The Science of Energy Balance: Calorie Intake and Physical Activity

under a contract from the
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National Institute of Diabetes and Digestive and Kidney Diseases

BSCS

5415 Mark Dabling Boulevard
Colorado Springs, Colorado 80918

BSCS Development Team
Rodger Bybee, Principal Investigator
Jerry Phillips, Project Director
April Gardner, Curriculum Developer
Sharmila Basu, Curriculum Developer
Gerry Saunders, Curriculum Developer
Carrie Hamm, Project Assistant
Ted Lamb, Evaluator
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Design Conference Participants
Jo Ann Carson, University of Texas, Dallas, Texas
Stephen Havas, University of Maryland at Baltimore School of Medicine, Baltimore, Maryland
Susan Johnson, University of Colorado Health Sciences Center, Denver, Colorado
Joel Maier, New Options Middle School, Seattle, Washington
Jeffery Marshall, Irving Middle School, Colorado Springs, Colorado
Angela McDaniel, Taylor County Middle School, Grafton, West Virginia
Marguerite Nunnally, Woodward Academy, College Park, Georgia
Janice Ryan, Brandeis Hillel Day School, San Francisco, California
Diane Stadler, Oregon Health Sciences Center, Portland, Oregon
Brian Tobin, Mercer University School of Medicine, Macon, Georgia

Primary Field-Test Teachers
Joey Beckett, Beckley Stratton Junior High, Beckley, West Virginia
Louisa Bliss, Gilman Middle School, Gilman, Vermont
Nicole Cavaliere, Cheyenne Elementary School, Peoria, Arizona
Sally Greer, Whitford Middle School, Beaverton, Oregon
Randie Haws, Cheyenne Elementary School, Peoria, Arizona
Anna Kong, Stone Academy, Chicago, Illinois
Marvin Nochowitz, Irving School, Chicago, Illinois
Peter Petrossian, Thomas Pyle Middle School, Bethesda, Maryland

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Please contact the NIH Office of Science Education with questions about this supplement at *supplements@science.education.nih.gov.*

Contents

Foreword

This curriculum supplement, from *The NIH Curriculum Supplements Series*, brings cutting-edge medical science and basic research discoveries from the laboratories of the National Institutes of Health (NIH) into classrooms. As the largest medical research institution in the United States, NIH plays a vital role in the health of all Americans and seeks to foster interest in research, science, and medicine-related careers for future generations. NIH's Office of Science Education (OSE) is dedicated to promoting science education and scientific literacy.

We designed this curriculum supplement to complement existing life science curricula at both the state and local levels and to be consistent with *National Science Education Standards*.[1] It was developed and tested by a team composed of teachers, scientists, medical experts, and other professionals with relevant subject-area expertise from schools and institutes from across the country, and by NIH scientists and curriculum-design experts from Biological Sciences Curriculum Study (BSCS), SAIC, and Edge Interactive. The authors incorporated real scientific data and actual case studies into classroom activities. A three-year development process included geographically dispersed field tests by teachers and students.

The structure of this module enables teachers to effectively facilitate learning and stimulate student interest by applying scientific concepts to real-life scenarios. Design elements include a conceptual flow of activities based on BSCS's 5E Instructional Model of Learning, multisubject integration emphasizing cutting-edge science content, and built-in assessment tools. Activities promote active and collaborative learning and are inquiry-based to help students develop problem-solving strategies and critical thinking.

Each curriculum supplement comes with a complete set of materials for both teachers and students, including printed materials, extensive background and resource information, and a Web site with interactive activities. The supplements are distributed at no cost to teachers across the United States. All materials may be copied for classroom use but may not be sold. We welcome feedback from our users. For a complete list of curriculum supplements, updates, availability and ordering information, or to submit feedback, please visit our Web site at *http://science.education.nih.gov* or write to

Curriculum Supplements Series
Office of Science Education
National Institutes of Health
6705 Rockledge Dr., Suite 700 MSC 7984
Bethesda, MD 20892-7984

We appreciate the valuable contributions of the talented staff at BSCS, SAIC, and Edge Interactive. We are also grateful to the NIH scientists, advisors, and all other participating professionals for their work and dedication. Finally, we thank the teachers and students who participated in focus groups and field tests to ensure that these supplements are both engaging and effective. I hope you find our series a valuable addition to your classroom and wish you a productive school year.

Bruce A. Fuchs, Ph.D.
Director
Office of Science Education
National Institutes of Health
supplements@science.education.nih.gov

1 In 1996, the National Academy of Sciences released the *National Science Education Standards*, which outlines what all citizens should understand about science by the time they graduate from high school. The *Standards* encourages teachers to select major science concepts that empower students to use information to solve problems rather than stressing memorization of unrelated information.

About the National Institutes of Health

Begun as the one-room Laboratory of Hygiene in 1887, the National Institutes of Health (NIH) today is one of the world's foremost medical research centers and the federal focal point for health research in the United States.

Mission and Goals

The NIH mission is science in pursuit of fundamental knowledge about the nature and behavior of living systems and the application of that knowledge to extend healthy life and reduce the burdens of illness and disability. The goals of the agency are to

- foster fundamental creative discoveries, innovative research strategies, and their applications as a basis for advancing significantly the nation's capacity to protect and improve health;
- develop, maintain, and renew scientific resources—both human and physical —that will ensure the nation's ability to prevent disease;
- expand the knowledge base in medical and associated sciences in order to enhance the nation's economic well-being and ensure a continued high return on the public investment in research; and
- exemplify and promote the highest level of scientific integrity, public accountability, and social responsibility in the conduct of science.

NIH works toward meeting those goals by providing leadership, direction, and grant support to programs designed to improve the health of the nation through research in the

- causes, diagnosis, prevention, and cure of human diseases;
- processes of human growth and development;
- biological effects of environmental contaminants;
- understanding of mental, addictive, and physical disorders; and
- collection, dissemination, and exchange of information in medicine and health, including the development and support of medical libraries and the training of medical librarians and other health information specialists.

Organization

Composed of 27 separate institutes and centers, NIH is one of eight health agencies of the Public Health Service within the U.S. Department of Health and Human Services. NIH encompasses 75 buildings on more than 300 acres in Bethesda, Md., as well as facilities at several other sites in the United States. The NIH budget has grown from about $300 in 1887 to more than $27.8 billion in 2004.

Research Programs

One of NIH's principal concerns is to invest wisely the tax dollars entrusted to it for the support and conduct of this research. Approximately 82 percent of the investment is made through grants and contracts supporting research and training in more than 2,000 research institutions throughout the United States and abroad. In fact, NIH grantees are located in every state in the country. These grants and contracts make up the NIH Extramural Research Program.

Approximately 10 percent of the budget goes to NIH's Intramural Research Programs, the more than 2,000 projects conducted mainly in its own laboratories. These projects are central to the NIH scientific effort. First-rate intramural scientists collaborate with one another regardless of institute affiliation or scientific discipline and have the intellectual freedom to pursue their research leads in NIH's own laboratories.

These explorations range from basic biology to behavioral research, to studies on treatment of major diseases.

Grant-Making Process

The grant-making process begins with an idea that an individual scientist describes in a written application for a research grant. The project might be small, or it might involve millions of dollars. The project might become useful immediately as a diagnostic test or new treatment, or it might involve studies of basic biological processes whose clinical value may not be apparent for many years.

Each research grant application undergoes peer review. A panel of scientific experts, primarily from outside the government, who are active and productive researchers in the biomedical sciences, first evaluates the scientific merit of the application. Then, a national advisory council or board, composed of eminent scientists as well as members of the public who are interested in health issues or the biomedical sciences, determines the project's overall merit and priority in advancing the research agenda of the particular NIH funding institutes.

About 38,500 research and training applications are reviewed annually through the NIH peer-review system. At any given time, NIH supports 35,000 grants in universities, medical schools, and other research and research training institutions, both nationally and internationally.

NIH Nobelists

The roster of people who have conducted NIH research or who have received NIH support over the years includes some of the world's most illustrious scientists and physicians. Among them are 115 winners of Nobel Prizes for achievements as diverse as deciphering the genetic code and identifying the causes of hepatitis.

Five Nobelists made their prize-winning discoveries in NIH laboratories. You can learn more about Nobelists who have received NIH support at *http://www.nih.gov/about/almanac/nobel/index.htm*.

Impact on the Nation's Health

Through its research, NIH has played a major role in making possible many achievements over the past few decades, including

- Mortality from heart disease, the number one killer in the United States, dropped by 36 percent between 1977 and 1999.
- Improved treatments and detection methods increased the relative five-year survival rate for people with cancer to 60 percent.
- With effective medications and psychotherapy, the 19 million Americans who suffer from depression can now look forward to a better, more productive future.
- Vaccines are now available that protect against infectious diseases that once killed and disabled millions of children and adults.
- In 1990, NIH researchers performed the first trial of gene therapy in humans. Scientists are increasingly able to locate, identify, and describe the functions of many of the genes in the human genome. The ultimate goal is to develop screening tools and gene therapies for the general population for cancer and many other diseases.

About the National Institute of Diabetes and Digestive and Kidney Diseases

The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) conducts and supports research on many diseases that affect public health, including diabetes, hepatitis, and glomerulonephritis (a serious kidney disease). Other disorders that affect metabolism, the endocrine system, blood, and digestive and urological organs are also in the Institute's research portfolio.

To learn how people develop these diseases and how to cure them, NIDDK supports researchers at universities and teaching hospitals around the country and in its own labs in Bethesda, Maryland, and Phoenix, Arizona. The Institute's researchers also collaborate with scientists from other institutes of the National Institutes of Health, other governmental agencies, and the private sector who are interested in similar problems.

Investigators and institutions interested in the scientific areas supported by NIDDK compete for a wide variety of grants to do basic and clinical research. Basic researchers tackle fundamental questions about biological processes. How fat cells develop, how beta cells (the pancreas's insulin-producing cells) function, and how to introduce foreign genes into humans are basic research questions of interest to NIDDK. On the clinical side, NIDDK funds physician researchers and other healthcare professionals to evaluate new treatments for diseases. Those treatments can be pharmacological or behavioral or both. In a recent clinical trial sponsored by NIDDK and several other groups, researchers showed that lifestyle changes—eating less and moving more—could significantly lower the chances of developing diabetes for people at high risk for the disease.

Funding is also available for conferences and workshops where scientists can share information, for training young scientists and physicians who wish to pursue scientific careers, and for small businesses developing innovative technologies of use to the research community.

NIDDK-sponsored researchers represent many fields of science, among them biochemistry, developmental and cell biology, computer science, epidemiology, genetics, physiology, pharmacology, physics, and mathematics. NIDDK is especially interested in nutrition and energy balance, the subject of this curriculum supplement. Energy balance gone awry—meaning that people eat more calories than they burn off—contributes significantly to obesity, which, in turn, is a major risk factor for type 2 diabetes and other diseases. Obesity and type 2 diabetes, once considered a disease of middle age, are both on the rise in young people. An estimated 15 percent of children aged 6 to 19 years are overweight.

For more information about NIDDK, visit its Web site at *http://www.niddk.nih.gov*.

Introduction to *The Science of Energy Balance: Calorie Intake and Physical Activity*

In the United States, 15 percent of children and adolescents are overweight.[40] Alarmingly, the proportion of overweight children continues to grow. Over the past two decades, the proportion of overweight adolescents has tripled. Children have fewer weight-related health problems than adults do. However, overweight children are at high risk of becoming overweight adolescents and adults. Overweight adults are at risk for health problems including heart disease, diabetes, high blood pressure, stroke, and some forms of cancer. Approaches to this major health issue focus on several areas, including educating the public about basic nutrition principles and the value of physical activity. Maintaining a healthy body weight and lifestyle requires a long-term commitment and relies on individuals making the right choices about food intake and exercise.

What Are the Objectives of the Module?

The Science of Energy Balance: Calorie Intake and Physical Activity has several objectives. One is to introduce students to the key concept of energy balance and provide a context within which nutrition concepts learned at other times can be better understood. Through inquiry-based activities, students investigate energy intake and energy output as they develop their understanding of energy balance. A second objective is to allow students to develop the understanding that achieving energy balance is a long-term, rather than a short-term, goal. The lessons in this module help students sharpen their skills in observation, critical thinking, experimental design, and data analysis. They also make connections to other disciplines such as English, history, mathematics, and social science. A third objective is to convey to students the purpose of scientific research. Ongoing research affects how we understand the world around us and gives us the foundation for improving choices about our personal health and the health of our community. In this module, students experience how science provides evidence that can be used to understand and treat human disease. Because the mission of the National Institute of Diabetes and Digestive and Kidney Diseases includes helping the public understand the importance of calorie intake and physical activity to their health, education is an important activity for the Institute.

The lessons in this module encourage students to think about the relationships among knowledge, choice, behavior, and human health in this way:

Knowledge (what is known and not known) + Choice = Power

Power + Behavior = Enhanced Human Health

The final objective of this module is to encourage students to think in terms of these relationships now and as they grow older.

Why Teach the Module?

Middle school life science classes offer an ideal setting for integrating many areas of student interest. In this module, students participate in activities that integrate inquiry, science, human health, mathematics, and science-technology-society relationships. The real-life context of the module's classroom lessons is engaging for students, and the knowledge gained can be applied immediately to students' lives.

"The module focuses on and supports scientific inquiry. It encourages learners to think hypothetically, to extrapolate, and to hypothesize. The module challenges students to reflect on personal choices, thereby empowering them to make better decisions regarding their own energy balance. The module engages students in the use of technology to promote better understanding of concepts, and to explore and analyze data." – Field-Test Teacher

"The best aspect was the ability to individualize most of the things we did. This was good because it got us more involved. Another aspect was the Web site, which was a nice change from the usual media used in the classroom. The third good thing was that the lessons related to our lives more than most science, which made it more interesting."
– Field-Test Student

What's in It for the Teacher?

The Science of Energy Balance: Calorie Intake and Physical Activity meets many of the criteria by which teachers and their programs are assessed.

- The module is **standards based** and meets science content, teaching, and assessment standards as expressed in the *National Science Education Standards*. It pays particular attention to the standards that describe what students should know and be able to do with respect to **scientific inquiry**.
- As described above, it is an **integrated** module, drawing most heavily from the subjects of science, social science, mathematics, and health.
- The module has a Web-based **technology component** that includes an interactive database and simulations.
- Finally, the module includes built-in **assessment tools**, which are noted in each of the lessons with an assessment icon.

In addition, the module provides a means for **professional development**. Teachers can engage in new and different teaching practices like those described in this module without completely overhauling their entire program. In *Designing Professional Development for Teachers of Science and Mathematics*, Susan Loucks-Horsley et al. write that replacement modules such as *The Science of Energy Balance* can "offer a window through which teachers can get a glimpse of what new teaching strategies look like in action." [27] By experiencing a short-term unit like this one, teachers can "change how they think about teaching and embrace new approaches that stimulate students to problem solve, reason, investigate, and construct their own meaning for the content." The use of a supplemental unit like this module can encourage reflection and discussion and stimulate teachers to improve their practices by focusing on student learning through inquiry.

The following table correlates topics often included in the middle school life science curriculum with the major concepts presented in this module. This information is presented to help teachers make decisions about incorporating this material into the curriculum.

Correlation of *The Science of Energy Balance: Calorie Intake and Physical Activity* to Common Middle School Life Science Topics

Topics	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Chemical composition of matter		✔	✔		
Individual variation and susceptibility	✔	✔	✔	✔	✔
Human health and medicine			✔		✔
Risk assessment and management			✔		✔
Scientific methods	✔	✔	✔	✔	
Relationships among science, technology, and society			✔	✔	
Energy changing from one form into another	✔	✔	✔	✔	
Organisms sensing and responding to environmental stimuli				✔	

Implementing the Module

The five lessons in this module are designed to be taught in sequence for approximately eight days as a replacement for a part of the standard curriculum in middle school life science. The following pages offer general suggestions about using these materials in the classroom; you will find specific suggestions in the procedures provided for each lesson.

What Are the Goals of the Module?

The Science of Energy Balance: Calorie Intake and Physical Activity is designed to help students reach these major goals associated with scientific literacy:

- to understand a set of basic scientific principles related to the nature of energy balance and the relationships of energy balance to human health;
- to experience the process of scientific inquiry and develop an enhanced understanding of the nature and methods of science; and
- to recognize the role of science in society and the relationship between basic science and human health.

What Are the Science Concepts and How Are They Connected?

The lessons are organized into a conceptual framework that allows students to move from what they already know about energy balance, some of which may be incorrect, to gaining a scientific perspective on the nature of energy balance and its importance to science and to their lives. Students begin by developing their own definition of energy balance through investigations of their own energy use (*Burning It Up*) and energy intake (*A Serving by Any Other Name*). Students then explore energy balance by acting as energy balance experts to evaluate five fictitious characters (*A Delicate Balance*). An investigation of factors affecting energy balance using an animal model (*Munching Mice*) allows students to gain a deeper understanding of energy balance and its impact on our lives. The final lesson, *Dear Me*, allows students to consider what they have learned in the context of how they envision themselves in the future. The following two tables illustrate the science content and conceptual flow of the classroom lessons and activities.

Science Content of the Lessons

Lesson	Science Content
Lesson 1	What is energy?; physical activity ($Energy_{out}$)
Lesson 2	Food as a source of energy ($Energy_{in}$)
Lesson 3	The energy balance equation
Lesson 4	Factors affecting energy balance
Lesson 5	Strategies for achieving energy balance

Conceptual Flow of the Lessons

Lesson	Learning Focus*	Major Concepts
Lesson 1 *Burning It Up*	Engage Explore Explain	Humans require energy to function. The total energy used by an individual depends on the type and intensity of the activity and the energy required for basic life processes. The amount of energy required to maintain minimum essential life functions is called basal metabolic rate, or BMR. The amount of energy used by an individual varies from day to day and from one individual to another.
Lesson 2 *A Serving by Any Other Name*	Explore Explain	Humans obtain energy from the food they consume. Food labels contain information about the types of nutrients, number of calories per serving, and serving size.
Lesson 3 *A Delicate Balance*	Explore Explain	Maintaining a particular weight requires consuming the same number of calories in food that are used in BMR and physical activities—that is, balancing energy intake and energy output. The balance over a long period of time, such as weeks and months, will affect weight gain and loss. Children, adolescents, and teenagers need to consume more calories than they use for BMR and physical activities because of the energy requirements for growth.
Lesson 4 *Munching Mice*	Explore Explain Elaborate	Energy balance can be affected by several variables, including genetics, food availability, and physical activity. Laboratory animals can be used as experimental models for humans. Graphing data on weight change helps researchers draw conclusions about the impact of factors on energy balance.
Lesson 5 *Dear Me*	Evaluate	Strategies can be developed for maintaining a healthy body weight. Choice is an important variable. Energy balance is a lifelong issue.

*See *How Does the 5E Instructional Model Promote Active, Collaborative, Inquiry-Based Learning?* on page 9.

How Does the Module Correlate to the *National Science Education Standards*?

NSES

The Science of Energy Balance: Calorie Intake and Physical Activity supports teachers in their efforts to reform science education in the spirit of the National Research Council's 1996 *National Science Education Standards* (*NSES*). The content of the module is explicitly standards based. Each time a standard is addressed in a lesson, an icon appears in the margin and the applicable standard is identified. The following chart lists the specific content standards that this module addresses.

Content Standards: Grades 5–8

Standard A: **As a result of activities in grades 5–8, all students should develop**	**Correlation to *The Science of Energy Balance: Calorie Intake and Physical Activity***
Abilities necessary to do scientific inquiry	
• Identify questions and concepts that guide scientific investigations.	Lessons 1, 4
• Design and conduct a scientific investigation.	Lessons 1, 4
• Use appropriate tools and techniques to gather, analyze, and interpret data.	Lessons 1, 2, 3, 4
• Develop descriptions, explanations, predictions, and models using evidence.	Lessons 1, 3, 4
• Think critically and logically to make the relationships between evidence and explanations.	Lessons 1, 3, 4
• Recognize and analyze alternative explanations and predictions.	Lessons 1, 2, 3, 4
• Communicate scientific procedures and explanations.	Lessons 1, 3, 4
• Use mathematics in all aspects of scientific inquiry.	Lessons 1, 2, 3, 4
Understandings about scientific inquiry	
• Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects; and some involve making models.	Lessons 1, 2, 3, 4
• Mathematics is important in all aspects of scientific inquiry.	Lessons 1, 2, 3, 4
• Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.	Lessons 1, 3, 4
Standard B: **As a result of their activities in grades 5–8, all students should develop understanding of**	
Transfer of energy	
• Energy is a property of many substances.	Lessons 1, 2, 3
Standard C: **As a result of their activities in grades 5–8, all students should develop understanding of**	
Structure and function in living systems	
• Cells carry on the many functions needed to sustain life. They take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.	Lessons 2, 3

• Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.	Lesson 5
Reproduction and heredity	
• The characteristics of an organism can be described in terms of a combination of traits. Some are inherited, and others result from interactions with the environment.	Lessons 1, 3, 4, 5
Regulation and behavior	
• All organisms must be able to obtain and use resources, grow, reproduce, and maintain stable internal conditions while living in a constantly changing environment.	Lessons 3, 4, 5
• Behavior is one kind of response an organism can make to an internal or environmental stimulus. Behavioral response is a set of actions determined in part by heredity and in part from experience.	Lessons 1, 2, 3, 4, 5
Standard F: **As a result of their activities in grades 5–8, all students should develop understanding of**	
Personal health	
• Regular exercise is important to the maintenance and improvement of health.	Lessons 1, 3, 4, 5
• Food provides energy and nutrients for growth and development. Nutrition requirements vary with body weight, age, sex, activity, and body functioning.	Lessons 2, 3, 4, 5
Risks and benefits	
• Risk analysis considers the type of hazard and estimates the number of people who might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.	Lesson 5
• Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), chemical hazards (pollutants in air, water, soil, and food), biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and personal hazards (smoking, dieting, and drinking).	Lesson 5
• Individuals can use a systematic approach to thinking critically about risks and benefits.	Lesson 5
• Important personal and social decisions are made based on perceptions of benefits and risks.	Lesson 5

Standard G: As a result of activities in grades 5–8, all students should develop understanding of	
Science as a human endeavor	
• Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skills, and creativity.	Lessons 1, 2, 3, 4
• Science also relies on scientific habits of minds, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.	Lessons 1, 3, 4
Nature of science	
• Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.	Lessons 1, 4

Teaching Standards

The suggested teaching strategies in all the lessons support teachers as they work to meet the teaching standards outlined in the *National Science Education Standards*. This module helps teachers of science plan an inquiry-based science program by providing short-term objectives for students. It also includes planning tools such as the Conceptual Flow of the Lessons chart and the Suggested Timeline for teaching the module. Teachers can use this module to update their curriculum in response to their students' interest in this topic. The focus on active, collaborative, and inquiry-based learning in the lessons helps teachers support the development of student understanding and nurture a community of science learners.

The structure of the lessons in this module enables teachers to guide and facilitate learning. All the activities encourage and support student inquiry, promote discourse among students, and challenge students to accept and share responsibility for their learning. Using the 5E Instructional Model, combined with active, collaborative learning, allows teachers to respond effectively to the diversity of student backgrounds and learning styles. The module is fully annotated, with suggestions for how teachers can encourage and model the skills of scientific inquiry, as well as foster the curiosity, skepticism, and openness to new ideas and data that characterize successful study of science.

Assessment Standards

Teachers can engage in ongoing assessment of their teaching and of student learning using the variety of assessment components embedded within the module's structure. The assessment tasks are authentic; they are similar in form to tasks that students will engage in outside the classroom or to practices in which scientists participate. Annotations guide teachers to these opportunities for assessment and provide answers to questions that can help teachers analyze student feedback.

How Does the 5E Instructional Model Promote Active, Collaborative, Inquiry-Based Learning?

Because learning does not occur through a process of passive absorption, the lessons in this module promote active learning. Students are involved in more than listening and reading. They are developing skills, analyzing and evaluating evidence, experiencing and discussing, and talking to their peers about their own understanding. Students work collaboratively with others to solve problems and plan investigations. Many students find that they learn better when they work with others in a collaborative environment than when they work alone in a competitive environment. When all this active, collaborative learning is directed toward inquiry science, students succeed in making their own discoveries. They ask questions, observe, analyze, explain, draw conclusions, and ask new questions. These inquiry-based experiences include both those that involve students in direct experimentation and those in which students develop explanations through critical and logical thinking.

This viewpoint that students are active thinkers who construct their own understanding out of interactions with phenomena, the environment, and other individuals is based on the theory of **constructivism**. A constructivist view of learning recognizes that students need time to

- express their current thinking;
- interact with objects, organisms, substances, and equipment to develop a range of experiences on which to base their thinking;
- reflect on their thinking by writing and expressing themselves and comparing what they think with what others think; and
- make connections between their learning experiences and the real world.

This module provides a built-in structure for creating a constructivist classroom: the 5E Instructional Model. This model sequences the learning experiences so that students have the opportunity to construct their understanding of a concept over time. The model leads students through five phases of learning that are easily described using five words that begin with the letter *E*: Engage, Explore, Explain, Elaborate, and Evaluate. The following paragraphs illustrate how the five Es are implemented across the lessons in this module.

Engage

Students come to learning situations with prior knowledge. This knowledge may or may not be congruent with the concepts presented in this module. The Engage lesson provides the opportunity for teachers to find out what students already know or what they think they know about the topic and concepts to be developed.

The Engage phase of this module, found in Lesson 1: *Burning It Up*, is designed to

- pique students' curiosity and generate interest;
- determine students' current understanding about energy and the body;
- invite students to raise their own questions about energy use;
- encourage students to compare their ideas with the ideas of others; and
- enable teachers to assess what students do or do not understand about the stated outcomes of the lesson.

Explore

In the Explore phase of the module, Lesson 1: *Burning It Up*, Lesson 2: *A Serving by Any Other Name*, and Lesson 3: *A Delicate Balance*, students investigate energy balance by considering foods as the source of energy in and physical activity as energy out. These lessons require students to make observations, evaluate and interpret data, and draw conclusions. Students

- interact with materials and ideas through classroom demonstrations and simulations;
- consider different ways to solve a problem or answer a question;
- acquire a common set of experiences with their classmates so they can compare results and ideas;
- observe, describe, record, compare, and share their ideas and experiences; and
- express their developing understanding of energy balance by using graphs, analyzing simulations, and answering questions.

Explain

The Explain phase provides opportunities for students to connect their previous experiences and to begin to make conceptual sense of the main ideas of the module. This stage also allows for the introduction of formal language, scientific terms, and content information that might make students' previous experiences easier to describe and explain.

In the Explain lessons in this module, Lesson 1: *Burning It Up*, Lesson 2: *A Serving by Any Other Name*, and Lesson 3: *A Delicate Balance*, students

- explain concepts and ideas about energy balance in their own words;
- listen to and compare others' explanations of their results with their own;
- become involved in student-to-student discourse in which they explain their thinking to others and debate their ideas;
- revise their ideas;
- record their ideas and current understanding;
- use labels, terminology, and formal language; and
- compare their current thinking with what they previously thought.

Elaborate

In Elaborate lessons, students apply or extend the concepts in new situations and relate their previous experiences to new ones. In the Elaborate lesson in this module, Lesson 4: *Munching Mice*, students make conceptual connections between new and former experiences. They draw upon their knowledge about energy balance to investigate factors that affect energy balance in an animal model. In this lesson, students

- connect ideas, solve problems, and apply their understanding in a new situation;
- use scientific terms and descriptions;
- learn about experimental design and data analysis;
- draw reasonable conclusions from evidence and data;
- add depth to their understanding of concepts and processes; and
- communicate their understanding to others.

Evaluate

The Evaluate lesson is the final stage of the instructional model, but it only provides a "snapshot" of what the students understand and how far they have come from where they began. In reality, the evaluation of students' conceptual understanding and ability to use skills begins with the Engage lesson and continues throughout each stage of the instructional model, as described in the following section. Combined with the students' written work and performance of tasks throughout the module, however, the Evaluate lesson can serve as a summative assessment of what students know and can do.

The Evaluate lesson in this module, Lesson 5: *Dear Me*, provides an opportunity for students to

- demonstrate what they understand about energy balance and how well they can apply their knowledge to solve a problem (what advice would they give their future self?);
- share their current thinking with others;
- assess their own progress by comparing their current understanding with their prior knowledge; and
- ask questions that take them deeper into a concept.

To review the relationship of the 5E Instructional Model to the concepts presented in the module, see the chart, Conceptual Flow of the Lessons, on page 6.

When a teacher uses the 5E Instructional Model, he or she engages in practices that are very different from those of a traditional teacher. In response, students also participate in their learning in ways that are different from those seen in a traditional classroom. The following charts, What the Teacher Does and What the Students Do, outline these differences.

What the Teacher Does

Stage	That is *consistent* with the 5E Instructional Model	That is *inconsistent* with the 5E Instructional Model
Engage	• Piques students' curiosity and generates interest • Determines students' current understanding (prior knowledge) of a concept or idea • Invites students to express what they think • Invites students to raise their own questions	• Introduces vocabulary • Explains concepts • Provides definitions and answers • Provides closure • Discourages students' ideas and questions
Explore	• Encourages student-to-student interaction • Observes and listens to the students as they interact • Asks probing questions to help students make sense of their experiences • Provides time for students to puzzle through problems	• Provides answers • Proceeds too rapidly for students to make sense of their experiences • Provides closure • Tells the students that they are wrong • Gives information and facts that solve the problem • Leads the students step-by-step to a solution
Explain	• Encourages students to use their common experiences and data from the Engage and Explore lessons to develop explanations • Asks questions that help students express understanding and explanations • Requests justification (evidence) for students' explanations • Provides time for students to compare their ideas with those of others and perhaps to revise their thinking • Introduces terminology and alternative explanations after students express their ideas	• Neglects to solicit students' explanations • Ignores data and information students gathered from previous lessons • Dismisses students' ideas • Accepts explanations that are not supported by evidence • Introduces unrelated concepts or skills
Elaborate	• Focuses students' attention on conceptual connections between new and former experiences • Encourages students to use what they have learned to explain a new event or idea • Reinforces students' use of scientific terms and descriptions previously introduced • Asks questions that help students draw reasonable conclusions from evidence and data	• Neglects to help students connect new and former experiences • Provides definitive answers • Tells students that they are wrong • Leads students step-by-step to a solution

Evaluate	• Observes and records as students demonstrate their understanding of concept(s) and performance of skills • Provides time for students to compare their ideas with those of others and perhaps to revise their thinking • Interviews students as a means of assessing their developing understanding • Encourages students to assess their own progress	• Tests vocabulary words, terms, and isolated facts • Introduces new ideas or concepts • Creates ambiguity • Promotes open-ended discussion unrelated to the concept or skill

What the Students Do

Stage	That is *consistent* with the 5E Instructional Model	That is *inconsistent* with the 5E Instructional Model
Engage	• Become interested in and curious about the concept/topic • Express current understanding of a concept or idea • Raise questions such as, What do I already know about this? What do I want to know about this? How could I find out?	• Ask for the "right" answer • Offer the "right" answer • Insist on answers or explanations • Seek closure
Explore	• "Mess around" with materials and ideas • Conduct investigations in which they observe, describe, and record data • Try different ways to solve a problem or answer a question • Acquire a common set of experiences so they can compare results and ideas • Compare their ideas with those of others	• Let others do the thinking and exploring (passive involvement) • Work quietly with little or no interaction with others (only appropriate when exploring ideas or feelings) • Stop with one solution • Demand or seek closure
Explain	• Explain concepts and ideas in their own words • Base their explanations on evidence acquired during previous investigations • Record their ideas and current understanding • Reflect on and perhaps revise their ideas • Express their ideas using appropriate scientific language • Compare their ideas with what scientists know and understand	• Propose explanations from "thin air" with no relationship to previous experiences • Bring up irrelevant experiences and examples • Accept explanations without justification • Ignore or dismiss other plausible explanations • Propose explanations without evidence to support their ideas

Elaborate	• Make conceptual connections between new and former experiences • Use what they have learned to explain a new object, event, organism, or idea • Use scientific terms and descriptions • Draw reasonable conclusions from evidence and data • Communicate their understanding to others • Demonstrate what they understand about the concept(s) and how well they can implement a skill	• Ignore previous information or evidence • Draw conclusions from "thin air" • Use terminology inappropriately and without understanding
Evaluate	• Compare their current thinking with that of others and perhaps revise their ideas • Assess their own progress by comparing their current understanding with their prior knowledge • Ask new questions that take them deeper into a concept or topic area	• Disregard evidence or previously accepted explanations in drawing conclusions • Offer only yes-or-no answers or memorized definitions or explanations as answers • Fail to express satisfactory explanations in their own words • Introduce new, irrelevant topics

How Does the Module Support Ongoing Assessment?

Because teachers will use this module in a variety of ways and at a variety of points in their curriculum, the most appropriate mechanism for assessing student learning is one that occurs informally at various points within the five lessons, rather than just once, formally, at the end of the module. Accordingly, integrated within the lessons are specific assessment components. These "embedded" assessment opportunities include one or more of the following strategies:

- performance-based activities, such as developing graphs or participating in a discussion of health effects or social policies;
- oral presentations to the class, such as reporting experimental results; and
- written assignments, such as answering questions or writing about demonstrations.

These strategies allow the teacher to assess a variety of aspects of the learning process, such as students' prior knowledge and current understanding, problem-solving and critical-thinking skills, level of understanding of new information, communication skills, and ability to synthesize ideas and apply understanding to a new situation.

An assessment icon and an annotation that describes the aspect of learning that teachers can assess appear in the margin beside each step in which embedded assessment occurs.

How Can Controversial Topics Be Handled in the Classroom?

Teachers sometimes feel that the discussion of values is inappropriate in the science classroom or that it detracts from the learning of "real" science. The lessons in this module, however, are based on the conviction that there is much to be gained by involving students in analyzing issues of science, energy balance, and society. Society expects all citizens to participate in the democratic process, and our educational system must provide opportunities for students to learn to deal with contentious issues with civility, objectivity, and fairness. Likewise, students need to learn that science intersects with life in many ways.

In this module, students have a variety of opportunities to discuss, interpret, and evaluate basic science and health issues, some in light of their values and ethics. As students encounter issues about which they feel strongly, some discussions might become controversial. The degree of controversy will depend on many factors, such as how similar the students are with respect to socioeconomic status, perspectives, value systems, and religious preferences. In addition, the language and attitude of the teacher factor into the flow of ideas and the quality of exchange among the students.

The following guidelines may help teachers facilitate discussions that balance factual information with feelings.

- Remain neutral. Neutrality may be the single most important characteristic of a successful discussion facilitator.
- Encourage students to discover as much information about the issue as possible.
- Keep the discussion relevant and moving forward by questioning or posing appropriate problems or hypothetical situations. Encourage everyone to contribute, but do not force reluctant students into the discussion.
- Emphasize that everyone must be open to hearing and considering diverse views.
- Use unbiased questioning to help students critically examine all views presented.
- Allow for the discussion of all feelings and opinions.
- Avoid seeking consensus on all issues. The multifaceted issues that students discuss result in the presentation of divergent views, and students should learn that this is acceptable.
- Acknowledge all contributions in the same evenhanded manner. If a student seems to be saying something for its shock value, see whether other students recognize the inappropriate comment and invite them to respond.
- Create a sense of freedom in the classroom. Remind students, however, that freedom implies the responsibility to exercise that freedom in ways that generate positive results for all.
- Insist upon a nonhostile environment in the classroom. Remind students to respond to ideas instead of to the individuals presenting those ideas.
- Respect silence. Reflective discussions are often slow. If a teacher breaks the silence, students may allow the teacher to dominate the discussion.
- At the end of the discussion, ask students to summarize the points that they and their classmates have made. Respect students regardless of their opinion about any controversial issue.

Using the Student Lessons

The heart of this module is a set of five classroom lessons that allow students to discover important concepts related to energy balance in adolescent and adult humans. To review these concepts in detail, refer to the chart Conceptual Flow of the Lessons, found on page 6.

Format of the Lessons

As you review the lessons, you will find that each contains several major features.

At a Glance gives you a convenient summary of the lesson.

- The **Overview** provides a short summary of student activities.
- The **Major Concepts** section presents the central idea(s) that the lesson is designed to convey.
- **Objectives** lists specific understandings or abilities students should have after completing the lesson.
- **Teacher Background** specifies which portions of the background section titled *Information about Energy Balance* relate directly to the lesson. This reading material provides the science content that supports the key concepts covered in the lesson. This information is *not* intended to form the basis of lectures to students nor is it intended as a direct resource for students. Rather, it enhances your understanding of the content so that you can facilitate class discussions, answer student questions, and provide additional examples.

In Advance provides instructions for collecting and preparing materials required to complete the activities in the lesson.

- **Web-Based Activities** tells you which of the lesson's activities use *The Science of Energy Balance* Web site as the basis for instruction.
- **Photocopies** lists the paper copies and transparencies that need to be made from masters that are provided after Lesson 5, at the end of the module.
- **Materials** lists all the materials other than photocopies needed for each activity in the lesson.
- **Preparation** outlines what you need to do to be ready to teach the activities in the lesson.

Procedure outlines the steps in each activity in the classroom. It provides implementation hints and answers to discussion questions.

Within the Procedure section, annotations provide additional commentary.

- **Tip from the field test** details suggestions from field-test teachers for teaching strategies, class management, and module implementation.
- **Assessment** provides strategies for gauging student progress throughout the module, and is identified by an assessment icon (see page 18).
- **Icons** identify specific annotations:

NSES identifies teaching strategies that address specific science content standards as defined by the *National Science Education Standards*.

identifies when to use the Web site as part of the teaching strategy. Instructions tell you how to access the Web site and the relevant activity. Information about using the Web site can be found in *Using the Web Site* (see page 19). A print-based alternative to each Web activity is provided for classrooms in which Internet access is not available.

identifies a print-based alternative to a Web-based activity to be used when computers are not available.

identifies when an assessment is embedded in the module's structure. An annotation suggests strategies for assessment.

