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IDENTIFIERS	Public Broadcasting Service

ABSTRACT

This educational materials packet was designed to help teachers use the Public Broadcasting Service's (PBS) program called "Newton's Apple" in the classroom. This book contains information on how these materials support the latest science standards; an index to the 13th season lesson pages and an index to the past three seasons; a science subject index that gives a quick overview of the science concepts presented in each lesson as well as additional subject applications; lessons which contain background information, interdisciplinary connections, key words, resources, and hands-on activities that are focused on the major topics explored during the season; Hands-on Science Try It experiments and a Street Smart quiz; a guide to enjoying Newton's Apple at home that can be duplicated and sent home with students to encourage family participation in science education; and information on America's Most Scientific Home videos contest. Topics covered include wildlife, human anatomy, physics, chemistry, and technology. (PVD)

NEWTON'S APPLE®

Free Educational Materials

Developed in partnership with the National Science Teachers Association

Meet the new NEWTON'S APPLE Team

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

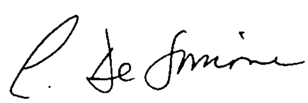
3M Innovation

Greetings from 3M and NEWTON'S APPLE!

3M is proud to continue sponsorship of NEWTON'S APPLE and these companion materials for the thirteenth season. This season is particularly noteworthy, as it introduces a new team of diverse hosts, truly an "innovation" in science television programming. Each of these hosts shares that special zest for revealing the insights, thrills, and fun of science that has become the hallmark of NEWTON'S APPLE.

To supplement the show, we are confident these NEWTON'S APPLE classroom packets, produced in partnership with the National Science Teachers Association and KTCA-TV, will provide you with high-quality, stimulating materials that will motivate students to observe and understand the world around them.

We are also working with NEWTON'S APPLE to provide special programming for National Engineers Week. During the week of February 18, 1996, thousands of engineers around the nation will visit classrooms to share their enthusiasm for science. All of these efforts have common goals: to encourage our nation's youth to stay in school, to make them curious about their world, and to help them see how bright their future can be.



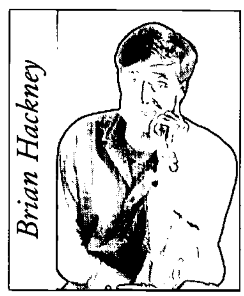
L. D. DeSimone
Chairman
and Chief Executive Officer
3M

Peggy Knapp

In her tenth season with NEWTON'S APPLE, Peggy works up a sweat riding with the MayaQuest bicycle trek through Belize, as students back in the States interact with the bikers via the Internet. And, in the Warehouse, Peggy learns about reflexes from some *very* young experts.

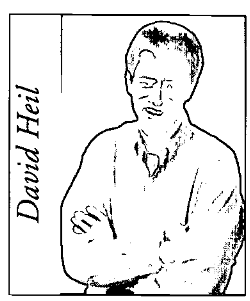
Dave Huddleston

Dave comes to NEWTON'S APPLE with a track record as a prize-winning TV journalist. But the track he follows this season takes him out to the edge, and nearly beyond. He'll be rushing into the flames surrounding a simulated airplane disaster, and high-stepping it on the circus high wire.



Brian Hackney

This former electrical engineer and current meteorologist offers his wry wit and sense of discovery to NEWTON'S APPLE when he unwraps the secrets of mummies, and becomes an expert balloon "baker." In another show, he gets caught red-handed and becomes a case study in DNA "fingerprinting."

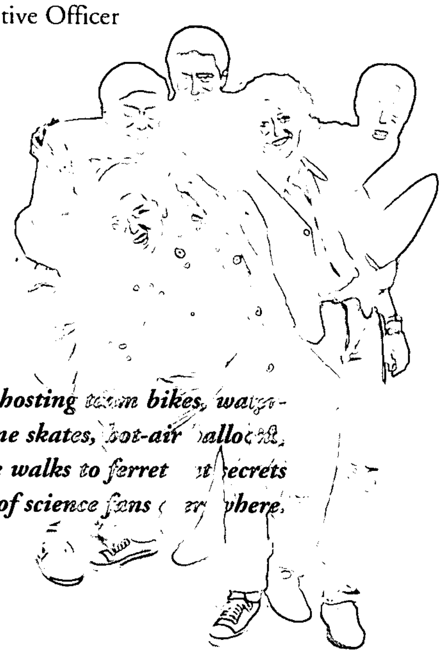


David Heil

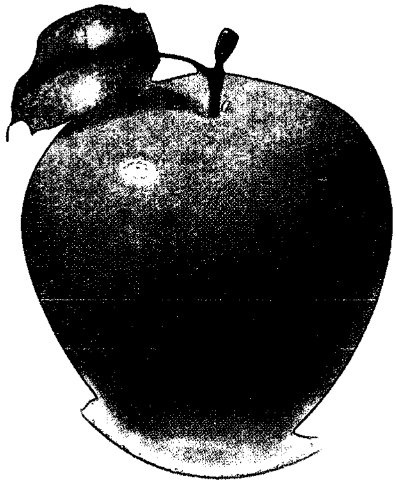
The 13th season of NEWTON'S APPLE has David (now in his eighth year with the show) heading off on an African safari—cruising over spectacular woodland and savanna in a hot-air balloon. Back on terra firma, David visits a coffee plantation, and explores the unique features of the Earth's equator.

SuChin Pak

At an age when many teenagers are still hanging out at the mall, SuChin hosts a TV show for young people in northern California. Now, for her first NEWTON'S APPLE season, she gets into the show's hands-on style in a big way. That includes being flung into the sky on a human slingshot ride, and ice surfing across a frozen lake.



The new five-member hosting team bikes, water-skis, ice surfs, in-line skates, hot-air balloons, slingshots, and tightrope walks to ferret out secrets on behalf of science fans everywhere.



Welcome to the NEWTON'S APPLE Educational Materials packet. These materials were developed to help you use the 13th season of NEWTON'S APPLE in your classroom.

Look what we have for you!

Information about how these materials support the latest science standards.

An index to the 13th 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 13th season lesson.

Lessons, lessons, and more lessons (including background information, interdisciplinary connections, key words, resources, and hands-on activities) focused on the major topics explored in the 13th 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.

Information about America's Most Scientific Home Videos contest.

Our 13th season poster, with a listing of PBS stations printed on the back.

How do I find NEWTON'S APPLE on TV?

The 13th season of NEWTON'S APPLE will air on most PBS stations beginning in October 1995 (check your local PBS listings for exact airdates and times). 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 13th season will be airing in your area.

NEWTON'S APPLE allows three-year, off-air record rights for educational purposes.

You can help ensure the continued airing of NEWTON'S APPLE by contacting your local PBS station and letting them know how much you depend on it in your classroom. If you have trouble finding NEWTON'S APPLE on TV, contact us. We know how much teachers appreciate and support our program, and we want you to be able to see NEWTON'S APPLE in your area.

If you have any comments or questions, please write to:
Director of Outreach
NEWTON'S APPLE
Twin Cities Public Television
172 East 4th Street
St. Paul, MN 55101
e-mail: newtons.apple@umn.edu

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NEWTON'S APPLE®

Focusing on the Science Education Standards

Call them what you will—standards, benchmarks, frameworks, guidelines—you undoubtedly have heard about the challenges all science educators face in coming up with effective ways to create a scientifically literate public in the decades to come.

Several national organizations and tens of thousands of scholars and educators have been diligently addressing these urgent calls to improve science education. We encourage you to become familiar with the work of some of these task forces, including:

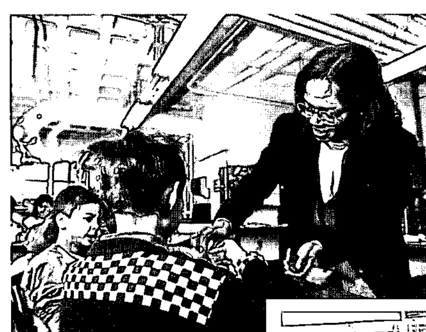
Benchmarks for Science Literacy
American Association for the Advancement of Science, Project 2061

National Science Education Standards
National Research Council of the National Academy of Sciences

Scope, Sequence, and Coordination of Secondary School Science
National Science Teachers Association

Together, these programs represent a widespread effort to improve science literacy by addressing teaching styles, curriculum and content reform, assessment methods, educational systems, technology, and more. Each effort may take a slightly different tack to achieve similar goals, but they are consistent in one message: It is vital to get teachers, supervisors, curriculum developers, administrators, parents, and scientists working together to improve science education and science literacy in this country.

So how can NEWTON'S APPLE help?



NEWTON'S APPLE can be a partner in helping you approach some of the goals of these new standards: identifying what a scientifically literate person should know, developing effective ways to teach that information, and, perhaps most important, creating checkpoints to assess how that knowledge is evident.

Since NEWTON'S APPLE began production more than 13 years ago, we have had as our goal to inform viewers not just of the facts and numbers related to scientific discovery (however important they may be!), but of the relevance of basic science concepts to our everyday lives. Finding that relevance can be a fun, exhilarating adventure!

Our hosts are nonscientists, interacting with and questioning an "expert." Many times the guest expert never really answers the host's questions, but rather guides all of us—host and viewers alike—through the information until we all reach a moment of understanding. This moment is what we like to call the "A-ha!" moment, when we realize that we actually "get it." The new standards describe such an inquiry-based approach to learning, which you will find in most NEWTON'S APPLE segments and the lessons contained in this guide.

Our educational materials are designed to inspire both teacher and student to engage in multimedia, hands-on, inquiry-based activities. We're confident that your science classroom will be enhanced by incorporating our lessons into your curriculum.

We encourage duplication for educational use!

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3M Innovation

Index to the 13th Season Lesson Pages

There are two ways 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.

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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., 1301, 1302) that corresponds to that topic. We've also included in the same corner the approximate segment 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.

Show 1301
Waterskiing
Reflexes

Show 1302
Circus High Wire
Mummies

Show 1303
Maya Bike Trek
Hearing

Show 1304
Africa Special
Balloon Safari

Show 1305
Ice Surfing
DNA Fingerprinting

Show 1306*
Aircraft Fire Rescue
Balloons

Show 1307
Disney World Special
Simulator Rides
Dolphin Communication

Show 1308
Hazardous Materials
In-line Skating

Show 1309
Human Slingshot Ride
Bone Marrow

Show 1310
Wild Lion Vets
Bicycles

Show 1311
Equator Special
Equator
Coffee

Show 1312
Bird Songs
Ergonomics

Show 1313
Jungle Survival
Liver

*Your chance to appear on NEWTON'S APPLE!

Check out *America's Most Scientific Home Videos* contest in Show 1306. This is a great opportunity to get students, parents, and teachers working together on a project that just might win your team an appearance on NEWTON'S APPLE! To find out more about this contest, watch Show 1306 and turn to "A Guide to Enjoying NEWTON'S APPLE at Home," found after the lesson pages.

Remember...If you have any questions about when NEWTON'S APPLE airs in your area, check your local TV schedule or PBS viewer's guide. You can also call or write your local PBS station and ask. Check the back of the poster included in this packet for a quick reference guide to the PBS stations across the country.

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Index of Past Seasons

NEWTON'S APPLE
10th Season

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

Show 1002
Hollywood Stunts
Household Chemistry
Cream in Coffee
Musk Ox

Show 1003
Election Polls and Surveys
Electric Car
Ceramics Chat
Cougar

Show 1004
Monster Makeup
Ozone
Car Mirror
Artificial Sweeteners

Show 1005
Oil Spills
Diet and Nutrition
Crystal Gayle
Caribou

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

Show 1007
HIV/AIDS
Glass Recycling
Cement
Science Challenge
Wolverine

Show 1008
Cockroaches
Broken Bones
Dentist Chair
Rhinoceros

Show 1009
Omnimax Technology
Archery
Lightbulbs
Condor

Show 1010
Aurora Borealis
Air Pressure
Al Gore
Piranha

Show 1011
Traffic Control
Cryogenics
Static Electricity
Russian Kids Visit

Show 1012
Locks and Dams
Blood Typing
Moles
Penguin

Show 1013
Diabetes
Galaxy Mapping
Dweezil Zappa
Ostrich

NEWTON'S APPLE
11th Season

Show 1101
Rock Climbing
Taste Test
Monty Hall
Baby Bobcat

Show 1102
Emergency Rescue
Black Holes
Pizza
Reindeer

Show 1103
Memory
In vitro Fertilization
Goose Bumps
Hummingbird

Show 1104
Newspaper
Bomb Squad
Echoes
Mosquito

Show 1105
Jumbo Jets
Meteors
Knuckle Crack
Paper Recycling

Show 1106
Windsurfing
Permafrost
Tumbleweeds
Zebra

Show 1107
Spotted Owl
Carpal Tunnel
Foggy Mirrors
Lizards

Show 1108
Archaeology
Mazes
Dolphin

Show 1109
Firefighting
Dairy Farm
Inventor's Fair
Otter

Show 1110
Bison Roundup
Heart Attack
Dead Fingernails
Chile Peppers

Show 1111
The Bends
Compact Discs
Michael York
Wolf

Show 1112
Garbage
Infrared
Shelley Duvall
Polar Bear

Show 1113
Mt. Rushmore
Virtual Reality
Candles
Chimpanzee

NEWTON'S APPLE
12th Season

Show 1201
Hang Gliding
Karate
Robin Leach
Elephant

Show 1202
Arctic Expedition Special
- Sled Dogs
- Arctic Travel
- Life in Camp
- Arctic Weather

Show 1203
Aircraft Carrier
Carrier Technology
Brain

Show 1204
Brain Mapping
Garlic
Sunscreens
Tasmanian Devil

Show 1205
Movie Dinosaurs
Bread Chemistry
Scott Hamilton
Wallaby

Show 1206
Movie Sound Effects
Sun
Globetrotters
Hedgehog

Show 1207
Dinosaur Extinction
Floods
Blue Seas
Siberian Tiger

Show 1208
Internet
Antibiotics
Panning for Gold
Taxidermy

Show 1209
Ethnobotany
Hubble Telescope
Inventor's Fair
Komodo Dragons

Show 1210
Raptor Hospital
Photography
Skipping Stones
Snakes

Show 1211
Redwoods
Electricity
Monuments
Red Fox

Show 1212
Printing Money
Gravity
Nature Labs

Show 1213
Bridges
Earthquakes
Chromakey
Grizzly Bear

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Science Subject Index

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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
Aircraft Fire Rescue (1306)		●	●			●	Engineering
Balloon Safari (1304)	●			●		●	Ecology Environment Geography
Balloons (1306)		●	●		●	●	Engineering Meteorology
Bicycles (1310)			●		●	●	Engineering
Bird Songs (1312)	●					●	Language Zoology
Bone Marrow (1309)	●				●	●	Health Medical Science
Circus High Wire (1302)	●		●			●	Physical Education
Coffee (1311)		●		●		●	Botany Geography Meteorology
DNA Fingerprinting (1305)	●	●				●	Criminology Journalism
Dolphin Communication (1307)	●					●	Language Zoology
Equator (1311)	●		●	●	●		Ecology Geology Social Studies
Ergonomics (1312)	●		●			●	Engineering Social Studies
Hazardous Materials (1308)		●				●	Ecology Environment

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Science Subject Index

NEWTON'S APPLE®

Segments	Biology	Chemistry	Physics	Earth/Space	Mathematics	Technology	Additional Applications
Hearing (1303)	●		●				Health
Human Slingshot Ride (1309)	●		●		●	●	Engineering
Ice Surfing (1305)			●		●	●	Engineering, Physical Education
In-line Skating (1308)			●		●	●	Physical Education
Jungle Survival (1313)	●			●			Botany, Ecology, Environment, Food/Nutrition
Liver (1313)	●	●					Health, Medical Science
Maya Bike Trek (1303)				●	●	●	Archaeology, Computer Science
Mummies (1302)	●	●			●	●	Archaeology, History
Reflexes (1301)	●				●		Health
Simulator Rides (1307)	●		●			●	Engineering
Waterskiing (1301)			●		●	●	Engineering, Physical Education
Wild Lion Vets (1310)	●			●			Ecology, Environment, Medical Science, Zoology

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How does the shape of a water ski help keep someone on top of the water? How fast would a boat have to be traveling to pull a barefoot water-skier?

SHOW NUMBER

1301

SuChin flies over the waves on water skis.

Segment length: 6:15

Waterskiing

How do water skis stay up?

Insights

Who says you have to be in the sky to fly? Your feet may never leave the ground (well, the water), but the amazing sensation of waterskiing definitely compares to soaring through the air.

The first person to master this sport was an 18-year-old named Ralph Samuelson. In 1922, Samuelson tried skiing over water first on barrel staves and then on snow skis. He finally found success on pine boards 2.5 meters (8 feet) long and 23 centimeters (9 inches) wide. Waterskiing really picked up speed after World War II, when affordable, high-horsepower outboard motors meant more people could own the fast boats needed to tow water-skiers.

But how do you stand on water? The pressure on top of the water skis (including the weight of the ski, the person, and the air above both) remains constant, whether the skier is at rest or moving. However, as the skier picks up speed, the water pushes against the bottom of the skis. The larger or longer the ski, or the faster a boat is traveling, the easier it is for a skier to stay up on the water. The average speed to keep a 68-kilogram (150-pound) adult afloat on water skis would be 32–40 kilometers per hour (20–25 miles per hour). But for *barefooting,* where all 68 kilograms of weight are concentrated on the soles of two feet, a speed of 56 kilometers per hour (35 miles per hour) is necessary.

Different lengths and *edges* of water skis offer different combinations of speed and control. For instance, a beginning skier would want two longer skis for stability, with flat bottoms for riding high and fast on the *wake.* A more advanced skier could switch to just one ski, called *slaloming,* and use a *beveled* bottom for more controlled turns. And highly experienced skiers may choose a ski with a *concave* bottom, which holds turns by cupping water underneath.

Some expert skiers even add an underwater *rudder* with wings set at a particular angle to aid turning. These wings create drag and slow down the ski like a brake, making it easier to turn. Then, when the skier leans back to come out of a turn, the wings become parallel to the flow of water and offer minimal resistance.

Connections

1. Why did Ralph Samuelson's first attempts on barrel staves and snow skis fail? What technological advances allow skiers to go completely barefoot or to build pyramids of people on water skis?
2. Trick skis are short and stubby and have beveled edges both on the bottom and top. How would this shape help a skier do side-slides, somersaults, and 180-degree turns?

Key Words

barefooting to water-ski on bare feet
bevel rounded edge on some types of water skis
concave inward-curved bottom on some types of water skis
edge side of a ski, used for acceleration and deceleration
freestyle type of water ski competition using a jump ramp for somersaults and other tricks
kneeboard extrawide water ski which is ridden in a kneeling position
rudder a sort of fin attached to the bottom of a ski, similar to ones used to steer boats
slalom to ski on a single ski, or the ski itself
wake the "V" wave behind a boat

Resources

Benzel, D. (1989) *Psyching for slalom: An illustrated guide to the mind & muscle of the complete skier.* Winter Park, FL: World Publications.

Duvall, C. & Crowell, N. (1992) *Camille Duvall's instructional guide to waterskiing.* New York: Simon & Schuster.

Finn, T. (1989) *Skurfer's guide to water skiboarding: An illustrated guide to learning and mastering the sport.* Winter Park, FL: World Publications.

Kistler, B. (1988) *Hit it! Your complete guide to water skiing.* Champaign, IL: Human Kinetics Publishers, Inc.

Scarpa, R. & Dorner, T. (1988) *Barefoot waterskiing: An illustrated guide to learning and mastering the sport.* Winter Park, FL: World Publications.

Scherer, R. (1994, Jan 14) Tug of war with a boat isn't easy. *The Christian Science Monitor,* p. 17.

Additional sources of information
Water Skier magazine
799 Overlook Drive
Winterhaven, FL 33884
(813) 324-4341
(Publication of the American Water Ski Association. Also available: videos, safety and competition information, instructional materials.)

Waterski and *Wakeboarding* magazines
330 West Canton, Box 2456
Winter Park, FL 32790
(407) 628-4802

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3M Innovation

Skimming the Surface

Mold an aerodynamic water ski from clay and see if it stays afloat.

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SHOW NUMBER
1301
Waterskiing

Main Activity

Every time water-skiers cut into a curve, fluid dynamics are at work to keep them upright. In this activity, you'll work with—and against—fluid dynamics to learn how water skis are designed for different purposes.

Materials

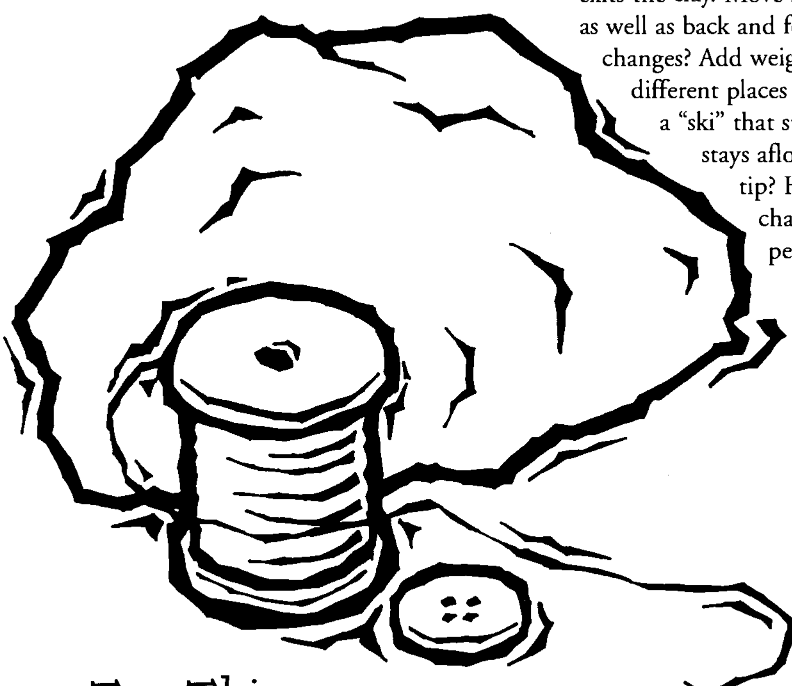
- modeling clay
- thread
- button
- tub filled with water

1. First, experiment with the buoyancy of your clay. Mold different amounts of clay into aerodynamic and nonaerodynamic shapes. Drop them into the water from 30 cm (1') above the surface. Do some shapes sink faster than others? Does a higher or lower dropping distance affect how quickly they sink?

2. Tie the button onto the end of the thread. Shape the clay around the button into your most aerodynamic shape from step 1. Using constant speed, pull the clay along the surface of the water. Does it spin or travel straight? Now try your most nonaerodynamic shape, using the same amount of clay, and pulling it along at the same speed as before. Is it more difficult to keep the speed constant? Which of the two sinks faster when you stop pulling?

3. Start thinking like a water ski designer. First, experiment with different bottom shapes—square, beveled, and concave. What happens when you alter the bottom of one side of your clay "ski" but not the other? Can you create a ski that turns right while your "towrope" travels straight? One that dives underwater?

4. Try changing the point where your thread exits the clay. Move it up and down in front, as well as back and forth in the body. What changes? Add weight with pennies at different places on the clay. Can you build a "ski" that still moves straight and stays afloat with five pennies at the tip? How does your design change when you move the pennies to the back?



Try This

Powerboat engines are measured according to their horsepower, with one horsepower being equal to 550 foot-pounds per second. You can measure your own horsepower and compare it to a boat engine. First measure the vertical height of a flight of stairs. Have a friend time how quickly you can run up the stairs. Your horsepower equals:

$$\frac{\text{your weight in pounds} \times \text{stairway height in feet}}{\text{number of seconds it took you to run up the stairs}}$$

Try This

Dig through some old clothes and select about five of different fabrics, choosing pieces large enough for you to sit on. Take them to a park that has a large slide. Experiment with the friction level for each fabric by sitting on it as you slide. Does the friction level change if you switch to squatting rather than sitting? What happens when you only half-sit on a slippery fabric?

Try This

Water-skiers hold onto the towrope using an opposed grip, rather than an overhand. This increases power and makes it easier to pull your arms close to your body and control speed and balance. Make a tug-of-war towrope using 30-cm (1') lengths of plastic pipe as handles on each end. Try pulling against a friend, once with your hands gripping with all your fingers the same way, and once with the opposed "baseball bat" grip. Do you notice a difference in your pulling power?

Try This

Water-skiers always wear a personal flotation device made of closed-cell foam covered with vinyl or nylon fabric. Using a blunt table knife, carve different shapes out of Styrofoam®. Fill a sink with water and experiment with the different sizes and shapes. Do different shapes seem to offer more resistance to sinking when you weigh the pieces down with coins? Can you create a shape that sinks?

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Why in the world do we sneeze, cough, yawn, blink, and belch? How do these reflex actions help protect us?

SHOW NUMBER

1301

Peggy learns about reflexes from some very young experts.

Segment length: 6:30

Reflexes

Why does a doctor test my reflexes when I have a check up?

Insights

Sneezing, coughing, and blinking are simple reflexes. But they aren't as simple as they seem.

It's true that reflexes have a simple definition. They're involuntary actions or movements that occur in response to a stimulus. And you may not think that much goes on when you yawn, for example. But you might be surprised.

Each reflex action can involve countless complex communications and intricate coordination among nerve cells called neurons. These neurons are found in the *central nervous system*, which includes your brain and spinal cord, and the *peripheral nervous system*, which includes all the nerves that reach your body's extremities. Not all neurons are alike, however.

- Sensory (or *afferent*) neurons carry messages to the brain and spinal cord.
- Motor (or *efferent*) neurons carry messages away from the brain and spinal cord. They tell muscles to contract or relax and spur glands into action.
- *Interneurons* send messages between nerve cells within the brain, spinal cord, and the periphery. These busy characters make up over 99 percent of the more than 10 billion neurons in our nervous system.

But why is the brain involved in reflex actions at all? As part of the nervous system, the brain has specialized functions, only some of which control thought or voluntary movement. The brain stem, for example, manages involuntary reflexes such as breathing and keeping our balance. We don't consciously decide to do these things. But a part of our brain is still involved.

Reflexes serve as primitive responses that protect our bodies from danger and help us adjust to our surroundings. We cough, for example, when an irritant enters our windpipe and we need to expel it through our mouth. We sneeze when we need to clear our nasal air passages of irritants and allergens. We blink when danger threatens the sensitive tissues of the eye and when we need to moisten and clean the cornea. (This reflex occurs 900 times an hour!) We yawn when nerves in the brain stem find there's too much carbon dioxide in the blood. A yawn makes the muscles in our mouth and throat contract and forces our mouth wide open, allowing us to expel carbon dioxide and take in a large amount of oxygen-rich air.

Without these reflex actions, we would be unable to survive. So even though they may be simple, these reflexes are a really big deal.

Connections

1. What other reflex actions do we have? How do they protect us? Which reflexes can we control more than others?
2. If you could design new reflexes for yourself, what would they be?

Key Words

afferent carrying toward a given point
central nervous system the part of the nervous system in vertebrates that consists of the brain and spinal cord
efferent carrying away from a given point
interneurons connecting neurons
patellar tendon reflex knee-jerk reflex
peripheral nervous system nerves and nervous tissue outside the central nervous system
receptor specialized cell or ending on a sensory neuron that a stimulus can excite
synapse tiny gap between the axon of one neuron and the cell body of another neuron across which messages are transmitted chemically or electrically

Resources

Kittredge, M. (1990) *The senses.* New York: Chelsea House Publishers.

Ornstein, R. & Thompson, R.F. (1991) *The amazing brain.* New York: Houghton-Mifflin.

Restak, R.M. (1994) *Receptors.* New York: Bantam Books.

Xenakis, A.P. (1993) *Why doesn't my funny bone make me laugh: Sneezes, hiccups, butterflies, and other funny feelings explained.* New York: Villard Books.

Additional resources
Coronet Films: *Human body: Nervous system* and *Human body: Brain.* Videotapes. (800) 777-8100.

Encyclopedia Britannica Films: *The nervous system.* Videotape. (800) 621-3900.

Queue, Inc.: *Experiments in human physiology.* Software for Apple II. (800) 232-2224.

Queue, Inc.: *Nervous and hormonal systems.* Software for Apple II, IBM and compatibles, or Macintosh. (800) 232-2224.

Additional sources of information
American Academy of Neurology
2221 University Ave. SE
Suite 335
Minneapolis, MN 55414
(612) 623-8115

BrainLink: Explorations in Neuroscience
Baylor College of Medicine
Houston, TX 77030
(800) 798-8244

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3M Innovation

A Nervewracker

Pit your reflexes against the clock in this reaction-time challenge.

NEWTON'S APPLE®

SHOW NUMBER

1301

Reflexes

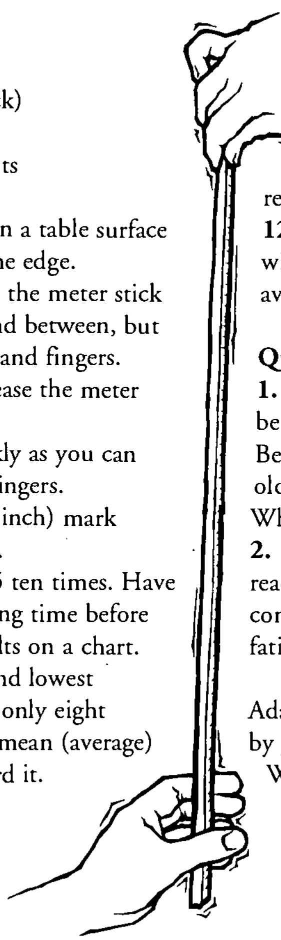
Main Activity

How fast do your nerves send and receive messages? Involuntary reflexes are very fast, traveling in milliseconds. The nerve impulses in the neurons that control these reflexes travel an express route. In fact, the fastest impulses reach 520 kilometers (320 miles) per hour! Our conscious muscular response to a stimulus takes a much longer route. See just how fast your brain and nerves respond to stimuli in this experiment.

Materials

- meter stick (yardstick)
- table and chair
- chart to record results

1. Sit with your forearm on a table surface so the hand extends over the edge.
2. Have your partner hold the meter stick (yardstick) with the zero end between, but not touching, your thumb and fingers.
3. Ask your partner to release the meter stick without warning.
4. Catch the stick as quickly as you can between your thumb and fingers.
5. Record the centimeter (inch) mark where you caught the stick.
6. Repeat steps 3, 4, and 5 ten times. Have your partner vary the waiting time before each drop. Record the results on a chart.
7. Cross out the highest and lowest numbers on your chart, so only eight numbers are left. Find the mean (average) of these numbers and record it.



