National Aeronautics and
Space Administration

Langley Research Center
Hampton, VA 23681-2199

Educational Product	
Educators	Grades 3–5

EG-2004-09-12-LARC

The NASA Sci Files™

The Case of the Great Space Exploration

An Educator Guide with Activities in Mathematics, Science, and Technology

Please Note:
Our name has changed!
The NASA "Why" Files™ is now
the NASA SCIence Files™ and is
also known as the NASA SCI Files™.
http://scifiles.larc.nasa.gov

The Case of the Great Space Exploration educator guide is available in electronic format through NASA Spacelink– one of NASA's electronic resources specifically developed for the educational community. This publication and other educational products may be accessed at the following address: **http://spacelink.nasa.gov/products**
A PDF version of the educator guide for NASA SCI Files™ can be found at the NASA SCI Files™ web site: **http://scifiles.larc.nasa.gov**

www.swe.org

www.sbo.hampton.k12.va.us

www.buschgardens.com

www.nsbri.org

www.cnu.edu

The NASA Science Files™ is produced by the NASA Center for Distance Learning, a component of the Office of Education at NASA's Langley Research Center, Hampton, VA. The NASA Center for Distance Learning is operated under cooperative agreement NCC-1-02039 with Christopher Newport University, Newport News, VA. Use of trade names does not imply endorsement by NASA.

The NASA SCI Files™

The Case of the Great Space Exploration

A Lesson Guide with Activities in Mathematics, Science, and Technology

Segment 1

Segment 2

Segment 3

Segment 4

For additional information about the NASA SCI Files™, contact Shannon Ricles at (757) 864-5044 or **s.s.ricles@larc.nasa.gov**.

Production of the NASA SCI Files™ is made possible by the generous support provided by the Society of Women Engineers (SWE); Busch Gardens, Williamsburg; Hampton City Public Schools; and the NASA Langley Research Center's Aerospace Vehicle Systems Technology Program Office.

Writers and Teacher Advisors: Shannon Ricles, Becky Jaramillo, and Michelle Fargo

Graphic Designer: René Peniza

Editor: Susan Hurd

Registered users of the NASA SCI Files™ may request a Society of Women Engineers (SWE) classroom mentor. For more information or to request a mentor, e-mail kimlien.vu@swe.org or visit the NASA SCI Files™ web site http://scifiles.larc.nasa.gov

The NASA Sci Files™

Program Overview

In *The Case of the Great Space Exploration*, the tree house detectives are excited about the new vision for exploring space. Bianca's dream has always been to become an astronaut. Realizing that astronauts need to be healthy and physically fit, she sets the tree house detectives in motion and develops a rigorous training schedule. RJ is a little worried about such an arduous routine and decides to check out other careers at NASA and to learn more about uncrewed missions. Kali visits Dr. Carol Stoker at NASA Ames Research Center in California to discuss robotic missions and the important role they play in exploration. Dr. Stoker explains that the Phoenix Mars Lander will travel to Mars and land in the Polar Regions to analyze samples of water ice found there. Water is fundamental to all life as we know it, and the lander may even find evidence of past or present life! Finally, the tree house detectives meet Dr. D in the Strange Matter Exhibit at the Virginia Air and Space Museum in Hampton, Virginia to learn about new materials that could help in space exploration.

Meanwhile, Bianca is off to Space Camp in Huntsville, Alabama where she learns how astronauts train to go into space. Catherine heads to Houston to speak with Dr. Grant Schaffner to learn how long-term space flight affects the human body and the role that exercise plays in minimizing the effects. She also talks with Ms. Janis Davis-Street to learn the importance of proper nutrition while in space. To better understand an astronaut's caloric and dietary needs, the tree house detectives dial up students at Maryvale Elementary School in Rockville, Maryland, who are learning about Calories, serving size, and the Food Pyramid with the help of their mentors from the Society of Women Engineers. Last stop in this segment is Dr. D's Lab where the tree house detectives find Dr. D doing just a few experiments with computerized robots.

As Bianca continues to learn about the rigors of astronaut training, the tree house detectives talk to Mr. Mark Weyland at NASA Johnson Space Center in Houston, Texas to learn about the spectrum of light and radiation. Mr. Weyland helps the detectives understand the effects of radiation on the human body during long-term space travel and what NASA is doing to counteract those effects. To learn more about how spacecraft will be able to make the long distances, the detectives talk to Ms. Dana Novak at the University of California at Santa Barbara to learn about nanotechnology.

Ms. Novak explains how bio-inspired research with mussels and bloodworms is being done to learn how to create self-healing materials that will enable spacecraft to fly farther and safer. In between training schedules, Bianca goes to NASA Marshall Space Flight Center to see Mr. Steve Cook and learn about some new innovative ideas for future propulsion systems. On her way back, she runs into Dr. D, who teaches her about gravity, G-Forces, and the feeling of weightlessness on a ride that is out of this world.

Back in the tree house, the detectives are excited to learn about the X-Prize, a $10 million prize for the first privately funded spacecraft that can carry three people to space and back. Mr. Erik Lindberg, grandson of Charles Lindberg, explains the importance of contests throughout history and how contests have helped develop aviation. Excited about being the first tourists in space, the tree house detectives hear from Corrinne, one of the NASA SCI Files™ Kids' Club members, who is in Utah at the Mars Analog Research Station. Dr. Tony Muscatello shows Corrinne the habitat and explains the importance of simulating living and working on Mars. Finally, Dr. D and Bianca meet once again at Space Camp and help the tree house detectives wrap up what they have learned about the exciting future of space exploration. The detectives all hope that they just might be the next generation of explorers who will walk on the surface of Mars!

National Science Standards (Grades K – 4)

STANDARD	SEGMENT 1	2	3	4
Unifying Concepts and Processes				
Systems, order, and organization	●	●	●	●
Evidence, models, and explanations	●	●	●	●
Change, constancy, and measurement	●	●	●	●
Evolution and equilibrium	●			●
Science as Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	●	●	●	●
Understandings about scientific inquiry	●	●	●	●
Physical Science (B)				
Properties of objects and materials	●		●	
Position and motion of objects			●	
Light, heat, electricity, and magnetism			●	
Life Science (C)				
Characteristics of Organisms	●	●		
Organisms and their environments	●	●	●	●
Earth and Space Science (D)				
Properties of earth materials	●			
Objects in the sky			●	
Changes in earth and sky	●			
Science and Technology (Content Standard E)				
Abilities of technological design	●	●	●	●
Understandings about science and technology	●	●	●	●
Abilities to distinguish between natural objects and objects made by humans	●	●	●	●
Science in Personal and Social Perspectives (Content Standard F)				
Personal health	●	●	●	●
Types of resources				●
Changes in environment	●			●
Science and technology in local challenges	●	●	●	●
History and Nature of Science (Content Standard G)				
Science as a human endeavor	●	●	●	●

National Science Standards (Grades 5 – 8)

STANDARD	SEGMENT			
Unifying Concepts and Processes	1	2	3	4
Systems, order, and organization	●	●	●	●
Evidence, models, and explanations	●	●	●	●
Change, constancy, and measurement	●	●	●	●
Evolution and equilibrium	●			
Science as Inquiry (Content Standard A)				
Abilities necessary to do scientific inquiry	●	●	●	●
Understandings about scientific inquiry	●	●	●	●
Physical Science (B)				
Properties and changes of properties in matter	●			
Transfer of energy	●	●	●	
Life Science (C)				
Structure and function in living systems	●			
Regulation and behavior		●		
Earth and Space Science (D)				
Structure of the Earth system	●			●
Earth's history	●			
Earth in the solar system			●	
Science and Technology (Content Standard E)				
Abilities of technological design	●	●	●	●
Understanding about science and technology	●	●	●	●
Science in Personal and Social Perspectives (Content Standard F)				
Personal Health	●	●	●	●
Risks and benefits	●	●	●	●
Science and technology in society	●	●	●	●
History and Nature of Science (Content Standard G)				
Science as a human endeavor	●	●	●	●
Nature of science	●	●	●	●
History of science				●

National Mathematics Standards for Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Number and Operations				
Understand numbers, ways of representing numbers, relationships among numbers, and number systems	●	●	●	●
Understand meanings of operations and how they relate to one another.	●	●	●	●
Compute fluently and make reasonable estimates.	●	●	●	●
Algebra				
Understand patterns, relations, and functions.			●	
Represent and analyze mathematical situations and structures using algebraic symbols.		●		
Use mathematical models to represent and understand quantitative relationships.			●	
Analyze change in various contexts		●	●	
Geometry				
Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships.			●	
Specify location and describe spatial relationships using coordinate geometry and other representational systems.	●			
Apply Transformations and use symmetry to analyze mathematical situations.			●	
Use visualization, spatial reasoning, and geometric modeling to solve problems.			●	
Measurement				
Understand measurable attributes of objects and the units, systems, and processes of measurement	●	●	●	●
Data Analysis and Probability				
Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them	●	●	●	●
Select and use appropriate statistical methods to analyze data	●	●	●	●
Problem Solving				
Build new mathematical knowledge through problem solving	●	●	●	●
Solve problems that arise in mathematics and in other contexts	●	●	●	●

National Mathematics Standards for Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Problem Solving *(continued)*				
Apply and adapt a variety of appropriate strategies to solve problems	●	●	●	●
Monitor and reflect on the process of mathematical problem solving	●	●	●	●
Communication				
Organize and consolidate mathematical thinking through communication	●	●	●	●
Communicate mathematical thinking coherently and clearly to peers, teachers, and others	●	●	●	●
Analyze and evaluate the mathematical thinking and strategies of others	●	●	●	●
Connections				
Recognize and apply mathematics in contexts outside of mathematics other contexts	●	●	●	●

National Educational Technology Standards Performance Indicators for Technology-Literate Students Grades 3-5

STANDARD	SEGMENT 1	2	3	4
Basic Operations and Concepts				
Use keyboards and other common input and output devices efficiently and effectively.	●	●	●	●
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	●	●	●	●
Social, Ethical, and Human Issues				
Discuss common uses of technology in daily life and the advantages and disadvantages those uses provide.	●	●	●	●
Discuss basic issues related to responsible use of technology and information and describe personal consequences of inappropriate use.	●	●	●	●
Technology Productivity Tools				
Use general purpose productivity tools and peripherals to support personal productivity, remediate skill deficits, and facilitate learning throughout the curriculum.	●	●	●	●

National Educational Technology Standards Performance Indicators for Technology-Literate Students Grades 3–5

STANDARD	SEGMENT 1	2	3	4
Technology Productivity Tools *(continued)*				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	●	●	●	●
Technology Communication Tools				
Use technology tools for individual and collaborative writing, communication, and publishing activities to create knowledge products for audiences inside and outside the classroom.	●	●	●	●
Use telecommunication efficiently and effectively to access remote information, communicate with others in support of direct and independent learning, and pursue personal interests.	●	●	●	●
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	●	●	●	●
Technology Research Tools				
Use telecommunication and online resources to participate in collaborative problem-solving activities for the purpose of developing solutions or products for audiences inside and outside the classroom.	●	●	●	●
Use technology resources for problem solving, self-directed learning, and extended learning activities.	●	●	●	●
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	●	●	●	●
Technology Problem-Solving and Decision-Making Tools				
Use technology resources for problem solving, self-directed learning, and extended learning activities.	●	●	●	●
Determine when technology is useful and select the appropriate tools and technology resources to address a variety of tasks and problems.	●	●	●	●

International Technology Education Association Standards for Technological Literacy Grades 3–5

STANDARD	SEGMENT 1	2	3	4
The Nature of Technology				
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	●	●	●	●
Standard 2: Students will develop an understanding of the core concepts of technology.	●	●	●	●
Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.	●	●	●	●
Technology and Society				
Standard 5: Students will develop an understanding of the effects of technology on the environment.	●			●
Standard 6: Students will develop an understanding of the role of society in the development and use of technology.	●	●	●	●
Standard 7: Students will develop an understanding of the influence of technology on history.				●
Design				
Standard 8: Students will develop an understanding of the attributes of design.	●	●	●	●
Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.	●	●	●	●
The Designed World				
Standard 18: Students will develop an understanding of and be able to select and use transportation technology.	●	●	●	●

The National Geography Standards

STANDARD	SEGMENT 1	2	3	4
The geographically informed person knows and understands:				
The World in Spatial Terms				
How to use maps and other graphic representations, tools, and technologies to acquire process and report information from a spatial perspective	●			
How to use mental maps to organize information about people, places, and environments in a spatial context	●	●	●	●
Places and Regions				
The physical and human characteristics of places	●	●	●	●

Segment 1

Excited about the new vision for space exploration, the tree house detectives want to learn about manned (crewed) and unmanned (uncrewed) missions. With hundreds of exciting careers to choose from in the space industry, the detectives decide to investigate a few as they learn the mission requirements of the next generation of explorers who will go back to the Moon, on to Mars, and beyond. The detectives visit Dr. Carol Stoker at NASA Ames Research Center in California. Dr. Stoker discusses the importance of robotic missions in space exploration and explains the role of the *Phoenix* Lander, the next lander scheduled to go to Mars in search of water ice and possible evidence of previous life. As the detectives continue their investigations, they join Dr. D at the Virginia Air and Space Museum in Hampton, Virginia where they learn about some truly "strange matter."

Objectives

Students will

- identify the characteristics of a living thing
- demonstrate how robotic technology can be used to collect data
- construct a simulated robotic hand
- learn about the power of solar radiation
- explain the importance of water to life
- demonstrate the presence of microbial life
- understand how technology can be used to solve problems
- demonstrate how magnets can be used to move liquid

Vocabulary

aerogel – an extremely lightweight, strong material that is 99% air

dormant – inactive

ferrofluid – a liquid that contains tiny particles of suspended magnetic solids

lander – a spacecraft designed to land on a planet and collect data from one location; does not have the capability to move from one location to another

manned mission – exploration in space that includes human beings; also known as a crewed mission

microbes – tiny organisms too small to be seen with the unaided eye

organic – containing carbon; produced by animal or plant activities

subsurface – below the top layer

unmanned mission – exploration to space that uses robotic technology in place of human beings; also known as uncrewed mission

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Before viewing Segment 1 of *The Case of the Great Space Exploration*, read the program overview to the students. List and discuss questions and preconceptions that students may have about space flight, the importance of exploration, and the difference between manned and unmanned space flights.
2. Record a list of issues and questions that the students want answered in the program. Determine why it is important to define the problem before beginning. From this list, guide students to create a class or team list of three issues and four questions that will help them better understand the problem. To locate the following tools on the NASA SCI Files™ web site, select **Educators** from the menu bar, click on **Tools**, and then select **Instructional Tools**. You will find them listed under the **Problem-Based Learning** tab.

   Problem Board—Printable form to create student or class K-W-L chart

   Guiding Questions for Problem Solving—Questions for students to use while conducting research

   Problem Log and Rubric—printable student log with the stages of the problem-solving process

   Brainstorming Map—Graphic representation of key concepts and their relationships

   The Scientific Method and Flowchart—Chart that describes the scientific method process
3. **Focus Questions**—These questions at the beginning of each segment help students focus on a reason for viewing. They can be printed ahead of time from the **Educators** area of the web site in the **Activities/ Worksheet** section under **Worksheets** for the current episode. Students should copy these questions into their science journals prior to viewing the program. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.

   "What's Up?" Questions—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. Print them by selecting **Educators** on the web site in the **Activities/Worksheet** section under **Worksheets** for the current episode.

View Segment 1 of the Video

For optimal educational benefit, view *The Case of the Great Space Exploration* in 15-minute segments and not in its entirety. If you are watching a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Students should work in groups or as a class to discuss and list what they know about space flight and the reasons we explore. Have the students conduct research on the differences between manned and unmanned space flights and the technology, such as robotics, which helps us explore. Brainstorm for ideas about what space flight may be like in the future. As a class, reach a consensus on what additional information is needed. Have the students conduct independent research or provide them with the information needed.
4. Have the students complete **Action Plans**, which can be printed from the **Educators** area or the tree house **Problem Board** area in the **Problem-Solving Tools section** of the web site for the current online investigation. Students should then conduct independent or group research by using books and Internet sites noted in the **Research Rack** section of the **Problem Board** in the **Tree House**. Educators can also search for resources by topic, episode, and media type under the **Educators** main menu option **Resources**.
5. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. The variety of activities is designed to enrich and enhance your curriculum. Activities may also be used to help students "solve" the problem along with the tree house detectives.
6. For related activities from previous programs, download the appropriate **Educator Guide.** On the NASA SCI Files™ home page, select **Educators**. Click on **Episodes** in the menu bar at the top. Scroll down to the 2002–2003 Season and click on *The Case of the Biological Biosphere*. In the green box, click on **Download the Educator Guide**.

   a. In the Educator Guide you will find

   1 **Segment 1** – *Growing Cold, page 18*

   2. **Segment 1** – *Virus Versus Bacteria, page 20*

   Close the PDF window to return to the **Educator Guide** page. Using the yellow back arrow on the NASA SCI Files™ page (do NOT use the back button on your browser), return to the Episode description page. In the green box, click on **Activities/Worksheets**

   b. On the web site in the **Activities/Worksheet** section, you will find

   1. *Coconuts for You* (microbes)

7. Have the students work individually, in pairs, or in small groups on the problem-based learning (PBL) activity on the NASA SCI Files™ web site. To locate the PBL activity, click on **Tree House** and then the **Problem Board**. Choose the 2004–2005 Season and click on ***Mars or Bust!***
   - To begin the PBL activity, read the scenario (Here's the Situation) to the students.
   - Read and discuss the various roles involved in the investigation.
   - Print the criteria and problem log for the investigation and distribute.
   - Have students begin their investigation by using the **Research Rack** and the **Problem-Solving Tools** located on the bottom menu bar for the PBL activity. **The Research Rack** is also located in the **Tree House**.
8. Having students reflect in their journals what they have learned from this segment and from their own experimentation and research is one way to assess student progress. In the beginning, students may have difficulty reflecting. To help them, ask specific questions that are related to the concepts.
9. Have students complete a **Reflection Journal**, which can be found in the **Problem-Solving Tools** section of the online PBL investigation or in the **Instructional Tools** section under **Educators**.
10. The NASA SCI Files™ web site provides educators with general and specific evaluation tools for cooperative learning, scientific investigation, and the problem-solving process.

Careers

astronaut
microbiologist
museum exhibit or designer
researcher
robotics engineer
scientist

Resources *(additional resources located on web site)*

Books

Beyer, Mark: *Robotics*. Scholastic Library Publishing, 2001, ISBN: 0516240072.

Birch, Beverly: *Pasteur's Fight Against Microbes*. Barnes and Noble Books, 2001, ISBN: 0760726612.

Bocknek, Jonathan: *The Science of Magnets*. Gareth Stevens Audio, 1999, ISBN: 0836825721.

Branley, Franklyn Mansfield: *Is There Life Out There?* HarperCollins Publishers, 1999, ISBN: 0064451925.

Branley, Franklyn Mansfield: *Mission to Mars*. HarperCollins Publishers, 2002, ISBN: 0064452336.

Burgan, Michael: *John Glenn: Young Astronaut*. Simon and Schuster Children's, 2000,
ISBN: 0689833970.

Cole, Joanna and Nancy Krulik: *The Magic School Bus in a Pickle: A Book about Microbes*. Scholastic, Inc., 1998, ISBN: 0590393774.

Gifford, Clive: *How To Live on Mars*. Scholastic Library Publishing, 2001, ISBN: 053116201X.

Murphy, Patricia: *Exploring Space with an Astronaut*. Enslow Publishers, 2000, ISBN: 0766011992.

Schraff, Anne E.: *Are We Moving to Mars?* Avalon Travel Publishing, 1996, ISBN: 1562613103.

Schyffert, Bea Uusma: *The Man Who Went to the Far side of the Moon: The Story of Apollo 11 Astronaut Michael Collins*. Chronicle Books, 2003, ISBN: 0811840077.

Siy, Alexandra: *Footprints on the Moon*. Charlesbridge Publishing, 2001, ISBN: 1570914095.