The **Lesson Organizer** provides a brief summary of the lesson. It outlines procedural steps for each activity and includes icons that denote where in each activity masters, transparencies, and the Web site are used. The lesson organizer is intended to be used only after you become familiar with the detailed procedures for the activities. It can be a handy resource during lesson preparation as well as during classroom instruction.

The **Masters** to be photocopied are found after Lesson 5, at the end of the module.

Timeline for the Module

The timeline below outlines the optimal plan for completing the five lessons in this module. This schedule assumes you will teach the activities on consecutive days. If your class requires more time for discussing issues raised in this module or for completing activities, adjust your timeline accordingly.

Suggested Timeline

Timeline	Activity
3 weeks ahead	Reserve computers Check performance of Web site
7 days ahead	Make photocopies and transparencies Gather materials
Day 1 Friday	**Lesson 1** Activity 1: *What Is Energy?*
Day 2 Monday	**Lesson 1** Activity 2: *Where Does the Energy Go?*
Day 3 Tuesday	**Lesson 2** Activity 1: *A Serving by Any Other Name*
Day 4 Wednesday	**Lesson 3** Activity 1: *A Delicate Balance*
Day 5 Thursday	**Lesson 3** Activity 2: *Evaluation and Recommendations*
Day 6 Friday	**Lesson 4** Activity 1: *Energy Balance—Are We All the Same?*
Day 7 Monday	**Lesson 4** Activity 2: *Energy Balance—What Are the Effects of Food and Exercise?*
Day 8 Tuesday	**Lesson 5** Activity 1: *Dear Me*

Using the Web Site

The Web site for *The Science of Energy Balance* is a wonderful tool that can engage student interest in learning, enhance the student's learning experience, and orchestrate and individualize instruction. The Web site features simulations that articulate with three of the unit's lessons. To access the Web site, type the following URL into your browser: *http://science.education.nih.gov/supplements/energy/*. Click on the link to a specific lesson under *Web Portion of Student Activities*. If you do not have computer or Internet access, you can use the print-based alternative provided for each Web activity. Text pertaining only to Web-based activities is lightly shaded.

Hardware/Software Requirements

The Web site can be accessed from Apple Macintosh and IBM-compatible personal computers. Links to download the Macromedia Flash plug-in are provided on the Web site's Getting Started page. *This plug-in is required for the activities to function properly*. The recommended hardware and software requirements for using the Web site are listed in table below. Although your computer configuration may differ from those listed, the Web site may still be functional on your computer. The most important items in this list are current browsers and plug-ins.

Downloading and Installing Macromedia Flash Player

To experience full functionality of the Web site, Macromedia Flash Player, version 6 or higher, must be downloaded and installed on the hard

Recommended Hardware/Software Requirements for Using the Web Site*

CPU/Processor (PC Intel, Mac)	Pentium III, 600 MHz; or Mac G4
Operating system (DOS/Windows, Mac OS)	Windows 2000 or higher; or Mac OS 9 or newer
System memory (RAM)	256 MB
Screen setting	800 × 600 pixels, 32 bit color
Browser	Netscape Communicator 7.1 or Microsoft Internet Explorer 6
Browser settings	JavaScript Enabled
Free hard drive space	10 MB
Connection speed	56 kbps modem or high-speed Internet connection
Plug-ins, installed for your Web browser	Macromedia Flash Plug-In, version 6 or better; or Apple QuickTime Plug-In, version 6 or better
Audio	Sound card with speakers

* For users of screen-reader software, a multichannel sound card such as Sound Blaster® Live!™ is recommended.

drive of each computer that will be used to access the site. The procedure for downloading and installing Macromedia Flash Player is outlined below.

- Open a Web browser.
- Access the main page of the Web site at *http://science.education.nih.gov/supplements/energy/*.
- Click on the "Getting Started" section
- Click on the link to "Macromedia Flash." This will bring up the Macromedia Flash Player Download Center Web site.
- The Download Center Web site should present you with the option of installing the latest version (highest number) of Macromedia Flash Player. As of August 2004, this should be at least version 7.0.
- Click on the button marked "Install Now," or "Download Now." Clicking this button will allow Macromedia's Web site to download and install Flash Player on your computer's hard drive. If you are using Internet Explorer, the installation will happen automatically after clicking the "Install Now" button. If you are using Netscape, you will have to download and run the installation file. Follow the on-screen instructions provided.
- Your Web browser may present you with a Security Dialog Box asking if you would like to install and run Macromedia Flash Player. Click "Yes."
- After a minute or so, you should once again see the Macromedia Download Center Web page on your browser. There will be a box toward the top of the page containing clickable text. The appearance of this box in your browser window indicates that you have successfully downloaded and installed Macromedia Flash Player.

Getting the Most out of the Web Site

Before you use the Web site, or any other piece of instructional software in your classroom, it may be valuable to identify some of the benefits you can expect the software to provide. Well-designed instructional multimedia software can

- motivate students by helping them enjoy learning and want to learn more because it enlivens content that students otherwise might find uninteresting;
- offer unique instructional capabilities that allow students to explore topics in greater depth and in ways that are closer to actual real-life experience than print-based resources can offer;
- provide teachers with support for experimenting with new instructional approaches that allow students to work independently or in small teams and that give teachers increased credibility among today's technology-literate students; and
- increase teachers' productivity by helping them with assessment, record keeping, and classroom planning and management.

The ideal use of the Web site requires one computer for each student team. However, if you have only one computer available, you can still use the Web site. For example, you can use a projection system to display the monitor image for the whole class to see. Giving selected students in the class the opportunity to manipulate the Web activities in response to suggestions from the class can give students some of the same autonomy in their learning that they would gain from working in small teams. Alternatively, you can rotate student teams through the single computer station.

Collaborative Groups

Many of the activities in the lessons are designed to be completed by teams of students working together. Although individual students working alone can complete these activities, this strategy will not stimulate the types of student-student interactions that are part of active, collaborative, inquiry-based learning. Therefore, we recommend that you organize collaborative teams of two to four students each, depending on the number of computers available. Students in teams larger than this will have difficulty organizing student-computer interactions equitably. This can lead to one or two students' assuming the primary responsibility for the computer-based work. Although this type of arrangement can be efficient, it means that some students will not have the opportunity to experience the in-depth discovery and analysis that the Web site was designed to stimulate. Team members not involved directly may become bored or disinterested.

We recommend that you keep students in the same collaborative teams for all the activities in the lessons. This will allow each team to develop a shared experience with the Web site and with the ideas and issues that the activities present. A shared experience will also enhance your students' perceptions of the lesson as a conceptual whole.

If your student-to-computer ratio is greater than four to one, you will need to change the way you teach the module from the instructions in the lessons. For example, if you have only one computer available, you may want students to complete the Web-based work over an extended time period. You can do this several ways. The most practical way is to use your computer as a center along with several other centers at which students complete other activities. In this approach, students rotate through the computer center, eventually completing the Web-based work you have assigned.

A second way to structure the lessons if you have only one computer available is to use a projection system to display the desktop screen for the whole class to view. Giving selected students in the class the opportunity to manipulate the Web activities in response to suggestions from the class can give students some of the same autonomy in their learning they would have gained from working in small teams.

Web Activities for Students with Disabilities

The Office of Science Education (OSE) is committed to providing access to the Curriculum Supplement Series for individuals with disabilities, including members of the public and federal employees. To meet this commitment, we will comply with the requirements of Section 508 of the Rehabilitation Act. Section 508 requires that individuals with disabilities who are members of the public seeking these materials will have access to and use of information and data that are comparable to those provided to members of the public who are not individuals with disabilities. The online versions of this series have been prepared to comply with Section 508.

If you use assistive technology (such as a Braille reader or a screen reader) and the format of any material on our Web sites interferes with your ability to access the information, please let us know. To enable us to respond in a manner most helpful to you, please indicate the nature of your accessibility problem, the format in which you would like to receive the material, the Web address of the requested material, and your contact information.

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Curriculum Supplement Series
Office of Science Education
National Institutes of Health
6705 Rockledge Drive, Suite 700 MSC 7984
Bethesda, MD 20892-7984
supplements@science.education.nih.gov

The Science of Energy Balance: Calorie Intake and Physical Activity
508-Compliant Web Activities

Lesson	For students with hearing impairment	For students with sight impairment
Lesson 1, *Burning It Up*	No special considerations are required.	After logging in, students must proceed through a three-page form in the Enter Energy Balance Data section. The form has been set up so that a student using screen-reading software can access the form. Supervision is recommended.
Lesson 3, *A Delicate Balance*	Students may click on the closed-captioning icon to view the captioning for each character's introduction.  The icon is located in the top left corner of the character illustration. The text appears below the character.	If students are using screen-magnification or screen-reading software, they will be presented with an alternate, text-based version of the activity. The content of the two versions of the activity is equivalent. Note: Images within the reference manual are kept to a minimum. The print version of the activity should be kept handy for reference. Note: Students using a screen magnifier may prefer the original version of the activity. When the activity loads, students can click on a button to proceed to the original version or the screen-reader-friendly version. Supervision is recommended.
Lesson 4, *Munching Mice*	No special considerations are required.	Same as Lesson 3. Additionally, the computer the students use must be linked to a printer.
Lesson 5, *Dear Me*	No special considerations are required.	Same as Lesson 3. Additionally, the computer the students use must be linked to a printer.

Information about Energy Balance

1 Introduction

Students are generally introduced to **nutrition** in grade school, where the Food Guide Pyramid is discussed. They are taught the need for a balanced diet in the context of growth and maintaining a healthy body. However, little consideration may be given to physical activity and energy expenditure. Additionally, students may be unaware of the need to provide energy in excess of their activity requirements to maintain the growth they are experiencing. Consequently, this curriculum supplement was created to introduce students to the key concept of energy balance and provide a context within which they can better understand nutrition concepts they learn at other times. A key concept is that energy balance is a long-term, rather than a short-term, goal. Two important consequences of energy imbalance for adolescents are obesity and undernutrition.

Obesity is a chronic metabolic disease resulting from an imbalance between energy intake and energy output. It is caused by the interaction of multiple genetic and environmental factors. Among these are excessive caloric and food intake, insufficient physical activity, genetic predisposition, family history of obesity, individual metabolism, and behavioral factors. The defining feature is excess body fat.[11] Obesity increases the risk of developing many conditions, including heart disease and stroke, high blood pressure, type 2 (non-insulin-dependent) diabetes, gallstones, sleep apnea, back pain, osteoarthritis of the weight-bearing joints, and some forms of cancer (for example, breast and colon). Fortunately, many of these conditions improve with successful treatment for obesity.[53]

Undernutrition is a complex issue. Individuals may suffer from an insufficient intake of both calories and specific nutrients. In some cases, energy intake may be sufficient, but the diet may be lacking in nutrient content. The diagnosis of undernutrition used to depend on deficits in weight compared with reference standards. More recent recommendations classify children as undernourished depending on their height-for-age and weight-for-height measurements. Interestingly, low height-for-age (that is, stunting) is much more prevalent worldwide than is low weight-for-height (that is, wasting).[41]

Nutrition in general is a concern for adolescents, who are entering a stressful, confusing, and sometimes frightening time of social, emotional, and physical development.[25,26,28] Many adolescents do not understand the changes that are occurring during this time, including the weight gain associated with growth and sexual development. There is great pressure to fit in and gain acceptance. Teenagers may worry excessively about what others think of them, especially their physical appearance. Unfortunately, emphasis in the media generally is on being thin, and the "ideal" body image is that of today's models and TV and movie stars.[2] Additionally, adolescents may be confronted with problems in their family environment. Some teenagers may develop eating disorders as a result of complex psychological, environmental, and/or genetic factors. An important goal of this curriculum supplement is to help adolescents and teenagers recognize that healthy bodies come in a variety of shapes and sizes.

Nutrition in general is a concern for adolescents, who are entering a stressful, confusing, and sometimes frightening time of social, emotional, and physical development.

Eating disorders have both mental and physical components that can have serious medical consequences.[37] However, not all individuals with eating disorders suffer serious medical consequences. Indeed, some individuals may not suffer from any apparent medical problems. These disorders may develop as a means of gaining control, of focusing on something pleasant, of blocking out painful feelings or experiences, or of providing punishment through self-abuse. Three eating disorders are among the key health issues affecting adolescents and young adults:[20]

- **Anorexia nervosa**: This disorder is characterized by significant weight loss resulting from excessive dieting. Because of their obsession to be thin, those suffering from anorexia consider themselves fat, no matter what their weight actually is. They have a powerful and irrational fear of gaining weight and becoming fat. About 1 of every 100 adolescent girls develops anorexia nervosa. Some individuals who have anorexia also binge and purge.
- **Binge eating disorder**: This disorder is characterized by frequent episodes of uncontrolled eating. About 5 percent of people have this disorder.[56] The binge eater feels out of control, and episodes of overeating are followed by feelings of disgust, guilt, or depression. It is common for episodes of overeating to be followed by bulimic behavior, such as vomiting, using laxatives, or over exercising.
- **Bulimia nervosa**: This disorder is characterized by behaviors such as vomiting, taking laxatives, or overexercising after eating to rid the body of the calories consumed. Victims of this disorder also have a fear of being fat, even if their size and body weight are normal. Approximately 2 to 5 of every 100 young women develop bulimia. This condition can develop in those with anorexia nervosa, or it can occur as a separate condition.

Eating disorders may begin at very young ages. Children as young as 8 years of age have voiced complaints about their body size and shape and expressed a fear of being fat. Furthermore, young people in all ethnic and cultural groups may develop eating disorders.

Early detection of an eating disorder is important and contributes to the likelihood of successful treatment and recovery. Treatment is complex and requires input from psychological, medical, and nutritional experts, as well as strong support from family and friends.

Healthy diet and regular physical activity help children and adults feel better, learn and work more effectively, and avoid developing a variety of risk factors for disease. Unfortunately, most adolescents in the United States are not moderately active—that is, they do not get 30 or more minutes of physical activity on five or more days of the week.[10] The proportion of high school students who participated daily in physical education classes declined from 42 percent in 1991 to 25 percent in 1995. Furthermore, 48 percent of high school students are not enrolled in any type of physical education class.[8] In general, older children are less active than younger children, and girls are less active than boys.[22] Additionally, recent surveys by the U.S. Department of Agriculture (USDA) point out some shortcomings in children's diets. For instance, over half of children and adolescents aged 2 to 17 consume more total fat, saturated fat, and sodium than is recommended in dietary guidelines for Americans.[26,33] Additionally, they do not eat enough fruits, vegetables, or dairy products.[13,26,33] Adolescent girls ingest considerably less iron and calcium than recommended by the Food and Nutrition Board of the National Research Council.[26,33,50]

The proportion of high school students who participated daily in physical education classes declined from 42 percent in 1991 to 25 percent in 1995.

Social and technological trends of the 20th century contributed to the current poor state of diet and physical activity among Americans, most notably innovations in transportation, communication, computer technologies, food processing, and food marketing. Fewer daily opportunities exist today to burn calories: leisure and workplace activities are increasingly sedentary, motorized travel for all but the shortest distances has become almost universal, and school systems continue to cut back on physical education programs. At the same time, there are more opportunities to eat each day now than 20 years ago because the marketing and distribution of high-calorie fast foods and snacks has increased, the number of restaurants has increased, and social interactions increasingly involve food and drink.

This combination of poor diet and lack of physical activity is associated with an "epidemic of obesity" in the United States.[31,36] Obesity among adults increased in the population from about 15 percent in 1980 to about 30 percent in 2000.[18] Increases were recorded in all states and demographic groups. Overweight is increasing as well among children and adolescents. The percentage of overweight adolescents (12 to 19 years of age) in the United States has tripled during the past 20 years, and about 15 percent of this age group is considered overweight now.[9,10,12,40,51]

The health burden of overweight and physical inactivity is substantial.[38] Poor diet and physical inactivity together account for 300,000 deaths each year in the United States.[30] Only tobacco consumption exceeds the combination of poor diet and lack of exercise as an actual cause of preventable deaths each year (20 percent versus 14 percent of all deaths).[30] In young people, obesity is associated with an increased incidence of elevated blood cholesterol,[16] elevated blood pressure,[24] and type 2 diabetes.[42] Furthermore, obesity during childhood or adolescence is associated with increased morbidity and mortality during adulthood in both males and females. Significantly, the risk of persistence of adolescent obesity into adulthood is three times greater for adolescent girls than for boys.[14]

Poor diet and physical inactivity together account for 300,000 deaths each year in the United States.

Because adolescence is a period of intense physiological, psychological, and psychosocial development, young people's bodies may change more rapidly than do their attitudes toward them. Adolescence can be an awkward period of adjustment under the best of circumstances. However, overweight or underweight adolescents in particular may have feelings of low self-esteem, self-consciousness, social isolation, failure, and depression.[3] Any classroom discussion of nutrition and its effects on the body must be sensitive to these issues. Nutrition curricula that are informative, nonjudgmental, and inclusive of all students may be better accepted by and more effective with adolescents.[4,29,39]

2 Preconceptions about Energy Balance

Some preconceptions about energy balance and healthy nutrition are presented below. Detailed information about the topics introduced here follows in subsequent sections.

Preconception 1: Being overweight as an adolescent is not a problem because adolescents will "grow into their weight." Students should appreciate that being overweight in childhood or adolescence is likely to persist into adulthood unless they take steps toward weight control. About 80 percent of obese adolescents become obese adults, and there is evidence that they become heavier than those who become obese as adults.[55] Significantly, the risk of persistence of adolescent obesity into adulthood is three times greater for adolescent girls than for boys.[14]

Preconception 2: Forgoing food while ignoring the sensation of hunger is an effective way for adolescents to control body weight. The teenager is a rapidly changing organism. Students should appreciate that the events of puberty and the simultaneous growth spurt during adolescence place special demands on their nutritional needs. Adolescents require adequate calories and nutrients in order to sustain the physical growth and maturation, cognitive development, and psychosocial development that characterize this time of life. Students should appreciate that growth during adolescence involves an increase in body tissues that results in increases in both height and weight. Hunger is an important signal, and students should learn the value of responding to this signal by choosing nutritious foods, such as fruits, vegetables, whole-grain products, dairy products, and meats to satisfy hunger. Additionally, students benefit by knowing the effects of unsafe weight-loss methods and the characteristics of safe weight-loss programs. Overweight adolescents should be aware that it is important to stop gaining weight (or to slow the rate of weight gain), and to be under the supervision of a healthcare provider to ensure proper growth and maturation.

Students should appreciate that being overweight in childhood or adolescence is likely to persist into adulthood unless they take steps toward weight control.

Preconception 3: Fad diets are an effective way to lose weight permanently. Many fad diets may offer the promise of rapid and permanent weight loss. Although these diets may allow an initial weight loss, many may limit the intake of essential nutrients to unhealthy levels. Also, many of these diets are not appealing for long-term use. However, the same precaution applies here as above: adolescents should be aware that weight loss, if undertaken, should be on the advice of a physician and done under a physician's care. Depending on the adolescent's age and stage of growth, it may be better not to attempt weight loss because this may hamper normal development.

Preconception 4: Eating after a certain time of night, especially in the evening, causes weight gain. The time of food consumption is not a factor in weight gain. Instead, consideration should be given to energy balance, that is, balancing energy (calories) consumed with energy expended. Any energy consumed in excess of energy expended is stored as fat.

Preconception 5: Certain foods can burn fat and, thus, make up for lower physical activity levels. There are no foods that can "burn fat," although some foods with caffeine or certain spices can increase metabolism for a short time. Eating these foods does not constitute an effective strategy for weight loss. The most effective means of maintaining a healthy body weight is balancing calories consumed with calories used for activities.

3 Important Concepts Related to Energy Intake and Energy Output

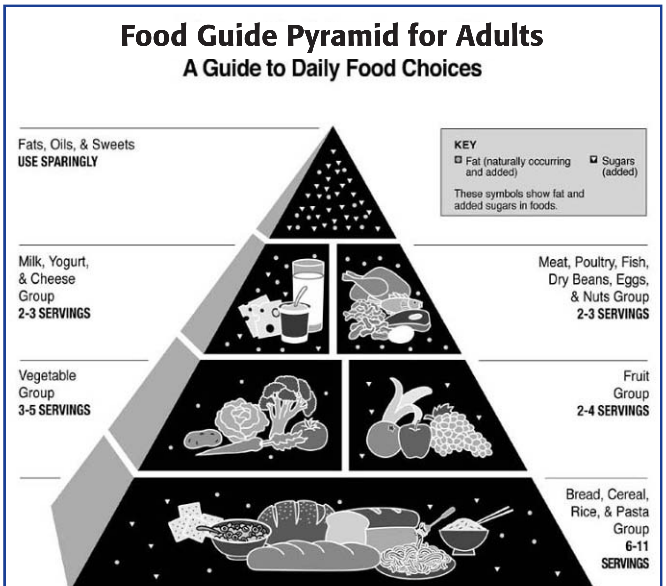
3.1 The energy balance equation. The energy balance equation includes terms that refer to energy intake and energy output. For some individuals, the equation must also include terms for the energy required for growth and for energy that is stored.

Energy In (E_{in}): Energy is available from the foods we eat; this energy input is represented by Energy In, or E_{in}. Although foods contain a number of nutrients, energy is provided by proteins, carbohydrates, and fats. Vitamins and minerals in foods, although essential for normal metabolic functions, do not contribute calories to our diets. Each gram of protein or carbohydrate we consume contributes 4 calories of energy. In contrast, fat provides 9 calories per gram. Interestingly, alcohol has 7 calories per gram. Alcohol-containing products have calories and few nutrients; their consumption may upset both energy balance and nutritional status.

A food calorie is the equivalent of 1,000 calories, or 1 kilocalorie. The food calorie is sometimes represented by "Calorie," with a capital

C. In keeping with the usual format in nutrition studies, this curriculum supplement uses "calorie" to mean the food calorie. A food calorie (1 kilocalorie) is defined as the amount of energy required to raise the temperature of a liter of water 1°C at sea level.

The Food Guide Pyramid was developed by the U.S. Department of Agriculture and is supported by the U.S. Department of Health and Human Services.[7] The Food Guide Pyramid, which is based on the foods Americans typically eat and the nutrients in these foods, is designed to help people choose what and how much to eat from each food group to get needed nutrients, without excessive intake of calories, saturated fat, cholesterol, total fat, and sugar. The Food Guide Pyramid shows a range of servings for each major food group. This range is based on the caloric needs of the individual. Almost everyone should have at least the lowest number of servings in the ranges. However, older children and teenagers (ages 9 to 18 years) and adults over the age of 50 need three servings from the milk group daily.



Source: U.S. Department of Agriculture/U.S. Department of Health and Human Services, 1996.

The Food Guide Pyramid is easily adaptable to ethnic and cultural preferences by including specific types of fruits, vegetables, and grain products. It is also adaptable to vegetarian diets by allowing for meat substitutes, such as beans, soy-based meat substitutes, and eggs (although some vegetarians (vegans) do not eat eggs).

A balanced diet provides 45 to 65 percent of total daily calories as carbohydrate, most of which should be from complex carbohydrates, such as starches; 10 to 35 percent of daily calories from protein; and no more than 30 percent of calories from fat.[52] The needs of athletes and other more physically active people may differ in both energy and nutrient intakes, depending on the intensity and duration of their physical activities. People with special needs due to illness or medications should consult a physician and a registered dietitian to create an appropriate plan to meet nutritional demands.

Energy Out (E_{out}): Total energy expenditure is represented by Energy Out, or E_{out}. E_{out} has three major components, which, added together, provide an accurate measure of an individual's daily caloric requirement: the **basal metabolic rate** (BMR), the energy used for physical activity, and the **thermic effect of food**.

The BMR represents the energy used to carry out the basic metabolic needs of the body. Energy must be provided for maintaining a heartbeat, breathing, regulating body temperature, and carrying out other activities that we take for granted. Most of our daily energy expenditure, about 60 to 70 percent, is represented by our BMR. The BMR can be estimated as follows: for adult males, multiply the body weight (in pounds) by 10, and add double the body weight to this value (example: for a 160-pound male, BMR = 1,600 + (2 × 160) = 1,920 calories/day); for adult females, multiply the body weight by 10, and add the body weight to this value (example: for a 110-pound female, BMR = 1,100 + 110 = 1,210 calories/day).

BMR calculations, as in the examples above, are average estimations. A person's actual BMR changes over time. This depends on a number of factors, including several that distinguish groups of people:

Age—Younger people have higher-than-average BMRs. As children grow, their body composition (percent body fat and muscle mass) changes. As they continue to age, BMR decreases as the percent muscle mass decreases.
Growth—Children and pregnant women have higher-than-average BMRs.
Height—Tall, thin people have higher-than-average BMRs.
Body Composition—People with higher-than-average or increased muscle mass have higher-than-average BMRs.

Other factors cause variation within individuals:
Fever—Fever increases your BMR.
Stress—Physical stress, such as recovering from an illness, increases your BMR; mental or emotional stress may lead to lethargy or depression and decrease your BMR.
Inside/Outside Temperature—Both heat and cold raise your BMR.
Fasting—Fasting lowers your BMR.

Physical activity amounts to about 20 to 30 percent of the body's total energy output. Energy expended during physical activity varies with the level and duration of the activity. It is also affected by the age, gender, height, and weight of the individual performing the activity. Examples of the calories used by different individuals for walking and running are presented in the table below. The values in the table include the calories for BMR.

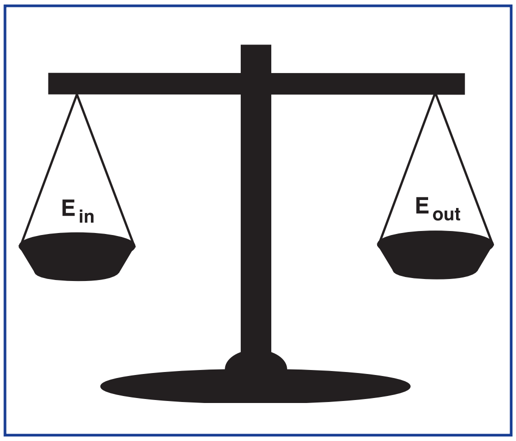
The "thermic effect of food" refers to the energy required to digest food. This term indicates what is usually obvious: we must expend some energy to make materials available in the body that will be used for the production of much larger amounts of energy. The thermic effect of food can be estimated as approximately 10 percent of total calories consumed. Because it makes a relatively small contribution to energy expended, the thermic effect of food is not included as part of E_{out} in the lessons in this curriculum supplement.

As an alternative to adding the three terms discussed above, daily caloric requirements (E_{out}) can also be estimated as follows:
For less-active individuals: weight (in pounds) × 14 = estimated calories/day.
For moderately active individuals (3 to 4 aerobic sessions/week): weight (in pounds) × 17 = estimated calories/day.
For active individuals (5 to 7 aerobic sessions/week): weight (in pounds) × 20 = estimated calories/day.

The energy balance equation. The equation for energy balance is $\mathbf{E_{in} = E_{out}}$. This means that caloric intake equals caloric output. It is the desirable condition for adults who are at a healthy weight. One way to understand the concept of energy balance is to use a two-pan-balance analogy. On one pan of the balance are weights representing $\mathbf{E_{in}}$ (foods, which contain carbohydrate, protein, fat, and alcohol). On

Individual	**Calories Used Per Hour***		
	Walking for pleasure (2.5–3.0 mph)	**Walking for exercise (3.5–4.0 mph)**	**Running (5.0 mph)**
12-year-old girl, 4'11", 92 pounds	187	203	426
12-year-old boy, 4'11", 89 pounds	188	204	430
30-year-old woman, 5'4", 133 pounds	204	221	465
30-year-old man, 5'10", 155 pounds	251	273	574

*Compiled by BSCS staff using various health education resources.



the other pan are weights representing energy expenditures (E_{out}) as metabolic activities and physical activities (and the thermic effect of food). If adults consume more calories than are used for metabolic and physical activities, then $E_{in} > E_{out}$, and the extra energy is stored as body fat. They are in a state of positive energy balance. The pan scale would tip to the E_{in} side. If adults lose weight (as, for example, with dieting), they are in a state of negative energy balance. In this case, $E_{in} < E_{out}$, and the pan scale would tip to the E_{out} side.

Healthy children and adolescents (until they stop growing) are in a state of positive energy balance. The extra calories are used primarily to increase the amount of important body tissues such as bone, muscle, blood, and body organs. Some of the extra calories may also be stored as body fat, which can be used at a later time as a source of energy. Thus, food components (protein, fat, and carbohydrate) taken into the body have the following fates: they can be used to fuel metabolic activities and physical activities, they can be incorporated into growing body tissues, and they can be stored as fat. If food intake contributes to all three of these fates, then $E_{in} = E_{out} + E_{growth} + E_{stored}$, and the body is in *positive energy balance*. If $E_{in} < E_{out} + E_{growth}$ for children or adolescents the body will be in *negative energy balance* and will not be able to grow properly.

Extra E_{in} is an important consideration during periods of growth. The amount of energy (calories) required for growth during most of a child's life accounts for about 1 to 2 percent of the youngster's daily energy intake. However, during infancy and adolescence, growth does have a significant impact on energy requirements. The appetites of healthy youngsters, at any age, are usually reliable guides to the amount of food they should eat. Presented with a well-balanced diet, healthy children will eat all they need. Importantly, attempts to force low-calorie diets on children and adolescents may interfere with normal growth processes. Furthermore, such diets alone have not been very successful in achieving long-term weight control (discussed below). An important consideration is that growing children and adolescents are not in energy balance until they stop growing. Rather, they are in positive energy balance, taking in more energy than is expended in physical activities and in maintaining the BMR. That extra energy is used for growth.

An important consideration is that growing children and adolescents are not in energy balance until they stop growing.

In summary, there are two important concepts of energy balance for adolescents. First, to allow for normal body growth, more food energy must be consumed than can be accounted for solely on the basis of energy required for metabolic and physical activities. Second, insufficient energy intake may affect cellular metabolic activities, body weight, growth, tissue formation, and health.

3.2 Body-fat composition. Understanding the relationship between energy requirements and desirable body weights should take into account not only the total weight, but also the composition of the weight. This is important because muscle mass and body fat make different demands on daily energy requirements[15] and can have different long-term health consequences.[23] Considerable variation among individuals in resting metabolic rates is due in part to variation in body composition or, more specifically, to the ratio of muscle to fat tissue in the body.[43] Muscle tissue is more effective than fat at burning calories, expending more than three times as much energy under resting conditions.[15] Therefore, the ratio of muscle to fat tissue is an important determinant of the total daily energy requirement.

Significant changes in the ratio of muscle tissue to fat tissue occur during adolescence. In females, body fat increases from a mean of 17 percent of body weight to 25 percent of body weight during adolescence. Males, in contrast, experience a decline in body fat, from a mean of 18 percent of body weight to 11 percent of body weight during this period. In addition, the pattern of body-fat distribution changes during adolescence: in both genders, body fat redistributes from peripheral sites to central sites (gluteal region in females, abdomen in males).[19] These normal changes during adolescence are due primarily to genetic and physiologic factors. Nevertheless, energy balance still plays an important role in influencing the direction and magnitude of these changes. Because of changes in body composition with growth, weight is a less reliable measure of body composition for children and adolescents than for adults. Consequently, it is important to emphasize to students that great variation exists in body shapes and sizes among healthy individuals. Conditions of overweight and obesity should be diagnosed only by qualified health professionals and should not be based on appearance.

Consequently, it is important to emphasize to students that great variation exists in body shapes and sizes among healthy individuals.

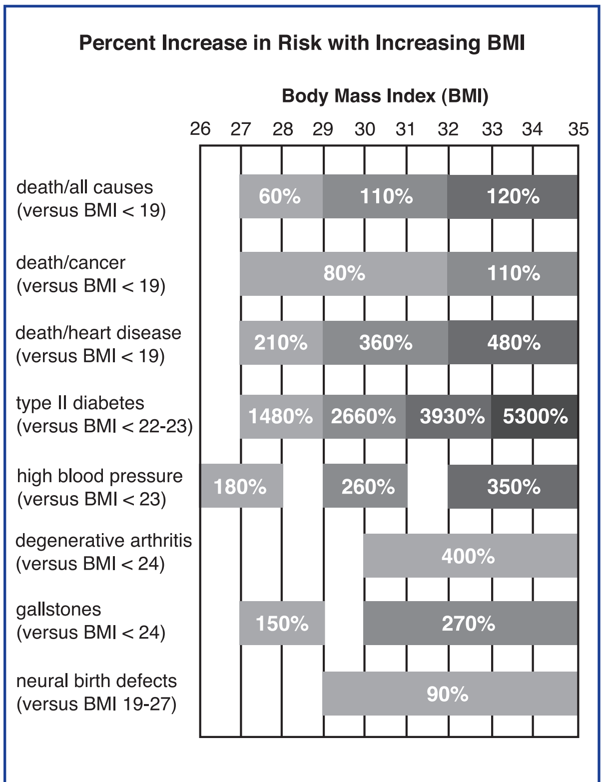
Body composition is a much better predictor of one's level of health and risk of disease than is weight. Muscle mass or a measure of body fat is used to assess body composition. Professionals estimate body-fat content using tools and techniques such as circumference measurements (of abdomen, hips); a height and hip-girth chart; ultrasound measurements; electrical-impedance measurements; the caliper-measurement method; and the water-weighing-measurement method.

3.3 Body mass index (BMI). BMI expresses the relationship between an individual's weight in kilograms (or pounds divided by 2.2) and height in meters (or inches divided by 39.4). For adults, the formula is **BMI = weight/height**^{2}. For children over two years old and adolescents, the formula is **BMI = (weight in pounds/height in inches**^{2}**) × 703**.[35] BMI is a helpful indicator of obesity and underweight and has two primary uses. It can be used to screen and monitor a population for risks to health or for nutritional disorders. Alternatively, BMI, along with other necessary information, can be used to assess risks to health for an individual.

What does a BMI value mean? Scientists and health officials have arrived at the following classifications for *adults*, based on the effect that body weight has on disease and death:

BMI less than 18.5	underweight
BMI between 18.5 and 24.9	healthy range
BMI between 25 and 29.9	overweight
BMI equal to or over 30.0	obese

Justification for these ranges become apparent in the following figure:



Source: *http:www.people.virginia.edu/~rjh9u/bmi.html* (1998)

More information about overweight in adults can be found at *http://www.nhlbi.nih.gov/guidelines/obesity/ob_home.htm*.

Average BMI values rise throughout adolescence, and the changes are similar for both genders.[14] Typical ranges for BMI during adolescence are 16 to 22 at age 12, rising to 18 to 25 at age 17.[18] Students need to appreciate these age-related trends in order to interpret correctly the BMI as an assessment tool for their own weight status. Students should also understand that the similar range of BMIs for females and males during adolescence conceals significant gender differences in body composition. Adolescent females tend to have a higher ratio of fat to fat-free tissue than do males of comparable BMI. Students should understand that these gender-related differences in body composition are normal and that small gains in fat tissue and weight in girls are a normal part of physiological preparation for reproduction.

3.4 Factors affecting energy intake.

Portion size: Nutritionists caution that effective weight management places equal importance on both the kind and the amount of food consumed. However, in a recent survey by the American Institute for Cancer Research, 78 percent of those responding believed that the kind of food they eat is more important for managing weight than how much they eat.[1] In part, this is attributed to advertising and emphasis on "low-fat" and "fat-free" foods. Trends in the food industry have also contributed to increased consumption. Competition has resulted in serving larger portion sizes. Fast-food restaurants have "super-sized" and "value" meals, while other restaurants have replaced the former industry standard 10-inch plate with a 12-inch plate. Interestingly, information from the U.S. Department of Agriculture shows that while the percentage of fat in the American diet dropped from 40 percent to 33 percent over the past 20 years, total daily caloric intake increased about 8 percent, from 1,854 calories to 2,002 calories.

In many ways, these trends are not surprising. Our lack of concern about portion size may result from our general lack of understanding about what actually constitutes "a serving" of food. Even though today's food labels offer more complete nutrition information than they did in the past, the information is not always easy to translate into practical terms. For instance, to calculate our energy intake in calories, we must multiply the calories per serving given on the label by the number of servings we eat. But what is a serving? "Serving size" may not reflect what a person actually eats. Indeed, food consumption varies widely across the population, especially as a function of age. How many of us consume 1 ounce of dry cereal at breakfast? What is 1 ounce of dry cereal? How much is 3 ounces of meat? What is a medium apple as opposed to a small or a large apple? And a food-label serving size is not necessarily the same as a Food Guide Pyramid serving size. However, a label serving and a Food Guide Pyramid serving are each a standardized amount that reflects a certain nutritional content. No matter how confusing serving size might be or how inconvenient it might be to determine the number of servings consumed, it should be apparent that no understanding of energy intake can be achieved without attention to the actual amounts of foods consumed. Consider the examples in the Estimating Amounts of Common Foods table, which provides a practical and simple means of estimating how much of various foods we consume.

Hunger and appetite: The input side of the energy balance equation, E_{in}, is controlled in large part through the opposing sensations of hunger and satiety. Hunger is a physiological state modulated by internal factors. It is often associated with the question, Is there anything to eat? Key to understanding the physiological control of body weight is understanding how eating behavior (food intake) and metabolism are coordinated. This area is complex, and a detailed understanding of the mechanisms is lacking. Early models of the control of food intake held that hunger was a simple response to stomach contractions or to temporary low concentrations of glucose, amino acids, or fatty acids circulating in the blood. In the past decade, however, this simplistic view has been refined into a more comprehensive model involving the nervous and endocrine systems.