8. Repeat this experiment with your partner catching the stick. Record the results.
9. Then switch hands and perform the same experiment. Record these results as well. Is there a difference in reaction time between your writing hand and your other hand?
10. See if an auditory stimulus affects your reaction time. Close your eyes and have your partner say "go" when he or she releases the stick. React as soon as possible. Record your results.
11. Does distraction affect your reaction time? Have your partner ask you simple math questions and repeat the experiment. Again, record your results.
12. Compare your reaction time averages with those of your classmates. Derive a class average.

Questions

1. Are there differences in reaction times between right- and left-handed people? Between genders? Between younger and older people? Experiment with test groups. What accounts for any differences?
2. How can you improve your reflex reactions? Test your theories. What can you conclude about the effects of practice and fatigue on reaction time?

Adapted in part from *A+ Projects in Biology* by Janice VanCleave. Published by John Wiley & Sons, Inc. (1993).

Try This

Check your knee-jerk reflex. Ask a partner to sit on the edge of a table with legs hanging freely. Use the side of your hand to chop lightly at your partner's leg just below the kneecap (patella) at the patellar tendon. Switch places and repeat the experiment. What could you do to prevent this reflex from happening?

Try This

Research a disease that affects our reflexes, such as polio or amyotrophic lateral sclerosis (ALS, for short). Read the inspiring stories of people who suffered from these diseases—for example, Franklin Delano Roosevelt, Lou Gehrig, and Stephen W. Hawking.

Try This

Hold a ruler horizontally just below your eyes, resting it on the cheekbones. Close your eyes for a minute. As you open them, have a friend shine a flashlight directly into your eyes and measure the distance the pupils contract. Test to see if this pupillary reflex works with both eyes or just the eye exposed to the light. Why does this reflex occur?

Try This

Hold a pane of clear plastic or Plexiglas in front of your face, with your nose touching it. Have someone throw a crumpled ball of paper at the plastic, aiming at your eyes. Can you control your blinking reflex?

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3M Innovation

NEWTON'S APPLE®

How do high-wire artists balance on such a thin wire? Why do they carry such long poles?

SHOW NUMBER
1302

Dave tries to find his balance for a high-wire act.

Segment length: 6:15

Circus High Wire

How do tightrope walkers keep their balance?

Insights

Imagine yourself 20 meters (66 feet) above the ground on a platform, as thousands of faces watch and wait for you *to style*. Now imagine taking a step, with only a 1/2-inch metal wire between you and the ground. Welcome to the world of high wire.

High wire's roots are as old as ancient Egypt and first century China, where the art of "rope dancing" was performed over knives. In the 1850s, Jean Francois Gravelet received world acclaim for cooking and eating an omelette (complete with stove and neatly set table) on a high wire stretched over Niagara Falls.

Three different types of *funambulism* have evolved. Slack wire, where the rope or wire hangs a bit loose, is popular for juggling, clowning, and sword fights. Sloped wires are attached to the ground at one end and to a pole at the other, creating an angle of about 40 degrees. The most popular of all is the high-wire act, where a taut, springy wire is used to launch dizzying acrobatic tricks and phenomenal feats of balancing.

One way to view the high-wire act is to see the wire as an axis and the *center of mass* of the performer as having the potential to rotate about the axis. If the center of mass is not directly above the wire, gravity will cause the performer to begin to rotate about the wire. If this is not corrected, the performer will fall.

The artist often carries a balancing pole that may be as long as 12 meters (39 feet) and weighs up to 14 kilograms (31 pounds). This pole increases the *rotational inertia* of the artist, which allows more time to move his or her center of mass back to the desired position directly over the wire. This effect can be magnified by making the pole as long as possible and by weighting its ends.

The pole also helps balance the funambulist by lowering the center of gravity. High-wire artists use drooping, rather than rigid, balance poles. It's possible, in fact, to have such heavy weights attached to the ends of a long, drooping pole that the center of gravity of the performer/pole system is below the wire. In this case, the performer would require no more sense of balance than a person hanging from the wire.

Acrobats train for years and use *mechanics* to safely develop routines. Although a high-wire performance may seem like a combination of courage and magic, remember that there's a lot of work and good, old-fashioned physics thrown into the balance as well!

Connections

1. How would maintaining control over your center of balance change as you moved from a high wire to a slack wire to an angled wire?
2. Why do squirrels have long tails?

Key Words

center of mass the point at which the entire mass of a body can be considered to be concentrated
funambulism tightrope walking—from the Latin *funis* (rope) and *ambulare* (walk)
inertia tendency of an object in motion to remain in motion and an object at rest to remain at rest
mechanics circus term for the safety wire attached to a performer executing a difficult or dangerous trick or feat
riggers circus term for the people who hang the cable and wires for performers
static not moving
to style circus term for a performer's particular way of bowing and posing to acknowledge the audience
rotational inertia the resistance of a body to a change in its rotational motion

Resources

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Burgess, H. (1976) *Circus techniques: Juggling, equilibristics, vaulting.* New York: Drama Book Specialists.

Collins, G. (1994, Dec 8) An inner light, a leap of faith. *The New York Times,* p. B1.

Cushman, K. & Miller, M. (1990) *Circus dreams: The making of a circus artist.* Boston: Little, Brown and Company.

Dubner, S.J. (1991, Apr 22) Four little girls that fold. *New York,* p. 28.

Moss, M. (1987) *Fairs & circuses.* New York: The Bookwright Press.

Rosenfeld, M. (1993, Oct 31) Body & Soleil. *Washington Post,* p. G1.

Vial, V. & Dufresne, H. (1993) *Cirque du Soleil.* New York: International Publications.

Wallenda, D. & DeVincentis-Hayes, N. (1993) *The last of the Wallendas.* Far Hills, NJ: New Horizon Press.

Wiley, J. (1974) *Basic circus skills.* Harrisburg, PA: Stackpole Books.

Additional resource
Encyclopedia Britannica: *Circus!* Videotape. (800) 621-3900.

Additional source of information
Circus World Museum
426 Water Street
Baraboo, WI 53913-2597
(608) 356-8341

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Balancing Act

Build a tightrope setup and go for a walk!

NEWTON'S APPLE

SHOW NUMBER

1302

Circus High Wire

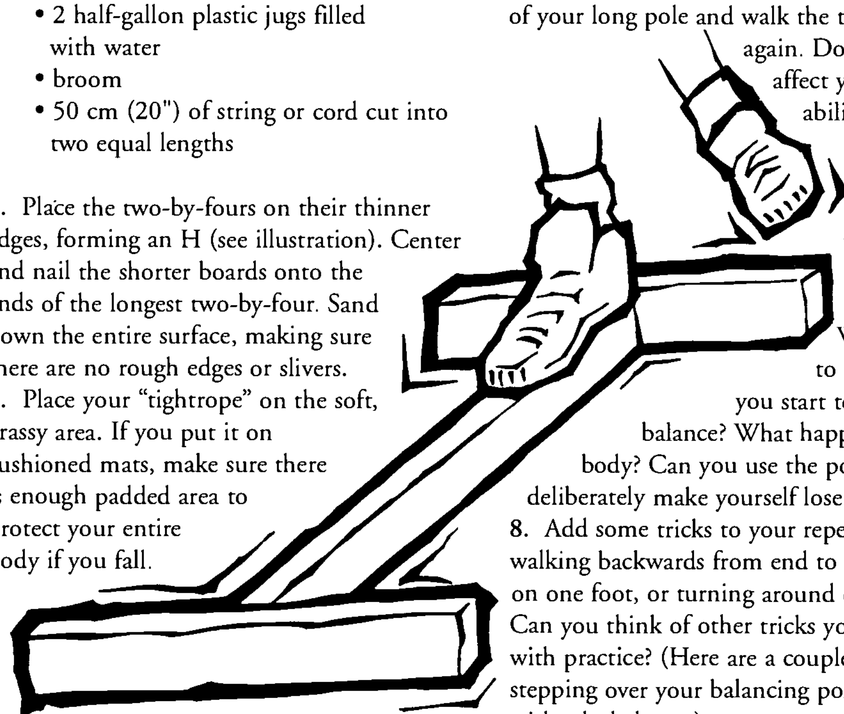
Main Activity

Make your dreams of running away to join the circus come true—at least for a little while. In this activity, you'll 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
- 2 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.



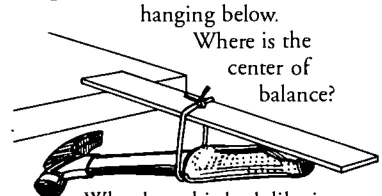
3. First, try walking from end to end very slowly. Where do you find yourself holding your hands and arms? Try holding them still—first straight out from your body, then overhead, then stiff by your sides. How do these different positions affect your balance? Why? Try these same positions holding a filled 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?

Try This

Here's a simple model to help you understand how center of balance and counterbalances work: Take a piece of string about 30 cm (1') in length and form it into a circle. Take a ruler and a hammer and assemble them together as shown. Balance the end of the ruler against the edge of a table with the hammer hanging below. Where is the center of balance?



Why does this look like it shouldn't work?

Try This

Hold a large book in your hands. Have a friend gently try to disturb your balance. Now hold the book in different locations. Which location makes it easiest for you to keep your balance? Why?

Try This

Stand on a pillow in a safe, open, soft area. Can you balance on one foot? Now put on a blindfold. How does that affect your sense of balance?

NEWTON'S APPLE®

What conditions are needed for mummification to take place? How did ancient Egyptians prepare mummies? What can mummies teach scientists about the way people lived in the past?

SHOW NUMBER

1302

Brian unwraps the mysteries of mummies.

Segment length: 7:30

Mummies

How are mummies able to "survive" the tests of time?

Insights

Imagine that you could step through a time portal and get a firsthand look at what daily life in ancient Egypt was like. For decades, *archaeologists* have been taking just these types of journeys, and their tour guides have been the mummified remains of individuals who died centuries ago. Even though their lips are silent, *mummies* speak volumes to those who know how to ask the right questions.

When most people hear the word "mummy," they usually think of ancient Egypt. But mummies have been found all over the world, including China, Europe, Peru, and Mexico. In fact, many mummies have formed naturally without any human preparation at all.

For mummification to occur, all water must be removed from the body. Little or no decomposition from bacterial action can take place. As you might expect, most mummies have been discovered in desert environments. But they have also been found in peat *bogs,* where the water is extremely acid and has little or no oxygen, and in the tundra, where individuals have become trapped in glacial ice. In both environments, bacteria cannot break down the body tissue. Some scientists argue whether "bog men" and "ice men" are true mummies, but these bodies still can reveal a great deal about the world they lived in.

The earliest Egyptian mummies date back to around 3200 B.C. By interpreting the text on the walls of tombs, scientists have learned that the mummification process evolved over time. In early days, preparers would simply treat the body by covering it with a natural salt, called *natron* (now called baking soda), to help dry it out, and then wrap it in bandages soaked in a type of resin. By about 1500 B.C., the art of mummification reached its peak. Before treating the body, morticians would remove the brain and many vital organs. Then they would pack the abdominal cavity with natron, sand, or sawdust and immerse the body in more natron for about 40 days. After that, the body was washed, repacked with spices and more natron, and wrapped in bandages. The whole process took about 70 days.

People were often buried with food, tools, jewelry, clothes, and even pets. By studying these artifacts and using modern-day clinical analysis on the mummies, scientists have unlocked many mysteries about diet, health, and even grooming habits. With the help of *CAT scans, X rays, MRIs,* and other clinical techniques, these silent sentries of past civilizations tell us much about how they lived.

Connections

1. Some believe that opening tombs to study mummies shows disrespect for the dead. Others feel that it is justified for the valuable information it reveals. Does the need for scientific knowledge outweigh the rights of the dead?

Key Words

archaeologist individual who studies past human cultures
bog stagnant pond of oxygen-poor water with low pH
CAT scan computerized axial tomography; imaging technology used to view soft and hard tissue in the human body
MRI magnetic resonance imaging; imaging technology based on magnetic fields and used to view soft tissue in the human body
mummy body whose skin and soft-tissue remains are preserved
natron naturally occurring salt (sodium carbonate) used by ancient Egyptians to dry and preserve mummies
X ray imaging technology used to view the hard tissue (bones) in a body

Resources

Hadingham, E. (1994, Apr) The mummies of Xinjiang. *Discover,* pp. 68–77.

Handt, O., et. al. (1994, June 17) Molecular genetic analysis of the Tyrolean ice man. *Science,* pp. 1775–1778.

Polosmak, N. (1994, Oct) A mummy unearthed from the pastures of heaven. *National Geographic,* pp. 80–103.

Roberts, D. (1993, June) The iceman: Lone voyager from the Copper Age. *National Geographic,* pp. 36–67.

Ross, P. (1992, May) Eloquent remains. *Scientific American,* pp. 114–125.

Schobinger, J. (1991, Apr) Sacrifices of the high Andes. *Natural History,* pp. 63–68.

Sjovold, T. (1993, Apr) Frost and found. *Natural History,* pp. 60–63.

Svitil, K. (1994, June) What the Nubians ate. *Discover,* pp. 36–38.

Wright, K. (1991, July) Tales from the crypt: With the help of modern medical imagery and a supercomputer, an archaeologist probes an ancient mummy. *Discover,* pp. 54–58.

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Salt of the Earth

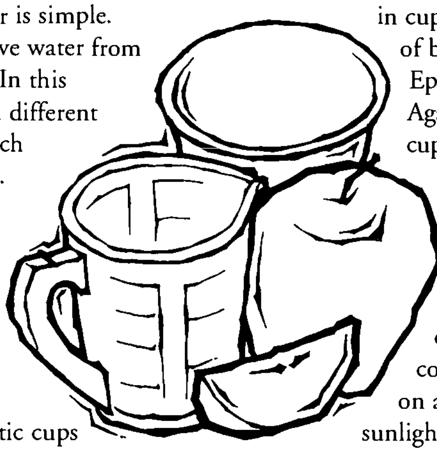
Discover how you can make your own mummy.

NEWTON'S APPLE®

SHOW NUMBER **1302** *Mummies*

Main Activity

Have you ever wondered why every time you eat salty foods, you get thirsty? Or why fresh vegetables tend to shrivel up when you sprinkle salt on them? The answer is simple. Salt is a desiccant—it helps remove water from things, including human bodies. In this activity, you will experiment with different salt compounds and discover which makes the best mummified apple.



Materials

- 2 fresh apples
- large box of table salt
- large box of Epsom salts
- large box of baking soda
- knife
- eight 12-oz disposable plastic cups
- measuring cup
- large mixing bowl
- permanent marking pen
- roll of masking tape
- sensitive balance or food scale
- piece of graph paper and pencil

1. Slice the two apples into quarters so that you have eight slices similar in size. Place a piece of tape on each cup and write the words "starting weight." Select one slice, weigh it, and record the weight on the outside of cup 1. Follow the same procedure with the other seven apple slices until each cup has been labeled with the appropriate starting weight.
2. Add exactly 1/2 cup of baking soda to cup 1, making sure to completely cover the apple. Write the words "baking soda only" on the outside label. Fill cup 2 with 1/2 cup Epsom salts. Fill cup 3 with 1/2 cup table salt. Make sure you label each cup.
3. Repeat the same procedure for cups 4–6 using a 50:50 mix of Epsom and table salts in cup 4, 50:50 mix of table salt and baking soda in cup 5, and a 50:50 mix of baking soda and Epsom salts in cup 6. Again, make sure each cup has the correct label.
4. In cup 7 make a mixture of 1/3 baking soda, 1/3 Epsom salts, and 1/3 table salt. Leave cup 8 alone as a control. Place the cups on a shelf out of direct sunlight and let them sit for seven days. After a week has gone by, take out each apple slice, brush off as much salt as possible, and reweigh. (Do not rinse the apple off because that will rehydrate it.) Compare the starting and ending weights of each slice and calculate the percentage of weight which is moisture lost for each by dividing the difference in weight by the starting weight.

Questions
1. Which compound would seem to work best at making an apple mummy?
2. Would you have achieved the same results if you used a whole, unpeeled apple? Try it and find out.
3. What was the point of leaving one of the apple slices in a cup without any salt at all?
4. Where did the moisture in the slices go? How could you confirm this?

Try This

How do you look inside something without opening it up? This is a problem that archaeologists face every time they find a new mummy. To get an idea of how tough this really is, try the following activity. Take an old shoe box with a lid and have a friend place a "mystery object" inside. Tape the lid closed and try to figure out what's inside by sliding it back and forth, shining a light in it, tapping on it with a pencil, etc. The only thing you can't do is open it up and look inside!

Try This

Salts and special drying solutions played important roles in preserving mummies, but they also served another purpose. Before refrigerators and freezers, people had to preserve food by pickling, drying, salting, and smoking. Visit a local food store and see how many foods you can find that have been preserved the same way as mummies. Try your hand at drying different fruits. How do the textures and tastes compare?

Try This

Find out how hard it is to reconstruct pottery at an archaeological site. Assemble five or six old clay flower pots and decorate them on the outside with either magic marker or paint. Try to make each design distinctive. Now, place all the pots into a large paper bag and close the top. With a hammer, gently bang on the pots inside the bag until they are all broken into pieces. Next, shake the bag several times and dump out half the pieces. Using white glue, try to reassemble as many of the original pots as you can.

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NEWTON'S APPLE®

What's it like to travel through Central America with nothing but a bicycle, a laptop computer, a satellite dish, a few supplies, and a few hundred thousand friends?

SHOW NUMBER

1303

Peggy travels through Belize with a high-tech tour guide—the Internet.

Segment length: 8:30

Maya Bike Trek

How can technology help you take a bike trip through Central America?

Insights

What if you had the chance to go on a three-month trip to Central America to explore *la ruta Maya?* What if you planned to cover over 2,000 miles but had only your bike for transportation? What if you brought the maps you needed, but wouldn't know exactly where to go until students from over 40,000 schools sent you *e-mail* to vote on your route? What if you had to go on this trip with your brother?

Explorers (and brothers) Dan and Steve Buettner did all this and more on their MayaQuest expedition. But this wasn't their first bike trip. They rode 15,536 miles from Alaska to Argentina, covered 12,888 miles in the former Soviet Union, and biked 12,107 miles from Tunisia to South Africa. During the MayaQuest trek, each team member rode over 1,200 miles.

Dan, team leader, and Steve, team journalist and *videographer,* were joined by Julie Acuff, who served as the *epigrapher,* and photographer Doug Mason. To prepare for the trek, they consulted with Maya researchers, including *archaeologists* and *ethnobotanists.* They studied Maya history for clues to the collapse of this advanced civilization during the ninth century.

The team limited the supplies they brought—clothing, passports, money, bicycle repair supplies, maps, medical supplies, sleeping bags, tents, pots and pans, food, and toiletries. Water bottle purifiers allowed them to drink whatever water they could find.

A unique aspect of the trek was the technology that encouraged anyone with access to the Internet to interact with the team. Using a laptop computer powered by solar panels, team members recorded daily journal entries, calculated distances, and communicated via e-mail with students and others who followed the trek. With a portable satellite telephone, the team sent faxes, photos, and data and voice transmissions. Using two 8mm video cameras, they recorded sights and discoveries and transmitted the images via satellite.

Team members entered information onto a computer, connected to a suitcase-sized satellite transmitter. The information was sent as a radio signal to a satellite orbiting 22,400 miles above the equator. The satellite relayed the signal to a station in Southbury, Connecticut, which transmitted it over 800 miles of phone lines to Hamline University in St. Paul, Minnesota. There the message was placed on the Maya-Quest home page on the Internet. In just three months, it received over 1.1 million visits.

Connections

1. What effect might the MayaQuest trek have on the lives of modern Maya?
2. Why do we study other civilizations?

Key Words

archaeologist a scientist who studies the life and culture of ancient people

e-mail electronic mail sent from one computer to another by means of special software and a modem connected to a telephone line, or between computers connected to a network

epigrapher someone who deciphers hieroglyphs

ethnobotanist scientist who studies how humans use and relate to plants

la ruta Maya Spanish for "Maya route." The term refers to the regions of Mexico, Belize, Guatemala, and Honduras where the Maya lived.

videographer person who records events with a video camera

Resources

Brosnahan, T. (1994) *Guatemala, Belize & Yucatan—La ruta Maya. A travel survival kit.* Berkeley, CA: Lonely Planet.

Dreher, D. (1992) *Explorers who got lost.* New York: Tom Doherty Associates.

Maynard, C. (1995) *Questions and answers about explorers.* New York: Kingfisher Books.

Taylor, B. (1993) *Maps and mapping.* New York: Kingfisher Books.

Trout, L. (1991) *The Maya.* New York: Chelsea House Publishers.

Volkmer, J. (1994) *Song of the chirimia: A Guatemalan folktale.* Minneapolis, MN: Carolrhoda Books.

Additional resources

MayaQuest home page:
mayaquest@mecc.com
On Prodigy: mayaquest

MayaQuest theme-based projects:
http:/www.ties.k12.mn.us/mayaquest

MECC: *MayaQuest, Africa Trail,* and *Oregon Trail.* Software/CD-ROM for Macintosh or Windows. (800) 685-6322.

Additional source of information

Earthwatch Expeditions, Inc.
680 Mount Auburn St.
PO Box 403
Watertown, MA 02272
(800) 776-0188
E-mail: info@earthwatch.org
World Wide Web:
http://gaia.earthwatch.org

Hit the Trail

Choose a location and prepare for a bike trek.

NEWTON'S APPLE®

SHOW NUMBER

1303

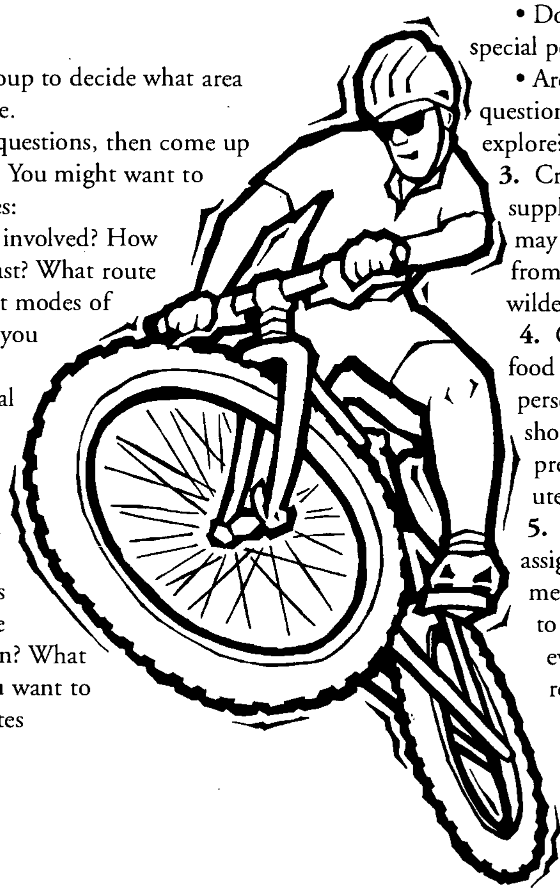
Maya Bike Trek

Main Activity

Want to design your own bicycle trek? A lot of careful planning is required to make sure everything's ready before you get started.

Materials

- paper
- markers
- area maps



1. Work with a group to decide what area you'd like to explore.
2. Create a list of questions, then come up with some answers. You might want to consider these issues:

- Who will be involved? How long will the trek last? What route will you take? What modes of transportation will you use?
- What physical training do you need to get in shape for the trip?
- What should you research about the terrain, the sites on the way, and the history of the region? What information do you want to collect about the sites you'll see? How will you collect the information? Will you share it with anyone?
- Is someone in the group an expert photographer or videographer? Do you need to learn more about photography before the trip?
- Do you need to obtain special permits?
- Are there any special questions that you want to explore?

3. Create a list of basic supplies you'll need. You may want to get suggestions from a company that outfits wilderness trips.
4. Calculate how much food you'll need to take per person and make a shopping list. Who will prepare it? What cooking utensils will you need?
5. Discuss the roles assigned to the team members. Will you need to rotate duties so that everyone can try every role?

Try This

Students around the world will be helping direct the MayaQuest II bike trek, scheduled to depart for Central America in 1996. Find out how you can be a part of this adventure by contacting MayaQuest by e-mail: mayaquest@mecc.com
You can also find them on the World Wide Web: http://mayaquest.mecc.com
Or write to MayaQuest, 529 S. 7th St., Suite 320, Minneapolis, MN 55415.

Try This

Much of what we know about a culture, including our own, is found in folk stories. Many folktales explain why something happened, or how something got its name. Write your own folktale to explain something about your culture. You could even be the main character!

Try This

In the math you do daily, you use a base 10 system. Computers use a binary system (zero and one are the only numbers). The system developed by the Maya was base 20. It used a dot for one, a bar for five, and a shell for zero. How would you create your own math system using another base? What symbols would you use to represent each group of numbers?

Try This

The MayaQuest team traveled over 1,200 miles on their bicycle trek through the Maya region. Set up a stationary exercise bicycle (someone's parent probably has one you can borrow) in your classroom. Attach an odometer if it doesn't already have one. Take turns riding it daily, and keep a journal of how "far" you travel, how long it takes, and how you feel when you're done. What is the ratio between how far you ride each day and how far the trekkers went daily? How long would it take you to match the miles ridden by the MayaQuest team?

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3M Innovation

NEWTON'S APPLE®

How can noise be hazardous to your hearing? What causes hearing loss? What can we do to protect ourselves from noise pollution?

SHOW NUMBER
1303

Dave hears all about the ear.

Segment length: 7:30

Hearing

Can I damage my hearing by listening to loud music?

Insights

Have you ever heard a ringing in your ears after a loud concert? Did sounds seem muffled? These could be early signs of permanent hearing loss. Constant or even occasional loud noises can damage your hearing beyond repair. More than 35 percent of the 28 million cases of hearing loss in the United States are caused, at least in part, by exposure to hazardous noises.

Hazardous noise can be anything from loud music to the sounds of a lawn mower. To find out how hazardous a sound is, we measure its loudness in *decibels,* which tell us its power or intensity. The decibel scale is logarithmic—each 10-dB increase is a factor of 10.

The normal human ear can hear sounds down to 0 dB. The roar of a rocket lifting off registers over 140 dB. Experts consider noise levels above 85 dB hazardous, particularly when you're exposed to them for long periods. The louder the noise, the less time it takes to damage your hearing. Many rock concerts are 110 dB or more. If you attend often, you can damage your hearing before you know you are in danger.

The ear has three parts—the outer, the inner, and the middle ears. The outer ear includes the visible part outside our head and the ear canal, which ends at the *eardrum.* The middle ear contains three tiny bones called *ossicles.* The inner ear contains the *cochlea,* housing thousands of hair cells and nerve endings.

When sound waves travel down the ear canal and strike the eardrum, it vibrates. This causes the ossicles to vibrate. The sound is then transmitted to the inner ear. Vibrations set the fluid within the cochlea in motion, stimulating the hair cells. The movement of the hair cells stimulates the auditory nerve endings, which send the sound pattern to the part of the brain that interprets it.

Hearing problems in the outer and middle ears can cause *conductive hearing loss.* An example is otitis media, fluid in the middle ear caused by infection. These problems can often be corrected with medicine or surgery. *Sensorineural hearing loss* is usually permanent and is caused by damage to hair cells in the inner ear. When hair cells or auditory nerves are destroyed, they cannot be repaired. Loud and persistent sounds can damage hair cells and cause permanent hearing loss and *tinnitus.*

Next time you listen to music, keep the volume low and rest your ears often. Use earplugs at concerts. Remember, once your hearing is damaged by loud noise, it's gone forever!

Connections

1. Name ten jobs that involve loud noise. How could you protect your hearing at these jobs?
2. How would society and life as we know it change if no one could hear?

Key Words

cochlea spiral-shaped cavity of the inner ear that contains hair cells and nerve endings
conductive hearing loss hearing loss caused by a problem in the outer and middle ears
decibel logarithmic system of rating where the larger the number, the louder the sound
eardrum membrane forming a tight seal between the outer ear and middle ear
ossicles the three bones—malleus, incus, and stapes—that send sound from the eardrum to the inner ear
sensorineural hearing hearing loss caused by a problem in the inner ear, along the auditory nerve, or in the brain
tinnitus ringing, roaring, or other sensation of noise in the ears

Resources

Bahadori, R.S. & Bohne, B.A. (1993, Apr) Adverse effects of noise on hearing. *American Family Physician,* p. 1219.

Jaret, P. (1990, July-Aug) The rock & roll syndrome. *Health,* pp. 50–57.

Kittredge, M. (1990) *The senses.* New York: Chelsea House Publishers.

Vernick, D. (1993) *The hearing loss handbook.* New York: Consumers Union.

Additional resources
Boston Broadcasters: *The ear.* Videotape. MTI: (800) 777-8100.

Centron Educational Films: *Ears: Have you heard the latest?* Videotape. Simon & Schuster Communications: (212) 698-7000.

Pyramid Film & Video: *I am Joe's ear.* Film and videotape. (800) 421-2304.

Queue Inc.: *Learning all about heat & sound.* CD-ROM for Macintosh or MS-DOS. (800) 336-2481.

3M Learning Software: *What's the secret?* CD-ROMs for Macintosh or Windows. (800) 219-9022.

Additional sources of information
American Speech-Language-Hearing Association
10801 Rockville Pike
Rockville, MD 20852
(800) 638-8255

Hearing Education and Awareness for Rockers
PO Box 460847
San Francisco, CA 94146
(415) 773-9590

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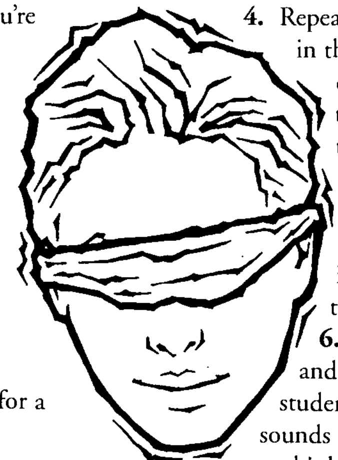
Name That Noise

Identify the type and location of a sound without the help of your eyes.

Main Activity

How good are you at listening when you can't rely on your eyes for help? Test your skill at identifying odd sounds coming from different directions when you're blindfolded. Gain a new appreciation for the way those two little funnels on either side of your head work.



