

THE SCIENCE OF

FOOD AND

FITNESS

**Energy Sources***by***Nancy P. Moreno, Ph.D.****Sonia Rahmati Clayton, Ph.D.****Paula H. Cutler****Martha S. Young****Barbara Z. Tharp, M.S.****RESOURCES**

For online presentations of each activity and  
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<http://www.bioedonline.org> or <http://www.k8science.org>.

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# BioEd<sup>SM</sup>

Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.  
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# TEAMING WITH BENEFITS

by Jeffrey P. Sutton, M.D., Ph.D., Director, National Space Biomedical Research Institute (NSBRI)

Space is a challenging environment for the human body. With long-duration missions, the physical and psychological stresses and risks to astronauts are significant. Finding answers to these health concerns is at the heart of the National Space Biomedical Research Institute's program. In turn, the Institute's research is helping to enhance medical care on Earth.



Dr. Jeffrey P. Sutton

The NSBRI, a unique partnership between NASA and the academic and industrial communities, is advancing biomedical research with the goal of ensuring a safe and productive long-term human presence in space. By developing new approaches and countermeasures to prevent, minimize and reverse critical risks to health, the Institute plays an essential, enabling role for NASA. The NSBRI bridges the research, technological and clinical expertise of the biomedical community with the scientific, engineering and operational expertise of NASA.

With nearly 60 science, technology and education projects, the NSBRI engages investigators at leading institutions across the nation to conduct goal-directed, peer-reviewed research in a team approach. Key working relationships have been established with end users, including astronauts and flight surgeons at Johnson Space Center, NASA scientists and engineers, other federal agencies, industry and international partners. The value of these

collaborations and revolutionary research advances that result from them is enormous and unprecedented, with substantial benefits for both the space program and the American people.

Through our strategic plan, the NSBRI takes a leadership role in countermeasure development and space life sciences education. The results-oriented research and development program is integrated and implemented using focused teams, with scientific and management directives that are innovative and dynamic. An active Board of Directors, External Advisory Council, Board of Scientific Counselors, User Panel, Industry Forum and academic Consortium

help guide the Institute in achieving its goals and objectives.

It will become necessary to perform more investigations in the unique environment of space. The vision of using extended exposure to microgravity as a laboratory for discovery and exploration builds upon the legacy of NASA and our quest to push the frontier of human understanding about nature and ourselves.

The NSBRI is maturing in an era of unparalleled scientific and technological advancement and opportunity. We are excited by the challenges confronting us, and by our collective ability to enhance human health and well-being in space, and on Earth.

## NSBRI RESEARCH AREAS

### CARDIOVASCULAR PROBLEMS

The amount of blood in the body is reduced when astronauts are in microgravity. The heart grows smaller and weaker, which makes astronauts feel dizzy and weak when they return to Earth. Heart failure and diabetes, experienced by many people on Earth, lead to similar problems.

### HUMAN FACTORS AND PERFORMANCE

Many factors can impact an astronaut's ability to work well in space or on the lunar surface. NSBRI is studying ways to improve daily living and keep crewmembers healthy, productive and safe during exploration missions. Efforts focus on reducing performance errors, improving nutrition, examining ways to improve sleep and scheduling of work shifts, and studying how specific types of lighting in the craft and habitat can improve alertness and performance.

### MUSCLE AND BONE LOSS

When muscles and bones do not have to work against gravity, they weaken and begin to waste away. Special exercises and other strategies to help astronauts' bones and muscles stay strong in space also may help older and bedridden people, who experience similar problems on Earth, as well as people whose work requires intense physical exertion, like firefighters and construction workers.

### NEUROBEHAVIORAL AND STRESS FACTORS

To ensure astronaut readiness for spaceflight, preflight prevention programs are being developed to avoid as many risks as possible to individual and

group behavioral health during flight and post flight. People on Earth can benefit from relevant assessment tests, monitoring and intervention.

### RADIATION EFFECTS AND CANCER

Exploration missions will expose astronauts to greater levels and more varied types of radiation. Radiation exposure can lead to many health problems, including acute effects such as nausea, vomiting, fatigue, skin injury and changes to white blood cell counts and the immune system. Longer-term effects include damage to the eyes, gastrointestinal system, lungs and central nervous system, and increased cancer risk. Learning how to keep astronauts safe from radiation may improve cancer treatments for people on Earth.

### SENSORIMOTOR AND BALANCE ISSUES

During their first days in space, astronauts can become dizzy and nauseous. Eventually they adjust, but once they return to Earth, they have a hard time walking and standing upright. Finding ways to counteract these effects could benefit millions of Americans with balance disorders.