Video

Careers for Kids: *I Wanna Be an Astronaut*
(Hosted by Steve Pool) Grades K–6

NASA Space Series: *Life on Mars?*
Grades 4 to adult

Schlessinger Media: *Electromagnetic Energy*
Grades 5–8

The Learning Channel: *Android*
Grades 6 to adult

Web Sites

NASA: How To Become an Astronaut
Use this web site to find out how to become an astronaut. There is also great information on what astronauts actually do.
http://www.spaceflight.nasa.gov/outreach/jobsinfo/astronaut.html

NASA: Astronauts in Training
This great site shows how astronauts train to prepare for space. There are links to more information and video clips to demonstrate some of the training tools astronauts use.
http://www.nasa.gov/audience/forstudents/5-8/features/F_Astronauts_in_Training.html

NASA: Astronaut School
Visit this web site to play a simulation of astronaut school, watch video clips, and learn fun facts about what it takes to be an astronaut.
http://edspace.nasa.gov/astroschool/

NASA: Manned vs. Unmanned Space Flight
This web site describes and examines the differences between manned and unmanned space flight.
http://www-spof.gsfc.nasa.gov/stargaze/Spaccrft.htm

The *Phoenix* Mission to Mars
Visit this web site for detailed information about the Phoenix Mars Lander, including the mission summary and the science objectives for the mission.
http://phoenix.lpl.arizona.edu/

NASA: Mars Activities
This site has a comprehensive list of classroom activities related to Mars exploration: directions for an edible rover, searching for life on Mars, and exploring the surface.
http://marsrovers.jpl.nasa.gov/classroom/pdfs/MSIP-MarsActivities.pdf

Robotics
Visit this site to learn about the history and workings of robotics, to see robot art, to get more classroom activities, and to control your own remotely operated vehicle.
http://www.thetech.org/robotics/

NASA: Mars, Water, and Life
Find out why scientists want to explore Mars and what they are looking for on Mars.
Also learn the importance of water on Mars.
http://mars.jpl.nasa.gov/msp98/why.html

Virginia Air & Space Center
Take flight to the Virginia Air & Space Center, the visitor center for NASA Langley Research Center and Langley Air Force Base. Your imagination will soar as you launch

a rocket, pilot a space shuttle, become an air traffic controller, fly an airplane, and more! Come face-to-face with the Apollo 12 Command Module that went to the Moon. See a Mars meteorite and a DC-9 passenger jet. Experience a 3D IMAX film in the giant-screen Riverside IMAX Theater...you have to see it to believe it! There is always something new landing at the Virginia Air & Space Center! http://www.vasc.org/

Strange Matter
Discover the secrets of everyday stuff. This web site lets you explore everyday materials to see what they are made of, how you can transform them, and what the properties of certain materials are. Discover some innovative uses for some materials. There is also a link to a family guide of home activities, including an activity with ferrofluids.
http://www.strangematterexhibit.com/index.html

NASA: Space Wardrobe
Find out on this interactive web site why astronauts wear space suits and why space is a harsh environment. The site provides two different levels for a variety of learners.
http://starchild.gsfc.nasa.gov/docs/StarChild/space_level2/wardrobe.html

Microbes Around Us
Unravel the mysteries of microbes on this interactive web site. Learn what microbes are, where they live, and how we use them.
http://www.microbe.org

The Microbe Zoo
Discover the many worlds of hidden microbes. Visit the major attractions, such as Space Land, Water World, and Dirt Land, as you learn more about microbes here on Earth and the possibility of finding them on other planets.
http://commtechlab.msu.edu/sites/dlc-me/zoo/

Activities and Worksheets

I'm Alive! I'm Alive!

Segment 1

Purpose

To create an operational definition of life and to identify the characteristics of a living thing

Background

All living things have processes not found in nonliving things. There are six main life processes. The first life process is to obtain energy. Plants and animals vary in the ways they get energy, but both must get energy to sustain life. The second life process is to use energy. The energy that is used allows living things to get the nutrients necessary to survive. The third life process is to release waste. Waste products are poisonous and must be released or the organism will die. The fourth life process is the ability to respond to a change in the environment. A hibernating bear is an example of a living thing responding to a change in its environment. The fifth life process is reproduction. Some individuals of a species must reproduce or create others of the same kind. Without reproduction, a species would become extinct. The sixth life process is to grow. Growth is the process of making more living material.

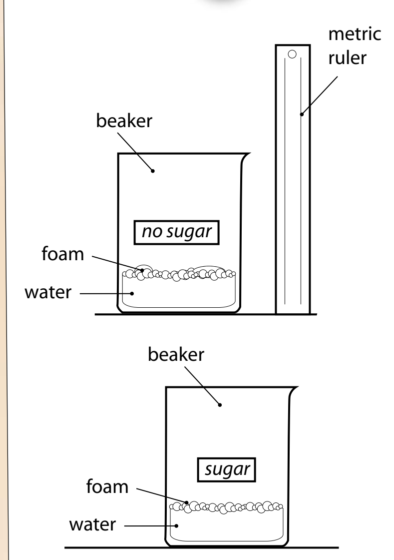
Procedure

1. In your science journal, write or draw the characteristics that make something living or nonliving.
2. Use the dictionary and/or encyclopedia to find pictures and definitions of living and nonliving things.
3. Discuss your findings with your group.
4. Measure and pour 50 mL of water into each beaker.
5. Use masking tape and a marker to label one beaker "sugar" and the other beaker "no sugar."
6. In the space provided on the Living or Nonliving chart, write your prediction for what will happen when yeast and water are mixed and when yeast, water, and sugar are mixed.
7. Add one yeast package to each beaker of water.
8. Use a craft stick and stir gently.
9. Observe the mixture.
10. Use the ruler to measure, on the outside of the beaker, the height of the mixture from the bottom of the beaker to the top of the mixture (including any foam).
11. Record your observations in the chart, noting the time and height of the mixture.
12. Use a measuring spoon to measure 10 mL of sugar.
13. Add the sugar to the beaker marked "sugar."
14. Gently stir the mixture.
15. Observe the sugar mixture and record your observations in the chart, noting the time and height of the mixture.
16. For 30 minutes total, check the beakers every 5 minutes and record your observations in the chart at each interval.
17. Stir the mixtures every time you check them.
19. Share your group's results with the class and find the average height of each mixture at each interval.
20. Use the average height data and create a class graph.

Materials

Per student:
Life Criteria Chart, page 19
Living or Non-Living
graph paper
science journal

Per Group
dictionary
encyclopedias
examples or pictures of living things
100-mL room temperature water
2 beakers or plastic cups (250 mL each)
2 packages of rapid rising yeast
10 mL of sugar (2 tsp)
2 craft sticks
plastic centimeter ruler
permanent marker
masking tape
scissors
metric measuring spoons
timer or clock



I'm Alive! I'm Alive!

Segment 1

21. In the Life Criteria Chart, list as many criteria for life as you can for yeast.
22. Choose 4 other living things and write their names in the living organisms column.
23. For each organism, write as many criteria for life as you can in the appropriate row.
24. Share your findings with your group and class.

Conclusion

1. Did your observations of the yeast match your predictions? Why or why not?
2. What role did sugar have in the experiment?
3. What do you think would happen if you added more yeast?
4. What do you think would happen if you added more sugar?
5. Is the yeast living? Explain your answer.
6. What are the main criteria for life?

Extension

1. Make a Venn diagram to compare the characteristics of living organisms and nonliving organisms.
2. Measure the temperature of each yeast mixture at each 5-minute check. Make a line graph to show the temperature changes.
3. Look at the yeast mixtures under a microscope.
4. Try a similar experiment with other substances, such as baking powder or fizzing cold tablets, instead of the yeast.

LIFE CRITERIA CHART

Predictions:

Yeast and Water: ______________________________

Yeast, Water, and Sugar: ______________________________

	Yeast + Water		Yeast + Water + Sugar	
Time	Appearance	Height of Mixture (cm)	Appearance	Height of Mixture (cm)

Living Organisms	Criteria	Criteria	Criteria	Criteria	Criteria
Yeast					

I Want To Hold Your Hand

Segment 1

Purpose

To construct a robotic-like hand and to demonstrate how data are collected when using robotic technology

Background

A robot is a machine that collects information from its surroundings. It uses that information to follow instructions and to complete a task. Today's Robots have multiple sensors and are able to make their own decisions based on given information. Robots come in all shapes and sizes. The jobs they do are also varied. Some robots are used in factories. Others are experimental robots that use artificial intelligence. Artificial intelligence allows robots to behave more like human beings and to act independently in a changing environment. Today, robots are used in hospitals, space and ocean exploration, and other dangerous areas.

Materials

Per Group

narrow rubber bands
drinking straws
cardboard
tape
scissors
nylon cord
centimeter ruler
pen

Procedure

1. To make the palm of the robotic hand, cut a piece of cardboard 10 cm x 10 cm.
2. To make the fingers, cut three pieces of cardboard 2 cm x 9 cm.
3. To make one of the fingers jointed, cut one of the cardboard pieces into three equal pieces. See diagram 1.
4. Place the three equal finger pieces back together and use tape to reconnect them. Label one side of the taped finger "inside." See diagram 2.
5. Cut a rubber band 5 cm long.
6. Turn the segmented finger over so the "inside" is face down.
7. Put the rubber band across the middle of the first joint. See diagram 3.
8. Tape the rubber band on both sides of the joint, making sure to leave the ends of the rubber band untaped.
9. Fold the ends of the rubber band so that they rest on top of the tape and tape them firmly in place. See diagram 4. Taping prevents the rubber bands from slipping.
10. Repeat steps 5 through 9 for the second joint.
11. Tape the finger onto the palm with "inside" facing up.
12. Turn the hand over.
13. Cut a rubber band 5 cm long.
14. Put the rubber band across the last joint (touching the palm).
15. Repeat steps 8–9 for the last joint, connecting the finger to the palm. See diagram 5.
16. Cut a piece of nylon cord 35 cm long.
17. Tape one end of the nylon cord over the end of the finger. See diagram 6.
18. Cut four pieces of straw 2 cm each.
19. Thread the pieces of straw onto the nylon cord.
20. Tape a piece of straw in the middle of each finger section.
21. Tape the last straw to the palm. See diagram 7.

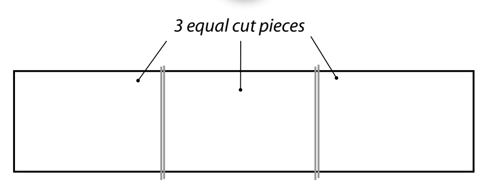


Diagram 1

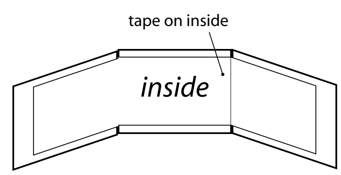


Diagram 2

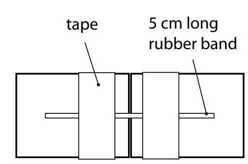


Diagram 3

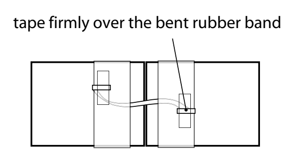


Diagram 4

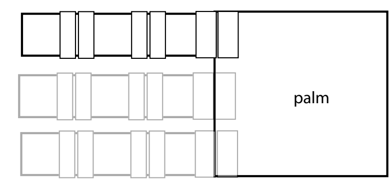
I Want To Hold Your Hand

Segment 1

22. Repeat steps 3–21 for the last two fingers.
23. Operate the hand by pulling the nylon cord.
24. You should be able to pick up an empty soda can or other lightweight objects.

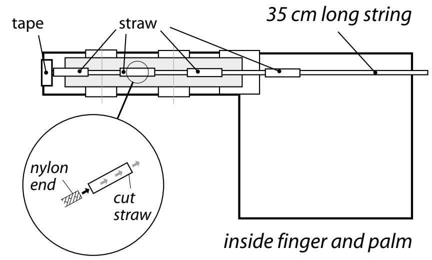
Tips:

- *You may need to cut the tape pieces to make them thinner.*
- *Make sure the rubber bands are taped firmly. If there is any loose area, the hand will not work properly.*



connecting fingers to palm

Diagram 5



inside finger and palm

Diagram 6

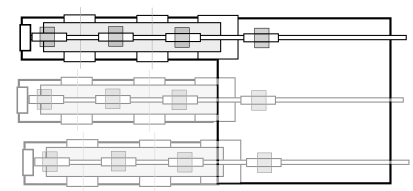

inside finger and palm finished

Diagram 7

Conclusion

1. What items can you pick up with your robotic hand?
2. What would happen if you added more fingers?
3. What would happen if you added a thumb?
4. Why is it difficult to pick up certain items with your robotic hand?
5. What could a real robotic hand be used for? Write or draw your ideas in your science journal.

Extension

1. Fold your thumb in toward the palm of your hand. Wrap a piece of masking tape around your hand to immobilize your thumb. Now try to do various daily tasks without the use of your thumb. Were you able to tie your shoes, put a button through a buttonhole, or fasten a snap? Try holding a fork or spoon or peeling a banana. Can you catch a ball?
2. Make a Venn diagram to compare your hand to the robotic hand you made.
3. Add more fingers or a thumb to your robotic hand. Does it make a difference?
4. In your science journal, draw or write about some of the things you can and cannot pick up. Write why you think some things cannot be picked up with your robotic hand.

There's a Radio in My Meter

Segment 1

Purpose

To demonstrate how a radiometer works and to understand the power of solar radiation

Background

Solar radiation is radiation from the Sun made up of a wide range of wavelengths. The wavelengths can range from the long infrared to the short ultraviolet. The solar radiation Earth receives is more limited because the ozone layer and atmosphere absorbs many wavelengths. Therefore, the Earth generally receives mostly the visible and near-infrared radiation.

In 1875, Sir William Crookes conducted experiments in a vacuum. From these experiments he devised a device, named after him, called Crookes Radiometer. Unfortunately, it didn't have any practical use, but it is still sold today as curiosity item.

When a radiometer is exposed to light, the vanes revolve. The gas near the black surface is warmer than the shiny surface because dark colors absorb more solar energy than light colors. The faster gas molecules from the warmer side strike the edges of the vane at an angle and create a higher force than the colder molecules on the other side.

Materials

Per Group

black marker
yellow marker
1 foil gum wrapper
jar
pencil
strong glue
thread
used matchstick
tape
stopwatch or clock

Procedure

1. Have an adult strike a matchstick, blow it out, and allow it to cool.
2. Using the black marker, color the paper side of the foil gum wrapper.
3. Cut the wrapper into 4 equal pieces (2 cm x 2.5 cm). See diagram 1.
4. On the black side of one piece, place a small yellow dot in the corner.
5. Using strong glue, attach the pieces of paper to one end of the matchstick. Make sure to have all the shiny surfaces face the same direction. See diagram 2.
6. Attach 12 cm of thread to the other end of the matchstick.
7. Wrap the other end of thread (the loose end) around a pencil and secure with tape.
8. Place the pencil on top of the jar with the thread and matchstick hanging inside the jar. Make sure the matchstick is suspended and not touching the bottom of the jar. See diagram 3.
9. Place the jar in a sunny location.
10. Observe the piece of paper with the yellow dot. Try to count the number of times it passes a given point in 10 seconds.
11. Record your observations in your science journal.
12. Move the jar away from the sunny area and repeat steps 10–11.

Diagram 1

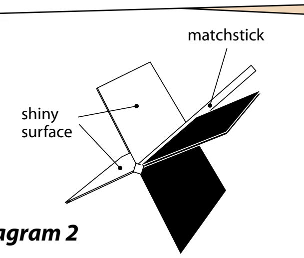


Diagram 2

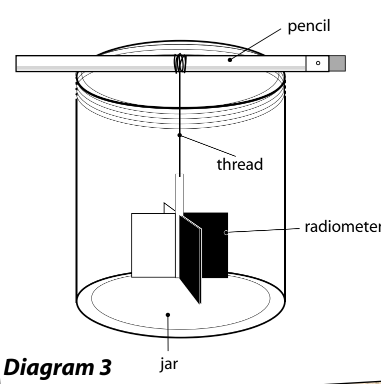


Diagram 3

Conclusion

1. What happened to the radiometer after it was placed in the sunlight? Why?
2. What would happen if all the shiny surfaces faced different directions?
3. What would happen if the matchstick were resting on the bottom of the jar?
4. Why might a radiometer be important to a scientist?

Extension

1. Use different sources of light, such as a flashlight, lamp, and so on and record the number of spins (in 10 seconds) for each source. Repeat for several trials and find the average number of spins. Create a class chart and graph.
2. Move the radiometer forward and backward from a light source and note any changes.
3. Conduct research to learn more about the different types of radiation. In your science journal, draw and describe the instruments used to measure the types of radiation.

Squiggly Little Things

Segment 1

Purpose

To understand the importance of water to life

To demonstrate the presence of microbial life

To observe microbes such as algae, protozoa, and bacteria

Materials

2 empty jars
hay
pond or creek water
corn syrup
microscope slides and slip covers
microscope
2 eyedroppers
antibacterial soap for cleanup
science journal

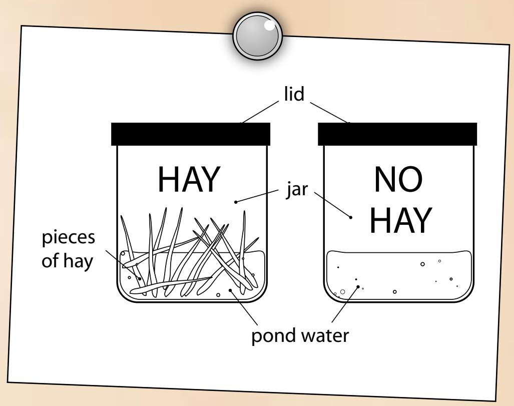
Background

Microbes are tiny creatures that are everywhere. They include bacteria, archaea, fungi, protists, and viruses. These creatures are too small to be seen without a microscope. There are more microbes on a person's hand than there are people on the entire earth! Microbes are in the air we breathe, the ground we walk on, and the food we eat. Without them we couldn't digest food, plants couldn't grow, and garbage wouldn't decay.

A hay infusion is a great way to produce a variety of microbes during any time of the year. The water is necessary for the microbes to reproduce. The sugars in the dried grass or hay provide food for the bacteria and other microbes. The bacteria serve as food for other microbes, such as protozoa. Since the protozoa breathe oxygen, it is important to pump air into the hay infusion at least once a day. Use an eyedropper to pump in the air. Although most bacteria are harmless to people, be sure to wash your hands, equipment, and counters with antibacterial soap.

During the first week of the hay infusion, a scum may form on top of the water. This scum is perfectly normal. It may actually contain rod-shaped cells that may be a form of sulfur bacteria. After the first week, protozoa should be visible under the microscope. In weeks four and five, flagellates and diatoms should be present. By the tenth week, amoebas should be present in the bottom water samples. Spiral bacteria may also be present at this time. The bacteria may produce a somewhat unpleasant smell in the hay infusion.

Procedure



1. Put equal amounts of pond water into each jar.
2. Label one jar "No Hay" and the other jar "Hay."
3. Add pieces of hay to the jar labeled "Hay" and cover the jar loosely.
4. Loosely cover the other jar.
5. Collect a drop of water from the "Hay" jar and place it on a microscope slide. NOTE: Be careful to keep the eyedroppers separated and use the same one for each jar.
6. Place the slipcover over the drop of water on the slide and place a prepared slide under a microscope to examine the water drop.
7. In your science journal, draw what you see.
8. Repeat steps 5–7 with the "No Hay" jar.
9. Set both jars aside but remember to use the eyedropper to pump oxygen into the water each day.
10. On the second, fourth, and sixth day, make a new microscope slide for each jar and record your observations in your science journal. Be sure to date the entries to measure change over time.
11. On about the seventh or eighth day, the hay infusion population will peak.
12. For the best chance of getting different types of microbes, use the eyedropper to take samples from the top, near the top, and middle of each jar. NOTE: If the microbes on the microscope slide move too quickly to compare, add a drop of corn syrup to the sample.
13. Record your observations in your science journal and date them.
14. Each week add more pond water to each jar and add more hay to the "Hay" jar.

Squiggly Little Things

Segment 1

15. Repeat steps 12–13 to make new slides from the water samples of each jar every four to five days.
16. Record your observations and any changes or new microbes in your science journal.
17. Using the Internet or other reference materials, identify as many of the organisms as you can.
18. Research why microbes are important to us in everyday life.
19. Learn about harmful and helpful microbes.
20. Make a poster to show what you learned about these microbes.

Conclusion

1. What changes did you notice each day in the hay infusion jar?
2. Why was the water important to the project?
3. Which water sample produced the most microbes?
4. How many different microbes were you able to draw?
5. Explain how we use microbes.

Extension

Try organic matter other than hay.

Just a Little Air in My Gel

Segment 1

Purpose

To understand how technology can be used to solve problems

Background

Aerogel is an amazingly strong, lightweight man-made material. It is the least dense material on Earth. Aerogel, sometimes called frozen smoke, is composed of 99% air and 1% silica dioxide, the substance used to make glass. A block of aerogel the size of a person may weigh less than half a kilogram (kg) yet support the weight of a small car (about 454 k). A thickness of only 2.5 centimeters (cm) has the same insulating power as more than 15 cm of fiberglass and can withstand temperatures up to 1,400° C (2,552° F). Aerogel begins as a silica dioxide gel, much like the gelatin you might eat. The material then goes through a process known as supercritical drying, in which the liquid is removed without collapsing the gel.

Aerogel has been used to provide insulation on various spacecraft and is currently being used to capture comet particles that are traveling at 6 times the speed of a rifle bullet. When these particles hit the aerogel, they leave behind cone-shaped hollow tracks. Scientists can then follow each cone to its point to collect the particle. The particle is captured intact, without any damage to it. The track of the particle through the aerogel also gives scientists important information about the path of the particle and the direction it was traveling when captured.

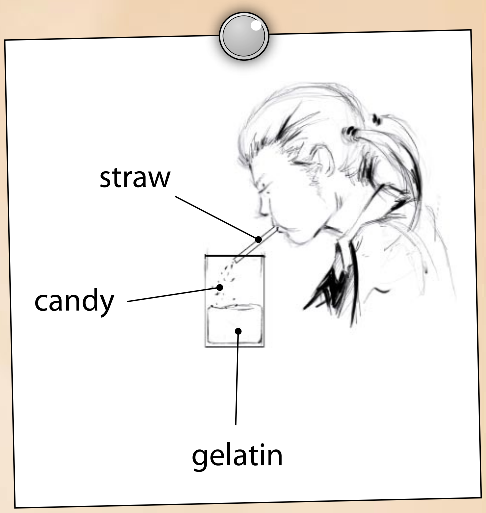
Materials

Per Group

- 1 package gelatin
- 415-mL boiling water
- 1–2 drops of blue food coloring (optional)
- clear plastic cups
- straws
- Nerds® candies
- science journal

Procedure

1. With an adult's help, mix the boiling water, the food coloring, and the gelatin.
2. Let the mixture cool slightly.
3. Pour the cooled mixture into clear plastic cups, filling each one about half full.
4. Refrigerate overnight.
5. Remove the cups from the refrigerator and let stand at room temperature for about two hours.
6. Put a few of the candies in the end of a straw. The candies represent comet particles in space.
7. Point the straw towards the cup of "aerogel" and blow as hard as you can.
8. Examine the tracks left by the "comet particles" in the gel.
9. Record your observations in your science journal.



