: interactive science discovery programs for both Macintosh and Windows that explore a wide range of science subjects, from the heart to bees, roller coasters to glue, flight to skeletons.
* NEWTON'S APPLE...Live: A live in-school theatre production that explores and demonstrates air pressure and the weather through a fanciful drama about a young girl's fear of thunder.
* NEWTON'S APPLE Multimedia Interactive Collection: two videodisc packages (Physical Sciences and Life Sciences) that offer easy access to NEWTON'S APPLE segments and teaching materials to help build curriculum.
* NEWTON'S APPLE Science Charts: 10 inquiry-based science charts using the real-life questioning approach of the television show that include four reproducible activities on the back.

For information about any of the many science education resources or to obtain a free NEWTON'S APPLE Teacher's Guide, call 612-222-1717 or write to:

NEWTON'S APPLE
172 4th Street E
Saint Paul MN 55101

NEWTON'S APPLE is made possible on PBS by 3M. If you appreciate NEWTON'S APPLE and would like to see the show continue bringing science discovery to people of all ages, please write us and we'll forward your thoughts to 3M.

World Wide Web

NEWTON'S APPLE's award-winning World Wide Web site is chock full of useful information for teachers, students, parents, and viewers of all ages. Teacher's Guides are available on-line, as well as NEWTON'S APPLE show information; an interactive forum for viewer suggestions and questions; a CD-ROM demo from *What's the Secret?*; more information about the growing array of educational resources; and biographical information on the show's hosts. The NEWTON'S APPLE World Wide Web address is:

http://www.mnonline.org/ktca/newtons

WHAT IS LIFT?

PROGRAM NUMBER 1106

Build a model wing and find out what happens when you move it through the air.

NEWTON'S APPLE.

The lift on the sail of a sailboard is similar to that on a wing of an airplane. What forces and pressures generate lift? Construct a model to demonstrate the force of lift.

Materials

- two 8 1/2" x 11" sheets of paper
- ruler
- transparent tape
- sharpened pencil
- 60-cm (24") piece of monofilament fishing line
- one 15-cm (6") straw
- two 7.5-cm (3") straws

1. Fold one sheet of paper in half, but do not crease the fold.

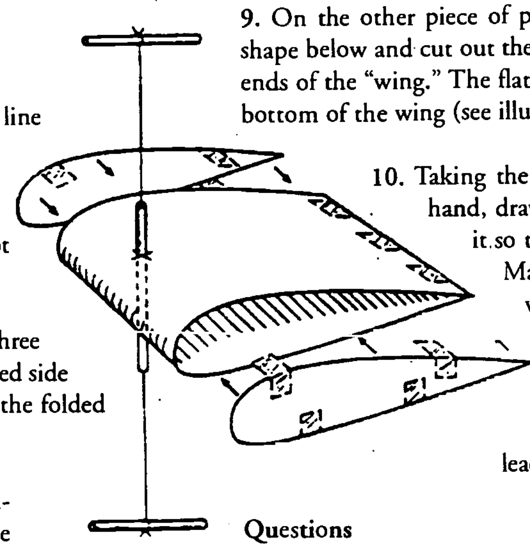
2. Tape the long opened edge of paper with three small pieces of tape to keep it closed. This taped side will be known as your "trailing edge," while the folded side will be known as the "leading edge."

3. With the pencil, mark an "X" on the center line of the paper about one inch from the leading edge.

4. Punch a hole through both the top and bottom of the paper at the "X." (Be careful not to crease the paper at the fold.)

5. Place the 15-cm straw through the hole you just punched. Use tape, if necessary, to hold the straw in place.

6. Tie one end of the fishing line to the middle of a 7.5-cm straw.



7. Pass the other end of the fishing line through the 15-cm straw which is attached to the paper.

8. Pull the fishing line through and tie this end to the other 7.5-cm straw. The 7.5-cm straws will be your handles.

9. On the other piece of paper, trace two copies of the airfoil shape below and cut out the shapes. Tape the shapes to the open ends of the "wing." The flat edge of the shapes should be on the bottom of the wing (see illustration).

10. Taking the 7.5-cm straw handles, one in each hand, draw the fishing line tight and position it so the line is perpendicular to the floor. Make sure the flatter surface of the wing faces down.

11. With your arms out in front of you, make a quick sweeping motion through the air. Be certain that the leading edge of the wing is in front.

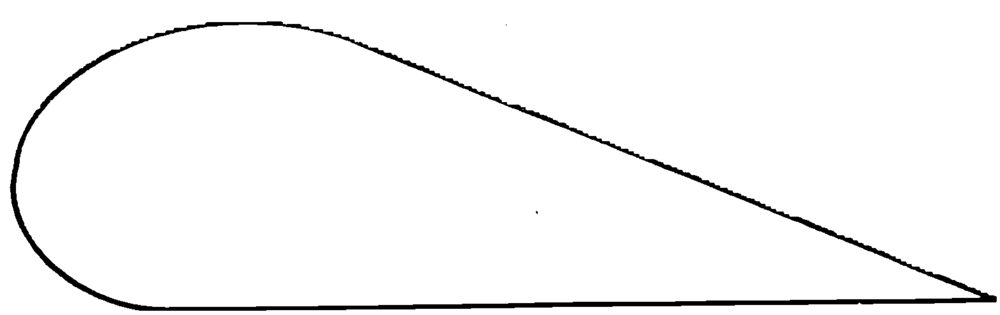
Questions

1. What did your piece of paper do?

2. What caused the wing to move upward?

3. Explain how this demonstration relates to a sail.

4. Explain the forces that move the paper upward.



NEWTON'S APPLE premieres in October on public television stations nationwide. Contact your local PBS station to find out the exact air date and time of NEWTON'S APPLE and other public television programs. If you find out that your PBS station isn't planning to air NEWTON'S APPLE, call or write them and explain how you plan to use the program and how valuable it is to you and your students. If they are airing NEWTON'S APPLE, let them know you appreciate it!