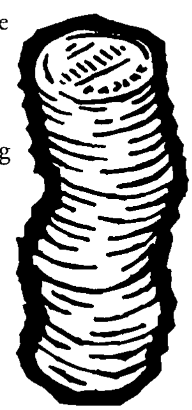
Materials

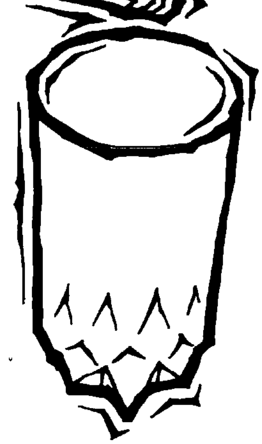
- objects to make noise with, such as blocks, stones, coins, a glass, empty can, or pen
- scarf or handkerchief for a blindfold
- earplugs (available at most hardware, drug, music, or sporting-goods stores)

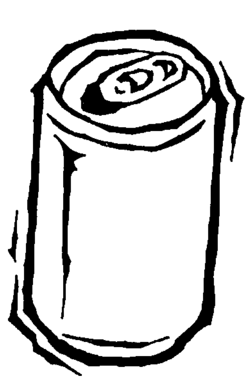
1. Choose a classmate to sit blindfolded in the middle of a circle of students seated at various points around the room. Have this student place an earplug in one ear.
2. Silently point to a student in the surrounding circle, who then makes a sound with one of the objects you've gathered. For instance, that person can use the object to clap, tap, click, snap, or rattle.
3. Ask the blindfolded student to point back in the correct direction of the sound and identify it.
4. Repeat this step with five other students in the circle, each of whom makes different sounds. Record how often the blindfolded student identifies the correct location and sound.
5. Ask the blindfolded student to unplug her or his ear. Repeat the process. Is she or he better able to identify the location and source of the sounds?
6. Select other students in the class and repeat the experiment. Are some students more accurate in distinguishing sounds and locations than others? Why do you think this is so?

Questions

1. What sounds were easiest to identify? Which were hardest? Does this tell you anything about the way we hear and the sounds we expect to hear?
2. What are some things you can do to improve your hearing or listening ability?







NEWTON'S APPLE

SHOW NUMBER

1303

Hearing

Try This

Get a stopwatch and hold it close to a classmate's ear. Then move it out from the ear until your partner can no longer hear the sound. Measure and record this distance. Repeat for the other ear. Is the distance the same?

Try This

Watch your favorite TV show with the sound off. How much of the plot or dialogue did you understand? What did you find yourself paying attention to that you might not have noticed normally?

Try This

Bats and dolphins use ultrasonic sound waves to "see" with sound. Conduct research on how they navigate and sense the world by echo. Find out how insects, birds, reptiles, and fish hear. Do they have ears? What kind of ossicles do they have?

NEWTON'S APPLE®

Where is the Serengeti? What makes its ecosystem unique?

SHOW NUMBER 1304

David explores the Serengeti ecosystem in a hot-air balloon.

Segment length: 5:30

Balloon Safari

How does the Mara ecosystem work?

Insights

To the *Maasai* people, Serengeti means "endless plain." To others, it means Africa itself. The Maasai Mara National Reserve in Kenya and the Serengeti National Park in Tanzania preserve much of the Serengeti-Mara *ecosystem,* a 26,000-square-kilometer (10,000-square-mile) home to three million animals. This ecosystem is defined as much by the boundaries of the wildebeest *migration* as by the characteristics of the land and climate.

Twice a year the rains come to the Serengeti. The heaviest rains pour from March until May; the lighter rains fall from November to December. Two million *grazers,* including wildebeests, have spent the dry months browsing in the northern woodlands of the park. As the rains come, the wildebeests make their several-hundred-mile journey to the Serengeti Plain and the new grasses of the *savanna.*

The grass knits the Serengeti together. As the great herds return to the plains, the new grass awaits them and will form the staple of their diet. These grazers have evolved a set of front teeth for biting and back teeth for grinding. Each species grazes on specific parts of the grass. Zebras bite off the grass's tough tops, wildebeests chew on the middle leaves and stems, and gazelles and other antelopes eat the stems closest to the ground. The *food chain* doesn't stop there. Carnivorous (meat-eating) predators lie *camouflaged* in the grasses, readying themselves for the kill.

As in all ecosystems, the animals of the Serengeti have adapted to their *habitat.* The giraffe's tough 46-centimeter-long (18-inch-long) tongue reaches between the thorns of the acacia to eat its tender leaves 5 meters (16 feet) above the ground. The cheetah's flexible spine enables it to sprint over 97 kilometers (60 miles) per hour to topple and kill a gazelle. The hippopotamus's eyes, ears, and nose are located at the top of its head so that its 3,175-kilogram (7,000-pound) body can stay submerged under water. The vulture's keen eyesight can spot a dead animal from 300 meters (1,000 feet).

The Serengeti remains one of the last places on earth where life in the wild surpasses the imagination. Yet with the encroachment of people, pollution, and poaching, the balance of nature is being disturbed. If the world doesn't cry out for the Serengeti's preservation, this vast wild place could soon be gone.

Connections

1. What are the characteristics of the ecosystem in which you live? How is it similar to the Serengeti? How is it different?

2. Animal adaptation in the Serengeti is fascinating. How have the animals adapted to the ecosystem in which you live?

Key Words

camouflage to blend in with the environment

ecosystem community of organisms occupying a habitat, together with the physical environment it interacts with

food chain succession of plants and animals, each of which is eaten by the next higher organism

grazer animal that feeds on growing grass

habitat place where a plant or animal lives and grows naturally

Maasai native tribal people of the Serengeti who maintain their traditional village life

migration movement of animals to find food, warmth, or breeding grounds

savanna plain with grasses and scattered trees, especially near the equator where rainfall is seasonal

wildebeest a hoofed mammal of the Serengeti with a face like a cow and a body like a horse

Resources

Collinson, A. (1992) *Ecology watch: Grasslands.* New York: Dillon Press.

Estes, R.D. (1993) *The safari companion.* White River Junction, VT: Chelsea Green Publishing.

Iwago, M. (1986) *Serengeti: Natural order on the African plain.* San Francisco: Chronicle Books.

Lindblad, L. & S. (1989) *The Serengeti: Land of endless space.* New York: Rizzoli International Publications.

Silver, D.M. (1994) *One small square: African savanna.* New York: W.H. Freeman and Company.

Stelson, C.B. (1988) *Safari.* Minneapolis, MN: Carolrhoda Books.

Additional resources

D. Moss Productions: *Portrait of Africa.* Videotape. Tapestry Video: (212) 505-2288.

National Geographic: *African wildlife.* Videotape. (800) 368-2728.

Sunburst Communications: *Animal trackers.* Software for Apple II. (800) 321-7511.

Tom Snyder Productions: *What's the difference? The classification key toolkit.* Software for Macintosh. (800) 342-0236.

Additional sources of information

Nature Conservancy
1815 N. Lynn St.
Arlington, VA 22209

World Wildlife Federation
PO Box 96220
Washington, DC 20077

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Adopt a Plot

Put on your naturalist's hat and record the activity on a piece of land near you.

NEWTON'S APPLE®

SHOW NUMBER

1304

Balloon Safari

Main Activity

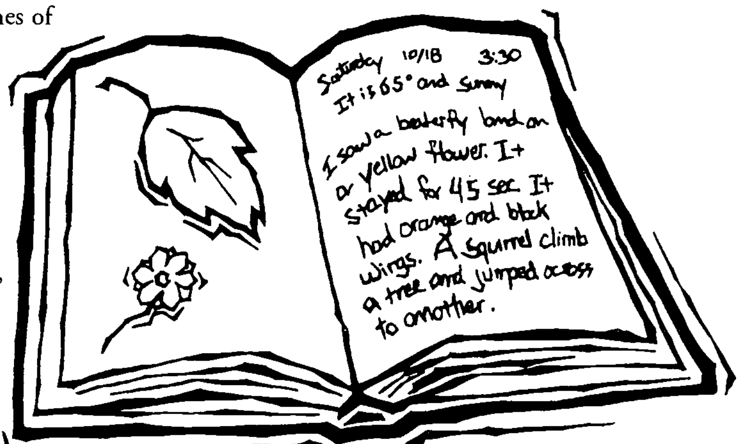
Naturalists who study the Serengeti and its animals have sharp observational skills. They spend hours watching and recording data. One of their most useful tools is a log book, where they record notes, sketches, and questions for further research. You may not be able to sharpen your observation skills on the Serengeti, but you can by walking out your door. Adopt a plot in your backyard, playground, or park. Start your own log and observe the environment at your toes.

Materials

- notebook with unlined paper
- pencil
- magnifying glass
- plot of land approximately 6 m x 6 m (20' x 20')
- large pan with sand
- jar and funnel

Adopt a plot

Find a spot that is home to a variety of plants and animals. Visit your plot over a specific period—two weeks or more. Schedule visits at different times of day. Start recording in your log by entering the date, weather conditions, temperature, and time.



Observe your plot

Find out how many different birds, animals, insects, and plants come to your plot. Which can you identify? Research the rest. Using a magnifying glass, sketch the grass in detail. Do all blades look alike? Quietly study one animal or insect. Identify the trees in your plot. Press samples of their leaves. Make bark rubbings. Tape these samples into your log.

Discover animal tracks

Place a pan filled with sand in your plot and check it daily. Are there any animal footprints? Can you identify them?

Measure precipitation

Make a rain gauge with a jar and a funnel. Paint a measuring scale on the outside of the jar and put the funnel in the opening. Put your rain gauge in an open area of your plot and record the amount of precipitation. (Remember to empty the gauge after each rainfall.)

Design other experiments

Share and compare your observations with your friends. What did you learn about your own environment?

Try This

Take a trip to your nearest zoo. Choose an animal to observe. Using a log book, jot down your observations and make sketches of your animal—its coloration, movement, food, sleeping position, etc. When you return, continue gathering information about this animal at the library or by computer. Design, write, and illustrate several pages about your animal. Combine your pages with those completed by classmates to create a book about the animals at the zoo.

Try This

The migrations of the wildebeests play a critical role in the Serengeti. Which mammals, birds, or insects migrate where you live? Do some research. Where does each migratory animal make its home in the winter and summer? Draw a map to show the migratory patterns of as many animals in your area as possible.

Try This

The animals of the Serengeti depend upon its grass. Find out more about grass. Plant several types of grasses in cut-off milk cartons. After the grass sprouts, start observing. Using a magnifying glass, compare and contrast characteristics of the different grasses. Cut the plants at the top, middle, and bottom. Observe these plants over the next few weeks. Dig up the grass and study the root system.

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3M Innovation

How does ice surfing compare to wind surfing? How fast can ice surfers go? How is it possible for ice surfers to travel into the wind?

SHOW NUMBER
1305

SuChin surfs the bright, white ice.

Segment length: 7:00

Ice Surfing

How do ice surfers go so fast?

Insights

Grab your board and hit the beach—it's surfing time again. But instead of baggies and a tank top, you might want to put on a parka and thermal socks, because the kind of surfing we're talking about only happens on solid water. That's right, the topic is ice surfing, and it's the hottest sport on frozen lakes around the world.

Ice surfing is really a hybrid sport, mixing the speed of ice boating with the agility and power of wind surfing. The ice surfing board is similar in size and shape to a big skateboard. Most boards have two blades in the back for stability and either one or two blades in the front to control the steering. Just like the wheels on a skateboard, the blades on an ice surfing board are mounted on flexible "trucks" so the rider can control the steering by leaning forward or backward while standing sideways on the board.

As with ice skates and ice boats, the blades on the ice board are quite sharp on the bottom, putting a great deal of pressure on the ice below. This pressure, combined with the friction between blade and ice, causes some of the ice to melt directly below the blade. A thin film of water lubricates the ice under the blade, which helps it glide smoothly over the ice. This really cuts down on the *drag* and means that the ice surfer is actually riding on liquid water, not solid ice. Because there is far less friction involved, ice surfers can go much faster than wind surfers, often approaching speeds of 113 kilometers (70 miles) per hour.

Just like wind surfers, ice surfers *power up* on an ice board by using a sail. In fact, most ice boards use the same type of sail as wind surfing boards. But because there is less friction on the ice, an ice surfer can get away with a much smaller sail. To make the board go, the rider sets her or his back to the wind and *sheets in* by pulling in on the *boom*—a bar attached to the bottom of the sail. As the sail catches the wind, the board starts moving forward. The highest speeds are attained when moving nearly perpendicular to the wind. By *trimming the sail* at the correct angle, the ice surfer can actually move almost three times faster than the wind itself. It's not possible to sail directly into the wind, but by *tacking* at an angle, surfers can zigzag across the wind, heading upwind little by little.

Connections

1. How do you think an ice surfing board would work if it were fitted with skis instead of blades?

2. Do you think it would be possible to adapt the design of an ice board to make a two-passenger commuter vehicle? How might you do it?

Resources

Evans, J. (1992) *Windsurfing*. New York: Crestwood House.

Hewitt, P. (1992) *Conceptual physics* (2d ed.). New York: Addison-Wesley.

Robberson, K. (1988, Jan) The thrill of sailing on ice. *Women's Sports and Fitness*, p. 82.

Additional resources
NEWTON'S APPLE Show 1106 (windsurfing).
GPN: (800) 228-4630. Or call your local PBS station to find out when it will be rerun.

3-2-1 Classroom Contact: *Friction: Getting a grip*. Videotape. GPN: (800) 228-4630.

Additional sources of information
Fiberspar
West Wareham, MA 02576
(508) 291-2770
(ice board manufacturer)

U.S. Windsurfing Association
PO Box 978
Hood River, OR 97031
(503) 386-8708

Key Words

boom horizontal post on the bottom of the sail which the rider uses for control
drag force of resistance between the bottom of the blade and the surface it's riding on
luff flapping of the sail when it is pointed directly into the wind or the sail is sheeted out
mast vertical pole, extending up from the board, that supports the sail and boom
power up to lift the sail and capture wind to get the board moving
sheet in to pull in on the boom so that the sail can capture wind and move forward
sheet out to let the wind out of the sail, thereby slowing the board
tack to sail in a zigzag pattern across the wind to move upwind
trim sail to adjust the sail to either capture more wind or let it out

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Angling Your Attack

Discover the best angle for sailing into the wind.

NEWTON'S APPLE®

SHOW NUMBER

1305

Ice Surfing

Main Activity

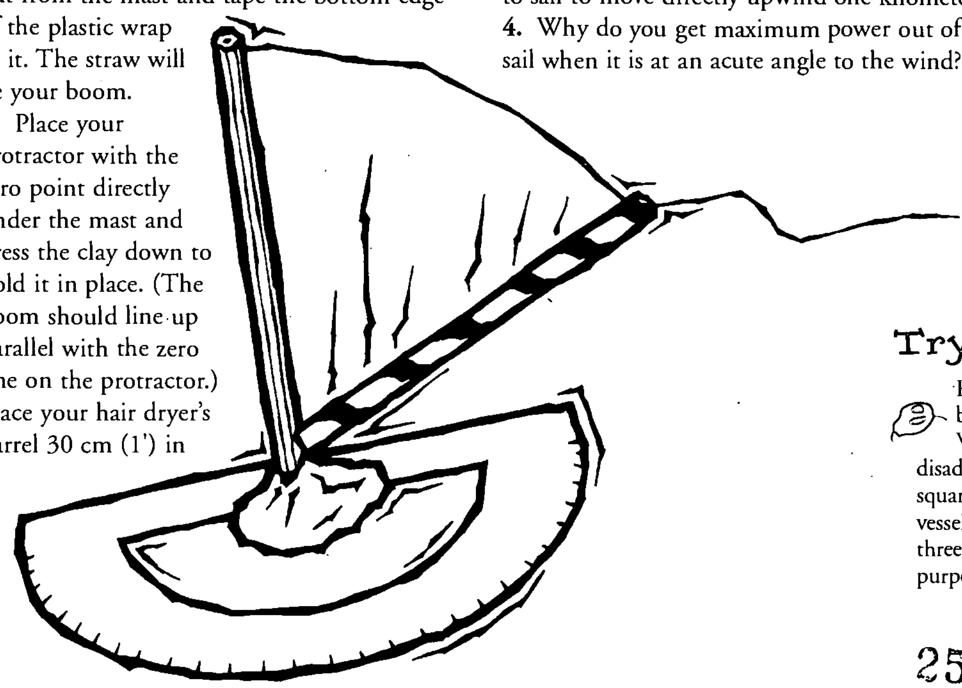
While it is impossible to sail directly into the wind, it is possible to move upwind by sailing at an angle across the wind. This is called tacking. Construct a simple model sail and test it to see what your minimal tack angle is.

Materials

- small lump of clay
- protractor
- pair of scissors
- transparent tape
- metric ruler
- unsharpened pencil
- clear plastic wrap
- plastic straw
- kite string about 30 cm (1') long
- blow dryer

1. To construct your sail, cut a piece of plastic wrap into an equilateral triangle whose sides are each 15 cm (6") long. Cut the straw to 14 cm and roll the clay into a ball. Insert the pencil into the clay so that it is standing vertically. This will be your *mast.* Wrap one side of the triangle around the pencil so that it overlaps about 1 cm and tape it in place. Thread the string through the straw and tie one loose end around the base of the pencil where it sticks into the clay. Hold the straw out from the mast and tape the bottom edge of the plastic wrap to it. The straw will be your boom.

2. Place your protractor with the zero point directly under the mast and press the clay down to hold it in place. (The boom should line up parallel with the zero line on the protractor.) Place your hair dryer's barrel 30 cm (1') in front of the mast. Turn it on low and aim it directly at the mast. The sail should *luff.* If the sail and mast blow over, move the dryer farther back.



3. Slowly pull the loose end of the string out at right angles across the protractor and watch the sail. As soon as the sail begins to fill with air, measure the angle that the boom makes with the zero line on the protractor. Repeat this so you get an accurate reading, and then average your readings.

4. Place the hair dryer directly behind the sail at the same distance that you had it in front of the mast. Start with your sail out perpendicular to the barrel of the hair dryer and slowly use the string to pull the sail in until it ends up parallel with the wind direction. Watch the sail and mast and feel the tug of the string as you do this.

Questions

1. At what angle did the sail first fill with air when you were running into the wind? What does this tell you about the minimum angle at which you can sail into the wind?

2. When you were sailing with the wind, at what angle did the sail appear to have the most power?

3. Can you calculate how far you would have to sail to move directly upwind one kilometer?

4. Why do you get maximum power out of a sail when it is at an acute angle to the wind?

Try This

How does the amount of water or surface roughness affect how much friction there is between a blade and the ice surface? Freeze water in a rectangular pan. Try dragging a brick across the ice, using a spring scale to measure the amount of force needed. What combination of water and ice produces the least resistance? Which produces the most?

Try This

Ever since the Egyptians first built the pyramids, people have been looking for ways to reduce friction. Today, many superlubricants exist for specialized purposes. Research some of these products and explain why each can work under certain conditions.

Try This

Research how sail designs for boats have changed over time. What were some of the disadvantages of old-fashioned square riggers compared to modern vessels? Why do racing yachts have three or four different sails? What purpose does each one serve?

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3M Innovation

NEWTON'S APPLE®

What is DNA fingerprinting? Why is it so important, so useful, and so argued about in court cases?

SHOW NUMBER

1305

Brian gets caught red-handed as he investigates DNA evidence.

Segment length: 8:00

DNA Fingerprinting

Can blood found at a crime scene really identify a criminal?

Insights

The O.J. Simpson trial has generated much interest in *DNA*. Formerly used only in research labs, DNA fingerprinting (called *DNA profiling* by scientists) has entered an intense public spotlight, where lawyers, crime investigators, and scientists constantly discuss its merits and pitfalls. Although usually used to establish paternity, DNA profiling is such good evidence that prosecutors are relying on it more and more to help convict suspects in criminal cases.

A DNA molecule resembles a long, twisted ladder. The supports of the ladder are the same for everyone, but the rungs are what make us all different. Each rung is made of a pair of organic molecules called nitrogen bases—adenine, thymine, cytosine, and guanine—usually symbolized as A, T, C, and G. The sequence of the rungs is important. The bases constitute a code for different proteins, much like the letters of an alphabet form words and sentences. Certain areas of the DNA molecule have no currently understood function, but they appear to vary widely among individuals. The most common form of DNA profiling, abbreviated RFLP, is a way of showing the unique patterns of bases in some of these areas.

Before the "fingerprint" analysis, the DNA must be sampled and stored properly. Even blood or semen that has soaked into a rug or dried in the sunlight can be a source for sample cells. An analysis can be done from as few as 100 cells but requires several steps:

1. Scientists extract DNA from the cells.
2. *Restriction enzymes* cut the DNA into pieces of various sizes.
3. *Gel electrophoresis* separates pieces by size.
4. Separated pieces are transferred to a nylon membrane, and some sequences are labeled with a radioactive substance called a probe.
5. X-ray film is exposed by the radioactive emissions of only the labeled sequences. The developed film, called an autorad, shows the familiar track pattern of a DNA profile.

To eliminate any possibility of a mistaken identity, analysts use several different probes to look at several different DNA fragment patterns in a sample. More than one person might have a particular RFLP pattern, but it becomes less likely that multiple people will have two or more sequences in common. Statisticians call this the *multiplication rule*, because the individual probabilities of a mistaken identity for each pattern are multiplied together to find the overall probability.

Connections

1. Should an individual have the right to refuse to give a blood sample for DNA analysis, or should the authorities have the right to take such samples without permission?

2. Biotechnologists want to map the DNA of the entire human population. How would this help us? What problems could it create?

Key Words

DNA genetic material contained in every cell and unique to the individual

DNA profiling identifying people by visual representations of unique regions of their DNA

Frye standard of admissibility Scientific evidence may only be considered in court if the type of evidence is generally accepted by the scientific community.

gel electrophoresis technique used to separate pieces of DNA by size

multiplication rule method used to obtain likelihood of more than one event occurring simultaneously

restriction enzyme protein that cuts DNA at specific base sequences

Resources

Fackelmann, K.A. (1994, Nov 5) Beyond the genome: The ethics of DNA testing. *Science News*, pp. 298–299.

Glausiusz, J. (1994, Jan) Royal D-loops: Remains of Russian Czar Nicholas II and family proved authentic with DNA. *Discover*, p. 90.

Horgan, J (1994, Oct) High profile: The Simpson case raises the issue of DNA reliability. *Scientific American*, pp. 33–36.

McElfresh, K.C., Vining-Forde, D., & Balazs, I.C. (1993, Mar) DNA-based identity testing in forensic science. *BioScience*, pp. 149–157.

Zurer, P. (1994, Oct 10) DNA profiling fast becoming accepted tool for identification. *Chemical and Engineering News*, pp. 8–15.

Additional resources

Several catalogs sell complete DNA fingerprinting kits:
Flinn Biological Catalog Reference Manual (800) 452-1261.
Fisher Catalog—Educational Materials Division (800) 955-1177.
Fotodyne Catalog—Educational Products Division (800) 362-4657.
Ward's Catalog—Biology and Lab Supplies (800) 962-2660.

America Online: Select in order: Reference. Access Excellence—Biotech. (Includes experiments, information, resources, and monographs on biotechnology, including DNA profiling.)

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3M Innovation

The Tell-tale Band

Put your detective skills to the test by creating and comparing chromatograms.

NEWTON'S APPLE®

SHOW NUMBER

1305

DNA Fingerprinting

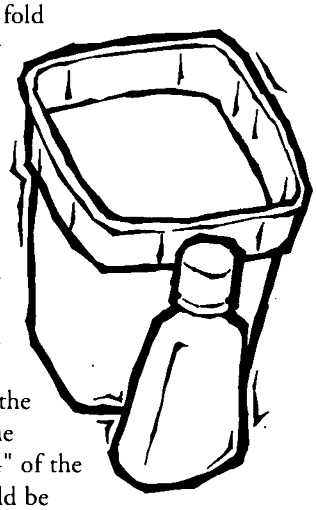
Main Activity

You can separate different mixtures of chemicals by using chromatography, a technique similar to the electrophoresis that scientists employ to separate DNA fragments. These techniques depend on matching a standard mixture with the unknown mixture and producing a visual representation of the components. A band that appears at the same location for the sample and the standard is likely to be the same substance.

Materials

- 2 freezer storage boxes or other tall, square, flat-bottomed containers with lids
- filter paper, cut into rectangles just narrow enough to fit into each storage box and about 1/2" taller than the box (Coffee filters or other absorbent paper may be substituted, but the resolution will not be as good.)
- water
- isopropyl (rubbing) alcohol
- toothpicks
- food coloring in a set of four different colors (preferably the three primaries—red, blue, and yellow—and one secondary color, such as green or purple, that is a mixture of those primaries). The box should give the dye names on the back, so the food colorings can serve as standards.

1. Pour about 1/4" of rubbing alcohol into one freezer box and cover it. Keep the lid on as much as possible, since the alcohol evaporates readily. Pour about 1/4" of water into the other freezer box and cover it.
2. Use the toothpicks to make four spots of different food colorings evenly across a piece of the filter paper, in a horizontal row about 1/2" from the bottom. Repeat on a second piece of the paper. Allow the spots to dry.
3. Make a fold in the filter papers about 1/2" from the top and place one in each freezer box. The top fold should hook over the side of the box, and the bottom 1/4" of the paper should be dipped in the liquid. Cover the box. Do not immerse the spots in the liquid.



4. The alcohol and water will crawl up the papers, pulling the components of the food coloring along. When the liquid reaches an inch from the top of the paper, remove it and, with a pencil, mark how far the liquid traveled. Dry the papers. Did the secondary color separate into two primary colors? Did similar colors travel the same distance?

Questions

1. What other artificially colored food items could you analyze in this way?
2. If someone used a black felt-tipped pen to scrawl graffiti on a building, could you use chromatography to identify the ink? How would you design the experiment? What might interfere with the analysis?

Try This

Collect newspaper clippings and magazine articles on court cases that involved DNA profiling evidence. What do lawyers usually criticize about this kind of evidence? What do they usually try to prove with it? What other kinds of evidence do they also need to win a case?

Try This

Write a descriptive profile of each suspect from a Clue board game. What type of evidence might each suspect leave at a crime scene that would distinguish him or her from the other suspects? Pass out the weapon cards, one for each suspect. What evidence might the suspect leave at a crime scene using that particular weapon?

Try This

Collect fingerprints from the class by inking the thumb and index finger on a stamp pad and then rolling each firmly on an index card. Enlarge them on a photocopier. Do any two match exactly? If there is a set of twins in your school, are their fingerprints identical?

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NEWTON'S APPLE®

How is an airplane fire different from a regular fire? When firefighters crash jets to practice on, how do they keep people from getting hurt?

SHOW NUMBER
1306

Dave feels the heat during a simulated air crash rescue.

Segment length: 7:00

Aircraft Fire Rescue

How does a firefighter put out an airplane fire?

Insights

A passenger jet has crashed. Flames shoot into the air. Dozens of people are trapped inside. How can firefighters rescue anyone in a raging inferno like that?

It takes skilled professionals with special training. That's why men and women from around the country come to the new Aircraft Rescue and Fire Fighting (ARFF) Facility in Duluth, Minnesota.

There, they practice rescue techniques in a state-of-the-art airplane crash *simulator* designed to replicate a Boeing 757 jet. Nearly a hundred computer-controlled nozzles in and around the simulator shoot *propane* gas flames. When that happens, the firefighters pump *foam* onto the fire. But since this is a simulator, the foam doesn't actually put the fire out—the computer turns off some of the nozzles instead.

When the fire outside is under control, firefighters cut their way through replaceable panels and into the jet's "cabin." Smoke is everywhere, so they may wear goggles equipped with *IRIS* (*infrared* imaging system). In the simulation, however, the smoke isn't real. It's hydraulic fluid that has been heated to 427°C and blown out nozzles.

If trainees don't put out the fire in two and a half minutes or less, they fail the test. That may sound like a tough challenge but if a real jet crashes and the interior begins to burn, firefighters would only have about two minutes to rescue the passengers. (Fortunately, passengers can survive most jet crashes if they follow evacuation directions given on board.)

Every effort is made to see that nothing gets hurt during training—not the firefighters, not the environment. For example, in a real crash, firefighters would use aqueous film forming foam (AFFF). The chemicals in AFFF mix with water and are "fluffed up" into a foam, but they won't mix with the fuel in a jet crash fire. This means the water can float on top of the fuel and smother the fire. AFFF creates a seal around the firefighters' boots as they try to rescue the passengers. If the foam didn't do this, the fire could flash back and endanger the rescuers as well as those being rescued.

The foam used during the simulation, however, is *biodegradable* dish washing soap. Once it is sprayed, it slides into a pit under the simulator where it is treated and released into the regular water treatment facility.

Connections

1. What other situations could be simulated to give people the practice they need to face an emergency?
2. What would you include in a simulation to prepare firefighters for a fire in a skyscraper during the middle of a working day?

Key Words

biodegradable substance that can be broken down by natural processes
FAA Federal Aviation Administration; government agency that operates the national air traffic control system
foam mass of gas bubbles in a liquid film matrix
fuselage central body of an airplane that holds passengers, crew, and luggage
infrared electromagnetic radiation invisible to the human eye but detectable as heat
IRIS infrared imaging system; allows firefighters to see heat images even through smoke
mockup scale model used for demonstration, study, or testing
propane a natural gas, C_3H_8, usually used to make heat
radiative heat heat transferred from a distance. The sun and car radiators emit this kind of heat.
simulator apparatus that generates test conditions close to real

Resources

Andriuolo, R. (1993) *Firefighter: Written tests, physical exams* (10th ed). Englewood Cliffs, NJ: Prentice Hall.

Field, F. (1992) *Get out alive: Save your family's life with fire survival techniques.* New York: Random House.

Maas, R. (1989) *Firefighters.* Jefferson City, MO: Scholastic.

Smith, D. (1988) *Firefighters: Their lives in their own words.* New York: Doubleday.

Smith, D. (1978) *The history of fire fighting in America: 300 years of courage.* New York: Dial Press.

Watson, T.W. (1992) *Unhappy landings: Why airplanes crash.* Melbourne, FL: Harbor City Press.

Additional resource
NEWTON'S APPLE Shows 1102 (emergency rescue), 1105 (jumbo jets), and 1109 (firefighting). GPN: (800) 228-4630. Or call your local PBS station to find out when it will be rerun.

Additional sources of information
Duluth Technical College
ARFF Training Center
11501 Highway 23
Duluth, MN 55808

National Fire Protection Association—NFPA
(800) 344-3555
Source for two books: *SFPE handbook of fire protection engineering* and *Fire protection handbook* (17th ed.).

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3M Innovation

Rescue Squad

Simulate a plane crash and practice saving passengers.

NEWTON'S APPLE®

SHOW NUMBER

1306

Aircraft Fire Rescue

Main Activity

Time is critical in an airplane crash rescue. From the moment they arrive, firefighters have less than two and a half minutes to put out a fire and make a rescue. How many people could you rescue in a similar situation? This simulation will help you find out.

Materials

- masking tape, red chalk, or red construction paper
- a large, open area such as a playground
- duffel bags, backpacks, or pillow cases filled with heavy books or weights
- blindfolds or sunglasses with all but a narrow strip blocked out with tape to simulate smoke
- a stopwatch or a watch with a second hand
- squeeze bottles, enough for each rescuer. Empty, rinsed-out bottles of dish washing soap work well.

