How Your Brain Understands What Your Ear Hears

Under a Contract from the
National Institutes of Health

National Institute on
Deafness and Other Communication Disorders

BSCS

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Contents

Foreword

This curriculum supplement, from *The NIH Curriculum Supplement 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. The NIH 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 from across the country, scientists, medical experts, other professionals with relevant subject-area expertise from institutes and medical schools across the country, representatives from the NIH National Institute on Deafness and Other Communication Disorders (NIDCD), 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 lessons based on BSCS's 5E Instructional Model of Learning, multi-subject 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. These 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, and availability and ordering information, or to submit feedback, please visit our Web site at *http://science.education.nih.gov* or write to

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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
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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

Founded in 1887, the National Institutes of Health (NIH) today is the federal focal point for medical research in the United States. Composed of 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. The NIH mission is to uncover new knowledge about the prevention, detection, diagnosis, and treatment of disease and disability, from the rarest genetic disorder to the common cold. It does this through

- *Research.* Enhancing research outcomes across the medical research continuum by supporting research in NIH's own intramural laboratories as well as the research of nonfederal scientists working in universities, medical schools, hospitals, and research institutions throughout the country and abroad; communicating scientific results; promoting the efficient transfer of new drugs and other technologies; and providing effective research leadership and administration.
- *Research Training and Career Development Program.* Supporting research training and outreach designed to ensure a continuing supply of well-trained scientists.
- *Research Facilities Program.* Modernizing and improving intramural and extramural research facilities to ensure that the nation's scientists have adequate facilities in which to conduct their work.

Science education efforts by NIH and its institutes and centers are critical in ensuring the continued supply of well-trained basic research and clinical investigators, as well as the myriad professionals in the many allied disciplines who support the research enterprise. These efforts also help educate people about the scientific results so that they can make informed decisions about their own health as well as the health of the public.

This curriculum supplement is one such science education effort, done through the partnership of the NIH National Institute on Deafness and Other Communication Disorders, the NIH Office of Science Education, and Biological Sciences Curriculum Study (BSCS).

About the National Institute on Deafness and Other Communication Disorders

James F. Battey, Jr., M.D., Ph.D.

What We Do

Fundamental processes of hearing, balance, smell, taste, voice, speech, and language allow humans to interact and to experience and manipulate their environment. NIH's primary research institute devoted to human communication research is the National Institute on Deafness and Other Communication Disorders (NIDCD). The NIDCD supports research across the 50 states. Some of that research may be going on right now in your state. For more information on the NIDCD, consult the section *More About the NIDCD and Its Research*, page 145, or visit us on the Web at *http://www.nidcd.nih.gov.*

Your Young Scientists

The NIDCD is committed to encouraging young people who have an interest in science to delve into it further. It also is working to improve public understanding about how normal and diseased processes work so that individuals can make well-informed decisions about their health over a lifetime. Please let us know about your experience with the module, or let us answer any questions you have about any aspect of the material presented or the research of the NIDCD.

As director of the NIDCD, I am indebted to you for your work with these young people, and as the father of two middle schoolers, I appreciate the challenges you will face! Thank you for your interest in human communication research.

Jim Battey, M.D., Ph.D., Director NIDCD
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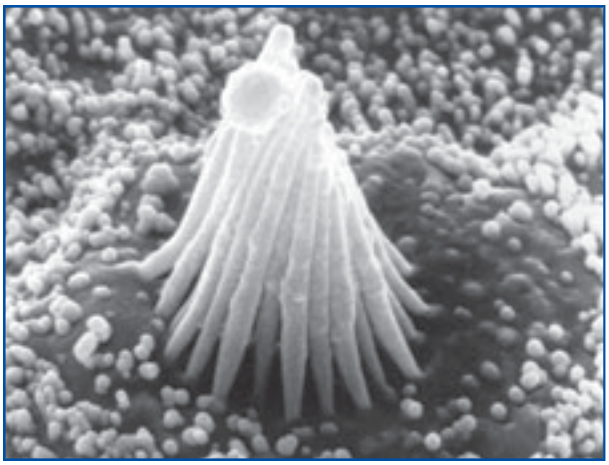

Electron micrograph of a healthy hair cell.