### SMART MEDICAL SYSTEMS AND TECHNOLOGY

Since astronauts on long-duration missions will not be able to return quickly to Earth, new methods of remote medical diagnosis and treatment are necessary. These systems must be small, low-power, noninvasive and versatile. Portable medical care systems that monitor, diagnose and treat major illness and trauma during flight will have immediate benefits to medical care on Earth.

For current, in-depth information on NSBRI's cutting-edge research and innovative technologies, visit [www.nsbri.org](http://www.nsbri.org).

# OVERVIEW

Students will compare how much energy is released as heat from two different food types.



## ACTIVITY

# ENERGY SOURCES

Living things that cannot harness solar energy through photosynthesis must eat other organisms or the products of other organisms as food. Consumers, which include members of the animal and fungus Kingdoms, frequently use a variety of food sources to meet their energy and nutritional needs.

The amount of energy stored in food usually is measured in **calories**. One calorie is defined as the amount of energy it takes to raise the temperature of one gram of pure water (equivalent to one milliliter of water) one degree Celsius. The calories shown on most food labels are written with an uppercase “C” and represent one kilocalorie or 1,000 calories.

Carbohydrates, fats and proteins are the

primary sources of energy in foods. Sugars, starches (such as those in bread, pasta and potatoes) and fiber (such as in many vegetables, whole fruits and whole grains) are the main forms of carbohydrates. Foods rich in fats include animal and vegetable oils, lard, butter and cream. Proteins, the building blocks of muscles and molecules within cells, are present in meats, eggs, and animal products, as well as in plant materials, like nuts and beans.

Each of these classes of nutrients provides a different amount of energy as food. Fats and oils provide about nine Calories (Cal) per gram. Carbohydrates and proteins each provide four Cal per gram. The amount of energy provided by each of these kinds of foods is independent of the source and presence of other nutrients. In other words, olive oil and peanut oil both provide about nine Cal per gram.

This activity introduces students to the concept of “calorie” and allows them to compare the relative amounts of energy in similar-sized portions of a carbohydrate-based food and a food rich in oils.

### TIME

15 minutes for setup; 45 minutes for activity

### MATERIALS

- Single-hole punch

### Each group will need:

- Prepared soft drink can (see Setup)
- Pencil (to be used as a holder for can)
- Graduated cylinder or beaker
- 6-in. thermometer (°C)

### Fast Facts

- Carbohydrates provide most people with about 50% of their energy needs.
- The word “calorie” comes from the Latin word for heat.
- Energy also is measured in joules. One calorie is about 4.2 joules.
- Food must be digested before the body can use it. Digestion changes food into substances like glucose, a simple sugar, that can be carried in the bloodstream to provide energy for cells throughout the body.

### Teacher Resources



Downloadable activities in PDF format, annotated slide sets for classroom use, and other resources are available free at [www.bioedonline.org](http://www.bioedonline.org) or [www.k8science.org](http://www.k8science.org).

### SCIENCE EDUCATION CONTENT STANDARDS\* GRADES 5–8

#### LIFE SCIENCE

- All animals, including humans, are consumers, which obtain food by eating other organisms.

#### PHYSICAL SCIENCE

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, and the nature of chemicals. Energy is transferred in many ways.

#### SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

- Food provides energy and nutrients for growth and development. Nutrition requirements vary with body weight, age, sex, activity, and body functioning.

#### SCIENCE, HEALTH & MATH SKILLS

- Observing
- Comparing
- Predicting

\* National Research Council. 1996. National Science Education Standards. Washington, D.C., National Academies Press.

*Continued*



- 2 pieces of round unsweetened oat cereal (“Cheerios”)
- 1/2 pecan (without shell)
- Large paper clips
- 2-cm piece of clay
- Matches or birthday candles
- Safety goggles (one pair per student)
- Water
- Copy of student sheet

## SAFETY

Students should wear goggles and conduct the activity on a nonflammable, flat surface.

## SETUP & MANAGEMENT

For each group, cut the top one third off of a soft drink can using scissors. Discard top half. Smooth the edges by cutting around again or by covering them with masking tape. Use a single-hole punch to make a pencil sized hole on each side of the open end of the can, so that a pencil may be inserted as a holder (see sidebar). Each class will need a new set of cans.

Have students work in teams. Set out all materials for each group of students to collect. OR you may choose to conduct this activity as a demonstration to the class.

