BioEd℠

# THE SCIENCE OF FOOD AND FITNESS


## Energy for Life

*by*

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**RESOURCES**

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# TEAMING WITH BENEFITS

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


Dr. Jeffrey P. Sutton

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.

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.

## OVERVIEW

Students will observe and quantify the growth of yeast (a single-celled fungus) when it is given table sugar as a food source.

ACTIVITY

# ENERGY FOR LIFE

All living things on Earth require energy to move, grow and maintain themselves. Some organisms, especially plants and algae, are able to build all of the materials they need from very simple substances. Using energy from light, these organisms, known as **producers**, are able to make food in the form of carbohydrates from water and carbon dioxide. All other organisms, called **consumers**, rely on producers for food. Food provides energy and other raw materials necessary for life.

When used by organisms, food is broken down and energy is released. Oxygen is consumed during this process, and carbon dioxide is given off as a waste product. Some energy in living things is used to maintain their bodies and conduct the reactions necessary for life. During these processes, some of the energy also escapes as heat.

This activity is designed to introduce students to the relationship between food and energy. Students will observe what happens when yeast, a single-celled fungus, is provided with food (table sugar).

### SCIENCE EDUCATION CONTENT STANDARDS*

GRADES 5–8

#### LIFE SCIENCE

- All organisms are composed of cells—the fundamental unit of life. Most organisms are single cells.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires them to take in nutrients, which they use to provide energy.
- Reproduction is a characteristic of all living systems. Some organisms reproduce asexually.
- Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food.

#### PHYSICAL SCIENCE

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

#### SCIENCE, HEALTH & MATH SKILLS

- Observing
- Measuring
- Graphing
- Using a microscope

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

## TIME

15 minutes for setup; 45 minutes to conduct activity. (Optional: If students make temperature observations, total time is one hour.)

## MATERIALS

**Each group will need:**

- 100 mL of water at room temperature
- 2 250-mL beakers or plastic cups
- 2 craft sticks or plastic spoons
- 2 pkgs of rapid rising yeast
- 2 tsp of sugar (or 2 single serve sugar packets)
- Plastic ruler, metric (mm marked)
- Sheet of graph paper
- Tape, paper and marker (for labeling)
- Copy of student sheet

**Optional, per group (see Setup):**

- 12-in. laboratory thermometer or temperature probe
- Dropper or plastic pipette

*Continued*

### Yeasts

Yeast are tiny members of the Fungus Kingdom, which also includes mushrooms. Fungi (plural of fungus) are important decomposers of waste and dead plant and animal materials. Yeast also is used for baking bread.

### Sugars

Sugars are small molecules made of carbon, hydrogen and oxygen. The energy in sugar is held in the chemical bonds between atoms. When sugar molecules are used for energy, carbon dioxide ($CO_2$) and water ($H_2O$) are given off. The energy that becomes available can be used immediately or stored as other chemical bonds. Some energy also is transformed and given off as heat.

- Glass or plastic slides and coverslips
- Microscope

## SETUP & MANAGEMENT

Students will observe yeast growing in sugar water. Adjust the temperature of the water to room temperature.

Read "Using Cooperative Groups in the Classroom," page 3. Prepare name tags for each group of four students. Place all materials in a central location for each group of students to collect.

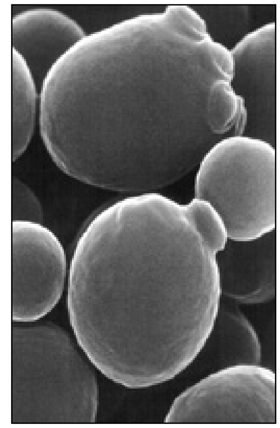
**Optional:** If you have access to 12-in. laboratory thermometers or electronic probes to measure temperature, have students also measure the starting temperature of the yeast mixtures and record the temperatures at 10 minute intervals. OR set up a demonstration with a temperature probe inserted in the yeast, sugar and water mixture. Students will be able to observe that the temperature of the water in which the yeast is growing will increase between 0.5–1.5°C during the class period. Have students construct a graph showing the change in temperature over time.