1. In your open area, mark out a rectangle 40 meters (130 feet) long and 4 meters (13 feet) wide. This will be your *fuselage*. If you don't have access to a space this large, reduce the lengths accordingly.
2. Mark emergency exits, three on each side, so they are evenly spaced apart.
3. Place chairs and other items in the area to serve as obstacles. The duffel bags, backpacks, or pillow cases will represent the people you must save. Make sure to vary the weights in these bags—you could even include one that is the weight of an adult.
4. With the masking tape or red chalk, mark Xs to indicate your fire. Or make representations with the red construction paper.
5. Your fire and rescue team will stand 6 meters (20 feet) from the outline of the fuselage. Start the timer and race to get into the "plane." Before you can enter the fuselage, you must put out all the fires. A fire will be considered "put out" when you have drawn a wet circle around it with a squeeze bottle.
6. Then rescue as many "people" as possible from inside the burning fuselage.
7. Record the initial time it takes to rescue the victims.
8. Now repeat the entire exercise, this time wearing the blindfolds or sunglasses to represent smoke. Is there any variation in your times?
9. Repeat the rescue process a number of times, keeping track of each team's time. Chart each team's progress.

Questions

1. Do you get quicker with each simulation? What are some ways you could improve your rescue time?
2. How do the "sighted" rescues compare with the "blinded" rescues?
3. In what ways did you use teamwork rather than simply acting as a group of individuals?

Try This

Wrap your hand in a "glove" you've made from aluminum foil and then slip a big mitten over that. Slip a thermometer in next to your hand. Record the temperature at five-minute intervals. What do you begin to feel after the first ten minutes? Switch so that the mitten is next to your skin and the foil is wrapped on the outside. Any differences?

Try This

Interview several firefighters and find out why they chose this job. Ask about their "scariest" fire and find out why it was so scary. If you can, try and find one who has had special training for fighting jet crash fires. Ask why she or he went into this special field.

NEWTON'S APPLE®

What are balloons made of?
How do they hold air?
What are they used for?

SHOW NUMBER
1306

Brian pops the question about balloons.

Segment length: 7:30

Balloons

Why are balloons stretchy?

Insights

We make funny animals out of them. We celebrate birthdays with them. We use them to play games. Balloons are a blast, but they're also super for science.

Meteorologists monitor atmospheric conditions by sending up *weather balloons*. Doctors open blocked veins and arteries by inserting special medical balloons into them. Scientists are even investigating something called superpressure balloons. Sealed against leakage and strong enough to handle the sun's heat, these *helium*-filled balloons would float in the upper reaches of Earth's atmosphere. They may replace some satellites because they're so much cheaper to launch—just let them go!

The material that makes balloons stretch is *latex*, obtained from rubber trees. Latex is collected as it flows out of cuts in the tree bark. At this stage, it is fairly gooey. People make balloons by dipping a balloon mold into the latex and then heating it for a while to make the latex firmer and more elastic.

Latex is a *polymer*, which means that it has long, chainlike molecules made up of repeating units. When it first comes out of the rubber tree, its molecules are loosely tangled up, so they flow slowly. If you heat the latex, you create chemical *cross-links* between the molecule strands. Long, tangled polymer molecules that have a few cross-links between them can extend and then regain their original shape. These stretchy materials are called *elastomers*.

The only problem for the serious balloon collector is that the open mesh structure of latex, particularly when it's stretched tightly, lets helium and other gases escape right through the tangled molecules. Mylar, a type of polyester that can be rolled into thin films, is better at trapping helium because its molecules are more closely packed and Mylar does not stretch out like latex. But even a Mylar balloon can't hold all the tiny helium atoms forever, and eventually it loses lift also.

Balloons are a great example of how the *pressure* and the *volume* of a gas are interconnected. When you blow up a balloon, you exert pressure on the inside walls of the balloon. When that pressure exceeds the outside air pressure plus the pressure exerted by the latex itself, the balloon begins to expand. The pressure inside a balloon is always a little higher than the surrounding air pressure, because the latex is pushing back as the air inside pushes out. When a weather balloon rises in the atmosphere, for example, the outside pressure decreases and the balloon expands. Eventually, the inside pressure causes the balloon to burst.

Connections

1. How many different uses for balloons can you think of?
2. What effects do balloons have on the environment?

Key Words

cross-links chemical bonds between the molecules of polymers
elastomer general name for any polymer that stretches and then can regain its shape
helium gas that is less dense than air
latex principal raw material used to make balloons
polymer a long, chainlike molecule
pressure force per unit area that a gas exerts on the walls of a container
volume the space that a particular quantity of a gas occupies at a specific temperature and pressure
weather balloons helium-filled balloons released to lift instruments that record atmospheric conditions

Resources

Dane, A. (1993, Feb) A new balloon. *Popular Mechanics*, pp. 106–107.

deSeve, K. (1994, Nov 18) He, he, helium. *Science World*, pp. 12–15.

Mullen, M. (1988, Nov-Dec) The return of scientific ballooning. *Technology Review*, pp. 8–9.

Walker, J. (1989, Dec) Why are the first few puffs the hardest when you blow up a balloon? *Scientific American*, pp. 136–139.

Additional resources
Flinn Biological Catalog Reference Manual: Lung volume activity. Catalog #AB1242. (800) 452-1261.

Flinn Chemical Catalog Reference Manual: *Dynamic gas behavior*. Software for Apple II. Catalog #AP4420. (800) 452-1261.

Flinn Chemical Catalog Reference Manual: *Soap bubbles—their colors and forces which mold them*. Book. Catalog #AP1852. (800) 452-1261.

Producers Studio: *Balloon animal safari*. Videotape. (503) 683-1400.

Additional source of information
The Balloon Council
Princeton House
160 West State St.
Trenton, NJ 08608
(800) 233-8887
(Literature on the history of balloons and an inexpensive balloon experiment kit for schools.)

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3M Innovation

Expand on This!

Inflate balloons with different gases and weigh your results.

NEWTON'S APPLE®

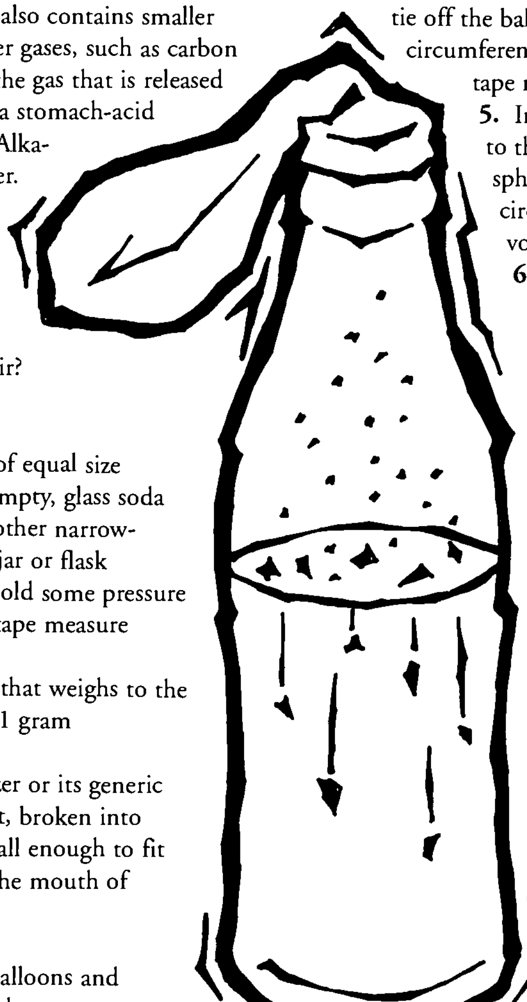
SHOW NUMBER

1306

Balloons

Main Activity

Air is mostly a mixture of oxygen and nitrogen, but it also contains smaller amounts of other gases, such as carbon dioxide. That's the gas that is released when you drop a stomach-acid neutralizer like Alka-Seltzer into water. Do you think a balloon full of carbon dioxide will weigh more or less than a balloon full of air?



Materials

- balloons of equal size
- a small, empty, glass soda bottle or other narrow-mouthed jar or flask that can hold some pressure
- string or tape measure
- cotton
- a balance that weighs to the nearest .01 gram
- water
- Alka-Seltzer or its generic equivalent, broken into pieces small enough to fit through the mouth of the bottle

1. Weigh two balloons and record their weights.
2. Pour about 150 ml of water into the bottle.
3. Working as quickly as possible, drop in six Alka-Seltzer tablets. Lightly stuff the mouth of the bottle with cotton and stretch the open end of a balloon securely over the top of the bottle. (The cotton allows the carbon dioxide through, but soaks up any splashed water.)
4. When the balloon is filled with carbon dioxide, or the tablets have stopped fizzing, tie off the balloon and measure its circumference with a string or tape measure.
5. Inflate another balloon with air to the same circumference. (Two spherical objects of the same circumference will have the same volume.)
6. Weigh both balloons again.

Questions

1. Which balloon is heavier—the one with carbon dioxide or the one with an approximately equal volume of air? (Be sure to take into account any difference in the initial weights of the balloons.) What is the weight of the gas in each balloon? Why do you think one is heavier than the other? If you repeat the experiment, do you get similar results?
2. Part of the weight of a full balloon is supported by the air around it, a phenomenon called buoyancy. Therefore, the balance measures a lower value than the actual mass of either gas. The size of the buoyancy is the same for two balloons of equal volume. How might you find the value of that buoyancy so you could add its effect to find the actual mass of the gas in either balloon?
3. If you let the balloons sit out for a while, which one loses gas pressure faster? Why do you think that occurs?

Try This

Submerge an upside-down test tube or small beaker in a large beaker of water. What do you notice about the level of water in the tube as it is raised and lowered in the beaker? Can you explain why this happens in terms of pressure and volume? Why doesn't the air come out of the tube? Tip the tube slightly. What happens?

Try This

Pretend that you and your classmates are gas molecules. How is the inside of your classroom like a balloon? How could your group of gas molecules escape? Is the playground like a balloon? Is it easy or hard to get out? At absolute zero, you're packed all together in a corner of the room. As the temperature goes up, you begin to vibrate and move around. Can you stay close as the temperature increases?

Try This

Inflate two balloons to equal size. Place one in a pan of hot water and the other in a pan of cold water. What happens? What will happen to equal-sized balloons in a range of temperatures?

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NEWTON'S APPLE®

When should you not believe what your eyes and ears are telling you? How do amusement ride designers create the illusions that make you think you're doing something when you're not?

SHOW NUMBER

1307

SuChin has a "real" experience on a simulator ride.

Segment length: 6:00

Simulator Rides

How are amusement park rides designed to create illusions?

Insights

Have you ever tried one of those motion *simulator* rides at an amusement park? How do the designers manage to fool you into thinking you're on an incredible journey?

For the answer, look at how your own eyes play tricks on you. Anthropologists believe humans developed *peripheral vision* to survive in the wild—we needed to see predators out of the corners of our eyes. Designers of simulators and *virtual reality* rides make use of this to create illusions. When the lights go off, your seat moves in conjunction with peripheral images projected around you.

Ride designers also take advantage of our ability to sense the distance of objects as we move. Our eyes perceive nearby objects moving more than objects in the distance. This visual cue to depth is called *motion parallax.* Sixty years ago, Disney Studios developed a camera to make cartoon characters look real. They placed several layers of *celluloid* drawings at different distances from the camera lens. When the layer of objects in front of a character was moved to the right and the layer behind to the left, the viewer's eyes sensed the characters moving in three dimensions. Today, designers use motion parallax in rides.

Another visual trick involves persistence of vision. Your brain retains an image for about one-tenth of a second after the image is gone. If you see 10 still pictures per second, your brain will tell you that you're seeing moving pictures. When you watch a movie, you're seeing at least 24 individual pictures per second.

Even your ears can be fooled. In your inner ear, three semicircular canals contain fluid and tiny hairs connected to nerve endings of the auditory nerve. Rapid movement causes the fluid to move back and forth through these canals, bending the hairs. This triggers the nerve endings, sending electrical signals to the brain that demand you move your eyes and head to adjust to rotating movements.

Some nerve endings are very sensitive to gravity, helping the brain know what postion your body is in. On a ride that uses *hydraulic lifts* to move your seat or that spins your body, your inner ear adjusts to provide a sense of orientation and movement. After you've stopped moving, the *Coriolis illusion* causes you to feel like you're still spinning for awhile. That's why it's hard to walk—your brain is trying to adjust to the spinning or abrupt movements rather than the ground.

Connections

1. What makes your favorite ride scary?
2. Nerves in your ears that are sensitive to gravity send messages to your brain about your body's position. Do you think astronauts in space would feel better floating or attached to a corner of the spacecraft?

Key Words

celluloid old-style film made from camphor and pyroxylin
Coriolis illusion an illusion caused by the apparent spinning of a body
hydraulic lift equipment that creates movement in rides with pressure from liquids forced through tubes
motion parallax ability to sense how far things are from us as we move
peripheral vision what we see at the edges of our field of vision
simulator device or ride that creates the illusion of an environment
virtual reality illusion of reality created by computers and other technology

Resources

Adams, J. (1991) *The American amusement park industry: A history of technology and thrills.* Boston: Twayne.

Funston, S. & Ingram, J. (1994) *It's all in your brain.* New York: Grosset and Dunlap.

Heweston, S. (1994) *Eye magic.* New York: Western Publishing Company.

Koenig, D. (1994) *Mouse tales: A behind-the-ears look at Disneyland.* Irvine: Bonaventure Press.

Lefkon, W. (Ed.) (1993) *Birnbaum's Walt Disney World for kids by kids.* New York: Hyperion and Hearst Business Publications.

Salzsider, J. (1994, Feb) Exposing the bathtub Coriolis myth. *The Physics Teacher,* p. 107.

The surprise behind the rides. (1994, Sept) *Discover,* pp. 44–52.

Additional resources
3M Learning Software: *What's the secret?* CD-ROMs for Macintosh or Windows. (800) 336-2481.

NEWTON'S APPLE Shows 907 (amusement parks) and 1113 (virtual reality). GPN: (800) 228-4630. Or call your local PBS station to find out when it will be rerun.

Scholastic: *Magic School Bus explores the human body.* CD-ROM for Windows. (800) 426-9400.

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Eye Witness

Look out of the corner of your eye to see why you need both rods and cones.

NEWTON'S APPLE®

SHOW NUMBER **1307** *Simulator Rides*

Main Activity

Your inner eyeball is lined with a light-sensitive membrane called the retina, which is connected to the brain by the optic nerve. The retina has lots of cells—120 million rods and 8 million cones. The periphery of the retina contains rods and does not see images clearly but sees motion and where things are. The fovea of the retina contains mostly cones, and you use it to see what something is. Try this activity to see how these two areas of your retina differ.

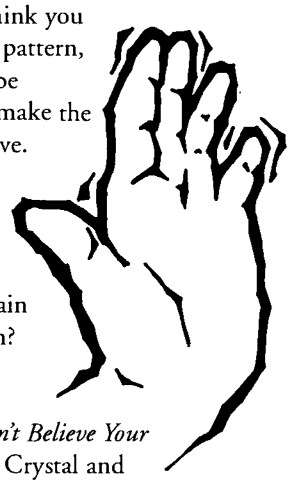
Materials

- partner
- chair
- several objects of different colors

1. Ask your partner to sit on the chair and look straight ahead. You should stand behind the chair.
2. Raise two fingers and, starting from behind your friend's head, slowly bring your hand into view.
3. Ask your partner to say "stop" as soon as she or he sees your hand. Stop moving your hand, and ask how many fingers you have raised. The number will probably be wrong because the periphery only sees the movement of the hand—the fovea can see how many fingers.
4. Keep moving your hand forward until your partner can count the fingers correctly.
5. Switch roles, and see how you do.
6. Switch again. This time, as your partner stares straight ahead, slowly bring a colored object forward from behind that person's head.
7. Tell him or her to say "stop" as soon as he or she sees the object. Ask what color it is. The rods of the periphery see motion, but not color. Only the cones, found in the fovea, can see color.
8. Continue moving the object forward until your partner can tell you the correct color.

Question

1. The rods in your retina see movement better in the dark, but they don't see as clearly as the cones. You think you are focusing on the pattern, but your eyes may be moving enough to make the pattern seem to move. Think about the scary things you may have imagined seeing in the dark. Does this help explain why you saw them?



Adapted from an activity in *You Won't Believe Your Eyes* by Nancy Crystal and Milan Tytla. Published by Annick Press, Ltd., Toronto (1992).

Try This

Think about the best parts of every ride you remember and design a ride that would be the coolest you and your friends have ever been on. Use construction materials to create a model of your ride.

Try This

Get a book of drawings by M. C. Escher. Study the illusions in the drawings. Do you see connections between the animals that turn into other animals, or people that seem to be suddenly walking up the down stairs, or down the up stairs? Try to create a pictorial illusion of your own. (First you might have to copy one of his.)

Try This

Test your peripheral vision and find your blind spot with the apple and the 3M logo on opposite ends of this page. Turn the page so that the apple is on the left and the 3M logo is on the right. Hold the page in front of your face; your nose should face the middle of the page. Cover your left eye with your hand and stare at the apple. Slowly move the page closer to your face. At some point you will no longer see the red 3M. Next, cover your right eye and repeat the exercise. Now, hold the page about one foot in front of you. Cover one eye and focus on the apple. Move the page from right to left and back to find your blind spot, the place where the 3M logo disappears.

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3M Innovation

NEWTON'S APPLE®

Can humans really understand animals? How would animals and humans benefit by learning to speak a common language?

SHOW NUMBER

1307

Peggy dives into the language of dolphins.

Segment length: 6:00

Dolphin Communication

Can animals communicate with humans?

Insights

You're hiking in the woods with a friend one evening when a wind kicks up and rain starts to pour down. Suddenly you realize your friend isn't with you anymore. You shout, but your voice gets lost in the storm. Taking out your flashlight, you signal "SOS" in Morse Code. A few hundred feet away you see your friend's flashlight signaling, "I'm coming."

Humans and animals both communicate in many ways. Humans use almost 6,000 spoken, written, and code languages and also depend on *body language,* sight, touch, and smell to relay messages. Animals communicate with many sounds, actions, and cues as well.

Dolphins, toothed whales, and porpoises depend on *vocalization, echolocation,* and *ultrasound* to communicate with each other and navigate. With echolocation, dolphins emit and process up to 700 clicking sounds per second to detect the size and location of an object hundreds of meters away. Researchers at the Living Seas exhibit at the Epcot® Center in Orlando, Florida, found that dolphin echolocation is sensitive enough to detect a three-inch steel ball from 100 yards away.

Another experiment at EPCOT Center involved a communications keyboard. Each key on the keyboard had a word written on it, and each key had a related cubbyhole containing an object that represented the word. Humans activated the keyboard by touching a key. Dolphins activated it by inserting their beaks into one of the cubbyholes. Inside each cubbyhole was an infrared beam. When that beam was broken by a dolphin's beak, the human word was heard on an overhead speaker. Dolphins used vision and echolocation to determine which cubbyhole to select when the keyboard was activated.

The dolphins seemed to expect certain behaviors from the trainers. When a human touched the key, the dolphins would swim ahead, then turn to make sure their trainer was following them to the right place.

Scientists don't know if the dolphin's interaction with humans is sophisticated communication or a *conditioned response* motivated by a reinforcer (food). It may be a long time, if ever, before we can speak "dolphin" and find out what's on their minds.

Connections

1. How do you communicate with your pet? How does your pet communicate with you? What do you communicate about?
2. If you could speak dolphin language, what questions would you ask?

Key Words

body language use of facial expressions, posture, gestures, and other nonverbal communication
conditioned response first demonstrated by Ivan Pavlov, a Russian scientist. Dogs heard a bell when fed, teaching them to associate food with the sound of a bell. Eventually the dogs' response to the bell was to salivate in anticipation of food.
echolocation bouncing sound off objects to provide information about size, location, and movement of those objects
frequency the number of cycles or complete "waves" (sound, radio) per unit of time
ultrasound high frequency sound that humans are unable to hear
vocalization formation of sounds

Resources

Cohen, S. (1994) *The intelligence of dogs.* New York: Bantam.

Dawkins, M. (1993) *Through our eyes only? The search for animal consciousness.* New York: W.H. Freeman and Company.

Ganeri, A. (1991) *Animal talk.* New York: Barron's Educational Series.

Linden, E. (1993, Mar 22) Can animals think? *Time,* pp. 54–58.

Peterson, I. (1992, Nov 14) Dolphin sonar: Using their heads to click. *Science News,* p. 325.

Wexler, M. (1994, Apr/May) Thinking about dolphins. *National Wildlife,* pp. 4–9.

Additional resources
3M Learning Software: *What's the secret?* CD-ROMs for Macintosh or Windows. (800) 219-9022.

NEWTON'S APPLE Multimedia Collection: *Life Sciences: Bees.* Videodisc with software for Macintosh. National Geographic: (800) 368-2728.

SeaWorld Education Department: http://www.bev.net/education/SeaWorld
Or send e-mail to: Sea.World@bev.net

Additional sources of information
Dolphin Research Center
PO Box 2875
Marathon Shores, FL 33052

The Living Seas
Epcot Center
PO Box 10,000
Walt Disney World
Lake Buena Vista, FL 32830–1000

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Educational materials developed with the National Science Teachers Association.

Smell and Tell

Follow your nose to find the person wearing the same scent as you.

NEWTON'S APPLE

SHOW NUMBER
1307
Dolphin Communication

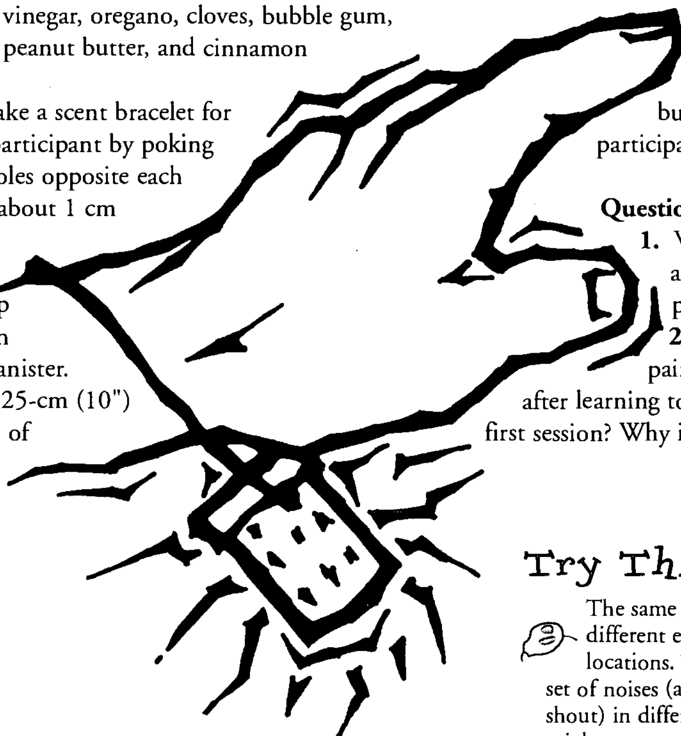
Main Activity

Many animal communication systems depend on matching scents or sounds to identify friends and enemies. Explore what it would be like to use your nose to find out who your friends and enemies are.

Materials

- 1 plastic film canister or similar small container per person
- poster board
- yarn or string
- scissors
- cotton balls
- spoons
- a variety of strongly scented materials, such as vanilla flavoring, peppermint flavoring, pine-scented room freshener, lemon-scented cleaning liquid, cedar chips, freshly chopped or pressed garlic, vinegar, oregano, cloves, bubble gum, peanut butter, and cinnamon

1. Make a scent bracelet for each participant by poking two holes opposite each other about 1 cm (3/8") from the top of each film canister. Cut a 25-cm (10") length of string or yarn to pull through the holes. Tie a knot in the yarn to complete the bracelet.
2. Poke several holes in the canister lids to allow the scent to escape.
3. Place the same scent in pairs of canisters to create matching sets of scent-filled canister bracelets. For the liquid scents, such as vanilla or peppermint flavoring, pour a small amount of liquid onto a cotton ball and place it in the canister. Cover each canister with a lid to hide the contents.
4. Distribute the bracelet sets at random to the participants.
5. Instruct the participants that they may use only their noses to find the other person with the same scent. No words, sounds, or gestures are allowed. When they find their friend, they should report to you.
6. Record on a poster board which pairs were easiest or hardest to find.
7. Repeat the exercise, but be sure that each participant has a different scent.



Questions

1. What factors could have affected the discovery process?
2. Is it easier for the new pairs to locate each other after learning to use their noses in the first session? Why is that the case?

Try This

The same sound produces different echoes in different locations. Try making the same set of noises (a whisper, a loud shout) in different places. You might try standing in a large room with a high ceiling, a bathtub or shower, outside next to a building, outside in the middle of a field, and in a car. What does the sound tell you about the environment?

Try This

Cut out pictures of faces that show different expressions. Mount each on a separate piece of poster board. Ask several friends, one at a time, to look at each and tell you what emotion they see. Record each person's answers. How do the answers compare? Did everyone see the same thing in each picture?

Try This

Use a dictionary of America Sign Language (ASL) to lea to communicate a short story. Ask a friend who doesn't know any ASL to watch you tell the story. Ask that person to write down what your story is about. Then teach your friend what you learned about ASL and try telling the story again. Did your friend understand it better?

Try This

Humans speak almost 6,000 different languages. Make a list of 10 important words or phrases and find out how to say them in five other languages. If you have friends who speak other languages, ask them (or their parents or grandparents) for help in pronouncing the words correctly.

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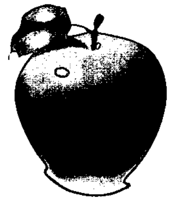

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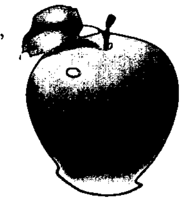

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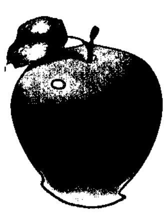

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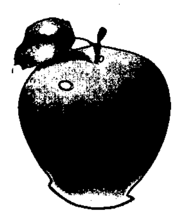

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NEWTON'S APPLE salutes National Engineers Week, February 18–24, 1996

In communities all around the country, millions of people—young and old—will be finding out just what engineers do and how their work affects our lives. NEWTON'S APPLE wants to make sure your community is one of them. We've created this special flyer to help you get involved in **National Engineers Week.**

- Share these bookmarks with your friends. Think about all the things that engineers have done and are doing to make our lives better.
- Watch NEWTON'S APPLE and see which science topics on each show have an engineering connection. (Given the breadth and depth of what an engineer does, it will probably be most of them!)
- Contact a local engineering company, a technology-based government agency, or a college engineering department to see how their employees are getting involved in **National Engineers Week.**
- Contact **National Engineers Week** headquarters to receive a packet of activities related to the week, and information about other events:

  National Engineers Week Headquarters
  1420 King Street
  Alexandria, VA 22314
  (703) 684-2852

From One Endeavor Aboard Another

WOMEN have a long and proud history among the ranks of engineers and inventors. They hold patents on everything from the windshield wiper to the bottle stopper, the forerunner of tamper-proof packaging.

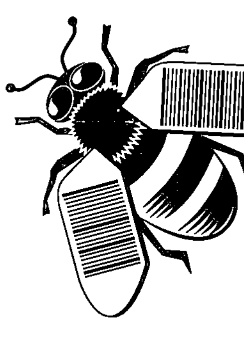
The first patent awarded to an African-American woman went to Sarah Goode in 1885. She invented the "Cabinet Bed," similar to today's convertible couch. In 1892, Sarah Boone received a patent for the ironing board. In 1992, chemical engineer and astronaut Mae Jemison became the first African-American woman in space as she rode the Space Shuttle Endeavor.

In conjunction with Black History Month, National Engineers Week reminds you of the contributions African-American women in technology have made to improve our quality of life.

ENGINEERS Turning Ideas Into Reality.

National Engineers Week® February 18-24, 1996

Special thanks to: Needham Science Center, Needham, MA



Nature's Engineers

ENGINEERING achievements help us preserve and observe our natural world. Gigantic bridges blend with their surroundings. The computerized bar code on your groceries has been adapted to fit on a honey bee's wings by scientists studying their habits.

But have clever human inventors and engineers derived some of their greatest ideas by observing what nature had "engineered" before? Here are just a few examples from this source of "inspiration" and what might have resulted:

Observed	Invented
Wasps making a nest	Paper from wood pulp
Poisonous snake fang	Hypodermic needle
Airborne seeds	The parachute
Birds flying	The airplane

With a little thought you can add many more "inventions" to this list. By observing nature's engineers at work, perhaps you will find an "inspiration" for something that is brand new to the human world!

ENGINEERS Turning Ideas Into Reality.

National Engineers Week® February 18-24, 1996

Special thanks to: Needham Science Center, Needham, MA

A Bird? A Plane? A Flying Tube!

THE first "flying tube" was probably engineered by chance by an ancient Native American. He or she picked up a short piece of hollow tree branch. As this "tube" was being tossed away it was accidentally given a spin and the flying tube was born.

You can engineer your own flying tube. Roll this bookmark into a cylinder from top to bottom and tape the ends together.

The tube uses the same principle — called Bernoulli's Principle — as jumbo jets and boomerangs. To fly the tube requires trial and error but is actually simple. With your arms hanging down, hold the tube in one hand, by the sides, between your fingers and thumb. Point the end of the tube forward. Give it a hard toss forward while sharply twisting your wrist. Done right, the tube will spin and fly far.

You can engineer the tube by changing its shape, size, or materials.

ENGINEERS Turning Ideas Into Reality.

National Engineers Week® February 18-24, 1996

Engineers transform ideas into reality, solving practical problems to serve people's needs. They have built much of our past and they will build much of our future. I am happy to take part in honoring them during National Engineers Week—and throughout the year.

L.D. DeSimone
Chairman and CEO, 3M
Honorary Chair, National Engineers Week

Our nation's engineers can take great pride in their contributions to our country's growth and prosperity. By transforming the latest innovations and the most advanced ideas into realities, they harness the engine of scientific discovery.

President Bill Clinton

National Engineers Week provides a tremendous opportunity to plant a seed in the minds of millions of people nationwide. Engineering is essential to life and, more important, to a better quality of life.

Jack Ferrell
1996 President, Society of Manufacturing Engineers
Chair, National Engineers Week

Regardless of who you are or what you do, rule technology. Don't let it rule you. Get smart! Discover science and mathematics now.

James Doohan, "Scotty" on *Star Trek*

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What is a hazardous material spill? What is hazardous waste? How can we clean up spills safely and dispose of hazardous waste properly?

SHOW NUMBER

1308

Peggy dons protective gear to handle a hazardous spill.

Segment length: 7:30

Hazardous Materials

What are the best ways to dispose of hazardous materials?

Insights

Headlines about hazardous material spills can be scary. Sometimes entire communities must be evacuated until a spill is cleaned up. Who performs this sometimes dangerous work? They're called *emergency response teams,* and they have to be ready for just about anything.