## PROCEDURE

1. Remind students of the previous activity, in which they cultivated yeast in sugar water. Ask, *What happened to the temperature or appearance of the water in which the yeast cells were growing?* Students should be able to report that water became warmer or that the yeast used sugar as food. Follow by asking, *What do you think would happen if we tried to release all of the energy in the sugar as heat?* Use students’ answers to guide them into a discussion of energy stored in food. Ask, *Do all kinds of food provide the same amount of energy?*
2. Challenge students to predict which provides more energy: the same portion of a carbohydrate-rich food or an oil-rich food.
3. Have the Materials Managers collect

the materials for their groups from a central area in the classroom.

4. Each group will need to make a holder for the food they will be investigating. They should bend a paper clip so that it looks like the image on the right and anchor the base using clay.
5. Have students follow the instructions on their activity sheets to complete the investigation. They will pour 50 mL of water into the prepared soft drink can and measure the temperature of the water. Next, they will hang two oat cereal pieces on the paper clip and light them from below. They should hold the can by the pencil support with the bottom of the can about one inch above the flame. If necessary, they should relight the cereal pieces until they will no longer burn. They should record the final water temperature.
6. Have students repeat the investigation using a piece of pecan approximately the same size as two pieces of cereal together (place on top of holder).
7. Have students follow the instructions on the student page to calculate (approximately) the number of calories released by the similar volume of different foods.
8. Discuss results with students. Ask, *Which food released more heat when burned? Which volume of food had more calories?* Help students understand that fats and oils are more energy-rich than carbohydrates, because of the nature of the chemicals involved.

## EXTENSIONS

- Have students conduct the investigation again using similar masses of cereal and pecan. Have students weigh the pieces in advance and make adjustments so that similar masses of cereal and pecan are compared.
- The diets of some ethnic groups living in extremely cold climates are very high in fats. Have students investigate why such diets might be necessary.

## Fats

Fats are rich sources of energy. Certain fats and oils are healthier than others. Fats that are solid at room temperature, such as shortening, margarine and lard, should be avoided. Healthier choices include olive, flaxseed, nut, and fatty fish or canola oils. Foods that can contain large amounts of unhealthy fats include some red meats, whole milk dairy products and cream, some salad dressings, chocolate, cakes, cookies and some crackers.

## NASA CONNECT™



The NASA Connect online broadcast, “Better Health from Space to Earth,” is based on *The Science of Food and Fitness*.

The program features NASA scientists using measurement and estimation skills to 1) help characterize health, environmental, and other operational human biomedical risks associated with living in space, and 2) to identify strategies, tools, or technologies to prevent or reduce those risks.

To view this episode, visit <http://connect.larc.nasa.gov/episodes.html>.

# ACTIVITY

## CALORIES = ENERGY

What has more calories, breakfast cereal or a similar-sized portion of nuts? To find out, you will need: a piece of pecan, two pieces of cereal, clay, a large paper clip, a thermometer, 100 mL of water, matches or a birthday candle, a soft drink can and a pencil.

1. Straighten the sections of a paper clip so that it looks like the image on the right. Anchor the base in the clay, with the curved part of the paper clip in the air.
2. You also will need a soft drink can with the top removed. Slide a pencil through the holes in the sides of the can to make a handle.



### CEREAL

3. Add 50 mL of water to the can. Measure the starting temperature of the water and record your result in the box on the right.
4. Hook the cereal pieces on the paper clip. Carefully light the cereal from below using a match or candle.
5. Hold the can by the pencil, about one inch above the top of the flame from the cereal. If the cereal stops burning, light it again until it won't burn any more. Measure the temperature of the water again and record the result in the box to the right.
6. How many degrees did the temperature of the water change? Record your answer.



| CEREAL                      |    |
|-----------------------------|----|
| Starting water temperature: | °C |
| Final water temperature:    | °C |
| Change in temperature:      | °C |

### PECAN

7. Repeat steps 3 through 6 using the pecan piece. Place the pecan on top of the holder. Record the water temperatures in the box on the right.

| PECAN                       |    |
|-----------------------------|----|
| Starting water temperature: | °C |
| Final water temperature:    | °C |
| Change in temperature:      | °C |

### MEASURING ENERGY

A calorie is the amount of energy needed to raise the temperature of one mL of water by one degree Celsius. Based on this information and your investigation, answer the following questions. Use the back of this sheet or a separate sheet of paper to record your answers.

1. How many calories are needed to raise the temperature of 50 mL of water by one degree?
2. Based on your observations, how many calories were given off by the cereal? (Hint: multiply the change of temperature in degrees that you observed by 50.)
3. How many calories were given off by the pecan?
4. Would you get more energy from eating a similar size portion of pecans or cereal? Why?