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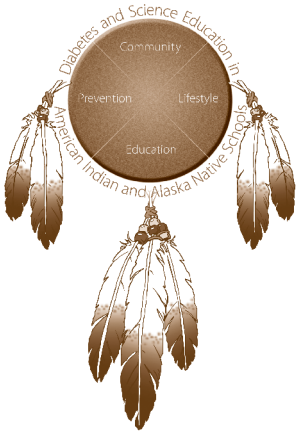

DIABETES EDUCATION
IN TRIBAL SCHOOLS

Life in Balance: Understanding Homeostasis and Diabetes

Department of
Health & Human Services
USA

National Institutes of Health

NIDDK National Institute of Diabetes and Digestive and Kidney Diseases

CDC Centers for Disease Control and Prevention

Office of science education

Indian
Health
Service

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Diabetes Education in Tribal Schools

Dear Teacher,

Thank you for your interest in teaching the Diabetes Education in Tribal Schools (DETS) curriculum in your classroom.

Diabetes was rare among American Indian and Alaska Native peoples until about 50 years ago. Since then, diabetes has become one of the most common and serious illnesses in the Tribal Nations of North America. In 2003, almost 100,000 American Indian and Alaska Native adults, or nearly 13 percent of those receiving care from the Indian Health Service (IHS), were estimated to have diabetes. Prevalence rates vary by Tribal Nations, rising to 26 percent among the Plains Tribes (Centers for Disease Control [CDC], 2005). In a new and alarming turn of events, type 2 diabetes, typically considered an adult disorder, is now emerging in all populations of youth in the United States, including American Indian and Alaska Native populations. The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) has determined that effective programs should be initiated to decrease the rising incidence and prevalence and the severe complications of diabetes in the American Indian and Alaska Native communities.

In response to these findings, NIDDK, the Centers for Disease Control and Prevention (CDC), Indian Health Service (IHS), Tribal Colleges and Universities (TCU), and the Tribal Leaders Diabetes Committee collaborated to develop this curriculum. The lessons are designed to enhance the understanding and appreciation of the problems of diabetes in American Indian and Alaska Native communities, to empower students to make healthy lifestyle choices, and to stimulate general student interest in diabetes-based science careers.

The DETS curriculum includes K–12, multidisciplinary units that are sequenced and interrelated to give a continuum of involvement with diabetes-based education. The curriculum is based on national education standards for the respective subject area, along with Native American cultural content. Teachers can assist in this critical prevention education effort while addressing the national content standards of their subject area. Culturally relevant activities are incorporated in the learning to increase the effectiveness of the diabetes prevention effort and to enhance students' cultural awareness.

The initial versions of the curriculum were tested in select K–12 schools to assess teacher acceptance and student reception of the message. Appropriate revisions followed before publication and distribution to schools serving American Indian and Alaska Native students.

The lessons are based on the BSCS 5E Instructional Model and feature multisubject integration. Each lesson includes learning activities that also serve as assessment tools. Activities promote active and collaborative learning, and are inquiry-based to help students develop problem-solving and critical-thinking skills.

The curriculum comes with a complete set of materials for both teachers and students, including printed materials and extensive background and resource information. It is distributed by the Indian Health Services at no cost to teachers. All materials may be copied for classroom use, but may not be sold.

Sincerely,

The DETS Team

Table of Contents

Overview of the Diabetes Education in Tribal Schools Project

The Diabetes Education in Tribal Schools (DETS) project is part of a national effort to decrease the incidence of type 2 diabetes among American Indians and Alaska Natives, and also to improve the care of those who have type 2 diabetes. The DETS project is a K–12 curriculum that has a multidisciplinary approach and consists of units that incorporate national education standards, inquiry learning, and American Indian and Alaska Native cultural and community knowledge.

Background

The Tribal Leaders Diabetes Committee formed a partnership with the Indian Health Service (IHS) in 1998 as a result of the Special Diabetes Program for Indians. The Tribal Leaders Diabetes Committee challenged the National Institutes of Health (NIH) to develop a curriculum to teach diabetes science in tribal schools. This challenge brought together multiple funding partners.

In 2001, the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), along with the Native Diabetes Wellness Program of the Centers for Disease Control and Prevention (CDC), and the Division of Diabetes Treatment and Prevention of the Indian Health Services (IHS), initiated a multiyear, national, K–12 curriculum project—Diabetes Education in Tribal Schools. This effort is a direct response to the recognition that type 2 diabetes is an epidemic in American Indian and Alaska Native communities.

Eight Tribal Colleges and Universities (TCU) were involved in this endeavor: Cankdeska Cikana Community College (Fort Totten, North Dakota); Fort Peck Community College (Poplar, Montana); Haskell Indian Nations University (Lawrence, Kansas); Keweenaw Bay Ojibwa Community College (Baraga, Michigan); Leech Lake Tribal College (Cass Lake, Minnesota); Northwest Indian College (Bellingham, Washington); Southwestern Indian Polytechnic Institute (Albuquerque, New Mexico); and Stone Child College (Box Elder, Montana).