Factors that may lead to decreased food intake include

- increased blood glucose concentration;

Estimating Amounts of Common Foods

Food	Amount	Estimated size
Apple, orange, pear, peach	1 medium	1 tennis ball
Cooked beans or peas	½ cup	1 cupcake wrapper
Cooked cereal	½ cup	1 cupcake wrapper
Cooked or raw vegetables	½ cup	½ baseball
Cut or mixed fruit	½ cup	½ baseball
Dry cereal	1 cup	2 cupcake wrappers
Meat, fish, or poultry	2 to 3 ounces	1 deck of cards
Natural cheese	1½ ounces	3 dominoes
Pasta	½ cup	1 cupcake wrapper
Peanut butter	2 tablespoons	1 golf or Ping Pong ball
Potato	1 medium	Size of standard computer mouse
Processed cheese	1½ ounces	2 9-volt batteries
Raw, leafy vegetables	1 cup	4 outer romaine or iceberg lettuce leaves
Rice	½ cup	1 cupcake wrapper

- increased production of certain hormones (such as insulin, glucagon, gastrointestinal hormones, and pituitary hormones), certain peptides and proteins (such as those released during illness), or molecules involved in the function of the nervous system (such as serotonin);
- increased body temperature;
- stress (such as from illness or from emotional or mental causes);
- conditioned responses (such as taking small portions and eating slowly); and
- sensory mechanisms (such as mechanoreceptors in the stomach that sense stretching and chemoreceptors in the stomach that are sensitive to glucose and amino acids).

Factors that may lead to increased food intake include

- sensory mechanisms (such as those relating to the pleasant smell and taste of food),
- stress (such as from emotional or mental causes),
- conditioned responses (such as learning to “clean the plate” or eating rapidly),
- pituitary hormones (such as growth hormone and prolactin), and
- brain peptides (such as the endogenous opiates and neuropeptide Y).[21]

Although we do not yet understand all of the factors regulating food intake, it is clear that regulation is complex and involves the coordinated interaction of many signals.

Appetite is a learned condition influenced by both external and internal cues. It is often associated with the question, What do I want to eat? Appetite seems better related to energy need when we are regularly physically active. When physical activity is low, appetite may increase out of boredom or a need to do something. Eating also may be a means of achieving immediate satisfaction or gratification.

An important molecule that regulates energy balance through its effects on metabolism and appetite is *leptin*, a protein produced by fat cells.[5,6,44] Leptin is able to reduce food intake, inhibit the synthesis and release of neuropeptide Y (a peptide that increases appetite), increase body temperature, increase metabolic rate, and reduce blood concentrations of glucose and insulin. The overall result is lower body weight and lower percentage of body fat. More information about leptin is presented in the next section (*Genetics*).

How does integration of all the signals relating to hunger and appetite occur? Experiments have shown that specific regions of the brain integrate various inputs to control food intake. It is thought that the most important region for control of hunger and satiety is the hypothalamus. This structure lies deep in the center of the brain, and it regulates biologically based motives such as hunger, thirst, and sex drive. The hypothalamus receives smell, taste, and visual inputs, and it senses changes in blood glucose concentration. One area of the hypothalamus contains the satiety center, which tells us when to stop eating. A second area contains the hunger center. Other areas of the brain are involved in the regulation of hunger and satiety as well. Additionally, the brain stem regulates the mechanical events of eating, such as saliva production, chewing, and swallowing.

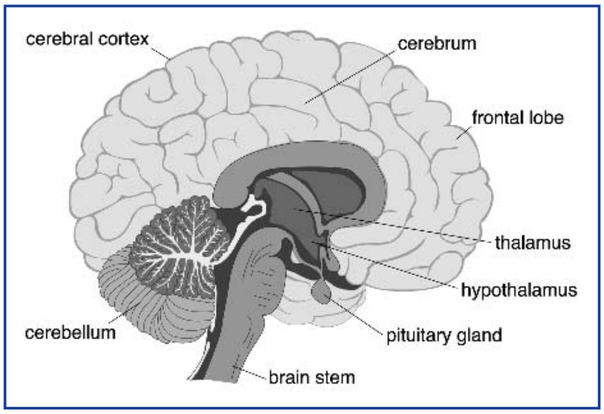


Figure 1. The hypothalamus lies deep within the brain.

Genetics. Food intake and body weight, like all physiological variables, are influenced by genes. The genetics of feeding behavior has been studied in rodents, in which single gene mutations that result in increased feeding and obesity have been identified. Functional analysis of the ways the mutated products of these genes contribute to overeating began only recently.

Progress has been made in understanding the genetic relationship between two defective gene products in the mouse. These are the OB protein (also called leptin; see above), which is the product of the recessive *ob* gene, and OB-R protein (leptin receptor), which is the product of the recessive *db* gene. The initial observation was that a protein secreted by fat tissue of normal lean mice was absent in obese mice (*ob/ob*). When leptin became available in recombinant form and was injected into obese (*ob/ob*) mice, they ate less and their metabolic heat production increased, followed by weight loss.[6] *ob/ob* mice fail to produce leptin because of a mutation in the OB gene. Lacking leptin, which inhibits food intake, the mutants tend toward obesity.

Leptin may exert its inhibitory effect on food intake indirectly, by inhibiting production in the brain of the powerful eating stimulant neuropeptide Y and/or by increasing production of an appetite-suppressing brain peptide.[45] In the *db/db* strain of obese mice, on the other hand, it is the receptor for leptin, OB-R, that is defective. In this case, a mutation in the receptor gene results in a receptor that has greatly reduced binding affinity for leptin in the brain. Such mutants fail to respond to injected leptin.[45]

The first single-gene defect associated with human obesity was described only recently and involved leptin deficiency in both a child and an adult.[32] However, most obese humans have high circulating concentrations of leptin and normal leptin receptors, so any defect in the leptin signaling pathway likely resides beyond the receptor and leads to a state of leptin resistance. Also, children with Prader Willi syndrome, a genetic disorder caused by deletion of a small piece of chromosome 15 donated by the father, have a voracious appetite and insatiable hunger.[47] They tend to become obese early in life. It is believed that genes for appetite regulation are contained on the missing piece of chromosome 15.

In general, the genetics of human food intake and obesity is not yet well understood. However, clear genetic effects do exist. Scientific studies have evaluated the contributions of genetic factors and the family environment to BMI. These studies have taken two different approaches. Some have compared adoptees with both their biological parents and their adoptive parents,[46,49] while others have studied BMI in identical and fraternal twins.[17,48] Scientists have concluded from these studies that BMI is under substantial genetic control. Additionally, one research study concluded that human obesity may be influenced by behaviors that themselves are regulated genetically.[17] Nonetheless, some studies

Figure 2. *A* db/db *mouse (right) next to a control white mouse.*

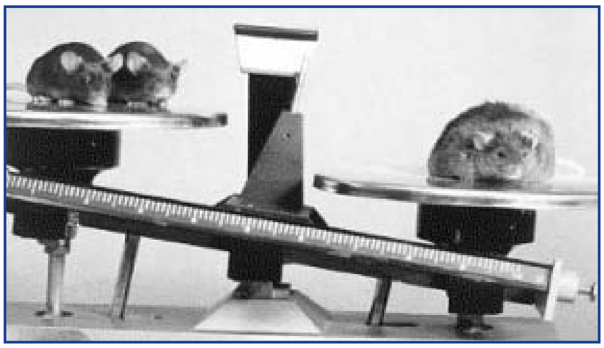


Figure 3. *Two control mice (left scale pan) and an* ob/ob *mouse (right scale pan).*

have indicated a large contribution of nonshared individual environmental influences on BMI.[54]

The relative importance of genetics and environment to BMI is not clearly defined. What is clear, however, is that despite the popular attribution of overweight to "glandular problems," known endocrine disorders are actually a rare cause of obesity.

3.5 Strategies for achieving and maintaining a healthy body weight and size. Attention to energy balance *over time* is required for promoting health and maintaining a stable body weight. For overweight people, steps must be taken to stop the weight gain and reduce weight to a healthy level, and then to maintain that healthy weight. Accomplishing these goals requires an understanding of energy balance—that is, of the general concepts of energy in and energy out. Individuals have direct control over both their food (calorie) intake and their physical activity level. By gaining knowledge of the caloric content of various foods and the caloric costs of various activities, individuals can evaluate their current E_{in}/E_{out} regimens and devise plans to achieve energy balance. People are generally surprised to learn just how small a contribution sedentary activities, such as watching TV or playing video games, make to daily calorie expenditures. On the other hand, any type of physical activity, from running or playing sports to walking or household work, increases the number of calories the body uses.

As emphasized by the National Institute of Diabetes and Digestive and Kidney Disorders, the key to successful weight control and improved overall health is making physical activity a part of our daily routine. Interestingly, behavioral research suggests that attempts to change the activity patterns of overweight students may be more effective when students are reinforced for choosing ways to limit their inactivity than when they are reinforced directly for activity.[14]

How much physical activity *is* necessary? The Dietary Guidelines for Americans recommends 30 minutes a day for adults and 60 minutes a day for children and adolescents.[52] A new report from the National Academy of Sciences recommends a goal of one-hour-a-day total exercise for adults.[34] The report indicates that energy expenditure is cumulative, including both low-intensity activities, such as stair climbing and house cleaning, and more vigorous exercise, such as swimming and cycling. Sixty minutes of moderate physical activity most days of the week is recommended for children, adolescents, and teenagers up to age 18. Substantial health benefits may still be gained by accumulating at least 30 minutes' of moderate-to-intense physical activity a day, at least five times a week. However, care should be taken not to exercise more frequently and more intensely than is required for good health or to compete well.

Developing appropriate strategies for achieving and maintaining a healthy body size and weight can be challenging for some individuals, and it may require more than one approach to the problem. Education may be necessary for an understanding of energy balance and basic nutrition principles. Counseling with an appropriate professional may be essential, for instance, for helping individuals find suitable physical activities and motivating factors. Counseling with a registered dietician or other qualified professional may also be necessary for developing meals and daily food plans. Medical or psychological therapy may be necessary for dealing with issues of undereating or overeating. Additionally, physical activity classes and programs should be available and accessible.

4 Useful Resources

For more information on this important topic, visit the following Web sites:

http://www.niddk.nih.gov/
http://www.nal.usda.gov/
http://www.cdc.gov/nccdphp/dnpa/bmi/bmi-for-age.htm
http://rover.nhlbi.nih.gov/cgi-bin/chd/diet.cgi

The following document is also recommended: U.S. Department of Health and Human

Services. 2001. *The Surgeon General's call to action to prevent and decrease overweight and obesity*. Rockville, Md.: U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General. This publication is available online at *http://www.surgeongeneral.gov/library* or from the U.S. Government Printing Office by calling 866-512-1800.

The 2005 *Dietary Guidelines for Americans*, by the U.S. Department of Health and Human Services and the U.S. Department of Agriculture, was published as this supplement went to press. It is available at *http://www.healthierus.gov/dietaryguidelines*.

Glossary

aerobic exercise: An activity that uses the large muscles and involves increased breathing and heart rate over an extended period of time, usually a minimum of 20 minutes.

anorexia nervosa: A serious psychological disorder most often affecting young women and characterized by refusal to eat. Those affected exert extreme discipline over their eating habits and are usually obsessed about food. They carefully plan their meals and are fearful of overindulging.

appetite: A learned behavior and an emotional or mental desire for food that may be brought about by the sight or smell of food or by thinking of a pleasurable food or meal eaten in the past.

basal metabolic rate (BMR): A measure of the energy necessary for maintaining basic functions, such as breathing, heart rate, and digestion.

binge eating disorder: A condition characterized by frequent episodes of uncontrolled eating. The binge eater feels out of control, and episodes of overeating are followed by feelings of disgust, guilt, or depression. It is common for episodes of overeating to be followed by bulimic behavior, such as vomiting, using laxatives, or overexercising.

body mass index (BMI): A measure relating body weight to height. It is derived from a person's weight (in kilograms) divided by their height (in meters) squared.

bulimia nervosa: An eating disorder aimed at averting weight gain. It is characterized by behaviors such as vomiting, taking laxatives, or over exercising after eating to rid the body of the calories consumed.

calorie: A unit of energy. In nutrition, calorie is used instead of the more precise scientific term kilocalorie. A kilocalorie is the amount of energy required to raise the temperature of a liter of water 1 °C at sea level. The common usage of the word *calorie* is understood to refer to a kilocalorie when referring to food energy.

diabetes: A chronic disease associated with abnormally high concentrations of the sugar glucose in the blood. It may be due to inadequate production of insulin (a hormone made by the pancreas that lowers blood glucose) or inadequate sensitivity of body cells to the action of insulin. The major complications of diabetes include dangerously elevated blood sugar, abnormally low blood sugar due to diabetes medications, and disease of the blood vessels, which can damage the eyes, kidneys, nerves, and heart.

energy: As used in this curriculum supplement, it is the potential work value found in foods, measured in calories, and the work value found in animals after they eat foods.

energy balance: A condition determined by both energy intake and energy output. Energy balance is achieved when energy intake equals energy output. This is the desired condition for healthy adults.

hunger: The uneasy or painful sensation caused by lack of food. It may be defined as a consequence of a sequence of events that leads up to and follows a lack of adequate food intake.

hypothesis: A testable statement that predicts an outcome.

leptin: A protein produced by fat cells that appears to play an important role in how the body manages its supply of fat.

metabolism: The sum of all chemical reactions occurring in the body.

negative energy balance: A condition in which energy output exceeds energy intake. This condition results in weight loss.

nutrition: The process by which food is assimilated and used for growth and maintenance.

obesity: A chronic metabolic disease characterized by having a high amount of body fat. Individuals traditionally have been considered obese if they are more than 20 percent over their ideal weight. That ideal weight must take into account a person's height, age, sex, and build. Obesity in adults (not children and adolescents) has been defined more precisely by the National Institutes of Health as having a BMI of 30 or higher (a BMI of 30 is about 30 pounds overweight for a woman who is 5′4″ tall).

osteoarthritis: A type of arthritis caused by breakdown of cartilage with eventual loss of the cartilage of the joints. Arthritis is a joint disorder characterized by inflammation. Cartilage is a protein that serves as a "cushion" between the bones of the joints.

osteoporosis: A disease characterized by a reduction in bone mass due to depletion of calcium and bone protein.

ounce: A traditional unit of weight. The avoirdupois ounce, the unit commonly used in the United States, is 1/16 pound, or about 28 grams.

ounce, fluid: A traditional unit of liquid volume, called the fluid ounce to avoid confusion with the weight ounce. There are 16 fluid ounces in a pint, and each fluid ounce represents approximately 30 milliliters.

overweight: A condition in which one is too heavy for one's height. The National Institutes of Health defines overweight in adults (not children and adolescents) as having a body mass index (BMI) of 25 to 29. Body weight comes from fat, muscle, bone, and body water. Overweight does not always mean "overfat."

positive energy balance: A condition in which energy intake exceeds energy output for basal metabolic rate (BMR) and physical activities. Children, adolescents, and teenagers should be in positive energy balance. For these age groups, energy intake in excess of energy used for BMR and physical activities is used for growth or may be stored for use at a later time.

sleep apnea: A disorder in which breathing stops during sleep. It may be caused by blockage of the airways, cessation of respiration that is usually brain-related, or a combination of these two.

stroke: The sudden death of some brain cells due to a lack of oxygen when blood flow to the brain is impaired by blockage or rupture of an artery to the brain.

thermic effect of food: The energy needed to digest food.

undernutrition: Inadequate nutrition due to not enough or poor assimilation of food.

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Lesson 1
Engage
Explore
Explain

Burning It Up

At a Glance

Overview

This lesson consists of two activities and takes two to three days to complete. In the first activity, students develop an understanding of energy as it relates to body function. Students collect data about their own physical activities for a school day and a weekend day and then estimate the energy used in these activities. In the second activity, students enter energy expenditure data from their diaries into a Web or a classroom database. The Web database contains entries from other students in their class as well as from students across the country. Using this information, students can test their own hypotheses about energy use in middle school students. Alternatively, students enter their data into a classroom database, which they then use to test their hypotheses about their classmates' energy use. More questions can be asked and answered with the Web database than with the classroom database.

Major Concepts

Humans require energy to function. The total energy used by an individual depends on the type and intensity of that person's activity and the energy required for basic life processes. The total energy used by an individual varies from day to day and from one individual to another.

Objectives

After completing this lesson, students will

- be able to describe ways humans use energy,
- demonstrate increased understanding of the scientific process,
- demonstrate increased knowledge about how they spend their time,
- be able to evaluate their personal activity level, and
- explain that activity levels vary from day to day and among individuals.

Teacher Background

See the following sections in Information about Energy Balance:
1 Introduction
2 Preconceptions about energy balance
3.1 The energy balance equation

In Advance

Web-Based Activities

Activity	Web Version
1	No
2	Yes

Photocopies

Activity 1	• Master 1.1, *Physical Activity Diary: School Day,* 1 copy per student • Master 1.2, *Physical Activity Diary: Weekend Day,* 1 copy per student • Master 1.3, *Some Typical Activities, by Intensity Level,* 1 transparency • Master 1.4, *Sample Physical Activity Diary for a School Day,* 1 transparency
Activity 2	• Master 1.5, *Total Calories Used Per Day at Various Intensity Levels,* 1 copy per student and 1 transparency for class use

Materials

Activity 1	none needed (except photocopies)
Activity 2	none needed (except photocopies)

Preparation

Activity 1

Ask students to have their completed physical activity diaries available.

Activity 2

Ask students to bring a calculator to class. If you are using the **Web version** of this activity, you must establish a unique class code for each class that will enter data into the Web database. To do this, go to the URL *http://science.education.nih.gov/supplements/energy/student*. Click on "Teacher Database Administration." When prompted, enter the username "**energyadmin**" and the password "**admin.**" Click "**Okay**" to enter this site and register your classes. Write down the password (or passwords) that appears on the screen. The password(s) will also be sent to your e-mail address. Verify that the computer lab is reserved for your classes to do Activity 2 or that classroom computers are ready to use.

If you are using the **print version** of this activity, no other preparation is needed.

Activity 1: *What Is Energy?*

Teacher note: In this activity, students record their physical activities for two 24-hour periods, one school day and one weekend day. We suggest that you begin this activity on a Friday. During class, provide each student with a copy of Master 1.1, *Physical Activity Diary: School Day,* and begin helping students fill out the form. Students complete the form on their own. Also on that Friday, provide each student with a copy of Master 1.2, *Physical Activity Diary: Weekend Day,* and ask students to keep a physical activity record for either Saturday or Sunday. This allows students to compare physical activity levels on a school day with those on a weekend day in Activity 2.

Procedure

NSES

Content Standard B:
Energy is a property of many substances.

1. **Ask students, "What is energy?"**

   Accept all responses and post them on the board. Energy allows us, or provides us with the ability, to do work. Energy may be stored for later use, or it may be used immediately to do something, such as provide light, heat, or motion. Students may view energy simply as something that lets you do things, such as run, walk, or just stay alive.

   Teacher note: Asking this question requires students to call on their prior knowledge and to engage their thinking. At this point, do not critique student responses. Appropriate teacher comments are short and positive, such as "good" and "what else?" Other appropriate teacher responses include, "Why do you believe that?" or "How do you know that?" Questions such as these allow the teacher to assess current student knowledge about the subject and adjust lessons accordingly. They also provide a springboard to "Let's find out" or "Let's investigate." In general, it is time to move forward when the teacher sees that thinking has been engaged.

2. **Continue by asking, "Do living things require energy?" Follow this with, "How do living things get their energy?"**

   It is important to establish that all living things do need energy. This could be a time to reinforce the idea that the continuous use of energy is one of the features that helps distinguish living from nonliving things. This is also a good place to define food as the source of materials and energy needed to support life. Food as a source of energy will be explored in Lessons 2 and 3.

3. **After establishing the idea that living things require and use energy, ask students to name things they do that use energy.**

   List student responses on the board. List enough activities that a wide range of types and intensities is included. Students may respond with activities such as running, walking, riding bicycles, or playing sports. Ask them to consider reading, thinking, sleeping, and growing. Do these activities require energy? Lead students to the idea that humans, like all living things, require energy continuously.

   Teacher note: The base level of energy required to maintain basic body function is called the **basal metabolic rate**, or BMR. Typical teenagers use 60 to 70 percent of their energy to maintain normal body function, or basal **metabolism**. You may need to define metabolism for students: the sum of all chemical reactions occurring in the body.

4. **Referring to the list of activities on the board, ask students if these activities all use the same amount of energy.**

   Students should recognize that the energy required to perform different activities varies.

5. **Ask students what determines how much energy they use in a physical activity.**

   Energy use is determined by both the intensity and the duration of the activity. Students may not know that energy use is also determined by body size.

6. **Give each student one copy of Master 1.1, *Physical Activity Diary: School Day*, and one copy of Master 1.2, *Physical Activity Diary: Weekend Day*.**

   Students will record their physical activities for 24 hours on a school day using their copy of Master 1.1. They will repeat this for a weekend day using Master 1.2.

7. **Show students the transparency of Master 1.3, *Some Typical Activities, by Intensity Level*.**

   Teacher note: The values listed in the table on Master 1.3 represent average values for middle-school–aged individuals for a range of activities within each category. The values include the calories used for BMR.

8. **Refer to the list of activities on the board from Step 3. Ask students to consider the activity category (resting/sleeping, very light, light, moderate, or heavy) into which their typical activities fall.**

   Students should recognize that activities can be separated and organized based on their intensity. Resting activities use the least energy over a given time, while high-level activities require the most energy over that same time period.

   Tip from the field test: Emphasize that the calories listed for the activities in Master 1.3 are calories *per hour*. This will help students understand why they need to divide the number of minutes they spent at each activity level by 60 on Master 1.5, *Total Calories Used Per Day at Various Intensity Levels*, in Activity 2, Steps 2 and 3.

9. **Show students the transparency of Master 1.4, *Sample Physical Activity Diary for a School Day*. Explain that each line represents a full one-hour period (60 minutes).**

   This sample demonstrates that students are to use abbreviated descriptions of their activities in each 60-minute period and estimates of the number of minutes spent in activities at the various intensity levels.

10. **Point out that the first time period on the diaries is from 5:00 a.m. to 6:00 a.m. that morning. The last period they will enter is 4:00 a.m. to 5:00 a.m. the next morning.**

11. **Tell students that they will begin their own physical activity diary for today in class. They first will consider the time from 5:00 a.m. to 6:00 a.m. that morning. Ask students to describe the activity or activities in the column labeled *Activity* and then enter the minutes spent in activities at each intensity level.**

    Use the transparency of Master 1.4 to point out that the individual in this example was sleeping during that one-hour period. Students, however, should enter their own activities during that time period. Tell students to estimate the time spent at each type of activity to the nearest five minutes.

    Tip from the field test: Emphasize that the total minutes on each line should add to 60. Students are likely to participate in activities at more than one level during most one-hour periods. Tell students that they need to write only one or a few words to remind themselves of activities in which they participated in each time slot. Point to examples on the transparency. For example, within a single hour, students may sit and listen in class, stand up and complete a lab exercise, walk to their lockers and to their next class, and stand in the hall and talk with friends. These students may record "science/walk & talk" in the Activity blank on the diary, and indicate 30 minutes of sitting activity for the time they sat and listened in science class and 30 minutes of light (walking) activity for the time they worked on the lab exercise, walked through the hallways, and stood and talked with friends. This gives a total of 60 minutes.

12. **Ask students to enter their activities from 6:00 a.m. to 7:00 a.m. Students should continue until they reach the present time.**

    Assist students as they estimate the intensity levels of their activities and the amount of time they spent doing each activity. Be prepared to hold brief class discussions about activities that are difficult to categorize. Strive to develop a class consensus on how to categorize these activities. For example, a two-hour basketball practice may be composed of 30 minutes of sitting and listening and 90 minutes of running drills and playing the game. Students should enter both types of activity on their sheets (30 minutes of sitting and 30 minutes of heavy activity for the first hour and 60 minutes of heavy activity for the second hour).

13. **Ask students to continue to fill in their diary throughout the day. Their final entry should be for the period from 4:00 a.m. to 5:00 a.m. the next morning.**

    Emphasize that the total minutes for the 24-hour period must add to 1,440 (24 hours × 60 minutes/hour), as indicated in the diary.

14. **Ask students to consider activities they are likely to engage in over the weekend that are different from their school-day activities. Resolve issues of how to categorize activities, as described above.**

    Doing this now will save time later when students enter their results in the database. You may also want to explain to students that they will enter information from their physical activity diary into a database on Monday. Emphasize that they will need a complete (24-hour) diary for both a school day and a weekend day.

Teacher note: The activity diaries contain rough profiles for each student's activity over two days. Nutrition specialists and physicians may combine more detailed activity diaries with food diaries to help diagnose possible relationships between activity and food intake for individuals outside normal weight guidelines. The diaries prepared for this activity are *not* diagnostic. They are simple estimates that do not offer sufficiently detailed information to make recommendations about changes in diet or activity. They are intended only to provide data for the following activity and allow students to investigate the concept of Energy_{out}.

Activity 2: *Where Does the Energy Go?*

Teacher note: Throughout the lessons in this supplement, we use the food calorie as the unit of energy. A food **calorie**, as listed on food labels, is the equivalent of 1,000 calories, or 1 kilocalorie (kcal). This is actually a unit of heat energy. One food calorie (1 kcal) is the amount of energy needed to raise a liter of water 1° Celsius at sea level. If you have covered heat energy previously and used the calorie unit, you may want to explain to students the difference between a food calorie and calorie as you used it previously.

For classes using the *Web-based version* of this activity:

Teacher note:

- This activity begins with students entering their personal energy-consumption data from their activity logs into a database on the Web. Students thus help establish a large data set, which they can use to evaluate their own activity levels. This large data set also allows students to generate and test hypotheses about energy use in middle school students in general.

- Students may need help with filling in the spreadsheet used to create the database. You will need to examine your school's computer and Web resources to determine the most effective way to enter data into the database. Can an entire class get computer access and enter data simultaneously? Can small groups access a few computers while the remainder of the class is working on other tasks? Will one person need to enter data for everyone?

- If students are going to enter their own data, it will save time to have the computers online and at the correct URL: *http://science.education.nih.gov/supplements/energy/student*. This is a main menu page from which you and students can access this activity ("Lesson 1—Burning It Up"). Students will need the unique identifier you established for their class to access the data entry and report menu pages.

- We recommend that data entry and discussion of the use of the database be completed during class. Students can then generate reports during class or from home.

- If students formulate hypotheses and generate reports during class, divide the class into groups of four to increase interaction and collaboration.

- If you are using Netscape or Internet Explorer as your browser and students want to print out their reports, instruct them to click first on File and then Page Setup. They should set the left and right margins to 0.1 inch so they can print the entire page width.

Procedure

Content Standard A: Mathematics is important in all aspects of scientific inquiry.

For classes using the *Web-based version* of this activity:

1. **Ask students to have their completed physical activity diaries available. Ask students to add the total minutes they spent each day at each intensity level if they have not already done so.**

   Students should do this for the school day (Master 1.1, *Physical Activity Diary: School Day*) and the weekend day (Master 1.2, *Physical Activity Diary: Weekend Day*). They should check the accuracy of their diaries by adding the total number of minutes allotted to all activity levels. This should equal 1,440 minutes (60 minutes/hour × 24 hours/day).

2. **Give each student a copy of Master 1.5, *Total Calories Used Per Day at Various Intensity Levels*. Ask students to copy the total minutes of activity at each intensity level from the last row of their two diaries (labeled *Total Minutes*) to the first row in the tables (labeled *Minutes of Activity*) on this master.**

3. **Guide students through the instructions at the top of Master 1.5 to allow them to calculate the calories used at each of the five intensity levels and the total calories used for both a school day and a weekend day.**

   Use a transparency of Master 1.5 to guide students through the calculations.

   Tip from the field test: Students who forgot to complete their activity diaries should use data from one of their classmates so that the numbers are real student data rather than fabricated.

   Teacher note: The energy values (kcal/hour) used in this exercise are age-adjusted, average values that include the BMR. They provide only a rough estimate of each student's energy expenditure. To be more precise, the values would have to be activity-specific and adjusted for age, gender, and weight. This issue is addressed in the Discussion Questions at the end of this lesson.

4. **Tell students that they will be entering the summary data from Master 1.5 into a database on the Web. In addition, they will provide responses to four items:**

- **gender (M/F);**
- **school location (urban/suburban/rural);**
- **sports participation (yes/no); and**
- **participation in other physical activities such as cycling, jogging, or skateboarding (yes/no).**

The four variables, along with the school-day and weekend-day activity levels, allow students to pose multiple questions and test a variety of hypotheses.

5. **Explain to students that they are to enter their data only once.**

    Tip from the field test: Distribute highlighter pens to students and suggest that they highlight the last row of each table on Master 1.5 (the summary data). This will help ensure that students enter the correct data into the Web database.

    Teacher note: The database will not accept entries if fields are left blank or if a dash is placed in the fields. If students did not participate in activities at some of the intensity levels, they should place a *zero* in that field rather than leave it blank.

6. **When students have completed their data entry, tell them that they are now ready to do what scientists do: interpret the data.**

    Scientists ask questions, formulate hypotheses, and then test the hypotheses. On the basis of the results, more questions might be asked.

7. **Organize students into groups of two to four. Ask them to click on "Reports Menu" on the Student Menu page. Then ask them to click on "Summary Report."**

    The summary report provides students with summary data for both their own class and for all entries in the database from throughout the country. This information allows students to make quick comparisons of average values for energy use by activity intensity level and total energy use on a school day and a weekend day.

8. **Ask students to suggest ways they can compare their own data with the summary data for their class and to the summary data for all entries in the database.**

    This is a short brainstorming session to stimulate thinking about ways to look at and interpret results. For instance, students might ask how their energy consumption compares with the class average. How does it compare with all students in the database? How does it compare with other students in their subset, such as other males or

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Content Standard A:
Use appropriate tools and techniques to gather, analyze, and interpret data.

females or those who also do or do not participate in sports? How does their distribution of activities by level of intensity compare with others?

9. **Point out to students that they can generate the information they need to answer these questions. Ask them to click on the link to the Reports Menu on the Student Menu page.**

   Guide students through this page. The Reports Menu includes the following options:
   - Summary Report,
   - Build Custom Report,
   - Return to Student Menu, and
   - Return to Main Menu.

   The Summary Report provides students with summary data for both their own class and for all entries in the database. This information allows students to make quick comparisons of average values for energy use by activity intensity level and total energy use on a school day and a weekend day. To make comparisons based on gender, school location, sports participation, and/or participation in other physical activities, students must return to the Reports Menu page and click on the link to Build Custom Report. For example, if students are interested in the summary results for males only, they should click on "Male Only" and indicate no preference for the other three items. Other reports can be generated by making appropriate selections on the Custom Report page.

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Content Standard A:
Design and conduct a scientific investigation.

10. **Ask students to suggest questions about physical activity levels in middle school students that could be answered using the information in the database.**

    If necessary, make suggestions to get students started. For instance, do females use more energy than males? Does where a student lives (urban, suburban, rural) affect energy use? Do middle school students who are involved in organized sports have higher activity levels than middle school students who are not involved in organized sports? Remind students that each report provides the following information:
    - number of entries for the preferences selected;
    - total reports in the database;
    - average total calories used for a school day and a weekend day;
    - average calories used at each of the five activity-intensity levels.

    There are many ways to construct the reports, which means there are many questions students can ask.

11. **Tell students they are ready to begin. They, as scientists, are to collaborate with their fellow scientists (members of their group) and decide on at least one question to answer using the information in the database.**

    See Step 10 for examples of questions.

12. **After students pose their question(s), they need to establish a hypothesis.**

    Converting the question to a statement is an acceptable method to establish a hypothesis. For the example question in Step 11, a hypothesis can be, "Middle-school students who are involved in organized sports use more energy than middle school students who are not involved in organized sports." Students could then compare the average calories used by each group of students to test this hypothesis.

    The alternative hypothesis, "Middle school students who are not involved in organized sports use more energy than middle school students who are involved in organized sports," is equally acceptable. A hypothesis is a statement that predicts an outcome. Hypotheses are testable. The statement is tentative because empirical evidence has not yet been obtained to support or contradict it. However, it is a reasonable statement because it is based on prior knowledge about the phenomenon. For example, some students may know that they expend a great deal of energy practicing their sport and during the sporting events. For these students, a reasonable hypothesis would be the first one suggested. Other students may know that they expend a lot of energy in recreational activities that they would not have time to do if they were involved in organized sports. For these students, the second hypothesis is a reasonable one.

    The validity of either hypothesis is tested using data. The data will either support or not support the hypothesis. Many students think that a good hypothesis is one that the data support. In fact, neither hypothesis (one that the data support or one that the data fail to support) is better. The important result is that students will have engaged in authentic scientific activity: they will have formulated a hypothesis and used data to determine whether the hypothesis is supported or not supported. Using empirical evidence to draw conclusions about phenomena is a key feature of science.

13. **On the Build a Custom Report page, students must enter their hypothesis (only one hypothesis at a time) and select the four variables they need to generate a report (or reports) that will test their hypothesis.**

Assessment: Asking students to write a summary of their findings encourages them to organize their thoughts before they report to the class. Listening to students' reports will help you evaluate their understanding. For a more formal assessment, ask students to submit their reports. The reports should include a statement of the hypothesis, a statement indicating what reports were generated, data from the reports, interpretation of the data, and a discussion of how the results support or do not support the hypothesis.

Content Standard A: Communicate scientific procedures and explanations.

Teacher note: Testing most hypotheses will require students to generate *more than one* report.

Tip from the field test: Tell students to include their names on their hypotheses. For example, "Anna, Bryan, and Caitlin's hypothesis is that middle school students use more calories on weekend days than on school days." This will make it easier to distribute printed reports to the correct group.

14. **After students have posed hypotheses and generated reports to test their hypotheses, they should summarize their findings in writing.**

    Do the data support or not support their hypothesis? What evidence are students using to form their conclusion?

15. **Reconvene the class. Ask each group to share its results with the class.**

    Students should be encouraged to critique one another. Did members of another group use appropriate data to evaluate their hypothesis? On the basis of the reports generated, did the group draw correct conclusions?

16. **As an extension activity, students can be assigned as homework the task of formulating another hypothesis, generating reports, analyzing whether the reports support or do not support the hypothesis, and submitting their results as a written report.**

    Teacher note: Students may be tempted to say a hypothesis has been *proved* or *not proved*. However, better terms are *supported* and *not supported*. In this activity, students draw conclusions on the basis of limited data collected for only two days. The results would be more reliable if data had been taken for a longer period of time. Scientists are hesitant to use the word *proven*. It indicates a very high degree of certainty. The key point to look for in the discussions is the evidence students use to support their conclusions.

In classrooms using the *print version* of this activity:

1. **Ask students to have their completed physical activity diaries available. Ask students to add the total minutes they spent each day at each intensity level if they have not already done so.**

    Students should do this for the school day and the weekend day. They should check the accuracy of their diaries by adding the total number of minutes allotted to all activity levels. This should equal 1,440 minutes (60 minutes/hour × 24 hours/day).

2. **Give each student a copy of Master 1.5, *Total Calories Used Per Day at Various Intensity Levels*. Ask students to copy the total minutes of activity at each intensity level from the last row of their two diaries (labeled *Total Minutes* on Masters 1.1 and 1.2) to the first row in the tables (labeled *Minutes of Activity*) on Master 1.5.**

3. **Guide students through the instructions at the top of Master 1.5 to allow them to calculate the calories used at each of the five intensity levels and the total calories used for both a school day and a weekend day.**

   Use a transparency of Master 1.5 to guide students through the calculations.

   Tip from the field test: Students who forgot to complete their activity diaries should use data from one of their classmates so that the numbers are real student data rather than fabricated.

   Teacher note: The energy values (cal/hour) used in this exercise are age-adjusted, average values that include the BMR. They provide only a rough estimate of each student's energy expenditure. To be more precise, the values would have to be activity-specific and adjusted for age, gender, and weight. This issue is addressed in Discussion Questions at the end of this lesson.

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Content Standard A: Mathematics is important in all aspects of scientific inquiry.

4. **Draw two tables on the board, with the following headings:**

Resting "Sleep" (calories)	**Very Light** "Sitting Activities" (calories)	**Light** "Walking Activities" (calories)	**Moderate** "Medium-Level Activities" (calories)	**Heavy** "High-Level Running Activities" (calories)	**Total Calories**	**Male (M) or Female (F)**

   Label one table *School Day* and the other *Weekend Day*.

5. **Ask students to enter their summary data (bottom row of the table) from Master 1.5 into the two tables on the board. Also ask them to put an M in the last column for males and an F for females.**

   Because individual activity levels may vary widely, the data entry needs to be done with sensitivity. As an alternative, you can collect the diaries and prepare a summary table yourself. Retain a copy of the class data for later reference.

Tip from the field test: Distribute highlighter pens to students and suggest that they highlight the last row of each table on Master 1.5 (the summary data). This will help ensure that students enter the correct data on the board.

6. **Ask students to count off using the numbers 1 through 12. Instruct students to calculate the class average for one table column based on their number.**

   Use the following code: students with numbers 1 to 6, school-day table; 1 = resting calories, 2 = very light calories, and so forth; and students with numbers 7 to 12, weekend-day table; 7 = resting calories, 8 = very light calories, and so forth.

   Make sure students have the correct number of entries when they calculate the average values.

7. **Ask students who have made the same calculation to compare answers and resolve any discrepancies before reporting results to the class.**

8. **Ask a representative of each student group to write the averages for each column on the board at the bottom of the appropriate column.**

9. **Tell students that they will make two bar graphs to analyze their results.**

   Students will construct one bar graph to compare their own physical activity data with the class averages for a school day and another graph for comparison with the weekend-day results.