Conclusion

1. What is aerogel used for now?
2. What can scientists learn about comets by capturing the particles in space?
3. Why is aerogel an important discovery?
4. What other uses might be found for a product like aerogel?

Extensions

1. Examine a piece of bubble wrap. What do you see? What is between the layers of plastic? How do you know? Find out how bubble wrap is used. Make a clay ball about the size of a walnut. Using the bubble wrap, create a way to catch the clay ball that will not change the shape of the ball as you drop it.
2. Collect other foam products. Be creative. Some of these products, like sponge cake, may be edible. Try the clay ball experiment with other products. Did you get the same results? Did some of the products work better than others? Why do we use foam products? What makes the foam lightweight?

Ferreting Out the Fluids

Segment 1

Purpose

To demonstrate how magnets can be used to move liquid and to understand the importance of spinoff products to everyday life

Materials

baby oil
iron filings or shavings
strong magnet
small jar or bottle with a tight-fitting lid
tap water
plastic cup
craft stick
safety glasses
food coloring
science journal

Background

Ferrofluids are substances that behave like liquids but have the magnetic properties of solids. The ferrofluids actually contain tiny particles of a magnetic solid suspended in a liquid. Ferrofluids were originally discovered in the 1960s at a NASA Research Center where scientists were investigating possible methods for controlling liquids in space. The benefits of a magnetic liquid were obvious. The location of a liquid could be controlled through the application of a magnetic field and liquids could then be forced to flow without the aid of gravity. Ferrofluids can also be used to form tight seals in rotating generators and are used in high-speed computer disk drives to eliminate harmful dust particles or other impurities that can damage the data-reading heads. Ferrofluids have also been used to improve the performance of loudspeakers, leading to an overall improved sound quality. Research is currently being conducted for biomedical applications in the hope that these liquids could be used to carry medications to specific parts of the body through the use of magnetic fields.

Teacher Notes

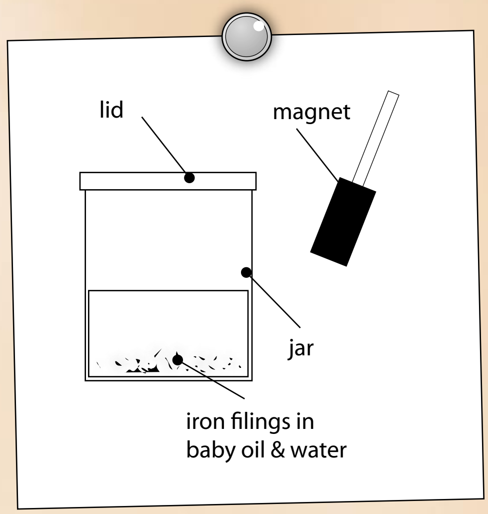
Although actual ferrofluids are available for purchase, these products must be used with extreme caution. The following classroom simulation activity safely and effectively demonstrates the use of ferrofluids.

Iron filings can be purchased from a science supply store. A quick, inexpensive way to obtain the filings is to purchase a magnetic drawing game at a toy store. Open the game and carefully remove the filings for use.

NOTE: *A magnet with a handle and a jar with smooth sides work best.*

Procedure

1. Put safety glasses on to protect your eyes from the iron filings.
2. Place about 5 mL of iron filings in the bottom of a small jar.
3. Put the lid on the jar.
4. Using a powerful magnet, rearrange the iron filings by running the magnet along the outside of the jar.
5. Notice the shape and position of the filings.
6. Record your observations in your science journal.
7. Record what happens to the filings when you remove the magnet from the side of the jar.
8. Open the jar.
9. Add just enough baby oil to the iron filings to moisten them thoroughly, mixing with a wooden stick to make a paste.
10. Add a few drops of food coloring to a cup of tap water.
11. Slowly pour the tap water into the jar with the iron filings, filling the jar about halfway.
12. Replace the lid.



Ferreting Out the Fluids

Segment 1

13. In your science journal, record the location of the iron mixture in comparison to the water.
14. Move the magnet over the outside of the jar.
15. Observe what happens to the iron filings.
16. Using the magnet, move the iron mixture up the side of the jar above the water line.
17. Move the magnet away from the side of the jar and observe what happens.
18. In your science journal, record your observations.
19. Compare and contrast the movement of the filings suspended in the baby oil to the dry filings you observed earlier.

Conclusion

1. What happens to the dry iron filings when the magnet is nearby? Why?
2. What happens to the dry filings when the magnet is removed? Why?
3. What happens to the filings suspended in the baby oil when the magnet is nearby?
4. What happens to the filings suspended in the baby oil when the magnet is removed?
5. Why are ferrofluids important in space?

Extension

Ferrofluids were designed for space use but have applications in the everyday world around us. We call products that come from basic research, spinoffs. You may have scratch resistant lenses in your glasses, but did you know that they were a spinoff of the NASA space program? Night vision cameras and heart monitors are two other commonly used NASA spinoffs. Find out about more spinoff products at ***http://www.sti.nasa.gov/tto/*** and make a poster or PowerPoint presentation showing the importance of spinoff products in our lives.

Answer Key

Segment 1

I'm Alive! I'm Alive

1. Answers will vary.
2. The sugar provides "food" (energy) for the yeast.
3. Because the yeast would have to share the food, little growth would occur.
4. The yeast should begin to once again reproduce and grow. (Note: yeast growth is dependent on temperature; the experiment must be completed while the mixture is still warm.)
5. Yes. The yeast grows; reproduces; responds to its environment, particularly temperature and light; gives off waste; and uses energy obtained from the sugar.
6. A living organism must be able to grow, reproduce, respond to stimuli, get and use energy, and produce waste materials.

I Want To Hold Your Hand

1. Answers will vary.
2. The hand should be able to pick up more items because more fingers will add strength.
3. Having an opposable, or moving thumb, allows us greater dexterity. Adding a thumb to the hand should allow you to pick up smaller items and complete tasks that require some skill.
4. Answers will vary.
5. Answers will vary.

There's a Radio in My Meter

1. The vanes on the radiometer began to spin. The gas molecules near the black surface are warmer than the ones near the shiny surface because dark colors absorb more solar energy than light colors. The faster gas molecules from the warmer side strike the edges of the vane at an angle and create a higher force than the colder molecules on the other side.
2. There would be no movement in the radiometer because the gas molecules would be trapped between the vanes.
3. The friction between the matchstick and the bottom of the jar would prevent the radiometer from spinning.
4. Although Crookes thought his radiometer could be used to measure solar radiation, it actually has no practical purpose. Advanced, very high-resolution radiometers are used today to remotely determine cloud cover and Earth surface temperature. A series of sensors on the vanes collects different bands of radiation wavelengths. The data are then interpreted to determine surface temperature.

Squiggly Little Things

1. Answers will vary, but more microbes should be seen each day in the hay infused jar than in the jar without hay.
2. Water is the source of life. All living things known to us at this time require water to survive. The water provides an environment for the microbes as well as a way to release the nutrients in the dried hay.
3. Although different microbes should be seen at different levels, approximately the same number should be found throughout the water samples. The later samples will reveal the most microbial life.
4. Answers will vary.
5. Answers will vary but may include these: help decompose trash, thicken products, ward off spoilage.

Just a Little Air in My Gel

1. Aerogel is being used on the Stardust mission to capture pieces of a comet.
2. Scientists are able to study the material that makes up a comet, as well as the comet particles' path, direction, and speed.
3. Aerogel is extremely lightweight, yet very strong. It can insulate at very high temperatures.
4. Answers will vary.

Ferreting Out the Fluids

1. The filings stand up on end and begin to arc toward the poles of the magnet, showing the magnetic field. Iron is a magnetic material and is attracted to the magnet.
2. As soon as the magnet is removed, the filings fall back to the bottom of the container. As the magnet is removed, the force of attraction becomes less and less until the distance is so great that there is no longer any magnetic force to act upon the iron filings and they fall.
3. The filings are attracted toward the magnet and can be moved throughout the liquid in the jar.
4. The filing mixture runs down the side of the jar, behaving as a liquid, flowing toward the bottom of the jar.
5. Ferrofluids are used to help move liquids, such as rocket fuel, in microgravity environments.

On the Web

Why Explore?

1. Unmanned missions allow scientists to gather data in locations that are not accessible to human beings. The environment may be too harsh for human beings, temperatures may be too extreme, or radiation may be too high for safety. Even distance is a factor. If a site is too far for human space travel, an unmanned mission may collect the data from the far reaches of the solar system and beyond.
2. Answers will vary.
3. Answers will vary.

Segment 2

Bianca goes to Space Camp in Huntsville, Alabama to learn how an astronaut trains for space travel. Meanwhile, Catherine goes to NASA Johnson Space Center in Houston, Texas to talk to Dr. Grant Schaffner about the effects of long-term space travel on the human body. Dr. Schaffner emphasizes the importance of exercise to overcome the effects of space travel. Next, Catherine visits Ms. Janis Davis-Street to learn why it is important for astronauts to eat a healthy, well-balanced diet while on Earth and in space. The NASA SCI Files™ Kids' Club at Maryvale Elementary School in Rockville, Maryland helps the detectives learn more about Calories, serving sizes, and the Food Pyramid. Finally, the detectives meet Dr. D in his lab, where he just needs to make a few computations on his robots.

Objectives

Students will

- demonstrate the effects of microgravity on the human body
- investigate bone loss in microgravity environments
- determine Basal Metabolic Rate (BMR)
- calculate total energy needs
- measure the amount of energy contained in particular foods
- demonstrate food dehydration
- examine the challenges faced by scientists when exploring unknown territories
- analyze the benefits of stereoscopic vision
- investigate three-dimensional technology

Vocabulary

Basal Metabolic Rate (BMR) – an estimate of a person's energy needs at rest

calorie – the unit for measuring the energy supplied by food; based on the large Calorie or the amount of heat energy needed to raise the temperature of a kilogram of water one degree centigrade

exercise – activity that requires physical exertion, especially when done to develop or maintain fitness

microgravity – an environment where astronauts are freely falling towards the Earth and feel nearly weightless

nutrition – food or nourishment

robotics – the study and design of robots, mechanical devices that can perform work and collect data

rovers – a spacecraft that is designed to land on a planet and move from one location to another to collect data

serving – a recommended portion size

stereo cameras – two cameras spaced some distance apart, which take pictures of the same scene at the same time to simulate depth perception

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 2 of *The Case of the Great Space Exploration*, discuss the previous segment to review the problem and reaffirm what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 1 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 1. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 1.
5. Read the Overview for Segment 2 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes while viewing the program to help them answer the questions. An icon will appear when the answer is near.
7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the tree house detectives should take next in the investigation process and how the information learned will affect the case. They can be printed from the web site ahead of time for students to copy into their science journals.

View Segment 2 of the Video

For optimal educational benefit, view *The Case of the Great Space Exploration* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about space flight, the reasons we explore space, and how astronauts train for a mission.
4. Organize the information and determine whether any of the students' questions from the previous segments were answered.
5. Decide what additional information is needed for the tree house detectives to better understand future space exploration. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
6. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.

Careers

astronaut strength conditioning and rehabilitation specialist
dietitian
exercise equipment designer
fitness trainer
health scientist
nutritionist

7. For related activities from previous programs, download the **Educator Guide**. On the NASA SCI Files™ home page, select **Educators**. Click on **Episodes** in the menu bar at the top. Scroll down to the 2002–2003 Season and click on *The Case of the Galactic Vacation*. In the green box, click on **Download the Educator Guide.**

a. In the Educator Guide, you will find

1. Segment 2 – *The Taste of the Matter*

2. Segment 2 – *Dressing for Space*

Close the PDF window to return to the Educator Guide page. Using the yellow back arrow on the NASA SCI Files™ page *(do NOT use the back button on your browser)*, return to the Episode description page. In the green box, click on **Activities/Worksheets**.

b. On the web site in the **Activities/Worksheet** section, you will find

1. My Life as an Astronaut

2. Too Short?

Close the PDF window to return to the Educators Activities page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2002–2003 Season and click on *The Case of the Biological Biosphere*. In the green box, click on **Download the Educator Guide**.

a. In the Educator Guide you will find

1. **Segment 3** – *You Are What You Eat*

2. **Segment 3** – *Fitness for Life*

3. **Segment 4** – *Flexing Your Muscles*

4. **Segment 4** – *Flexibility Is the Key*

5. **Segment 4** – *Getting to the Heart of the Matter*

Close the PDF window to return to the Educator Guide page. Using the yellow back arrow on the NASA SCI Files™ page, return to the Episode description page. In the green box, click on **Activities/Worksheets**.

b. On the web site in the **Activities/Worksheet** section, you will find

1. *Where Are the Nutrients?*

2. *Body System Booklet*

Close the PDF window and return the **Educators Activities** page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Inhabitable Habitat*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

a. **Segment 3** – *Vomit Comet*

b. **Segment 3** – *Properly Gloved*

8. If time did not permit you to begin the web activity at the conclusion of Segment 1, refer to number 6 under **After Viewing** on page 15 and begin the Problem-Based Learning activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, Problem-Based Learning activity:

- **Research Rack**–books, Internet sites, and research tools
- **Problem-Solving Tools**–tools and strategies to help guide the problem-solving process
- **Dr. D's Lab**–interactive activities and simulations
- **Media Zone**–interviews with experts from this segment
- **Expert's Corner**–listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

9. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.
10. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. For more assessment ideas and tools, go to **Educators** and click on **Instructional Tools** in the menu bar.

Resources *(additional resources located on web site)*

Books

Berger, Melvin and Berger, Gilda: *Can You Hear a Shout in Space?: Questions and Answers About Space Exploration*. Scholastic, Inc., 2000, ISBN: 0439148790.

Bredeson, Carmen, Vargus, Nanci R., and Palaquibay, Minna Gretchen: *Getting Ready for Space*. Scholastic Library Publishing, 2003, ISBN: 0516269534.

Fritz, Sandy: *Robotics and Artificial Intelligence*. Smart Apple Media, 2004, ISBN: 1583403647.

Haduch, Bill: Food Rules!: *What You Munch, Its Punch, Its Crunch, and Why Sometimes You Lose Your Lunch*. Puffin, 2001, ISBN: 0141311479.

Hayden, Kate: *Astronaut, Living in Space*. DK Publishing, 2000, ISBN: 0789454211.

Jacobson, Michael F. and Hill, Laura: *Kitchen Fun for Kids: Healthy Recipes and Nutrition Facts for 7–12-Year Old Cooks.* Henry Holt & Company, 1991, ISBN: 0805016090.

Nicholson, Cynthia Pratt: *Exploring Space*. Kids Can Press, Limited, 2000, ISBN: 1550747134.

Vogt, Gregory and Shearer, Deborah: *Robotix Robot Inventor's Workshop*. Running Pres Book Publishers, 2000, ISBN: 0762407417.

Video

Dealstar Video: *Case of the U.S. Space Camp Mission* (starring the Olsen twins)
Grades K–4

Discovery Channel School: *The Food Pyramid*
Grades 3–6

Discovery Channel School: *People and Space*
Grades 3–6

Schlessinger Media: *All About Nutrition and Exercise*
Grades K–4

Web Sites

Space Camp
Learn about space camp and aviation challenge programs offered for students and adults.
http://www.spacecamp.com/camponline/index.jsp

NASA Johnson Space Center
Find out about programs, news, and research going on at NASA Johnson Space Center in Houston, Texas.
http://www.jsc.nasa.gov/

Living and Working in Space
In many ways, living in space is not very different from living on Earth. In other ways, it is quite different. Space travelers in orbit above the Earth eat, work, exercise, relax, maintain hygiene, and sleep. Learn about endeavors to sustain life on future missions into unfamiliar territories.
http://spacelink.nasa.gov/NASA.Projects/Human.Exploration.and.Development.of.Space/Living.and.Working.In.Space/.index.html

KidsHealth
On this web site, you can learn all about nutrition, ways to stay healthy, fitness, and many other fun topics. There are fun activities and cool movies to view.
http://kidshealth.org/kid/

NASA Spacelink – Space Food
Space food to the Mercury astronauts meant freeze-dried powders and semi-liquids in aluminum tubes. The astronauts on the International Space Station can choose from shrimp cocktail, stir fried chicken, and Fettuccine Alfredo. Use the resources here to design your space meals for a day.
http://spacelink.nasa.gov/NASA.Projects/Human.Exploration.and.Development.of.Space/Living.and.Working.In.Space/Space.Food/

Society of Women Engineers
The Society of Women Engineers is the largest nonprofit educational and service organization representing both student and professional women in engineering and technical fields. Visit this site to learn about their objectives and missions.
http://www.swe.org/

NASA Spacelink - Robotics
Robots and human beings working together are demonstrating new exploration strategies. This page offers information and activities that explain how robots play an important role in space exploration.
http://spacelink.nasa.gov/Instructional.Materials/Curriculum.Support/Technology/Robotics/

National Space Biomedical Research Institute (NSBRI)
Visit this web site for some great activity guides for teachers. Download the series of educational units developed by the Baylor College of Medicine-*From Outerspace to Innerspace: Activity Guides for Teachers*. Units include *Sleep and Daily Rhythms*, *Muscles and Bones*, and *Food and Fitness*.
http://www.nsbri.org/Education/Elem_Act.html

Activities and Worksheets

Puffy Head, Bird-Leg Syndrome

Segment 2

Purpose

To demonstrate the effects of microgravity on the human body

Materials

stopwatch or clock with a second hand
cm measuring tape
science journal

Background

When astronauts are in space, they experience the phenomenon known as "Puffy-Head, Bird-Leg" Syndrome. The astronauts feel a sensation of sinus stuffiness and develop puffiness in the face. Measurements taken before, during, and after space flight show that the legs do change their shape during space flight. Astronauts with larger leg circumference show a larger decrease in leg volume than astronauts with smaller legs. This change in shape makes sense because increased muscle requires more fluid and blood flow to feed that muscle. The more blood and fluid there is in one area, the more there is to move. The reported sensations in the head and the measured changes in the legs support the hypothesis that fluids in the body shift upwards during space flight.

Teacher Note: *Students who participate in this activity should be wearing pants or shorts.*

Procedure

1. Using a measuring tape, measure the circumference of your leg near the top of the thigh.
2. Record your measurement in your science journal.
3. Sit on the floor facing the wall.
4. Now put your feet up on the wall with your legs as flat against the wall as possible. See diagram.
5. As soon as you are settled, stay still and begin timing for 3 minutes.
6. At the end of 3 minutes, stand quickly and measure your leg again.
7. Be sure to measure at the same place on your leg each time.
8. Record your measurements.
9. Walk around the room several times or jog in place.
10. Measure your leg again.
11. Record this measurement.
12. Label the time each measurement was taken.

Diagram

Conclusion

1. What happened to the circumference of your leg after you had your feet up on the wall?
2. Why do you think this change happened?
3. How is this result similar to what the astronauts experience?
4. What happened to your legs after you resumed some physical activity?
5. What can astronauts do to overcome Puffy-Head, Bird-Leg Syndrome?

Extensions

Learn more about the effects of space on the human body. Go to the NASA web site and search for information about what happens to the astronauts in a microgravity environment. Find out what the astronauts do to compensate for these effects.

Boney Bones

Segment 2

Purpose

To learn the importance of calcium to bones and to investigate bone loss in microgravity environments

Background

Bones are living tissue. On Earth, we need bones for support and protection. Calcium is a mineral that your body needs to help build healthy teeth and bones. Calcium keeps bones strong. Low levels of calcium pose a serious health risk, such as the increased chance of broken bones and fractures. Astronauts face many changes while in a microgravity environment. One of those changes is bone loss. On Earth, bones support the body's weight. However, in the microgravity environment of space, the stresses upon bones are reduced. The calcium in the bones begins to break down. As a result, the astronauts' bones begin to weaken. The excess calcium is then released into the bloodstream. The kidneys must filter the calcium rich blood, often causing kidney stones to develop. Bone loss appears to increase in proportion to mission length. An astronaut who has been in space for more than 180 days may lose 20% of his or her bone mass. When the astronauts return to Earth, they are at a higher risk of breaking bones because of the calcium loss. Exercise, diet, and in-flight rest can help counteract bone loss in space.

Materials

- box of corn puff cereal
- 1 sandwich size, zip-locking plastic bag
- calcium antacid tablets
- coffee filters
- magnifying lens
- warm water
- small bowl
- spoon
- measuring cup
- science journal

Procedure

1. Place 1 cup of cereal in the zip-locking plastic bag and seal.
2. Observe the cereal and record your observations in your science journal. The cereal represents the material of which bones are made, including calcium.
3. Slowly apply pressure to the cereal.
4. Observe and record your observations. What happened to the cereal?
5. The residue in the bag represents the calcium lost in space.
6. Measure 240 mL of warm water and pour it into a bowl.
7. Place 5 or 6 antacid tablets into the warm water and let dissolve. Note: To dissolve tablets more quickly, break them into smaller pieces. See diagram 1.
8. Observe and record your observations.
9. Use the spoon to help mix the tablets and the water.
10. Over a sink or outside, slowly pour the water through the coffee filter. See diagram 2.
11. Set the coffee filter in a safe place and allow it to dry.
12. Once the coffee filter is dry, use the magnifying lens to observe the surface of the coffee filter.