Purpose

The purpose of the DETS project is to develop and implement a school-based diabetes curriculum that supports the integration of American Indian and Alaska Native cultural and community knowledge with diabetes-related scientific knowledge.

Goals of the DETS Project

The goals for the DETS project include the following:

1. Increase the understanding of health, diabetes, and maintaining life in balance among American Indian and Alaska Native students.

a. Positive health is a continual process of maintaining life in balance.

b. Diabetes is an imbalance of health at many levels.

c. Some risk factors and imbalances contribute to the likelihood of diabetes.

d. Individuals, families, and communities can maintain health and balance and prevent type 2 diabetes risk.

2. Increase American Indian and Alaska Native students' understanding and application of scientific and community knowledge about health, diabetes, and maintaining balance, and their understanding of the processes of the development of that knowledge.

a. Health, preventing and treating diabetes, and maintaining balance and enhancing health require both scientific and community knowledge.

b. Individuals, families, and communities can effectively apply scientific and community knowledge to maintain health and prevent type 2 diabetes.

c. Both scientific and community knowledge develop over time.

3. Increase interest in science and health professions among American Indian and Alaska Native youth.

a. Science and health professionals can work with people and communities to prevent and care for type 2 diabetes.

b. American Indian and Alaska Native students can and do have future careers in science and health.

Introductory Information

An Overview of Diabetes

Almost everyone knows someone who has diabetes. An estimated 20.8 million people in the United States—7.0 percent of the population—have diabetes, a serious, lifelong condition. Of those, 14.6 million have been diagnosed, and 6.2 million have not yet been diagnosed. In 2005, about 1.5 million people aged 20 or older were diagnosed with diabetes.

What Is Diabetes?

Diabetes is a disorder of metabolism—the way our bodies use digested food for growth and energy. Most of the food we eat is broken down into glucose, which is the form of sugar in the blood. Glucose is the main source of fuel for the body.

After digestion, glucose passes into the bloodstream, where it is used by cells for growth and energy. For glucose to get into most cells, insulin must be present. Insulin is a hormone produced by the pancreas, a large gland behind the stomach (figure I1).

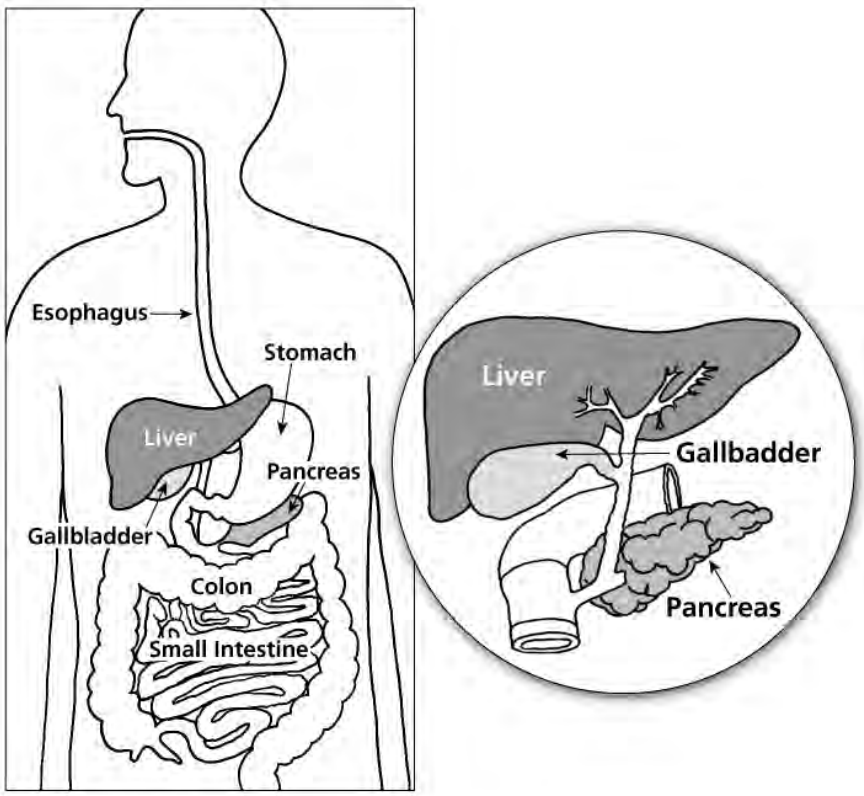


Figure I1:
Digestive tract and pancreas.

For most people, when we eat, the pancreas automatically produces the right amount of insulin to move glucose from the blood into our cells. In people with diabetes, however, the pancreas either produces too little or no insulin, or the cells do not respond appropriately to the insulin that is produced. Glucose builds up in the blood, overflows into the urine, and passes out of the body in the urine. As a result, the body loses its main source of fuel even though the blood contains large amounts of glucose.

What Are the Types of Diabetes?