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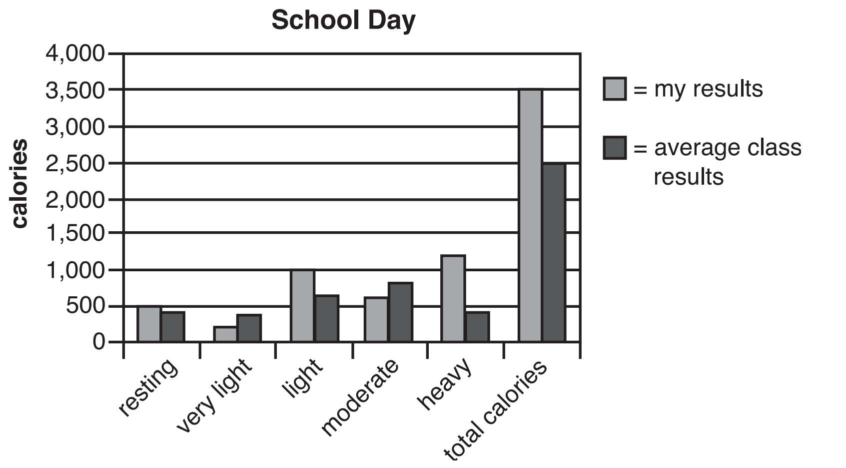
Content Standard A: Use appropriate tools and techniques to gather, analyze, and interpret data.

10. **Instruct students to graph calories on the y-axis. The x-axis will contain these categories: resting, very light, light, moderate, heavy, and total calories.**

    One bar in each category will represent the student's own results. The other bar represents the average class results. An example graph is presented here. Students can use two different colored pencils to distinguish their results from the average class results, or they can use other means to distinguish one bar from the other.

    Graphing results in this way allows students to compare their energy (calories) used (total calories as well as calories in each activity intensity level) with the average results of the whole class. Students construct a similar graph for the weekend-day results.



Assessment: If you wish, collect and score the graphs for a more formal assessment of students' graphing skills.

Teacher note: This activity introduces students to data analysis. This topic is addressed in greater detail in Lesson 4, where students explore the value of different types of graphs for analyzing data. Lesson 4 is a good time to discuss why bar graphs, and not line graphs, were appropriate for this activity.

11. **Ask the class what questions they can ask that can be answered using these data. Can they formulate a** hypothesis **they can test using the class data?**

There are several questions students could ask. For example, students might ask, "Do students have higher activity levels on weekends than on school days?" This question can be transformed into a hypothesis by rewording it as a statement: "Middle school students have higher activity levels on weekend days than on school days." Students could compare the average calories used for each activity level on the two days to test this hypothesis.

Content Standard A: Design and conduct a scientific investigation.

An alternative hypothesis, "Middle school students have higher activity levels on school days than on weekend days," is equally acceptable. A hypothesis is a statement that predicts a result. The statement is tentative because empirical evidence has not yet been obtained to support or contradict it. However, the statement is reasonable, because it is based on prior knowledge about the phenomenon. For example, some students may know that they spend more time doing outdoor chores and running around with friends on weekend days than on school days. For these students, the first hypothesis is reasonable. Other students may know that they spend more time watching TV and playing computer games on weekend days than on school days. For these students, the second hypothesis is reasonable.

The validity of either hypothesis is tested using data. The data will either support or not support the hypothesis. Many students think that a good hypothesis is one that the data support. In fact, neither hypothesis (one that the data support or one that the data do not support) is better. The important result is that students will have engaged in authentic scientific activity: they will have formulated a hypothesis and used data to determine whether their hypothesis is supported or not supported. Using empirical evidence to draw conclusions about phenomena is a key feature of science.

Assessment: If you want to use this activity as a more formal opportunity to evaluate students' science skills (writing hypotheses, analyzing data, and drawing conclusions), collect and review the student reports. The reports should include a statement of the hypothesis, a statement indicating what reports were generated, data from the reports, interpretation of the data, and a discussion of how the results support or do not support the hypothesis.

12. **As a written assignment, ask students to formulate another hypothesis and then test their hypothesis using the data available.**

Students may need to be reminded that their research questions need not deal only with total calories for all five activity-intensity levels. They might ask about changes in the distribution of activity intensity levels between the two days. Or, they might compare high-intensity activities with resting activities on the two days. Many different questions can be asked. Reports should contain a statement of the hypothesis, the data collected to test the hypothesis, and an evaluation and interpretation of the data. Students should indicate whether the data supported or did not support their hypothesis.

Teacher note: Information in the tables on the board allows students to compare results between males and females. To do this, students pool male and female results separately and calculate average values for each of these two groups.

Teacher note: Students may be tempted to say a hypothesis has been *proved* or *not proved*. However, better terms are *supported* and *not supported*. In this activity, students draw conclusions on the basis of limited data collected for only two days. The results would be more reliable if data had been taken for a longer period of time. Scientists are hesitant to use the word *proven*. It indicates a very high degree of certainty. The key point to look for in the discussions is the evidence students use to support their conclusions.

13. **Ask the class what other questions they believe would be interesting to ask, even if they do not have the information to produce an answer. What additional information would they need to answer the question?**

This allows students to use their imaginations. You might need to make some suggestions to get them going. For instance, students might want to know whether time of year has an effect on activity level. To answer this question, they would need information about the time of year the activity diary was kept. As an extension of this question, students might speculate about, or even investigate, the combined effects of geographical location and time of year.

Discussion Questions

1. **Tables that list energy used for different activities (in calories per hour) usually include a statement similar to the following: "These values (calories/hour) are for an adult male who weighs 150 pounds." The values take into account a person's BMR. What might this statement tell you about BMR in different people?**

   The statement correctly indicates that BMR values vary from person to person, and that BMR depends on the age, gender, and weight of the individual.

2. **The total energy expenditures calculated by students are rough estimates of their actual energy expenditures. What would they need to do to make their estimates more accurate?**

   They may respond that they should be more precise in determining how long they spend in each activity and that they should have better information available to determine the energy expended for specific activities. More importantly, they should recognize that they would need to take into account their age, gender, and weight in calculating energy expenditures.

   Teacher note: The BMR value is comparable to the energy used by a person who sleeps all day. Students may be interested in seeing how much of their total daily energy expenditure is due to BMR. If students would like to *estimate* their BMR, we recommend using a formula that accounts for differences due to age, gender, and weight.
   For males 10 to 18 years old, BMR = (17.5 × weight in kilograms) + 651
   For females 10 to 18 years old, BMR = (12.2 × weight in kilograms) + 746

   Pounds may be converted to kilograms by dividing weight in pounds by 2.2. For example a student who weighs 110 pounds would weigh about 46 kilograms (that is, 100 pounds ÷ 2.2 pounds per kilogram = 45.45 kilograms).

   To simplify the arithmetic, the formulas are
   For males 10 to 18 years old, BMR = (7.95 × weight in pounds) + 651
   For females 10 to 18 years old, BMR = (5.55 × weight in pounds) + 746

   One factor that is not accounted for in this equation is overall activity level. People who are more active have a slightly higher BMR than less active people. The BMR also decreases in starvation conditions. This is one reason why radical dieting is not recommended and is not as effective as gradual changes in diet and exercise.

3. **Ask students to examine their physical activity diaries and look**

for patterns. Do they use more energy on weekend days or school days? What would happen to their energy consumption if they got two more hours of sleep every day? What would be the effect of watching TV for one hour less and doing one hour more of light or moderate activity?

This is a time for students to talk about choices they make. Which of their daily activities can they choose? Can they choose how active they are in school? What about how active they are after school? Be prepared for comments about homework being a Very Light Activity and taking time during which they could be more active. Suggest that students look at the amount of time they choose to watch television or play computer games.

Lesson 1 Organizer: Web Version

Activity 1: *What Is Energy?*

What the Teacher Does	Procedure Reference
Ask the class questions about energy: • What is energy? • Do living things require energy? • How do living things get energy? • Name activities that use energy; do these activities use the same amount of energy? • What determines how much energy is used in a physical activity?	Pages 45–46 Steps 1–5
Give each student a copy of both Master 1.1, *Physical Activity Diary: School Day*, and Master 1.2, *Physical Activity Diary: Weekend Day*.	Page 46 Step 6 M
Show students a transparency of Master 1.3, *Some Typical Activities, by Intensity Level.* • Ask students to consider the activity category into which their typical activities fall.	Pages 46–47 Steps 7–8 T
Show students a transparency of Master 1.4, *Sample Physical Activity Diary for a School Day*. • Explain that each line represents a one-hour period. • Indicate that the first time period is from 5:00 a.m. to 6:00 a.m. that morning; the last time period is 4:00 a.m. to 5:00 a.m. the next morning. • Tell students to begin their school day diary in class; they enter activities and times for earlier that day and then continue entering data for the remainder of the day.	Pages 47–48 Steps 9–13 T
Ask students to consider their weekend activities; resolve issues of how to categorize activities according to intensity level.	Page 48 Step 14

M = Involves copying a master. T = Involves using a transparency.

Activity 2: *Where Does the Energy Go?*

What the Teacher Does	Procedure Reference
Log on to the teacher administration site and enter the requested information to generate class codes.	Page 49 Preparation
Ask students to calculate total calories used per day at each of the five intensity levels. • Give each student a copy of Master 1.5, *Total Calories Used Per Day at Various Intensity Levels.* • Ask students to total the minutes they spent each day at each intensity level. • Ask students to calculate the calories used at each intensity level. • Ask students to calculate the total calories used for the school day and the weekend day.	Page 50 Steps 1–3
Have students log on to the student Web site, click on **"Student Activities,"** and then click **"Enter Data."** • Students use the class identifier created on the teacher administration page to enter class-average data obtained from the physical activity diaries.	Pages 50–51 Steps 4–6
Divide the class into small teams and instruct them to think of a hypothesis that can be answered using information from the energy balance database. • They should test their hypothesis by generating appropriate reports. • They should write a short summary of their findings.	Pages 51–54 Steps 7–14
Ask for volunteers to state their hypotheses and findings. • Have students explain why they chose their question. • If their data are inconclusive, ask what additional data they would need to answer their question.	Page 54 Step15
As an extension activity, students can formulate another hypothesis, generate reports, analyze data, and submit their results as a written report.	Page 54 Step 16

= Involves using the Internet.

Lesson 1 Organizer: Print Version

Activity 1: *What Is Energy?*

What the Teacher Does	Procedure Reference
Ask the class questions about energy: • What is energy? • Do living things require energy? • How do living things get energy? • Name activities that use energy; do these activities use the same amount of energy? • What determines how much energy is used in a physical activity?	Pages 45–46 Steps 1–5
Give each student a copy of both Master 1.1, *Physical Activity Diary: School Day*, and Master 1.2, *Physical Activity Diary: Week-end Day*.	Page 46 Step 6 M
Show students a transparency of Master 1.3, *Some Typical Activ-ities, by Intensity Level.* • Ask students to consider the activity category into which their typical activities fall.	Pages 46–47 Steps 7–8 T
Show students a transparency of Master 1.4, *Sample Physical Activity Diary for a School Day*. • Explain that each line represents a one-hour period. • Indicate that the first time period is from 5:00 a.m. to 6:00 a.m. that morning; the last time period is 4:00 a.m. to 5:00 a.m. the next morning. • Tell students to begin their school day diary in class; they enter activities and times for earlier that day and then continue entering data for the remainder of the day.	Pages 47–48 Steps 9–13 T
Ask students to consider their weekend activities; resolve issues of how to categorize activities according to intensity level.	Page 48 Step 14

M = Involves copying a master.   T = Involves using a transparency.

Activity 2: *Where Does the Energy Go?*

What the Teacher Does	Procedure Reference
Ask students to calculate total calories used per day at each of the five intensity levels. • Give each student a copy of Master 1.5, *Total Calories Used Per Day at Various Intensity Levels.* • Ask students to total the minutes they spent each day at each intensity level. • Ask students to calculate the calories used at each intensity level. • Ask students to calculate the total calories used for the school day and the weekend day.	Pages 54–55 Steps 1–3
Collect data from student physical activity diaries on the board. Use the following categories: • Resting • Very light • Light • Moderate • Heavy • Total calories • Male or female	Pages 55–56 Steps 4–5
Instruct students to calculate the class averages for each of the items from Steps 4–5 and enter the values on the board.	Page 56 Steps 6–8
Instruct students to make two bar graphs to analyze their results. • One bar graph compares their own physical activity data with the class averages for a school day. • The second bar graph compares their own physical activity data with the class averages for a weekend day.	Page 56 Steps 9–10
Discuss questions about energy expenditure that can be answered using the class data.	Page 57 Step 11
As a written assignment, ask students to formulate a hypothesis about energy expenditure and then test their hypothesis using the class data.	Page 58 Step 12
Ask the class what other questions they believe would be interesting to ask, even if they do not have the information to produce an answer. • What additional information would they need to answer the questions?	Page 58 Step 13

A Serving by Any Other Name

At a Glance

Overview
This lesson consists of one activity and takes one day to complete. Students discover the information included in food labels and explore the concept of serving size by comparing amounts of food that they eat with the serving size indicated on the food label. They use this information to calculate the number of calories consumed when they eat various foods.

Major Concepts
Humans obtain energy from the foods they consume. Food labels contain information about nutrients, number of calories per serving, and serving size.

Objectives
After completing this activity, students will
- recognize that their energy input comes from consuming food,
- be able to use food labels to gather information about the calorie content of food, and
- demonstrate increased awareness of serving sizes.

Teacher Background
Refer to the following sections in Information about Energy Balance:
1 Introduction *(pages 23–25)*
3.1 The energy balance equation *(pages 26–30)*
3.4 Factors affecting energy intake *(pages 31–35)*

In Advance

Web-Based Activities

Activity	Web Version
1	No

Photocopies

Activity 1	• Master 2.1, *How Much Is One Serving?*, 1 copy per student • Master 2.2, *Serving Sizes for Various Beverages*, 1 transparency • Master 2.3, *Cheese and Hamburger Food Labels*, 1 transparency • Master 2.4, *The Energy Balance Equation*, 1 transparency

Materials

Activity 1	• bowls of various sizes, 1 per group • cereal (all the same brand) in 1-gallon plastic bags, 1 per group • cereal box from the brand of cereal distributed above • ½- or 1-cup dry measuring cups, 1 per group • ½- or 1-cup liquid measuring cups, 1 per group • yellow Play-Doh, approximately 4 ounces per group • red Play-Doh, approximately 4 ounces per group • balances, preferably 1 for every two groups • half- or 1-gallon plastic milk bottles or cartons filled with water, 1 per group • plastic drinking cups of various sizes, 2 per group • calculators (at least 1 per group)

Teacher note: Make sure there is more than enough cereal to fill the largest bowl, and put approximately the same amount of cereal in each bag.

Preparation

Part 1

Photocopy and enlarge the food label from the cereal box and prepare a transparency from it. Tell students to bring calculators to class, or have at least one calculator available for each group.

Part 2

If you prefer to make your own Play-Doh rather than purchasing the commercial brand, you can find a variety of recipes on the Web. One that has worked well for BSCS staff is: 1 cup flour, 1cup water, ½ cup salt, 1 tablespoon mineral or vegetable oil, 2 tablespoons cream of tartar, and food coloring. Mix all ingredients. Heat over low heat, stirring constantly until the mixture thickens and sticks together in a ball. Remove from heat and knead until smooth. This recipe makes approximately 16 ounces. (To reduce costs, you could buy cream of tartar in bulk at a food cooperative or warehouse stores.) Tell students to bring calculators to class, or have at least one calculator available for each group.

Part 1, Breakfast Foods

Procedure

1. **Begin by asking students to recall what they did in Lesson 1 (they estimated the amount of energy they expended in BMR and physical activities). Then ask, "Where do you *get* the energy for your activities?"**

   Students will probably respond that they get energy from food, and this is an accurate response for this question. Food also provides matter for forming new tissues during growth (particularly important for children and adolescents) and repair. However, this is not the emphasis of this curriculum supplement.

2. **Tell students that in Lesson 2, they will explore how much energy they get from typical breakfast and lunch foods.**

   In Parts 1 and 2 students will consider serving sizes and calories for typical breakfast and lunch items. In neither case, however, are the foods students consider intended to represent complete, nutritious meals. They merely represent some of the foods that might be included in meals students consume.

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Content Standard B: Energy is a property of many substances.

3. **Organize students into groups of three or four. Give each group a bowl and a bag containing cereal. Ask them to pour an amount of cereal into the bowl that would be their serving for breakfast.**

   Each should receive a bowl of a different size. Distribute the same kind and amount of cereal to each group, so the only difference between groups is the size of the bowl. Instruct students *not* to eat the cereal! Students will have to resolve any disagreements they may have about the amount of cereal to pour, perhaps by a compromise between the largest amount and smallest amount preferred.

4. **Ask students how many of them drink juice with their breakfast. Distribute a plastic cup to each group and tell students to pour into the cup an amount of water equal to the amount of juice they drink.**

   Distribute a different-size cup to each group. Again, students will have to negotiate about the amount of "juice" to pour into the cup.

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Content Standard F: Food provides energy and nutrients for growth and development.

5. **Ask students how much energy in calories they would have obtained from the two breakfast foods they poured. How many calories were in the cereal and the "juice"?**

   Students will probably have no idea, but some may suggest that the labels on the food containers will give them the information they need. If no student suggests checking food labels, ask the class where they could find the needed information. This may elicit a response about food labels.

For the cereal, the number of calories per serving will vary. For example, Cheerios and Wheaties each provide 110 calories per serving, while Rice Krispies provides 160 calories per serving. Students may be surprised to learn that granola-type cereals provide about 250 calories per serving. (Given here are calories for cereal only; adding milk increases the calories per serving.)

6. **Display a transparency that shows an enlargement of the cereal-box food label and point out the serving-size information and the number of calories per serving.**

   Students may ask how serving sizes are determined. The serving sizes on food labels are provided by the Food and Drug Administration and represent average quantities usually consumed based on data from national food consumption surveys. However, this information is not relevant to the goal of this lesson. The focus here is that the food label provides the information needed to calculate the calories in the portions of food we actually eat.

   The food label provides additional information, such as the number of grams of various nutrients and the percent daily values for several vitamins and minerals. Although this information is not relevant to this lesson, you may want to point out to students the additional information available on food labels.

7. **Distribute one copy of Master 2.1, *How Much Is One Serving?* to each student. Tell students to write the food-label serving size for cereal in column 1 and the number of calories per food-label serving size in column 4.**

   The food-label serving sizes vary from ½ to 1½ cups, depending on the cereal you use. A serving of Cheerios or Wheaties is 1 cup (1 ounce), while a serving of Rice Krispies is 1¼ cups (about 1.2 ounces). A serving of nugget or granola cereal is typically ½ cup (about 1.9 ounces). Calories per serving vary with the product.

8. **Display a transparency made from Master 2.2, *Serving Sizes for Various Beverages*. Tell students to record the serving-size information for juice in column 1 and the calories per serving in column 4 of Master 2.1, *How Much Is One Serving?***

Master 2.2 indicates the volume (in cups and fluid ounces) of single servings of fruit juices and the number of calories in several varieties of these beverages. Tell students to use the serving sizes and calorie values for their choice of juice (apple, grapefruit, or orange).

9. **Ask, "How can you figure out the number of calories in your servings of cereal and juice?"**

   Students should recognize that they need to measure the actual amount of food they poured.

10. **Provide each group with a dry and a liquid measuring cup and ask the students to measure the amount of cereal and "juice" they poured for themselves.**

    Students may have to estimate fractional amounts, depending on the measuring cups provided and how they are calibrated. If necessary, students can estimate fractions of a cup.

    Tip from the field test: You may want to collect the measuring cups as soon as students have completed and recorded their measurements. This reduces distractions before students begin calculations in the next steps.

11. **Tell students to record the amounts they measured for each food in column 2 on Master 2.1, *How Much Is One Serving?***

12. **Instruct students to calculate the number of food-label servings of cereal and juice they would have consumed in these breakfast foods by dividing the numbers in column 2 by the numbers in column 1. They should record this number in column 3.**

    The units for the numbers in the two columns must be the same, such as cups.

    Tip from the field test: Many middle school students find the calculations in this and the next steps challenging. You may want to make a transparency of Master 2.1 and display it as you walk through the calculations with the students.

NSES

Content Standard A: Mathematics is important in all aspects of scientific investigation.

13. **Instruct students to calculate the total number of calories in the breakfast foods by multiplying the number of food-label servings they poured (column 3) by the number of calories per serving (column 4). Tell students to record this amount in column 5.**

For example, if students poured 1½ cups of Cheerios and 1 cup of "juice," the relevant portion of Master 2.1 would look like this:

	Column 1	Column 2	Column 3	Column 4	Column 5
Food	Food label serving size	Amount in MY GROUP'S portion (what you measured)	Number of food-label servings in our portion (divide column 2 by column 1)	Calories per food label serving	Calories in OUR portion (multiply column 3 and column 4)
Dry cereal (Cheerios)	1 cup	1.5 cup	1.5	110 cal	165 cal
Juice (orange)	1 cup	1 cup	1.0	110 cal	110 cal

Assessment:
If you wish to use this discussion as a more formal opportunity to evaluate students' understanding, ask them to write down their answers to the questions. You may then review the responses from each student. Asking students to write down their answers before sharing them with the class allows them to organize their thoughts and reflect on what they have learned.

14. **Initiate a brief class discussion by asking, "How did your portion of cereal and juice compare with the serving sizes listed on the food labels?" Listen to several responses, then ask, "Why do you think the amounts of cereal and juice varied from group to group?"**

    Student answers will vary: some groups may have poured close to a single serving size, while others may have prepared more or less than a serving. Stimulate students to think more deeply by asking the second question. Students will likely respond with answers such as some students were hungrier than others, some students are larger or smaller and require more or less food, or some students don't like that type of cereal. If no one comments about the different sizes of bowls and cups, ask, "Did the size of the bowl or cup make any difference in the amount you poured?" Why or why not? Affirm all reasonable responses by noting that appetite, size, personal taste preferences, and size of serving containers all affect how much food we consume.

NSES

Content Standard A:
Use appropriate tools and techniques to gather, analyze, and interpret data. Some investigations involve making models.

Part 2, Lunch Foods

1. **Tell students that they will now explore serving sizes of typical lunch foods. Distribute lumps of red and yellow Play-Doh to each group.**

    Tip from the field test: Make sure that students have more than enough Play-Doh to represent servings of hamburger and cheese.

2. **Ask the groups to use the red Play-Doh to make a model of a hamburger patty. This should be about the size they would eat as a single serving.**

   In both Steps 2 and 3, emphasize that students need not use all the Play-Doh. They should use *only* the amount they need for their model. If you have students who are vegetarians, tell them to model a "veggie burger."

3. **Ask students, "How many of you like cheeseburgers?" Tell the groups to use the yellow Play-Doh to make a model of a slice of cheese that is about the size they would eat as a single serving.**

   After making the serving-size slice of "cheese," students could put it on the "hamburger." This may give them a better idea of how much cheese is in the slice they see on cheeseburgers.

4. **Tell students they will consider milk as another typical lunch item. Distribute a cup to each group and tell students to use their carton or bottle of water to pour an amount of "milk" they would drink with lunch.**

5. **Display a transparency made from Master 2.3, *Cheese and Hamburger Food Labels*, and tell students to record the serving size in column 1 and number of calories in column 4 on their copy of Master 2.1, *How Much Is One Serving?***

   For students who prepared "veggie burgers," the relevant information is 71 grams (2.5 ounces) per serving and 120 calories per serving.

6. **Display the transparency made from Master 2.2, *Serving Sizes for Various Beverages.* Ask students to record the serving size in column 1 and the number of calories per serving in column 4 on the report form for milk.**

   Students should use the information for the type of milk they usually drink. However, note that using fat-free of low-fat milk is more consistent with the Dietary Guidelines for Americans recommendations for saturated fat intake than is using milk with more fat.

7. **Direct the groups to weigh their burger-and-cheese models using a balance and record the weights (in grams) in column 2 of Master 2.1, *How Much Is One Serving?***

8. **Tell students to measure the actual volume of water they poured into their glasses and tell them to record that information in column 2 as well.**

Be sure students use their liquid measuring cup for this.

9. **Instruct students to calculate the number of food-label servings in their hamburger and cheese models, and the drink volume they chose. They should divide the values in column 2 by the values in column 1 and enter the results in column 3.**

   Students may be able to complete the calculations here and in the next steps on their own, based on their experience in Activity 1. If necessary, use the transparency of Master 2.1 to walk through the calculations with students.

10. **Instruct students to calculate the number of calories in their lunch foods and milk. They should multiply the values in columns 3 and 4 and enter the results in column 5 of their report forms.**

    If students made hamburgers that weigh 144 grams and a slice of cheese that weighs 56 grams and poured 1 cup of 1 percent milk, the relevant portion of Master 2.1 would look like this:

	Column 1	Column 2	Column 3	Column 4	Column 5
Food	**Food label serving size**	**Amount in MY GROUP'S portion (what you measured)**	**Number of food label servings in our portion (divide column 2 by column 1)**	**Calories per food label serving**	**Calories in OUR portion (multiply column 3 and column 4)**
Hamburger patty	112 g	144 g	1.3	240 cal	312 cal
Cheddar cheese	28 g	56 g	2.0	120 cal	240 cal
1% milk	1 cup	1 cup	1.0	118 cal	118 cal

11. **Initiate a brief class discussion by asking, "How did your portion of cheese, hamburger, and milk compare with the food-label serving size?" "What may have affected the size of your hamburger and cheese portions?"**

    Student responses should be similar to their responses to Step 14 in Part 1 of the activity.

12. **Set up Lesson 3 by asking students to work in their groups to connect the concept they learned in Lesson 1 about the energy they use in BMR and physical activities with the concept they learned in Lesson 2 about the energy they take in from food.**

    This will likely be challenging for students. Suggest that students use words, pictures, or a combination of words and pictures to show how the energy they take in is related to the energy they use. You can help them by asking, "Why do you need food?" Students will likely respond that they need food for energy for activities such as walking, running, and breathing. Then tell them to show this idea (food is needed for activities) in words and/or pictures.

13. **Pair the groups and give them two or three minutes to share their ideas with each other.**

14. **Display the top part of a transparency made from Master 2.4, *The Energy Balance Equation.* Point out how this equation is similar to their depictions of the connections between the food they consume and their activities, and explain the terms $Energy_{in}$ and $Energy_{out}$.**

    $Energy_{in}$ represents the calories consumed in food, and $Energy_{out}$ represents the calories expended in BMR and physical activities.

    Teacher note: As explained on pages 27 and 28, E_{out} also includes the thermic effect of food. Because it represents a relatively small energy expenditure, the thermic effect of food is not included in the lessons in this curriculum supplement.

15. **Ask students, "What else do children, adolescents, and teenagers need energy for?" After they have responded, fill in the bottom part of Master 2.4, *The Energy Balance Equation*, with the energy balance equation for children, adolescents, and teenagers: $E_{in} = E_{out} + E_{growth} + E_{stored}$.**

    Students may need some prodding to come up with the answer. Ask, "What is a difference between children and adults?" Students will likely respond that adults are bigger than children. Ask, "Why?" and when students respond that children are still growing, you can point out that growth requires energy. Children and adolescents need energy for growth, while adults do not. It is important for this age group to be aware of the extra energy they need to build the new tissues associated with growth and development. They also may not be aware that they store energy as fat for use in growth at a later time. Emphasize that this helps explain some of the diversity in body shapes and sizes, and why healthy bodies

Assessment:
Move around the room and listen to students as they work on this problem. Listen as they explain the source of energy for their bodies (food) and the ways in which that energy is used (BMR and physical activities). This discussion provides an opportunity for students to summarize and reflect on what they have learned.

Content Standard C:
Cells take in nutrients, which they use to provide energy and to make the materials that a cell or an organism needs.

come in many shapes and sizes. For children and adolescents, E_{in} should be greater than E_{out} until they stop growing.

16. **Tell students that they will examine the energy balance equation in more detail in Lesson 3.**

Lesson 2 Organizer

Activity 1: *A Serving by Any Other Name*

What the Teacher Does	Procedure Reference
Part 1, Breakfast foods Ask students to recall what they did in Lesson 1 and then ask, "Where did you get the energy for your activities?" • Tell students they will explore how much energy they get from typical breakfast foods.	Page 67 Steps 1–2
Organize students into groups of three or four. Students investigate amounts of cereal and liquid ("juice") that they consider servings.	Page 67 Steps 3–4
Ask students how many calories were in their cereal and juice servings. • Display transparency of cereal box food label. • Give each student a copy of Master 2.1, *How Much Is One Serving?* and have them fill in the information in columns 1 and 4. • Display a transparency of Master 2.2, *Serving Sizes for Various Beverages*, and have students fill in the information in columns 1 and 4.	Pages 67–69 Steps 5–8 T M
Ask students how they could determine the number of calories in their servings of cereal and juice. • Provide groups with dry and liquid measuring cups. • Ask students to measure the amount of cereal and juice they poured for themselves. • Have students record the amounts they measure in column 2 of Master 2.1, *How Much Is One Serving?* • Have students divide the numbers in column 2 by the numbers in column 1 to determine the number of food-label servings; record this result in column 3. • Have students multiply the numbers in column 3 by the numbers in column 4 to determine the total calories in their breakfast foods; record this result in column 5.	Pages 69–70 Steps 9–13

T = Involves using a transparency. **M** = Involves copying a master.

Initiate a class discussion by asking • How did your portion of cereal and juice compare with the serving sizes listed on the food labels? • Why do you think the amount of cereal and juice varied from group to group?	Page 70 Step 14
Part 2, Lunch foods Tell students they will explore serving sizes of typical lunch foods. • Distribute red and yellow Play-Doh to each group. • Ask groups to model a serving of hamburger with the red Play-Doh. • Ask groups to model a serving of cheese with the yellow Play-Doh. • Using cups and water, ask students to pour an amount of "milk" they would drink with lunch.	Pages 70–71 Steps 1–4
Display a transparency of Master 2.3, *Cheese and Hamburger Food Labels*. • Have students fill in the appropriate information in columns 1 and 4 of Master 2.1, *How Much Is One Serving?* • Display a transparency of Master 2.2, *Serving Sizes for Various Beverages*, and have students fill in the information in columns 1 and 4.	Page 71 Steps 5–6 T M
Have students determine the number of calories in their servings of hamburger, cheese, and milk. • Have students weigh their burger and cheese models. • Have students measure the amount of milk they poured for themselves. • Have students record the amounts they measure in column 2 of Master 2.1, *How Much Is One Serving?* • Have students divide the numbers in column 2 by the numbers in column 1 to determine the number of food label servings; record this result in column 3. • Have students multiply the numbers in column 3 by the numbers in column 4 to determine the total calories in their lunch foods; record this result in column 5.	Page 71 Steps 7–10
Initiate a brief discussion. Ask, • "How did your portion of cheese, hamburger and milk compare with the food-label serving size?" • "What may have affected the size of your hamburger and cheese portions?"	Page 72 Step 11

Set up Lesson 3. • Ask students to work in their groups to connect the concept they learned in Lesson 1 about the energy they use in BMR and physical activities with the concept they learned in Lesson 2 about the energy they take in from food. • Pair the groups and give them two or three minutes to share their ideas with each other. • Ask students, "What else do children, adolescents, and teenagers need energy for?" and then fill in the bottom part of Master 2.4, *The Energy Balance Equation*, with the energy balance equation for children, adolescents, and teenagers: $E_{in} = E_{out} + E_{growth} + E_{stored}$. • Tell students that they will examine the energy balance equation in more detail in Lesson 3.	Pages 73–74 Steps 12–16 M

Lesson 3
Explore
Explain

A Delicate Balance

At a Glance

Overview

This lesson takes two to three days to complete. Students use an energy balance clinic scenario to investigate the energy balance equation for five fictitious middle school students. This allows them to combine their understanding of $Energy_{out}$ from Lesson 1 and their understanding of $Energy_{in}$ from Lesson 2. In Activity 1, student teams evaluate one patient's energy balance by analyzing the patient's physical activity and food diaries. In Activity 2, students present recommendations for changes in $Energy_{in}$ and $Energy_{out}$ that provide a healthy energy balance for their patient. This activity can be done on the Web or with printed materials.

Major Concepts

Maintaining a specific weight requires consuming calories equal to those used in BMR and physical activities; that is, $Energy_{in} = Energy_{out}$, where $Energy_{out} = Energy_{BMR} + Energy_{PhysicalActivities}$. Healthy children, adolescents, and teenagers need to consume more calories than they use for BMR and physical activities because of energy requirements for growth. In this case, $Energy_{in} = Energy_{out} + Energy_{growth} + Energy_{stored}$, where $Energy_{stored}$ represents calories that are not used immediately and may be stored in the body for use at a later time.

Objectives

After completing this activity, students will

- be able to calculate calorie intake from grams of carbohydrate, protein, and fat;
- be able to calculate calorie expenditures from physical activities;
- be able to describe the relationship of energy balance to weight loss, maintenance, and gain;
- be able to describe energy balance for adolescents and teenagers; and
- be able to develop energy input-output strategies that allow a healthy weight for adolescents and teenagers.

Teacher Background

See the following sections in Information about Energy Balance:
1 Introduction *(pages 23–25)*
2 Preconceptions about energy balance *(pages 25–26)*
3.1 The energy balance equation *(pages 26 to 30)*
3.5 Strategies for achieving and maintaining a healthy body weight and size *(page 35)*

In Advance

Web-Based Activities

Activity	Web Version
1	Yes
2	No

Photocopies

Activity 1	For **Web** version • Master 3.1, *The Memo*, 1 copy per team or 1 transparency for class use • Master 3.2, *Calculating* $Energy_{in}$ *and* $Energy_{out}$, 1 copy per student (optional) • Master 3.3, *Patient Notes*, 1 copy per team • Master 3.4, *Evaluating Energy Balance Review Board Presentations*, 1 copy per team For **print** version • Master 3.1, *The Memo*, 1 copy per team or 1 transparency for class use • Master 3.2, *Calculating* $Energy_{in}$ *and* $Energy_{out}$, 1 copy per student • Master 3.3, *Patient Notes*, 1 copy per team • Master 3.4, *Evaluating Energy Balance Review Board Presentations*, 1 copy per team • Master 3.5, *Ashley's Patient File* (2 pages), 2 copies • Master 3.6, *Emily's Patient File* (2 pages), 2 copies • Master 3.7, *Enrique's Patient File* (2 pages), 2 copies • Master 3.8, *Jerome's Patient File* (2 pages), 2 copies • Master 3.9, *Kim's Patient File* (2 pages), 2 copies • Master 3.10, *Energy Balance Reference Manual* (3 pages), 1 copy per team • Master 3.11, *Energy Balance Diagram*, 1 copy per team
Activity 2	None

Materials

Activity 1 (Print and Web versions)	• calculators
Activity 2	• blank transparencies, 1 per team • transparency pens, 1 per team

Preparation

Activity 1

Students will need calculators for this activity.

For classrooms using the **Web version** of this activity, you will need computers with an Internet connection and a sound card. Verify that the computer lab is reserved for your classes to do Activity 1 or that classroom computers are ready to use. To save time, have computers online and at the correct URL: *http://science.education.nih.gov/supplements/energy/student*. Click on “Lesson 3—A Delicate Balance.” This brings up the unit’s “desktop,” which contains links to this lesson’s Web activity.

For classrooms using the **print version** of this activity, you will need to create 10 patient files by labeling 10 file folders, 2 each with “Ashley’s File,” “Emily’s File,” “Enrique’s File,” “Jerome’s File,” and “Kim’s File.” Place photocopies of Masters 3.5 to 3.9 in the appropriate files. You will also need to assemble 10 copies of Master 3.10, *Energy Balance Reference Manual*, and place one copy in each of the patient files.

Activity 2

Have overhead projector available.

Activity 1: *A Delicate Balance*

Procedure

In classrooms using the *Web-based version* of this activity:

1. **Tell the class that they will explore the energy balance equation introduced at the end of Lesson 2.**

2. **Organize students into 10 teams and distribute one copy of Master 3.1, *The Memo*, to each team. Tell students to read the memo. Alternatively, show the transparency of the memo and read it with the class.**

   The memo sets up the scenario. Student teams play staff scientists at an energy balance clinic directed by a physician who specializes

Assessment:
Consider asking students to describe the energy balance equation in their own words. This will stimulate thinking about the topic and give you an opportunity to assess informally students' understanding of key concepts from Lessons 1 and 2.

in energy balance issues. This physician, Dr. Chu, has delayed his return from a conference. The students' task is to analyze the energy balance state of a fictitious patient (a middle school student) of the physician and to make recommendations about the patient's energy-input and energy-output levels to the clinic's review board.

3. **Assign one of the five patients from the energy balance clinic to each of two student teams. Direct the teams to their computer stations and ask them to wait for instructions.**

   Computers should be at the URL *http://science.education.nih.gov/supplements/energy/student*. Students should click on "Lesson 3—A Delicate Balance" and then, on the unit's desktop, "A Delicate Balance." When students click on this link, they see all five characters and a view of the energy balance clinic's waiting room. Students are *not* to click on their patient yet.

   Tip from the field test: Remind students to bring calculators with them to their computer stations.

4. **Explain that the students' first task is to evaluate the patient's concern. They will have the following information available to them:**
   - **a patient file, which contains a statement of the patient's concern;**
   - **a typical one-day food diary for their patient;**
   - **a typical one-day physical activity diary for their patient; and**
   - **an energy balance reference manual.**

5. **Ask students to click on the link labeled "Reference Manual." Point out the topics covered in the manual. Stress that the manual contains valuable information students need to complete their tasks.**

   The energy balance reference manual provides students with necessary information:
   - the number of calories per gram of protein, carbohydrate, and fat;
   - the calories used per hour for activities at each of five intensity levels;
   - the energy balance equation;
   - information about energy balance in adolescents and teenagers; and
   - information about normal weight gains in middle school–aged males and females.

   Tip from the field test: Reviewing the reference manual with students at this time is important; otherwise, they tend not to consult it for the information they need to complete the activity.