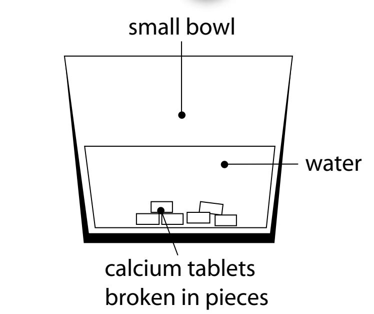


Diagram 1

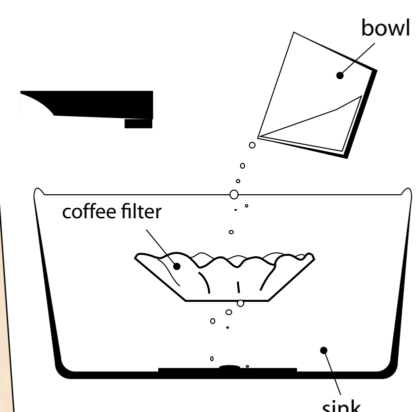


Diagram 2

Boney Bones

Segment 2

Conclusion

1. What is the residue on the coffee filter surface?
2. What does the coffee filter represent?
3. How does this experiment demonstrate what happens to the astronauts in space?
4. What can be done to prevent bone loss in space?

Extension

1. Visit the NASA Explores web site, ***http://www.nasaexplorers.com/show_k4_teacher_st.php?id=021223102504***. Complete the "Bendy Bones" activity to see how chemical changes can affect your bones.
2. Complete the NASA Explores activity "1,300 Milligrams a Day" found at ***http://www.nasaexplorers.com/show_k4_teacher_st.php?id=040409130625***. This activity demonstrates how much calcium we need per day.
3. Conduct research to find out more about calcium rich foods and a healthy diet. Present your findings to the class.

Basal Metabolic Rate and Calories*

Segment 2

Purpose

To determine Basal Metabolic Rate (BMR) and to calculate total energy needs

Materials

Baseline Energy Needs worksheet p. 39
calculator
bathroom scale
measuring tape

Background

All living things must get and use energy to live. Plants get their energy from the Sun in a process called photosynthesis. Human beings and other animals cannot process energy in the same way plants do. We must use a variety of food sources to meet our energy needs. The amount of energy stored in food is measured in calories. One calorie is the amount of energy needed to raise the temperature of 1 gram of pure water (or 1 mL) of water 1 degree Celsius. Most food labels are written with a capital "C," which represents a kilocalorie, the equivalent of 1,000 calories. A person's energy needs are based on gender, weight, height, and daily activities. Basal Metabolic Rate (BMR) stands for the number of Calories necessary to maintain life. This number is the baseline estimate of a person's energy needs when the body is resting. Your total energy needs depend on the type of activities you do and the time you spend doing them.

***Note**: Some of the numbers in the equation (to find the BMR) have been rounded for easier calculation.*

- For boys: BMR = 66.5 + (13.8 x W) + (5.0 x H) – (6.8 x Age)
- For girls: BMR = 655.1 + (9.5663 x W) + (1.9 x H) – (4.7 x Age)

W = actual weight in kilograms (1 kg = 2.2 lb)**

H = height in centimeters (2.54 cm = 1 in.)

Age = in years

** *Weight is not measured in kilograms, only mass. Weight is the amount of force acting on the mass. However, for simplicity, the term weight is used here.*

Procedure

1. Using the scale, obtain your weight in pounds.
2. Using your calculator, divide your weight in lb by 2.2 to give your weight in kg.
3. Record your weight in kg on the Baseline Energy Needs worksheet on page 39.
4. Using the measuring tape, obtain your height in cm. *(If a cm measurement is not available, divide your height in in. by 2.5 to give your height in cm).*
5. Record your height in cm on the Baseline Energy Needs worksheet.
6. Using the information from steps 2 and 4, complete the steps on the Baseline Energy Needs worksheet to get your own BMR.
7. Now that you know your BMR, let's find out your total energy needs.
8. In the Total Energy Needs chart, choose which energy level best suits your lifestyle *(low, medium, or high)*.
9. Multiply your BMR by the number listed for your energy level.
10. Record your answer on the appropriate line next to your energy level.
11. You now know approximately what your daily caloric needs are.

*** This hands-on activity was adapted from activities in *From Outer Space to Inner Space/Food and Fitness: Activities Guide for Teachers* created by Baylor College of Medicine for the National Space Biomedical Research Institute under NASA Cooperative Agreement NCC 9-58. The activities used with permission of Baylor.**

• For additional activities visit *http://www.nsbri.org/Education/Elem_Act.html*

Basal Metabolic Rate and Calories*

Segment 2

Conclusion

1. Why is your BMR important?
2. What could a person do if he or she wanted to use more or fewer Calories in a day?
3. What would happen if you consumed more Calories than you actually need? Fewer Calories?
4. Why should astronauts worry about their BMR and total energy needs?

Extension

1. In your science journal, keep track of the amount of Calories you eat in a day. Compare that amount to the number of Calories you might consume in a day based on your total energy needs. Research foods that make a healthy diet. Plan a diet based on your specific total energy needs.
2. Find out about The President's Challenge: Active Lifestyle Program. This physical activity and fitness awards program is designed to motivate and reward students who work to become more physically active. Convince other people in your school to become involved. With the help of an adult, you can start your own physical fitness programs!

Basal Metabolic Rate and Calories*

Chart

Baseline Energy Needs

Weight = _______ lb ÷ 2.2 = ________ kg

Height = _______ in. ÷ 2.5 = _______ cm

Total Energy Needed

Resting energy needs, also called BMR, account for only some of the Calories used by the body. Physical activities also use energy. The total amount of energy used depends on the kind of activity and time spent working on it.

Use the BMR you calculated to find out how many Calories you might actually use each day.

BOY	***GIRL***
______ *kg x 13.8 =* ______ (A)	______ *kg x 9.6 =* ______ (A)
______ *cm x 5 =* ______ (B)	______ *cm x 5 =* ______ (B)
______ (A) + ____ (B) = ______ (C)	______ (A) + ____ (B) = ______ (C)
______ (C) *+ 66.5 =* ______ (D)	______ (C) *+ 655.1 =* ______ (D)
______ (Age) *x 6.8 =* ______ (E)	______ (Age) *x 4.7 =* ______ (E)
______ (D) - ____ (E) = ______ (BMR)	______ (D) - ____ (E) = ______ (BMR)

Select the category that best describes the exercise level for you and solve the corresponding equation that follows. You also will need your BMR number from the Baseline Energy Needs worksheet.

- **Low Energy:** Most strenuous activities in a day include at least an hour of one of the following: reading, sitting, or eating.

  Equation: 1.3 x BMR = ______Cal/Day

- **Medium Energy:** Most strenuous activities in a day include at least an hour of the following: walking, dancing, skating, bowling, golfing, or other light exercise.

  Equation: 1.7 x BMR = ______Cal/Day

- **High Energy:** Most strenuous activities in a day include at least one hour of one of the following: running, bicycling, playing basketball, playing soccer, gymnastics, playing tennis, or other moderate to intense exercise.

  Equation: 1.9 x BMR = ______Cal/Day

A Little Dry Around the Edges

Segment 2

Materials

- dehydrated foods (dehydrated bananas, figs, beef jerky, apple chips, fruit, instant pudding, powdered drink mix, dehydrated ice cream)
- plastic sandwich bags
- straws
- scissors
- water
- science journal

Purpose

To demonstrate food dehydration

Background

The food NASA astronauts eat in space is very similar to the food you can find at a grocery store. Astronauts may choose their menus from a standard menu, or they may substitute food choices of their own provided they meet nutritional guidelines. Dietitians check the astronaut's menus to ensure they are balanced and nutritional. Weight and volume are problems for anything launched into space. Food is no different. Weight allowed for food is limited to 1.7 kg per person per day, including the packaging, which weighs 0.45 kg. All food is either eaten fresh or precooked and needs no refrigeration. Precooked food is ready to eat by heating it or adding water to it. Water is added to foods that have been dehydrated. Dehydration is one method of preparing food for space. Dehydrated food has had the water it contains removed. To rehydrate these foods, water or saliva can be added.

Note: *Dehydrated ice cream has separate instructions to rehydrate. Check the package for the correct method.*

Procedure

1. Examine the dehydrated food.
2. In your science journal, describe the food with words and pictures.
3. Some dehydrated food can be rehydrated with just the saliva from the mouth.
4. Rehydrate the bananas, apple chips, fruit, figs, and beef jerky in your mouth. Pay attention to the way the food feels and tastes as it rehydrates.
5. Record your observations in your science journal.
6. Some dehydrated food must be rehydrated by adding water.
7. Place the instant pudding in a plastic bag. Put the powdered drink mix in another bag.
8. Taste a small amount of the dehydrated instant pudding and powdered drink mix.
9. Add a small amount of water to each bag.
10. Now taste the rehydrated food.
11. Record your observations in your science journal.

Conclusion

1. Why do astronauts use dehydrated food?
2. What are some other uses of dehydrated food other than food for space travel?
3. What other kinds of dehydrated foods can you think of?
4. Explain why some dehydrated foods can be rehydrated by mouth and others must be rehydrated with water?

Extension

Dehydrate some foods on your own. Place various types of fruit in the sun (i.e., grapes, plums, apricots). Record what happens in your science journal.

Find the space grocery list online. Visit your grocery store to see how many items you can find. Why do you think some of the products on the list were chosen?

Eating Healthy in Space*

Segment 2

Problem

To plan a menu for an astronaut by using caloric values, serving sizes, and food groups

Materials

(per group)

- assortment of different size needles
- thread
- 1 large cup
- 1 small cup
- water
- paper towels
- soft ball
- science journal
- blindfold (optional)

Optional Web Sites

NASA: National Space Biomedical Research Institute

Go to this web site to download a PDF copy of Food and Fitness and use pages 18–19 to find the caloric value of various foods.

http://www.nsbri.org/Education/Elem_Act.html

Mike's Calorie and Fat Gram Chart for 1000 Foods

At this web site, foods are listed alphabetically for easy use.

http://www.caloriecountercharts.com/chart1a.htm

Calorie Counter Database

Visit this web site to search by food categories and find your favorite brand name foods with nutritional information.

http://www.calorie-count.com/

Caloriesperhour.com: Food Calories and Nutrition Calculator

Visit this web site to find the caloric value of food as well as the number of calories you burn while doing various activities. If you enter your height, weight, and age, you can even calculate your body mass index (BMI), basal metabolic rate (BMR), and resting metabolic rate (RMR). This site also provides a sample of what you can eat to burn the number of calories in each activity. *http://www.caloriesperhour.com/index_food.html*

Kids' Health—For Kids: The Food Guide Pyramid

Visit this great web site for kids to learn about the food pyramid and serving sizes. *http://kidshealth.org/kid/stay_healthy/food/pyramid.html*

Food and Nutritional Information Center: Food Guide Pyramid

Check out this site to view or download a copy of the Food Guide Pyramid booklet produced by the US Department of Agriculture (USDA). The booklet is also available in Spanish. *http://www.nal.usda.gov/fnic/Fpyr/pyramid.html*

Procedure

Part 1. Planning a Menu

1. Using your current knowledge, discuss in your group what constitutes a healthy diet for an astronaut. Be sure to discuss the number of calories, nutrition needs (food groups), portion sizes, and variety.
2. Use the Menu Planner to plan a 3-day menu for an astronaut.
3. Use a calorie counter book or web site to determine the number of calories for each food and record the daily total at the bottom of the Menu Planner.
4. Use a food pyramid to determine the food group(s) for each food and record the total for each food group at the bottom of the Menu Planner on page 44.

*** This hands-on activity was adapted from activities in *From Outer Space to Inner Space/Food and Fitness: Activities Guide for Teachers* created by Baylor College of Medicine for the National Space Biomedical Research Institute under NASA Cooperative Agreement NCC 9-58. The activities used with permission of Baylor. All rights reserved.**

- **For additional activities visit *http://www.nsbri.org/Education/Elem_Act.html***

Eating Healthy in Space*

Segment 2

5. Discuss in your group and decide whether your 3-day menu plan is healthy and sufficient for an astronaut.
6. Share your menu with the class and discuss the pros and cons of your menu plan.

Part 2. Serving Size

Food labels and other guides often use "serving size" to describe a recommended single portion of food. Serving sizes are different for various foods (liquid versus solid foods and cooked versus raw foods). In many cases, the amount specified as a "serving size" for a particular food is smaller than the amount typically eaten. Food portions frequently are measured in terms of cups, pieces, ounces, and other units.

1. Using the Menu Planner, write down everything you had to eat yesterday.
2. Use a calorie counter book to help determine the serving size of each food. For example, one serving (portion) is equal to either 1 slice of bread, 2 tablespoons of peanut butter, 1 tablespoon of jelly, about 15 potato chips (1 oz), or 1 cup of milk. If you ate a peanut butter and jelly sandwich with a bag of chips and a glass of milk, you probably consumed 2 servings of bread, 1–3 servings of peanut butter, 1–4 servings of jelly, 1–2 servings of chips, and 1–2 servings of milk.
3. Were serving sizes different from what you perceived as a single serving? Discuss and record the similarities and differences.
4. Often, the serving sizes listed on the labels of food packages are larger than the serving sizes listed by other guides, such as the Food Pyramid. Look at the Nutrition Facts on various labels and compare the serving sizes listed in other guides. Discuss how they differ and why.

Part 3. Calorie Counting

Our bodies constantly use energy. Food provides us with the energy we need for our daily activities. The amount of energy stored in food is usually measured in calories; however, to maintain an appropriate weight, we must balance the foods we eat with the energy we spend. Calorie intake must match calorie expenditure. When the body takes in too many calories, part of the excess is stored as fat. Conversely, when more calories are used than are consumed, stored fat is burned to make up the energy difference.

1. Using the portion size determined for each food listed in Part 2, determine the number of calories consumed for the day.
2. An average, moderately active 7 to 10 year old needs about 2,000 calories per day. Did your diet have more or fewer calories than the average needed?

Eating Healthy in Space*

Segment 2

Part 4. Nutritional Needs

The Food Pyramid helps you choose a healthy diet by recommending the number of servings you should eat daily from each of the six food groups. Be careful and don't be fooled by serving sizes. The serving sizes may be different from the ones on nutrition facts labels. For a balanced diet, it is not only important to eat the correct number of calories, it is also important to eat a variety of foods so that you get all the nutrients you need to maintain a healthy body. Here are some general guidelines for a healthier diet. Choose the following whenever possible:

1. Use the Food Pyramid Guide (page 45) and a food pyramid resource to determine the food groups consumed in your diet (listed in part 2). Be sure to list a group twice or more if you ate more than one serving of the food. For example, a large bagel is about 3.5 servings, so it would be about 3.5 servings of wheat and grains.
2. Tally the number of servings in each food group and record.
3. Discuss whether your diet was a "balanced" diet.

Part 5. Evaluate and Correct

It is important to remember that everyone has unique nutritional and health care needs. However, for this exercise, it has been determined that an average astronaut needs about 3,000 calories per day.

1. Using what you have learned about serving size, calories, and food groups, carefully evaluate the 3-day menu you planned for an astronaut in Part 1.
2. Make any necessary changes to your menu to create a well-balanced diet with the proper number of daily calories.
3. Share your menu with the class and discuss.

Conclusion

1. What other factors should be considered when planning a menu?
2. Was it difficult to balance calories and nutrition? Why or why not?

Extensions

1. Look up the number of calories for small, large, and super size orders of French fries from your favorite fast food restaurant. Discuss the disadvantages to "super-sizing" your fries.
2. Visit the web sites of various fast food restaurants and determine which foods on the menu are the healthiest choices.
3. Discuss how you can improve your diet by making better choices.

Eating Healthy in Space*

Menu Planner

DAY / DATE

Water: Eight cups (8-oz glasses) per day

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

TIME	FOOD ITEM & AMOUNT *(List major ingredients for prepared foods.)*	CALORIES	FOOD GROUP					
			Breads	Vegetables	Fruit	Meats	Milk	Fats
			Br	Ve	Fr	Me	Mi	Fa

Physical Activity

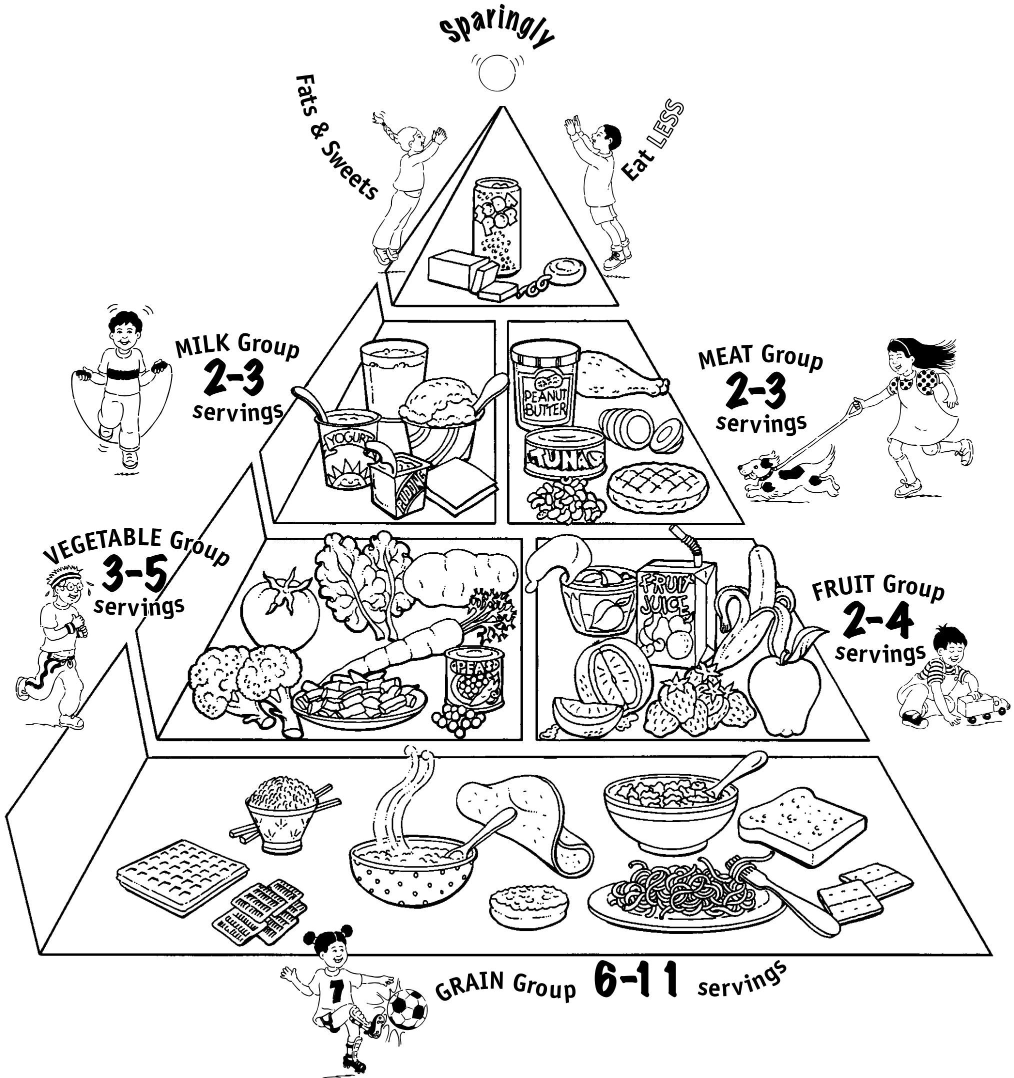
DAILY TOTALS

Calories ___________

Br	Ve	Fr	Me	Mi	Fa

Eating Healthy in Space*

Food Pyramid Guide



Note: The Food Pyramid is changing in 2005.
http://www.nal.usda.gov/fnic/fpyr/pyramid.html

Eating Healthy in Space*

Labels & Estimates

Serving sizes often are smaller than the portions we actually eat.

Look for low levels of saturated, hydrogenated, and trans fats. They are unhealthy.

Cholesterol is found in foods of animal origin.

Look for foods that have more carbohydrates as fiber and fewer as sugar. Only foods from plants provide fiber.

Protein is important for muscles and growth. It is found in animal and plant foods.

Vitamins and minerals are essential for health. Calcium is important for bones and teeth.

Use this section as a guide for daily planning. The amount of calories needed by each person depends on many factors, including exercise.

Refried Beans Fat Free

Nutrition Facts

Serving Size 1/2 cup (125g)
Serving Per Container 3.5

Amount Per Serving	
Calories 130	Calories from Fat 0
	% Daily Value*
Total Fat 0g	**0%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 490mg	**20%**
Total Carbohydrate 24g	**8%**
Dietary Fiber 7g	**28%**
Sugars 0g	
Protein 9g	**16%**
Vitamin A	**0%**
Vitamin C	**0%**
Calcium	**6%**
Iron	**15%**

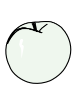
* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

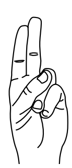
	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Use the Quick Hand Measures to estimate the size of one serving of different foods.