The three main types of diabetes are

- type 1 diabetes,
- type 2 diabetes, and
- gestational diabetes.

Type 1 Diabetes

Type 1 diabetes is an autoimmune disease. An autoimmune disease results when the body's system for fighting infection (the immune system) turns against a part of the body. In diabetes, the immune system attacks and destroys the insulin-producing beta cells in the pancreas. The pancreas then produces little or no insulin. A person who has type 1 diabetes must take insulin daily to live.

At present, scientists do not know exactly what causes the body's immune system to attack the beta cells, but they believe that autoimmune, genetic, and environmental factors, possibly viruses, are involved. Type 1 diabetes accounts for about 5–10 percent of diagnosed diabetes cases in the United States. It develops most often in children and young adults but can appear at any age.

Type 2 Diabetes

The most common form of diabetes is type 2 diabetes. About 90–95 percent of people with diabetes have type 2. This form of diabetes most often occurs in adults and in people who are obese, have a family history of diabetes, have a previous history of gestational diabetes, are physically inactive, and are of certain ethnicities. About 80 percent of people with type 2 diabetes are overweight. Type 2 diabetes is increasingly being diagnosed in children and adolescents.

When type 2 diabetes is diagnosed, the pancreas is usually producing some insulin, but for unknown reasons the body cannot use the insulin effectively, a condition called insulin resistance. After several years, insulin production decreases. The result of this condition is the same as for type 1 diabetes—glucose builds up in the blood and the body cannot make efficient use of its main source of fuel.

The symptoms of type 2 diabetes develop gradually. Symptoms may include fatigue, frequent urination, increased thirst and hunger, weight loss, blurred vision, and slow healing of wounds or sores. It is also important to realize that some people have no symptoms.

Gestational Diabetes

Some women develop gestational diabetes late in pregnancy (figure I2). Although this form of diabetes usually disappears after the birth of the baby, women who have had gestational diabetes have a 20–50 percent chance of developing type 2 diabetes within five

Figure I2:
Checking for gestational diabetes.
(Source: National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health)

to 10 years. Maintaining a reasonable body weight and being physically active may help prevent the development of type 2 diabetes.

How Is Diabetes Diagnosed?

The fasting blood glucose test is the usual test for diagnosing diabetes in children and nonpregnant adults. It is most reliable when performed in the morning. However, a diagnosis of diabetes can be made based on certain test results, which are confirmed by retesting on a different day.

What Is Pre-diabetes?

People with pre-diabetes have blood glucose levels that are higher than normal, but not high enough for a diagnosis of diabetes. This condition raises the risk of developing type 2 diabetes, heart disease, and stroke.

What Are the Scope and Impact of Diabetes?

Diabetes is widely recognized as one of the leading causes of death and disability in the United States. In 2005, it was the sixth-leading cause of death. However, diabetes is likely to be underreported as the underlying cause of death on death certificates. About 65 percent of deaths among those with diabetes are attributed to heart disease and stroke.

The high blood glucose levels of diabetes are associated with long-term complications that affect almost every part of the body. The disease may lead to blindness, heart and blood vessel disease, stroke, kidney failure, amputations, and nerve damage. Uncontrolled

diabetes can complicate pregnancy, and birth defects are more common in babies born to women with diabetes. Diabetes also carries emotional, spiritual, and financial burdens for the individual, family, and community.

Who Gets Diabetes?

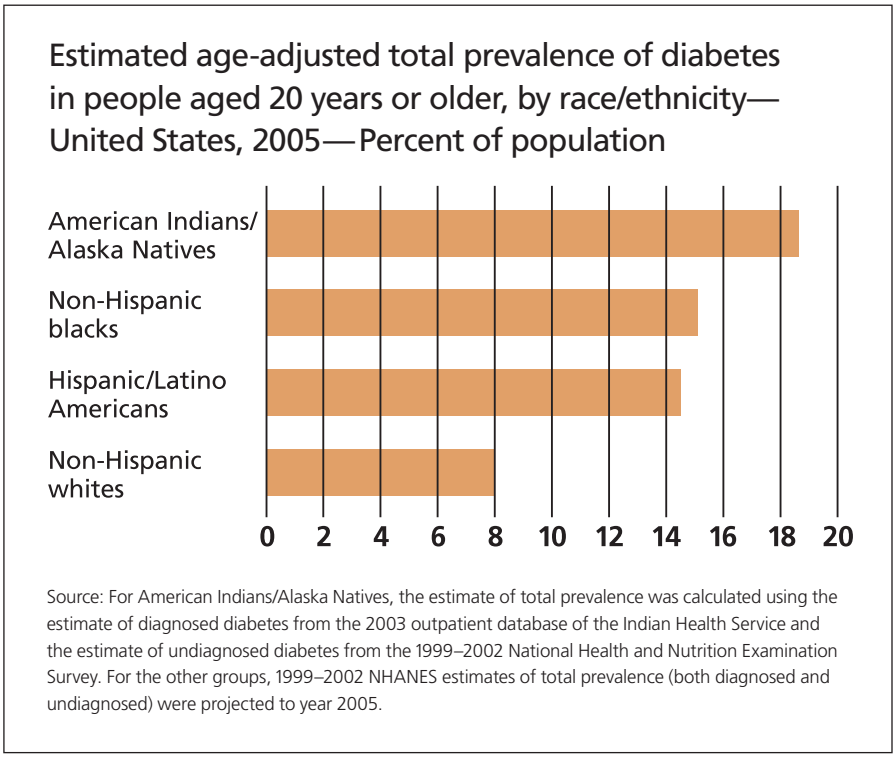
Diabetes is not contagious. People cannot "catch" it from each other. Certain factors can increase the risk of developing diabetes.