Hazardous materials are chemicals (such as paints or bug killers), biological agents (such as disease-causing materials), or physical agents (such as radioactive materials) that are dangerous to humans or to animals and plants. Hazardous waste is unusable hazardous material that results from the activities of human society. Research institutes, industrial plants, individual households, and government agencies all generate chemical waste. About one percent is classified as hazardous.

A hazardous spill occurs when hazardous material or waste gets into the environment in an uncontrolled fashion. Many manufacturing processes use hazardous materials or generate hazardous waste, but a hazardous spill doesn't always come from a chemical plant or a factory. Any substance in the wrong place at the wrong time in too large an amount can cause harm to the environment. What if a tank truck dumps milk into a small stream, for example? Or a giant vat of mayonnaise splits open at a food processing company? Those spills may be classified as hazardous, too.

The response to a spill depends on the situation. When the emergency response team is notified of a spill, it must quickly decide what sort of danger is likely. Members of the team collect appropriate clothing and equipment and travel to the scene. There they try to contain the spill, sometimes testing a sample to identify it. If necessary, they decontaminate themselves before leaving the area. Once the material has been identified, other personnel arrive to remove it.

In the past, hazardous wastes were buried in special landfills. Some industrial and government operations also used fields, pits, ponds, and lagoons as disposal sites. Over the years many of these leaked, contaminating soil and drinking water. *Spill cleanup* can take many more permanent forms, including incineration, neutralization, and vitrification (sealing the waste at high temperature in glass). New techniques look very promising. For example, certain bioengineered organisms can digest specific hazardous chemicals. Some of these organisms have already been used on oil slicks from ocean spills.

Connections

1. How can we as a society prevent hazardous spills from happening in the first place?
2. What would you want to know if a hazardous waste spill happened near your home?

Key Words

emergency response team the people first on the scene to help with a hazardous material spill

EPA Environmental Protection Agency; federal agency responsible for formulating regulations under which people dispose of hazardous waste

hazard material or situation that causes harm under particular circumstances

risk likelihood of a hazard actually causing harm. A hazard is an event, situation, or thing; risk is a statistical evaluation.

spill cleanup process of removing hazardous materials from the spill site and rendering them harmless or storing them under safe conditions

Resources

Brooks, A. (1995, Jan. 21) A glass melange: New options for hazardous waste? *Science News,* pp. 40–41.

Hazardous waste at home: Handle with care. (1994, Feb) *Consumer Reports,* p. 101.

Peart, K.N. (1994, Apr 15) Three deadly legacies. *Scholastic Update,* pp. 6–9.

Additional resources

American Online: Select in order: Reference. Environment. Network Earth. Search with keyword "hazardous waste."

Flinn Biological Catalog Reference Manual: *Oil spill cleanup.* Classroom activity. (800) 452-1261.

Focus Media: *Easy search: Chemical hotline.* Software for Apple and IBM. Creative Computer Visions: (800) 843-5576.

Georgia DNR: *The disposal dilemma.* Videotape. (404) 657-9851.

Educator's Progress Service, Inc.
214 Center St.
Randolph, WI 53956
(Request guide to free science materials.)

MECC: *Cleanwater detectives.* Software for Apple. Creative Computer Visions: (800) 843-5576

Additional source of information
Project WET
4614 Chatham Lane
Houston, TX 77027
(K–12 curriculum and activity guide.)

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3M Innovation

Stop the Spill

Build a lakeshore and try to stop hazardous waste from spreading through it.

NEWTON'S APPLE®

SHOW NUMBER

1308

Hazardous Materials

Main Activity

A hazardous waste spill might look or smell bad, but often the worst problem for cleanup crews is finding out where it goes after it gets into the ground. How far do you think a hazardous waste spill can spread? How can it be stopped, at least temporarily?

Materials

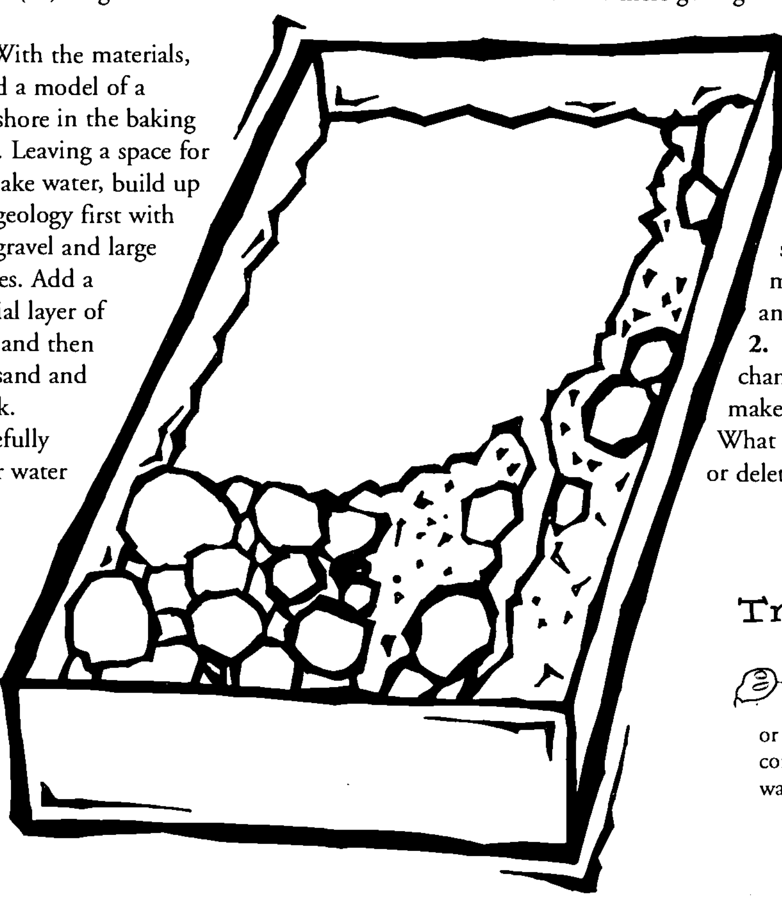
- materials for simulating the geology of a lakeshore, such as sand, aquarium gravel, clay, chalk, and a few large stones (Try to obtain materials as lightly colored as possible, to ensure clear observation of the colors.)
- large rectangular glass or clear plastic baking dish
- four colors of food coloring
- water
- miniature shovel (a toy or one for house plant gardening)
- a spray-type watering can to simulate rain
- narrow drinking straws, cut in 7.5 cm (3") lengths

1. With the materials, build a model of a lakeshore in the baking dish. Leaving a space for the lake water, build up the geology first with the gravel and large stones. Add a partial layer of clay and then the sand and chalk. Carefully pour water into the lake and allow it to seep underground. Add more water if necessary to make it about .6 cm (1/4") deep.

2. Spill several drops of food coloring on your model, using different colors in different places. Take core samples with the drinking straws in various places on the model to track the progress of the spill, recording the results of the core analysis on a chart. (These core samples will work best if the land parts of the model are slightly moist.)

3. Spray water on the land part of the model, and evaluate how this affects the spread of the spill.

4. Try various methods of cleaning up or blocking in the spill, such as plastic wrap, clay, digging, etc.



Questions

1. What geological features does the spill spread through fastest? In what direction does the spill spread? Does it get into the groundwater? How long does it take to reach the lake? Are there geological features that prevent it from spreading? How do you think the spill would spread if no water were present? Do some of the spills meet underground and mix together?

2. How could you change the model to make it more realistic? What would you add or delete?

Try This

Take an inventory of the potentially hazardous chemicals in your home and school. (Don't forget the art department—they use many paints and solvents that are potentially hazardous.) Are the chemicals stored properly? What can you get rid of? How can you get rid of them?

Try This

Study the hazard warnings in a chemical supply catalog or on the labels of chemical reagent bottles. Under what conditions would each of these chemicals be considered a hazard? What specific problems would be caused if each of them spilled? Would the location of the spill matter? How does the labeling differ between chemicals sold for home use and for laboratory use? What would the best cleanup procedure be for each one?

Try This

Pretend you're an ant marching along. What kinds of events or substances would constitute hazardous waste for you?

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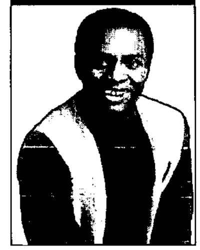
How does physics keep you zipping along on your in-line skates?

SHOW NUMBER
1308



Dave improves his skating technique with a lesson in physics.

Segment length: 7:30

In-line Skating

Do in-line skates really go faster than roller skates?

Insights

Push and glide. Push and glide. Faster and faster, until you're cruising along somewhere near 25–32 kilometers (15–20 miles) per hour. The wind whistles around your helmet. The wheels on your in-line skates whisper as you race along. Science and math are a long way from your mind. But they aren't a long way from the sport. Side-surfing, crossovers, backward skating, swizzling, arabesques, and roller hockey all depend on physics.

Physics is the science that tries to explain things like matter and energy. Energy added to matter can produce motion. Motion can be changed by *force*. And when you're having fun skating, serious forces come into play.

For starters, you push and glide to increase your speed. But you aren't just moving, you're moving in a certain direction—hopefully forward, though backwards works and "down" happens a lot when you're first learning. Motion in a particular direction is *velocity*. You increase your speed while trying to pass the slowpoke on the bike in front of you, decrease your speed to let the five-wheeled in-line racer pass you, or swerve to avoid a pothole. All of these actions involve changes in velocity and are therefore *accelerations*.

Still not convinced that something so popular could have anything to do with physics? Then how about *center of gravity?* You may not realize it but you're finding your center of gravity every time you try to keep your balance while you're slaloming, tweaking, or wall-riding. And if you don't find it, you experience the forces of gravity (and *friction)* firsthand. Ouch!

When you're stair-riding or checking someone into the boards during a roller hockey game, you're dealing with another principle of physics—*inertia*. Newton's first law of motion talks about inertia, which is the tendency of a moving object to maintain a constant velocity. It's the principle you benefit from in the "glide" part of "push and glide." After you push, you'll keep on going until friction within the wheels' bearings, between the wheels and the ground, and between you and the air rob you of your forward motion.

The physics of motion—acceleration, velocity, center of gravity, inertia, and friction—are all part of every in-line race, hockey game, or zing around the park. Who knows—understanding the science better may help you become a faster, better, and more powerful skater!

Connections

1. How would lowering your center of gravity (by squatting down) change your velocity? How is doing an arabesque the ultimate exercise in finding your center of gravity?
2. How might the hardness of the wheels on the in-line skate affect your speed?

Key Words

acceleration change in the speed or direction of motion
center of gravity point around which the entire mass of an object can equally balance
force push or pull exerted on or by an object
friction force that acts against forward motion
inertia tendency of an object in motion to remain in motion and an object at rest to remain at rest
mass amount of matter an object has
newton unit used to measure the amount of force you need to accelerate a one-kilogram object to a velocity of one meter per second in one second
velocity the speed and direction of motion of a body

Resources

Freeman, I.M. (1990) *Physics made simple*. New York: Doubleday Books.

Giancoli, D.C. (1991) *Physics: Principles and applications*. Englewood Cliffs, NJ: Prentice Hall.

Gutman, B. (1992) *Blazing bladers*. New York: Tor Books/Tom Doherty Associates.

Powell, M. & Svensson, J. (1993) *In-line skating*. Champaign, IL: Human Kinetics Publishers.

Rappelfeld, J. (1992) *The complete blader*. New York: St. Martin's Press.

Sullivan, G. (1993) *In-line skating: A complete guide for beginners*. New York: Cobblehill Books.

Walpole, B. (1987) *Fun with science: Movement*. New York: Warwick Press.

Additional sources of information

In-line magazine
1919 14th St., #421
Boulder, CO 80302

International In-line Skating Association
Lake Calhoun Executive Center
3033 Excelsior Blvd.
Minnetonka, MN 55416

U.S. Amateur Federation of Roller Skating
4739 South St.
PO Box 6579
Lincoln, NE 68506

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3M Innovation

Be a Force on Wheels!

Find out how many newtons you can generate with your in-line skates.

NEWTON'S APPLE®

SHOW NUMBER
1308
In-line Skating

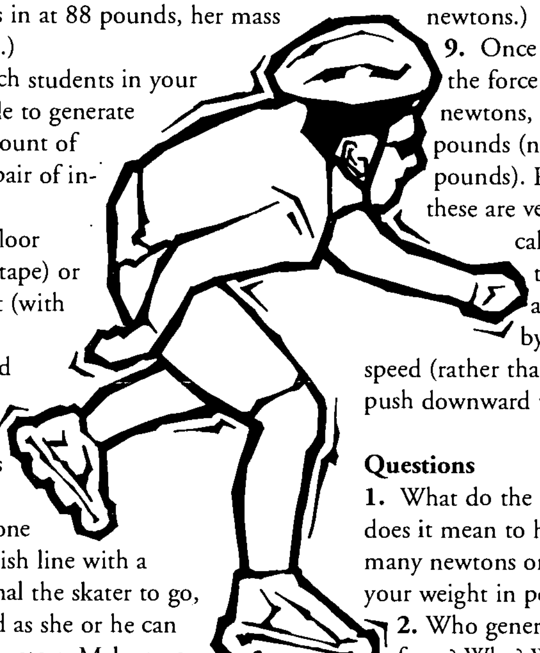
Main Activity

Arnold Schwarzenegger is a powerful human being, no doubt about it. But how much force do you think he can generate in *newtons*? When he holds a 300-pound barbell above his head, he's exerting 1,336 newtons of force. Here's an activity that lets you figure out how much force in newtons you generate on a pair of in-line skates.

Materials

- in-line skates
- stopwatch
- masking tape or chalk
- meter stick
- calculator
- human weight scale

1. Weigh each person in your class.
2. For this activity, you need to know the *mass* of each person. To do that, divide the weight in pounds by 2.2. This is each person's mass *(m)* measured in kilograms. Record the mass of each person on a chart. (For example, if Emily weighs in at 88 pounds, her mass is 40 kilograms.)
3. Predict which students in your class will be able to generate the greatest amount of force *(F)* on a pair of in-line skates.
4. On a gym floor (with masking tape) or in a parking lot (with chalk), mark a starting line and another line (your distance, or *d)* 20 meters away.
5. Have someone stand at the finish line with a stopwatch. Signal the skater to go, pushing as hard as she or he can for the full 20 meters. Make sure the skater and the stopwatch start at the same time.



6. Stop the stopwatch when the person crosses the 20-meter mark. That number (in seconds) is that skater's time *(t)*.
7. Do this for as many students as you want, keeping careful records. When everyone is done, you're ready to figure the average acceleration *(a)*. Acceleration can be calculated using the following formula: $a = (2 \times d)/t^2$. (If Emily covers 20 meters in 5.0 seconds, her average acceleration is 1.6 meters per second squared. This means that she is adding one meter per second to her speed every second.)

8. Now you're ready to figure the force generated by each skater. Force is measured in newtons. One newton is the amount of force you'd need to get one kilogram (2.2 lb) of mass accelerating at one meter per second squared. You can figure out the force by using this formula: $F = ma$. (Emily's force would be 64 newtons.)
9. Once you've figured out the force measured in newtons, convert newtons to pounds (newtons x 0.22 = pounds). Remember that these are very rough calculations. We are assuming that acceleration is constant and that all the force exerted by the skater goes to increase speed (rather than to overcome friction and to push downward to avoid slipping).

Questions

1. What do the final numbers mean? What does it mean to have generated a force of so-many newtons or pounds? Compare this to your weight in pounds.
2. Who generated the greatest amount of force? Why? Were your predictions correct?
3. Did each person's mass affect his or her acceleration? How?

Try This

Spin a raw egg on its side in a bowl. Stop it, then let go of it quickly. What happens? Why would the egg start to spin again?

Try This

Make a number of odd shapes out of cardboard. Poke three holes in each one. Pin the shape to a bulletin board through one of the holes. Hang a weighted string from the pin and draw a line on the cardboard along the edge of the string. Repeat this using a different hole. Wherever the lines cross is the center of gravity. What would happen if you pinned the cardboard shape at the center of gravity?

Try This

Tape a quarter to the inside wall of a can. On a board that is slightly inclined, place the can on its side and turn it so that the quarter is slightly past the top position on the "uphill" side. Let go. Why would the can roll up the board? Can you explain this in terms of center of gravity?

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NEWTON'S APPLE®

Does a human slingshot–or ejector seat–ride work on the same science principles as a bungee jump? Why do rides like that make a person feel a little queasy?

SHOW NUMBER

1309

SuChin is propelled 150 feet into the air—all in the name of science.

Segment length: 6:15

Human Slingshot Ride

How does the "ejector seat ride" work?

Insights

Life is full of ups and downs. Sometimes, though, moving between these extremes can be quite entertaining. Just check out the human slingshot–or ejector seat–ride.

The ejector seat ride has its roots in *bungee jumping.* Both depend on the *elasticity* of bungee cords to provide a *force.* In bungee jumping, the elastic force is used to negatively accelerate (decelerate) and halt a jumper's body as it plummets toward the ground. The ejector seat works in reverse. Elasticity overcomes gravity by yanking upward and positively accelerating (propelling) the riders sky-high.

Riders are strapped into a cage that has been pulled down to the ground, stretching the bungee cords connected high above to maximize *potential energy.* Then the entire unit is released skyward, converting the potential energy of the bungee cords into the *kinetic energy* of the riders, shooting them 45 meters (150 feet) into the air. At the moment of release, the rider feels the maximum *acceleration.* Of course, energy is *dissipated* with each pass as heat is generated by friction between the bungee cords and air and within the cords themselves.

The *g-forces* caused by the bungee acceleration are the very same forces that affect race car drivers and astronauts. Even when we're just standing around, our bodies experience the force of 1*g,* as gravity pulls our bodies toward the center of Earth. On the ejector seat, force due to the ride alone may be up to 2*g,* but the force your body feels is actually 3*g,* once you add in gravity as well.

The sudden shifting of your body's position upsets the fluid in your inner ear, affecting your sense of balance and triggering responses such as an increased heart rate and tightening of your stomach muscles. Your body seems incredibly heavy as *g*-forces push you and the blood in your body back in the direction you started from. Your heart works harder to get the oxygen- and nutrient-bearing blood back to the brain and overworked stomach muscles. This creates a temporary chemical imbalance resulting in faintness or queasiness.

At the moment acceleration stops and the bungee cords stop pulling on you, the only force from then on is gravity–you actually experience free fall. Somehow, your body adapts and often you even enjoy the experience.

Connections

1. On the ejector seat, when gravity cancels out upward motion, the rider returns in a brief free fall and is actually weightless. On what other rides would you experience this?

2. In what ways do you experience *g*-forces in your everyday life? (Hint: *G*-forces only occur during acceleration—a change in speed.)

Key Words

acceleration change in the speed or direction of motion

bungee jumping sport where a person jumps, while attached to elastic cords, off of a high platform

dissipated released, dispersed

elasticity property of a material to stretch beyond its original shape, as well as to return to its original shape, with varying degrees of strength depending on the material

force of gravity how much the acceleration of gravity makes you weigh against the floor or a scale

force push or pull exerted on or by an object

***g*-force** force exerted by gravity on an object near Earth's surface

kinetic energy energy of a moving body

potential energy amount of energy a body has stored, ready to be converted into kinetic energy

trajectory path a launched object takes through the air

zenith the highest point in the trajectory of a launched object

Resources

Breckenridge, J. (1993) *Simple physics experiments with everyday materials.* New York: Sterling Publishing.

Chaos for fun and profit. (1994, Feb 26) *Science News,* p. 143.

Epstein, L.C. (1994) *Thinking physics is Gedanken physics.* San Francisco: Insight Press.

Frase, N. (1992) *Bungee jumping for fun and profit.* Merrillville, IN: ICS Books.

Freeman, I.M. & Durden, W.J. (1990) *Physics made simple.* New York: Doubleday.

Gardner, R. (1990) *Famous experiments you can do.* New York: Franklin Watts.

Pearce, F. (1992, Aug 29) Licensed to thrill. *New Scientist,* p. 23.

Wellnitz, W.R. (1993) *Be a kid physicist.* Blue Ridge Summit, PA: Tab Books.

Whitelaw, I. (1992) *Eyewitness science: Force and motion.* New York: Dorling Kindersley.

Additional resources

3M Learning Software: *What's the secret?* CD-ROMs for Macintosh or Windows. (800) 219-9022.

NEWTON'S APPLE Multimedia Collection: *Physical Sciences* (roller coasters). Videodisc and software for Macintosh and Windows. National Geographic: (800) 368-2728.

We encourage duplication for educational use!

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3M Innovation

Ups and Downs of *G*-forces

Take a spin on a roller coaster to find out how gravity comes into play.

NEWTON'S APPLE

SHOW NUMBER
1309
Human Slingshot Ride

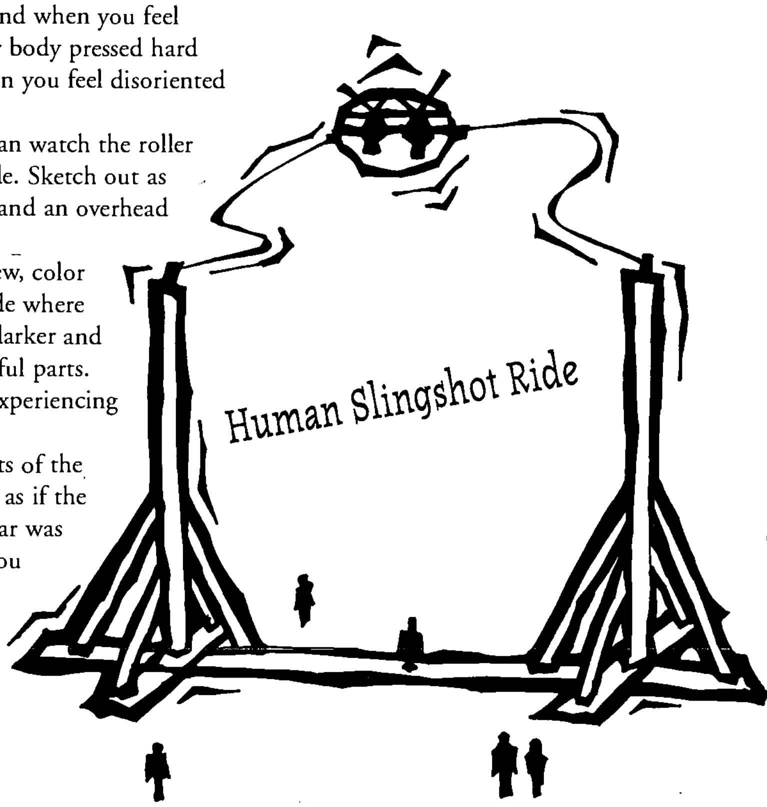
Main Activity

In the name of science, and for you to completely understand the difference between positive and negative *g*-forces, NEWTON'S APPLE respectfully requests that you make a sacrifice to collect data for this very important experiment. Unfortunately, you'll have to do it at an amusement park.

Materials

- amusement park with a roller coaster
- paper
- regular and colored pencils
- calculator

1. First, go for a couple of rides. Pay attention to when you feel heavy and when you feel light, when you feel your body pressed hard against the seat, and when you feel disoriented or dizzy.
2. Next, sit where you can watch the roller coaster go through its ride. Sketch out as best you can a side view and an overhead view.
3. On your overhead view, color in red the parts of the ride where you felt heavy, coloring darker and heavier at the most forceful parts. This is where you were experiencing positive *g*-forces.
4. Color in blue the parts of the ride where you felt light, as if the restraining bar on your car was the only thing keeping you from flying out of your seat. This is where you were experiencing negative *g*-forces.
5. How does this color map compare to your side view? Do positive and negative *g*-forces correlate with altitude? Do they seem to be associated with certain parts of a turn or an incline or descent? Now mark some dizzy or disoriented spots on your color map. Are they associated with the positive or with the negative *g*-force experiences?
6. Extra credit: If you hold a penny in the flat palm of your hand (facing toward what is originally upward) throughout the entire ride, it never falls out. Why? Is this due to *g*-forces or others?



Try This

Why do you suppose "ride films" (where people are enclosed in a movie-watching environment to simulate roller coasters or outer space rides) can make you as nauseous as the real thing? Which of your senses are fooled, and which are not? (Check out Simulator Rides, Show 1307, in this packet for more information.)

Try This

Can you sense *g*-forces on a trampoline? Do you ever feel negative *g*-forces?

Try This

Is there any way you can change your apparent weight, as measured on a bathroom scale, while riding a fast elevator in a tall building? Try to determine the positive and negative accelerations of the elevator by watching the readings as you stand on the scale.

Try This

Both bungee jumping and the ejector seat ride depend on the elasticity in bungee cords to exert forces, whether stopping a falling jumper or launching a human slingshot. Put on some eye protection and gather up a ruler and rubber bands of different sizes and lengths. Using the ruler as a launcher, shoot the rubber bands into an open area where there is no danger of hitting anyone. Do wide bands travel farther than thin bands of the same circumference? Why? How does the traveling distance of the rubber bands change as you pull back on the ruler to different measurements? Why?

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3M *Innovation*

SHOW NUMBER
1309

Peggy finds out why bone marrow matches are so rare.

Segment length: 6:45

Why do we have bone marrow? Why would a person need a bone marrow transplant?

Bone Marrow

What is a bone marrow transplant and how does it work?

Insights

Inside your bones is a thick mass of cells called bone marrow. Every hour, a small number of *stem cells* in it create all other kinds of blood cells that exist in your body, including *leukocytes, erythrocytes,* and *platelets.* These cells are essential to your health—leukocytes fight infection, erythrocytes carry oxygen, and platelets help the blood clot.

When a person has a blood disease, such as *aplastic anemia* or *leukemia,* doctors may perform bone marrow transplants to re-establish a healthy blood supply. Many transplants occur after a patient has received *chemotherapy* or *radiation treatment* to destroy cancerous or other disease-causing cells. Both abnormal and normal cells are killed by these treatments, including stem cells. A bone marrow transplant starts the blood production process from scratch with normal stem cells.

An allogeneic transplant—where another person's bone marrow is given to a patient—doesn't always work because of rejection or because of graft-versus-host disease. Rejection of the donor's marrow occurs because our bodies fight off invading foreign cells. If a donor's marrow doesn't match perfectly, the recipient's immune system may identify the new cells as foreign and destroy them, leaving the patient unable to create new blood.

Graft-versus-host disease occurs because the new immune system from the donor's marrow may identify the patient's body as foreign and try to destroy it. When the donor's immune cells in the marrow attack the patient, many symptoms may result and, in severe cases, the patient could die.

Doctors decrease these risks by trying to select a patient/donor pair whose immune cells will identify each other as "self." An identical twin's cells will see the other twin's cells as self. But most patients do not have an identical twin. So doctors look at a person's human leukocyte antigens (HLA) to match donor and patient bone marrow. These are proteins present on the surface of our cells. They play a big role in telling immune cells that other cells are either foreign or "friendly" self cells.

Doctors will look at HLA antigens on your siblings' cells, because you have a 25 percent chance of having an HLA match with a brother or sister. Among unrelated people, only one in 20,000 people will be an acceptable match.

Connections

1. How would the ability to create blood in a lab affect the availability of marrow transplants?
2. In an autologous bone marrow transplant, a patient's bone marrow is extracted and then reintroduced into the body. What transplant problems might this eliminate? What new complications might occur?

Key Words

aplastic anemia blood deficiency whereby reduced levels of red blood cells, platelets, and leukocytes result in a shortage of oxygen in the blood, bleeding, and infection
chemotherapy using chemicals to treat disease by poisoning the disease-producing cells
erythrocytes red blood cells that transport oxygen in the blood to the tissues
leukemia cancer of the blood characterized by excessive production of white blood cells
leukocytes white blood cells that fight off infection or destroy foreign cells
platelets cells in the blood that cause it to clot after an injury
radiation treatment using energy from a radiation source to eliminate disease
stem cells unspecialized cells that create specialized cells
transfusion transfer of blood from one person to another

Resources

A transplant program looks to black donors. (1993, Mar 23) *The New York Times*, p. B6.

Altman, L.K. (1994, July 19) Baboon cells might repair AIDS-ravaged immune system. *The New York Times*, p. C3.

Brooks, A.C. (1994, Dec 10) Bone marrow transplants: Upping the odds. *Science News*, p. 391.

Coghlan, A. (1993, Apr 10) Blood cell 'factory' aims to end transfusions. *New Scientist*, p. 17.

Maugh, T.H. (1994, Dec 1) New tactic may ease transplants of bone marrow. *Los Angeles Times*, p. A1.

Stewart, S.K. (1994) *Bone marrow transplants: A book of basics for patients* (rev. ed.). Highland Park, IL: BMT Newsletter.

Wiegner, K. (1994, Dec 7) He's not my brother. *Los Angeles Times*, p. D10.

Additional resource
NEWTON'S APLE Show 1012 (blood typing). GPN: (800) 228-4630. Or call your local PBS station to find out when it will be rerun.

Additional sources of information
BMT Newsletter
1985 Spruce Ave.
Highland Park, IL 60035
(708) 831-1913

National Marrow Donor Program
3433 Broadway St. NE, #400
Minneapolis, MN 55413
(800) 627-7692

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What Are the Odds?

Find the connection between rolling dice and a genetic match.

NEWTON'S APPLE

SHOW NUMBER

1309

Bone Marrow

Main Activity

What are the chances of getting a match at random from an unrelated donor? In this activity, you will learn about probability using a pair of dice.