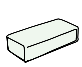
Quick Hand Measures

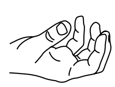
A closed fist = Piece of fruit or cup of raw vegetables



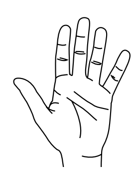


Two fingers = Ounce of cheese

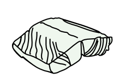




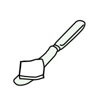
A cupped hand = Cup of dry cereal



An open hand = Single serving of meat



Tip of thumb = Teaspoon of butter



Are Two Eyes Better Than One?

Segment 2

Purpose

To understand the benefits of stereoscopic vision

Background

People have two eyes positioned side by side. Each eye takes a view of the same area but from a slightly different angle. The two images are sent to the brain where the similarities are combined and the small differences are added in. All this information combined creates the final image we actually "see" and is called stereoscopic vision. With stereoscopic vision, we can more accurately see the position of objects in relation to our bodies. Robots that explore other planets must be able to see where they are going. Just like people, robots make good use of two eyes. Why are two eyes so much better than one?

Materials

(per group)

assortment of different size needles
thread
1 large cup
1 small cup
water
paper towels
soft ball
science journal
blindfold (optional)

Procedure

1. Cover or shut one eye.
2. Try to thread a needle.
3. With one eye still closed, try to thread a bigger needle.
4. Now try to thread the same needles with both eyes open.
5. Was there a difference?
6. Write or draw in your science journal what happened.
7. Cover or shut one eye.
8. Try to pour water from the large cup into the smaller cup.
9. Now try to pour the water from the large cup into the smaller cup with both eyes open.
10. Was there a difference?
11. Write or draw in your science journal what happened.
12. Clean up any spilled water with the paper towels.
13. In a small group, stand in a circle.
14. Have every person cover or shut one eye.
15. Toss a ball that is soft around the circle.
16. Make sure every person has a chance to participate.
17. Now do the same thing with both eyes open.
18. Was there a difference?
19. Write or draw in your science journal what happened.
20. Focus on one object in the room.
21. Cover or shut one eye.
22. Hold up your thumb and line it up so that it covers the object completely.
23. Still holding your thumb up, open the closed eye and cover or shut the other eye.
24. In your science journal, write or draw what happened.

Are Two Eyes Better Than One?

Segment 2

Conclusion

1. Why was it challenging to do some of the previous activities with one eye closed?
2. What would happen if your eyes were spaced farther apart? Would you still be able to see the same way?
3. Why is it important for the Mars rovers to have stereoscopic vision?

Extension

Not all animals have stereoscopic vision. Some animals have monocular vision. Conduct research to find out more about monocular vision. Find out which types of animals have stereoscopic vision and which ones have monocular vision. Make a Venn diagram to compare and contrast stereoscopic and monocular vision.

Red Rover, Red Rover

Segment 2

Purpose

To explore the challenges faced by scientists and engineers operating rovers and to understand the importance of stereoscopic vision

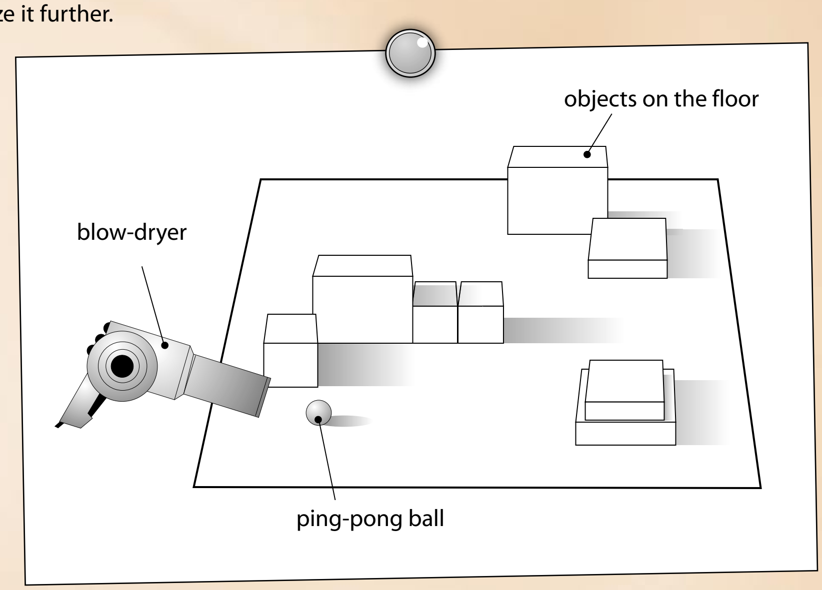
Materials

ping-pong ball
different sized objects to make obstacles (blocks, cans, books)
science journal
blow-dryer
blindfold (optional)

Background

A rover is a remotely operated vehicle built mostly for use on unmanned missions. A rover can go to places human beings can't due to the harshness of space, distance, or possible threats to people (e.g., radiation and extreme temperatures). Rovers scan the ground, move toward a selected item such as a rock, collect information, and send that information back to scientists here on Earth. Just like human beings, rovers have "eyes," an arm, mobility, and the ability to communicate. Because of the large distances from Earth to the rover's location, scientists cannot communicate with the rover in real time. The rovers communicate with Earth only a few times a day. Scientists are looking for places of interest, so they use the rover's cameras to decide where to send the rover. In the morning, the rover receives destination coordinates but is not told how to reach the destination. The rovers must use their "brain" (computer software) and "eyes" (stereoscopic cameras) to navigate to the correct destination. Navigating on another planet hundreds of millions of miles away is an incredible challenge. The surface might have hazards such as deep canyons, volcanic mountains, craters, boulders, or sand dunes. The "brain" of the rover is programmed with a given set of responses. When the rover encounters a hazard or an obstacle, it must "think" of how best to maneuver around the area. The stereoscopic cameras are essential for proper navigation. They give the rover the ability to judge distances and to maneuver around or over obstacles. Once the rover arrives at its destination, it samples the soil and rocks around the site. At the end of the day, scientists on Earth download the information the rover has collected to analyze it further.

Procedure



1. Arrange your obstacles in various locations on the floor.
2. Some obstacles can be stacked upon each other.
3. Place the ping-pong ball near the obstacles.
4. With adult supervision, use the blow-dryer to blow the ball towards the obstacles.
5. Try to make the ball go over the obstacles.
6. Record in your science journal what happened.
7. Close one eye or cover it with a blindfold.
8. Try to make the ball go over the obstacles.
9. Record what happened.
10. Close both eyes.
11. Have a partner give you directions to help you maneuver the ball over the obstacles and record what happened.
12. Arrange the objects to make a maze.

Red Rover, Red Rover

Segment 2

13. Using both eyes, try to maneuver the ball through the maze by using the blow-dryer and record what happened.
14. Close one eye and try to make the ball go through the maze. Record what happened.
15. Close both eyes and have a partner give you directions to help you maneuver the ball through the maze. Record what happened.

Conclusion

1. Was it better to have one eye, two eyes, or no eyes to maneuver the ball over the obstacles and through the maze? Why?
2. What would make it easier to maneuver the ball over the obstacles and through the maze?
3. What challenges might engineers face in sending a rover to another planet?

Extension

1. Create your own rover. Purchase a remote control model, build it, and try to maneuver it over the same obstacles and through the same maze. Was the result the same as with the ping-pong ball? Record your findings in your science journal.

2. Visit the NASAexplores web site and complete the activity, "Commanding a Robot." Why is communication such an important part of the command process?

   http://www.nasaexplorers.com/show_58_teacher_st.php?id=030109160421

Answer Key

Segment 2

Puffy-Head, Bird-Leg Syndrome

1. The circumference became larger.
2. Students answers will vary but should include remarks about the fluid in the legs moving downward toward the floor.
3. When the astronauts move or work in microgravity, the fluid in the lower part of their bodies moves upwards without the aid of gravity to maintain normal flow.
4. Your legs return to normal size.
5. Astronauts must do specific exercises and continue to physically move around while in microgravity to lessen the effects.

Boney Bones

1. The residue on the coffee filter is calcium.
2. The coffee filter represents the kidney.
3. Microgravity affects human bones by breaking down the calcium in the bones. This excess calcium is released into the bloodstream. The kidneys must then filter the calcium from the blood. Excess calcium hardens in the kidney ducts and becomes kidney stones.
4. Exercise, diet, and adequate in-flight rest help overcome this problem.

Basal Metabolic Rate and Calories

1. The BMR tells you how much energy the body requires to function when it is at rest.
2. A person should increase activity levels to increase the number of Calories used in a day or reduce activity levels to decrease the number of Calories needed in a day.
3. When a person consumes more Calories than the body uses, the leftover energy is converted to fats and stored in the body. A person may be sick or even die if the body does not take in enough Calories to maintain its vital functions for an extended period of time.
4. Astronauts want to be in the best possible physical condition to stay alert, complete their jobs, and return home safely. Understanding more about their own BMRs will help them plan and implement a diet that meets the needs of their bodies in the harsh microgravity environment.

A Little Dry Around the Edges

1. Dehydrated foods do not require refrigeration to avoid spoiling and weigh less because they have little or no water content.
2. People take dehydrated foods on camping trips. Soldiers use these foods for survival packs. Some dehydrated foods are healthy snacks. (Additional answers may vary.)
3. Answers will vary.
4. Whether the food can be rehydrated in the mouth or by using water depends on the amount of liquid required to rehydrate it.

Eating Healthy in Space

1. Answers will vary.
2. Answers will vary.

Are Two Eyes Better Than One?

1. If your brain is getting information from only one eye, you have no depth perception. One eye is better than none and you would need very good directions if you had no eyes.
2. Although peripheral vision would improve, a blind spot would develop between the eyes.
3. The rover can better maneuver over and around obstacles when it is using stereoscopic vision. The rover is able to determine distance from objects as well.

Red Rover, Red Rover

1. Two eyes give you more information about your surroundings.
2. Answers will vary.
3. The surface of the planet may be uneven, covered with rocks or debris, have canyons, mountains, craters, or sand dunes. Most of the terrain explored by the Rover is unknown territory that has never before been seen or mapped.

On the Web

Sources of Energy

1. Since 1 calorie is needed to raise 1 mL of water 1 °C, 50 calories would be needed to raise the temperature of 50 mL of water.
2. Answers will vary.
3. Answers will vary. (Whichever food yielded the most calories will provide the most energy.)
4. When the body digests food, enzymes in the digestive system release the energy in the foods. This process is similar to what occurs when the food is burned with the flame.
5. Foods that contain more potential or stored energy provide larger amounts of calories when they are burned in the body.

3-D and Me

1. Answers will vary but might include that the pictures looked fuzzy and that there are lines of blue and red in the pictures. Answers will vary but might include that after the glasses were put on, the picture looked more real and had depth to it.
2. Answers will vary, but might include that rovers need the depth perception provided by 3-D vision to more easily maneuver on a planet and avoid obstacles.

The NASA SCI Files™

The Case of the Great Space Exploration

Segment 3

Bianca continues her training at Space Camp while Catherine visits Mr. Mark Weyland at NASA Johnson Space Center in Houston, Texas. Mr. Weyland explains that there are two basic types of radiation and that it is one of the top biological concerns facing our astronauts during long-term space travel. He also tells Catherine about new technology that NASA is exploring to overcome the effects of space radiation. This new technology will enable the next generation of explorers to travel safely to the Moon, Mars, and beyond. Next, the tree house detectives dial up Ms. Dana Novak at the University of California at Santa Barbara to learn how mussels and bloodworms are helping scientists invent new self-healing materials for spacecraft. Bianca takes a break from her training to go over and talk with Mr. Steve Cook at NASA Marshall Space Center in Huntsville, Alabama to learn about future propulsion systems for space travel. Finally, Dr. D goes to Space Camp and meets with Bianca to learn about gravity, G forces, and the feeling of weightlessness on a ride that is "out-of-this-world."

Objectives

Students will

- demonstrate the power of solar radiation.
- investigate the effect of solar radiation on an object.
- analyze the effectiveness of different Sun Protection Factors (SPF).
- understand how technology can be inspired by nature.
- demonstrate the symmetrical shape of nanotubes.
- explain nanotube technology.
- simulate the properties of self-healing materials.
- demonstrate self-assembly characteristics of materials.
- investigate alternative sources of energy.
- understand that weight is a result of gravity.
- simulate microgravity.

Vocabulary

bio-inspired — designed to copy patterns in nature

biology — the science or study of life and living things

composite – made up of more than one material

electromagnetic spectrum — forms of electromagnetic radiation that include radio waves, microwaves, infrared radiation, visible light, ultraviolet rays, X-rays, and gamma rays.

g — a unit of force equal to the force exerted by gravity on a body at rest; used to indicate the force to which a body is subjected when accelerated

nanotechnology — applying technical knowledge or tools to build things on a microscopic level by controlling how the atoms are arranged

photon — a tiny packet or bundle of energy belonging to a particular wavelength that is released when an electron loses its extra energy. Light is made up of a stream of photons.

propulsion system — the source of energy that moves an object forward

radiation — the emission or putting off of energy, especially light and heat, in waves or particles

ray — a straight line that represents the motion of light in one direction

self-healing — able to repair itself by sealing small cracks or holes

solar array — panels used to collect and store energy from the Sun

visible spectrum — the only part of the electromagnetic spectrum that we can see, including the colors of the rainbow: red, orange, yellow, green, blue, and violet

wavelength — distance between any two corresponding points on successive waves, usually crest to crest or trough to trough

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 3 of *The Case of the Great Space Exploration*, discuss the previous segment to review the problem and assess what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on **Tools**. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use this section of the web site to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 2 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during previous segments. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 2.
5. Read the overview for Segment 3 and have students add any questions to their list that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the **Educators** area of the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program so they will be able to answer the questions. An icon will appear when the answer is near.
7. **"What's Up?" Questions**—These questions at the end of the segment help students predict what actions the

Careers
biologist
biomedical researcher
communications expert
chemical engineer
chemist
electrical engineer
mechanical engineer
nanotechnologist
radiologist
spacecraft design engineer
Health Physicists
Nuclear Engineer

tree house detectives should take next in the investigation process and how the information learned will affect the case. Teachers can print them from the Educators area of the web site ahead of time for students to copy into their science journals.

View Segment 3 of the Video

For optimal educational benefit, view *The Case of the Great Space Exploration* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. Have students reflect on the "What's Up?" Questions asked at the end of the segment.
2. Discuss the Focus Questions.
3. Have students work in small groups or as a class to discuss and list what new information they have learned about space flight and its effects on human beings, the importance of good nutrition and exercise, and how astronauts train for missions. Organize the information, place it on the **Problem Board**, and determine whether any of the students' questions from the previous segments were answered.
4. Decide what additional information is needed for the tree house detectives to determine what else astronauts need to deal with radiation, weightlessness, and the harsh environment of space. Have students conduct independent research or provide students with information as needed. Visit the NASA SCI Files™ web site for an additional list of resources for both students and educators.
5. Choose activities from the Educator Guide and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
6. For related activities from previous programs, download the **Educator Guide**. On the NASA SCI Files ™ home page, select **Educators**. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Inhabitable Habitat*. In the green box, click on **Download the Educator Guide.**

a. In the **Educator Guide** you will find

1. **Segment 3** – *Vomit Comet*

Close the PDF window to return to the **Educator Guide** page. Using the yellow back arrow on the NASA SCI Files™ page (do NOT use the back button on your browser), return to the Episode description page. In the green box, click on **Activities/Worksheets**.

b. On the web site in the **Activities/Worksheets** section you will find

1. *Creating Microgravity*

Close the PDF window and return to the **Educator Guide** page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Mysterious Red Light*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

1. **Segment 1** – *Natural or Artificial*
2. **Segment 1**—*Traveling the Straight and Narrow*
3. **Segment 1** – *Roping the Wave*
4. **Segment 1** – *Wave Upon Wave*
5. **Segment 1** – *Roll out the Frequency*
6. **Segment 3**—*Spinning White Light*
7. **Segment 3**—*Primary Colors of Light*
8. **Segment 3**—*Rainbow of Knowledge*

Close the PDF window to return to the **Educator Guide** page. Using the yellow back arrow on the NASA SCI Files™ page (do NOT use the back button on your browser), return to the Episode description page. In the green box, click on **Activities/Worksheets**.

b. On the web site in the **Activities/Worksheets** section, you will find

1. *Pouring a Little Light on the Subject*
2. *Incredible Edible Wave*
3. *The Edible Spectrum*

Close the PDF window and return to the **Educator Guide** page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Galactic Vacation*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

1. **Segment 3** – *There's a Micro in my Gravity*
2. **Segment 3** – *All Aboard for Destinations Unknown*
3. **Segment 3** – *Rocket Go Round*
4. **Segment 3** – *Rocket Racer*
5. **Segment 3** – *There's an Ant in Your Acid*

Close the PDF window to return to the **Educator Guide** page. Using the yellow back arrow on the NASA SCI Files™ page (do NOT use the back button on your browser), return to the Episode description page. In the green box, click on **Activities/Worksheets**.

b. On the web site in the Activities/Worksheet section, you will find

1. *3-2-1 Launch!*
2. *Newton's Car*

7. If time did not permit you to begin the web activity at the conclusion of Segments 1 or 2, refer to number 6 under After Viewing on page 15 and begin the PBL activity on the NASA SCI Files™ web site. If the web activity was begun, monitor students as they research within their selected roles, review criteria as needed, and encourage the use of the following portions of the online, PBL activity:

   Research Rack – books, Internet sites, and research tools

   Problem-Solving Tools – tools and strategies to help guide the problem-solving process

   Dr. D's Lab – interactive activities and simulations

   Media Zone – interviews with experts from this segment

   Expert's Corner – listing of Ask-an-Expert sites and biographies of experts featured in the broadcast

8. Have students write in their journals what they have learned from this segment and from their own experimentation and research. If needed, give students specific questions to reflect upon as suggested on the **PBL Facilitator Prompting Questions** instructional tool found by selecting **Educators** on the web site.

9. Continue to assess the students' learning, as appropriate, by using their journal writings, problem logs, scientific investigation logs, and other tools that can be found on the web site. Visit the **Research Rack** in the **Tree House** and find the online PBL investigation main menu section, **Problem-Solving Tools**, and the **Tools** section of the **Educators** area for more assessment ideas and tools.

Resources *(additional resources located on web site)*

Books

Gherman, Beverly: *Mysterious Rays of Dr. Roentgen.* Simon and Schuster, 1994, ISBN: 0689318391.

Goodman, Susan E.: *Ultimate Field Trip: Blasting off to Space Academy.* Simon and Schuster Children's, 2002, ISBN: 0689848633.

Hillerman, Astrid and Hillerman, Anne: *Done in the Sun: Solar Projects for Children.* Sunstone Press, 1990, ISBN: 0865340188.

Petersen, Christine: *Alternative Energy.* Scholastic Library, 2004, ISBN: 0516228048.

Petty, Kate: *You Can Jump Higher on the Moon and Other Amazing Facts About Space Exploration.* Millbrook Press, 1997, ISBN: 0761305920.

Riley, Peter D.: *Energy.* Heinemann Library, 1998, ISBN: 1575726173.

Snedden, Robert: *Energy.* Heinemann Library, 1999, ISBN: 1575728796.

Stewart, Melissa: *Life Without Light.* Scholastic Library, 1999, ISBN: 0531115291.

Walisiewicz, Marek: *Essential Science: Alternative Energy.* DK Publishing, Inc., 2002. ISBN: 0789489198.

Video

Interactions Real Math – *Real Careers: Building a Rover*
Grades 7–adult

Scholastic: *Magic School Bus: The Space Adventures*
Grades K–5

TMW Media Group: *Cool Space Stuff: Delivering Destiny*
Grades 6–adult

Web Sites

NASA: Space Radiation Health Project
Visit this web site to learn what NASA is doing to overcome the effects of radiation during long-term space travel.
http://srhp.jsc.nasa.gov/

Space Radiation Shielding
The Space Radiation Shielding Program is part of Space Radiation Health Research, a new research initiative sponsored by the Office of Biological and Physical Research to help understand the effects of longer duration radiation exposure to astronauts.
http://www.radiationshielding.nasa.gov/about.html

NASA: Radiation Belts
An in-depth look at Earth's radiation belts.
http://www-istp.gsfc.nasa.gov/Education/Iradbelt.html

NASA: Electromagnetic Spectrum
Take a closer look at the electromagnetic spectrum and learn about wavelength, frequency, and more.
http://imagers.gsfc.nasa.gov/ems/ems.html

Radiation and Long-Term Space Flight
Visit this web site to learn more about space radiation, methods used to measure radiation, the effect of radiation on human beings, and NASA's plans to deal with space radiation.
http://www.nsbri.org/Radiation/

NASA Aerospace Scholars: Radiation
A great resource for educators to learn about radiation and its effects on the human body in space.
http://aerospacescholars.jsc.nasa.gov/HAS/cirr/em/11/5.cfm

Radiation for Kids
This web site has a wealth of information related to radiation, with many links to other sites that contain information about radiation, including a site to calculate your annual radiation exposure.
http://www.philrutherford.com/radiation_kids.html

NASA Marshall Space Flight Center
Find out more about the missions, organizations, history, and projects of NASA Marshall Space Flight Center in Huntsville, Alabama.
http://www.msfc.nasa.gov/

NASA Advanced Space Transportation
Visit this web site to learn about future transportation systems.
http://www.spacetransportation.com/ast/index.html

How Stuff Works: Solar Sails
Learn how solar sails will use photons from the Sun to propel spacecraft across the solar system.
http://science.howstuffworks.com/solarsail1.htm

In-Space Propulsion Innovations
NASA's Office of Space Science has issued a research announcement asking academic and industry researchers to propose in-space propulsion technology innovations—ideas that could revolutionize exploration and scientific study of the solar system.
http://www.msfc.nasa.gov/NEWSROOM/news/releases/2002/02-269.html

Exploring the Nanoworld With LEGO® Bricks
This web site shows how various physical and chemical principles relate to nanoscale science and technology and can be demonstrated with LEGO® models. Three-dimensional models are excellent tools for grasping structure-function relationships.
http://www.mrsec.wisc.edu/edetc/LEGO/index.html

What is a Nanotechnologist?
Interested in becoming a nanotechnologist? Visit this web site to learn what a nanotechnologist does.
http://www.mrsec.wisc.edu/edetc/technologist/index.html

The Next Big Thing (Only Smaller)
Watch a video about nanotechnology.
http://www.mrsec.wisc.edu/edetc/cineplex/nanotech.html

Microgravity
This educator guide contains excellent background information accompanied by classroom activities that enable students to experiment with the forces and processes microgravity scientists are investigating today.
http://spacelink.nasa.gov/Instructional.Materials/NASA.Educational.Products/Microgravity/

Your Weight on Other Worlds
Ever wonder what you might weigh on Mars or the Moon? Here's your chance to find out.
http://www.exploratorium.edu/ronh/weight/

Activities and Worksheets

Somewhere Over the Rainbow

Segment

Purpose

To discover the colors and order of the visible spectrum

Procedure

1. Place the mirror in the plastic shoebox and lean it against one end.
2. Slowly pour water into the box until the mirror is covered halfway.
3. Hold the poster board above the box at the opposite end of the mirror where the air, mirror, and water touch.
4. Shine the flashlight on the water just in front of the mirror.
5. Adjust the mirror's angle until a rainbow's reflection appears on the poster board.
6. On your art paper, draw the rainbow, making sure to place the colors in the correct order.