Type 1 diabetes occurs equally among males and females but is more common in whites than in non-whites. Data from the World Health Organization's Multinational Project for Childhood Diabetes indicate that type 1 diabetes is rare in most African, American Indian, and Asian populations.

Type 2 diabetes is more common in adults, especially in people who are over-weight. It occurs more often in African Americans, American Indians, some Asian Americans, Native Hawaiians and other Pacific Islander Americans, and Hispanic/Latino Americans. On average, non-Hispanic African Americans are 1.8 times as likely to have diabetes as non-Hispanic whites of the same age. Mexican Americans are 1.7 times as likely to have diabetes as non-Hispanic whites of similar age. (Data are not available for estimating diabetes rates in other Hispanic/Latino American groups.)

American Indians have one of the highest rates of diabetes in the world. On average, American Indians and Alaska Natives are 2.2 times as likely to have diabetes as non-Hispanic whites of similar age (figure I3). Although prevalence data for diabetes among Asian Americans and Pacific Islanders are limited, some groups, such as Native Hawaiians, Asians, and other Pacific Islanders residing in Hawaii (aged 20 or older) are more than twice as likely to have diabetes as white residents of Hawaii of similar age.

Figure I3:
Prevalence data.



Source: For American Indians/Alaska Natives, the estimate of total prevalence was calculated using the estimate of diagnosed diabetes from the 2003 outpatient database of the Indian Health Service and the estimate of undiagnosed diabetes from the 1999–2002 National Health and Nutrition Examination Survey. For the other groups, 1999–2002 NHANES estimates of total prevalence (both diagnosed and undiagnosed) were projected to year 2005.

How Is Diabetes Managed?

Before the discovery of insulin in 1921, everyone with type 1 diabetes died within a few years after diagnosis. Although insulin is not considered a cure, its discovery was the first major breakthrough in diabetes treatment.

Today, healthy eating, physical activity, and taking insulin are the basic therapies for type 1 diabetes. The amount of insulin must be balanced with food intake and daily activities. Blood glucose levels must be closely monitored through frequent blood glucose checking (figure I4).

Healthy eating, physical activity, and blood glucose testing are the basic management tools for type 2 diabetes. In addition, many people with type 2 diabetes require oral medication, insulin, or both to control their blood glucose levels.

People with diabetes must take responsibility for their day-to-day care. Much of the daily care involves keeping blood glucose levels from going too low or too high. When blood glucose levels drop too low—a condition known as hypoglycemia—a person can become nervous, shaky, and confused. Judgment can be impaired, and if blood glucose falls too low, fainting can occur. A person can also become ill if blood glucose levels rise too high, a condition known as hyperglycemia. The goal of diabetes management is to keep levels of blood glucose, blood pressure, and cholesterol as close to the normal range as safely possible.

Figure I4:
Keeping track of glucose levels.
Source: National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health.

How Can People Lower Their Risk of Diabetes?

People can do a lot to lower their risk. Some ways to do that include the following:

- Reach and maintain a reasonable body weight
- Make wise food choices most of the time
- Be physically active every day (figure I5)

Doing these things can reduce the risk of developing type 2 diabetes.

Figure I5:
It's important to exercise every day.
Source: National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health.

Solutions through Research

In 1996, NIDDK launched its Diabetes Prevention Program (DPP). The goal of this research effort was to learn how to prevent or delay type 2 diabetes in people with pre-diabetes, a strong risk factor for type 2 diabetes. The findings of the DPP, released in August 2001, showed that people at high risk for type 2 diabetes could sharply lower their chances of developing the disorder through diet and exercise. In addition, results of the oral diabetes drug metformin had a smaller reduction of diabetes risk.

In other research before the DPP, with the help and participation of many Akimel O'odham (Pima) Indians over the years, scientists at the National Institutes of Health identified several ways people with diabetes can improve their health. Scientists found that keeping blood glucose, blood pressure, and blood cholesterol under control is very important. Pregnant women with diabetes need to keep their blood glucose under control so that their babies will be healthy and have a lower risk of getting diabetes. Breastfeeding, even for a few weeks, helps protect babies from becoming overweight and developing diabetes.