Introduction to *How Your Brain Understands What Your Ear Hears*

Human communication depends on taking in information from the environment through the five senses and processing that information in the brain. The sense of hearing is critical to this process. Other mental abilities such as attention and memory are also important.

Because human communication is a complex process, it may be impaired in a variety of ways. About one in six Americans must cope with some form of communication disorder, such as

- not being able to hear at all or having a hearing impairment,
- dizziness or balance problems,
- stuttering,
- ringing in the ears (tinnitus),
- not being able to speak (laryngeal cancer, aphasia), or
- autism.

Research has helped us better understand communication disorders and what causes them. Already, research has led to the development of vaccines for diseases such as measles, mumps, meningitis, and rubella—diseases that previously caused hearing loss for many people. Technologies to assist individuals with communication disorders have also been developed. Current and future research will help us better detect, diagnose, intervene, rehabilitate, or treat newborns with hearing loss; understand the genetic contributions to hearing and communication; and apply appropriate technologies to assist those who have communication disorders.

What Are the Objectives of the Module?

How Your Brain Understands What Your Ear Hears has four objectives. The first is to help students understand the interrelationship of hearing, language, and human communication. It also helps students develop healthy hearing habits so they avoid noise-induced hearing loss.

The second objective is to use hearing and communication as a way of understanding important scientific concepts. 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, mathematics, and social science.

The 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 a foundation for improving our choices about personal health and the health of our community. In this module, students experience how science provides evidence that hearing is key to language acquisition, that human communication is multisensory, and that excessive exposure to loud noise can lead to hearing loss. 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 the interweaving of science, technology, and society. The real-life context of the module's classroom lessons is engaging, and the knowledge gained can be applied immediately to students' lives.

"Nice reflection on self-issues of hearing. Many students are amazed at how many times they might be causing damage." – Field-Test Teacher

"I learned a lot about how hearing works and what you can do to keep it working well." – Field-Test Student

What's in It for the Teacher?

How Your Brain Understands What Your Ear Hears 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**.
- 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** on which there are sound clips, video, and interactive animations.
- 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 such as those described in this module without completely overhauling their entire program. In *Designing Professional Development for Teachers of Science and Mathematics*, the authors write that supplements such as this one "offer a window through which teachers get a glimpse of what new teaching strategies look like in action."[6] By experiencing a short-term unit, 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 such as 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 a biology 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 *How Your Brain Understands What Your Ear Hears* to Middle School Life Science Topics

Topic	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Organisms sense and respond to environmental stimuli.	✔	✔	✔	✔	✔
Sound is a form of energy.	✔	✔	✔	✔	
Energy can change from one form to another.				✔	
Human health and medicine			✔	✔	✔
Risk assessment and management					✔
Relationship of science, technology, and society					✔

Implementing the Module

The five lessons in this module are designed to be taught in sequence for one to two weeks (as a supplement to the standard curriculum) or as individual lessons that support or enhance your treatment of specific concepts in middle school 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?

How Your Brain Understands What Your Ear Hears is designed to help students achieve the following major goals associated with scientific literacy:

- to understand a set of basic scientific principles related to hearing and communication and their relationship 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 hearing, some of which may be incorrect, to gaining a scientific perspective on the nature of hearing and communication. Students learn about hearing and human communication by investigating the diversity of languages and their acquisition (*Getting the Message*). Students then explore the multisensory nature of communication and classify the types of sounds in their environment (*Sound Communication*). Students proceed to learn how sound is studied by scientists. They are introduced to the concepts of loudness and pitch, and they learn how these concepts relate to hearing and hearing loss in humans (*Do You Hear What I Hear?*). Students are then introduced to the hearing pathway and the concept of transduction in *A Black Box Problem: How Do I Hear?* In the final lesson, students evaluate the risk of noise-induced hearing loss for fictitious individuals. They also consider whether their own lifestyle places them at risk (*Too Loud, Too Close, Too Long*). The table on pages 8 and 9 illustrates the scientific content and conceptual flow of the five lessons.