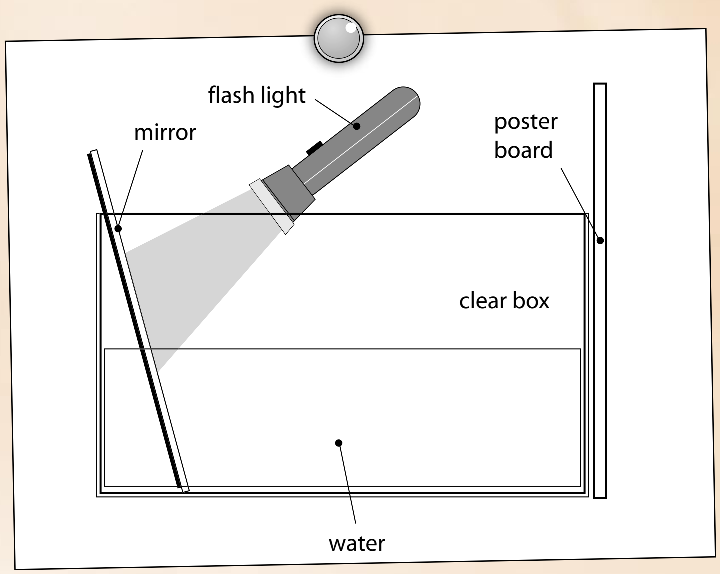
Materials

clear plastic shoebox or glass baking pan
9-in. x 12-in. white poster board
small mirror
ruler
white art paper
marker or crayons
water
flashlight

Conclusion

1. What are the colors of the rainbow? ____
____
2. How did the light, water, and mirror make a rainbow? ______________________________
____
3. Where have you seen other "rainbows?" ____
____

Misconception: *The visible spectrum has six colors: red, orange, yellow, green, blue, and violet. Scientists originally thought that the color indigo was between blue and violet. However, with more modern equipment, they now know there are only six colors. Therefore, Mr. ROY G BIV became Mr. ROY G BV.*



Photons and More Photons

Segment 3

Purpose

To simulate photons in light

Note: A teacher or parent should guide this activity. Prior to conducting this activity, students should have a basic understanding of the electromagnetic spectrum, visible light, and wavelength. Find activities in the Educator Guide for The Case of the Mysterious Red Light. Download a copy of the guide (2001–2002 Season) at http://scifiles.larc.nasa.gov/educators/index.html?p=episodes/guides

Materials

large open area such as a playground or field
chalk or duct tape to outline areas
15–20 meters (m) of thick rope knotted on each end and sectioned off in 1-m increments (Use marker or tape.)

Background for Educator

When we look at a source of light, whether it be a candle or a star, our eyes respond to a particular range of energy that makes up what we call visible light. Visible light, however, is only a small portion of the electromagnetic spectrum, the whole range of radiant energies from radio waves to gamma rays.

One of the biggest hazards involved in interplanetary spaceflight is exposure to radiation. During interplanetary spaceflight, outside of the protection of Earth's magnetic field, crews will be exposed to radiation from the Sun (from solar flares) and from cosmic radiation (from the rest of the universe). Space radiation, often considered the primary hazard associated with space flight, is also important to study because it can have a great impact on human health. In space, crewmembers are subjected to greater amounts of natural radiation than they receive on Earth, exposing them to possible immediate and long-term risks.

There are three major sources of radiation in space. The first, trapped belt-radiation, occurs from particles found in the Earth's magnetic field. A second type, called galactic cosmic rays (GCRs), consists of particles that originate outside the solar system. The third type results from a solar particle event (SPE), which sometimes accompanies solar flares and may be the most potent space radiation hazard to lightly shielded spacecraft. Regardless of the source, large amounts of radiation exposure can lead to radiation sickness and have the potential to damage the body's chromosomes.

Procedure

1. Prior to the simulation, outline an area on the ground approximately 3 m by 3 m to represent the Earth.
2. To represent the Sun, outline another area as a large circle approximately 5–8 m in diameter and 15–20 m from the Earth.
3. Discuss with the class the definition of a simulation.
4. Explain that a photon is the smallest amount of visible light or other form of electromagnetic radiation that demonstrates both particle and wave properties. Light is made up of a stream of photons.
5. Place students in the center of the Sun.
6. Have one student stand on the edge of the circle facing the Earth and grasp one end of the rope. He/she will be the first photon.

Photons and More Photons

Segment 3

7. Stretch the rope in a straight path toward the Earth.
8. Explain that the students in the Sun represent emerging photons.
9. To begin the simulation, choose one of the photons to leave the Sun and tag the first photon at the edge of the circle.
10. Never letting go of the rope, the "tagged" photon will then move up the rope to the next mark.
11. Meanwhile, other photons should leave the Sun in an orderly fashion, tagging the last photon on the edge of the circle and repeating the previous steps to create a "chain reaction" that simulates a flow of photons (light) from the Sun.
12. Continue until all photons have left the Sun.
13. Discuss the simulation with the students.
14. Use activities from *The Case of the Mysterious Red Light* to discuss reflection, refraction, and scattering.
15. Afterwards, repeat this simulation to enhance student understanding of what happens to light as it enters the atmosphere and strikes the Earth. Use objects, such as a chair or box, to "reflect, absorb, refract, or scatter" the photons as they enter the Earth's atmosphere.
16. Discuss why Earth does not receive as much radiation as objects in space.

Discussion Questions

1. How do the photons represent a beam of light?
2. What would happen if the photons stopped coming from the Sun?
3. What happens to the photons as they enter the Earth's atmosphere?
4. Explain why radiation is dangerous to astronauts in space.
5. Have students draw a diagram that represents the simulation.

Extension

1. Place a single sheet of newspaper or other thin paper on top of a grassy area. With adult supervision, gather several small pebbles to represent radiation and throw the pebbles at the newspaper. Note how the pebbles tear the paper. Discuss how radiation affects the human body on a cellular level.

Solar Radiation and SPF Levels

Segment 3

Purpose

To investigate the effects of solar UV radiation on an object and to analyze the effectiveness of different Sun Protection Factors (SPF)

Materials

(per group)

- dark construction paper (blue, purple, or red are best)
- scissors
- permanent marker
- sunscreen of 5 different SPFs (same brand)
- gingerbread man template p. 63
- science journal

Background

The Sun's radiation is very powerful and can be dangerous to human beings. In space, astronauts are exposed to more UV radiation than they are here on Earth and must be particularly careful to protect themselves by wearing face shields as part of their helmets. On Earth, we have the ozone layer and lower atmosphere to help absorb and/or scatter some of the harmful ultraviolet (UV) rays of the Sun; however, there is still enough to harm us. Have you ever been sunburned? Exposing your skin to too much solar radiation causes sunburn. People protect their skin from harmful solar UV radiation by using sunscreen.

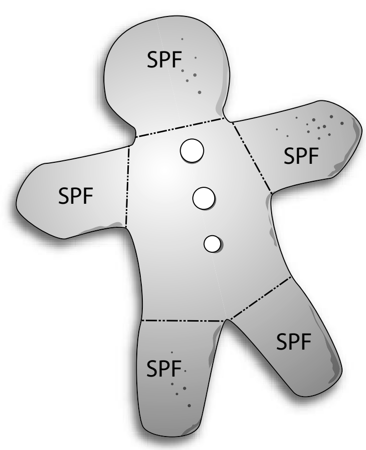
Sunscreen blocks or absorbs some of the UV light. Sunscreens offer various levels of protection and have a Sun Protection Factor (SPF), a number on the sunscreen. This number, multiplied by 10, gives you the number of minutes you can be exposed to the sun without getting burned. For example, an SPF 10 provides you with 100 minutes of protection from the Sun's harmful rays. Recent studies have shown that there is little difference between the protection power of SPF 30 and any of the higher SPFs.

On a sunny day, your shadow can be a great help in determining the amount of UV exposure to your skin. When the Sun is low in the sky, more of the UV light is absorbed, leaving less to harm you. As the Sun gets higher above the horizon, the atmosphere stops less of the UV light, allowing more of the harmful rays to burn you. To avoid being sunburned, you need to think about the **position** of the Sun in the sky. As a rule of thumb, when your shadow is longer than your height, your skin is getting less UV exposure. As your shadow shortens, more of the Sun's UV light can reach you and sunscreen is a must. One note of caution – even on cloudy days, when you can't see your shadow – UV rays are still there and can burn you.

Note: *Be sure to do this activity on a sunny day.*

Procedure

1. Use the template to cut one large gingerbread man from the dark construction paper.
2. Using the pen, divide the gingerbread man into sections: head, arms, and legs. See diagram.
3. Label each section with a different SPF number.
4. Coat the sections with the corresponding SPF sunscreen. Note: To control as many variables as possible, use the same brand of sunscreen for all samples.
5. Do not put sunscreen in the middle of the gingerbread man.
6. In your science journal, predict what will happen when you place the gingerbread man outside in the Sun.
7. Place your gingerbread man outside in a very sunny location.
8. Every 30–60 minutes check on your gingerbread man and record your observations in your science journal.
9. After a few hours, bring the gingerbread man inside.
10. Observe and record the appearance of the gingerbread man. Be sure to observe the other side of the gingerbread man.
11. Record your observations in your science journal.



Diagram

Solar Radiation and SPF Levels

Segment 3

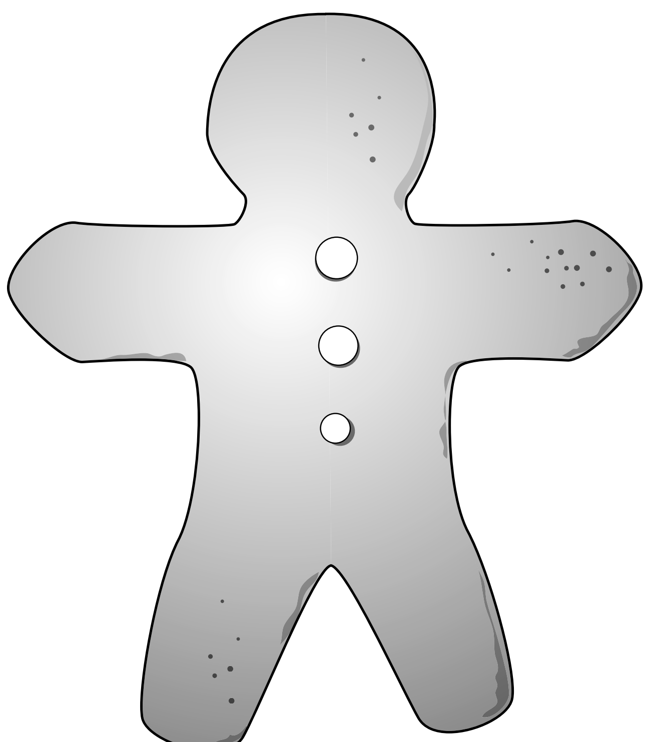
Conclusion

1. What happened to the gingerbread man when he was exposed to the Sun?
2. What happened to the unprotected part of the gingerbread man?
3. Which SPF gave the most protection? How can you tell?
4. Why is sunscreen important?
5. What conditions may change the amount of sunscreen needed?

Extension With UV Beads

Note: *UV beads change from white to various colors when exposed to UV light.*

1. Tie a UV bead to a string and take it, along with a ruler and a pail of water, outside. Lower the bead 2 centimeters (cm) into water and watch for a color change. Record your observations. Repeat by lowering the bead 2 more cm each time until no color change is observed. How far down does sunlight penetrate water?
2. Take a pair of sunglasses and place them in front of the UV bead, shading the bead from the Sun. Do the sunglasses protect the bead from UV light?
3. Observe UV beads indoors. What happens when the beads are indoors? Place the beads in a windowsill. Does UV light penetrate glass?
4. Take the beads outside on a cloudy day. Is there UV light on a cloudy day?
5. Try creating other experiments on your own with the UV beads.



Template

Let's Go Propelling

Segment 3

Purpose

To evaluate the effectiveness of a material

Background

Launching an object into space can be costly. NASA scientists are currently researching new methods to launch vehicles into space. They want to improve the fuel used for launch, to create new designs, new propulsion techniques, and new launch vehicles. Some new launch methods include orbital space planes, microwaves, and single-stage tethers. Because being in space is not at all like being on Earth, scientists must carefully test all materials for the new systems before they are actually used. In space there will be little gravity, no air, significant radiation, and extreme temperatures. The materials that are chosen must be effective in the space environment.

CAUTION: Adult supervision needed!

Materials

- empty aluminum soft drink can
- medium size balloon
- thick rubber band
- 60 mL very hot water
- large bowl
- ice cubes (optional)
- tongs
- scissors
- science journal

Procedure

1. Twist the pop tab off the empty soda can.
2. Being careful, stretch the balloon over the top of the can.
3. Fasten the rubber band around the rim of the can so the balloon will not pop off or leak air. See diagram 1.
4. With an adult's help, carefully pour the hot water into the bowl.
5. Using tongs, place the soda can in the bowl and hold it there for a couple of minutes. See diagram 2.
6. Observe the balloon and have your partner record the observations in your science journal.
7. Continue holding the can in the hot water and making observations every two minutes until the can cools completely.
8. Optional: If ice is available, empty the water from the bowl and refill it with ice.
9. Repeat steps 5–6, holding the soda can in the bowl for about 6–9 minutes.
10. Observe and record your observations.

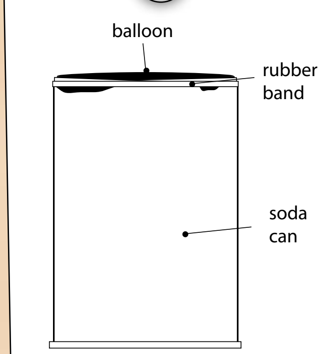


Diagram 1

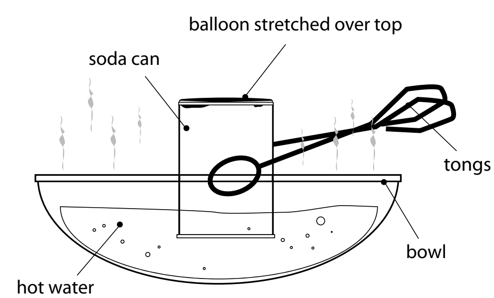


Diagram 2

Conclusion

1. What happened to the balloon when it was exposed to the hot water? Why?
2. What happened to the balloon as the water cooled? Why?
3. What happened to the balloon when the soda can was placed in the ice?
4. Would this material be appropriate for making a fuel tank on a spacecraft that was going to Jupiter? Why or why not?
5. Why is it important for scientists to carefully test new products?

Extensions

1. Scientists must also determine whether or not the cost of the new material is worth the expense. Go to the NASAexplores web site at *http://www.nasaexplorers.com/search_nav_5_8.php?id=03-033&gl=58* Read the article, *"Catch a Microwave."* Click on the link for the activity, *"What Are You Worth in Launch Bucks?"* Complete the activity. Decide which of the launch systems is the most cost effective. Should the least expensive choice always be used? Why or why not?
2. Research the NASA web site *http://www.nasa.gov* to find other types of propulsion systems NASA scientists are considering for future space flights. Make a poster explaining some of the new propulsion systems.

Hooks and Loops

Segment 3

Purpose

To understand how nature can inspire technology

Background

In 1948, a Swiss mountaineer named George de Mestral began to look closely at the burrs that had clung to his clothes during a walk through the woods. After examining the burrs under a microscope, he saw the small hooks on the seed-bearing burrs that allowed them to cling so tightly to the tiny loops in the fabric of his pants. De Mestral realized that it might be possible to use this principle to make a fastener that would compete with zippers. With the help of a weaver from France, de Mestral perfected his hook and loop fastener. He patented the design in 1955 and founded Velcro® Industries to manufacture his invention. Today the multimillion dollar company produces millions of yards of hook and fastener tape, the product inspired by nature.

Materials

- two matching pieces of hook and loop tape (such as Velcro®)
- magnifying lens
- white sock
- drawing paper
- pencil
- area with tall grass
- science journal

Procedure

1. Put the white sock on over the top of your shoe.
2. With adult supervision, go for a short walk in an area that has tall grass.
3. Return and carefully remove the sock.
4. Peel off any burrs that are stuck to the sock.
5. Observe the burrs with a magnifying lens.
6. In your science journal, draw a picture of your observations.
7. With a magnifying lens, observe each piece of the hook and fastener tape.
8. Put the two pieces together so that they stick.
9. Try to pull the pieces apart.
10. Change the direction of one of the pieces. Do they still stick?
11. Try to attach the pieces of hook and fastener tape together from the back side.
12. In your science journal, make a series of drawings to show how hook and fastener tape works.
13. Compare your drawings of the burrs to the drawings of the hook and fastener tape.

Conclusion

1. What makes the hook and fastener tape work?
2. What are some common uses for hook and fastener tape?
3. What is the advantage of hook and fastener tape over other kinds of fasteners?
4. What does bio-inspired mean?
5. What similarities to nature do you see in common, everyday tools and inventions?

Extension

1. Scientists look at animals to help discover new technology designs. Make a list of animals, other than birds, that might help scientists design new aircraft. Explain why you chose each animal.
2. What animals did the tree house detectives learn are inspiring stronger materials for future spacecraft. What other animals should scientists look at? Conduct research on biomemetics. Present your findings to the class.
3. Find out about other unique inventions. Where did the inventor get the inspiration for his/her invention? Make a poster advertising this "new" invention.

Nano, Nano, Nanotubes

Segment 3

Purpose

To explain nanotube technology and to demonstrate the symmetrical shape of nanotubes

Materials

3 brands of paper towels
water
measuring cup
large pan
pennies
magnifying lens
calculator

Background

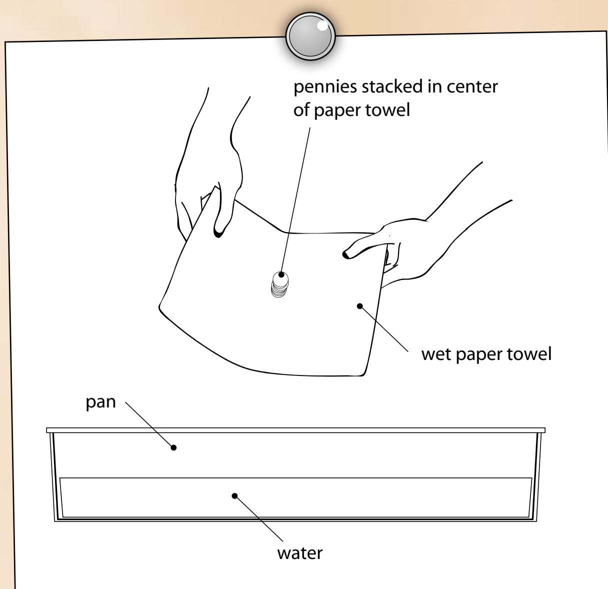
For more than a decade, scientists have dreamed of using carbon cylinders with walls just one atom thick as the building blocks for a new generation of sensors, transistors, and other tiny devices. Graphite is formed when carbon atoms are arranged in a honeycomb, or hexagonal, pattern. These honeycomb patterns are layered one above the other to create a single sheet of graphite that is stable, strong, and flexible. However, it does not bond well with other sheets of graphite. To bind graphite sheets together, a strong epoxy is used to form a composite that is often used for aircraft materials, tennis rackets, and racing bicycles. There is another way of arranging graphite sheets that makes them even stronger. Graphite sheets can be rolled to form carbon nanotubes. These microscopic nanotubes have superior mechanical and electrical properties. Scientists have been able to grow nanotubes in the lab that are several hundred meters long and the width of a human hair. When the tubes are spun into composite fibers, the fibers are tougher than steel, Kevlar, or spider silk.