Many people who might otherwise develop type 2 diabetes can prevent it by exercising regularly, lowering the amount of fat and number of calories they eat, and losing weight if they are overweight. Researchers are also studying the genetic and environmental factors that can lead to pre-diabetes and diabetes. About 100 tribes are evaluating demonstration programs to reduce the risk of developing type 2 diabetes or of developing heart disease, a complication of high blood glucose of diabetes that is not well controlled.

Adapted with permission from the National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health.

Life in Balance

Though belief systems vary with every tribe, striving for harmony and balance in life seems central to many American Indians. Harmony and balance is the American Indian belief in interrelatedness and connectedness with all that is natural. The concept not only explains the interdependence of humans with other animates and inanimates in the world, but it also recognizes the need for individual wellness—of the interdependence of physical, emotional, psychological, and spiritual well-being.

Individuals are considered whole when their physical, mental, spiritual, and emotional selves exist in harmony. If there is something negative going on with one part of the self, it affects the other parts and causes an imbalance in the whole self. (Cleary & Peacock, 1998)

Overview

The Diabetes Education in Tribal Schools (DETS) curriculum is part of a national effort to decrease the incidence of type 2 diabetes among American Indians and Alaska Natives and to improve the care of people in these populations who already have the disease. The overarching goal of the multidisciplinary curriculum is to increase the understanding of health, diabetes, and maintaining life in balance. The curriculum recognizes that students bring to the classroom cultural values, and prior knowledge and experience in connection with health and diabetes.

American Indian and Alaska Native cultures embody many generations of oral traditions and stories that encompass values and sense of place. Among many other contributions, American Indians and Alaska Native peopls developed diverse belief systems and social structures; sophisticated and imaginative forms of art; agriculture; architecture; and earth sciences. The challenge of incorporating into teaching American Indian and Alaska Native cultures demands sensitivity to the unique features represented in the diverse array of over 560 federally recognized American Indian and Alaska Native tribes, and many other state and federally nonrecognized tribes. The DETS curriclum incorporates dance, oral history, storytelling, and the circle of balance to reflect American Indian and Alaska Native cultural teaching of prior and new knowledge.

The Round Dance and Powwows

The Round Dance goes by many names for different tribes: *Kahomni*, 2-Step, Owl Dance, or Rabbit Dance. It is a social dance that is often a part of American Indian gatherings, including community social dances, ceremonies, and powwows.

A powwow is a celebration where people gather to sing, dance, see family and friends, conduct honor ceremonies, and compete in singing and dancing. Powwows take place all

over the United States and Canada. During the summer months, there is usually a powwow every weekend in different areas of the United States.

Oral History and Storytelling

American Indian and Alaska Native cultures are filled with tradition. These cultures have sustained their traditions through oral history or storytelling. Oral history is a significant method in Native cultures where wisdom is passed down through tribal elders and leaders and through members of the extended family, such as grandparents and great-grandparents. The practice of storytelling developed over many centuries to teach life lessons and traditional Native values as well as to preserve tribal history.

Families pass their culture on to their children by socializing them to become participating members in that culture through the oral tradition—the spoken word. Within American Indian and Alaska Native communities, knowledge is transmitted through the stories, legends, and prayers. Native people's sense of self is embedded in their languages and the stories that hold the promises for a good life.

The written stories in the DETS curriculum are narratives that are culturally based. They are recitations of an individual's way to a balanced life, and they are written with concern for the well-being of the next generation. These stories are meant to help others understand that they can live a balanced, healthy life, and that living a healthy life is a positive journey.

Circle of Balance

In recognizing and honoring cultural diversity, there are common themes: unity and balance in life, a profound sense of place, and strong values of family and community. The framing and relationship of place and balance interlock and are embedded within a spiritual and ecological-wisdom orientation—they are inseparable for Native peoples. Stewardship and the connectedness of self, community, and all that Mother Earth nurtures portray an integrated approach intrinsic to Native peoples. The premise of the circle of balance is that it is the foundation and the energy for all things.

The Circle of Balance is integrated multiple times within the curriculum. This interconnected approach for *self* is a metaphoric template that allows for the systematic discovery of balance within self and with the surrounding world. For Native people, the Circle of Balance is illustrated by four quadrants: spiritual, physical, emotional, and mental. This conceptual division helps frame the complexity of self in manageable ways, opening the way for reflection on how each quadrant interacts with the others that make up the circle. These four quadrants are always evolving throughout an individual's life span.

The DETS curriculum uses an integrated theme in illustrating the contextual content of Native culture throughout the units. Threading Native cultural themes and concepts throughout the K–12 curriculum provides a meaningful approach for students of all cultural backgrounds to understand their self-identity and expand it in ever-widening circles to include others. As students become engaged with their own cultural backgrounds, beliefs, attitudes, and ways of life, their engagement allows for connectedness and an understanding that *health is life in balance*.