If microscopes are available, have students observe a drop of water containing yeast cells from the beakers containing sugar. Students should place a drop of solution on a slide and cover it with a cover slip.

## PROCEDURE

1. Begin a class discussion of energy and living things by asking questions such as, *What are the basic needs of living things? Do all organisms need exactly the same things to live? What do plants need? What about animals? Do animals need the same things as plants?* Mention that plants are able to manufacture everything they need from very basic raw materials (carbon dioxide from air, water, nutrients from soil and energy from sunlight) through the process known as photosynthesis. Also mention that plants and other photosynthetic organisms are called producers, and that animals, fungi and others that rely on photosynthetic organisms for food are known as consumers.
2. Have the Materials Manager from each group collect all of the supplies. The Materials Manager should measure 50 mL of water into each of the 250-mL beakers before taking them to his or her work area.
3. Tell students that they will be investigating the behavior of a common fungus (baker's yeast) when it is fed. Ask students to share anything they know about yeast. Students will follow the instructions and record their observations on their student sheet.
4. Before beginning, each group should label one beaker as "Sugar" and the other beaker, "No Sugar."
5. Have each group predict what will happen when yeast and water are combined. They also should predict what might happen when yeast, water and sugar are combined. Let the groups add yeast to the water in each of the beakers and stir the mixture gently. Groups should observe the appearance of the mixtures and record their observations.
6. Next, have students add approximately two teaspoons of sugar to the beaker labeled "Sugar."
7. Have students observe the appearance of the yeast mixtures at 5-minute intervals and record their observations. They may gently stir the mixtures periodically with separate craft sticks or plastic spoons.
8. Once some of the yeast cultures have accumulated a thin layer of foam, ask students, *What is happening to the yeast?* Help students understand that the yeast cells have begun to grow and multiply in the presence of water and food (sugar). The gas being produced is carbon dioxide, the same waste product that we give off when food is processed inside cells in our bodies.
9. Next, students will observe the production of carbon dioxide gas by yeast. Have students measure and record the height of the foam in each

### Baker's Yeast



Scanning electron micrograph of common baker's yeast, *Saccharomyces cerevisiae*. (x3000).



### Energy from the Sun

Almost all energy on Earth comes from the sun. We can see part of this energy as visible light and feel part of it as heat. Heat and light that we can detect are just part of the entire spectrum of radiation given off by the sun.

Radiation travels in waves. Some kinds of radiation are listed below, from longest to shortest wavelengths.

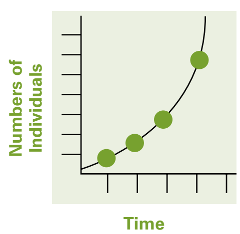
- Long wave radio
- Short wave radio
- Radar
- Microwaves
- Visible light
- Ultraviolet light
- X-rays
- Gamma rays
- Cosmic rays

Outside Earth's atmosphere, spacecraft are exposed to all types of radiation from the sun.

## Food Sources

Plants can manufacture all of the molecules they need. Most animals, on the other hand, have to obtain both energy and nutrients from food. Different animals vary in their abilities to use food sources. For example, cattle have a complex digestive system that allows them to break down and use tough fibers in grasses for food.

## Graphing Curve




**Typical Growth Curve**

Students might notice that their graphs of yeast foam are curved rather than straight lines. This is because the yeast with sugar are growing and reproducing very rapidly. Such patterns are seen in groups of organisms with abundant resources and no limits on growth.

## Did You Know?

Have you ever wondered why a room crowded with people becomes warmer?

At rest, the average person gives off about the same amount of heat as a 60 watt light bulb.