6. **Instruct students to click on their assigned patient in the clinic's waiting room and listen to the audio message from their patient.**

The patients are Ashley, Emily, Enrique, Jerome, and Kim. The Web site shows graphics of each character on the left side of the screen. Each graphic is an active link to that character's food, physical activity, and personal information files.

Teacher note: Students listen to a brief audio clip that presents their patient's energy balance concern. Students need to be aware that they must pay attention to the audio so that sound levels can be adjusted appropriately. If students miss the audio, they can click on the "Replay Audio" button in the upper-right-hand corner of the screen.

7. **Tell students to begin by clicking on the "Patient File" link.**

This information and that from the audio clip sets the stage for the students' work. For example, Ashley asks, "Am I going to get fat?" Student teams should begin by determining the energy balance state of their patient. Students should consult the energy balance reference manual for help with their evaluation.

Teacher note: Take this opportunity to point out that in some cases, students must scroll down the patient file to see all of the information. Scrolling is done by moving the cursor to the scroll bar on the right side of the Web page. By holding down the left mouse button, the page may be moved up and down. Students will also have to scroll on both the food-diary and physical activity pages to view all the information.

8. **Ask students to describe how they can evaluate their patient's energy balance.**

Students need to calculate $\text{Energy}_{\text{in}}$ from the one-day food diary and $\text{Energy}_{\text{out}}$ from the one-day physical activity diary.

9. **Tell students to proceed with the evaluation of their patient's energy balance.**

Allow students 20 to 30 minutes to complete this part of the activity. Students use the information in the files to calculate the total calories their patient consumes. They must first calculate the total grams each of fat, carbohydrate, and protein consumed by their patient during the day represented in the diary. Point out that the food diary provides the total grams of fat, carbohydrate, and protein for each meal in boldface. Students should add only the boldface numbers. These values are entered in the appropriate box on

NSES

Content Standard A: Develop descriptions, explanations, predictions, and models using evidence.

the Daily Energy Intake Calculator located in the lower right corner of the screen.

The calories-per-gram factors for fat, carbohydrate, and protein are found in the reference manual and also should be entered in the appropriate box on the Daily Energy Intake Calculator. When students are satisfied with the numbers they have entered, they should click on “Calculate.” The program will perform the multiplication and final sum for students. As they do this, the graphic above the calculator will change, and the blue arrow will move either up or down, depending on whether students do the $\text{Energy}_{\text{in}}$ or the $\text{Energy}_{\text{out}}$ calculations first. Students should note how this graphic changes.

Similarly, students calculate the total hours spent in physical activities at each intensity level represented in the one-day diary and enter these values in the appropriate box in the Daily Activity Calculator located in the lower-right corner of the screen. The calories-per-hour factors for activity at each intensity level are provided in the reference manual. Students also enter these values in the appropriate box in the Daily Activity Calculator. When students are satisfied with the numbers they have entered, they should click on “Calculate.” The program will perform the multiplication and final sum for students.

Tip from the field test: Give each student a copy of Master 3.2, *Calculating* $\textit{Energy}_{in}$ *and* $\textit{Energy}_{out}$. Although it was designed for the print version of this activity, this master provides students who do the Web activity with a form on which they can record the numbers they use in their calculations.

Teacher note: The Web calculator in this activity will accept any numbers entered, not just the correct ones. This allows students to make mistakes, which can be resolved through student-student discussions and teacher-student discussions. Move among the teams as they complete their analyses to answer questions that arise. Ask questions such as, “Why was your patient asked to provide food consumption and physical activity information for a *typical* day, rather than exactly what they ate and what activities they performed on only one specific day?” Emphasize that energy balance is evaluated over the long term (weeks and months) rather than over a single day. This point is made in the reference manual. Similarly, weight gain or loss is determined by the balance of $\text{Energy}_{\text{in}}$ and $\text{Energy}_{\text{out}}$ over the long term, rather than on any single day.

Teacher note: We realize that children should not be consuming alcohol-containing beverages. However, should students ask, alcohol alone contributes 7 calories per gram and no nutrients. There are concerns about alcohol intake among adolescents. Consumption of alcohol-containing products may upset both energy balance and nutritional status in addition to having other adverse effects on adolescent health and safety. *Understanding Alcohol: Investigations into Biology and Behavior* is a unit in the NIH curriculum supplement series that you will find useful for investigating this topic with your students.

10. **While teams complete their Energy_{in} and Energy_{out} calculations, give each team one copy of Master 3.3, *Patient Notes*.**

Students should record Energy_{in} and Energy_{out} for the patient in the appropriate space on Master 3.3, *Patient Notes*.

11. **Instruct students to click on the "Final Analysis" button.**

The students' next task is to evaluate their patient's concern and make recommendations regarding the patient's energy intake and energy output. The Final Analysis screen presents pictorially the state of energy balance for their patient and asks three of the questions found on Master 3.3, *Patient Notes*. Students should record their responses to the questions on the master.

Patient Notes will help students prepare their presentations for the Energy Balance Review Board in Activity 2. Information that will help students evaluate a normal weight gain for adolescents can be found in the reference manual.

12. **Combine the teams that evaluated the same patient and ask them to compare their analyses and resolve any discrepancies.**

Discrepancies can arise in several ways, including not selecting the correct numbers to add and not using the correct multiplication factor for activity level or for energy derived from protein, carbohydrate, and fat.

Teacher note: Students can use the Daily Energy Intake Calculator, Daily Activity Calculator, and the Final Analysis page on the Web site to develop extension activities. For instance, students might investigate the effects on energy balance of changes in daily physical activity with no change in Energy_{in}, as assessed by weight gain or loss over the summer. Students could also investigate the effects on energy balance of changes in Energy_{in} with no change in Energy_{out}, as assessed by weight gain or loss over a three-month period. Effects on energy balance of changes in both Energy_{in} and Energy_{out} can also be investigated.

Assessment:
Collect and review Master 3.3 from each group. Be sure to return the master to the groups before they make their presentations in Activity 2.

Content Standard A:
Think critically and logically to make the relationships between evidence and explanations.

Assessment:
Consider asking students to describe the energy balance equation in their own words. This will stimulate thinking about the topic and give you an opportunity to assess informally students' understanding of key concepts from Lessons 1 and 2.

In classrooms using the *print version* of this activity:

1. **Tell students they will explore the energy balance equation introduced at the end of Lesson 2.**

2. **Organize students into 10 teams and distribute one copy of Master 3.1, *The Memo*, to each team. Tell students to read the memo. Alternatively, show the transparency of the memo and read it with the class.**

   The memo sets up the scenario. Students play staff scientists at an energy balance clinic directed by a physician who specializes in energy balance issues. This physician, Dr. Chu, has delayed his return from a conference. The students' task is to analyze the energy balance state of a fictitious patient (a middle school student) of the physician and to make recommendations about the patient's energy-input and energy-output levels to the clinic's review board. Student teams will learn about their patient when you distribute the patient files.

3. **Assign one of the five patients from the energy balance clinic to each team and give each team the appropriate patient file (Master 3.5, *Ashley's Patient File*; 3.6, *Emily's Patient File*; 3.7, *Enrique's Patient File*; 3.8, *Jerome's Patient File*; or 3.9, *Kim's Patient File*). Give each team a copy of Master 3.10, *Energy Balance Reference Manual.***

   Assign two teams to each of the five fictitious characters.

4. **Explain that the students' first task is to evaluate the patient's concern. The following information is available to them:**
   - **a patient file, which contains a statement of the patient's concern;**
   - **a typical one-day food diary for the patient;**
   - **a typical one-day physical activity diary for the patient; and**
   - **an energy balance reference manual.**

5. **Ask students to look at their copy of the energy balance reference manual. Point out the topics covered in the manual. Stress that the manual contains valuable information students need to complete their tasks.**

   The reference manual contains information students will need: the number of calories per gram of protein, carbohydrate, and fat; the calories used per hour for activities at each of five intensity levels; the energy balance equation; information about energy balance in adolescents and teenagers; and information about normal weight gains in middle school–aged males and females.

Tip from the field test: Reviewing the reference manual with students at this time is important; otherwise, they tend not to consult it for the information they need to complete the activity.

6. **Tell students to begin by reading the first section of their character's patient file. This contains the patient's concern expressed as a question, followed by a short explanation.**

   This information sets the stage for the students' work. For example, Ashley asks, "Am I going to get fat?" Student teams should begin by determining the energy balance state of their patient. Students should consult their reference manual to aid in their evaluation.

7. **Ask students to describe how they can evaluate their patient's energy balance.**

   Students need to calculate $\text{Energy}_{\text{in}}$ from the one-day food diary and $\text{Energy}_{\text{out}}$ from the one-day physical activity diary.

8. **Tell students to proceed with the calculations to determine their patient's energy balance. Provide each student with a copy of Master 3.2, *Calculating Energy_{in} and Energy_{out}*, which will aid students in performing their calculations.**

   Allow students 20 to 30 minutes to complete this part of the activity. Students use the information in the files to calculate the total calories their patient consumes. They must first calculate the total grams each of fat, carbohydrate, and protein consumed by their patient in the day represented by the diary. The calories-per-gram factors for fat, carbohydrate, and protein are found in the reference manual. Similarly, students calculate the total hours spent engaging in physical activities at each intensity level. Using the calories-per-hour factors provided in the reference manual, students can calculate the total calories the patient uses in physical activity.

   Tip from the field test: Point out to students that the food diary provides the total grams of protein, carbohydrate, and fat by meal in boldface. These numbers are provided as "subtotals" for each meal and snack. Students should add only the boldface numbers, not the grams for each food within each meal and snack.

   Teacher note: Move among the teams as they complete their analyses to answer any questions that arise. Ask questions such as, "Why was your patient asked to provide information about food consumption and physical activity for a *typical* day, rather than exactly what they ate and what activities they performed on only one specific day?" Emphasize that energy balance is evaluated over the long term (weeks and months) rather than over a single day.

NSES

Content Standard A: Develop descriptions, explanations, predictions, and models using evidence.

This point is made in the reference manual. Similarly, weight gain or loss is determined by the balance of Energy_{in} and Energy_{out} over the long term, rather than on any single day.

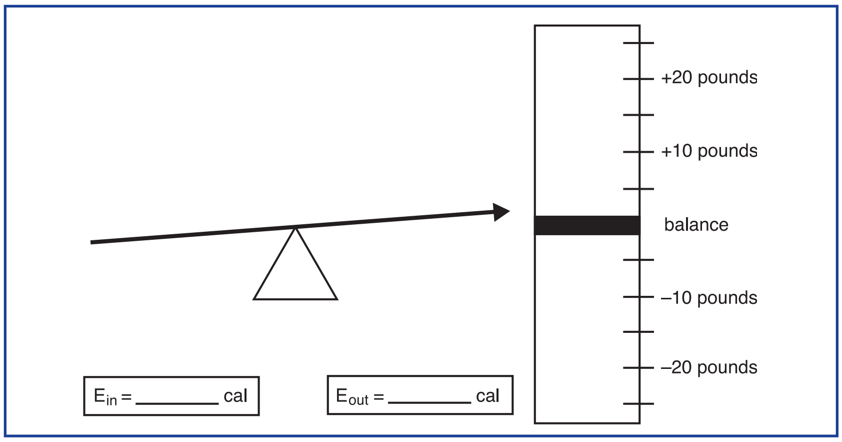
Teacher note: We realize that children should not be consuming alcohol-containing beverages. However, should students ask, alcohol alone contributes 7 calories per gram and no nutrients. There are concerns about alcohol intake among adolescents. Consumption of alcohol-containing products may upset both energy balance and nutritional status in addition to having other adverse effects on adolescent health and safety. *Understanding Alcohol: Investigations into Biology and Behavior* is a unit in the NIH curriculum supplement series that you will find useful for investigating this topic with your students.

9. **When students have completed their calculations, give each team one copy of Master 3.11, *Energy Balance Diagram*, and one copy of Master 3.3, *Patient Notes*. Instruct teams to complete Master 3.11 for their patient and answer the questions on Master 3.3.**

The students' next task is to evaluate the patient's concern and make recommendations regarding the patient's energy intake and energy output. To complete the *Energy Balance Diagram*, students need to determine the number of pounds their patient gained or lost over the summer. This is done using the typical day's calorie consumption and expenditure and the number of calories per pound of stored fat:

$[(E_{in} - E_{out}) \times 84 \text{ days in the summer}] \div 3{,}500$ calories per pound of stored fat = number of pounds lost or gained during the summer

For example, if a patient consistently consumed 100 more calories per day than he or she expended, the calculation is: $[100 \times 84] \div 3{,}500 = 2.4$ pounds gained over the summer. In this case, students would tilt the balance so that it points upward to a point approximately midway between "Balance" and "+ 5" pounds, as follows:



The *Patient Notes* will help students prepare their presentations for the Energy Balance Review Board in Activity 2 of the lesson. Information that will help students evaluate normal weight gain for adolescents can be found in the reference manual.

10. **Combine the two teams that evaluated the same patient and ask them to compare their analyses and resolve any discrepancies.**

Discrepancies can arise from not selecting the correct numbers to add, from adding or multiplying incorrectly, or from not using the correct multiplication factor for activity level or for energy derived from protein, carbohydrate, and fat.

NSES

Content Standard A: Think critically and logically to make relationships between evidence and explanations.

Activity 2: *Evaluation and Recommendations*

1. **Reconvene the combined teams from Activity 1 and direct them to prepare a short report (about five minutes) to the Energy Balance Review Board regarding their patient's energy balance and their recommendations to the patient.**

The Energy Balance Review Board is the teacher and the rest of the class. Give each combined team a transparency and a transparency pen so they can prepare visual aids. On the transparency, students could include their patient's question, their values for Energy_{in} and Energy_{out}, their scale graphic showing weight gain or loss, their recommendations for the patient, and anything else they deem relevant.

NSES

Content Standard A: Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories.

2. **Direct students to prepare two or three questions they could ask the other teams about their analyses and recommendations for the other patients.**

Give each team one copy of Master 3.4, *Evaluating Energy Balance Review Board Presentations*. The master includes the criteria that you will use to evaluate the students' presentation and participation in the review board portion of the activity.

You may want to assign roles to each team member to ensure that all members participate. For example, three students could be spokespersons (one to describe energy output, one to describe energy input, and one to summarize the patient's energy balance), one or two students could prepare the visual aids, and one or two students could write the script for the presentation. All team members should be prepared to answer questions from the review board.

3. **Ask each combined team to present its report to the Energy Balance Review Board (the rest of the class) and allow three to four minutes for questions from the board.**

Assessment:
For a formal assessment of student learning, assign points to each group's presentation using the evaluation rubric.

Content Standard F:
Nutrition requirements vary with body weight, age, sex, activity, and body functioning.

Explain to students that the role of the review board is to evaluate the accuracy of the analysis and the appropriateness of the recommendations before the physician speaks with the patient.

Point out that the evaluation rubric for the presentations also includes a category for their participation as members of the review board.

4. **Conclude the activity by conducting a brief class discussion. Ask, "Which of the five patients has a healthy energy balance state?"**

   Students should justify their answers. Ashley, Emily, and Jerome are in positive energy balance; that is, energy intake is greater than energy used and they are gaining weight. Students should have considered the issue of weight gain in adolescents (described in the energy balance reference manual) and concluded that Ashley's weight gain is normal and healthy for a girl her age. On the other hand, Emily and Jerome may be gaining too much weight. Kim is in energy balance, a state that is not healthy for adolescents because of the extra energy required for growth and development. Enrique is in negative energy balance; that is, his energy intake is less than his energy output and he is losing weight. This, too, is not healthy, since he needs to consume more calories than he expends in order to have energy to meet the needs for growth.

5. **Ask, "If the five patients were adults rather than middle school students, would your answer be the same?" Why or why not?**

   If the five patients were adults, achieving energy balance would be optimal; that is, over the long term, Energy_{in} and Energy_{out} would be equal. Kim is in this state. This is optimum for adults because they no longer need extra calories for growth and should strive to maintain a healthy weight. Recognizing this will prepare students for Lesson 5, in which they write a letter to their adult selves explaining the optimum energy balance they should strive for at that point in their lives.

   Teacher note: This unit focuses on energy balance, and it deals specifically with caloric intake and expenditure. It does not raise issues nor provide guidance about specific food choices and the nutritional content of foods. Nonetheless, students may comment about the diets of the five fictitious characters. Jerome's diet, for instance, contains no fruits or vegetables other than French fries. Enrique's diet also contains fewer than the recommended servings of fruits and vegetables. Because this unit may increase student interest in the foods they consume as their Energy_{in}, you might point out that there are guidelines for the appropriate number of servings from the basic food groups (students are generally exposed to the Food

Guide Pyramid in elementary school). For instance, the daily diets of adolescents should contain at least four servings of vegetables and three servings of fruit. This information may be found in Box 7 on page 14 of the pdf version of *Dietary Guidelines for Americans*, available online at *http://www.health.gov/dietaryguidelines/*.

Lesson 3 Organizer: Web Version

Activity 1: *A Delicate Balance*

What the Teacher Does	Procedure Reference
Tell the class that they will explore the energy balance equation introduced at the end of Lesson 2. • Organize students into 10 teams. • Give each team a copy of Master 3.1, *The Memo*, and have students read it. • Assign one of the five energy balance clinic patients to each of two student groups. • Direct students to computer stations.	Pages 81–82 Steps 1–3 M
Explain to students that their first task is to evaluate the patient's concern. • Describe information they have available to them: patient file, one-day food diary, one-day physical activity diary, and an energy balance reference manual. • Point out key features and stress the importance of the energy balance reference manual.	Page 82 Steps 4–5 www
Instruct students to click on their assigned patient and listen to the patient's audio message.	Page 83 Step 6 www
Have students click on the "Patient File" link. Ask students to describe how they can evaluate their patient's energy balance.	Page 83 Steps 7–8 www
Have students proceed with the evaluation of their patient's energy balance. • Give each student a copy of Master 3.2, *Calculating Energy$_{in}$*. • Give each team a copy of Master 3.3, *Patient Notes*. • Instruct students to click on the "Final Analysis" link.	Pages 83–85 Steps 9–11 M www
Combine teams that evaluated the same patient and ask them to compare their analyses and resolve any discrepancies.	Page 85 Step 12

M = Involves copying a master. www = Involves using the Internet.

Activity 2: *Evaluation and Recommendations*

What the Teacher Does	Procedure Reference
Reconvene teams from Activity 1. • Direct students to prepare a short presentation regarding their patient's energy balance and their recommendations. • Direct students to prepare several questions they could ask the other teams about their analyses and recommendations.	Page 89 Steps 1–2
Ask each combined team to makes its presentation.	Pages 89–90 Step 3
Conclude with a brief class discussion. Ask students, • Which of the five patients has a healthy energy balance state? • If the five patients were adults rather than middle school students, would your answer by the same? Why or why not?	Pages 90–91 Steps 4–5

Lesson 3 Organizer: Print Version

Activity 1: *A Delicate Balance*

What the Teacher Does	Procedure Reference
Tell the class that they will explore the energy balance equation introduced at the end of Lesson 2. • Organize students into 10 teams. • Give each team a copy of Master 3.1, *The Memo*, and have students read it. • Assign one of the five energy balance clinic patients to each of two student groups. • Give each group the appropriate patient file (Masters 3.5–3.9). • Give each group a copy of Master 3.10, *Energy Balance Reference Manual.*	Page 86 Steps 1–3 M
Explain to students that their first task is to evaluate the patient's concern. • Describe information they have available to them: patient file, one-day food diary, one-day physical activity diary, and an energy balance reference manual. • Point out key features and stress the importance of the energy balance reference manual.	Pages 86–87 Steps 4–5
Have students read the patient file. Ask students to describe how they can evaluate their patient's energy balance.	Page 87 Steps 6–7
Have students proceed with the evaluation of their patient's energy balance. • Give each student a copy of Master 3.2, *Calculating* $Energy_{in}$. • Give each team a copy of Master 3.3, *Patient Notes*. • Give each team a copy of Master 3.11, *Energy Balance Diagram*. • Instruct teams to complete Masters 3.3 and 3.11.	Pages 87–89 Steps 8–9 M
Combine teams that evaluated the same patient and ask them to compare their analyses and resolve any discrepancies.	Page 89 Step 10

M = Involves copying a master.

Activity 2: *Evaluation and Recommendations*

What the Teacher Does	Procedure Reference
Reconvene teams from Activity 1. • Direct students to prepare a short presentation regarding their patient's energy balance and their recommendations. • Direct students to prepare several questions they could ask the other teams about their analyses and recommendations.	Page 89 Steps 1–2
Ask each combined team to makes its presentation.	Pages 89–90 Step 3
Conclude with a brief class discussion. Ask students, • Which of the five patients has a healthy energy balance state? • If the five patients were adults rather than middle school students, would your answer by the same? Why or why not?	Pages 90–91 Steps 4–5

Munching Mice

Lesson 4
Explore
Explain
Elaborate

At a Glance

Overview
This lesson consists of two activities and takes two to three days to complete. The first activity begins with an introduction to the use of animals as models for scientific research. Students analyze data to determine the impact of genetics on weight gain in mice. In the second activity, students design experiments to test the impact of food availability and exercise on weight change in mice. They analyze and share the results of their experiments. Finally, students consider the validity of extending conclusions from their experiments with mice to humans. These activities can be done on the Web or with printed materials.

Major Concepts
Laboratory animals can be used as experimental models for humans. Energy balance is affected by several variables, including genetics, food availability, physical activity, and age. Continuous data are plotted most appropriately as a line graph. Graphing data on weight change helps researchers draw conclusions about the impact of factors on energy balance.

Objectives
At the completion of this activity students will

- be able to describe the effects of genetics, food availability, and physical activity on energy balance in mice,
- be able to describe the relationships between weight change and $Energy_{in}$ and $Energy_{ou}$t, and
- be able to explain the validity of using of laboratory animals as experimental models for humans.

Teacher Background
See the following sections in Information about Energy Balance:
3.1 The energy balance equation *(pages 26–30)*
3.4 Factors affecting energy intake *(pages 31–34)*

In Advance

Web-Based Activities

Activity	Web Version
1	Yes
2	Yes

Photocopies

Activity 1	For **Web** version: • Master 4.1, *Award to Study Factors Affecting Energy Balance*, 1 transparency • Master 4.2, *Memo to the Director on Research Question 1*, 1 copy per student For **print** version: • Master 4.1, *Award to Study Factors Affecting Energy Balance*, 1 transparency • Master 4.3, *Reference Manual for Scientific Research* (3 pages), 1 copy per team • Master 4.4, *Weights of Infant Mice from Strains A and B over Time*, 1 copy per team • Master 4.5, *Graph Paper*, 1 copy per student (if students do not have their own graph paper) • Master 4.2, *Memo to the Director on Research Question 1*, 1 copy per student
Activity 2	For **Web** version: • Master 4.6, *Memo to the Director on Research Question 2*, 1 copy for half of students • Master 4.7, *Memo to the Director on Research Question 3*, 1 copy for half of students • Master 4.8, *Summary of Research Findings*, 1 transparency • Master 4.9, *Impact of Exercise on Weight of Adult Males*, 1 transparency For **print** version: • Master 4.3, *Reference Manual for Scientific Research* (3 pages), reuse copies from Activity 1 • Master 4.6, *Memo to the Director on Research Question 2*, 1 copy for half of students • Master 4.7, *Memo to the Director on Research Question 3*, 1 copy for half of students • Master 4.8, *Summary of Research Findings*, 1 transparency

Activity 2 (continued)	• Master 4.9, *Impact of Exercise on Weight of Adult Males*, 1 transparency • Master 4.10, *Next Research Assignment*, 1 transparency • Master 4.11, *Experimental Design for Research Question 2*, 1 copy for half of teams • Master 4.12, *Experimental Design for Research Question 3*, 1 copy for half of teams • Master 4.13, *Weights of Juvenile Mice with Limited Food and Regular Exercise over Time*, 1 copy for half of teams • Master 4.14, *Weights of Juvenile Mice with Unlimited Food and Regular Exercise over Time*, 1 copy for half of teams • Master 4.15, *Weights of Juvenile Mice with Limited Food and No Exercise over Time*, 1 copy for half of teams • Master 4.16, *Weights of Juvenile Mice with Unlimited Food and No Exercise over Time*, 1 copy for half of teams • Master 4.17, *Weights of Adult Mice with No Exercise and Unlimited Food over Time*, 1 copy for half of teams • Master 4.18, *Weights of Adult Mice with Regular Exercise and Unlimited Food over Time*, 1 copy for half of teams • Master 4.19, *Weights of Adult Mice with No Exercise and Limited Food over Time*, 1 copy for half of teams • Master 4.20, *Weights of Adult Mice with Regular Exercise and Limited Food over Time*, 1 copy for half of teams

Materials

Activity 1	none needed (except photocopies)
Activity 2	none needed (except photocopies)

Preparation

Activities 1 and 2 (Web version)

Verify that the computer lab is reserved for your classes or that classroom computers are ready to use. Go to the URL *http://science.education.nih.gov/supplements/energy/student* and click on "Lesson 4—Munching Mice." This brings up the unit's "desktop." Click on "Munching Mice: Are we all the same?" or "Munching Mice—What are the effects of food and exercise?" as appropriate.

Activities 1 and 2 (print version)

Make one photocopy of Master 4.5, *Graph Paper*, for each student (if students do not have their own graph paper), and cut the copies in half. This will allow each student to have two pieces of graph paper, one for Activity 1 and one for Activity 2. You may wish to prepare extra copies in case students make mistakes. For Activity 2, cut the copies of pages containing Masters 4.13 through 4.20 in half so you can give each team the appropriate master.

Activity 1: *Energy Balance—Are We All the Same?*

Teacher note: The introduction to this activity uses a series of questions to stimulate thinking about the use of animal models in scientific research. Then, students in teams of three analyze the results of an experiment that compares weight gain in mice from different genetic strains. This introduces important concepts in data analysis and interpretation, such as the rationale for using averages and reporting range, the appropriateness of line graphs and bar graphs for particular types of data, and drawing conclusions from graphs. Student teams share and justify their analysis and conclusions with the class.

Procedure

Assessment:
Responses to this question provide an opportunity for informal assessment of students' understanding from the previous lessons.

Content Standard G:
Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

Part 1, Using animal models in scientific research

1. **Ask students, "What affects whether you gain weight or lose weight?"**

   Record all responses on the board. On the basis of their experiences in the previous lessons, students should identify activity level and the amount of food eaten as important factors that determine weight gain or loss. Others factors may be less apparent to students, such as variations in BMR, gender, and heredity. You may need to lead students to these genetic factors, or you can add them yourself at appropriate times in the discussion.

2. **Ask students, "How can scientists determine whether these factors affect energy balance and weight change?"**

   From earlier lessons, students have a sense that physical activity and food intake alter energy balance. Make the point that in order to conclude that these things really do affect energy balance and weight change, scientists need evidence obtained through observation and experimentation. Their conclusions must be verified by repeated tests.

   Students may suggest that scientists prescribe specific amounts of food and physical activity for people and measure the impact on their weight. Follow this suggestion with the questions in Steps 3 and 4.

3. **Ask students, "What are the advantages of using humans for research on energy balance?"**

A major advantage is that humans demonstrate how humans behave. You can give them instructions that you know are understood. They can communicate with you.

4. **Follow this by asking, "Can you suggest any disadvantages of using humans for the experiment you suggested?"**

   A major disadvantage is that it would be difficult to control all of the variables in the experiment. It would be very difficult, if not impossible, to maintain large groups of humans in exactly the same environmental conditions. There are also ethical issues to consider, such as the possibility of negative health effects on experimental subjects. It would be impossible to rule out the impact of genetics on energy balance because large numbers of genetically identical humans do not exist. Finally, asking people to record their food intake and physical activities may cause them to change their usual behavior patterns.

   Tip from the field test: To emphasize the last point, remind students about the physical activity diaries they completed in Lesson 1. Ask them whether they changed their activities because they knew they would be recording them in their diaries.

5. **Ask, "How could you get around these disadvantages?"**

   If students do not suggest using animal models, point out that this is a common way to study phenomena that affect both humans and other animals. In particular, all mammals have a similar physiology, so in many cases, what is true for mice, rats, or goats is also true for humans.

   One advantage of using animal models is that researchers can control the animal's environment. Students may not realize that another advantage is that genetically identical animals can be produced and used. Using the analogy of identical twins may help students understand this. By carefully selecting and breeding mice for many generations, scientists have produced genetically identical strains of mice. All mice in such strains could be considered identical twins of each other. Male and female mice differ only by those genes involved in determining sex.

   You may want to provide some examples of the many beneficial outcomes from experimentation involving laboratory animals. The benefits include the discovery of the causes and prevention of, and effective treatments for, many infectious diseases and the development and perfection of surgical techniques. For example, Louis Pasteur used rabbits and guinea pigs to identify the bacteria that cause anthrax and to develop a vaccine against this disease. Successful open-heart surgery and organ transplants are based on years of animal experimentation.

6. **Ask, "What are disadvantages of using animals other than humans for research on energy balance?"**

   A major disadvantage is that the animals may not respond exactly the same as humans. An animal's physiology may or may not be similar enough to a human's to make comparisons. Predictions about human responses to particular conditions can be made based on the results of experiments with animal models. If the predictions are accurate, the appropriateness of the animal model is confirmed. At the end of this lesson, students make predictions about weight changes in humans based on the results of their experiments with mice. They then examine existing evidence about human weight change to decide whether mice are useful models for investigating energy balance in humans.

   Teacher note: Ethical treatment is a concern for animal subjects as well as human subjects. However, try to avoid emotional issues by pointing out that scientists who use animals in their research must comply with stringent guidelines for humane treatment of the animals. For this discussion, focus on the limitations of using human subjects and the advantages and limitations of animal models.

Part 2, Experiment 1: Energy balance in infant mice

In classrooms using the *Web version* of Activity 1, Part 2:

Teacher note: This activity uses a simulation on the Web. It will save time to have the computers online and at the correct URL: *http://science.education.nih.gov/supplements/energy/student*. Click on "Lesson 4—Munching Mice." This brings up the unit's "desktop," which contains links to this lesson's Web activities. Students should click on the link to "Munching Mice—Are we all the same?" If you are using Netscape or Internet Explorer as your browser and students want to print their graphs, instruct them to click first on "File" and then on "Page Setup." They should set the left and right margins to 0.1 inch. This will allow the entire page width to print.

1. **Display a transparency made from Master 4.1, *Award to Study Factors Affecting Energy Balance*, and read it with the class.**

   The memo describes a research award given to the "Energy Balance

Institute." Students play the role of research scientists who design and analyze experiments to answer the three research questions in the memo. The first research question is investigated in Activity 1, and the second and third research questions are investigated in Activity 2.

2. **Organize students into groups of three. Number each group sequentially beginning with 1. Explain that the groups will be research teams at the "Energy Balance Institute," and direct the teams to their computer stations.**

3. **Tell students to display the homepage for the Energy Balance Institute by clicking on "Lesson 4—Munching Mice." This brings up the unit's "desktop," which contains links to this lesson's Web activities. Students should click on the link to "Munching Mice—Are we all the same?" Then ask them to read the e-mail message from the laboratory technician.**

   If you have a computer-screen projector, you could demonstrate this step for the whole class. The technician has collected the data for the first research question; the e-mail message explains that the research teams will find the results in the online lab notebook. Students will analyze these results.

4. **Tell students to click on the lab notebook icon. Briefly review the contents of the Experimental Design page that appears.**

   This page shows the research question, hypothesis, experimental procedure followed, and the mice used for Experiment 1. It is the model for the experiments students will design in Part 1 of Activity 2.

5. **Direct students to click the icon for the reference manual on the screen that appears, and review the table of contents with them.**

   Walking the class through the Web site (Steps 2 through 5) allows you to explain how to navigate through the activity, as you did in Lesson 3.

   Emphasize that consulting the reference manual will help students complete the activity more quickly and accurately. It provides information about laboratory mice and raising mice in the laboratory and, even more important for students' work in this lesson, advice for writing hypotheses, designing experiments, analyzing data, interpreting results, and drawing conclusions.

6. **Explain that clicking on the "View Data" button will take students to a screen where they can see results for the experiment and select the graph(s) they wish to make.**

Allow about 20 minutes for the teams to complete their analyses. Students will have to decide whether to use a line or a bar graph for the data, whether to graph individual mouse data or average data, and whether to place the data from both mouse strains on the same or different graphs. The reference manual provides guidance to help them make these decisions.

If students wish to make more than one graph, they may do so on Data Analysis, page 2, by selecting new parameters (graph type and results to be graphed) and then clicking on "Create Graph."

See the teacher note at the beginning of this part of the activity (page 102) for directions on printing the graphs if you are using Netscape or Internet Explorer for your browser.

7. **While the teams are working, distribute one copy of Master 4.2, *Memo to the Director on Research Question 1*, to each student and explain that they will present their findings at the end of class.**

8. **Reconvene the class and point out that the data collected in Experiment 1 focus on weight gain. Ask, "What does *weight gain* have to do with *energy balance*?"**

Assessment:
Question 8 also gives you an opportunity to assess informally what students have learned about energy balance from the previous lessons. They should be able to explain that in order to grow and gain weight, the mice have consumed more calories in their food than they are expending in their physical activities, or $\text{Energy}_{in} = \text{Energy}_{out} + \text{Energy}_{growth} + \text{Energy}_{stored}$.

9. **Ask three or four teams to show their graphs and describe why they analyzed the data as they did. Ask three or four other teams to give their answers to the questions on the memo, and ask the remaining teams to give their conclusions about energy balance.**

Students should use the results of the experiment to justify their conclusions. Allow the other teams in the class to challenge the graphing decisions and conclusions of their classmates, based on the results of the experiment.

Students should conclude that although the overall growth patterns of the two strains of mice are the same, genetics does affect the amount of weight gained.

Tip from the field test: Students may feel that 5 g is not much difference in final weight. If so, make the comparison to humans: 5 g in a 35-g mouse correlates to 15 pounds in a 100-pound human (5 g and 15 pounds are both about 15 percent of the total body weight). Thus, comparing mice weighing 30 g and 35 g is like comparing humans weighing 85 pounds and 100 pounds.

10. **Remind students about Research Questions 2 and 3. Tell them they will have the opportunity to design an experiment and collect and analyze the data for one of those two questions in Activity 2.**

Assessment:
Collect and review Master 4.2, *Memo to the Director on Research Question 1*, from each group.

In classrooms using the *print version* of Activity 1, Part 2:

1. **Display a transparency made from Master 4.1, *Award to Study Factors Affecting Energy Balance*, and read it with the class.**

   The memo describes a research grant given to the "Energy Balance Institute." Students play the role of research scientists who design and analyze experiments to answer the three research questions in the memo. The first research question is investigated in Activity 1, and the second and third research questions are investigated in Activity 2.

2. **Organize students into groups of three. Number each group sequentially beginning with 1. Explain that the groups are research teams at the Energy Balance Institute assigned to design and analyze experiments to answer the three research questions.**

3. **Distribute a copy of Master 4.3, *Reference Manual for Scientific Research*, to each team.**

   Explain that, just as in Lesson 3, the reference manual in this lesson contains helpful information. Point out several sections of the manual. The reference manual provides useful information about laboratory mice, including how to raise mice in the laboratory, and, even more important for students' work in this lesson, information about writing hypotheses, designing experiments, analyzing data, interpreting results, and drawing conclusions.

4. **Tell students that a research technician has completed an experiment to answer the first research question. Distribute a copy of the results, Master 4.4, *Weights of Infant Mice from Strains A and B over Time*, to each team.**

5. **Direct students to examine the tables and give them three to five minutes to write three observations about the data. List their observations on the board as they share them with the class.**

   Observations include the following: all mice have the same initial weight; they gain weight steadily for about six weeks and then maintain a constant weight; there is individual variation in the amount of weight gained; and overall, Strain B mice weigh more at eight weeks than Strain A mice.

6. **Point out that the data collected in Experiment 1 focus on weight gain. Ask, "What does *weight gain* have to do with *energy balance*?"**

Assessment:
This question also gives you the opportunity to assess informally what students have learned about energy balance from the previous lessons. They should be able to explain that in order to grow and gain weight, the mice have consumed more calories in their food than they are expending in their physical activities, or $Energy_{in} = Energy_{out} + Energy_{growth} + Energy_{stored}$.

Assessment:
Collect and review Master 4.2, *Memo to the Director on Research Question 1*, from each group.

7. **Distribute a piece of graph paper (from classroom supplies or photocopies of Master 4.5, *Graph Paper*) to each student. Explain that researchers find it useful to graph experimental data to help them interpret their results.**

8. **Direct teams to prepare line graphs from the data, using "Week" on the x-axis and "Average Weight" on the y-axis.**

   The data for Strains A and B should be plotted on the same graph using different colors or different symbols for data from the different strains. Tell students to include a legend that identifies which line corresponds to which strain's data. Allow about 20 minutes for students to complete their graphs.

9. **While students complete their graphs, distribute one copy of Master 4.2, *Memo to the Director on Research Question 1*, to each student. Tell them to complete the memo when they have finished constructing their graphs. Explain that they will present their findings at the end of class.**

10. **Reconvene the class and ask three or four teams to show their graphs. Ask three or four other teams to give their answers to the questions on the memo. Ask the remaining teams to give their conclusion about energy balance.**

    Students should use the results of the experiment to justify their conclusions. Allow the other teams in the class to challenge the graphs, answers, and conclusions of their classmates, based on the results of the experiment.

    Students should conclude that although the overall growth patterns of the two strains of mice are the same, genetics does affect the amount of weight gained.

    Tip from the field test: Students may feel that 5 g is not much difference in final weight. If so, make the comparison to humans: 5 g in a 35-g mouse correlates to 15 pounds in a 100-pound human (5 g and 15 pounds are both about 15 percent of the total body weight). Thus, comparing mice weighing 30 g and 35 g is like comparing humans weighing 85 pounds and 100 pounds.