Science as Inquiry

When teachers talk about inquiry in the science classroom, many images come to mind. We like to see students doing science. But inquiry is much more that conducting investigations. We want students to be able to ask scientifically testable questions, design appropriate investigations to answer those questions, and develop explanations based on the evidence they collect. We also want them to be able to consider alternative explanations and use math and technology to help them answer questions when appropriate.

In addition to being able to practice science, we want students to understand the nature of science. We want them to realize that science advances through logical skepticism, that different areas in science lead to different types of questions, and that people from different backgrounds and different ways of life have contributed to the scientific knowledge we have today.

When we think about what inquiry looks like in the science classroom, it is helpful to consider the work of the National Research Council. Following the release of the *National Science Education Standards* (National Research Council [NRC], 1996), the council also developed several addenda to further explore some fundamental ideas inherent in the standards. In one of the addenda, the National Research Council (2000, pp. 24–27) outlines five essential features of inquiry that define inquiry in the classroom across all grade levels. We provide this useful discussion here:

Essential Feature 1: Learners are engaged by scientifically oriented questions.

Scientifically oriented questions center on objects, organisms, and events in the natural world; they connect to the science concepts described in the content standards. They are questions that lend themselves to empirical investigation and lead to gathering and using data to develop explanations for scientific phenomena. Scientists recognize two primary kinds of scientific questions. Existence questions probe origins and include many "why" questions. Why do objects fall toward the earth? Why do some rocks contain crystals? Why do humans have chambered hearts? Many "why" questions cannot be addressed by science. There are also causal/functional questions, which probe mechanisms and include most of the "how" questions. How does sunlight help plants to grow? How are crystals formed?

Students often ask "why" questions. In the context of school science, many of these questions can be changed into "how" questions and thus lend themselves to scientific inquiry. Such change narrows and sharpens the inquiry and contributes to its being scientific.

In the classroom, a question robust and fruitful enough to drive an inquiry generates a "need to know" in students, stimulating additional questions of "how" and "why" a phenomenon occurs. The initial question may originate from the learner, the teacher, the instructional materials, the Web, some other source, or some combination. The teacher plays a critical role in guiding the identification of questions, particularly when they come from students. Fruitful inquiries evolve from questions that are meaningful and relevant to students, but they also must be able to be answered by students' observations and scientific knowledge they obtain from reliable sources. The knowledge and procedures students use to answer the questions must be accessible and manageable, as well as appropriate to the students' developmental level. Skillful teachers help students focus their questions so that they can experience both interesting and productive investigations.

Essential Feature 2: Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.

As the *Standards* note, science distinguishes itself from other ways of knowing through use of empirical evidence as the basis for explanations about how the natural world works. Scientists concentrate on getting accurate data from observations of phenomena. They obtain evidence from observations and measurements taken in natural settings such as oceans, or in contrived settings such as laboratories. They use their senses, instruments such as telescopes to enhance their senses, or instruments that measure characteristics that humans cannot sense, such as magnetic fields. In some instances, scientists can control conditions to obtain their evidence; in other instances, they cannot control the conditions or control would distort the phenomena, so they gather data over a wide range of naturally occurring conditions and over a long enough period of time so that they can infer what the influence of different factors might be. The accuracy of the evidence gathered is verified by checking measurements, repeating the observations, or gathering different kinds of data related to the same phenomenon. The evidence is subject to questioning and further investigation.

The above paragraph explains what counts as evidence in science. In their classroom inquiries, students use evidence to develop explanations for scientific phenomena. They observe plants, animals, and rocks, and carefully describe their characteristics. They take measurements of temperature, distances, and time, and carefully record them. They observe chemical reactions and moon phases and chart their progress. Or they obtain evidence from their teacher, instructional materials,

the Web, or elsewhere, to "fuel" their inquiries. As the *Standards* note, "explanations of how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific."

Essential Feature 3: Learners formulate explanations from evidence to address scientifically oriented questions.

Although similar to the previous feature, this aspect of inquiry emphasizes the path from evidence to explanation rather than the criteria for and characteristics of the evidence. Scientific explanations are based on reason. They provide causes for effects and establish relationships based on evidence and logical argument. They must be consistent with experimental and observational evidence about nature. They respect rules of evidence, are open to criticism, and require the use of various cognitive processes generally associated with science—for example, classification, analysis, inference, and prediction, and general processes such as critical reasoning and logic.

Explanations are ways to learn about what is unfamiliar by relating what is observed to what is already known. So, explanations go beyond current knowledge and propose some new understanding. For science, this means building upon the existing knowledge base. For students, this means building new ideas upon their current understandings. In both cases, the result is proposed new knowledge. For example, students may use observational and other evidence to propose an explanation for the phases of the moon; for why plants die under certain conditions and thrive in others; and for the relationship of diet to health.

Essential Feature 4: Learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding.

Evaluation, and possible elimination or revision of explanations, is one feature that distinguishes scientific from other forms of inquiry and subsequent explanations. One can ask questions such as: Does the evidence support the proposed explanation? Does the explanation adequately answer the questions? Are there any apparent biases or flaws in the reasoning connecting evidence and explanation? Can other reasonable explanations be derived from the evidence?

