BioEd℠

THE SCIENCE OF FOOD AND FITNESS

Your Energy Needs

by

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RESOURCES

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BCM®
Baylor College of Medicine

Printed in the United States of America

ISBN-13: 978-1-888997-56-9

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Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine. The mark "BioEd" is a service mark of Baylor College of Medicine.

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ACKNOWLEDGMENTS

The authors gratefully acknowledge the support of Bobby R. Alford, M.D., Jeffrey P. Sutton, M.D., Ph.D., William A. Thomson, Ph.D., Jeanne Lynn Becker, Ph.D., Marlene Y. MacLeish, Ed.D., and Kathryn S. Major, B.A., as well as the contributions of the following guest content reviewers: Lindsey Briggs, B.S., Michael Grusak, Ph.D., Helen W. Lane, Ph.D., Joanne Lupton, Ph.D., Barbara Rice, R.D, L.D., and Lisa Sanders, Ph.D.

This work was supported by National Space Biomedical Research Institute through NASA NCC 9-58.

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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 estimate average daily baseline energy (Calorie) needs and energy needs for different levels of activity.

ACTIVITY

YOUR ENERGY NEEDS

Energy fuels growth, movement and all the processes in every cell inside the body. It has many different forms and cannot be created or destroyed, only transformed from one form to another. Both light and heat are examples of energy.

Many students may have difficulty understanding energy and its measurement. One way to approach these concepts is to think of energy as the ability to make either a change or a movement. There are many ways of making a change or creating movement, and energy can have many forms. For example, when a person kicks a ball, the energy from the kick makes the ball move forward. Or in cooking, energy in the form of heat changes an egg white from a clear liquid to an opaque solid. Energy in food commonly is measured as calories.

The easiest way to describe calories is to introduce them as a unit of measure. Weight can be measured in kilograms or pounds; distance can be measured in meters or feet; and energy can be measured in calories. As shown in "Energy Sources," one calorie is the amount of energy necessary to raise the temperature of one milliliter of water by one degree Celsius. Usually, when we refer to calories in food, we actually are considering **kilocalories**. One kilocalorie equals one thousand calories and usually is written in the capitalized form, "Calorie."

In this activity, students will figure out how many Calories a typical teenager needs every day. Baseline Calorie needs (also called **Basal Metabolic Rate**, or BMR), can be estimated based on gender, age, height and weight. Each student also may calculate his or her own baseline Calorie needs (see Step 6, p. 2).

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 a chemical. 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.
- Regular exercise is important to the maintenance and improvement of health. The benefits of exercise include maintaining healthy weight.

SCIENCE, HEALTH & MATH SKILLS

- Calculating
- Predicting
- Converting measurements
- Drawing conclusions

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

TIME

10 minutes for setup; 45–60 minutes to conduct activity

MATERIALS

Each student will need:

- Copies of student sheets
- Calculator

Fitness Benefits

The benefits of physical fitness include maintaining healthy weight; having energy and strength for routine activities; promoting good muscle tone, bone strength, and strong heart/lung systems; reducing risk of some diseases; and contributing to improved mental health.

Teacher Resources

Online presentations of each activity, downloadable activities in PDF format, and annotated slide sets for classroom use are available free at www.bioedonline.org or www.k8science.org.

Physical Activity

For most people, physical activity accounts for individual differences in the actual amounts of calories expended during the day. The amount of lean body tissue also affects how much energy the body uses for basic functions.

Using Energy

Total energy expenditure includes energy used at rest and during physical activity. It also is important to consider age, sex, body size and composition, genetic factors and overall health. The rate at which the body uses energy (metabolic rate) increases after eating and reaches a maximum about one hour after a meal is consumed. Metabolism refers to all the chemical reactions inside a living organism. Metabolism also releases small amounts of energy as heat (as observed in Activity 1).

People with a high Basal Metabolic Rate (BMR) include: athletes, children, pregnant women, and tall, thin people.

Factors that raise BMR include: stress, fever and extreme temperatures (both heat and cold).

Humans expend less energy in space. Astronauts must exercise frequently to counteract some of the effects of living in microgravity.

SETUP & MANAGEMENT

Have students work individually.

PROCEDURE

Dr. John L. Phillips, Science Officer and Flight Engineer, NASA ISS Expedition 11, uses the cycle while participating in a Foot-Ground Reaction Forces During Spaceflight experiment. Phillips is wearing specially instrumented cycling tights outfitted with sensors for the experiment.

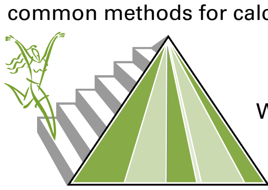
Photo courtesy of NASA.