11. **Collect Master 4.3, *Reference Manual for Scientific Research*. Remind students about Research Questions 2 and 3. Tell them they will have the opportunity to design an experiment and collect and analyze the data for one of those two questions in Activity 2.**

    You will redistribute copies of the reference manual when students begin Activity 2.

Activity 2: *Energy Balance—What Are the Effects of Food and Exercise?*

Part 1, Experiments 2 and 3: Energy balance in juvenile and adult mice

In classrooms using the *Web version* of Activity 2, Part 1:

Teacher note: This activity uses a simulation on the Web. It will save time to have the computers online and at the correct URL: *http://science.education.nih.gov/supplements/energy/student*. Click on "Lesson 4—Munching Mice." This brings up the unit's "desktop," which contains links to this lesson's Web activities. Students should click on the link to "Munching Mice—What are the effects of food and exercise?" If you are using Netscape or Internet Explorer as your browser and students want to print their graphs, instruct them to click first on "File" and then on "Page Setup." They should set the left and right margins to 0.1 inch. This will allow the entire page width to print.

1. **Organize students into their research teams from Activity 1. Assign even-numbered teams to research question 2 (the effect of food availability on energy balance in juvenile mice) and odd-numbered teams to research question 3 (the effect of exercise on energy balance in adult mice).**

2. **Tell students to display the homepage for the Energy Balance Institute by clicking on "Lesson 4—Munching Mice." This brings up the unit's "desktop," which contains links to this lesson's Web activities. Students should click on the link to "Munching Mice—What are the effects of food and exercise?" Then ask them to read the e-mail message from the director of research.**

   The e-mail message directs students to Research Questions 2 and 3.

3. **Students should read the e-mail and then click on the research question assigned to them.**

   Clicking on their research question opens the Experimental Design page, where students will see their research question and fill in their hypothesis for the experiment.

4. **Instruct teams to enter a hypothesis based on their research question in the appropriate box and then click on the "To Animal Care Laboratory" button to select two groups of mice appropriate for testing their hypothesis.**

   Remind students that the reference manual provides advice for developing a hypothesis and selecting research subjects. Four

Content Standard A:
Design and conduct a scientific investigation.

Assessment:
Move among the groups and listen as students develop their hypotheses and plan their experiments. Check that hypotheses are appropriate for the research question and that experiments are appropriate for the hypotheses.

Content Standard C:
Some traits of an organism are inherited and others result from interactions with the environment. Behavior is one kind of response an organism can make to an internal or environmental stimulus.

groups of mice will be available to students, and the program will allow students to select any two groups for their experiment.

5. **Tell students to click on the "To Experimental Design Page" button when they have finished writing their hypothesis and selecting the groups of mice they will use. After confirming the experiment they have designed, students should click the "View Data" button and proceed with graphing their data as they did in Activity 1.**

The Experimental Design page summarizes the experiment students have designed. It looks the same as in Activity 1, but with the appropriate research question. The program will automatically display the hypothesis students wrote and the two groups of mice they selected.

Clicking the "View Data" button takes students to a page with the results of their experiment and the graphing options available to them, as in Activity 1. Students can also return to the Animal Care Laboratory from this page if they decide they need to test their hypothesis with a different pair of mouse groups.

Although students can select any pair of the four mouse groups available for their experiment, there are only two pairs that are appropriate for answering each research question.

For Research Question 2 (juvenile mice), the correct pairs of mouse groups are Limited Food—Regular Exercise with Unlimited Food—Regular Exercise *or* Limited Food—No Exercise with Unlimited Food—No Exercise. The second pair of mouse groups is probably more appropriate because no exercise is the standard condition for raising mice. However, the first pair of mouse groups also allows students to answer the research question. Either pair leads students to the same conclusion: juvenile mice with limited food gain less weight than do juvenile mice with unlimited food.

For Research Question 3 (adult mice), the correct pairs of mouse groups are No Exercise—Unlimited Food with Regular Exercise—Unlimited Food *or* No Exercise—Limited Food with Regular Exercise—Limited Food. The first pair of mouse groups is probably more appropriate because unlimited food is the standard condition for raising mice. However, the second pair of mouse groups also allows students to answer the research question. Either pair leads students to the same conclusion: adult mice that exercise regularly lose weight, while adult mice that do not exercise regularly gain weight. However, the amounts of weight gain or loss vary considerably depending on food availability.

Using other pairs of mouse groups may answer a research question different from the one assigned to students, or students may not be able to determine which factor (exercise or food availability) has affected weight change. For example, if students compare weight gain in juvenile mice that had unlimited food and no exercise with weight gain in juvenile mice that had limited food and regular exercise, they cannot determine whether it was lack of food or regular exercise that limited weight gain in the second group.

6. **Distribute copies of either Master 4.6, *Memo to the Director on Research Question 2*, or Master 4.7, *Memo to the Director on Research Question 3*, as appropriate, to each student while they prepare their graphs. Tell them to complete the memo using the results of their experiment.**

   Move among the teams during this time, answering students' questions and providing suggestions as necessary. Point out that the reference manual provides guidance for analyzing their data and drawing conclusions from graphs.

7. **Pair odd- and even-numbered teams and ask them to share their results. Encourage teams to challenge their partner team's conclusions if they are not supported by the data.**

Assessment:
You can collect the completed memos and review them to evaluate students' understanding of data analysis and interpretation.

In classrooms using the *print version* of Activity 2, Part 1:

1. **Organize students into their research teams from Activity 1. Display Master 4.10, *Next Research Assignment*. Read this memo with the class.**

   The memo, from the institute research director, assigns even-numbered teams to conduct an experiment to answer Research Question 2 (the effect of food availability on energy balance in juvenile mice) and odd-numbered teams to conduct an experiment to answer Research Question 3 (the effect of exercise on energy balance in adult mice).

2. **Give each team a copy of Master 4.11, *Experimental Design for Research Question 2*, or Master 4.12, *Experimental Design for Research Question 3*, as appropriate. Redistribute a copy of Master 4.3, *Reference Manual for Scientific Research*, to each team.**

3. **Instruct teams to complete their master by first writing a hypothesis for their research question and then selecting two groups of mice appropriate for testing their hypothesis.**

   Remind students that the reference manual provides advice for developing a hypothesis and selecting research subjects. Four

Content Standard A:
Design and conduct a scientific investigation.

Assessment:
Move among the groups and listen as students develop their hypotheses and plan their experiments. Check that hypotheses are appropriate for the research question and that experiments are appropriate for the hypotheses.

Content Standard C:
Some traits of an organism are inherited and others result from interactions with the environment. Behavior is one kind of response an organism can make to an internal or environmental stimulus.

groups of mice will be available to students, and they may select any two groups for their experiment.

4. **Give the research teams the appropriate data sets for the two groups of mice they selected.**

Although students can select any pair of the four mouse groups available for their experiment, only two pairs are appropriate for answering each research question.

For Research Question 2 (juvenile mice), the correct pairs of mouse groups are Master 4.13, *Weights of Juvenile Mice with Limited Food and Regular Exercise over Time*, with Master 4.14, *Weights of Juvenile Mice with Unlimited Food and Regular Exercise over Time*, or Master 4.15, *Weights of Juvenile Mice with Limited Food and No Exercise over Time*, with Master 4.16, *Weights of Juvenile Mice with Unlimited Food and No Exercise over Time*. The second pair of mouse groups is probably more appropriate because no exercise is the standard condition for raising mice. However, the first pair of mouse groups also allows students to answer the research question. Either pair leads students to the same conclusion: juvenile mice with limited food gain less weight than juvenile mice with unlimited food.

For Research Question 3 (adult mice), the correct pairs of mouse groups are Master 4.17, *Weights of Adult Mice with No Exercise and Unlimited Food over Time*, with Master 4.18, *Weights of Adult Mice with Regular Exercise and Unlimited Food over Time*, or Master 4.19, *Weights of Adult Mice with No Exercise and Limited Food over Time*, with Master 4.20, *Weights of Adult Mice with Regular Exercise and Limited Food over Time*. The first pair of mouse groups is probably more appropriate because unlimited food is the standard condition for raising mice. However, the second pair of mouse groups also allows students to answer the research question. Either pair leads students to the same conclusion: adult mice that exercise regularly lose weight, while adult mice that do not exercise regularly gain weight. However, the amounts of weight gain or loss vary considerably depending on food availability.

Using other pairs of mouse groups may answer a research question different from the one assigned to students, or students may not be able to determine which factor (exercise or food availability) has affected weight change. For example, if students compare weight gain in juvenile mice that had unlimited food and no exercise with weight gain in juvenile mice that had limited food and regular exercise, they cannot determine whether it was lack of food or regular exercise that limited weight gain in the second group.

5. **Give each student one piece of graph paper and tell them to pre-**

pare line graphs of their data following the same procedure as for Activity 1.

6. **Distribute copies of either Master 4.6, *Memo to the Director on Research Question 2*, or Master 4.7, *Memo to the Director on Research Question 3*, as appropriate, to each student while they prepare their graphs. Tell them to complete the memo by entering the results of their experiment.**

   Move among the teams during this time, answering questions and providing suggestions as necessary. Point out that the reference manual provides guidance for analyzing data and drawing conclusions from graphs.

7. **When students have completed their graphs and memos, pair odd- and even-numbered teams and tell them to share their results. Encourage teams to challenge their partner team's conclusions if they are not supported by the data.**

Assessment:
You can collect the completed memos and review them to evaluate students' understanding of data analysis and interpretation of the results.

Part 2, Checking the validity of the animal model

1. **Reconvene the class and display Master 4.8, *Summary of Research Findings*. Ask students to summarize what they learned about energy balance by providing evidence-based answers to each of the three research questions.**

2. **Ask the class, "If what you learned about energy balance in mice is true for humans, what would you predict about weight change for human adults who consume their usual number of calories but increase daily exercise?"**

   On the basis of the results of Experiment 3 with mice, students should predict that adult humans would lose weight.

3. **Display Master 4.9, *Impact of Exercise on Weight of Adult Males*. Explain that the graph compares two groups of overweight adult males. Both groups consumed their usual number of calories for 12 weeks, but the exercise group added daily exercise.**

4. **Then ask, "Is your prediction confirmed by the evidence in this graph?"**

   Students should conclude that the information supports their prediction about energy balance in humans.

5. **Ask, "On the basis of these results, can experiments with mice be used to test hypotheses about energy balance in humans?"**

NSES

Content Standard G:
Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

Assessment:
This is an opportunity to assess understanding of the experimental results. Students should be able to explain that among infant mice, weight gain was affected by genetics (Experiment 1); among juvenile mice, greater food

consumption resulted in increased weight gain, regardless of exercise (Experiment 2); and among adult mice, no exercise resulted in weight gain while regular exercise resulted in weight loss, although the amounts of gain or loss were affected by food availability (Experiment 3).

Students should conclude that mice are a good animal model for investigating energy balance in humans.

6. **Set the stage for Lesson 5 by asking students, "Why does it matter whether adults gain weight?" Entertain several responses, then tell students that they will consider health concerns related to weight gain in Lesson 5.**

   Possible responses include that weight gain in humans matters for appearance, for good health, or for economic reasons. Accept all appropriate responses, but use this as an opportunity to emphasize that healthcare professionals are concerned about excessive weight gain in adults because of its impact on health.

Discussion Questions

1. **What is the advantage of plotting the *average* weights each week rather than all the individual weights?**

   Students will probably recognize that plotting all the data results in a cluttered graph that is difficult to interpret. It would also take them much longer to draw such a graph. Plotting the average data makes interpretation easier. Students may not realize that using the average also helps minimize distortions in the results due to individual variation. Point out the individual variation in the data and ask the question (included on Master 4.2), Why do you suppose the technician collected data from 10 mice of each strain rather than just 1 or 2 mice?

2. **Why is a line graph appropriate for the data on weight change?**

   Line graphs are used for measured data that relate trends in the measured characteristic, especially trends across time. The data collected in the experiments in this lesson are continuous; that is, the mice gained or lost weight continuously over the experimental time period. For example, you could accurately determine the unmeasured average weight of the infant mice at 2½ weeks by finding the y-coordinate at the midpoint of the line that connects their measured average weights at 1 week and 2 weeks. In other words, the points on the line in between the two measured intervals are logically meaningful.

3. **Why is a bar graph appropriate for the data from Lesson 1, the amount of time spent at different physical activity levels?**

   A bar graph is used for data that are placed into qualitative categories. In Lesson 1, the five physical activity levels are qualitative categories. It is not appropriate to use a line to connect the amount of time spent in activities at the different levels because these levels are not expected to depict a continuing trend. For example, if an individual spent eight hours resting, you would not necessarily expect a trend of decreasing or increasing amounts of time spent at each higher level of activity. On the other hand, for the current Lesson, plotting the data as a bar graph would imply that there is not necessarily a correlation between the measured weights at each weekly interval.

4. **What additional research questions could you answer using the groups of animals available to you?**

   Students could answer the research question, Does exercise affect weight gain in juvenile mice? by comparing juvenile mice with unlimited food and regular exercise with juvenile mice with unlimited food and no exercise or by comparing juvenile mice with limited food and regular exercise with juvenile mice with limited food and no exercise. The first pair is probably most appropriate because unlimited food is the standard condition for raising mice.

   Similarly they could answer the research question, Does the amount of food available affect weight gain or loss in adult mice? by comparing adult mice with no exercise and unlimited food with adult mice with no exercise and limited food *or* by comparing adult mice with regular exercise and unlimited food with adult mice with regular exercise and limited food. The first pair is probably most appropriate because no exercise is the standard condition for raising mice.

5. **Can you compare the effect of *age* on weight change in mice using the results from your experiments?**

   Students cannot do this directly with the Web version of the activity (the program does not allow students to pair a group of juvenile mice with a group of adult mice). However, they can compare final graphs for juvenile and adult mice that experienced the same conditions (for example, unlimited food and regular exercise). Point out that the adult experiments were conducted across five *months* while the juvenile experiments were conducted across five *weeks*. Students could compare weight changes after one month by comparing the adult averages at Month 1 to the juvenile averages at Week 4.

Lesson 4 Organizer: Web Version

Activity 1: *Energy Balance—Are We All the Same?*

What the Teacher Does	Procedure Reference
Part 1, Using animal models in scientific research Ask students, • "What affects whether you gain weight or lose weight?" • "How can scientists determine whether these factors affect energy balance and weight change?" • "What are the advantages of using humans for research on energy balance?" • "Can you suggest any disadvantages of using humans for the experiments you suggested?" • "How could you get around these disadvantages?" • "What are disadvantages of using animals other than humans for research on energy balance?"	Pages 100–102 Steps 1–6
Part 2, Experiment 1: Energy balance in infant mice • Display a transparency of Master 4.1, *Award to Study Factors Affecting Energy Balance.* • Organize students into groups of three and number groups (teams) sequentially beginning with 1. • Direct teams to computer stations.	Pages 102–103 Steps 1–2 T M
Guide students through activity. Have them • read e-mail message from technician, • review contents of Experimental Design page, • review contents of the reference manual, and • view data and construct graph(s). Give each student a copy of Master 4.2, *Memo to the Director on Research Question 1,* and tell students that they will present their findings to the class.	Pages 103–104 Steps 3–7 www M

Reconvene the class.
• Ask, "What does weight gain have to do with energy balance?"
• Ask different teams to
  o show their graphs and describe why they analyzed their data as they did,
  o give their answers to the questions on the memo, and
  o give their conclusions about energy balance.
• Remind students that they will answer Research Questions 2 and 3 in the next activity.
	Page 104
	Steps 8–10

Activity 2: *Energy Balance—What Are the Effects of Food and Exercise?*

What the Teacher Does	Procedure Reference
Part 1, Experiments 2 and 3: Energy balance in juvenile and adult mice Organize students into their teams from Activity 1. • Assign even-numbered teams to Research Question 2 and odd-numbered teams to Research Question 3.	Page 107 Step 1
Direct teams to computer stations. Guide students through activity. Have them • read the e-mail and then click on the research question assigned to them; • enter a hypothesis and then click on the Animal Care Laboratory link; • select two groups of mice to use in testing their hypothesis; • return to the Experimental Design page and review their hypothesis and mouse selections; • view their data and make their selections for graphical representation of the data.	Pages 107–109 Steps 2–5
Give each student a copy of Master 4.6, *Memo to the Director on Research Question 2*, or Master 4.7, *Memo to the Director on Research Question 3*, as appropriate, and ask them to complete the memo.	Page 109 Step 6
Pair even- and odd-numbered teams and ask them to share their results and challenge their partner team's conclusions, as appropriate.	Page 109 Step 7
Part 2, Checking the validity of the animal model Reconvene the class. • Ask students to summarize what they learned about energy balance; they should provide evidence-based answers to each of the three research questions. • Ask, "If what you learned about energy balance in mice is true for humans, what would you predict about weight change for human adults who consume their usual number of calories but increase daily exercise?"	Page 111 Steps 1–2

M = Involves copying a master.

WWW = Involves using the Internet.

T = Involves using a transparency.

Display and explain a transparency of Master 4.9, *Impact of Exercise on Weight in Adult Males*. Then ask, • "Is your prediction confirmed by the evidence in this graph?" • "On the basis of these results, can experiments with mice be used to test hypotheses about energy balance in humans?"	Pages 111–112 Steps 3–5 T
Set the stage for Lesson 5. • Ask, "Why does it matter whether adults gain weight?" • Tell students that they will consider health concerns related to weight gain in Lesson 5.	Page 112 Step 6

Lesson 4 Organizer: Print Version

Activity 1: *Energy Balance—Are We All the Same?*

What the Teacher Does	Procedure Reference
Part 1, Using animal models in scientific research Ask students, • "What affects whether you gain weight or lose weight?" • "How can scientists determine whether these factors affect energy balance and weight change?" • "What are the advantages of using humans for research on energy balance?" • "Can you suggest any disadvantages of using humans for the experiments you suggested?" • "How could you get around these disadvantages?" • "What are disadvantages of using animals other than humans for research on energy balance?"	Pages 100–102 Steps 1–6
Part 2, Experiment 1: Energy balance in infant mice • Display a transparency of Master 4.1, *Award to Study Factors Affecting Energy Balance*. • Organize students into groups of three and number groups (teams) sequentially beginning with 1. • Give each team a copy of Master 4.3, *Reference Manual for Scientific Research.*	Page 105 Steps 1–3 T M
Tell students that a research technician has completed an experiment to answer Research Question 1. Then • give each team a copy of Master 4.4, *Weights of Infant Mice from Strains A and B over Time*; • ask students to examine the data and write three observations about the data; • list their observations on the board; • ask, "What does weight gain have to do with energy balance?" • have students graph results, using "Week" on the x-axis and "Average weight" on the y-axis; • give each student a copy of Master 4.2, *Memo to the Director on Research Question* 1, and ask them to complete the memo; and • tell students they will present their results to the class.	Pages 105–106 Steps 4–9 M

Reconvene the class. • Ask, "What does weight gain have to do with energy balance?" • Ask different teams to o show their graphs and describe why they analyzed their data as they did, o give their answers to the questions on the memo, and o give their conclusions about energy balance. Remind students that they will answer Research Questions 2 and 3 in the next activity.	Page 106 Steps 10–11

Activity 2: *Energy Balance—What Are the Effects of Food and Exercise?*

What the Teacher Does	Procedure Reference
Part 1, Experiments 2 and 3: Energy balance in juvenile and adult mice Organize students into their teams from Activity 1. • Display a transparency of Master 4.10, *Next Research Assignment.* • Give each team a copy of Master 4.11, *Experimental Design for Research Question 2*, or Master 4.12, *Experimental Design for Research Question 3*, as appropriate. • Redistribute Master 4.3, *Reference Manual for Scientific Research*, to each group.	Page 109 Steps 1–2
Guide students through the activity. • Instruct teams to write a hypothesis for their research question. • Select two groups of mice to use in testing their hypothesis. • Give teams the data sets for the groups of mice they selected. • Instruct students to prepare line graphs of their data. • Give each student a copy of Master 4.6, *Memo to the Director on Research Question 2*, or Master 4.7, *Memo to the Director on Research Question 3*, as appropriate. • Ask students to complete the memo.	Pages 109–111 Steps 3–6
Pair odd- and even-numbered groups and have students share their results and challenge their partner team's conclusions, as appropriate.	Page 111 Step 7

Part 2, Checking the validity of the animal model Reconvene the class. • Ask students to summarize what they learned about energy balance; they should provide evidence-based answers to each of the three research questions. • Ask, "If what you learned about energy balance in mice is true for humans, what would you predict about weight change for human adults who consume their usual number of calories but increase daily exercise?"	Page 111 Steps 1–2
Display and explain a transparency of Master 4.9, *Impact of Exercise on Weight in Adult Males*. Then ask, • "Is your prediction confirmed by the evidence in this graph?" • "On the basis of these results, can experiments with mice be used to test hypotheses about energy balance in humans?"	Pages 111–112 Steps 3–5 T
Set the stage for Lesson 5. • Ask, "Why does it matter whether adults gain weight?" • Tell students that they will consider health concerns related to weight gain in Lesson 5.	Page 112 Step 6

T = Involves using a transparency.

M = Involves copying a master.

Dear Me

At a Glance

Overview

This lesson consists of one activity. It begins with a classroom discussion in which students observe data that show the incidence of obesity increasing since 1985 and the risk of several diseases is higher for people with obesity. Then students are given a homework assignment. They write a letter to the person they will be in 25 to 30 years. They use what they have learned about energy balance to give themselves advice about appropriate strategies for maintaining energy balance (and thus a healthy weight) in their adult years.

Major Concepts

Obesity is increasing in the United States, leading to increased risk for many diseases. Maintaining the appropriate balance between energy intake and energy output is a lifelong goal. Middle school students should be in positive energy balance ($Energy_{in} > Energy_{out}$). For adults, $Energy_{in}$ should equal $Energy_{out}$. Strategies can be developed to aid adults in achieving energy balance.

Objectives

After completing this activity, students will

- be able to explain obesity in terms of the energy balance equation,
- recognize that obesity is increasing in the United States,
- realize that many diseases are more likely to occur among overweight and obese individuals, and
- be able to describe strategies adults can use to maintain energy balance.

Teacher Background

See the following sections in Information about Energy Balance:

1 Introduction *(pages 23–25)*
3.1 The energy balance equation *(pages 26–30)*
3.3 Body mass index (BMI) *(pages 30–31)*
3.4 Factors affecting energy intake *(pages 31–35)*
3.5 Strategies for achieving and maintaining a healthy body weight (size) *(page 35)*

In Advance

Web-Based Activity

Activity	Web Version
1	Yes, only for obesity-trends slides (see Procedure, Step 2)

Photocopies

Activity 1	• Master 5.1, *Obesity Trends*, 1 transparency • Master 5.2, *Increased Risk of Several Diseases with Overweight and Obesity*, 1 transparency • Master 5.3, *Letter to Myself*, 1 transparency

Materials

Activity 1	none needed (except transparencies)

Preparation

None required.

Procedure

Assessment: Asking students to explain obesity in terms of energy balance gives you an opportunity to evaluate students' ability to integrate what they have learned in Lessons 1 through 4. Students should use the terms $Energy_{in}$ and $Energy_{out}$ correctly to explain that obesity (and overweight) may result when adults

1. **Begin this activity by giving students a simple definition of** obesity: **being significantly overweight for one's age, height, and gender due to increased body fat. Then ask students to explain obesity in terms of energy balance.**

   The National Institutes of Health defines obesity and overweight based on body mass index (BMI) as described in Section 3.3 in the Information about Energy Balance section. The BMI concept is not introduced to the students in this curriculum supplement.

2. **Display transparency made from Master 5.1, *Obesity Trends* (or alternative described below).**

   If you have Internet access and a computer-screen projector in your classroom, you can go to the URL *http://science.education. nih.gov/supplements/energy/student* and click on "Lesson 5—Dear Me." On the desktop, click on "Obesity Trends Maps" to display a series of maps that depict obesity in the United States every year from 1985 to 2002. (You can also download the maps as a series of PowerPoint slides at the URL *http://science.education.nih.gov/supplements/energy/guide/obesity-slides.ppt*. Click on "obesity-slides.ppt" to download the slides for classroom use.) The initial map on screen presents data for 1985. Maps for subsequent years can be viewed in series by clicking the arrowhead just to the right of 2002. This advances the maps one year at a time. Clicking the arrowhead just to the left of 1985 goes back one year at a time. You may also click on individual years to go directly to that data if students need to review a specific year. To view the data in table form, click on "Obesity Trends Table" from the desktop.

3. **Ask students to summarize what the maps reveal about obesity in the United States.**

   Students will likely say things like "Obesity is increasing" or "We're getting fatter." Accept these correct answers. You may want to add that nutritionists describe the trend they observed as an obesity epidemic because of the way obesity is rapidly increasing in the population.

4. **Ask students to suggest reasons why doctors and other healthcare professionals are concerned about increasing obesity.**

   Students will likely identify several answers to this question, including the social stigma against overweight people and the negative impact of obesity on health. Healthcare professionals are concerned about the latter issue, and the rest of the discussion will focus on this.

   Tip from the field test: Be sensitive to students' feelings during this discussion. Overweight students, in particular, will likely be uncomfortable. Emphasize that healthy bodies come in many shapes and sizes. Obesity is a metabolic disease among adults that does not occur quickly. Physicians diagnose it on the basis of height and weight and/or amount of body fat (which can be challenging to determine), not simply by appearance.

5. **Confirm that the negative impact of obesity on health is a major concern of healthcare professionals, including those at the National Institute of Diabetes and Digestion and Kidney Disorders, which sponsored this curriculum supplement. Then display a transparency made from Master 5.2, *Increased Risk of Several Diseases with Overweight and Obesity.***

   This graph shows the increased risk of colon cancer, heart disease, and diabetes among people who are obese and overweight compared with the occurrence of those diseases among adults who are not overweight. Point out that the increased risk of developing diabetes among obese adults is so large that it does not fit on the graph. Discuss the rise in diabetes in overweight children, and point out that complications from diabetes are beginning to occur before they reach adulthood.

consume more calories in their food than they expend through BMR and physical activities ($Energy_{in} > Energy_{out}$). For children and adolescents, overweight may result when $Energy_{in} > Energy_{out} + Energy_{growth} + Energy_{stored}$. Emphasize that this positive energy balance leads to obesity only if it occurs consistently across many months. As students saw in Lesson 3, 1 pound of body fat results from 3,500 calories in excess of what their body needs.

NSES

Content Standard F: The results of risk analysis are used to determine the options for reducing or eliminating risks.

NSES

Content Standard C: Disease is a breakdown in structure and functions of an organism.

6. **Ask students to draw conclusions from the graph.**

   Students should conclude that people are at increased risk of developing the diseases shown on the graph if they become overweight or obese.

Assessment:
Step 6 provides an opportunity for students to practice the graph-interpretation skills they used in Lesson 4, and for you to evaluate those skills informally. You may want to ask them why the information was presented as a bar graph rather than a line graph. Students should reply that the data are in categories.

7. **Using the energy balance equation, ask students to describe what adults in the United States could do to reverse the obesity trend.**

   They should explain that adults need to reduce Energyin, increase Energyout, or both. Weight loss results when $Energy_{in} < Energy_{out}$.

8. **Continue the discussion by asking students, "What challenges do you think adults face in maintaining energy balance?"**

   Students may describe challenges such as finding time to exercise and prepare healthy meals, large food portions at restaurants, and genetics.

9. **Follow this by asking, "What strategies could adults use to maintain energy balance?"**

   Students may suggest strategies such as snacking on low-calorie foods, sharing restaurant meals with a friend or taking home extra food for later, or walking to work instead of driving. Because this question and the question in Step 8 have many "right" answers, this is an opportunity for all students to develop their discussion skills.

Content Standard F:
Individuals can use a systematic approach to thinking critically about risks and benefits. Important personal and social decisions are made based on perceptions of risks and benefits.

10. **Assign students to use the class discussion as background for writing a four-paragraph letter to their 40-year-old selves that gives advice on maintaining energy balance. Display a transparency made from Master 5.3, *Letter to Myself*, which gives students the beginning of the first sentence for each paragraph.**

    Explain that you will collect their letters the next class period and will evaluate them based on their 1) description of an appropriate energy balance, 2) identification of challenges students are likely to face in achieving that balance, 3) strategies for managing calories consumed, and 4) strategies for managing calories used.

Assessment:
This step serves as a final assessment of student understanding of the major concepts presented in this unit.

Lesson 5 Organizer

Activity 1: *Dear Me*

What the Teacher Does	Procedure Reference
Give students a simple definition of obesity and then ask them to explain obesity in terms of energy balance.	Page 122 Step 1
Display transparency of Master 5.1, *Obesity Trends*. Alternatively, display the series of maps available under Student Activities at the Web site. • Ask students to summarize what the maps reveal about obesity in the United States. • Ask students to suggest reasons why doctors and other healthcare professionals are concerned about increasing obesity.	Pages 122–123 Steps 2–4 WWW T M
Confirm that the negative impact of obesity on health is a major concern of healthcare professionals, including those at the National Institute of Diabetes and Digestion and Kidney Disorders, which sponsored this curriculum supplement. Then • display a transparency made from Master 5.2, *Increased Risk of Several Diseases with Overweight and Obesity*, and • ask students to draw conclusions from the graph.	Page 123 Step 5 T
Ask students, • "Using the energy balance equation, what can adults in the United States do to reverse the obesity trend observed in the maps?" • "What challenges do you think adults fact in maintaining energy balance?" • "What strategies could adults use to maintain energy balance?"	Page 124 Steps 6–9
Assign students to write a four-paragraph letter to their 40-year-old selves that gives advice on maintaining energy balance. Display a transparency of Master 5.3, *Letter to Myself*, which gives students the beginning of the first sentence of each paragraph.	Page 124 Step 10 M

T = Involves using a transparency.

WWW = Involves using the Internet.

M = Involves copying a master.

Masters

Master 4.4, *Weights of Infant Mice from Strains A and B over Time* .... team copies (*print version* only)
Master 4.5, *Graph Paper* .... student copies (if students do not have their own graph paper) (*print version* only)
Master 4.6, *Memo to the Director on Research Question 2* .... 1 copy for half of students
Master 4.7, *Memo to the Director on Research Question 3* .... 1 copy for half of students
Master 4.8, *Summary of Research Findings* .... transparency
Master 4.9, *Impact of Exercise on Weight of Adult Males* .... transparency
Master 4.10, *Next Research Assignment* .... transparency (*print version* only)
Master 4.11, *Experimental Design for Research Question 2* .... 1 copy for half of teams (*print version* only)
Master 4.12, *Experimental Design for Research Question 3* .... 1 copy for half of teams (*print version* only)
Master 4.13, *Weights of Juvenile Mice with Limited Food and Regular Exercise over Time* .... 1 copy for half of teams (*print version* only)
Master 4.14, *Weights of Juvenile Mice with Unlimited Food and Regular Exercise over Time* .... 1 copy for half of teams (*print version* only)
Master 4.15, *Weights of Juvenile Mice with Limited Food and No Exercise over Time* .... 1 copy for half of teams (*print version* only)
Master 4.16, *Weights of Juvenile Mice with Unlimited Food and No Exercise over Time* .... 1 copy for half of teams (*print version* only)
Master 4.17, *Weights of Adult Mice with No Exercise and Unlimited Food over Time* .... 1 copy for half of teams (*print version* only)
Master 4.18, *Weights of Adult Mice with Regular Exercise and Unlimited Food over Time* .... 1 copy for half of teams (*print version* only)
Master 4.19, *Weights of Adult Mice with No Exercise and Limited Food over Time* .... 1 copy for half of teams (*print version* only)
Master 4.20, *Weights of Adult Mice with Regular Exercise and Limited Food over Time* .... 1 copy for half of teams (*print version* only)

Lesson 5, *Dear Me*

Master 5.1, *Obesity Trends* .... transparency
Master 5.2, *Increased Risk of Several Diseases with Overweight and Obesity* .... transparency
Master 5.3, *Letter to Myself* .... transparency

Physical Activity Diary: School Day

Name: ______________________________ Date: ______________

Keep track of your physical activities for a 24-hour period during the school week. Within each one-hour time slot, list the activities you participated in and indicate the number of minutes you spent on each of type of activity (such as sleep, sitting activities, or high-level running activities).

Time	Activity	Time spent on activity (minutes)					
		Resting/ Sleeping	Very Light/ Sitting	Light/ Walking	Moderate/ Medium	Heavy/ Running	Total Minutes (must = 60)
5:00 a.m.							
6:00 a.m.							
7:00 a.m.							
8:00 a.m.							
9:00 a.m.							
10:00 a.m.							
11:00 a.m.							
Noon							
1:00 p.m.							
2:00 p.m.							
3:00 p.m.							
4:00 p.m.							
5:00 p.m.							
6:00 p.m.							
7:00 p.m.							
8:00 p.m.							
9:00 p.m.							
10:00 p.m.							
11:00 p.m.							
Midnight							
1:00 a.m.							
2:00 a.m.							
3:00 a.m.							
4:00 a.m.							
Total minutes							1,440

Physical Activity Diary: Weekend Day

Name: ____________________ Date: ____________

Keep track of your physical activities for a 24-hour period during the school week. Within each one-hour time slot, list the activities you participated in and indicate the number of minutes you spent on each of type of activity (such as sleep, sitting activities, or high-level running activities).

Time	Activity	Time spent on activity (minutes)					
		Resting/ Sleeping	Very Light/ Sitting	Light/ Walking	Moderate/ Medium	Heavy/ Running	Total Minutes (must = 60)
5:00 a.m.							
6:00 a.m.							
7:00 a.m.							
8:00 a.m.							
9:00 a.m.							
10:00 a.m.							
11:00 a.m.							
Noon							
1:00 p.m.							
2:00 p.m.							
3:00 p.m.							
4:00 p.m.							
5:00 p.m.							
6:00 p.m.							
7:00 p.m.							
8:00 p.m.							
9:00 p.m.							
10:00 p.m.							
11:00 p.m.							
Midnight							
1:00 a.m.							
2:00 a.m.							
3:00 a.m.							
4:00 a.m.							
Total minutes							1,440

Some Typical Activities and Energy Expended, by Intensity Level

Intensity Level, Activity	Energy Expended* (calories/hour)
Resting/Sleeping	60
Sleeping	
Very Light (sitting activities)	85
Watching television	
Playing computer games	
Listening to music	
Sitting in class	
Talking	
Using the Internet	
Eating and bathing	
Light (low-level activities)	140
Doing household chores	
Walking	
Shopping	
Moderate (medium-level activities)	285
Mowing lawns	
Bicycling	
Dancing (practice)	
Playing tennis	
Heavy (high-level activities)	400
Swimming (practice)	
Playing basketball	
Participating in most athletic practices	

* Average values for middle-school–aged people. The values include calories expended for basal metabolic rate (BMR).

Sample Physical Activity Diary for a School Day

Name: [Student's Name] Date: [Date Completed]

Keep track of your physical activities for a 24-hour period during the school week. Within each one-hour time slot, list the activities you participated in and indicate the number of minutes you spent on each of type of activity (such as sleep, sitting activities, or high-level running activities).

Time	Activity	Time spent on activity (minutes)					
		Resting/ Sleeping	Very Light/ Sitting	Light/ Walking	Moderate/ Medium	Heavy/ Running	Total Minutes (must = 60)
5:00 a.m.	Sleep	60					60
6:00 a.m.	Sleep	60					60
7:00 a.m.	Eat, get dressed, walk to school, talk with friends		45	15			60
8:00 a.m.	English, walk to Social Studies		50	10			60
9:00 a.m.	Social Studies, walk to Math		40	20			60
10:00 a.m.	Math, walk to homeroom		50	10			60
11:00 a.m.	Homeroom, walk to lunch, Lunch		50	10			60
Noon	Eat, walk to Music, Music		50	10			60
1:00 p.m.	Music, walk to P.E., P.E. class		20	10	30		60
2:00 p.m.	P.E., walk to Science, Science		20	25	15		60
3:00 p.m.	Science, talk, basketball practice		30			30	60
4:00 p.m.	Basketball practice				20	40	60
5:00 p.m.	Walk home, chores, talk		15	45			60
6:00 p.m.	Eat, do dishes, talk		45	15			60
7:00 p.m.	Homework		60				60
8:00 p.m.	TV, phone		60				60
9:00 p.m.	TV, phone, go to bed	30	30				60
10:00 p.m.	Sleep	60					60
11:00 p.m.	Sleep	60					60
Midnight	Sleep	60					60
1:00 a.m.	Sleep	60					60
2:00 a.m.	Sleep	60					60
3:00 a.m.	Sleep	60					60
4:00 a.m.	Sleep	60					60
Total minutes		**570**	**565**	**170**	**65**	**70**	**1,440**

Total Calories Used Per Day at Various Intensity Levels

Name: ______________________________ Date: ____________

Review your school day and weekend day physical activities diaries. **Record the total minutes for each of the five intensity levels** in the tables below. Then, **divide the total minutes by 60** to calculate the number of hours of activity at each intensity level. Record your answer to the nearest 0.1 of an hour. **Multiply the hours of activity by the calories-per-hour factor** provided in the table to determine calories used. **Add the total calories used for each activity level** (bottom row) to estimate the total calories used for the day.