Materials

- pair of dice
- paper
- pencil
- calculator

1. If you rolled a pair of dice, what chance would you have of getting matching numbers? Write down how many times you think you'd have to try before you got a match.
2. The first concept you need to know is that the probability of something happening is expressed in this simple equation:

$$\text{probability} = \frac{\text{number of favorable outcomes}}{\text{number of possible outcomes}}$$

In this example, you're trying to get an outcome where the two dice match. A die is a cube with six possibilities: you can roll either a 1, 2, 3, 4, 5, or 6. So with one die, your probability of rolling a 5 is:

$$\text{probability} = \frac{\text{1 (number of favorable outcomes)}}{\text{6 (number of possible outcomes)}}$$

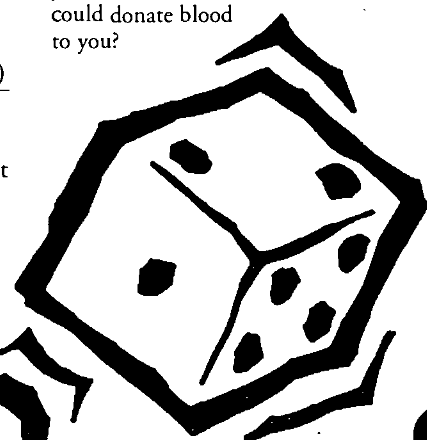
3. Next, you have to figure out how your probability changes when you roll a pair of dice. First, consider what the new number of possible outcomes is. Before, there were six. Now, there are many more combinations possible. Below is a chart listing all the possible rolls for your dice, naming them Die A and Die B. We started the chart to help you figure it out. Fill in the missing numbers to complete all the possible die rolls.
4. Count how many possible outcomes you can have when rolling two dice. If we wanted to calculate our chances of rolling a 5 on *either* or both dice, we would have to rewrite our probability equation:

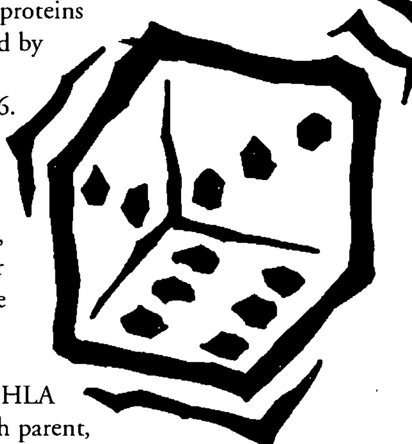
$$\text{probability} = \frac{\text{3 (Die A=5, Die B=5, or both=5)}}{\text{(fill in your count from above)}}$$

5. Now use what you've learned and the chart you've completed to calculate the chances of rolling matching die.

Questions

1. The HLA proteins are determined by genes on chromosome 6. Each parent has two of these chromosomes, and these four HLA types are almost always different. You inherited one HLA type from each parent, as did your siblings. What is the probability that one of your siblings inherited the same HLA types that you did?





Die A	Die B	Die A	Die B	Die A	Die B	Die A	Die B	Die A	Die B	Die A	Die B
1	1	2	1	3	1	4	1	5	1	6	1
1	2	2	2	3	2	4					
1	3	2	3	3	3						
1	4	2	4	3							
1	5	2	5								
1	6	2									

Try This

There are four different blood types: O, A, B, and AB. Try to find out the blood type for everyone in your family, including yourself. To whom could you donate blood? Who could donate blood to you?

Try This

Create a simple model showing how your blood cells are suspended in plasma, making blood. Fill a glass jar with corn syrup to represent plasma and add tea leaves, bits of confetti, and pepper to act as blood cells. Put the lid on tightly and shake the jar to get an idea of how blood cells travel in plasma through your system. What happens when you let the "blood" sit for a while? Does the heart's pumping action do more than just transport blood?

What is being done to ensure the future of lions in Africa. How have they adapted to life on the Serengeti?

SHOW NUMBER
1310

David travels with a big-cat veterinarian.

Segment length: 5:45

Wild Lion Vets

How are veterinarians aiding wild animals in Africa?

Insights

No other animal captures the image of strength and majesty like the lion. Thousands of years ago, these powerful *felines* were found from the Mediterranean to India. Today the "king of beasts" is largely restricted to Africa, south of the Sahara desert, where some live in the woodlands and *savannas* of protected reserves.

Like all cats, the lion is a muscular hunting machine. Unlike the cheetah, the lion is built for strength, not speed. A male lion often weighs between 160 and 180 kilograms (350 to 400 pounds) and is 3 meters (10 feet) long, including the tail. The female lion weighs about 150 kilograms (330 pounds). The shoulder and forelegs are well developed, enabling lions to clutch prey and pull it to the ground. If its prey is small, the lion may bite through the skull or neck with its powerful jaws. Larger animals (like the zebra or wildebeest—the lion's preferred prey) are usually strangled with a throat bite. Of its 30 teeth, the four *canine* teeth are used to hold and puncture, while the four *carnassial* teeth cut through tough skin and meat. With no teeth for chewing, this carnivore swallows its food in chunks, eating about 7 kilograms (15 pounds) of flesh a day.

Lions live in *prides,* often consisting of four to twelve adult females, their cubs, and one to six adult males. The lionesses are usually related to each other and stay together for their lifetimes. They are the main hunters of the pride. The males leave the pride when they grow up and are replaced by newcomers, sometimes in deadly fights.

Lions are *territorial.* The size of the territory is largely determined by the number of pride members and the amount of prey. It is the male's role to roar and mark its territory by urinating. The roar is often heard at dawn or dusk as a warning to intruders. It is produced by the vibration of *cartilage* in the back of the lion's throat, and the frightening sound may carry five miles (eight kilometers).

Tracts of land, such as Kenya's Maasai Mara Game Reserve and the Serengeti National Park in Tanzania, have been set aside to protect lions and other wild animals. But as the human population grows, there will be more pressure to turn parkland into farmland. And now lions face an additional threat. Many suffer from distemper, a viral disease which causes anemia, blindness, seizures, muscle spasms, and even death. Veterinarians from around the world are trying to isolate the virus and discover how the animals are exposed to it.

Connections

1. What would happen to the Serengeti ecosystem if the lion became extinct?
2. Who is responsible for the protection of lions?

Key Words

canine fang tooth for biting
carnassial bladelike tooth for shearing flesh
carnivore fleshing-eating animal
cartilage tough, white animal tissue
domesticated adapted to life in close association with humans and for their benefit
felines members of the cat family
pride the family grouping of the lion
savannas plain with grasses and scattered trees, especially near the equator where rainfall is seasonal
territorial characteristic of an animal that claims a certain area for hunting and other activities

Resources

Fogle, B. (1991) *Know your cat.* New York: Dorling Kindersley.

Green, C.R. & Sanford, W.R. (1987) *The African lion.* Mankato, MN: Crestwood House.

Hofer, A. & Ziesler, G. (1988) *The lion family book.* Saxonville, MA: Picture Book Studio.

Lawick, V.H. (1986) *Among predators and prey.* San Francisco: Sierra Club Books.

MacDonald, D. (1992) *The velvet claw: A natural history of the carnivores.* London: BBC Books.

Schaller, G. (1983) *Golden shadows, flying hooves.* Chicago: University of Chicago Press.

Taylor, D. (1989) *The ultimate cat book.* New York: Simon and Schuster.

Additional resources
Dorling Kindersley and BBC Lionheart Television, Intl.: *Eyewitness, cat.* Videotape. (800) 944-1419.

Encyclopedia Britannica: *The lion.* Videotape. (800) 621-3900.

National Geographic: *African wildlife* and *Lions of the African night.* Videotapes. (800) 368-2728.

Additional source of information
The Wildlife Conservation Society
Bronx Zoo
Bronx Park
New York, NY 10460

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Cat's Eyes

Shine some light on why cats see so well in the dark.

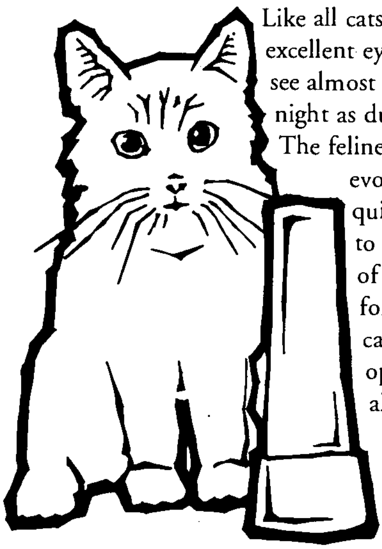
NEWTON'S APPLE®

SHOW NUMBER

1310

Wild Lion Vet

Main Activity



Like all cats, lions have excellent eyesight and see almost as well at night as during the day. The feline's pupils have evolved to quickly adjust to the amount of light needed for the hunt. A cat's pupils can open wide to allow in the faintest moonlight. The same pupil can close to the size of a pinhole during the day to shade out bright rays. Felines need only one-sixth the light humans do to make out the same details of movement and shape. When you compare your eyes to a cat's eyes, you will be learning about a lion's eyes, too.

Materials

- naturalist's notebook and pencil
- flashlight
- cat
- mirror (optional)

1. In a brightly lit room, study a partner's eyes or look at your own eyes in a mirror. Sketch them, noting the size of the pupils in relation to the iris.
2. Now dim the lights for five minutes. Sketch your partner's eyes or your eyes. Again, draw the size of the pupils in relation to the iris. Compare the two sketches.
3. Next, observe a cat under the same conditions. Draw what the cat's eyes look like when the room is brightly lit. Sketch the cat's eyes when the room is dimly lit. In a nearly dark room, shine a flashlight at the cat until you can see its eyes glow.

Questions

1. What are the differences in the pupil size of a human's eyes in various amounts of light? Why do the pupils change size? Can you explain the difference between human eyes and those of the cat?
2. Why do a cat's eyes glow in the dark? (Hint: Research the term *tapetum lucidum.)*
3. A cat's pupils dilate at dusk to hunt, but why do they dilate in a flight-or-fight situation?

Try This

With a friend, observe and record the activities of a cat every 15 minutes over a period of several hours. For each 15-minute segment, write down the primary activity of the cat. What proportion of the cat's time is spent eating, drinking, playing, exploring, or just plain sleeping? How does a cat's routine compare to that of a lion? How does it compare to yours?

Try This

Research as much as you can about lions. Then invite a local veterinarian to visit your class and share information about cats, their anatomical structures, common diseases, behaviors, etc. Find out what pet cats and lions have in common. What are their differences? For example, can a cat roar or a lion purr?

Try This

With a friend, write down as many members of the cat family as you can, listing them by continent. Try to find pictures of them. Make your own field guide of cats by doing research on each one. Page through a field guide first to find out the consistent characteristics to research, such as appearance, habitat, range, and food.

Try This

Observe a cat. How many claws does a cat have? How do the back feet differ from the front feet? How many whiskers does a cat have? Can you find the backward barbs on a cat's tongue? These are used for grooming and scraping meat off bones. Can you tell the canine teeth from the carnassial?

NEWTON'S APPLE®

How fast can bikes go? How have bikes changed since they were invented, and why?

SHOW NUMBER

1310

Peggy stays up on the science of bicycle balance.

Segement length: 6:20

Bicycles

How do a bike and its rider stay up?

Insights

In the Colorado desert in 1992, a speeder was clocked going 110 kilometers (68 miles) per hour. No ticket was issued to the driver. A lapse in law enforcement? Not at all.

The Dexter Hysol Cheetah, an experimental bicycle, had just broken the world record for human-powered speed. The Cheetah incorporated many new innovations in bicycling—a recumbent seating angle, *aerodynamic fairing*, and the latest lightweight materials. The result was a milestone in the annals of two-wheel transportation.

Two principles of physics explain how a bike works. First, *angular momentum*, the same force at work in a gyroscope, makes wheels want to keep turning in the same direction and position as they have been. So as your bike wheels spin underneath you, they're actually helping you stay upright as their angular momentum resists changes in the bike's upright position. Second, because of the way bicycles are constructed, *inertia* swings the upper part of a bicycle away from the center of a turn, even as the front wheel dips into the turn, keeping the bike in an upright position.

Bicycles have undergone few design changes since they were first invented. The earliest known bicycle design dates back to the 1490s, when a student of Leonardo da Vinci sketched a vehicle which looks remarkably like today's bicycle. The first functioning velocipedes of the 19th century also strongly resembled today's bikes, with two wheels of the same size. The old-fashioned bicycles most people think of with enormous front wheels and tiny back wheels were actually invented later. Called "ordinaries," these bikes were fun and fast, but quite unstable and dangerous.

Most innovations in biking happened as a result of the energy crisis of the '70s. Many of these innovations have already been incorporated into competition-class bicycles, such as aerodynamic carbon-fiber frames. Other improvements include wheels that attach on only one side, *two-wheel drive* for more traction, and tension wires that offer extra stability for less weight. *Recumbent bicycles* are also becoming popular, in part because the rider's lower *center of gravity* makes the bike more stable. Not only are you less likely to fall off—it's a shorter distance to the ground if you do!

Connections

1. What needs to happen for more people to use bicycles as daily transportation? What would help you make more trips on a bike?
2. The front wheel of an "ordinary" could be up to 1.5 meters (5 feet) tall, with the rider perched on a seat on top. How would this affect the stability of the ride when you compare it to a regular bicycle?

Key Words

aerodynamic designed to minimize wind resistance
angular momentum tendency of a spinning object to keep spinning with the same orientation
center of gravity point around which the entire mass of an object can equally balance
fairing bubble structure surrounding nonaerodynamic surfaces to reduce air drag
gears bicycle's driving system using cogs with teeth connected by a chain
inertia tendency of an object in motion to resist changes in direction or speed
recumbent bicycle bicycle slung low to the ground, with wheels far apart and a rider seated in a prone position between them
two-wheel drive drive assembly which diverts the pedaling force to both the back and front wheels

Resources

A new bike harnesses the best of all possible wheels. (1992, Feb 29) *The New York Times*, p. 52.

Ballantine, R. & Grant, R. (1992) *Richards' ultimate bicycle book.* New York: Dorling Kindersley.

Dream machines. (1992, Feb) *Bicycling*, pp. 56–58.

Evolution of a dream: From Da Vinci to Daedalus. (1988, Dec) *Bicycling*, pp. 68–74.

Fisher, L. (1992, Aug 5) Shifting a bike with centrifugal force. *The New York Times*, p. D4.

Korten, Tristram. (1991, Jan 21) Pedal power. *Design News*, pp. 111–114.

McGurn, J. (1987) *On your bicycle: An illustrated history of cycling.* New York: Facts On File Publications.

Posth, M.A. (1993, Oct) The world's fastest bike. *Popular Science*, pp. 78–80.

Sullivan, K. (1992, July 12) Laid-back bikers love this cycle. *The Washington Post*, p. B1.

Thisdell, D. (1992, Sept 12) For sale: The world's fastest bicycle. *New Scientist*, p. 23.

Additional resource
NEWTON'S APPLE Show 501 (high-speed bicycles). GPN: (800) 228-4630.

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Get in the Right Gear!

Find out how to bike more efficiently by calculating gear ratios.

NEWTON'S APPLE®

SHOW NUMBER

1310

Bicycles

Main Activity

The main driving action in a bicycle happens because of a *gear* system. Calculate the gear ratios of your bike, make predictions based on your calculations, and test them with a ride.

Materials
- one multigear bicycle
- pencil and paper
- measuring tape
- bike helmet

1. Stand the bicycle up. Count the number of teeth on the largest chain ring (the circle with the teeth that's connected to your pedals). Then count the teeth on the biggest and the smallest cogs on the back wheel.
2. Calculate the gear ratios for the biggest and smallest back cogs. The ratios will be for your highest and lowest gears. The formula for calculating gear ratios is:

$$\text{gear ratio} = \frac{\text{number of teeth on the back cog}}{\text{number of teeth on the front}}$$

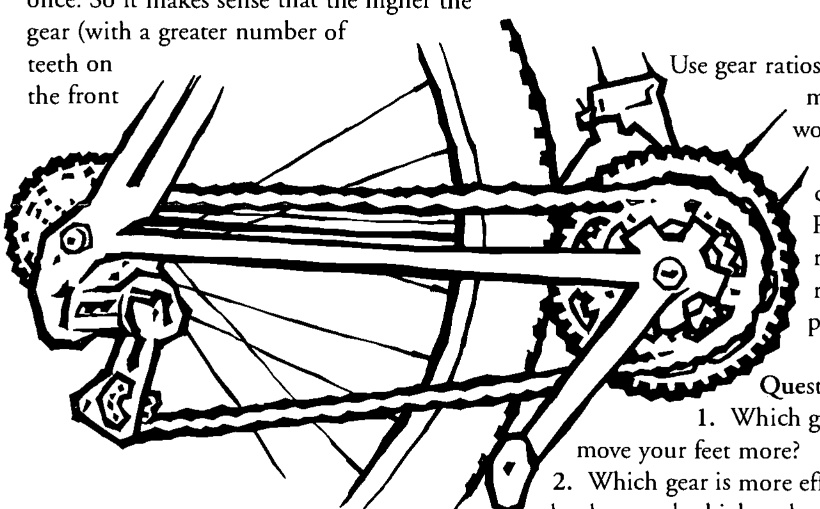
The ratio for your highest gear should be smaller than for the lowest gear. That's because the gear ratio measures how many rotations of the pedals you need to turn the back wheel once. So it makes sense that the higher the gear (with a greater number of teeth on the front gear and/or a lesser number on the back gear), the less often you have to turn the pedals to make the wheels go around.

3. Pedaling produces torque (rotary force) in the front gear, which is transmitted to the rear wheel. Compare the two gears by riding the bike first set at the highest gear and then set at the lowest. Do you have to push harder to start the bike in the higher gear? Which gear ratio is better for starting? Knowing the lowest and highest gear ratios, can you roughly predict the ratios for different gear settings in between? Don't forget your helmet!
4. With your gear ratios, figure out how many times you would need to pedal in high versus low gear to get from one end of an area to another. First, measure how long a distance you will cover. Then figure the circumference of your wheels, using this formula:

$$\text{circumference} = \text{diameter of wheel} \times \text{pi}$$

Now work backwards from your distance measurement to figure out how many rotations of your wheel it will take to travel from one end to the other:

$$\text{number of wheel rotations} = \frac{\text{distance you want to cover}}{\text{circumference of wheel}}$$



Use gear ratios to calculate how many times you would need to move your feet around to cover the distance. Remember, gear ratios are the relationship between pedals and wheels.

Questions
1. Which gear ratio makes you move your feet more?
2. Which gear is more efficient for biking on level ground—high or low?

Try This

You probably don't consciously know where your center of gravity is, but you've used it to steer your bike. To find your center of gravity, lie on the floor on your stomach with your arms at your side. Bend your elbows into your belly and try to balance on your hands. Think of your body as a seesaw, with your elbows at the center. It may take a while, but eventually you'll find it!

Try This

A heavy load on a bike makes it harder to start and stop due to inertia. See if you can borrow a friend's saddlebags for your bike. Try loads of books in different weights. What is the highest gear you can start in without any books at all? How quickly does this change as you add weight?

Try This

Compare a touring bicycle and a mountain bike. What design choices were made to adapt mountain bikes to the rocky trails and steep inclines of off-road biking? What are the features of a touring bike that make it suitable for racing?

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3M Innovation

NEWTON'S APPLE®

What do you picture when you hear the word "equator?" Can there be both extreme heat and extreme cold on the equatorial line?

SHOW NUMBER

1311

David dispels some misconceptions about life at the African equator.

Segment length: 6:00

Equator

What is life like for animals, plants, and people at the African equator?

Insights

Run your finger along the *equator* on a globe. What do you see in your mind's eye as your finger passes over continents and oceans? Tropical rain forests? Houses on stilts? Blazing temperatures? Stop your finger on the East African country of Kenya and be prepared for new impressions. Lying on the equator in the southwestern corner of Kenya is the *Maasai Mara National Reserve*—a nature preserve that defies the usual image of the equatorial tropics.

This reserve is a part of the Serengeti-Mara ecosystem. Here you will find not rain forests, but woodlands and *savanna.* Two million years ago, volcanic and *tectonic activity* pushed up the lush forest floors of this region, creating a plateau 1,520 meters (5,000 feet) above sea level. At this elevation, the warm ocean winds were cut off, forests disappeared, and volcanic ash settled over the highlands, creating the rolling plains of today. Temperatures can reach 38°C (100°F) and cool to 10°C (50°F).

Dramatic volcanic action also produced Mount Kenya. Once higher than Mount Everest, Mount Kenya now stands 5,200 meters (17,000 feet) high and is crowned with snow. Snow! On the equator?

Why doesn't the snow melt? First, as one ascends from sea level, the temperature decreases. In fact, according to the *adiabatic lapse rate,* for every thousand feet, the temperature drops approximately 3.1°C (5.5°F). Second, the shiny surface of the snow reflects the sun's rays, keeping the snow frozen. (This effect is called the *albedo.)* Third, the snow is so densely packed at the peak that the lower layers of snow cool the surface layer, counteracting the warming effects of the sun.

Life in the shadow of Mount Kenya may defy our equatorial image, too. For a thousand years, the nomadic *Maasai* have shared their home with wildebeest, lion, and giraffe. More precious to the Maasai are the herds of cattle upon which their livelihood, wealth, and prestige depend. The Maasai villages are built with the materials at hand—mud, cow dung, and sticks. Women are responsible for the construction of the family *boma.* Life in the *manyatta* follows traditional patterns, and the roles of its members are clearly defined. Boys take care of the cattle, girls help their mothers, and elders enjoy their honored roles as village leaders. Although life in nearby cities offers modern conveniences, many Maasai prefer the path of their ancestors under the direct rays of the equatorial sun.

Connections

1. Are there other places along the equator that resemble Kenya's geography?

2. What impressions do you have about life on the equator? Are your impressions facts, generalizations, or misconceptions?

Key Words

adiabatic lapse rate rate at which the temperature decreases in the troposphere, or lowest layer of the atmosphere

albedo reflection of the sun's energy off a highly reflective surface

altitude height above Earth's surface or sea level

boma Maasai's mud hut

equator imaginary circle on Earth's surface midway between the north and south poles

Maasai native tribal people of the Serengeti who maintain their traditional village life

Maasai Mara National Reserve Kenya's wildlife park on the Serengeti Plains

manyatta Maasai village

savanna plain with grasses and scattered trees, especially near the equator where the rainfall is seasonal

tectonic activity movement of Earth's upper crust

Resources

Amin, M., Willetts, D. & Tetley, B. (1991) *On God's Mountain: The story of Mount Kenya.* Nairobi, Kenya: Camerapix Publishers International.

Dinesen, I. (1985) *Out of Africa.* New York: Vintage Books. (First published in 1937.)

Eyewitness visual dictionary of the Earth. (1993) London: Dorling Kindersley.

Farndon, J. (1994) *The dictionary of the Earth.* London: Dorling Kindersley.

Jobb, J. (1977) *The night sky book.* Boston: Little, Brown and Company.

Krupp, E.C. (1989) *The Big Dipper and you.* New York: Morrow Junior Books.

Stott, C. (1993) *Eyewitness explorers: Night sky.* London: Dorling Kindersley.

Wood, R.W. (1992) *Science for kids: 39 easy geography activities.* Blue Ridge Summit, PA: Tab Books.

Additional resources

National Geographic: *Africa's animal oasis; Africa: Physical geography of the continents;* and *Serengeti diary.* Videotapes. (800) 368-2728.

Tom Snyder Productions: *Mapping the world by heart.* Curriculum kit. (800) 342-0236.

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3M Innovation

Ahoy There, Mate

Make your own sextant and find out how far you are from the equator.

NEWTON'S APPLE

SHOW NUMBER

1311

Equator

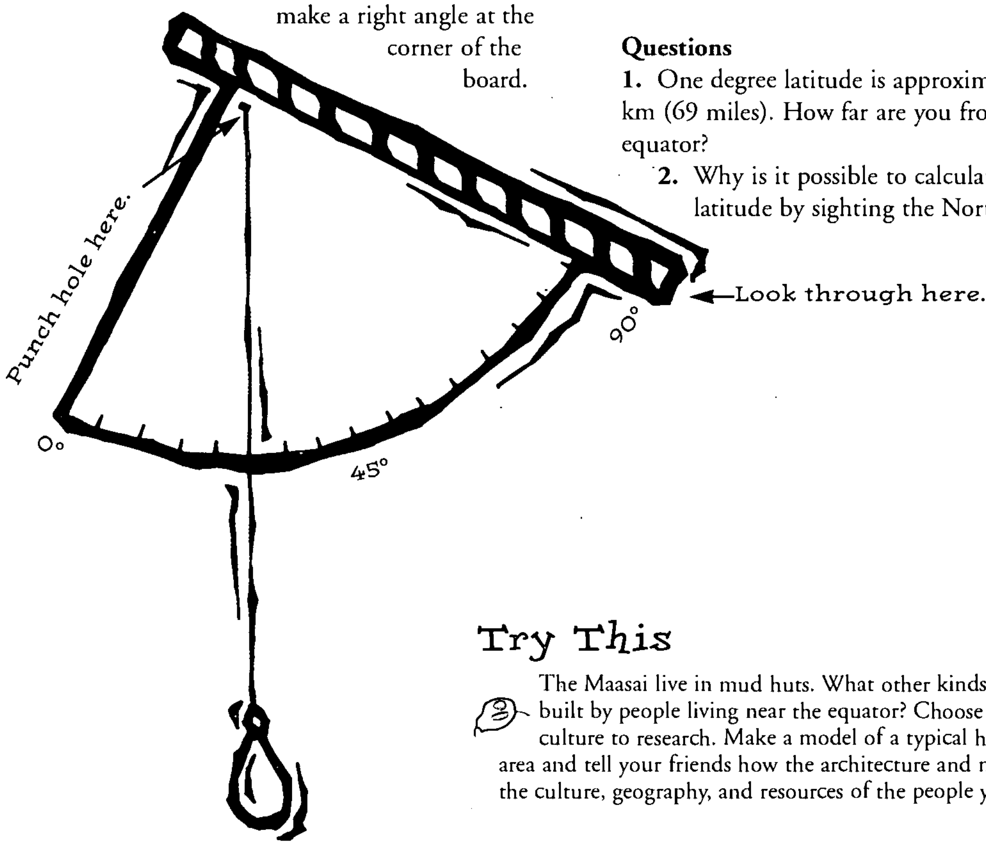
Main Activity

Explorers of old could determine their location in the Northern Hemisphere by using a sextant and sighting the North Star. From these, they could calculate their latitude. Follow these directions to make a simple sextant. Calculate your latitude to find out how far north you are from the equator.

Materials

- one 15 cm X 15 cm (6" X 6") piece of poster board
- one plastic drinking straw
- small weight such as metal sinker or washer
- paper clip
- transparent tape
- protractor
- pencil
- scissors

1. Draw two lines, each 1.25 cm (1/2") from the edge of the poster board, so that the lines make a right angle at the corner of the board.



2. With your protractor as a guide, draw an arc between the two lines.
3. Using the protractor, mark off every five degrees from 0 to 90 and label each mark. Trim off the extra poster board along the arc.
4. Make a hole at the right angle as shown and thread the piece of string through it. At one end, tie a paper clip so that the string doesn't slip through the hole. Tie the weight to the other end so that it hangs straight down.
5. Tape the straw to the edge of the poster board closest to the 90° mark.
6. On a clear night, go outside and find the constellation Ursa Major (also known as the Big Dipper). Using your sextant, sight the North Star through the straw. Notice you are actually measuring the angle from the horizon to the North Star. Write down the degree of the angle as marked by the string on the sextant. This shows your latitude from the equator. Check your answer using a map or globe.

Questions

1. One degree latitude is approximately 110 km (69 miles). How far are you from the equator?
2. Why is it possible to calculate the latitude by sighting the North Star?

Try This

The shiny surface of the snow on Mount Kenya reflects light, keeping the snow from melting. Try this activity to see why. Take two identical glass jars and fill them with equal amounts of water at the same temperature. Cover one jar with a piece of foil. Cover the other with a sheet of black paper. Place the jars outside on a sunny day. After an hour, measure the water temperature of each jar. Which one is cooler? Why?

Try This

Want to find north without a compass? Pound a stick into the ground at an angle so that it is pointing directly toward the sun and not casting a shadow. Wait about an hour until the stick casts a shadow about 15 cm (6") long. The shadow will be pointing east from the stick. Why? Stand with your right shoulder pointing in the direction of the shadow, and you will be facing north. Now, which direction is the equator?

Try This

The Maasai live in mud huts. What other kinds of houses are built by people living near the equator? Choose a country and culture to research. Make a model of a typical house from that area and tell your friends how the architecture and materials reflect the culture, geography, and resources of the people you studied.

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NEWTON'S APPLE®

Where does coffee come from? How is it processed? How does it fit into human culture?

SHOW NUMBER

1311

David follows a coffee bean from plantation to mug.

Segment length: 6:00

Coffee

How does a coffee bean become a cup of java?

Insights

It's been used as a medicine and an ingredient in wine. It's been linked with revolutionary ideas. First a food, later a beverage, coffee contributed significantly to the economic health of countries that controlled it. The coffeehouses in the Middle East and Europe that sprang up because of it became centers of intellectual ferment, often frowned upon by the authorities.

Native to Ethiopia, this crop is now grown around the world and is a major *commodity* in the world economy. The principal species, *Coffea arabica,* thrives at high elevations in a moist, mild climate where there is partial shade. That's why most of the big coffee producers are located in mountainous countries near the equator.

The coffee tree is a shrublike plant with glossy, dark-green leaves and small, white, fragrant flowers. The fruit, or cherry, is initially green and gradually ripens to a dark red. Although people used to eat the coffee cherries or chew the coffee leaves, the principal interest now is in the coffee seeds or beans.

Removal of the fruit from the beans requires several steps and considerable water because the inner part of the fruit is so sticky. Processors first *pulp* and wash the cherries, and then allow them to ferment before washing them again. During *fermentation,* microorganisms act on the sticky inner layer of the cherry to break it down. Finally, the seeds are dried, and a *hulling* machine crushes the remaining parchment covering so it can be removed. The seeds—now called green coffee beans—can be roasted in several different ways.

To prepare coffee, people *brew* the ground-roasted beans with hot water, a process that extracts flavor and fragrance chemicals. Only those chemicals that are soluble in hot water dissolve to make the coffee. The coffee grounds are left behind. One chemical naturally present in coffee is caffeine, which is a mild stimulant. But many different chemicals are manufactured by the coffee plant, and other chemicals are created in the *roasting* process.

Most coffee flavor comes from roasting—green coffee beans smell and taste completely different from roasted ones. Caffeine can be extracted from the beans to make decaffeinated coffee without altering the flavor much, since caffeine itself has very little flavor.

Connections

1. If you were a farmer, what things would you consider before growing coffee for sale? What plans would you have to make?
2. What are the known effects of caffeine on the human body? Is caffeine addictive? Are there medicinal uses for it? Do soft drinks with caffeine sell better than those without?

Key Words

brewing hot-water extraction of flavors, fragrances, and caffeine from ground-roasted coffee beans
commodity any object or material that is bought and sold
economic botany the study of plants bought, sold, traded, or otherwise involved in a society's commerce
fermentation in coffee processing, the action of microorganisms on the sticky inner pulp of coffee cherries
hulling removal of the dry parchment layer on coffee beans after they have been pulped, fermented, washed, and dried
pulping mashing coffee cherries to loosen the fruit pulp so it can be washed away
roasting heating green coffee beans in hot air to brown them and develop the distinctive aroma and flavor of coffee

Resources

Burns, G. (1994, July 11) Coffee isn't all that's perking in the pits. *Business Week,* p. 134.

Mattern, V. (1991, Dec) Indoor paradise! *Organic Gardening,* pp. 40–45.

Schapira, K., Schapira, J., & Schapira, D. (1982) *The book of coffee and tea* (rev. ed.). New York: St. Martin's Press.

Yang, D.J. & Hinchberger, W. (1994, Aug 1) Trouble brewing at the coffee bar. *Business Week,* p. 62.

Yang, D.J. (1994, Oct 24) The Starbucks enterprise shifts into warp speed. *Business Week,* p. 76.