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

How Your Brain Understands What Your Ear Hears 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 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 Content Standards chart on pages 6 and 7 lists the specific content standards that this module addresses.

Teaching Standards

The suggested teaching strategies in all of 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 Science Content and Conceptual Flow of the Lessons table and the Suggested Timeline for teaching the module. Teachers can use this mod-

Content Standards: Grades 5–8

Standard A: As a result of their activities in grades 5–8, all students should develop	Correlation to *How Your Brain Understands What Your Ear Hears*
Abilities necessary to do scientific inquiry	
• Identify questions that can be answered through scientific investigations.	Lesson 4
• Use appropriate tools and techniques to gather, analyze, and interpret data.	Lesson 3
• Develop descriptions, explanations, predictions, and models using evidence.	Lessons 3, 4
• Think critically and logically to make the relationships between evidence and explanations.	Lessons 3, 4, 5
• Recognize and analyze alternative explanations and predictions.	Lessons 1, 2, 3, 4
• Communicate scientific procedures and explanations.	Lessons 2, 4, 5
• Use mathematics in all aspects of scientific inquiry.	Lessons 3, 5
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.	All Lessons
• Mathematics is important in all aspects of scientific inquiry.	Lessons 3, 5
Standard B: As a result of their activities in grades 5–8, all students should develop an understanding of	
Transfer of energy	
• Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.	Lesson 4
Standard C: As a result of their activities in grades 5–8, all students should develop an understanding of	
Structure and function in living systems	
• Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.	Lesson 4
• Specialized cells perform specialized functions in multicellular organisms. Groups of specialized cells cooperate to form a tissue, such as muscle. Different tissues are in turn grouped together to form larger functional units, called organs. Each type of cell, tissue, and organ has a distinct structure and set of functions that serve the organism as a whole.	Lesson 4

• 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.	Lessons 3, 4, 5
Regulation and behavior	
• Behavior is one kind of response an organism can make to an internal or environmental stimulus.	Lessons 1, 2, 5
Standard E: As a result of their activities in grades 5–8, all students should develop	
Understandings about science and technology	
• Science and technology are reciprocal. Science helps drive technology. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable.	Lessons 3, 4, 5
• Technological solutions have intended benefits and unintended consequences.	Lesson 5
Standard F: As a result of their activities in grades 5–8, all students should develop an understanding of	
Personal health	
• The potential for accidents and the existence of hazards imposes the need for injury prevention. Safe living involves the development and use of safety precautions and the recognition of risk in personal decisions.	Lesson 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
• Important personal and social decisions are made based on perceptions of benefits and risks.	Lesson 5
Science and technology in society	
• Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact.	Lessons 4, 5
Standard G: As a result of their activities in grades 5–8, all students should develop an 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.	All Lessons
Nature of science	
• Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.	Lessons 3, 4

Science Content and Conceptual Flow of the Lessons

Lesson and Learning Focus*	Topics Covered and Major Concepts
1: *Getting the Message* ***Engage:*** Students become engaged in the study of hearing, communication, and understanding.	***Distinguishing between hearing and communication.*** • Hearing involves sound, while understanding involves the brain. ***Relating the concept of critical period to language acquisition.*** • There is a critical period during which language acquisition takes place.
2: *Sound Communication* ***Explore:*** Students watch and listen to human speech. They explore the multisensory nature of human communication. The Explore phase gives students a common set of experiences upon which to begin building their understanding.	***Communication is multisensory.*** • The most effective communication is multisensory. • Sound is a powerful and important means of communication. ***Sounds can be environmental, voiced, and musical.*** • There are three types of sound: environmental, voiced, and musical.
3: *Do You Hear What I Hear?* ***Explore/Explain:*** Students generate a hearing-response curve. They also listen to recordings that simulate hearing loss. Students express their understanding of the relationships among loudness, pitch, and hearing.	***Characteristics of loudness and pitch.*** • Loudness and pitch are distinct properties of sound. • Loudness is related to the amplitude of the sound wave; pitch is related to its frequency. ***The human hearing response and hearing loss.*** • Humans do not hear all pitches equally well. • The loudness of very-low- and very-high-pitched sounds must be increased for them to be detected. • A healthy sense of hearing is characterized by the recognition of a wide spectrum of pitches. • Hearing loss may involve failure to detect specific pitches.
4: *A Black Box Problem: How Do I Hear?* ***Elaborate:*** Students deepen their understanding of hearing by investigating the parts of the hearing pathway and their functions.	***The components of the hearing pathway and their functions.*** • The hearing pathway processes sound in a series of steps that involve different structures within the ear. • Hearing requires the passage of vibrational energy from one medium to another, as well as its conversion to electrical energy (in the form of nerve impulses). • Damage to specific parts of the hearing pathway results in predictable changes in hearing. ***The process of transduction.*** • Transduction is the conversion of vibrational energy into electrical energy that occurs in the cochlea.