Imagine what would happen if you cut off the ends of the nanotube and folded them into a top and a bottom. You would have another very stable, symmetrical form of carbon known as a buckyball. A buckyball contains sixty carbon atoms and is shaped like a soccer ball. Buckyballs can actually be produced under certain conditions. Meteorites frequently contain buckyballs because the vacuum of space is an ideal place for their formation. Buckyballs have also been produced in laboratories. They are being researched for their potential as propellants, superconductors, lubricants, and optical equipment.

Scientists must test the strength of new composite materials that are formed. To simulate testing of new composite materials, you will conduct an experiment to test the strength of several different brands of paper towels.

Procedure 1

1. Obtain three brands of paper towels.
2. Tear off three sheets from each roll and label each sheet with the brand name.
3. Using a magnifying lens, examine each set of paper towels.
4. In your science journal, record your observations about the shape and texture of each brand of paper towel.
5. Hold one sheet of the first brand of paper towel over a large pan and carefully pour 30 mL of water in the center.
6. While you hold the edges of the paper towel, ask your partner to carefully place pennies on the wet portion of the towel one penny at a time. See diagram.
7. Continue adding pennies until the towel breaks apart or tears.
8. In the chart, record the number of pennies the wet towel held.
9. Repeat steps 5–8 with the other two sheets from the same brand of paper towels.
10. Add the number of pennies for all three sheets and enter the results in the chart on page 67.



Nano, Nano, Nanotubes

Segment 3

11. Find the average number of pennies the paper towels would hold by dividing the total by 3. Record your average in the chart.
12. Repeat steps 5–11 with the second and third brands of paper towels.
13. Compare the results for each brand of paper towel.
14. Discuss and determine which paper towel is the strongest. Explain your reasoning.

Chart

Number of Pennies	***Brand 1***	***Brand 2***	***Brand 3***
Sheet 1			
Sheet 2			
Sheet 3			
Total Pennies *(sheets 1+2+3=total)*			
Average (total ÷ 3)			

Nano, Nano, Nanotubes

Segment 3

Procedure 2

Scientists are trying to form new and stronger materials by making nanotubes. In nanotubes, the arrangement of the molecules is changed to make the original material better, but the material itself, in this case carbon, is still carbon.

1. Place two books on the table 16–20 cm apart.
2. Lay a piece of plain paper on top of the books.
3. Begin gently adding pennies to the center of the paper not supported by the books.
4. Continue to add pennies until the paper falls. In your science journal, record the number of pennies the paper held before falling.
5. Now fold the piece of paper back and forth like an accordion.
6. Replace the folded paper on the books.
7. Gently add pennies to the paper until it falls and record your observations.
8. Did the folded paper hold more or fewer pennies than the flat paper?
9. Trace the hexagon template onto various types of materials, such as cloth, construction paper, or foil.
10. Cut out the shape and roll it into a tube.
11. Use either tape or glue to secure the sides of the tube.
12. With your partner, design a test to assess the strength of the various nanotubes.
13. Use what you learned from Procedure 2 and repeat Procedure 1 with the weakest brand of paper towel. How many pennies did it hold?

Materials

hexagon template p. 69
scissors
assortment of paper, fabric, foil
glue or tape
metric ruler
2 books

Conclusion

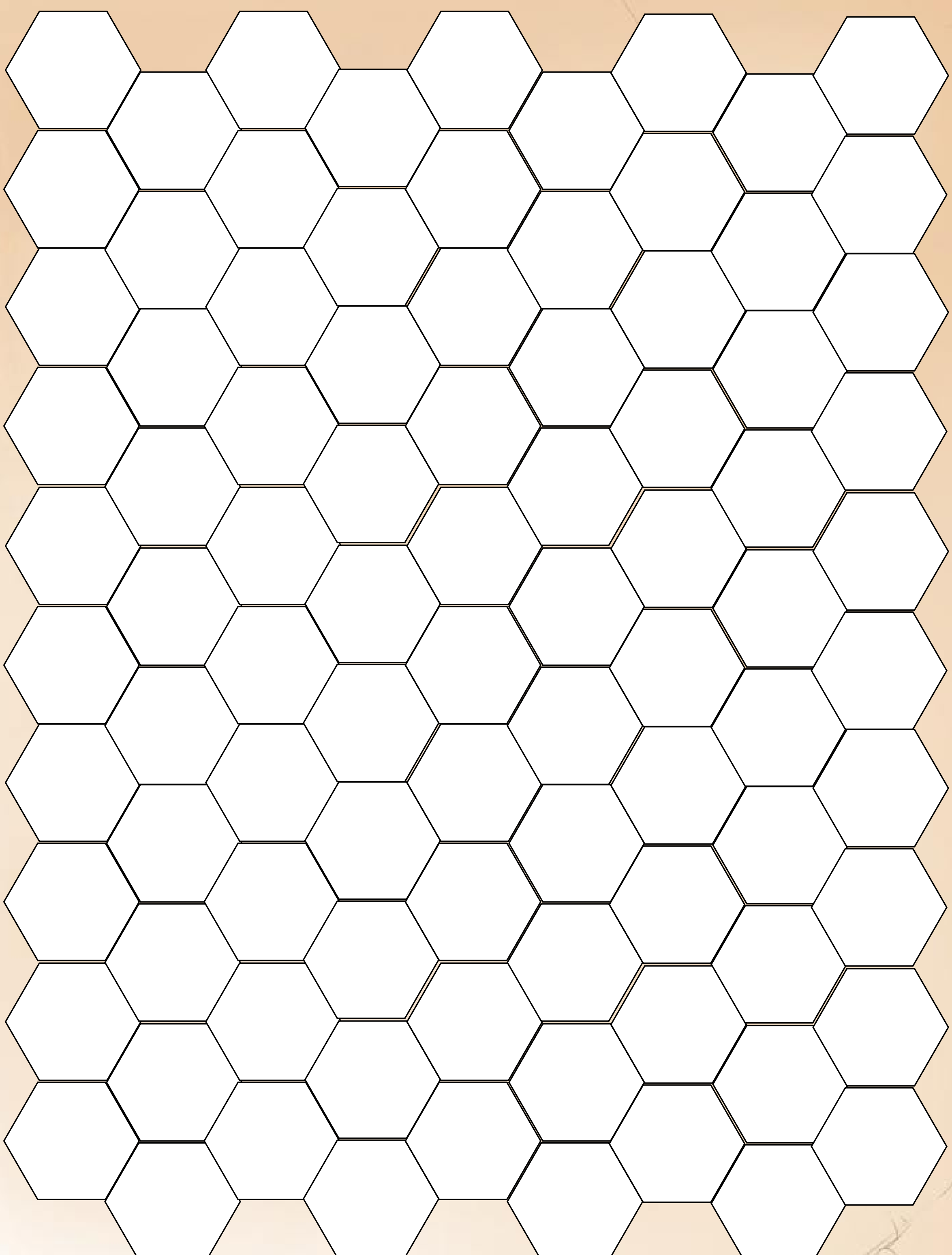
1. Which of your paper towels was the strongest?
2. What did you notice about the design of this paper towel compared to the others?
3. What changes in the material occur when nanotubes are made?
4. How is the folded paper model similar to the process used by scientists to form nanotubes?
5. How did you test the strength of the nanotube you designed?
6. Why are scientists concerned with making nanotubes?

Extension

1. Tessellations are patterns that cover a plane or flat surface by repeating the same shape over and over. Most tessellations are made of triangles, squares, and hexagons. The carbon nanotube contains a hexagon tessellation pattern. The artist, M. Escher, used tessellations to make unusual pictures and sculptures. Learn more about Escher's art. Find samples of his pictures on the Internet. Using these repeated patterns, try to design your own tessellations.
2. A Hoberman sphere is an interesting science toy that is based on the principles of the buckyball. The shape and size of the sphere can be changed by rearranging the interlocking pieces that form the sphere. Architectural structures, such as the Iris Dome at the Museum of Modern Art in New York or the Hoberman Arch that was built for the 2002 Olympic games in Salt Lake City, Utah, have been inspired by these mathematical and scientific discoveries. Using gumdrops, toothpicks, straws, or other common materials, build your own geodesic design. Be sure to use repeating patterns.
3. Collect the 6-pack rings from soft drinks and roll the rings into tubes. Connect the tubes together with string to form long nanotube models. Hang your nanotubes from the ceiling. Note: Plastic 6-pack rings are photodegradable. When exposed to UV light for an extended period of time, they will begin to break down. Do not hang heavy objects from the rings.

Nano, Nano, Nanotubes

Hexagon Template



Self-Healing Materials

Segment 3

Purpose

To simulate the properties of self-healing materials

Background

As human beings travel farther into space, NASA will need new, advanced materials to design and build the spacecraft that will take them there. As we journey millions of miles from Earth, we won't find parts stores or repair shops along the way; therefore, a spacecraft must be made of strong material that can repair itself. A weakness of current composite material is that it tends to form tiny hairline cracks that cause major damage over time. Scientists observing the human body noticed that the body has an amazing ability to heal itself. When you get a cut, the body works to heal the skin around the cut. A scar is evidence of the body's self-healing power. Scientists are now developing a new type of composite material that will give those same self-healing qualities to spacecraft. This new synthetic material will heal itself when cracks form.

Oobleck is a unique substance that appears to be both a solid and a liquid. It is, in fact, a non-Neutonian fluid, which means that when a small amount of force is used on the substance, it acts like a liquid. Hold some Oobleck in the palm of your hand and watch it puddle like thick syrup. When more force is applied, Oobleck behaves like a solid. Make a fist and the Oobleck will form a hard ball from the pressure of your fist. Release your fist and the ball will simply "melt" into a liquid again. In a container, pressure may be used on the Oobleck to form cracks, but as soon as the pressure is removed, the Oobleck flows together, "healing" the cracks and forming a smooth perfect surface again, much like the synthetic self-healing materials scientists are now developing.

Materials

- 454 grams (g) (one 16-oz box) cornstarch
- 400 mL (approximately 1 2/3 cups) water
- food coloring (optional)
- disposable pie pans
- heavy wooden or metal spoon
- bowl
- science journal

Procedure

1. Pour the cornstarch into a large mixing bowl.
2. Add a few drops of food coloring to the water.
3. Slowly add water to the cornstarch, stirring carefully. (The mixture will be very hard to stir.)
4. Continue stirring until no more powder is visible.
5. Pour the mixture into pie plates.
6. Use your senses of touch, sight, and smell to describe this substance.
7. In your science journal, record your observations.
8. Poke your finger quickly into the mixture. Describe what happens.
9. Now set your finger on the surface of the mixture. Describe your observations.
10. Pick up some of the mixture. Hold it in the palm of your hand. Describe your observations.
11. Now make a fist with the mixture. Describe what happens when force is added.
12. Set a spoon on the surface of the mixture. What happens?
13. Try stirring the mixture. What happens?
14. Push on the mixture in the pie pan until a crack or crevice forms.
15. Observe what happens as soon as you stop pushing on the mixture.
16. Record your observations.

Self-Healing Materials

Segment 3

Conclusion

1. What are the characteristics of a solid?
2. What are the characteristics of a liquid?
3. Is Oobleck more like a solid or a liquid? Why?
4. What happens when the pressure is removed after making a crack in the surface of the Oobleck?
5. What can the tree house detectives learn about self-healing materials from doing this experiment?
6. In your own words, explain why self-healing materials are necessary for space exploration.

Extension

Obtain a piece of memory metal wire from a science supply store. Many science stores, such as TeacherSource (www.teachersource.com) carry nitinol or some other smart metal alloy. Make a shape out of the wire. Place the wire in hot water to watch it return to its original shape. Find out more about memory (smart) metals. Why were they developed? How are they used? Record your findings in your science journal.

Weightless Clothespin

Segment 3

Purpose

To learn about microgravity

Materials

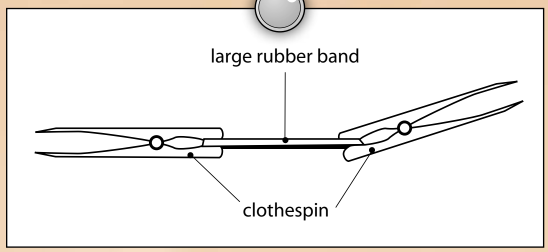
(per group)

2 clothespins
1 big, thick, rubber band
science journal

Background

Fortunately, on Earth we have gravity to keep us grounded so that we don't float away, but in space there is very little gravity, so astronauts are "weightless." NASA has special equipment to simulate a microgravity environment on Earth, such as the NASA Neutral Buoyancy Laboratory (NBL), a modified KC-135 jet aircraft nicknamed, "The Vomit Comet," and the NASA Weightless Environment Training Facility. However, there is a simple experiment you can do to learn more about microgravity and its effects.

Procedure



1. Observe the shape of the rubber band.
2. In your science journal, record the shape of the rubber band.
3. Clip one clothespin to one end of the rubber band.
4. Clip the other clothespin to the opposite end of the rubber band.
5. Hold up one of the clothespins.
6. Notice how the bottom clothespin pulls down on the rubber band, causing it to stretch.
7. In your science journal, record the shape of the rubber band with one clothespin hanging down.
8. Let go of the clothespin.
9. Observe the shape of the rubber band as it falls to the ground and record what happens.
10. Repeat the experiment several times.

Conclusion

1. Why did the rubber band stretch when you attached the clothespin to it?
2. Why did the clothespins and rubber band fall to the ground?
3. What shape did the rubber band take as it fell? Why?
4. Why do astronauts float while they are in space?

Extension

1. Visit the NASAexplores web site at *http://www.nasaexplorers.com/show_k4_teacher_st.php?id=030108124259*. Read the article *"Microgravity: Always a Bad Hair Day"* and complete the activity called *"Gravity at Work."* You will learn more about how gravity works.
2. Create a hat to demonstrate weightlessness. Securely attach 5–10 ribbons (approximately 10–15 cm each) to the center top of a baseball hat. Attach a clothespin to each ribbon. Place the hat on your head and make sure that the clothespins are not near your eyes. Cut ribbons if needed and reattach clothespins. Wearing the hat, bounce up and down (pogo sticks and trampolines work great) and have a partner observe what happens. Switch places with your partner.

Answer Key

Segment 3

Somewhere Over the Rainbow

1. Red, orange, yellow, green, blue, and violet (purple).
2. The light hit the wedge of the water between the mirror and the water's surface, causing the light to bend (refract). Because each wavelength of light bends at a different angle, the colors are refracted in slightly different directions, and the colors are spread out or split, creating a rainbow.
3. Answers will vary but may include that rainbows have been seen in the sky, on bubbles, CDs, dish soap, and many other places.

Photons and More Photons

1. The photons travel in a straight line just as a beam of light travels. Light is made up of a stream of photons.
2. If there were no photons, there would be no light.
3. As the photons enter the Earth's atmosphere, some are blocked by the ozone layer and absorbed, reflected, and/or refracted by the clouds and particles in the lower atmosphere.
4. In space there is no atmosphere to help protect the astronauts from radiation.
5. Drawings will vary.

Solar Radiation and SPF Levels

1. As the Sun shines on the construction paper, it fades at different rates, depending on the protection level of the sunscreen applied.
2. The unprotected sections should fade the most.
3. Answers will vary, but the higher SFP levels should provide the most protection.
4. Sunscreen protects our skin from harmful UV radiation.
5. Answers will vary, but may include the season, time of the day, location, and activity.

Let's Go Propelling

1. The balloon began to expand. The hot water in the bowl heated the can, which in turn heated the air inside the can. As the air inside the can was heated, it began to expand and rise, filling the balloon with warm air.
2. As the water cooled, the air inside the can also cooled. The air molecules began to compact (become denser) and sink toward the bottom of the can, thus deflating the balloon.
3. The ice cooled the air inside the can quickly and the balloon may have sunk into the opening of the can.
4. Answers will vary. Students may see a response to the environment as a positive adaptation; others will say that the flexibility of the material will make it unsuitable because you will not be able to compensate for size changes within the confines of the spacecraft.
5. Scientists must understand how materials will react in different situations, such as the high-pressure atmosphere on Jupiter or the extreme cold of Pluto.

Hooks and Loops

1. The "hook tape" has stiff little hooks on it, while the "loop tape" is soft and fuzzy. Together, they're called a "hook and loop fastener" or a "touch fastener."
2. Answers will vary, but may include these: hook and fastener tape can be used instead of shoelaces or buttons to hang pictures on walls or seal containers.
3. Hook and fastener tape is easier for young children or people with dexterity problems to use. The tape is stronger and holds longer than other types of tape.
4. "Bio-inspired" means to be patterned after something seen in the natural world.
5. Answers will vary, but students may talk about the shape of airplane wings that look like bird wings or shark fins, and/or the computer, which uses electrical impulses patterned after brain waves.

Nano, Nano, Nanotubes

1. Answers will vary.
2. Answers will vary depending on results. However, the towels with quilting will usually be stronger.
3. The parent material remains the same; only the structure or organization of the atoms changes.
4. The structure of the paper is changed; in this case, it is folded, but the paper is still the same paper. When nanotubes are formed, the carbon is still carbon, but the atoms are rearranged.
5. Answers will vary.
6. Nanotube technology can be used to develop specific characteristics of a material, such as strength or flexibility.

Self-Healing Materials

1. A solid has a specific volume and maintains a specific shape.
2. A liquid has a specific volume but does not have a definite shape; it takes on the shape of its container.
3. Answers will vary.
4. The mixture becomes liquid and fills in the cracks, forming a smooth surface once again.
5. Answers will vary.
6. Answers will vary but should include that they will help avoid repairs during long-term space travel.

Answer Key

Segment

Weightless Clothespin

1. The rubber band stretched because the force of gravity pulled the clothespin downward.
2. Gravity caused the clothespin and rubber band to fall. Gravity is the attraction between objects that causes objects on Earth to fall toward the surface of the Earth.
3. The shape becomes nearly round again (original shape) as it falls. Because the whole clothespin system is falling at the same speed, the bottom clothespin no longer pulls down; it appears weightless within the system.
4. The astronauts are actually falling in space; thus, they have no weight and float around.

On the Web

Cooking With Radiation—S'Mores Anyone?

1. The temperature should rise during the experiment.
2. The temperature will rise more slowly and the inside of the pan will not get as warm.
3. Answers will vary, but students should discuss heat conductivity.
4. The S'Mores would burn, just as if they had been left in an oven too long.
5. Human skin also burns, not from the heat, but from the ultraviolet radiation of the Sun. We use sunscreen with SPF to protect our skin.
6. The astronauts are exposed to more significant levels of solar radiation in space because of a lack of atmosphere, particularly the ozone layer, to help absorb and scatter the ultraviolet light.

No Assembly Line Needed

1. Answers will vary depending on the number of blocks given to each person.
2. The blocks began to float on the water, moving toward each other to form a shape.
3. Scientists can use the arrangement of molecules to make certain characteristics of a material better.

The Solar Wind in My Sails

1. A solar sail is like a large mirror that reflects sunlight. As the photons of sunlight strike the sail and bounce off, they gently push the sail along by transferring momentum to the sail. Because there are so many photons from sunlight, and because they are constant, there is a constant pressure exerted on the sail, creating a constant acceleration of the spacecraft. The solar sail constantly accelerates over time and achieves a greater velocity than conventional chemical rockets, such as the Space Shuttle.
2. Answers will vary but might include that scientists are looking for alternative sources for propulsion systems. Solar sails will enable spacecraft to move through the solar system and between stars without bulky rockets and the need for great amounts of fuel.
3. Answers will vary.

You Said I Weigh How Much?

1. The planet you weigh the most on is Jupiter. However, on the Sun, you would weigh even more. You would weigh the least on Pluto.
2. You weigh almost the same on Earth as you do on Venus and Saturn.
3. The amount of gravity determines your "weight." Because the Sun, Moon, and each planet are various sizes and densities, they have different gravities.

Segment 4

Bianca is wrapping up Space Camp and feels like she is ready to blast off for worlds unknown. She's not the only one who's excited. Back in the tree house, the detectives learn about the X-Prize, a $10 million prize awarded to the first privately funded spacecraft that can carry three people to space and back. Tony definitely needs to know more! The tree house detectives dial up Mr. Erik Lindberg, grandson of Charles Lindberg, to learn about the importance of contests in developing aviation and space innovations. Still excited about the possibility of being tourists in space someday, the tree house detectives receive a report from Corrinne, a NASA SCI Files™ Kids' Club member, who is in Utah at the Mars Analog Research Station operated by the Mars Society. Dr. Tony Muscatello explains the Mars habitat and the importance of simulating working and living on Mars. Finally, Dr. D and Bianca meet to practice their satellite repair simulation and help the detectives wrap up what they have learned. The detectives are certainly glad they took Mr. Gregory's (NASA's deputy administrator) advice and are excited about the possibility of being next generation explorers who might actually walk on the surface of Mars!

Objectives

Students will

- understand that science and technology advance through the contributions of different people.
- predict a scientific fact for the future.
- investigate alternative sources of energy.
- measure reaction time.
- understand why reaction time is important.
- compare a rover and a lander.
- demonstrate how scientists gather data on distant planets.