Additional resources
America OnLine: *Trade simulator* and *Wall Street simulator.* Shareware software for Windows.

Spices, etc. (800) 827-6373. (Catalog that sells gourmet coffee beans.)

Well-Sweep Herb Farm
317 Mt. Bethel Rd.
Port Murray, NJ 07865
(Catalog that sells food plants and seeds, including coffee.)

Additional source of information
National Coffee Association
110 Wall Street
New York, NY 10005
(Free history booklets on coffee—requests in writing only.)

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3M *Innovation*

Scent Notes

Extract and blend fragrances to make one that appeals to you.

NEWTON'S APPLE®

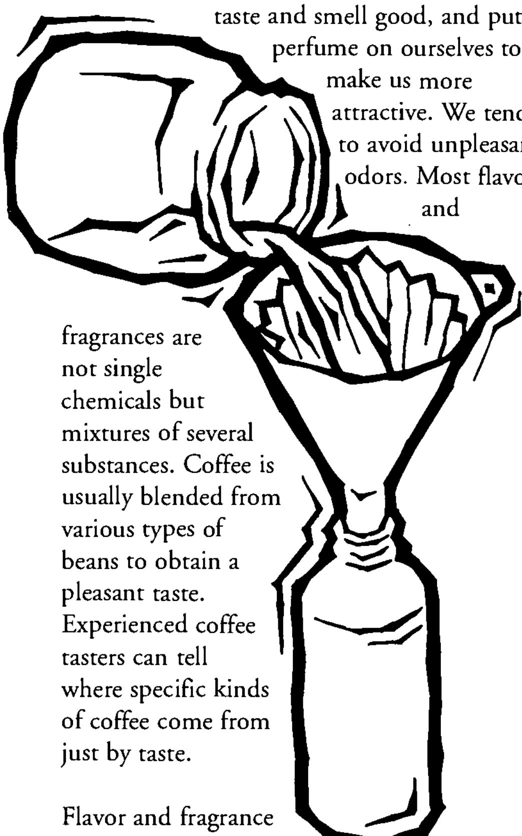
SHOW NUMBER

1311

Coffee

Main Activity

Flavors and fragrances play a large part in our daily lives. We add spices to food to make it taste and smell good, and put perfume on ourselves to make us more attractive. We tend to avoid unpleasant odors. Most flavors and fragrances are not single chemicals but mixtures of several substances. Coffee is usually blended from various types of beans to obtain a pleasant taste. Experienced coffee tasters can tell where specific kinds of coffee come from just by taste.



Flavor and fragrance experts talk about "notes" of scent—fruity, flowery, aromatic, earthy, musky, and so on. Some odors are unpleasant in large amounts, but smell good in small amounts or when mixed with other scents. Coffee, for example, contains sulfur compounds that are unpleasant by themselves, but that smell pleasant in the aroma of coffee. Most perfumes are specific blends of fragrance notes.

Materials

- odoriferous materials such as flowers, spices, pine needles or chips, sage and mint leaves, and fruits (Caution! Not all of these materials are edible, so stick to fragrance, not taste.)
- hot water
- mortar and pestle
- small beaker
- funnel
- filter paper
- medicine droppers
- small screw-top bottles for storing the extracts

1. Using the mortar and pestle, grind the material you are testing into a pulp.
2. Place the material in the beaker and soak with hot water. Be careful when handling the hot water.
3. After stirring the material in the hot water, set up the funnel with filter paper. Pour the mixture into the filter paper and collect the filtrate (extract) in a screw-top bottle. Label the bottle with the source of the extract. Manufacture as many different extracts as time allows.
4. Mix small portions of various extracts to make new fragrances. Experiment with a variety of combinations. Can you design your own personal fragrance with particular "notes"?
5. Health food stores often sell essential oils from various plants. What other scents would you like to obtain to add to your mixture?

Try This

Many foods and drinks contain caffeine. Find out what they are and add up your daily caffeine consumption.

Try This

Too much caffeine makes people jittery and irritable. In larger quantities it can be poisonous. Decaffeination removes the caffeine from coffee and other beverages. One type uses carbon dioxide under so much pressure that it becomes a semi-liquid called a supercritical fluid. Find out about other decaffeination processes. How will you plan your research?

Try This

Try your hand at *economic botany.* By studying back issues of the *Wall Street Journal, Business Week,* or other financial publications, track the weather in Brazil and the price of coffee. Can you graph these two things on a yearly or semi-annual basis? Does there seem to be a relationship between weather and price? What other environmental events might influence the price of coffee or other commodities?

Try This

A fruit is the enlarged ovary of a flowering plant, and it encloses the seeds from which a new plant can grow. Coffee cherries are fruits, and fruits all have some similarities. Dissect several fresh fruits. How are they different? How are they similar? Could you tell plants apart based entirely on their fruits?

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NEWTON'S APPLE®

SHOW NUMBER
1312

How does a bird learn its song? Why does it sing?

Peggy listens in on some bird talk.

Segment length: 6:45

Bird Songs

What is a bird "saying" when it sings?

Insights

You're walking in a park when suddenly a bird bursts into song. At a spot where a pile of leaves are flying, you see it—a large, robinlike bird with orange flanks and a white belly. It's a rufus-sided towhee. It's singing a song that sounds like "drink-your-tea-ee-ee-ee-ee." The bird spots you and changes its tune to "dreet, dreet, tow-hee, chee-wink."

Is the bird talking to you? What is it saying? Why does a towhee sing this song instead of a robin's song? Why do *songbirds* sing at all?

For the answers, you need to look at both *heredity* and experience. The songs a bird sings are usually distinctive to its *species.* Scientists believe a bird is born with a "neurological model" of what its song should sound like. The baby bird learns that song by matching the sounds it hears from its father and male neighbors. Scientists call this theory the auditory template hypothesis.

In this theory, song learning begins at about ten days after hatching and continues for about 40 days. Baby birds then practice their songs through the fall and winter. By spring, birds have developed a "crystallized" song.

To communicate, birds combine songs and other vocalizations with certain behaviors and outward appearances. Males tend to sing more than females, and they sing more in the spring. Songs help proclaim territory, attract mates, and maintain a pair bond.

Some birds like gulls and parrots have no songs. Instead they use complex calls to defend territory and attract mates. Oilbirds and cave swiftlets use vocalizations to maneuver in the dark, a process called echolocation. The ruffed grouse and mourning dove make sounds with their wings and woodpeckers with their beaks.

Most songbirds have several songs and calls. Birds in the Mimid family (the mockingbird, catbird, and brown thrasher) have very large repertoires. Scientists believe that repertoires increase with age and may indicate to females the health and experience of the male.

A songbird uses its *syrinx,* a vocal organ in its throat, to create a song. A bird's songs can vary in pitch, tone length, number of notes, and special sounds. The two halves of the syrinx can produce songs simultaneously so a bird may sing harmonies with itself, resulting in extremely rich and complex melodies. No human voice can equal this feat.

Connections

1. What different kinds of sounds do humans make? Why do humans sing and make music?
2. Why could the same word or gesture mean something different in different countries?

Key Words

dialect variation of a bird song that birds from a particular region sing
harmonics tone or sound wave found in a series of notes in harmony
heredity transmission of characteristics from parents to offspring, including genes and the abilities associated with them
ornithology branch of zoology that deals with the study of birds
songbird bird capable of producing complex vocalizations that resemble a melodious song
species category of classification that ranks organisms very similar to one another and capable of interbreeding
syrinx bird's vocal organ, made of thin muscles that vibrate during song

Resources

Crabb, C. (1991, Nov 25) Nature's symphonic mystery. *U.S. News & World Report,* pp. 60–61.

Elliott, L. (1991) *Know your backyard bird sounds: Yard, city, and garden birds* (eastern/central). Ithaca, NY: NatureSound Studio.

Freethy, R. (1990) *Secrets of bird life: A guide to bird biology* (rev. ed.). London: Blandford.

Stokes, D.W. & Stokes, L.Q. (1983) *A guide to bird behavior* (vol. II & III). Boston: Little, Brown and Company.

Walton, R.K. (1994) *Songbirds and familiar backyard birds* (eastern/ western regions). National Audubon Society pocket guides. New York: Alfred A. Knopf.

Additional sources of information

American Backyard Bird Society
PO Box 10046
Rockville, MD 20849
(301) 309-1431

Cornell Laboratory of Ornithology
159 Sapsucker Woods Road
Ithaca, NY 14850
(800) 843-2473

Migratory Bird Center
Smithsonian Institution
National Zoological Park
Washington, DC 20008

Office of Migratory Bird Management
U.S. Fish & Wildlife Service
Room 634, Arlington Square
4401 N. Fairfax Drive
Arlington, VA 22203
(703) 358-1821

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Calling All Birds

Examine why anatomy helps determine the sounds we make.

NEWTON'S APPLE

SHOW NUMBER
1312
Bird Songs

Main Activity

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 and 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.

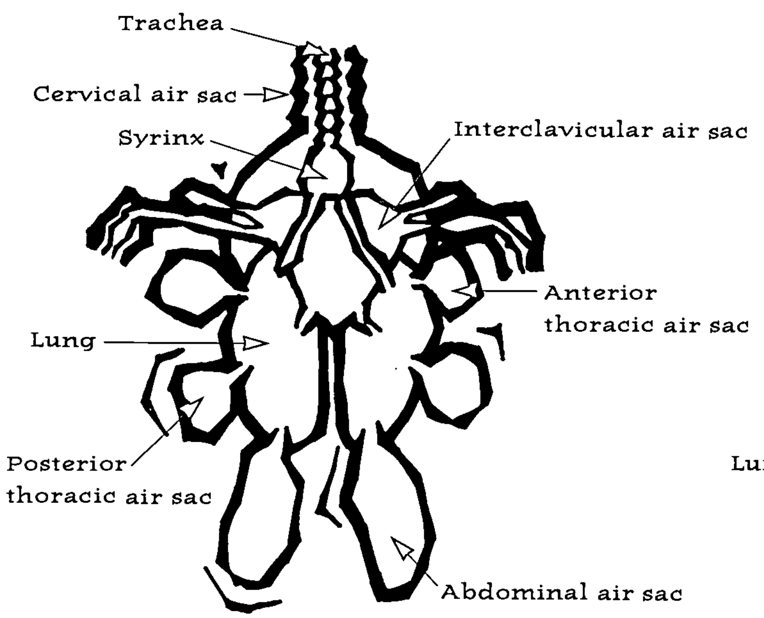
1. Give each student two sheets of paper.
2. Show the transparency with an overhead projector. Have everyone draw an outline of the bird's chest, neck, and head. As you explain the different parts of a bird's anatomy that help make its songs, have each student add those parts and label them.
3. Show 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?

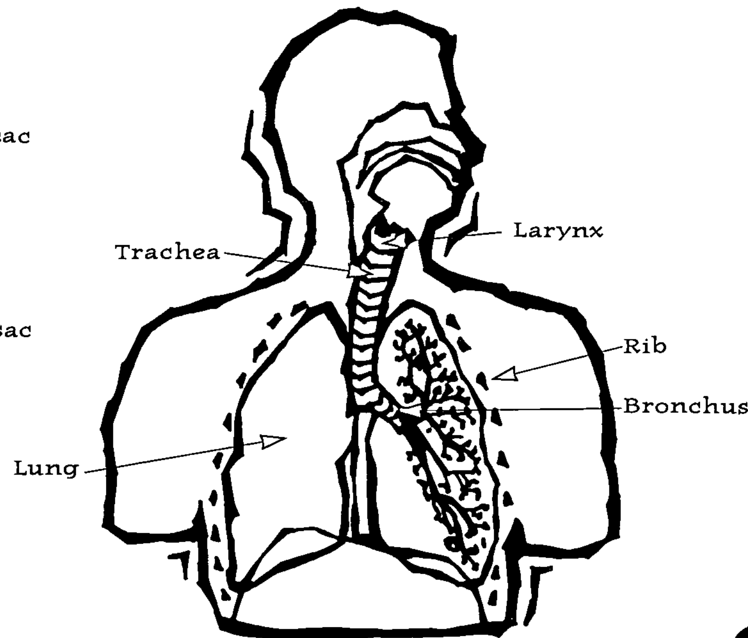
Questions

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?

Try This

Pick out a local bird whose calls and songs you can recognize. Keep records of where and when you hear it. Describe the sounds phonetically. Where is the bird and what is it doing when it vocalizes? How do the sounds relate to the bird's behavior?





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3M Innovation

NEWTON'S APPLE®

What do a split computer keyboard, air bags, and astronaut toothpaste have in common? What information do ergonomists need to design things?

SHOW NUMBER

1312

The team shows how ergonomics makes life more comfortable.

Segment length: 5:30

Ergonomics

What is ergonomics and why is it important?

Insights

Have you ever wondered how astronauts brush their teeth in space? You don't see any sinks in spacecraft, do you? And in zero gravity, how can they rinse and spit out after brushing?

Astronauts can brush in space thanks to a very clever invention. They use a foamless toothpaste that doesn't need water, has a pleasant taste, and is perfectly safe to swallow.

Edible toothpaste is just one example of *ergonomics* at work. Ergonomics is a term taken from the Greek word "ergon," meaning work, and "nomos," meaning natural laws. In other words, ergonomics refers to the natural laws of work. It's the science of designing the job, products, and place to fit the worker.

Ergonomics enters into the design of everything from equipment for space missions to the most comfortable car interior or athletic shoes. The idea behind it is simple. If you use a tool to do something it wasn't designed to do, then the tool can be damaged. In the same way, if you perform tasks beyond your physical capabilities, then you can get "damaged," too.

Many work-related injuries develop gradually over time. Called *cumulative trauma disorders* (CTDs), or repetitive motion disorders, they can be caused by repeated, constant, or excessive stress on muscles, tendons, ligaments, bones, and nerves. If your job requires you to continually bend, lift, or stretch, you could end up with a back sprain. If you need to constantly bend, twist, or make repetitive motions with your hands and wrists, such as typing on a keyboard, you might acquire *carpal tunnel syndrome.*

To prevent injuries, ergonomists first determine the needs and capabilities of the people who will use a work site or product. (These are called the *human factors.)* To do this, they conduct many tests to find out the typical body size and common physical tendencies of the workers, such as muscle movement and vision. They use instruments like *anthropometers* and *sliding calipers* to measure the human body, as well as workplace surveys to collect data. They also have volunteers test products and they conduct workplace simulations to watch how people do their jobs.

Based on this research, ergonomists design work areas, products, and equipment to fit the needs of workers. Because of them, people can work more safely, comfortably, and efficiently.

Connections

1. What information would ergonomists need to design a car interior?
2. If you were an ergonomist for the aerospace industry, what problems would you need to solve? Think of space suits, the interiors of spacecraft, and space stations.

Key Words

anthropometer instrument used to measure body dimensions
carpal tunnel narrow channel formed by bones, ligaments, and connective tissue at the wrist through which nerves, tendons, and blood vessels pass
carpal tunnel syndrome injury that usually comes from repetitive actions with hands and wrists
cumulative trauma disorder a group of medical disorders caused by repeated stress on muscles, tendons, ligaments, and nerves
ergonomics the science of designing the job, product, and place to fit the worker
human factors the needs and capabilities of human beings which are considered in the design of products and places
sliding caliper instrument used to measure a distance

Resources

Gay, K. (1986) *Ergonomics: Making products and places fit people.* New York: Enslow Publishers.

Inkeles, G. & Schencke, I. (1994) *Ergonomic living: How to create a user-friendly home & office.* New York: Simon and Schuster.

MacLeod, D. (1995) *The ergonomics edge: Improving safety, quality, and productivity.* New York: Van Nostrand Reinhold.

Pater, R. & Button, R. (1992, Nov) Organizing for strategic ergonomics. *Occupational Hazards,* p. 55.

Sanders, M.S. & McCormick, E.J. (1993) *Human factors in engineering & design.* New York: McGraw-Hill.

Additional resource
NEWTON'S APPLE Show 1107 (carpal tunnel syndrome). GPN: (800) 228-4630. Or call your local PBS station to find out when it will be rerun.

Additional sources of information
National Institute for Occupational Safety and Health
290 Independence Ave. SW
HHH Building, Room 714B
Washington, DC 20201

The National Safety Council
444 N. Michigan Ave.
Chicago, IL 60611

U.S. Department of Labor
OSHA Publication Office
200 Constitution Ave.
Room N-3101
Washington, DC 20210
(Request publication OSHA 3123: *Ergonomics—The study of work.)*

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3M Innovation

Be Ergo Gurus

Create a comfortable environment for three-headed, scaly, thirsty Zorbagians.

NEWTON'S APPLE®

SHOW NUMBER

1312

Ergonomics

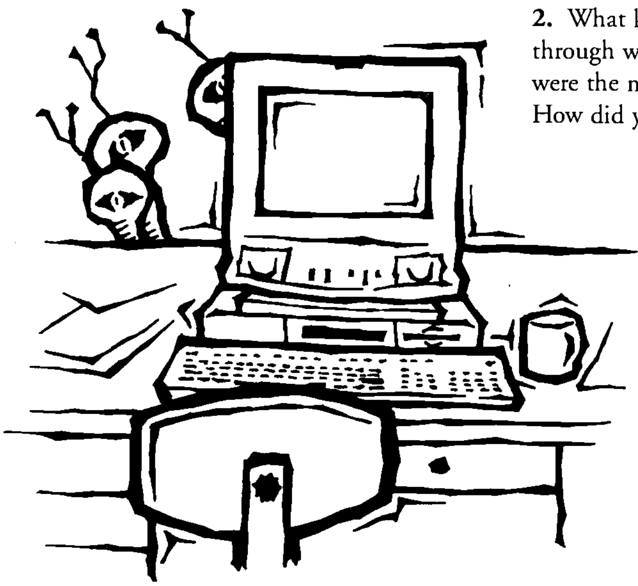
Main Activity

Congratulations! You're a famous ergonomics expert, so famous that your reputation has reached the Galaxy Zorbag where a group of friendly, superintelligent space aliens live. They've always planned to visit Earth one day, but they've worried about how they would adapt to an environment like ours.

Hearing about your skill and creativity in designing tasks, tools, and settings for human beings, they've just communicated with you telepathically and told you they'll be coming soon for a yearlong stay. They'll need a place to live and work during their visit. They know how to access our "primitive" computers, so they'll need comfortable workstations as well. Since they'd like to do some sightseeing, they'll also need transportation.

The problem is, like most space aliens, the Zorbagians have some peculiarities:

- They have three heads, with one eye stalk in the middle of each and one antenna on top of each stalk.
- They have three tentacles with four fingerlike digits and retractable claws.
- They have three legs.
- They have short, scaly tails.
- They're allergic to the sun and the color red.
- They require a constant, ongoing supply of water.



Your mission is to come up with ideas to help them adapt to this environment. You want them to be comfortable and productive as they live and work here. You need to protect them from any problems they may encounter, and still make them feel at home. Since this is such an important intergalactic visit, you have unlimited access to manufacturing plants and production facilities. All you have to do is come up with the design ideas. So go to it! The Zorbagians are coming soon!

- Work in teams of four.
- Focus on one problem or one setting at a time. Group major and minor problems.
- List any additional Zorbagian information you would like to have before you begin your design work.
- Try to imagine yourself as a Zorbagian in each setting. Have you overlooked any possible problems?
- Draw sketches of the Zorbagians and the settings and products you've designed for them.
- Share your design ideas with the other teams in your class.

Questions

1. Did any teams come up with similar ideas? Work as a class to select what you think are the most workable design ideas.

2. What kind of process did your team go through when working on this project? What were the main problems you encountered? How did you solve them?

Try This

Ergonomics is a relatively new science, although its basic principles are as old as the first humans who adapted a tool for their environment. Go to the library and research when and why ergonomics was first used in industry. (Here's a hint: World War II and aircraft.)

Try This

Think of six careers that might have high rate of injuries due to cumulative trauma disorders. Interview some people with these jobs to see if your guesses are correct. What do these people do to avoid injuries?

Try This

Find a photo of an old product, such as a tool, piece of furniture, vehicle, or appliance. Compare it to a similar product of today. What changes were made to this product over time? Why were these changes made?

Try This

Interview parents, grandparents, or other older adults to learn about typical work sites, equipment, products, or work procedures when they were young. Discuss the ergonomic improvements that have been made since then.

What do you really need to live? If you got lost in a jungle, how would you survive?

SHOW NUMBER

1313

Peggy finds out what she really needs to survive in the jungle.

Segement length: 6:00

Jungle Survival

How do people survive in the jungle without food or water?

Insights

Words like "jungle" and "survival" mean one thing in cities and towns, but they mean something entirely different in the humid forests of Belize. Show up for a trip into the jungle along *la ruta Maya* with "essentials" such as chocolate bars, soda, and a CD player, and your Maya guide would make you leave it all behind. The guide knows that to survive, you need only four things—water, food, shelter, and fire. Each can be found in the jungle, but you must know what to look for and how to use it.

First, a few safety tips. Never run from a jaguar—walk toward it, shouting and clapping. Always run away from dangerous snakes like the wowla (boa constrictor) and the poisonous coral snake and *fer-de-lance.* Stay away from most insects—many have special defense systems, like the machacha, which emits a foul spray, and the acacia ant, whose alarm *pheromone* can be smelled two meters away. Learn from the natives, who rub garlic on themselves to ward off bugs and snakes.

Need water? Springs, rivers, and lakes are obvious sources. But don't forget the water vine, which grows throughout rain forests. It holds several gallons of *potable* water—just cut off a meter or so and swallow the liquid as it pours out. You can use large leaves on tropical plants to collect rainwater or dew. Or you can collect water with a solar *still.*

The rain forests are full of biologically active *compounds,* many of which you can use for food or medicine. You can eat edible tubers, such as potato, yuca, and boniato, but be sure you can distinguish edible tubers from poisonous ones. For cooking and for warmth, you'll want to gather firewood, leaves, and grass (all as dry as possible).

Local weather and predators determine your shelter needs. Do you need warmth or just a roof? Are there animals or insects to avoid? The Maya use *cohune palm* fronds to build *thatched* roofs on their huts. These roofs withstand rain and wind and last up to 15 years.

The sun and stars are reliable navigational tools. You might want to brush up on your stargazing skills to figure out where you are.

Survival requires that you use all your senses to know what resources—and dangers—are around you. When you think about it, maybe jungle survival is not so different from survival in your corner of the world.

Connections

1. Think about all the things you own. Which are vital to your existence? Which could you live without, and for how long?

2. What images does the phrase "living in the tropical rain forest" conjure up? What about "jungle survival"? What makes them different?

Key Words

cohune palm palm tree found in rain forests. It provides food, fiber, medicine, and shelter.
compound substance composed of two or more chemical elements
fer-de-lance poisonous snake, also known as the terciopelo ("velvet") or yellow-jawed tommy goff
la ruta Maya Spanish for the Maya route in the regions of Mexico, Belize, Guatemala, and Honduras
pheromones chemicals secreted by animals to convey a message and produce a response in members of the same species
potable fit to drink
still system used to distill liquids
thatch material such as palm fronds, straw, and rushes used to create a roof

Resources

Arvigo, R. (1995) *Sastun: My apprenticeship with a Maya healer.* New York: Harper Collins.

Brill, S. (1994) *Identifying and harvesting edible and medicinal plants in wild (and not so wild) places.* New York: William Morrow.

Dessery B. & Robin, M. (1992) *The medical guide for third world travelers.* San Diego: K-W Publications.

Landsman, S. (1993) *Survival! In the jungle.* New York: Avon Books.

McManners, H. (1994) *The complete wilderness training book.* New York: Dorling Kindersley.

Nichol, J. (1994) *The mighty rainforest.* London: David and Charles.

Pragoff, F. (1989) *Survival: Could you be a squirrel?* Nashville: Ideals Children's Books.

Sierra Club, San Diego chapter. (1993) *Wilderness basics: The complete handbook for hikers and backpackers* (2d ed.). Seattle: The Mountaineers.

Additional resources

Earthwatch Program Officer for Rain Forest Projects: drobbins@earthwatch.org

Federal Emergency Management Agency: (800) 480-2520. (Free catalog of emergency preparedness guides, including *Emergency Preparedness Checklist,* #80963, and *Disaster Preparedness Coloring Book,* #81123.)

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3M Innovation

Be Prepared!

Create an all-purpose survival kit to keep in your family car or at home.

NEWTON'S APPLE

SHOW NUMBER **1313** *Jungle Survival*

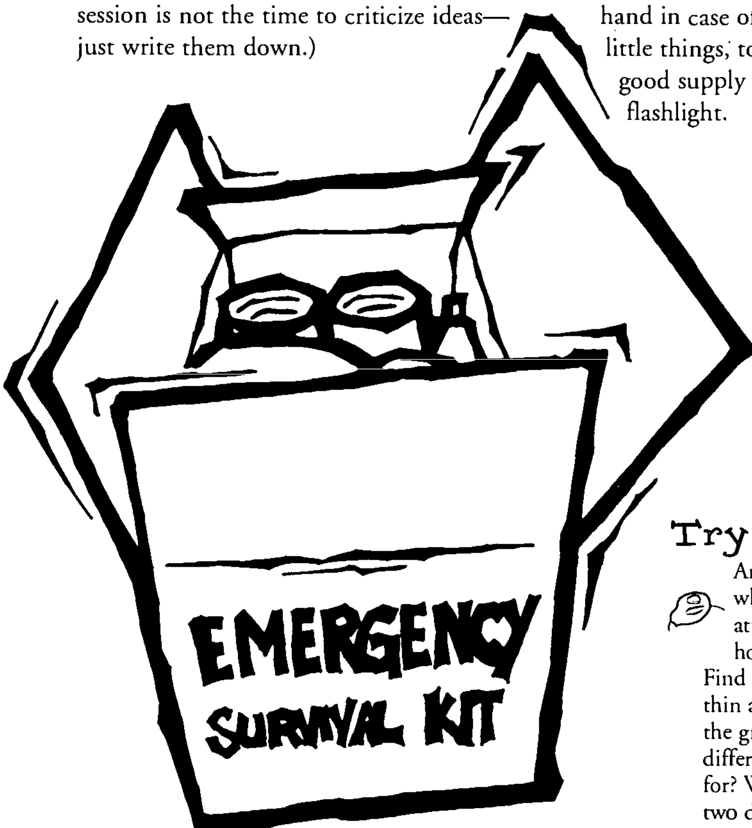
Main Activity

What situations might leave you and your family temporarily stranded without electricity, food, and shelter? How would you survive if you were stranded outdoors? In this activity, you'll decide what you'd need in a survival kit to help you stay safe and healthy.

Materials

- waterproof container (backpack or plastic box)
- chart paper
- markers
- scale

1. Make a chart with columns for water, food, shelter, fire, and other needs.
2. Break up into small groups. Choose a season of the year. Then brainstorm with your group to list whatever each person thinks you might need in each column to survive for at least a week in the outdoors during that season. (Remember that a brainstorming session is not the time to criticize ideas— just write them down.)
3. For each item in your list, assign a number to indicate its priority. For example, "1" could mean that the item is essential on a scale of 1 to 5, with a "5" meaning that the item is probably not important. Allow time for discussion.
4. Decide on the volume and weight of the survival kit. Estimate the weight of each item that you want to include in your kit, and decide whether you can include it. Would several people have to share carrying the weight?
5. Make a list of items to include in the kit.
6. If possible, gather or purchase the materials you selected, and make a sample survival kit. Weigh the kit and make a note of how much space the kit will take up. Where will you store it?
7. If you live where severe weather (hurricanes, snowstorms, flooding) could cut you off from electricity, water, and food, put together a list of basic supplies to keep on hand in case of emergency. Think about the little things, too, such as a can opener and a good supply of batteries for your radio and flashlight.



Try This

Any sailor, backpacker, or person who spends time outdoors will attest to the importance of knowing how to tie different kinds of knots. Find a book on knots. Get a meter of thin and thick rope for each person in the group. Practice making at least five different knots. What is each one used for? Which one should you use to tie two different kinds of rope together? Which is easiest to pull apart? Which would you use to build a rope bridge?

Try This

Collect water by building a simple solar still. Dig a hole about 1/2 meter (20") deep and 1 meter (40") wide. Place a clean cup at the bottom of the hole. Sprinkle grass clippings or leaves on the side of the hole. Cover the hole with plastic wrap (you may have to tape several lengths together to cover the hole completely). Use rocks or sticks to hold the plastic wrap in place. Place a marble-sized stone on top of the plastic. It should be heavy enough to create a point where the condensation can collect and drip into the cup. Now let the sun do its work. How long does it take to form condensation on the plastic? Where is the water coming from? How long does it take to get 2 cm (3/4") of water?

Try This

Humans develop survival skills for different environments. List the skills needed by the following: a baby, a soldier, a person in a wheelchair, a person who is blind, a person who can't read, a prisoner of war, a person who is homeless, a person living near the Arctic Circle, members of a tribe living in the Amazon jungle, a member of that tribe forced to move to the city, a person forced to move to a new country. Choose one of these people and write a story about survival from that person's perspective. Read the story to your class.

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3M Innovation

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Can you name one thing that the liver does? What are the parts of the liver? Does its size have anything to do with its productivity?

SHOW NUMBER

1313

David delves deep into the life of a liver.

Segment length: 11:00

Liver

Why do you need a liver?

Insights

How big is an average chemical factory? How big is a chemical factory that not only produces new chemicals, but also recycles old ones and turns them into more new chemicals? What if this factory also regulates other factories down the road and stores spare parts?

We're obviously talking about a very big and quite complex factory. Yet the tiny hepatic cell of the liver handles all these tasks and more, occupying a space so small that several hundred cells could fit on the head of a pin!

Located on your right side under the lower rib cage, the liver is actually the biggest *gland* in your body. It weighs about 1,600 grams (3.5 pounds) and contains millions of cells. Every single cell is its own complete factory, performing every job that needs to be done.

Here is a partial list of what one of these amazing cells can do:

- Make *bile* and send it down the bile *duct*. Bile is important for dissolving fats in the digestive tract.
- Collect *nutrients* from the *portal vein.*
- Synthesize important proteins for the blood, such as albumin, which is essential to the blood-clotting process.
- Convert extra *glucose,* the body's primary source of stored energy, into *glycogen.*
- Clean *toxins* from the blood.

Because of all this activity, the liver needs to be well-connected to the rest of the body. Two highways go into the liver: The portal *vein,* which carries nutrient-laden blood from the stomach and intestines, and the hepatic *artery,* which carries oxygen-rich blood from the heart and lungs. Two different kinds of highways lead out from the liver: The hepatic veins, which drain the blood from the liver, and the bile ducts, which take bile from the liver cells to the *gall bladder.* Every single cell is in close contact with all four of these highways. To get to each cell, each highway must divide into smaller and smaller branches.

The liver is truly a marvelous example of natural engineering. Next time you hear someone talk about recycling or chemical manufacturing, think about the recycling and manufacturing plant in your own body—the liver.