Calories Used on a School Day

Intensity Level	Resting (Sleeping)	Very Light (Sitting Activities)	Light (Walking Activities)	Moderate (Medium-Level Walking/ Running Activities)	Heavy (High-Level Running Activities)	Total calories
Minutes of Activity						
Minutes ÷ 60 = **Hours** of activity						
calories/hour*	**60**	**85**	**140**	**285**	**400**	
Hours × calories/hour = **calories used**						

Calories Used on a Weekend Day

Intensity Level	Resting (Sleeping)	Very Light (Sitting Activities)	Light (Walking Activities)	Moderate (Medium-Level Walking/ Running Activities)	Heavy (High-Level Running Activities)	Total calories
Minutes of Activity						
Minutes ÷ 60 = **Hours** of activity						
calories/hour*	**60**	**85**	**140**	**285**	**400**	
Hours × calories/hour = **calories used**						

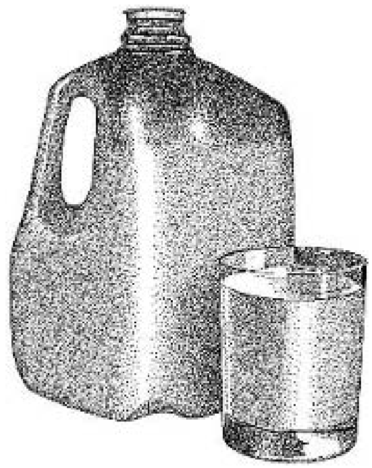
* These energy value factors are age-adjusted, average values for middle school students that include the calories expended for BMR. They provide a rough estimate of energy expenditure for students your age.

How Much Is One Serving?

Name: ______________________ Date: ____________

	Column 1	Column 2	Column 3	Column 4	Column 5
Food	**Food label serving size**	**Amount in MY GROUP'S portion (what you measured)**	**Number of food label servings in our portion (divide column 2 by column 1)**	**Calories per food label serving**	**Calories in OUR portion (multiply column 3 and column 4)**
Dry cereal					
Juice					
Hamburger patty					
Cheddar cheese					
Milk					

Serving Sizes for Various Beverages

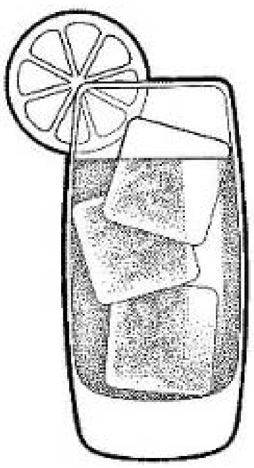


Milk

Serving size = 1 cup (8 fluid oz.)

Calories per serving:

Nonfat	= 85 calories
1%	= 118 calories
2%	= 137 calories
Whole	= 156 calories



Fruit Juice

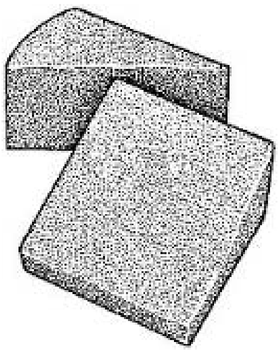
Serving size = 1 cup (8 fluid oz.)

Calories per serving:

Apple juice	= 116 calories
Grapefruit juice	= 93 calories
Orange juice	= 110 calories

Cheese and Hamburger Food Labels

Cheddar Cheese



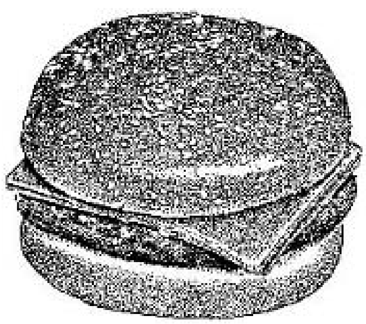
Extra Sharp Cheddar Cheese

Nutrition Facts
Serv. Size 1 oz (28g)
Servings varied
Calories 120
Fat Cal. 90
*Percent Daily Values (DV) are based on a 2,000 calorie diet.

Amount/serving	% DV*	Amount/serving	% DV*
Total Fat 10g	15%	**Total Carb.** 1g	0%
Sat. Fat 6g	31%	Fiber 0g	0%
Cholest. 40mg	13%	Sugars 0g	
Sodium 170mg	7%	**Protein** 7g	

Vitamin A 6% • Vitamin C 0% • Calcium 20% • Iron 0%

Hamburger—Just the Cooked Beef



100% PURE

GROUND BEEF

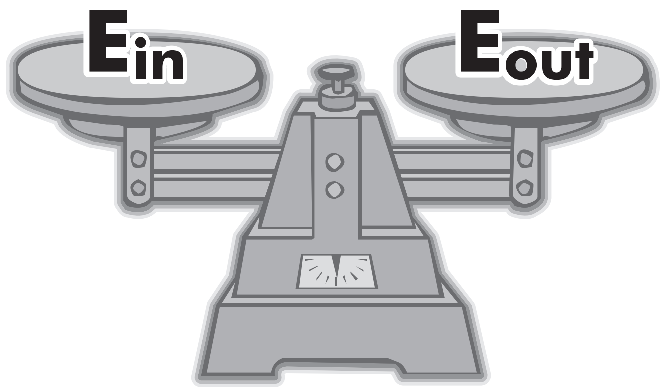
85/15

Nutrition Facts
Serving Size 4 oz. (112 g)
Servings Per Container: Varied
Calories 240
Fat Cal. 150
*Percent Daily Values (DV) are based on a 2,000 calorie diet.

Amount Per Serving	% DV*	Amount Per Serving	% DV*
Total Fat 17g	25%	**Total Carb.** 0g	0%
Sat. Fat 7g	33%	Dietary Fiber 0g	0%
Cholest. 75mg	25%	Sugars 0g	
Sodium 55mg	2%	**Protein** 22g	

Vitamin A 0% • Vitamin C 0% • Calcium 0% • Iron 10%

The Energy Balance Equation



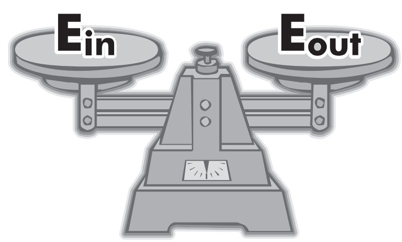
Energy Balance Equation: $E_{in} = E_{out}$

For adults, $E_{in} = E_{out}$ means there is no weight gain or weight loss.

For children, adolescents, and teenagers:

The Memo

Energy Balance Clinic



MEMORANDUM

TO: Clinic Staff

FROM: Dr. Chu

SUBJECT: Help

Dear Clinic Staff,

I'm learning a lot at the Energy Balance Conference, where I presented our paper on "Energy Balance in Adolescents." It was a great success. In fact, a teacher in the audience asked me to talk to her middle school class tomorrow. What a great opportunity to discuss this important topic with those for whom it matters most!

Unfortunately, I have five patients scheduled for evaluation tomorrow. I need you to see them for me. You will find their files at the clinic office. The patients have completed food and activity diaries for a typical day. Please use your expertise to analyze their energy balance. If you have any questions, consult the *Energy Balance Reference Manual* in the library.

Thanks so much. You're great members of our team!

Sincerely,

Dr. Chu

P.S. By the way, you will have to present your analyses and recommendations to the clinic's review board. We need their approval before we meet again with the patients.

Calculating $Energy_{in}$ and $Energy_{out}$

Name: ____ Date: ____________________

Place the appropriate numbers in the calculator boxes and then calculate your patient's total $Energy_{in}$ and total $Energy_{out}$.

Daily Energy Intake Calculator

	Grams		calories/gram		Total
Total Carbohydrates		x		=	
Total Fat		x		=	
Total Protein		x		=	
Calculate			Total calories		

$Energy_{in}$

Daily Activity Calculator

	Hours		calories/hour		Total
Resting		x		=	
Very Light		x		=	
Light		x		=	
Moderate		x		=	
Heavy		x		=	
Calculate			Total calories		

$Energy_{out}$

Patient Notes

Team: ______________________________ Date: ____________

ENERGY BALANCE CLINIC

PATIENT NOTES

Patient's name ____________________

Patient's question ____

Summary of Analysis

Total calories consumed (E_{in}):

Total calories used (E_{out}):

Explanation

How would you answer the patient's question? Explain.

What is the appropriate energy balance for the patient? Should the patient be gaining weight, losing weight, or maintaining the same weight? Explain.

Recommendations

What recommendations do you have for the patient about his/her food consumption and physical activities?

Why would following the above recommendations lead to the appropriate energy balance for the patient?

Evaluating Energy Balance Review Board Presentations

Criterion	Score		
	2	**1**	**0**
Explanation	The patient's question was answered clearly and completely, using appropriate visual aids.	The patient's question was not answered clearly *or* was partially answered *or* was inappropriate *or* no visual aids were used.	The patient's question was not answered and was inappropriate *or* no visual aids were used.
Recommendations	Appropriate recommendations were offered to help the patient attain a healthy energy balance.	Recommendations were offered to help the patient attain a healthy energy balance, but not all were appropriate.	No recommendations were offered to help the patient attain a healthy energy balance.
Team effort	All team members participated in developing the presentation.	Most team members participated in developing the presentation.	One or two team members did most of the work in developing the presentation.
Participation as board member	One or more team members asked appropriate questions about two or more of the other presentations.	One or more team members asked appropriate questions about one of the other presentations.	No team members asked questions about any of the other presentations *or* only inappropriate questions were asked about other presentations.

Ashley's Patient File

Am I going to get fat?

I always ate as much as I wanted and never worried about my weight. I love my summer job giving tours at the art museum, and I keep busy doing other things I like—drawing, dancing, just being with my friends. But now all my friends are worried about getting fat, and they told me that one of these days I'll understand why they're concerned. Sure enough, I've gained 3 pounds this summer! Am I going to get fat?

Official Patient Record — Confidential

Patient name Ashley V.

Age 13 **(years)** 1 **(month)** **Sex** X **female** ____ **male**

Height 61 **(in.)** **Weight** 103 **(lbs.)** 5 **(oz.)**

Referring physician Dr. Keller

Referral information:

Ashley was referred to the clinic by her family doctor, Dr. Keller. He noted that Ashley weighed 100 pounds at the end of the school year. He told Ashley and her parents that her weight and summer weight gain were acceptable for a female of her age and height. He felt that an analysis of her energy balance state at the clinic might provide reassurance to Ashley and her parents that her weight gain is normal.

Initial clinic visit:

Dr. Chu met with Ashley and her father on August 10. He asked Ashley to keep track of her food consumption and physical activities and record a typical day on our Food and Physical Activities forms. He requested that Ashley return the forms to clinic staff for evaluation before her next appointment.

Ashley's Patient File

Patient Name Ashley V.

Food Diary

Meal and Food	Carbohydrates (g)	Fat (g)	Protein (g)
Breakfast			
Light cream cheese (2 tbsp.)	1.8	4.7	2.9
Plain bagel, toasted	30.5	0.9	6.0
Orange juice (8 fluid oz.)	25.5	0.1	1.6
Breakfast total	**57.8**	**5.7**	**10.5**
Lunch			
1% milk (8 fluid oz.)	11.3	2.5	7.7
American cheese (1 oz.)	0.5	8.9	6.3
Ham (1 oz.)	0.0	2.6	6.4
Wheat bread (2 slices)	23.6	2.0	4.6
Peanut butter (1½ tbsp.)	3.8	12.4	6.9
Celery (3 sticks)	0.7	0.0	0.1
Lunch total	**39.9**	**28.4**	**32.0**
Dinner			
Sirloin steak (5 oz.)	0.0	9.6	43.0
Tossed green salad (2 cups)	3.1	0.3	1.5
Blue cheese dressing (2 tbsp.)	1.7	11.6	1.9
Baked potato, with skin	50.9	0.2	4.4
Light sour cream (2 tbsp.)	1.3	3.6	0.9
Strawberries (1/2 cup)	5.3	0.3	0.5
Pound cake (1 piece)	33.7	17.5	3.6
Light whipped cream (1/2 cup)	1.8	18.4	1.3
Dinner total	**97.8**	**61.5**	**57.1**
Snacks			
Popcorn, with oil and salt (4 cups)	25.2	12.4	4.0
Butter (1 tsp.)	0.0	3.8	0.0
Snack total	**25.2**	**16.2**	**4.0**

Physical Activity Diary

Intensity Level and Activity	Hours	Intensity Level and Activity	Hours
Resting		**Light**	
sleeping	9.0	doing household chores	1.0
Very light		conducting tours	2.0
eating and bathing	4.0	**Moderate**	
watching television	2.0	dancing (practice)	1.0
attending art class	3.0	**Heavy**	
talking on the telephone	1.0	(none)	0.0
reading	1.0		

Emily's Patient File

Am I gaining too much weight?

My doctor thinks I've gained too much weight this summer. I *have* gained weight, but I don't think it's that big a deal. My family just has big people—it's in our genes. My mom said she weighed more than I do at my age, so I think I'm fine. It's natural for me to be gaining weight now.

Official Patient Record — Confidential

Patient name Emily G.

Age 13 **(years)** 6 **(months)** **Sex** X **female** ____ **male**

Height 62 **(in.)** **Weight** 125 **(lbs.)** 2 **(oz.)**

Referring physician Dr. Russo

Referral information:

Emily was referred to the clinic by the family's doctor, Dr. Russo. Dr. Russo noted that Emily has gained 11 pounds over the summer. She recommends an energy balance evaluation for Emily. If necessary, perhaps the clinic staff can explain to Emily the health risks of being overweight, and give her advice about making changes in her diet and exercise so that she can avoid becoming overweight.

Initial clinic visit:

Dr. Chu met with Emily and her mother on August 3. He noted that both Emily and her mother commented that the visit was unnecessary because Emily "is perfectly healthy." He asked Emily to keep track of her food consumption and physical activities and record a typical day on our Food and Physical Activity forms. He asked that Emily return the forms to clinic staff for evaluation before her next appointment. Emily reluctantly agreed.

Emily's Patient File

Patient Name Emily G.

Food Diary

Meal and Food	Carbohydrates (g)	Fat (g)	Protein (g)
Breakfast			
Refried beans (1/2 cup)	24.2	9.0	8.1
Shredded cheddar cheese (1 oz.)	0.4	9.4	7.1
Flour tortilla (1)	27.2	3.5	4.3
Soda, cola (12 fluid oz.)	36.9	0.0	0.0
Breakfast total	**88.7**	**21.9**	**19.5**
Lunch			
Spaghetti (1½ cups)	59.5	1.4	10.0
Meatless spaghetti sauce (3/4 cup)	13.8	3.9	2.8
Ground beef (2 oz.)	0.0	10.4	13.6
Tossed green salad (2 cups)	3.1	0.3	1.5
Thousand Island dressing (4 tbsp.)	9.8	20.3	0.8
Soda, cola (12 fluid oz.)	36.9	0.0	0.0
Lunch total	**123.1**	**36.3**	**28.7**
Snacks			
Chocolate chip cookies (4)	24.7	11.7	2.2
Soda, cola (12 fluid oz.)	36.9	0.0	0.0
Snack total	**61.6**	**11.7**	**2.2**
Dinner			
Beef, bean, and cheese burrito (2 burritos)	39.7	13.3	14.6
Chopped tomatoes (1/8 cup)	0.8	0.1	0.2
Spanish rice (1/2 cup)	21.3	0.1	2.8
Soda, cola (12 fluid oz.)	36.9	0.0	0.0
Dinner total	**98.7**	**13.5**	**17.6**

Physical Activity Diary

Intensity Level and Activity	Hours
Resting	
sleeping	7.0
Very light	
watching television	4.0
cooking	1.0
visiting friends	2.0
reading	1.0
browsing the Internet	2.0
eating and bathing	4.0
Light	
doing household chores	1.0
shopping	2.0
Moderate	
(none)	1.0
Heavy	
(none)	0.0

Enrique's Patient File

Why am I losing weight?

I've been working out all summer. I need to build up my muscles for swimming and basketball. I eat well and I exercise, so I should be building muscle, right? But I've *lost* more than 5 pounds this summer! And on top of that, I'm tired all the time, so now I don't feel like I can work out any more. What's wrong with me? Am I sick or something?

Official Patient Record — Confidential

Patient name Enrique S.

Age 13 **(years)** 4 **(months)** | **Sex** ___ **female** X **male**

Height 62 **(in.)** | **Weight** 92 **(lbs.)** 3 **(oz.)**

Referring physician Dr. Phillips

Referral information:

Enrique was referred to the Clinic by his primary care physician, Dr. Phillips. Dr. Phillips noted that Enrique weighed 100 pounds at the end of the school year. He is concerned about Enrique's weight loss, but the tests he ran did not indicate any infections or other diseases. He would like the Clinic to evaluate Enrique's energy balance to see if that can explain his weight loss and fatigue.

Initial clinic visit:

Dr. Chu met with Enrique and his father on August 9. He asked Enrique to keep track of his food consumption and physical activities for the next week and record a typical day on our Food and Physical Activity forms. He asked Enrique to return the forms to clinic staff for evaluation before his next appointment.

Enrique's Patient File

Patient Name Enrique S.

Food Diary

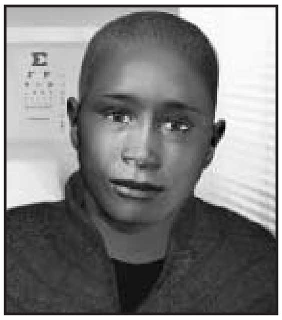
Meal and Food	Carbohydrates (g)	Fat (g)	Protein (g)
Breakfast			
2% milk (8 fluid oz.)	11.4	4.5	7.9
Apple-cinnamon Pop Tart	37.5	5.3	2.3
Breakfast total	**48.9**	**9.8**	**10.2**
Lunch			
2% milk (16 fluid oz.)	22.7	9.0	15.7
Peanut butter (2 tbsp.)	5.1	16.5	9.2
Jelly (1 tbsp.)	13.2	0.0	0.0
White bread (2 slices)	24.8	1.8	4.1
Pear	25.1	0.7	0.6
Chocolate cookies (3)	28.2	10.2	3.0
Lunch total	**119.1**	**38.2**	**32.6**
Dinner			
2% milk (12 fluid oz.)	17.0	6.8	17.0
Lasagna (6 oz.)	30.2	13.6	26.3
Garlic bread (2 slices)	29.5	8.7	5.0
Green beans (1 cup)	6.1	0.1	1.5
Dinner total	**82.8**	**29.2**	**49.8**
Snacks			
Banana	27.6	0.6	1.2
Sports drink (32 fluid oz.)	56.0	0.0	0.0
Fruit rolls (2)	47.8	1.7	0.6
Fruit punch (12 fluid oz.)	41.6	0.0	0.0
2% milk (8 fluid oz.)	11.4	4.5	7.9
Snack total	**184.4**	**6.8**	**9.7**

Physical Activity Diary

Intensity Level and Activity	Hours
Resting	
sleeping	10.0
Very light	
watching television	2.0
playing computer games	1.0
browsing Internet	1.0
listening to music	1.0
eating and bathing	3.0

Intensity Level and Activity	Hours
Light	
doing household chores	0.5
Moderate	
mowing lawn	1.0
bicycling	1.5
Heavy	
swimming (practice)	2.0
playing basketball	1.0

Jerome's Patient File



Why am I gaining weight?

I've gained more than 20 pounds this summer! I can't figure out why. I don't eat that much. Lots of my friends eat five or six different things at one meal, but I only have one or two foods. I keep busy with my computer hobbies and visiting my friends. And I usually walk to my friends' homes. What's going on? I must have a gland problem.

Official Patient Record — Confidential

Patient name Jerome J.

Age 13 **(years)** 8 **(months)**   **Sex** ____ **female** X **male**

Height 62 **(in.)**   **Weight** 134 **(lbs.)** 2 **(oz.)**

Referring physician Dr. Washington

Referral information:

Jerome was referred to the clinic by the family physician, Dr. Washington. Dr. Washington noted that Jerome weighed 110 pounds at the end of the school year. She is quite concerned about Jerome's weight gain and requested that the clinic staff evaluate Jerome's energy balance.

Initial clinic visit:

Dr. Chu met with Jerome and his mother on August 11. He asked Jerome to keep track of his food consumption and physical activities for the next week and record a typical day on our Food and Physical Activity forms. He asked Jerome to return the forms to clinic staff for evaluation before his next appointment.

Jerome's Patient File

Patient Name Jerome J.

Food Diary

Meal and Food	Carbohydrates (g)	Fat (g)	Protein (g)
Breakfast			
2% milk (8 fluid oz.)	11.4	4.5	7.9
Sugar Smacks cereal	63.1	1.4	4.7
Breakfast total	**74.5**	**5.9**	**12.6**
Lunch			
Meat and cheese pizza (4 slices)	79.5	27.8	40.5
Lunch total	**79.5**	**27.8**	**40.5**
Dinner			
Fast food double hamburger	42.9	27.9	29.9
Super-size French fries	77.0	29.0	9.0
Cola drink (12 fluid oz.)	36.9	0.0	0.0
Dinner total	**156.8**	**56.9**	**38.9**
Snacks			
Cola drink (12 fluid oz.)	36.9	0.0	0.0
Popcorn, with oil & salt (5 cups)	31.5	15.5	4.9
Butter (1 tsp.)	0.0	3.8	0.0
Snack total	**68.4**	**19.3**	**4.9**

Physical Activity Diary

Intensity Level and Activity	Hours
Resting	
sleeping	10.0
Very light	
watching television	4.0
playing computer games	3.0
browsing Internet	2.0
eating and bathing	3.0

Intensity Level and Activity	Hours
Light	
doing household chores	0.5
walking the dog	1.0
walking to friends' homes	0.5
Moderate	
(none)	0.0
Heavy	
(none)	0.0

Kim's Patient File

Why can't I lose weight?

I'm going to be a cheerleader next year, and you know what those cheerleading outfits are like. Mine is already a little tight, so I need to lose weight. I've been careful all summer not to overeat. I hardly ever have dessert and I only snack on carrots and reduced-calorie treats. But I haven't lost a *single* pound! It doesn't help that my mom keeps trying to fatten me up. She wants me to *gain* weight. Can you believe it?!

Official Patient Record — Confidential

Patient name Kim R.

Age 12 **(years)** 3 **(months)** **Sex** X **female** ______ **male**

Height 58 **(in.)** **Weight** 99 **(lbs.)** 12 **(oz.)**

Referring physician Dr. Abrams

Referral information:

Kim was referred to the clinic by her pediatrician, Dr. Abrams. Dr. Abrams noted that Kim began and ended the summer at the same weight, 100 pounds. She expressed concern about Kim's aversion to food and also noted a growing conflict between Kim and her mother regarding food issues.

Initial clinic visit:

Dr. Chu met with Kim and her mother on August 12. He asked Kim to keep track of her food consumption and physical activities and record a typical day on our Food and Physical Activity forms. He asked Kim to return them to clinic staff for evaluation before her next appointment.

Kim's Patient File

Patient Name Kim R.

Food Diary

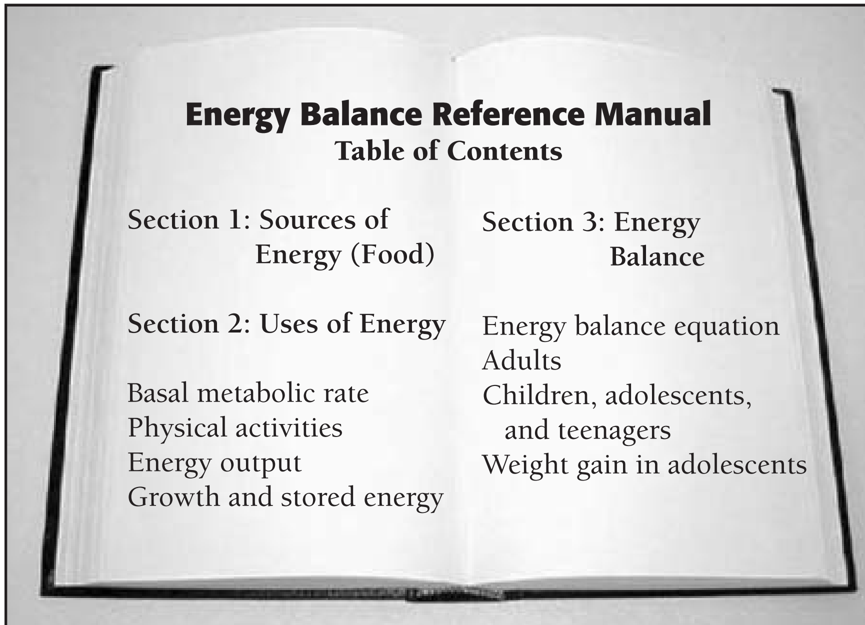
Meal and Food	Carbohydrates (g)	Fat (g)	Protein (g)
Breakfast			
Orange juice (8 fluid oz.)	25.5	0.1	1.6
Breakfast total	**25.5**	**0.1**	**1.6**
Lunch			
Creamy Italian dressing (4 tbsp.)	4.9	21.1	0.2
Shredded cheddar cheese (2 oz.)	0.7	18.8	14.1
Hard-cooked egg (1)	0.6	5.3	6.3
Tossed green salad (2 cups)	3.1	0.3	1.5
Seasoned croutons (1 oz.)	18.0	5.2	3.1
Lemonade (12 fluid oz.)	39.0	0.0	0.4
Lunch total	**66.3**	**50.7**	**25.6**
Snack			
Raw baby carrots (12)	9.8	0.6	1.0
Diet cola (20 fluid oz.)	0.6	0.0	0.6
Snack total	**10.4**	**0.6**	**1.6**
Dinner			
Chicken breast (8 oz.)	0.0	8.1	70.4
Green peas (1 cup)	21.4	0.6	7.5
Raw tomato (1/2)	2.9	0.2	0.5
Corn on the cob (1 ear)	19.3	1.0	2.6
White rice (1 cup)	44.5	0.4	4.3
Lemonade (16 fluid oz.)	52.1	0.0	0.5
Dinner total	**140.2**	**10.3**	**85.8**
Snacks			
Sherbet (1 cup)	45.0	3.0	1.6
Frozen yogurt ($1\frac{1}{2}$ cups)	53.8	13.0	8.6
Snack total	**98.8**	**16.0**	**10.2**

Physical Activity Diary

Intensity Level and Activity	Hours
Resting	
sleeping	8.0
Very light	
watching television	2.0
talking on the telephone	2.0
doing e-mail	1.0
reading	1.0
listening to music	2.0
eating and bathing	4.0

Intensity Level and Activity	Hours
Light	
doing household chores	0.5
Moderate	
playing tennis	1.0
cheerleading (practice)	2.5
Heavy	
(none)	0.0

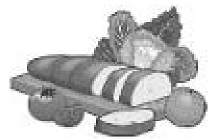
Energy Balance Reference Manual



Section 1: Sources of Energy (Food)

The human body uses food as a source of energy and for raw materials to maintain the body and produce new body tissues. The major nutrients in food are carbohydrates, fats, and proteins. The energy from these nutrients is represented as E_{in}.

E_{in} = energy from food consumed



Carbohydrates are the major source of energy for the body.

1 g carbohydrate = 4 calories

Fats are important for energy storage.

1 g fat = 9 calories

Proteins are used to build new body tissues, but they also can be energy sources.

1 g protein = 4 calories

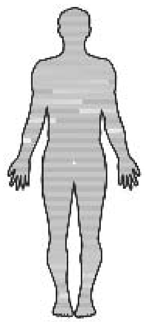
Section 2: Uses of Energy

Basal Metabolic Rate

Basal metabolic rate, or BMR, represents the energy used to carry out necessary body activities such as breathing, regulating body temperature, and maintaining a heart beat. The majority of daily energy output, 60 to 70 percent, is used for these activities.

BMR varies among individuals:

- Age: younger people have higher BMR
- Growth: children and pregnant women have higher BMR
- Height: tall, thin people have higher BMR
- Body composition: people with more lean tissue have higher BMR

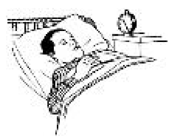


BMR varies across time for an individual:

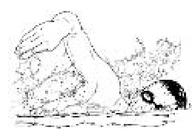
- Fever: fever increases BMR
- Stress: phyical stress increases BMR
- Temperature: hot and cold weather raises BMR
- Fasting: drastic dieting lowers BMR

Physical Activities

For most people, physical activities account for about 20 to 30 percent of the body's total energy output. The number of calories used for an activity varies with a person's age, weight, and gender. The total number of calories used for an activity depends on the intensity level and duration of the activity.



Activity Level	Calories/Hour
Resting sleeping, lying quietly	60
Very Light watching television, eating	85
Light walking, doing household chores	140
Moderate bicycling, dancing (practice)	285
Heavy swimming (practice), playing basketball, walking fast (5 mph)	400



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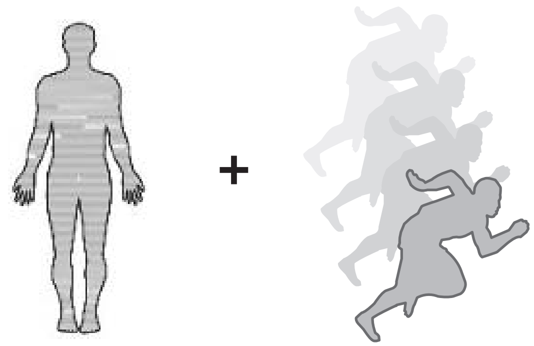
Energy Output

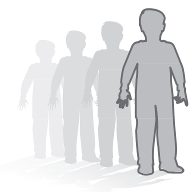
The energy used for basal metabolic rate and physical activities is represented by E_{out}.

E_{out} = energy used for BMR + energy used for activities



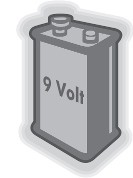
Growth and Stored Energy

In addition to BMR and physical activities, the bodies of growing children, adolescents, and teenagers use energy to produce new body tissues such as bone, muscle, and blood. This energy is represented by E_{growth}.



E_{growth} = energy used to produce new body tissues

Young people's bodies also store energy in the form of fat as a normal part of development. This stored energy, represented by E_{stored}, may be used later for growth. It takes 3,500 calories to make 1 pound of stored fat.



E_{stored} = energy stored as fat

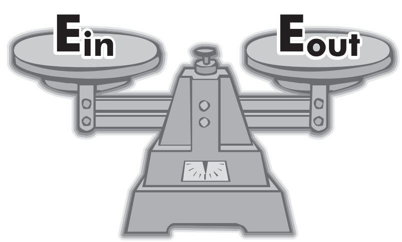
Section 3: Energy Balance

The Energy Balance Equation

$E_{in} = E_{out}$

The energy balance equation shows the relationship between energy input (E_{in}) and energy output (E_{out}). Energy balance is determined over long periods of time (months or years), not over short periods of time (days).

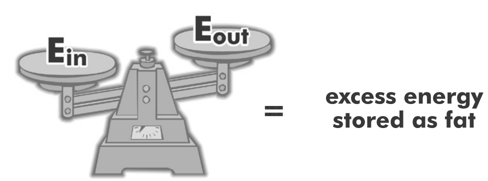
Energy input and output are expressed in calories.

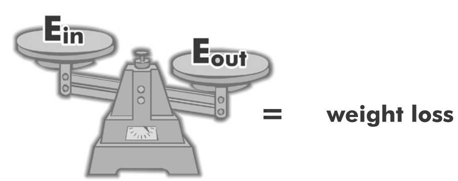


Adults

Adults who, over time, consume the same number of calories in food that they expend in BMR and physical activities are in energy balance: $E_{in} = E_{out}$. They maintain a constant body weight.

Adults who consistently consume more calories than they expend are in positive energy balance: $E_{in} > E_{out}$. They gain weight.



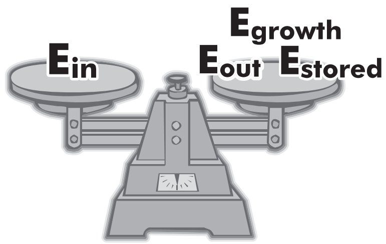


Adults who consistently expend more calories than they consume are in negative energy balance: $E_{in} < E_{out}$. They lose weight.

Energy Balance Reference Manual

Children and Adolescents

To grow properly and maintain a healthy state, children, adolescents, and teenagers must be in positive energy balance: $E_{in} > E_{out}$. They need to consume more calories than needed for BMR and physical activities (E_{out}). The extra calories they consume are used for increasing the amount of important body tissues such as bone, muscle, and blood (E_{growth}). Extra calories may also be stored as fat (E_{stored}).



For healthy children and adolescents, the energy balance equation is $E_{in} = E_{out} + E_{growth} + E_{stored}$.

Weight Gain in Adolescents

Adolescence is a time of rapid growth and development. Extra energy is required and weight is gained. Normal weight gain varies with age, gender, weight, and height.

A 12-year-old girl is expected to gain 8 to 13 pounds over the next year. Normal average weight gain is 10 pounds.

A 12-year-old boy is expected to gain 8 to 15 pounds over the next year. Normal average weight gain is 11 pounds.

A 13-year-old girl is expected to gain 7 to 11 pounds over the next year. Normal average weight gain is 7 pounds.

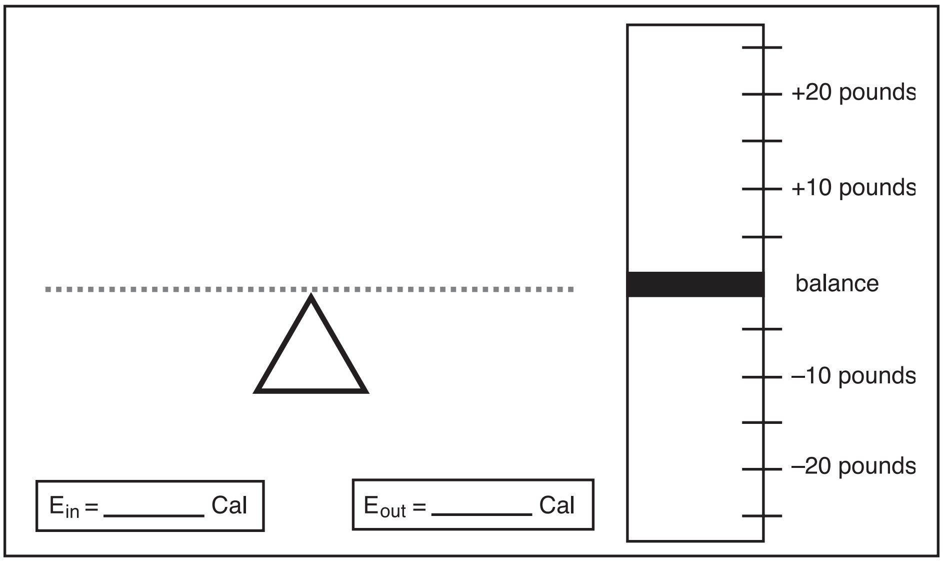
A 13-year-old boy is expected to gain 9 to 14 pounds over the next year. Normal average weight gain is 12 pounds.

Growth occurs in spurts. Young teens and pre-teens may gain several pounds in one month and none at all the next month. This is normal. Nutritionists consider weight gain over longer periods of time to evaluate whether the amount of weight gain is too little or too much.

Energy Balance Diagram

Team: ____ Date: __________________

______________________________ **'s Energy Balance**
(patient's name)



Directions:

1. Write in the number of calories consumed in food (E_{in}) and the number of calories expended in BMR and physical activities (E_{out}) on the appropriate blanks in the diagram.

2. Calculate the expected pounds gained or lost during the summer using the formula below.*

$$\frac{(E_{in} - E_{out}) \times 84}{3{,}500}$$

3. Draw in the balance so that it tilts upward or downward toward the appropriate number of pounds on the scale, as you determined from the calculation in Step 2.

4. Draw a box on the left side of the balance that represents the total number of calories consumed in food. Draw a box on the right side of the balance that represents the total number of calories used in BMR and physical activities. (If the same number of calories was consumed and used, the boxes should be the same size; if more calories were consumed than used, the box on the left side should be larger; and if more calories were used than consumed, the box on the right side should be larger.)

---

* This formula is based on 84 days in the summer and 3,500 calories per pound of stored fat tissue. A negative number indicates the number of pounds lost, and a positive number indicates the number of pounds gained.

Award to Study Factors Affecting Energy Balance

Energy Balance Institute

Memorandum

FOR IMMEDIATE RELEASE

TO: Research Scientists
FROM: Director of Research
RE: Research Award

Congratulations everyone! We recently received an award from the National Calorie Council to investigate important questions about factors that affect energy balance. We will use mice as our experimental model and measure weight change as an indication of energy balance in the mice. Our three research questions are

1. Does genetics have an effect on weight gain in healthy infant mice?
2. Does the amount of food available affect weight gain in juvenile mice?
3. Does exercise in adult mice affect weight gain or loss?

Our institute received this award because of our earlier studies of energy balance in adolescents. The results of those studies give us something to build on as we explore this new area.

This research is very important to our understanding of basic relationships that may affect an individual's energy balance. Your hard work is greatly appreciated. I look forward to hearing about your results.

Memo to the Director on Research Question 1

E_{in} E_{out}

Energy Balance Institute

Memorandum

TO: Director of Research
FROM: Research Team # ___________
RE: Analysis of Results from Experiment 1

Below, we describe the experiment to answer Research Question 1, our analysis of the results, and our conclusions.

Research question — Does genetics have an effect on weight gain in healthy infant mice?

Our hypothesis — Genetics does not affect weight gain in healthy infant mice.

Experiment — Our laboratory technician selected 10 newborn mice from Strain A and 10 newborn mice from Strain B. He weighed the mice weekly for eight weeks.

Note: We directed the lab technician to use 10 mice from each strain because ____________________

____

Results and data analysis — See attached graph.

Conclusions — Our hypothesis was SUPPORTED or NOT SUPPORTED (circle one).

Ways that weight gain in the two strains of mice were similar: ____________________

____

Ways that weight gain in the two strains of mice were different: ____________________

____

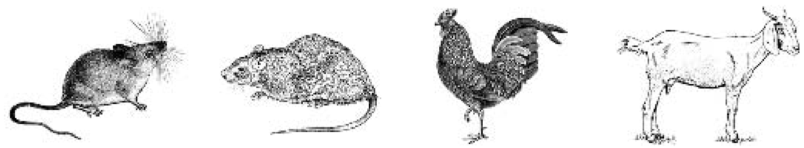
Our conclusion about energy balance from this experiment is that ____________________

____

Reference Manual for Scientific Research

Animal Models

Experiments that involve laboratory animal models are very important for increasing our understanding of conditions that affect humans. Animals that have been used as models systems include mice, rats, chickens, and goats. Animals are good models for humans because there are no basic differences between their physiology and human physiology: they all control their internal functions in about the same way and respond similarly to infections and injuries.