5: *Too Loud, Too Close, Too Long* ***Elaborate/Evaluate:*** Students reflect on what they learned in the module in the context of noise-induced hearing loss (NIHL). They evaluate risks for NIHL for several fictitious individuals as well as for themselves and recommend ways to reduce these risks.	***Understanding occurs in the brain.*** • Understanding what one hears occurs in the brain. • Damage to specific parts of the hearing pathway results in predictable changes in hearing. ***Characteristics, causes, and prevention of noise-induced hearing loss.*** • Noise-induced hearing loss leads to an inability to hear and understand speech and other sounds at normal loudness levels. • Noise-induced hearing loss can be temporary or permanent. • Noise-induced hearing loss can result from a one-time exposure to extremely loud sound, repeated or long-term exposure to loud sound, or extended exposure to moderate sound. • Noise-induced hearing loss can happen to people of all ages. • The best way to protect one's hearing is to avoid loud noise whenever possible.

*See How Does the 5E Instructional Model Promote Active, Collaborative, Inquiry-Based Learning? on pages 9 to 11.

ule 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 of the activities encourage and support student inquiry, promote discourse among students, and challenge students to accept and share responsibility for their learning. The use of 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 curiosity, openness to new ideas and data, and skepticism, which characterize the 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 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 by way 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 active, collaborative learning is directed toward scientific

inquiry, 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.

The viewpoint that students are active thinkers who construct their own understanding from 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. The 5E 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 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 think they know about the topic and concepts to be covered.

The Engage lesson in this module, Lesson 1: *Getting the Message*, is designed to

- pique students' curiosity and generate interest;
- determine students' current understanding about hearing and communication;
- invite students to raise their own questions about hearing and its relationship to human communication;
- encourage students to compare their ideas with those 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 2: *Sound Communication,* and Lesson 3: *Do You Hear What I Hear?*, students investigate the multisensory nature of human communication and communicating by way of sounds in their environment. Students also investigate the characteristics of sound, such as loudness and pitch. These lessons provide a common set of experiences within which students can begin to construct their understanding. 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 sound, hearing, and communication.

Explain

The Explain lesson 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. The Explain lesson for this module, Lesson 3: *Do You Hear What I Hear?*, encourages students to

- explain concepts and ideas (in their own words) about sound in terms of loudness and pitch;

- listen to and compare the explanations of others 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 previously introduced concepts in new situations and relate their previous experiences to new ones. In the Elaborate lesson in this module, Lesson 4: *A Black Box Problem: How Do I Hear?,* students

- make conceptual connections between new and former experiences, connecting the structure of the ear with their concepts of sound and communication;
- connect ideas, solve problems, and apply their understanding to a new situation;
- use scientific terms and descriptions;
- 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: *Too Loud, Too Close, Too Long,* provides an opportunity for students to

- demonstrate what they understand about the ear and hearing and how well they can apply their knowledge to solve a problem, namely reducing risk for noise-induced hearing loss;
- 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 table titled Science Content and Conceptual Flow of the Lessons, on pages 8 and 9.

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 learn in ways that are different from those experienced in a traditional classroom. The following charts, What the Teacher Does and What the Students Do, outline these differences.

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 the curriculum, the most appropriate mechanism for assessing student learning is one that occurs informally at various points within the lessons, rather than just once at the end of the module. Accordingly, integrated within the lessons in the module 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 about risk assessment;
- oral presentations to the class, such as reporting experimental results; and