Connections

1. Alcohol abuse can cause serious damage to the liver. Illicit drugs in the bloodstream can create other liver problems. Why might the liver be especially sensitive to the presence of drugs in the bloodstream?

2. Do you see any advantage in the liver's location? Could you find a better location?

Key Words

artery vessel that carries blood from the heart to the body tissues

bile yellowish substance released by the gall bladder into the small intestine to aid in the digestion or breakdown of fats

duct small tube or conduit in the body that carries body fluids from one place to another

gall bladder organ that stores bile until it is needed in the small intestine to aid in digestion

gland organ comprised of similar cells that synthesizes or produces certain substances the body needs

glucose simple sugar that the body uses as an energy source

glycogen complex compound made from glucose for the purposes of energy storage

nutrient any chemical that provides energy or building blocks for the body

portal vein special vein that carries nutrients, absorbed by the gut, to the liver

toxins substances that can harm or destroy body cells and tissues

vein blood vessel that carries blood from body tissues back to the heart

Resources

Caselli, G. (1987) *The human body and how it works.* New York: Grosset and Dunlop.

Dorling Kindersley staff. (1991) *The visual dictionary of the human body.* New York: Dorling Kindersley.

Gamlin, L. (1988) *The human body.* New York: Gloucester Press.

Gibbs, W. (1993, Dec) Deliverance: Medicine closes in on an artificial liver device. *Scientific American,* pp. 30–33.

Parker, S. (1993) *The body atlas.* New York: Dorling Kindersley.

Sherlock, S. (1991) *A color atlas of liver disease* (2d ed.). St. Louis: Mosby Year Book.

Stein, S. (1992) *The body book.* New York: Workman Publishing.

Additional sources of information

Foundation for Advanced Education in the Sciences
National Institutes of Health
9000 Rockville Pike
Bethesda, MD 20892
(301) 496-7976

American Medical Association
535 N. Dearborn St.
Chicago, IL 60610

U.S. Public Health Service
5600 Fishers Lane
Rockville, MD 20857

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Breaking Up Is Easy to Do

Mix detergent, oil, and water to show how bile breaks down fat.

NEWTON'S APPLE®

SHOW NUMBER

1313

Liver

Main Activity

The gut uses bile to physically break down fatty substances into smaller pieces. In this way, enzymes can more easily turn the fat chemically into fatty acids, which the small intestine can absorb for body needs. Simple dish detergents act on oils in a manner similar to the way that bile acts on fat. In the following activity, you will get a chance to see this process in action.

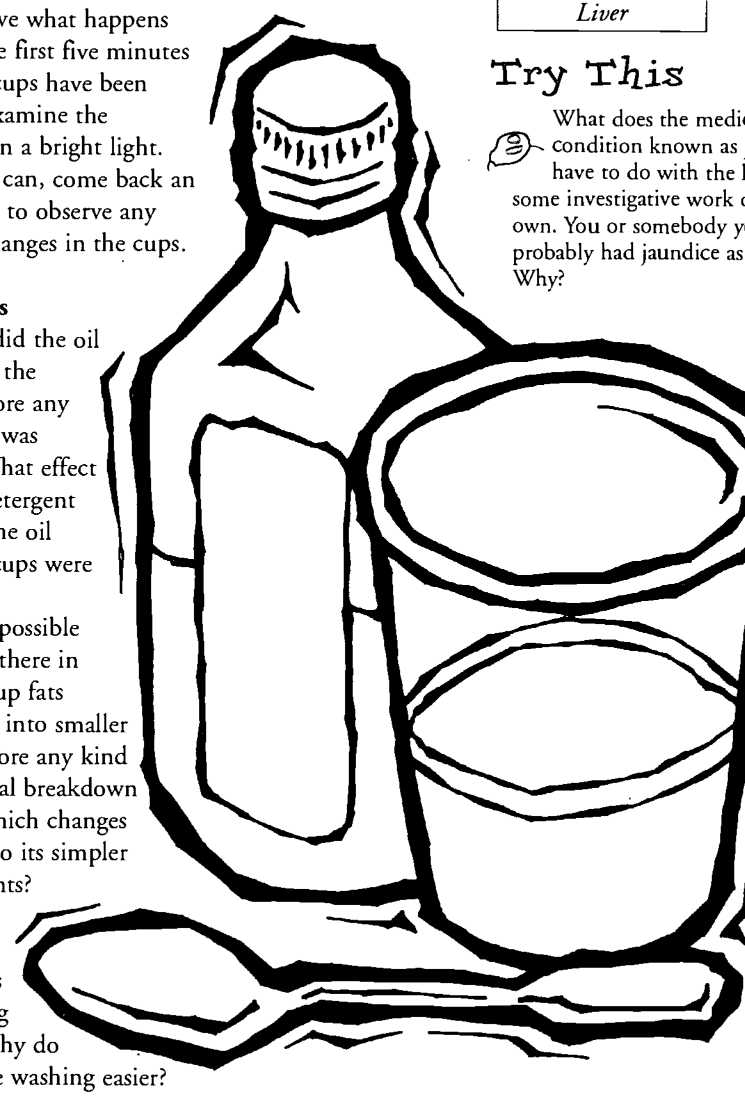
Materials

- 2 see-through glass or plastic cups, 240 ml (8 oz) in size
- dish detergent (for hand dish-washing)
- small amount of vegetable oil
- water
- 2 stirring rods or spoons

1. Pour about 120 ml (4 oz) of water into each cup.
2. Slowly and gently pour a small amount of vegetable oil into each cup. Pour enough so that there is a layer of about one or two centimeters of oil on top of the water. The exact amount is not crucial, but try to pour so that both cups contain about the same amount.
3. Take some time out to examine the way that the oil reacts with the water. Does the oil stay together as you pour it in? What happens to the oil if you wait two or three minutes?
4. After the oil has collected itself together (approximately five minutes), add a small amount (about seven drops) of the detergent to one of the cups.
5. Gently but quickly stir both of the cups with the stirring rods or spoons. Be careful to keep each stirring device in its own cup. Stir for about 15 seconds.
6. Observe what happens during the first five minutes after the cups have been stirred. Examine the contents in a bright light.
7. If you can, come back an hour later to observe any further changes in the cups.

Questions

1. How did the oil behave in the water before any detergent was added? What effect did the detergent have on the oil after the cups were stirred?
2. What possible benefit is there in breaking up fats physically into smaller pieces before any kind of chemical breakdown occurs, which changes the fat into its simpler components?
3. What use are detergents in washing dishes? Why do they make washing easier?



Try This

What does the medical condition known as jaundice have to do with the liver? Do some investigative work on your own. You or somebody you know probably had jaundice as a baby. Why?

Try This

The liver converts, produces, stores, excretes, and recycles many different substances. Try writing a job description for a liver cell. Be as complete as you can. Use an encyclopedia for more detailed information if you need it.

Try This

How does alcohol affect the liver? Is any amount of alcohol harmful? What is the treatment for cirrhosis of the liver? Call up a nurse or doctor and find out the health scoop on liver and alcohol.

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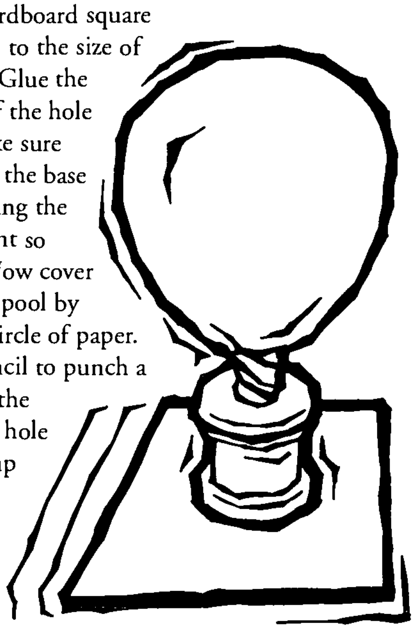
Science Try Its™

SuChin Pak, Peggy Knapp, Brian Hackney, David Heil, and Dave Huddleston invite you to try NEWTON'S APPLE experiments at home!

TRY IT! Build a Hovercraft

Make a hovercraft using cardboard, an empty thread spool, paper, scissors, a pencil, glue, and a balloon. First, cut out a 10-cm (4") square from the cardboard. Next, ask an adult to punch a hole in the cardboard. The hole has to be in the center of the cardboard square and it should be equal to the size of the hole in the spool. Glue the empty spool on top of the hole in the cardboard. Make sure the holes line up. Seal the base of the thread spool using the glue. (This is important so that no air escapes.) Now cover the top of the thread spool by cutting and gluing a circle of paper. Let this dry. Use a pencil to punch a hole in the middle of the paper cover where the hole of the spool is. Blow up the balloon and twist the end. Stretch the mouth of the balloon over the top of the spool. Let the balloon go and give your hovercraft a push. What happens?



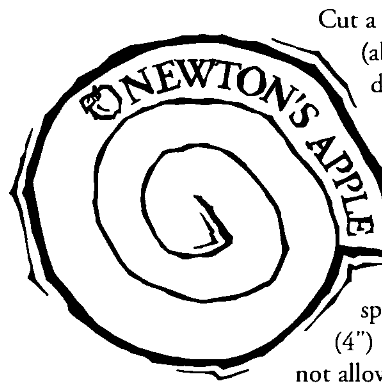
TRY IT! Hey, Marshmallow Face!

Draw a face on the end of a marshmallow. Place the marshmallow in a glass bottle (the bottle's mouth should be slightly larger than the marshmallow). Wrap clay around a straw about 2.5 cm (1") from one end. Place the short end of the straw in the bottle. Seal the bottle with clay. Stand in front of a mirror so you can see the face on the marshmallow. Suck air out of the bottle. (Make sure there are no leaks!) What happens to the marshmallow? Now stop sucking on the straw. What happens to the marshmallow?

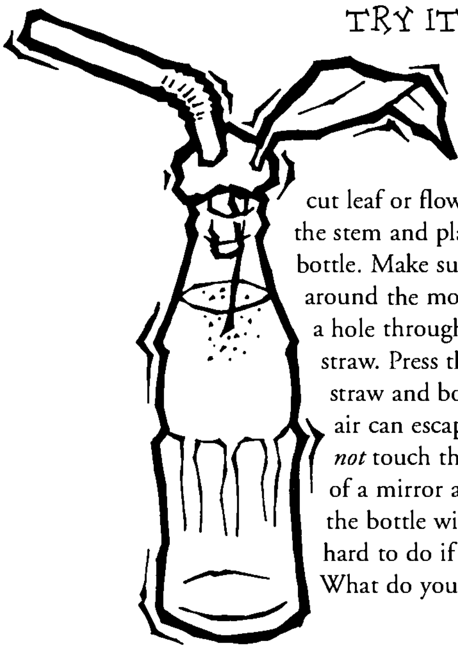
TRY IT! Steel Heat

Place a thermometer in a jar and close the lid. Wait five minutes and record the temperature. Remove the thermometer from the bottle. Soak half of a steel wool pad in vinegar for one minute. Squeeze excess vinegar out of the steel wool pad and wrap it around the bulb of the thermometer. Place the thermometer and the steel wool into the jar and close the lid. Wait five minutes. Record the temperature. What happened to the temperature?

TRY IT! It's Your Turn

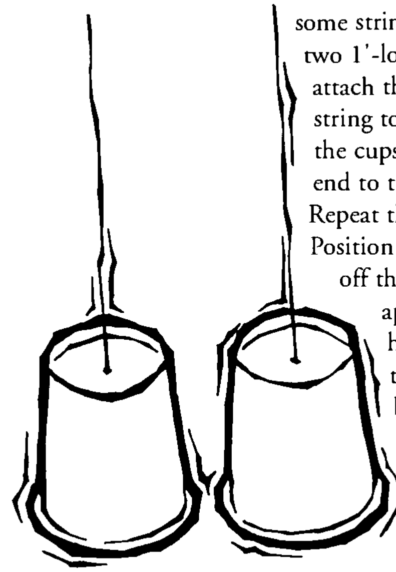


Cut a piece of tissue paper into a 6-cm (about 2") diameter spiral (use the diagram). Cut a piece of thread 15 cm (6") long and tape one end of the piece of thread to the center of the paper spiral. Position a desk lamp so that the light points upward. Ask an adult to hold the paper spiral by the thread about 10 cm (4") above the light. (Caution: Do not allow the paper to touch the light bulb.) What happens?



TRY IT! The Inner Life of a Leaf

Fill a bottle with water to within an inch of the top. Take a freshly cut leaf or flower, wrap clay around the stem and place the stem into the bottle. Make sure the clay fits snugly around the mouth of the bottle. Poke a hole through the clay, and insert a straw. Press the clay around the straw and bottle opening so that no air can escape. The straw should *not* touch the water. Stand in front of a mirror and suck the air out of the bottle with the straw. (This is hard to do if there are any leaks.) What do you observe in the mirror?



TRY IT! Move the Cups

Find two disposable cups and some string. Cut the string into two 1'-long pieces. Using tape, attach the end of one piece of string to the bottom of one of the cups, and attach the other end to the edge of a table. Repeat this with the other cup. Position the cups so they hang off the table two inches apart and at the same height. You might need to adjust the spacing between the cups. Blow between the two cups. What happens?

The science behind Science Try-Its

Why are the cups drawn together?

Bernoulli's principle states that in areas where air moves rapidly, pressure is low. Blowing between the cups drops the pressure so the higher air pressure of the surrounding air pushes the cups together.

How did you create a hovercraft?

The air flowing from the balloon through the holes forms a layer of air between the hovercraft and the table. This reduces the friction. With less friction, your hovercraft scoots across the table.

Why did the marshmallow expand?

The marshmallow is a spongy solid with air trapped inside the spaces. Sucking air out of the bottle decreases the pressure inside the bottle, which causes the spongy solid—the marshmallow—to expand. Removing the straw from your mouth allows air to rush back into the bottle, increasing the pressure and causing the marshmallow to return to its original size.

Why does the paper spiral twirl?

The energy from the light heats the air above it. Warm air is lighter than cool air, so as the air heats up, it rises above the lamp. Cool air moves in to replace the warmer, lighter air. This "convection current" causes the spiral to twirl.

Why does air appear at the end of the stem?

There are holes in the leaf called *stomata* and tiny tubes called *xylem* which run down the stem. The leaf and stem act as a straw for the plant. As you drew air out of the plant, more air was drawn into the bottle through the stomata and xylem. This is the same system that water moves in a plant.

Why did the temperature rise?

The vinegar removes any protective coating from the steel wool, allowing the iron in the steel to rust. Rusting is a slow combination of iron with oxygen. When this happens, heat energy is released. The heat released by the rusting of the iron causes the mercury in the thermometer to expand and rise.

This Science Try Its page was excerpted from the 13th season NEWTON'S APPLE Educational Materials packet. To receive the complete packet, write to:

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St. Paul, MN 55101
newtons.apple@umn.edu

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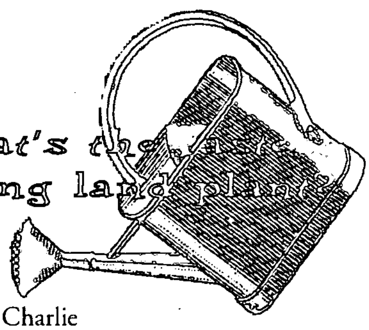
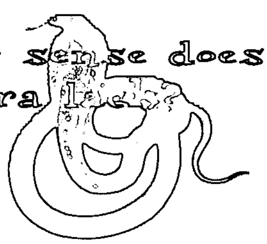
How Street Smart are you?



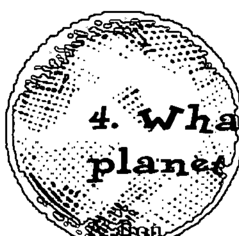
1. What's the [illegible] growing land plant?

A. Bamboo
B. Zucchini
C. Creeping Charlie
D. Redwood trees



2. What sense does the cobra [illegible]

A. Smell
B. Hearing
C. Touch
D. Common

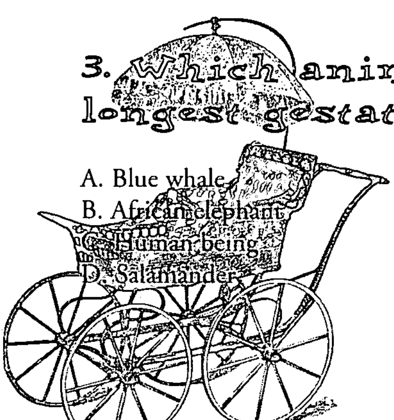


4. What makes the planet Mars red?

A. Iron
B. Sunburn
C. Rubies
D. Volcanic activity

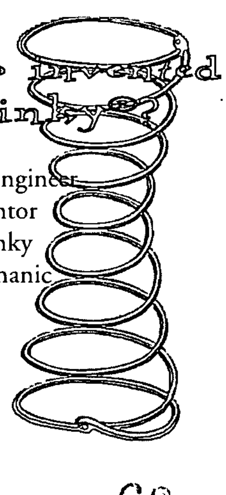
5. How [illegible] buds do [illegible]

A. 4
B. 458
C. 9,000
D. 2 million



3. Which animal has the longest gestation period?

A. Blue whale
B. African elephant
C. Human being
D. Salamander



6. Who invented the Slinky?

A. A marine engineer
B. A toy inventor
C. Ogden Slinky
D. A car mechanic

STREET SMART™

3M Innovation

NEWTON'S APPLE®

Answers

1. Which plant is on the fast track?

Bamboo has been known to grow as much as 1 meter (3') in 24 hours. Conditions for optimal (and rapid) growth include plenty of sunshine and lots of water in the soil. Consequently, most bamboo plants are found in tropical and subtropical regions of the world. Just what's going on inside that causes it to grow so fast? The growth is produced partly by cell division and partly by cell enlargement. Now that you know how fast bamboo grows, does that give new meaning to the word "bamboozled"?

2. What makes sense?

Cobras lack the sense of hearing. They don't have any eardrums. No eardrums, no ability to hear—they're deaf. Then why do they sway to the flute music played by those snake charmers? The snake is following the *motion* of the flute. Snake charmers keep the snake inside a dark basket. When the lid is lifted, the surprised snake must adjust to the sudden light. It assumes its distinctive hood-spread, defensive pose and follows the first thing it sees: the flute. And you thought that poor snake had to listen to the same song over and over again.

3. Gestating with the answer?

The Alpine black salamander has the longest gestation period—a whole 38 months. As its name implies, it can be found in the Swiss Alps. While these salamanders can live at different elevations, the higher the elevation, the longer the gestation period. When you get up to 1,402 meters (4,600'), the gestation period can last up to 38 months. The salamander bears two young at a time. A "pregnant pause" in the salamander world can mean a long, long wait.

4. The hills are alive with what?

There's iron in them thar' hills. Sixteen percent of the soil on Mars consists of iron compounds. In the distant past, oxygen existed in the atmosphere of Mars. The oxygen combined with the iron and created iron oxides, which have a characteristic red color. And you thought was because it had a permanent sunburn.

5. Did you pass the taste test?

You have 9,000 taste buds. However, contrary to what you might think, not all 9,000 are on your tongue. Some taste buds are located in other areas of your mouth. For example, lips (usually very salt-sensitive), inner cheeks, the underside of the tongue, the back of the throat, and the roof of the mouth are some of the areas of your mouth that are "flavor-sensitive." And just in case you're worried about losing your taste buds, here's some good news: They replace themselves about every 10 days. So that spicy enchilada you had the other day probably didn't do too much irreparable damage.

6. Slinking around?

Marine engineer Richard James accidentally "invented" the Slinky in the 1940s. He was trying to develop a spring that could keep sensitive nautical instruments balanced even as a ship pitched and yawed. One day, James knocked a set of experimental springs off a shelf. They "crawled" down rather than just falling. A few quick experiments revealed the springs were quite good at descending stairs. But it was his wife, Betty James, who saw the potential as a toy. She spent several days looking through a dictionary to come up with the perfect name for this irresistible toy. Betty James still runs the company she founded with her husband in 1946.

STREET SMART™

This Street Smart page was excerpted from the 13th season NEWTON'S APPLE Educational Materials packet. To receive the complete packet, write to:

Director of Outreach
NEWTON'S APPLE
... 'th Street
... IN 55101
...wtons.apple@umn.edu

A Guide to Enjoying NEWTON'S APPLE at Home

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.

We've developed a fun, new way for you to be part of the science discoveries on NEWTON'S APPLE! Check out *America's Most Scientific Home Videos* described in this flyer. Get together with friends and neighbors, children and adults, and send in an entry. This is a great opportunity for all of us to learn together!

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

NEWTON'S APPLE
PO Box 1300
172 East 4th Street
St. Paul, MN 55101

We may answer your question on the show!

NEWTON'S APPLE®

NEWTON'S APPLE 13th Season

This special guide to our 13th 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.

Show 1301
Waterskiing
Reflexes
Escalators
Fat-free Foods

Show 1302
Circus High Wire
Mummies
Bug Spray
Armadillos

Show 1303
Maya Bike Trek
Hearing
Parachutes
Owls

Show 1304
Africa Special
Balloon Safari
Grasslands
Maasai Mara
Animals

Show 1305
Ice Surfing
DNA Fingerprinting
Bubble Gum
Cold Remedies

Show 1306
Aircraft Fire Rescue
Balloons
Knives
Science Home Videos

Show 1307
Disney World Special
Simulator Rides
Dolphin Communication
Parade Technology
Laser Show

Show 1308
Hazardous Materials
In-line Skating
Skin Wrinkling
Compost

Show 1309
Human Slingshot Ride
Bone Marrow
King's Singers
Rotting Foods

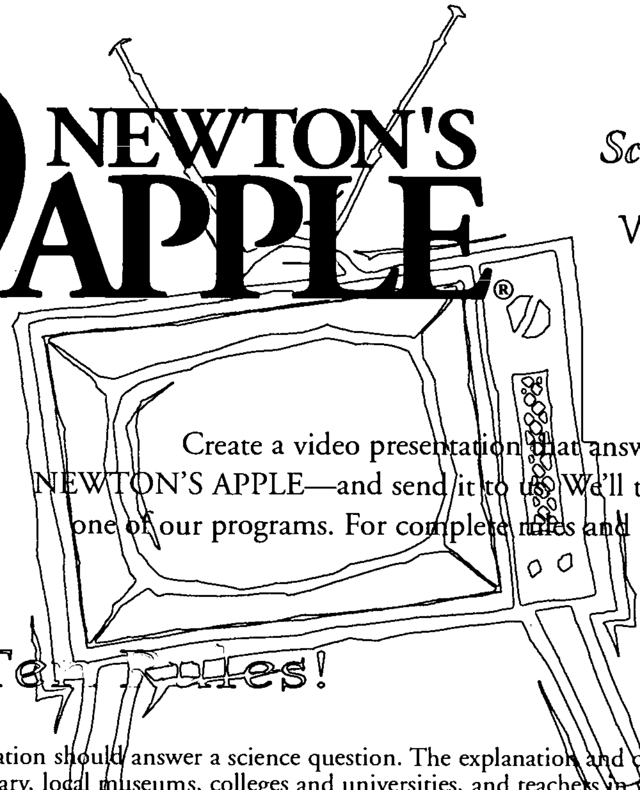
Show 1310
Wild Lion Vets
Bicycles
Fish Breathing
Insect Warfare

Show 1311
Equator Special
Equator
Maasai Village
Coffee
Baby Elephants

Show 1312
Bird Songs
Ergonomics
Inventor's Fair
Scorpions

Show 1313
Jungle Survival
Liver
Emus

NEWTON'S APPLE®



We're looking for *America's Most Scientific Home Videos*

Watch Show 1306 for more information about this contest!

Create a video presentation that answers a science question—like we do on NEWTON'S APPLE—and send it to us. We'll take the best ones and include them in one of our programs. For complete rules and prizes write to us at the address below.

Top Ten Rules!

10 Your presentation should answer a science question. The explanation and demonstration must be scientifically correct. Use your library, local museums, colleges and universities, and teachers in your school as information resources.

9 Originality and creativity count! Watch some episodes of NEWTON'S APPLE for examples.
Hints: A lecture to the camera is boring; a demonstration is better. Focus on activities that demonstrate one or two scientific principles. Camera shots should have good lighting, proper exposure, and be in focus. The sound track should be free of background noise, extra voices, and static.

8 Use the highest quality equipment and tape you can find. Contact your school's media resource center or your community cable TV channel and try to borrow their equipment—and their expertise!

7 **Don't do anything that could harm yourself, others, or any property. Make sure your activities are supervised by an adult.** Everyone who appears in the videotape *must* sign a release form, available by calling the NEWTON'S APPLE Hotline at (612) 229-1318, or by contacting us via e-mail at newtons.apple@umn.edu or at the address listed in rule #3.

6 Everything in your video must be original. You CANNOT use any photographs, drawings, slides, films, music, etc.; that are covered by a copyright.

5 Your tape can be any length and can be edited or unedited. (We recommend short and sweet—under 10 minutes.) We reserve the right to edit your videotape to fit into the show.

4 Submit your tape on any of the following formats: VHS, S-VHS, Hi-8, 8mm, 3/4" U-matic, or Betacam. Label your tape clearly with your name (or teacher's name, if you're submitting as a class), home or school address, **and a phone number**.

3 Send us your master tape and keep a copy for yourself. Tapes will not be returned. Include a list of who worked on your tape (camera, sound, scriptwriter, host, etc.). Send your tape to: *America's Most Scientific Home Videos* Contest, NEWTON'S APPLE, 172 East 4th Street, St. Paul, MN 55101.

2 **We must receive your tape by May 1, 1996.**

1 Wait to hear these words: You're going to be on NEWTON'S APPLE!

Twin Cities Public Television or any of its employees are not responsible for any injuries or damages caused by your participation in this event. Your participation represents your agreement to this waiver of liability.

Make two-sided copies of this page to share with parents, classmates, and friends.

NEWTON'S APPLE is a production of KTCA Twin Cities Public Television. Made possible by a grant from 3M.

3M Innovation

3M Science Encouragement Programs (K-12)

At 3M, we believe it is important to create enthusiasm for science in students of all ages. That's the philosophy behind our Science Encouragement Programs. This series of educational opportunities for aspiring scientists began in 1953 at a 3M Technical Forum-sponsored exhibit at a Minnesota high school science fair. Since then, we've added many other outreach programs, including NEWTON'S APPLE, the award-winning, nationally-televised family science show. Today, because of our innovative Science Encouragement Programs, 3M is recognized as a leader in partnering with academic communities. In fact, other companies have used the 3M model as a benchmark for organizing volunteers and retirees in administering similar programs.

Forty years ago, 3M began focusing resources to enhance education through various outreach efforts. These included scholarships, tutoring programs, mentorships, science fairs, research grants and aid, and teacher development support. In 1994, 3M's cash contributions to educational projects and institutions totaled nearly $8 million, including grants to more than 500 colleges, universities, and technical schools throughout the nation.

We're proud of the impact these programs have had on students and 3M volunteers alike. Former student participants now enjoying careers at 3M have credited these programs with stimulating their interest in science.

Just as important, we are looking forward to many more years of science encouragement. As David Heil of NEWTON'S APPLE said: "When it comes to learning about science, you can't start too early, and you can't get too much."

3M Visiting Wizards
3M Wizard volunteers bring sensational, hands-on science demonstrations to elementary and middle school classrooms. Since 1985, 3M Visiting Wizards have shared the magic and discovery of scientific experiments with nearly a quarter of a million children. The award-winning program is designed to expose children to science at an early age.

Super Science Saturday
3M Wizards host this annual internal program for other Wizards, their families, and local community groups. The day-long event, established in 1987, showcases hands-on science demonstrations that can be performed at home. More than 500 Wizards and their families participate each year.

Elementary Teacher Workshop
Regional elementary school teachers discover the fun of science by attending a hands-on, science resource fair at 3M. An average of 600 teachers participate in the program annually.

TWIST (Teachers Working in Science and Technology)
The TWIST program allows about 25 science and math teachers from selected school districts to spend six weeks during the summer working closely with a 3M host on a research project. It provides the teachers with an active and challenging technical experience in an industrial setting, so they learn more about the practical applications of science, mathematics, and technology.

TECH (Technical Teams Encouraging Career Horizons)
Teams of women and men scientists visit junior and senior high schools to inform students—especially girls and minorities—of career opportunities in science and engineering, and of the need to maximize their career options by studying math and science in school.

STEP (Science Training Encouragement Program)
3M provides St. Paul high school students from diverse backgrounds with the opportunity to explore their interests in scientific careers. Classroom training is provided by 3M technical volunteers, and the students receive full-time summer employment at a 3M laboratory. The STEP program began in 1973 and today focuses on minority and at-risk students, introducing them to "modern day heroes."

Richard G. Drew Creativity Award Program
These awards honor high school juniors in Minnesota and western Wisconsin who have demonstrated "creative flair" and persistence in technical projects. Award winners from over 200 schools are invited to spend a day at 3M Center in St. Paul escorted by a volunteer 3M host. The day includes a careers-in-science panel discussion and an evening program in which parents are invited to discuss science careers with the students and their hosts. Established in 1970, the program honors renowned 3M scientist Richard Drew, his creative spirit, and his encouragement of creativity in others.

Science Student Recognition Day (SSRD)
High school seniors from the Upper Midwest are invited—along with their teachers—to spend a day in a 3M laboratory with a scientist or engineer. About 100 students a year participate in the oldest of 3M's Science Encouragement Programs. SSRD began in 1958.

NEWTON'S APPLE
This Emmy Award-winning family science program has aired since 1982. 3M began full sponsorship of the PBS show in 1991, and 3M volunteers are involved as consultants on the show's programming and related educational materials. 3M Learning Software's new CD-ROM, "What's the Secret?", is the first in a series based on NEWTON'S APPLE programming. This interactive program engages the user in a science adventure and encourages independent discovery.

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

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

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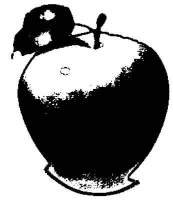

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Look inside for information about the newest season of NEWTON'S APPLE, including the debut of our new team of hosts. NEWTON'S APPLE is introducing new faces and going to new places to bring you and your students more science fun and discoveries!

In addition to this free educator's guide, NEWTON'S APPLE has lots of new science education products that help put kids, parents, and teachers in the driver's seat, including:

What's the Secret? CD-ROMs
NEWTON'S APPLE Multimedia Collection Videodiscs and Software
NEWTON'S APPLE Live! Traveling Theater Show
NEWTON'S APPLE Science Kits for Home and School
NEWTON'S APPLE Educational Materials On-line

For more information about these and other NEWTON'S APPLE educational products, call (612) 222-1717 and ask for NEWTON'S APPLE Outreach, or write us at:

172 East 4th Street
Saint Paul, MN 55101
or contact us via e-mail at newtons.apple@umn.edu

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(over)