1. Begin a class discussion of energy by asking questions such as, *What is energy? Where do we get our energy? What do we do with the energy? Do we all need the same amount of energy? What happens to the food we eat?* Tell students that they will be investigating how many Calories adolescents need every day. Explain that "calorie" is a measure of energy that can be applied to food.
2. Give each student copies of the two activity sheets and have them follow the instructions to calculate the daily Calorie needs of an average teenage boy and girl.
3. Students may need assistance with metric measurements, such as kilograms (kg) and centimeters (cm), necessary for their calculations. If appropriate, talk about conversion factors and different measurement systems. One kg is approximately 2.2 pounds (lb) and one cm is 0.4 inches (in.).
4. Discuss students' calculations. Mention that a person's energy needs are based not only on sex, weight and height, but also on daily activities. Explain that Basal Metabolic Rate (BMR) represents the amount of Calories necessary to maintain life. Ask, *What are the differences among caloric requirements of different physical activities?*
5. Expand the discussion by introducing the idea that athletes and other persons who are physically fit spend more Calories and as a result require more Calories. Help students understand that to stay fit and healthy, a person must maintain a balance between the intake and expenditure of Calories.
6. As a take-home activity, give students clean copies of both activity sheets and have them calculate their own BMRs and total daily Calorie needs.

THE HARRIS-BENEDICT EQUATION

To maintain a constant weight, the amount of Calories a person uses in a day should equal the amount of Calories he or she consumes. To calculate how many Calories are used each day, we first must determine the baseline rate at which the body uses energy. This rate is called the Basal Metabolic Rate (BMR).

At the beginning of the 20th Century, Francis Benedict directed numerous studies of human basal metabolic rate (BMR). He developed a set of equations that could estimate BMR in humans without complex measurements. The Harris-Benedict equations, shown below, continue to be the most common methods for calculating BMR.



For men, BMR = 66.5 + (13.75 x W) + (5.003 x H) - (6.775 x A)
For women, BMR = 655.1 + (9.5663 x W) + (1.85 x H) - (4.676 x A)
Where: W = actual weight in kilograms (0.454 kilograms per pound)
H = height in centimeters (2.54 cm per inch)
A = age in years

ACTIVITY

Baseline Energy Needs

How much energy does a person use in a day? To answer this question, you first need to know how much energy the body uses when it isn't doing anything. This number provides a baseline estimate of a person's energy needs. Use the information provided to calculate the amount of energy needed by an average 15-year-old boy and girl. Follow the instructions carefully to complete each equation.

1. Fill in the values to convert weight from pounds (lb) to kilograms (kg), and height from inches (in.) to centimeters (cm).

BOY (Weight = 136 lb | Height = 67 in.)	**GIRL (Weight = 127 lb | Height = 64 in.)**
______ (lb) × 0.45 = ______ (kg)	______ (lb) × 0.45 = ______ (kg)
______ (in.) × 2.54 = ______ (cm)	______ (in.) × 2.54 = ______ (cm)

2. Use the information from Item 1 to complete the equations below and figure out resting energy needs. This is called Basal Metabolic Rate, or BMR. Begin with the equations at the top and work down.

BOY	**GIRL**
______ (kg) × 13.8 = ______ (A)	______ (kg) × 9.6 = ______ (A)
______ (cm) × 5 = ______ (B)	______ (cm) × 1.9 = ______ (B)
______ (A) + ______ (B) = ______ (C)	______ (A) + ______ (B) = ______ (C)
______ (C) + 66.5 = ______ (D)	______ (C) + 655.1 = ______ (D)
______ (Age) × 6.8 = ______ (E)	______ (Age) × 4.7 = ______ (E)
______ (D) − ______ (E) = ☐ (BMR)	______ (D) − ______ (E) = ☐ (BMR)

Note. The tables and equation models on this page may be used to calculate your own resting energy needs.

ACTIVITY

TOTAL ENERGY NEEDS

Resting energy needs, also called BMR, account for only part of the Calories used by the body. Physical activities also use energy. The total amount of energy used depends on the kind of activity being done and time spent doing it. Use the BMRs (from the Baseline Energy Needs sheet) you already calculated for the boy and girl. Then, add their exercise habits (shown below) to the equation to find out how many Calories a typical boy and girl might actually use each day.

BOY: **Spends most of his time watching TV or sitting in school.**
GIRL: **Attends daily soccer practice after school for two hours and runs (jogs) for at least one hour each day on the weekend.**

1. Select the category that best describes the exercise level for each teenager and solve the corresponding equation below. You also will need the BMR numbers from the "Baseline Energy Needs" page.

Low Energy	Medium Energy	High Energy
Most strenuous activities in a day include at least an hour of one of the following: reading, sitting or eating.	Most strenuous activities in a day include at least an hour of one of the following: walking, dancing, skating, bowling, golfing or other light exercise.	Most strenuous activities in a day include at least an hour of one of the following: running, bicycling, playing basketball, playing soccer, gymnastics, playing tennis or other moderate to intense exercise.

BOY		GIRL	
Low Energy	1.3 × ______ BMR = ______ Cal/Day	**Low Energy**	1.3 × ______ BMR = ______ Cal/Day
Medium Energy	1.7 × ______ BMR = ______ Cal/Day	**Medium Energy**	1.7 × ______ BMR = ______ Cal/Day
High Energy	1.9 × ______ BMR = ______ Cal/Day	**High Energy**	1.9 × ______ BMR = ______ Cal/Day

2. What were the total energy needs of the boy? ______________ Cal/Day
3. What were the total energy needs of the girl? ______________ Cal/Day
4. Based on your calculations, did the boy or girl have higher total daily Calorie needs? ______________
5. What could a person do if he or she wanted to use more Calories in a day?

____

____

____