Vocabulary

altitude – height above the Earth's surface

extremophile – microscopic life forms that can survive in extreme environments

geology – the science or study of the Earth, including rocks, water, and layers of the Earth

habitat – a sealed, controlled environment in which people can live, for example, to do research

X-Prize – a $10 million dollar prize to be awarded to the first team who can build and launch a plane that can carry three people 100 kilometers (km) into space, return to Earth safely, and repeat the launch in the same ship within two weeks

Video Component

Implementation Strategy

The NASA SCI Files™ is designed to enhance and enrich existing curriculum. Two to three days of class time are suggested for each segment to fully use video, resources, activities, and web site.

Before Viewing

1. Prior to viewing Segment 4 of *The Case of the Great Space Exploration*, discuss the previous segment to review the problem and what the tree house detectives have learned thus far. Download a copy of the **Problem Board** from the NASA SCI Files™ web site, select **Educators**, and click on the **Tools** section. The **Problem Board** can also be found in the **Problem-Solving Tools** section of the latest online investigation. Have students use it to sort the information learned so far.
2. Review the list of questions and issues that the students created prior to viewing Segment 3 and determine which, if any, were answered in the video or in the students' own research.
3. Revise and correct any misconceptions that may have been dispelled during Segment 3. Use tools located on the Web, as was previously mentioned in Segment 1.
4. Review the list of ideas and additional questions that were created after viewing Segment 3.
5. Read the overview for Segment 4 and have students add any questions to their lists that will help them better understand the problem.
6. **Focus Questions**—Print the questions from the web site ahead of time for students to copy into their science journals. Encourage students to take notes during the program to answer the questions. An icon will appear when the answer is near.

View Segment 4 of the Video

For optimal educational benefit, view *The Case of the Great Space Exploration* in 15-minute segments and not in its entirety. If you are viewing a taped copy of the program, you may want to stop the video when the Focus Question icon appears to allow students time to answer the question.

After Viewing

1. At the end of Segment 4, lead students in a discussion of the Focus Questions for Segment 4.
2. Have students discuss and reflect upon the process that the tree house detectives used to learn more about the future of space exploration. The following instructional tools located in the **Educators** area of the web site may aid in the discussion: **Experimental Inquiry Process Flowchart** and/or **Scientific Method Flowchart**.
3. Choose activities from the **Educator Guide** and web site to reinforce concepts discussed in the segment. Pinpoint areas in your curriculum that may need to be reinforced and use activities to aid student understanding in those areas.
4. For related activities from previous programs, download the **Educator Guide**. On the NASA SCI Files™ home page, select Educators. Click on **Episodes in** the menu bar at the top. Scroll down to the 2000–2001 Season and click on *The Case of the Challenging Flight*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

1. **Segment 1** – *Lucky Lindy and the Spirit of St. Louis*
2. **Segment 2** – *Thinking Out of the Box*

3. **Segment 4** – *The Eggs-tra-ordinary Airplane*

Careers

airplane design engineer

geologist

Close the PDF window and return to the Educator Guide page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Phenomenal Weather.* In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

a. **Segment 3** – *3-2-1 Blast Off*

Close the PDF window and return to the **Educator Guide** page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Galactic Vacation*. In the green box, click on **Download the Educator Guide**.

a. In the **Educator Guide** you will find

a. **Segment 2** – *Mission to Mars*

Close the PDF window and return to the **Educator Guide** page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Inhabitable Habitat*. In the green box, click on **Activities/Worksheets**.

a. On the web site in the Activities/Worksheets section you will find

1. *Wish You Were Here!*

Close the PDF window and return to the **Educator Guide** page. Click on **Episodes** in the menu bar at the top. Scroll down to the 2001–2002 Season and click on *The Case of the Wright Invention*. In the green box, click on **Download the Educator Guide.**

b. In the **Educator Guide** you will find

1. **Segment 4** – *Testing 1,2,3*

5. Wrap up the featured online PBL investigation. Evaluate the students' or teams' final product, generated to represent the online PBL investigation. Sample evaluation tools can be found in the **Educators** area of the web site under the main menu topic **Tools** by clicking on **Instructional Tools**.
6. Have students write in their journals what they have learned about sand, minerals, rocks, plate tectonics, weathering and erosion, and beach erosion so that they can share their entry with a partner or the class.

Resources *(additional resources located on web site)*

Books

Becklake, Sue and Bond, Peter: *100 Things You Should Know About Space*. Barnes and Noble Books, 2004, ISBN: 0760753954.

Benford, Gregory: *Martian Race*. Warner Books, Inc., 2000, ISBN: 0446608904.

Bridgman, Roger: *Eyewitness Books: Robot*. DK Publishing, Inc., 2004, ISBN: 0756602548.

Dyson, Marianne: *Home on the Moon: Living on a Space Frontier.* National Geographic Society, 2003, ISBN: 0792271939.

George, Michael: *Space Exploration*. The Creative Company, 1991, ISBN: 0886824818.

Holland, Simon: *Space*. DK Publishing, Inc., 2001, ISBN: 0789478544.

Seuss, Dr.: *Bartholomew and the Oobleck*. Random House, 1976, ISBN: 0394800753.

Sneider, Cary I.: *Oobleck: What Do Scientists Do?* Lawrence Hall of Science, 1998, ISBN: 0924886099.

Willett, Edward: *Careers in Outer Space: New Business Opportunities.* Rosen Publishing Group, 2002, ISBN: 082393358X.

Video

Discovery Channel School: *Technology at Work*
Grades 3–6

FASE Productions: *Living and Working in Space: The Countdown Has Begun*
Grades 3–6

Holiday Space and Science: *History of Spaceflight: Reaching for the Stars*
Grades 6–adult

Just the Facts Learning Series: *Space Facts II*
Grades 6–adult

Universal: *October Sky*
Grades 5–adult

Web Sites

ANSARI X Prize
The ANSARI X PRIZE is a $10 million dollar prize to jumpstart the space tourism industry through competition among the most talented entrepreneurs and rocket experts in the world. The $10 million cash prize will be awarded to the first team that privately finances, builds, and launches a space ship able to carry three people 100 kilometers (km) (62.5 miles (mi)), returns safely to Earth, and repeats the launch with the same ship within 2 weeks.
http://www.xprize.org/

The Mars Society
The Mars Society web site has a great deal of information on the mission of the Mars Society. There are links to current research, news, and education-related topics. There is also a link to the Mars Desert Station, or Mars Habitat.
http://www.marssociety.org/

The Mars Millennium Project
Compare the geology and weather of Mars and Earth. Each analogy has two levels designed for a beginning or advanced learner.
http://www.lpi.usra.edu/education/MarsMillennium/earth_mars.html

Athena Mars Exploration Rovers
Visit this web site to learn about RATs (Rock Abrasion Tools), Mars facts, and Mars rovers.
http://athena.cornell.edu/

NASA: Mars Exploration Program
Come to this web site to explore the red planet Mars. Play games, do some activities, and learn about special events coming to a planet near you.
http://marsprogram.jpl.nasa.gov/funzone_flash.html

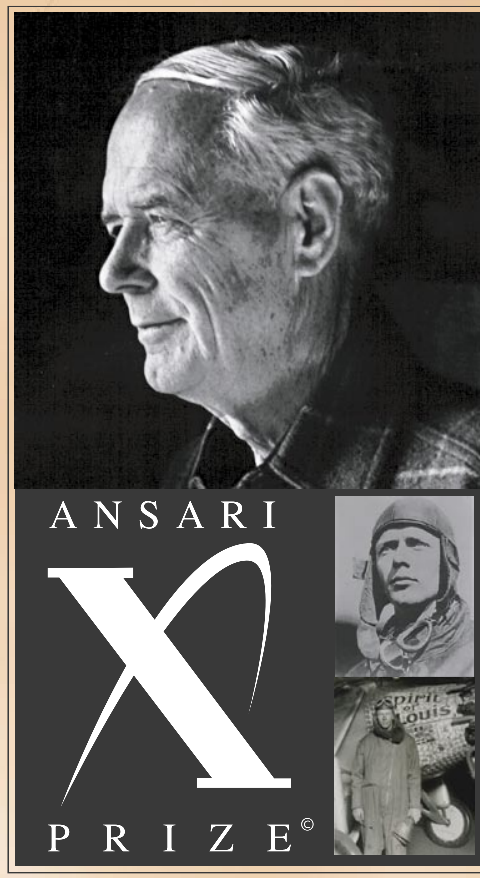
Activities and Worksheets

What's Your Prize?

Segment 4

Research various prizes, such as the Orteig prize won by Charles Lindberg, that have been awarded throughout history. Brainstorm for ideas of possible new prizes and the inventions or innovations that would win them. Determine the criteria for winning and design a trophy or other award for the winner.

In the space below, write a description of your contest and the prize and explain the criteria for winning. Justify why contests are important to inspiring innovations and inventions.



www.xprize.org

There's a RAT on the Rover!

Segment 4

Purpose

To demonstrate how scientists gather data on distant planets and to make scientific observations

Materials

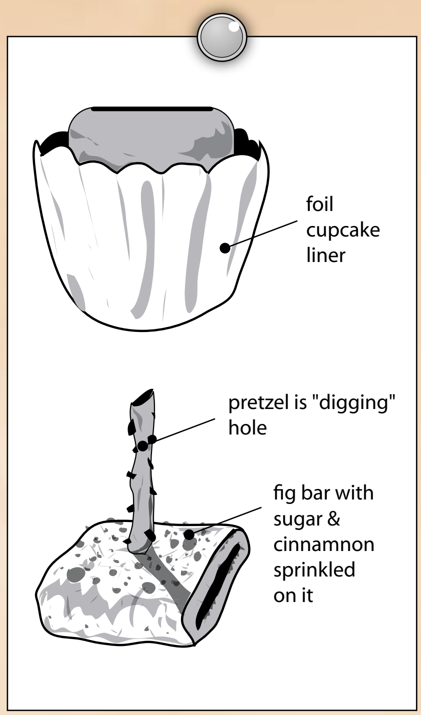
foil cupcake liners
different flavors of fig cookie bars
cinnamon
sugar
stick pretzels
metric ruler

Background

NASA uses robotic rovers to study the geology of planets far away. To observe rock samples on Earth, geologists would break the rock open with a rock hammer and carefully examine the pieces of rock with a hand lens or microscope. Instead of breaking the rock with a hammer, the Mars Exploration Rover has a special tool called the Rock Abrasion Tool (RAT) to remove the outer layers of rock and expose the underlying material. The RAT can dig approximately 5 mm into the rock and drill a diameter of approximately 4 cm. The abrasion tool, which is the size of a soda can, will shave away the top layers of the rock. This process may take anywhere from 30 minutes to 3 hours. A Microscopic Imager on the Rover, which is like a geologist's hand lens, and the Pancam, or Rover camera, will then be used to examine the materials the RAT uncovers.

Teacher Prep

1. Make a mixture of 1 part cinnamon to 3 parts sugar.
2. Sprinkle the mixture into the bottom of a cupcake liner.
3. Press each side of the fig bar into the cinnamon sugar mixture to cover the filling on the sides of the cookie. Note: Do not prepare too far in advance as the cookies will dry out quickly.
4. Repeat with all flavors of fig cookies, being careful to not mark the cookies in any way.
5. Set each cookie in a cupcake liner.
6. Sprinkle the tops of the fig bars with more of the cinnamon sugar mixture so the top surfaces of the cookies are also covered. The cinnamon sugar mixture represents Mars dust.



Procedure

1. Collect a "rock sample" from your teacher.
2. Observe the rock and in your science journal, record any observations about color, texture, size, and surface.
3. Measure the length, width, and height of the rock sample.
4. Using a pretzel as your RAT, gently begin rotating it a few times on the surface of the sample.
5. Observe the Mars dust (cinnamon sugar) as it begins to erode away, exposing the surface of the sample.
6. Observe the newly exposed region and record your observations.
7. Notice how the "dust" builds up along the edge of the drilled area, along with some of the rock surface.
8. Apply slightly more pressure to the RAT and rotate several more times to dig slightly deeper into the sample.
9. Remove the RAT and observe the interior of the rock (the filling).
10. Measure the depth and diameter of the hole left behind by the RAT.

There's a RAT on the Rover!

Segment 4

11. Conduct research to learn more about rocks and the rock cycle.
12. Using what you learned, make a hypothesis about the kind of rock you have uncovered and how it was formed.

Conclusion

1. What is a RAT?
2. What can scientists learn about a planet by studying data the RAT collects?

Extension

1. Using this formula: volume = length x width x height, calculate the volume of your rock sample. Now measure the size of the hole your RAT left. Estimate the volume of the material removed from the RAT hole.
2. Collect rocks in your area. Record the location where you found them. If possible, take a photograph or digital picture of the area. Examine the rocks. Using reference materials, classify the rocks. Every rock tells a story. What story does your rock tell about our Earth? Write and illustrate your story.

The Quickest Hand in the West

Segment 4

Purpose

To measure reaction time and to understand why reaction time is important when working in space

Materials

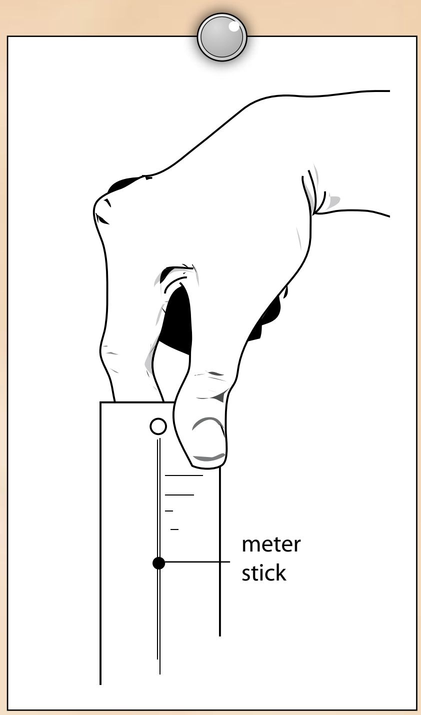
centimeter ruler
scissors
pen or pencil
meter stick
"Reaction Time" worksheet

Background

Reaction time is the time it takes the body to respond to the presentation of a stimulus. For example, pretend you are at a park. You are walking away from a baseball field and suddenly you hear, "Heads up!" Reaction time is how long it takes your body to react to the call to watch out. A quick reaction time is ideal, especially in the previous scenario. Reaction time can vary among individuals and can also vary for the same individual. The more tired a person is, the greater or slower his or her reaction time. Reaction time is especially important in space. Astronauts face many challenges while they are in such a harsh environment. They must have quick reaction times to ensure safety and to complete their missions. Adequate rest is necessary to keep astronaut reaction times quick. A Reaction Time Test can determine a person's reaction time. The test must be given several times, and an average must be taken to determine an individual's reaction time.

Procedure

1. Have your partner hold (with thumb and forefinger) a centimeter ruler vertically at the 30-cm mark with the 0-cm mark toward the floor. See diagram.
2. Place your thumb and forefinger at the end of the ruler at the 0-cm mark.
3. Your partner should be ready to catch the ruler between his/her thumb and forefinger but should not be touching the ruler yet.
4. Drop the ruler and have your partner try to catch the ruler as soon as he/she can.
5. Place your fingers where the ruler stopped and your partner caught it.
6. Observe the number on the ruler.
7. If the number is less than 5 cm, disregard the results and try again.
8. Record the number on the "Reaction Time" worksheet (page 83) next to trial number 1.
9. Repeat the process 19 more times, each time recording the number next to the corresponding trial number.
10. Change places with your partner and repeat the process 20 times.
11. Find the average for your reaction time by adding all the numbers together and dividing by 20.
12. Record your answer on the "Reaction Time" worksheet under average.
13. Make a line graph of your reaction times. Be sure to include a title and label the x axis and y axis on the graph.



The Quickest Hand in the West

Segment 4

Reaction Times for ____________ (name)		***Reaction Times for*** ____________ (name)	
Trial 1		*Trial 1*	
2		*2*	
3		*3*	
4		*4*	
5		*5*	
6		*6*	
7		*7*	
8		*8*	
9		*9*	
10		*10*	
11		*11*	
12		*12*	
13		*13*	
14		*14*	
15		*15*	
16		*16*	
17		*17*	
18		*18*	
19		*19*	
20		*20*	
Average Reaction Time: ____________		***Average Reaction Time:*** ____________	

Conclusion

1. Why do you think it was important to discard the results that were less than 5 cm?
2. Why did you have to do so many trials?
3. Why is it important to use the average from your trials to determine your reaction time?
4. Do you think your reaction time would change if you had more or less sleep? Why or why not?

Extension

On a weekend, ask for permission to stay up 1 or 2 hours later than usual. You must be feeling tired before starting the experiment. Remember, you will need a partner. Repeat the experiment at home. Was your average reaction time the same as at school? Why? Try the experiment again after you have had a good night's sleep. Was there a difference? Why?

To the Moon, Mars, and Beyond

Segment 4

Use the word bank, locate each word, and circle or highlight the word when you find it.

Phoenix Lander	rover	RAT
nutrition	Calorie	Food Pyramid
exercise	radiation	visible light
Mars	X-Prize	habitat
planet	ferrofluid	robot
solar sail	Space Camp	propulsion
nanotubes	water ice	astronaut

S	P	A	C	E	C	A	M	P	R	Y	N	E	A	P	T	A	M	O	O	N	S
T	N	M	O	M	A	R	S	I	N	B	A	B	E	T	U	G	U	Y	I	O	I
N	A	C	A	M	O	R	P	M	E	T	S	Y	O	H	T	R	A	E	L	D	G
O	O	R	D	X	P	E	R	I	A	K	M	B	I	C	L	I	P	A	O	N	N
I	N	M	A	P	I	O	M	B	N	G	O	M	S	T	O	N	R	H	T	A	E
T	H	E	E	R	T	I	U	A	I	R	A	P	X	R	Y	S	I	S	H	N	O
A	K	A	I	I	O	R	K	N	K	I	N	R	Y	V	A	I	O	I	Y	O	U
I	J	I	L	Z	E	S	N	M	D	C	C	O	T	I	L	L	E	R	D	T	E
D	L	P	L	E	T	E	T	E	C	T	O	P	L	S	S	A	G	O	R	U	S
A	A	I	E	E	E	R	G	E	H	Z	N	U	N	I	T	E	V	A	I	B	I
R	S	M	W	R	T	I	O	E	I	T	V	L	U	B	R	R	A	R	E	E	C
T	Z	Q	U	I	C	L	I	V	T	O	E	S	M	L	I	O	E	P	U	S	R
C	N	L	D	S	A	I	N	D	E	R	R	I	M	E	A	S	A	E	A	H	E
A	G	E	A	R	S	Z	A	I	E	R	G	O	O	L	T	P	E	N	D	A	X
L	I	V	E	R	T	S	S	N	G	P	T	N	C	I	I	A	N	O	I	B	E
O	S	P	A	C	E	S	T	A	T	I	O	N	T	G	O	C	L	I	M	I	H
R	E	D	N	A	L	X	I	N	E	O	H	P	R	H	N	E	I	T	A	T	E
I	E	N	E	I	G	P	L	A	N	E	T	K	O	T	S	A	C	I	R	A	R
E	E	R	C	P	G	S	I	C	I	Z	U	A	P	T	E	S	T	R	Y	T	I
A	K	A	T	I	I	T	G	U	D	T	B	I	R	B	I	L	L	T	P	I	N
F	E	R	R	O	F	L	U	I	D	R	I	R	I	O	Y	T	I	U	D	R	G
G	A	E	M	O	H	S	O	B	I	T	E	R	A	T	I	V	E	N	O	U	E
A	S	T	R	O	N	A	U	T	C	S	N	I	K	K	I	N	Y	N	O	P	V
M	F	A	E	B	Z	X	R	S	W	W	A	T	E	R	I	C	E	S	F	R	E

The Next Generation

Segment 4

Create a crossword puzzle with the following terms and the grid below.

astronaut
nutrition
propulsion
water ice
habitat
spacecraft
exercise
gravity
lander
Mars
crew
radiation
robot
nanotechnology

Across

1. ________________________
2. ________________________
3. ________________________
4. ________________________
5. ________________________
6. ________________________
7. ________________________
8. ________________________
9. ________________________
10. ________________________

Down

1. ________________________
2. ________________________
3. ________________________
4. ________________________
5. ________________________
6. ________________________
7. ________________________
8. ________________________
9. ________________________
10. ________________________

Answer Key

Segment 4

There's a RAT on the Rover

1. A RAT is a Rock Abrasion Tool used by scientists to study rocks on other planets.
2. Answers will vary but might include that they could learn the geology of a rock, which might help scientists understand how the planet was formed and learn whether life might have existed.

The Quickest Hand in the West

1. The average human brain is unable to respond that quickly to a stimulus, so a response distance of less than 5 cm would only be possible if directions were not accurately followed.
2. The greater the number of trials, the more statistically accurate the average becomes.
3. The human brain does not respond exactly the same way in the same time to identical responses. Factors such as how tired a person is, attention level, and outside distractions may all affect a response time.
4. Answers will vary, but students should understand that each person needs a particular amount of sleep so the body can rest and repair itself. However, too much sleep can slow reaction times and can be unhealthy for the human body.

To the Moon, Mars, and Beyond

On the Web

Edible Rover/Lander

1. Many destinations in space are too far or too harsh for human exploration at our current levels of technology.
2. A lander is designed to simply land at a given location on a planet and collect data from a stationary position. A rover is designed to move from one location to another to collect and transmit data.
3. Scientists choose spots that will best match the specific purpose of the mission. The spacecraft are designed to collect the kinds of data the scientists will need from that specific location to complete the mission.