## USING COOPERATIVE GROUPS IN THE CLASSROOM

Cooperative learning is a systematic way for students to work together in groups of two to four. It provides organized group interaction and enables students to share ideas and to learn from one another. Students in such an environment are more likely to take responsibility for their own learning. Cooperative groups enable the teacher to conduct hands-on investigations with fewer materials.

Organization is essential for cooperative learning to occur in a hands-on science classroom. Materials must be managed, investigations conducted, results recorded, and clean-up directed and carried out. Each student must have a specific role, or chaos may result.

The Teaming Up! model* provides an efficient system for cooperative learning. Four "jobs" entail specific duties. Students wear job badges that describe their duties. Tasks are rotated within each group for different activities so that each student has a chance to experience all roles. For groups with fewer than four students, job assignments can be combined.

Once a cooperative model for learning is established in the classroom, students are able to conduct science activities in an organized and effective manner. The job titles and responsibilities are as follow.

**Principal Investigator**
- Reads the directions
- Asks questions of the instructor/teacher
- Checks the work

**Maintenance Director**
- Directs carrying out of safety rules
- Directs the cleanup
- Asks others to help

**Reporter**
- Records observations and results
- Shares results with group or class
- Tells the teacher when the investigation is complete

**Materials Manager**
- Picks up the materials
- Directs use of equipment
- Returns the materials

* Jones, R.M. 1990. Teaming Up! LaPorte, Texas: ITGROUP.

beaker at 5-minute intervals. (The beaker labeled "No Sugar" may not produce any foam at all.) Students should record their observations on their student sheets.

10. Conclude by leading students in a discussion of yeast growth. Help them understand that they used different kinds of evidence to show that the yeast were using the sugar as food. First, the yeast were breaking down sugar to obtain energy. In the process, the yeast released observable carbon dioxide gas (visible as bubbles). Second, the yeast mixture became warmer. Heat was released as a by-product of the energy conversions happening inside the yeast cells. The yeast in the beaker without sugar did not have food to grow, so these reactions did not occur in this beaker.

## EXTENSIONS

- Challenge students to come up with other ways to measure yeast growth and development.
- Have students use an acid/base indicator solution (such as bromothymol blue) to detect the presence of carbon dioxide in the air they exhale. Students should blow through a straw into a glass of water and use the indicator to observe whether the water becomes more acidic from the presence of dissolved carbon dioxide (forms a weak acid in water). OR have them make their own indicator by boiling purple cabbage to create a dark blue or purple liquid. This liquid turns pink in the presence of acids, and green or blue in the presence of bases.
- Challenge students to compare and contrast the use of sugar by yeast and the burning of a candle. What are the similarities between the two processes? What are the differences?

# IS IT ALIVE?

What do you think will happen when yeast is combined with water, and with sugar and water? Write your predictions below.

Yeast and Water: ______________________________________________

______________________________________________

Yeast, Water and Sugar: ______________________________________________

______________________________________________

## Making Yeast and Water

1. Measure 50 mL of room temperature water into each beaker. Label one beaker "No Sugar" and the other "Sugar."
2. Add a package of yeast to each beaker and stir gently. Add two teaspoons of sugar to the beaker labeled "Sugar" and stir it gently. Observe the appearance of the mixtures every five minutes. After each observation, record the appearance of the mixtures, including any bubbles or foam that develop, and the total height of each mixture. Place a metric ruler on the outside of the beaker to measure the mixture in millimeters, from the bottom of the beaker to the top of the foam.

| Time | YEAST + WATER | | YEAST + WATER + SUGAR | |
|---|---|---|---|---|
| | Appearance | Height of mixture (mm) | Appearance | Height of mixture (mm) |
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3. On a sheet of graph paper, create a bar graph of the height of each mixture at each observation.
4. On a separate sheet of paper, write a paragraph describing your yeast observations. Did your observations match your predictions? Why or why not?
5. What was the role of the sugar in this experiment?

______________________________________________

______________________________________________

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