Alternative explanations may be reviewed as students engage in dialogues, compare results, or check their results with those proposed by the teacher or instructional materials. An essential component of this characteristic is ensuring that students make the connection between their results and scientific knowledge

appropriate in their level of development. That is, student explanations should ultimately be consistent with currently accepted scientific knowledge.

Essential Feature 5: Learners communicate and justify their proposed explanations.

Scientists communicate their explanations in such a way that their results can be reproduced. This requires clear articulation of the question, procedures, evidence, proposed explanation, and review of alternative explanations. It provides for further skeptical review and the opportunity for other scientists to use the explanation in work on new questions.

Having students share their explanations provides others the opportunity to ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations. Sharing explanations can bring into question or fortify the connections students have made among the evidence, existing scientific knowledge, and their proposed explanations. As a result, students can resolve contradictions and solidify an empirically based argument.

Essential Features of Classroom Inquiry and Their Variations

Less ← **Learner Self-Direction** → **More**
More ← **Direction from Teacher or Material** → **Less**

Feature				
1. Learner engages in scientifically oriented questions	**A.** Learner engages in question provided by teacher, materials, or other source	**B.** Learner sharpens or clarifies question provided by teacher, materials, or other source	**C.** Learner selects among questions, poses new questions	**D.** Learner poses a question
2. Learner gives priority to evidence in responding to questions	**A.** Learner given evidence (data) and told how to analyze	**B.** Learner given evidence (data) and guided in how to analyze it	**C.** Learner directed to collect certain evidence and asked to analyze	**D.** Learner determines what constitutes evidence, how to collect it, and how to analyze it
3. Learner formulates explanations from evidence	**A.** Learner provided with evidence and explanation	**B.** Learner given possible ways to use evidence to formulate an explanation	**C.** Learner guided in process of formulating explanations from evidence	**D.** Learner formulates explanation after summarizing evidence
4. Learner connects explanations to scientific knowledge	**A.** Learner given all connections between explanations and existing scientific knowledge	**B.** Learner given possible connections between explanations and existing scientific knowledge	**C.** Learner directed toward areas and sources of scientific knowledge in order to make connections to explanations	**D.** Learner independently examines other resources and forms connections to explanations
5. Learner communicates and justifies explanations	**A.** Learner given steps and procedures to justify and communicate explanations	**B.** Learner provided guidelines to justify and communicate explanations	**C.** Learner coached to form reasonable and logical arguments to justify and communicate explanations	**D.** Learner forms reasonable and logical arguments to justify and communicate explanations

Figure I6:
Essential features of classroom inquiry and their variations.
(NRC, 2000)

BSCS 5E Instructional Model

The instruction of major concepts is organized around an instructional model that is based on the constructivist philosophy of learning. This philosophy of learning maintains that learners build or construct new ideas on top of their old ideas.

We call the instructional model the "5Es" because each unit is organized around five phases of learning that can best be described by using five words that begin with *E*: Engage, Explore, Explain, Elaborate, and Evaluate. This instructional model allows students to use and build on prior knowledge and experience, to experience common activities, to construct meaning, and to assess their understanding of a concept continually:

- **Engage:** This phase of the instructional model initiates the learning. The activity should (1) activate prior knowledge and help students make connections between past and present learning experiences and (2) anticipate activities and focus students' thinking on the learning outcomes of upcoming activities. The learner should become mentally engaged in the concept, process, or skill to be explored.
- **Explore:** This phase of the instructional model provides students with a common set of experiences within which they identify and develop current concepts, processes, and skills. During this phase, students actively explore their environment or manipulate materials.
- **Explain:** This phase of the instructional model focuses learners on developing an explanation for the concepts they have been exploring. As a result, they have opportunities to verbalize their conceptual understanding or to demonstrate their skills or behaviors. This phase also provides opportunities for teachers to introduce formal labels, definitions, and explanations for concepts, processes, skills, or behaviors.
- **Elaborate:** This phase of the instructional model challenges and extends students' conceptual understanding, and it allows further opportunity for students to practice desired skills and behaviors. Through new experiences, the learners develop deeper and broader understanding of major concepts, obtain more information about areas of interest, and refine their scientific skills.
- **Evaluate:** This phase of the instructional model encourages learners to assess their understanding and abilities and provides opportunities for teachers to evaluate students' understanding of key concepts and development of essential skills.