Using animal models for research is usually less expensive and less time-consuming than using humans. Researchers can also control experimental conditions (such as the amount of food or exercise) more easily for animals than for humans. There are fewer ethical concerns when using animals for research studies; however, researchers must follow strict guidelines for ethical treatment of animals.

Mouse Life Spans

Infants
Mice are considered infants from birth to 21 days of age. At that age, they are weaned (prevented from nursing)—their mothers are removed from the cages.

Juveniles
Mice are considered juvenile (young) from 3 weeks to 8 weeks of age.

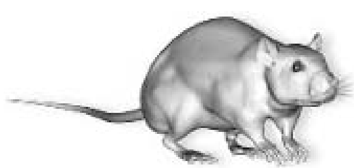
Adults
After 2 months, mice are considered adults. Laboratory mice live about $1\frac{1}{2}$ years.

Mouse Strains

Many different strains of mice are used in laboratory experiments. Each strain is composed of mice that are genetically identical. Researchers select the strain of mouse that is most appropriate for their work. This allows them to control the effect of genes on the results of their experiments.

The Animal Laboratory at the Energy Balance Institute has two strains of mice.

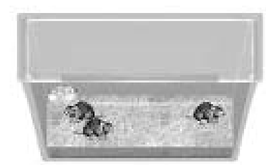
Strain A mice are brown.



Strain B mice are white.

Raising Mice

Cages
Mice are social animals that prefer to be housed together. At the Energy Balance Institute, the number of mice per cage is determined by the size of the mice and the size of the cage.



Food and water
Mouse cages are checked daily. Water is provided in unlimited amounts. Food dishes are kept filled, unless experiment design calls for limiting the amount of food available.

Exercise
Exercise wheels are not placed in mouse cages unless required by experiment design. When present, mice are allowed to use the wheels according to the experiment design.

Reference Manual for Scientific Research

Hypotheses

A hypothesis is a statement that predicts a result. For example:

Mice that have different genes will gain different amounts of weight in the first eight weeks following birth.

Researchers may be able to make the hypothesis more specific. For example, if they know that gene *X* affects weight gain in mice, they might write the following hypothesis:

Mice that have gene X *will gain more weight in the first eight weeks following birth than mice that do not have this gene.*

Experimental Design

Experimental groups, control groups, and growth groups
Researchers identify experimental and control groups of animals based on their hypothesis.

For example, suppose the hypothesis is, Rats that exercise daily will gain less weight than rats that do not exercise.

The **experimental group** would be rats that use an exercise wheel daily. The **control group** would be rats that do not use an exercise wheel, because exercise wheels are not provided for rats under standard laboratory conditions.

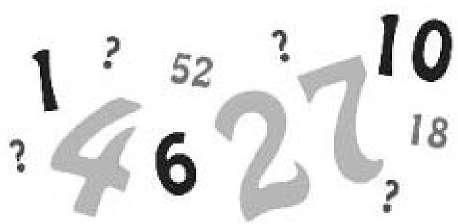
All other **growth conditions** should be the same for the two groups. They should receive the same amount of food and water, and they should be kept in cages of the same size with the same number of rats per cage.

Experimental Design (continued)

Selecting the number of mice
Because the amount of weight gain or loss varies from individual, all experiments conducted at the Energy Balance Institute use experimental and control groups with more than one mouse in each group.

However, raising mice and conducting experiments with them is expensive, so we do not use very large numbers of mice for every experiment.

Researchers at the Energy Balance Institute have decided that using 10 mice per condition is acceptable for our experiments.



Average and Range

Average
Calculate the average by adding all the measured values in a data set and dividing by the number of measures. For example, consider the following data:

Day of the Week	Calories Consumed Per Day
Sunday	3,200
Monday	2,200
Tuesday	2,500
Wednesday	2,400
Thursday	2,700
Friday	2,800
Saturday	3,000
Total	18,800
Average (Total ÷ 7)	**2,686**

The average number of daily calories consumed by this individual is 18,800 ÷ 7 days, or 2,686 calories per day.

The average of a set of measures evens out natural fluctuations, or variations, that often occur when measures are made across time or across individuals. The average provides researchers with an approximation of a “true” value for the measure.

Reference Manual for Scientific Research

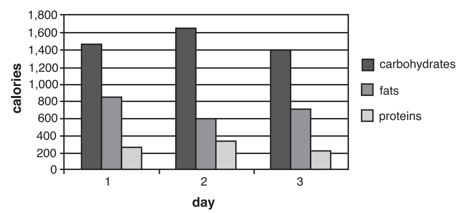
Average and Range (continued)

Range
The range for a data set gives the lowest and the highest value. For the individual in the previous example, calories per day ranged from 2,200 calories to 3,200 calories.

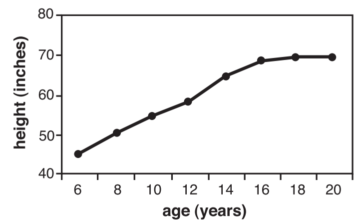
Reporting the range is useful to researchers because it indicates how much variation was observed in the measures.

Graphing Choices

Bar graphs
Bar graphs are used for data that can be sorted into categories. For example, nutrients fall into three categories: carbohydrates, fats, and proteins. A bar graph would compare the number of calories of each nutrient consumed on different days:

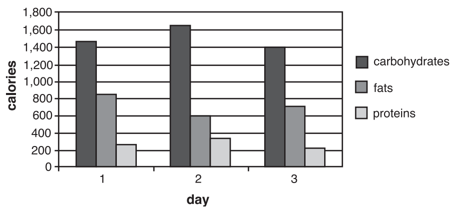


Line graphs
Line graphs are used for data that increase or decrease continuously. For example, an individual's height increases continuously across the first 12 to 20 years of life:

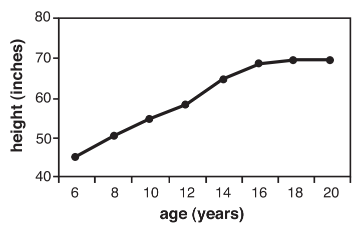


Interpreting Graphs

Graphs provide a picture of the data. Once the researchers have prepared a graph, they can identify trends or patterns in the results of their experiments.



This bar graph shows that the calories from carbohydrates, fats, and proteins vary from day to day for this individual. It also shows that regardless of the day, the majority of the calories come from carbohydrates.



This line graph shows that human height increases throughout childhood and adolescence, and then levels off and remains constant in the adult years.

Drawing Conclusions

Because the hypothesis and experiment are based on the research question, this question must be considered in drawing conclusions. First, ask,

Do the results from the experiment provide an answer for the research question?

If the answer is "No" or "I don't know," the experiment, as it was designed, was probably inappropriate for the question. Think about the question and redesign the experiment.

If the answer is "Yes," ask,

Do the results support the hypothesis?

Whether the answer to this question is "Yes" or "No," there is an answer for the research question. Use the evidence from the experiment to defend that answer.

Weights of Infant Mice from Strains A and B over Time

Weights of Strain A Infant Mice over Time

Mouse	Weight (grams)								
	Week 0*	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
1	1	5	9	17	21	25	29	29	29
2	1	6	9	17	23	27	30	30	30
3	1	7	11	16	21	26	30	30	30
4	1	4	10	14	20	25	30	30	30
5	1	4	9	15	21	24	31	31	31
6	1	4	11	16	19	25	33	33	33
7	1	5	12	17	19	25	32	32	32
8	1	7	9	18	23	23	28	28	28
9	1	4	10	15	23	25	28	28	28
10	1	4	10	15	20	25	29	29	29
Average weight	**1**	**5**	**10**	**16**	**21**	**25**	**30**	**30**	**30**

* The experiment began the day the mice were born. The first week of the experiment was called "Week 0."

Weights of Strain B Infant Mice over Time

Mouse	Weight (grams)								
	Week 0*	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**
1	1	5	13	18	24	30	36	36	36
2	1	6	12	19	24	29	35	35	35
3	1	4	11	19	24	29	36	36	36
4	1	8	13	19	25	30	36	36	36
5	1	6	11	18	23	27	33	33	33
6	1	5	11	21	26	31	35	35	35
7	1	6	13	20	23	28	33	33	33
8	1	7	14	19	24	29	35	35	35
9	1	6	10	18	22	27	35	35	35
10	1	7	12	19	25	30	36	36	36
Average weight	**1**	**6**	**12**	**19**	**24**	**29**	**35**	**35**	**35**

* The experiment began the day the mice were born. The first week of the experiment was called "Week 0."

Graph Paper

Name: ______________________________ Date: ______________

Memo to the Director on Research Question 2

E_{in} E_{out}

Energy Balance Institute

Memorandum

TO: Director of Research
FROM: Research Team # __________
RE: Analysis of Results from Experiment 2

Below, we describe the experiment to answer Research Question 2, our analysis of the results, and our conclusions.

Research question — Does the amount of food available affect weight gain in juvenile mice?

Our hypothesis — ____

____

Experiment — We selected 10 3-week old mice from each in the following two conditions:

______ Limited food, no exercise
______ Limited food, regular exercise
______ Unlimited food, no exercise
______ Unlimited food, regular exercise

We weighed the mice at the beginning of the experiment and weekly thereafter for five consecutive weeks.

Results and data analysis — See attached graph.

Conclusions — Our hypothesis was SUPPORTED or NOT SUPPORTED (circle one).

Ways that unlimited food availability affected weight gain in juvenile mice: ____________________

____

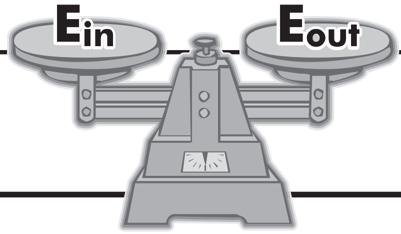
Ways that limited food availability affected the weight gain in juvenile mice: ____________________

____

Our conclusion about energy balance from this experiment is that ____________________

____

Memo to the Director on Research Question 3



Energy Balance Institute

Memorandum

TO: Director of Research
FROM: Research Team # __________
RE: Analysis of Results from Experiment 3

Below, we describe the experiment to answer Research Question 3, our analysis of the results, and our conclusions.

Research question — Does exercise in adult mice affect weight gain or loss?

Our hypothesis — ____

____

Experiment — We selected 10 mice from each in the following two conditions:

______ No exercise, limited food
______ No exercise, unlimited food
______ Regular exercise, limited food
______ Regular exercise, unlimited food

We weighed the mice at the beginning of the experiment and monthly thereafter for five consecutive months.

Results and data analysis — See attached graph.

Conclusions — Our hypothesis was SUPPORTED or NOT SUPPORTED (circle one).

Ways that regular exercise affected weight change in adult mice: ____________________

____

Ways that lack of exercise affected weight change in adult mice: ____________________

____

Our conclusion about energy balance from this experiment is that ____________________

____

Summary of Research Findings

Energy Balance Institute

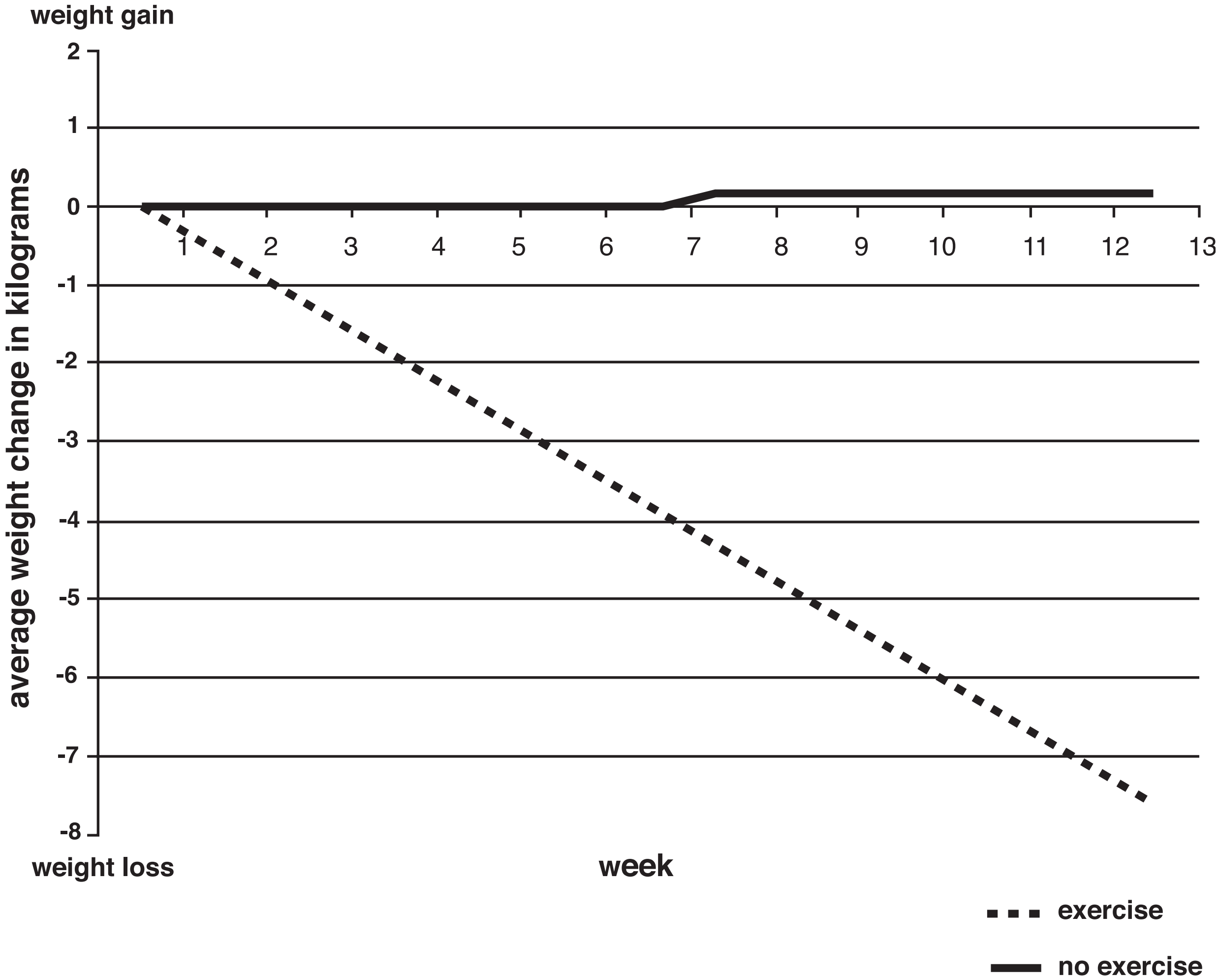
The Research Questions

1. Does genetics have an effect on weight gain in healthy infant mice?

2. Does the amount of food available affect weight gain in juvenile mice?

3. Does exercise in adult mice affect weight gain or loss?

Impact of Exercise on Weight of Overweight Adult Males



Source: Ross, R. et al. 2000. Reduction in obesity and related comorbid conditions after diet-induced weight loss or exercise-induced weight loss in men. *Annals of Internal Medicine, 133*(2): 92-103.

Next Research Assignment

Energy Balance Institute

Memo

TO: Research Scientists
FROM: Director of Research
RE: Next Assignment

Excellent work everyone! Thank you for conducting the experiment and data analysis to answer Research Question 1. Let's move on to the final research questions.

Even-numbered teams, please work on Research Question 2:

2. Does the amount of food available affect weight gain in juvenile mice?

Odd-numbered teams, please work on Research Question 3:

3. Does exercise in adult mice affect weight gain or loss?

Once again, I greatly appreciated your hard work. I look forward to hearing about your next results.

Experimental Design for Research Question 2

Team: ______________________________ Date: ______________

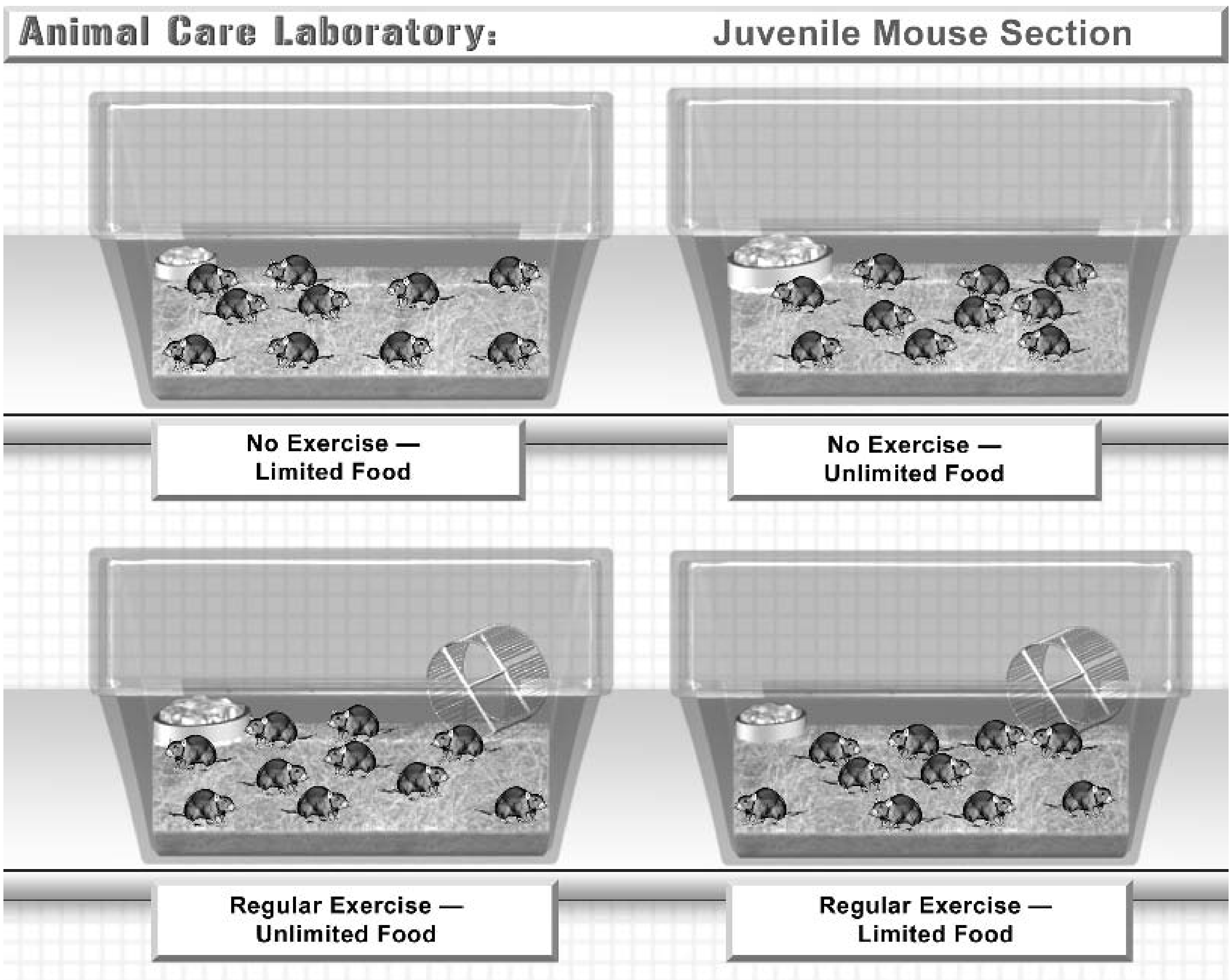
Experimental Design

Question: Does the amount of food available affect weight gain in juvenile mice?

Hypothesis: ____

____

Procedure: Ten three-week-old mice from each of the two groups circled below were selected and raised under the conditions indicated. They were weighed once a week on the same day at the same time for a total of five consecutive weeks.



Experimental Design for Research Question 3

Team: ______________________________ Date: ______________

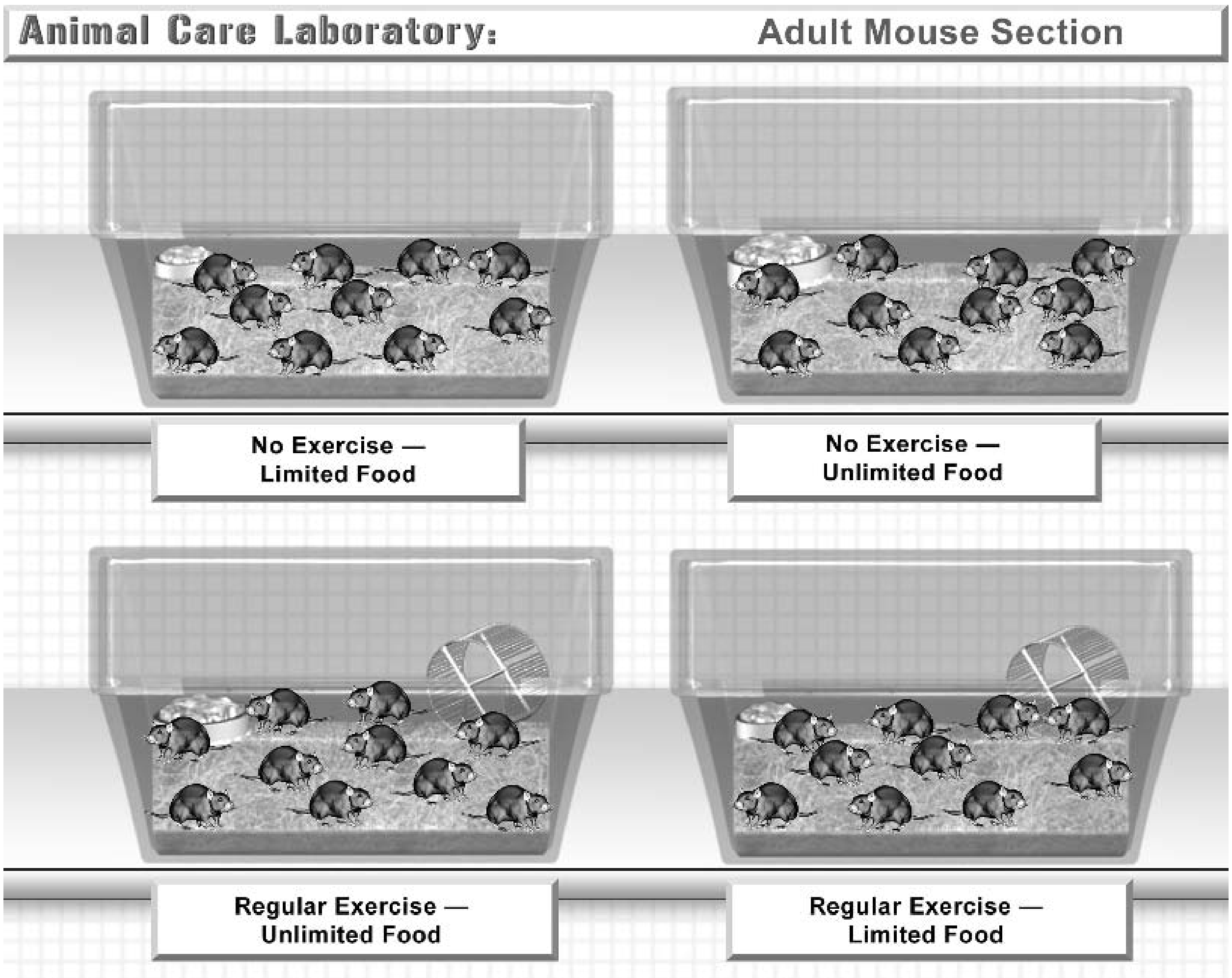
Experimental Design

Question: Does exercise in adult mice affect weight gain or loss?

Hypothesis: ____

____

Procedure: Ten two-month-old mice from each of the two groups circled below were selected and raised under the conditions indicated. They were weighed once a month on the same day at the same time for a total of five consecutive months.



Weights of Juvenile Mice with Limited Food and Regular Exercise over Time

Mouse	Weight (grams)					
	Week 0*	Week 1	Week 2	Week 3	Week 4	Week 5
1	16	20	25	31	31	31
2	16	19	24	30	30	30
3	16	18	23	28	28	28
4	16	19	23	27	27	27
5	19	18	22	26	26	26
6	13	16	22	26	26	26
7	19	16	23	28	28	28
8	13	19	24	29	29	29
9	19	18	23	28	28	28
10	13	17	21	28	28	28
Average weight	**16**	**18**	**23**	**28**	**28**	**28**

* Mice were three weeks old at the beginning of the experiment, which was called "Week 0."

Master 4.13

Weights of Juvenile Mice with Unlimited Food and Regular Exercise over Time

Mouse	Weight (grams)					
	Week 0*	Week 1	Week 2	Week 3	Week 4	Week 5
1	13	23	28	36	36	36
2	13	22	27	36	36	36
3	13	24	29	36	36	36
4	19	26	33	41	41	41
5	19	25	33	40	40	40
6	16	24	30	38	38	38
7	16	24	30	39	39	39
8	13	23	29	37	37	37
9	19	24	30	37	37	37
10	16	25	31	40	40	40
Average weight	**16**	**24**	**30**	**38**	**38**	**38**

* Mice were three weeks old at the beginning of the experiment, which was called "Week 0."

Master 4.14

Weights of Juvenile Mice with Limited Food and No Exercise over Time

Mouse	Weight (grams)					
	Week 0*	Week 1	Week 2	Week 3	Week 4	Week 5
1	17	19	23	30	31	31
2	16	18	24	30	31	31
3	15	18	24	32	33	33
4	14	17	22	29	30	30
5	13	17	22	27	28	28
6	15	18	24	30	31	31
7	18	22	26	32	33	33
8	19	23	27	33	34	34
9	17	20	25	29	30	30
10	16	18	23	28	29	29
Average weight	**16**	**19**	**24**	**30**	**31**	**31**

* Mice were three weeks old at the beginning of the experiment, which was called "Week 0."

Master 4.15

Weights of Juvenile Mice with Unlimited Food and No Exercise over Time

Mouse	Weight (grams)					
	Week 0*	Week 1	Week 2	Week 3	Week 4	Week 5
1	14	24	31	41	41	41
2	15	24	32	39	40	40
3	17	26	35	41	42	42
4	16	26	33	42	42	42
5	18	28	33	42	44	44
6	13	22	28	37	38	38
7	15	25	31	39	40	40
8	16	25	33	37	39	39
9	17	24	31	38	40	40
10	19	26	33	44	44	44
Average weight	**16**	**25**	**32**	**40**	**41**	**41**

* Mice were three weeks old at the beginning of the experiment, which was called "Week 0."

Master 4.16

Weights of Adult Mice with No Exercise and Unlimited Food over Time

Mouse	Weight (grams)					
	Month 0*	Month 1	Month 2	Month 3	Month 4	Month 5
1	30	32	33	35	37	39
2	30	32	33	34	36	38
3	30	34	34	36	38	40
4	30	31	33	33	36	37
5	30	33	33	35	36	38
6	30	31	32	32	34	36
7	30	30	31	33	35	38
8	30	34	35	36	38	39
9	30	30	31	32	34	38
10	30	33	35	35	36	37
Average weight	**30**	**32**	**33**	**34**	**36**	**38**

* Mice were two months old at the beginning of the experiment, which was called "Month 0."

Master 4.17

Weights of Adult Mice with Regular Exercise and Unlimited Food over Time

Mouse	Weight (grams)					
	Month 0*	Month 1	Month 2	Month 3	Month 4	Month 5
1	30	30	29	29	29	29
2	30	29	29	28	27	27
3	30	29	29	28	27	27
4	30	30	30	29	29	29
5	30	29	28	28	28	28
6	30	30	29	29	28	28
7	30	29	28	28	28	28
8	30	30	30	29	29	29
9	30	30	30	29	28	28
10	30	29	28	28	27	27
Average weight	**30**	**30****	**29**	**29****	**28**	**28**

* Mice were two months old at the beginning of the experiment, which was called "Month 0."
** Rounded off to nearest whole number.

Master 4.18

Weights of Adult Mice with No Exercise and Limited Food over Time

Mouse	Weight (grams)					
	Month 0*	Month 1	Month 2	Month 3	Month 4	Month 5
1	30	30	31	32	32	33
2	30	30	31	31	32	32
3	30	30	31	32	33	34
4	30	31	32	32	33	35
5	30	30	30	30	31	31
6	30	29	30	30	31	30
7	30	30	31	32	33	33
8	30	30	29	30	30	31
9	30	30	31	31	33	33
10	30	30	29	30	32	33
Average weight	**30**	**30**	**31****	**31**	**32**	**33****

* Mice were two months old at the beginning of the experiment, which was called "Month 0."
** Rounded off to nearest whole number.

Master 4.19

Weights of Adult Mice with Regular Exercise and Limited Food over Time

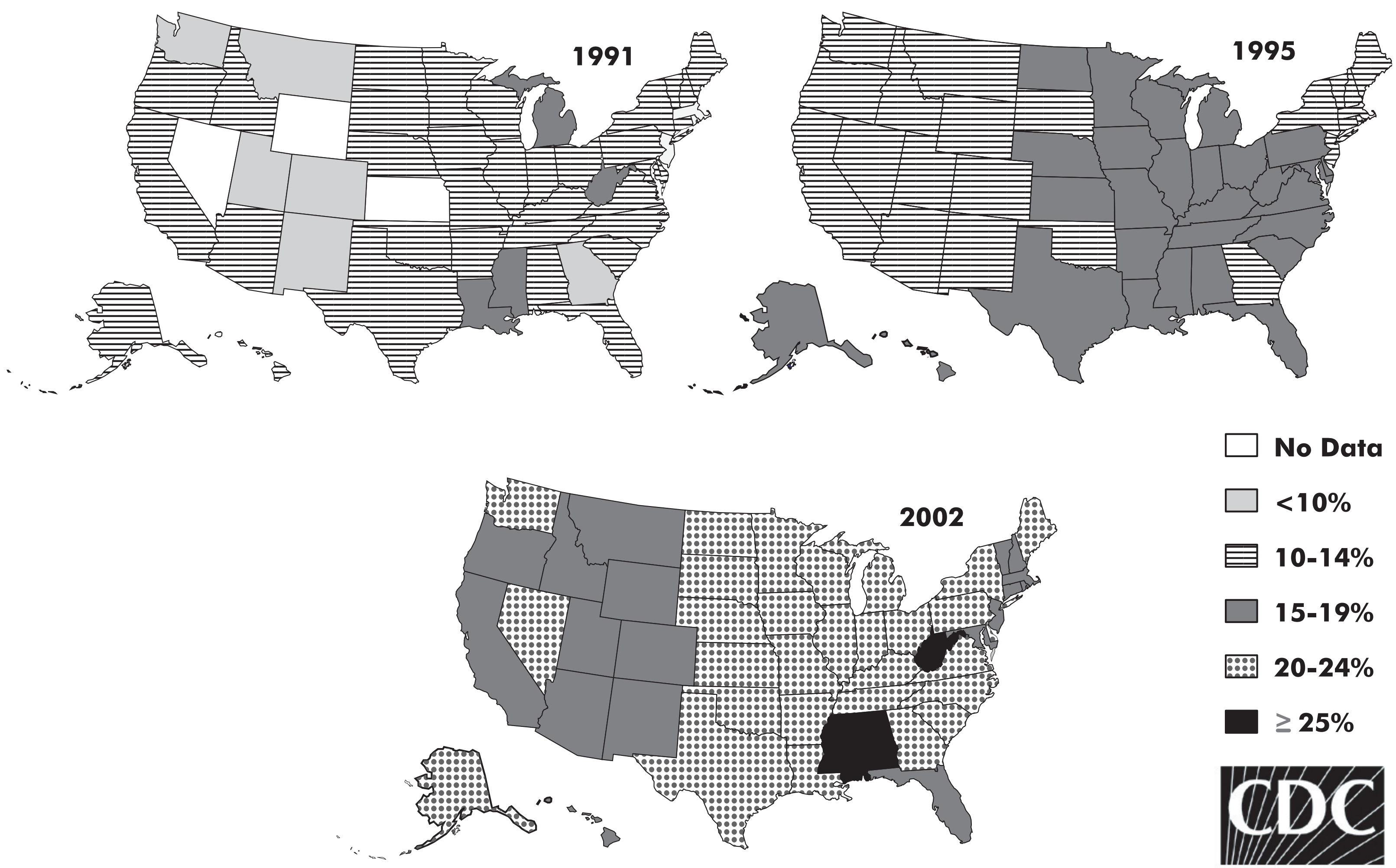
Mouse	Weight (grams)					
	Month 0*	Month 1	Month 2	Month 3	Month 4	Month 5
1	30	29	27	25	23	23
2	30	29	26	25	24	24
3	30	29	28	27	26	25
4	30	30	29	27	25	24
5	30	28	25	24	22	22
6	30	28	26	25	23	22
7	30	29	27	24	23	23
8	30	29	28	27	25	24
9	30	30	30	28	27	27
10	30	29	29	28	27	26
Average weight	**30**	**29**	**28****	**26**	**25****	**24**

* Mice were two months old at the beginning of the experiment, which was called "Month 0."
** Rounded off to nearest whole number.

Master 4.20

Obesity Trends

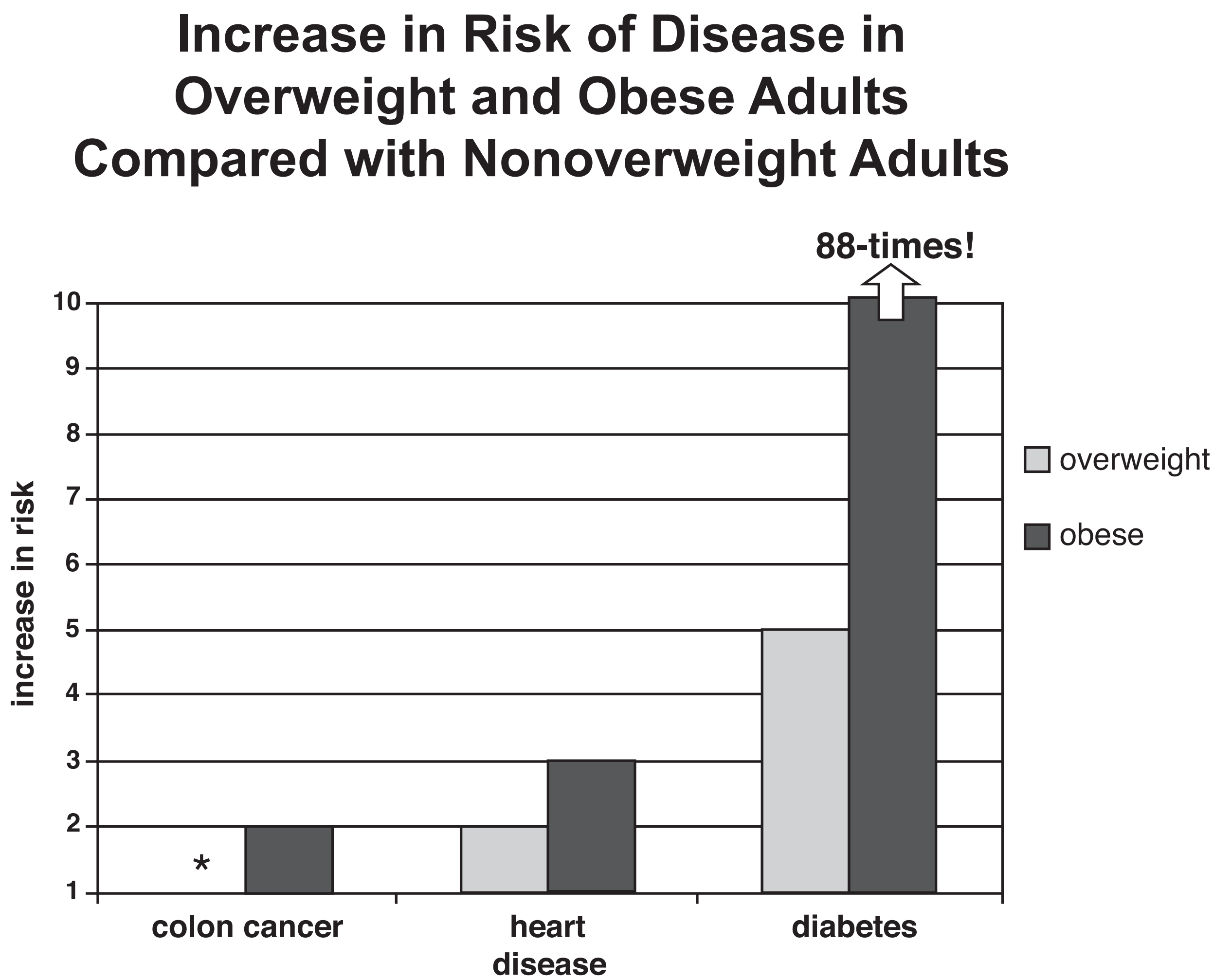
Obesity Trends Among U.S. Adults



Note: Data are for ages 18 years and over, based on self-reported weight and height via telephone interview. Obesity is defined as BMI ≥ 30.0.
Source: BRFSS, CDC. Mokdad A H, et al. JAMA 1999;282:16. Mokdad A H, et al. JAMA 2001;286:10. Mokdad A H, et al. JAMA 2003;289:1.

Master 5.1

Increased Risk of Several Diseases with Overweight and Obesity



* No data available for overweight adults.

Letter to Myself

Name: ______________________________ Date: ______________

Dear Me,

Now that I am 40 years old, a healthy energy balance for me is . . .

because . . .

The challenges I am likely to have as an adult in maintaining energy balance are . . .

Strategies I can use to manage the calories I consume are . . .

Strategies I can use to manage the calories I use are . . .