SPECIAL THANKS FOR DONATING SCIENCE PROPS AND IMAGES FOR THIS POSTER:

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The Science Museum of Minnesota and its Museum on the Move

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DESIGN: TWIN CITIES PUBLIC TELEVISION

DIGITAL IMAGING AND PHOTOGRAPHY: POPULAR FRONT STUDIO

Build a tightrope setup and go for a walk!

Make your dreams of running away to join the circus come true—at least for a little while. In this activity, you construct a tightrope setup, learn the basics of tightrope walking, and understand a little more about the physics behind balancing! Get an adult to help you build the setup, as well as to double-check cushioning and spot you as you learn.

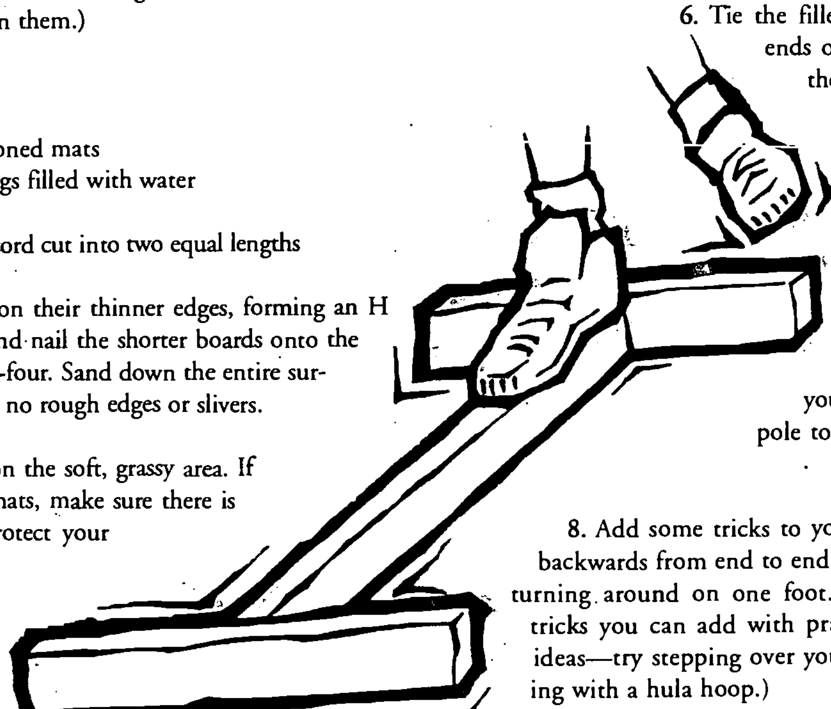
Materials

- one 8'-long two-by-four board
- two 4'-long two-by-four boards
- two smooth poles, one about 3' long, the other about 6' (The length doesn't have to be exact, so long as the two sticks have about 3' difference between them.)
- sandpaper
- hammer
- 3" nails
- soft, grassy area or cushioned mats
- two half-gallon plastic jugs filled with water
- broom
- 50 cm (20") of string or cord cut into two equal lengths

1. Place the two-by-fours on their thinner edges, forming an H (see illustration). Center and nail the shorter boards onto the ends of the longest two-by-four. Sand down the entire surface, making sure there are no rough edges or slivers.

2. Place your "tightrope" on the soft, grassy area. If you put it on cushioned mats, make sure there is enough padded area to protect your entire body if you fall.

3. First, try walking from end to end very slowly. Where do you find yourself holding your hands and arms? Try holding them still—first straight out from your body, then overhead, then stiff by your sides. How do these different positions affect your balance? Why? Try these same positions holding a filled plastic milk jug in each hand. Does the added weight make balancing easier or harder? Why?



4. Try walking your tightrope with your longer pole. Move your hands together until they touch in the middle of the pole and walk the tightrope holding the pole horizontally. Now spread your hands as far apart as possible on the pole and walk the tightrope again. Does your hand position affect your ability to balance? How? Why? Try the two hand positions again with a broom. Is there any difference? Why?

5. Using the hand position you found to be the best for balancing, try walking your tightrope first with your short pole, then with your long pole. Which length helps you balance better? Why?

6. Tie the filled plastic milk jugs to the ends of your long pole and walk the tightrope again. Do the weights affect your balancing ability? How? Why?

7. Using the short pole, walk across your tightrope. What happens to the pole when you start to lose your balance? What happens to your body? Can you use the pole to deliberately make yourself lose your balance?

8. Add some tricks to your repertoire. Try walking backwards from end to end, balancing on one foot, or turning around on one foot. Can you think of other tricks you can add with practice? (Here are a couple ideas—try stepping over your balancing pole, or playing with a hula hoop.)

Question

1. What combination of factors gave you the best balance? Why?

TWIN CITIES
PUBLIC TELEVISION
NEWTON'S APPLE
172 4TH ST E
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Look inside for information about the newest season of NEWTON'S APPLE. NEWTON'S APPLE is taking you around the world—and into your own backyard—to bring you and your students more science fun and discoveries!

In addition to this free teacher's guide, NEWTON'S APPLE has lots of new science education products that help put kids, teachers, and parents in the driver's seat, including:

- *WHAT'S THE SECRET? CD-ROMS*
- *NEWTON'S APPLE SCIENCE KITS FOR HOME AND SCHOOL*
- *NEWTON'S APPLE EDUCATIONAL MATERIALS ON-LINE*
- *NEWTON'S APPLE CLASSROOM SCIENCE CHARTS*
- *NEWTON'S APPLE LIVE! TRAVELING THEATER SHOW*
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