Stage of the Instructional Model	The BSCS 5E Instructional Model: What the Teacher Does	
	That Is Consistent with This Model	**That Is Inconsistent with This Model**
Engage	■ Creates interest ■ Generates curiosity ■ Raises questions ■ Elicits responses that uncover what the students know or think about the concept or topic	■ Explains concepts ■ Provides definitions and answers ■ States conclusions ■ Provides closure ■ Lectures
Explore	■ Encourages the students to work together without direct instruction from the teacher ■ Observes and listens to the students as they interact ■ Asks probing questions to redirect the students' investigations when necessary ■ Provides time for the students to puzzle through problems ■ Acts as a consultant for students	■ Provides answers ■ Tells or explains how to work through the problem ■ Provides closure ■ Tells the students that they are wrong ■ Gives information or facts that solve the problem ■ Leads the students step-by-step to a solution
Explain	■ Encourages the students to explain concepts and definitions in their own words ■ Asks for justification (evidence) and clarification from students ■ Formally provides definitions, explanations, and new labels ■ Uses students' previous experiences as the basis for explaining concepts	■ Accepts explanations that have no justification ■ Neglects to solicit the students' explanations ■ Introduces unrelated concepts or skills
Elaborate	■ Expects the students to use formal labels, definitions, and explanations provided previously ■ Encourages the students to apply or extend the concepts and skills in new situations ■ Reminds the students of alternative explanations ■ Refers the students to existing data and evidence and asks, "What do you already know?" "Why do you think …?" (Strategies from Explore apply here also.)	■ Provides definitive answers ■ Tells the students that they are wrong ■ Lectures ■ Leads students step-by-step to a solution ■ Explains how to work through the problem
Evaluate	■ Observes the students as they apply new concepts and skills ■ Assesses students' knowledge, skills, or both ■ Looks for evidence that the students have changed their thinking or behaviors ■ Allows students to assess their own learning and group-process skills ■ Asks open-ended questions such as, Why do you think …? What evidence do you have? What do you know about *x*? How would you explain *x*?	■ Tests vocabulary words, terms, and isolated facts ■ Introduces new ideas or concepts ■ Creates ambiguity ■ Promotes open-ended discussion unrelated to the concept or skill

Figure I7:
BSCS Instructional Model: What the Teacher Does.

Stage of the Instructional Model	The BSCS 5E Instructional Model: What the Student Does	
	That Is Consistent with This Model	**That Is Inconsistent with This Model**
Engage	■ Asks questions such as, Why did this happen? What do I already know about this? What can I find out about this? ■ Shows interest in the topic	■ Asks for the "right" answer ■ Offers the "right" answer ■ Insists on answers or explanations ■ Seeks one solution
Explore	■ Thinks freely, but within the limits of the activity ■ Tests predictions and hypotheses ■ Forms new predictions and hypotheses ■ Tries alternatives and discusses them with others ■ Records observations and ideas ■ Suspends judgment	■ Lets others do the thinking and exploring (passive involvement) ■ Works quietly with little or no interaction with others (only appropriate when exploring ideas or feelings) ■ "Plays around" indiscriminately with no goal in mind ■ Stops with one solution
Explain	■ Explains possible solutions or answers to others ■ Listens critically to others' explanations ■ Questions others' explanations ■ Listens to and tries to comprehend explanations that the teacher offers ■ Refers to previous activities ■ Uses recorded observations in explanations	■ Proposes explanations from "thin air" with no relationship to previous experiences ■ Brings up irrelevant experiences and examples ■ Accepts explanations without justification ■ Does not attend to other plausible explanations
Elaborate	■ Applies new labels, definitions, explanations, and skills in new but similar situations ■ Uses previous information to ask questions, propose solutions, make decisions, and design experiments ■ Draws reasonable conclusions from evidence ■ Records observations and explanations ■ Checks for understanding among peers	■ "Plays around" with no goal in mind ■ Ignores previous information or evidence ■ Draws conclusions from "thin air" ■ In discussion, uses only those labels that the teacher provided
Evaluate	■ Answers open-ended questions by using observations, evidence, and previously accepted explanations ■ Demonstrates an understanding or knowledge of the concept or skill ■ Evaluates his or her own progress and knowledge ■ Asks related questions that would encourage future investigations	■ Draws conclusions, not using evidence or previously accepted explanations ■ Offers only yes-or-no answers and memorized definitions or explanations as answers ■ Fails to express satisfactory explanations in his or her own words ■ Introduces new, irrelevant topics

Figure I8:
BSCS Instructional Model: What the Student Does.

Glossary

A1c: A test that measures a person's average blood glucose concentration over the past two to three months. Glucose sometimes joins with hemoglobin, the protein in red blood cells that carries oxygen. The A1c test shows the amount of glucose that sticks to the red blood cell, which is proportional to the amount of glucose in the blood. Also called hemoglobin A1c.

adult-onset diabetes: A term formerly used for type 2 diabetes.

balance: In general, being in harmony with the rest of one's world—physically, mentally, emotionally, and spiritually. In medicine and health, a similar concept: actively keeping major functions of the body within a narrow range or maintaining equilibrium. *See* homeostasis.

blood glucose: The main sugar found in the blood and the body's main source of energy. Also called blood sugar.

blood glucose concentration (level): The amount of glucose in a given amount of blood. It is noted in milligrams per deciliter, or mg/dL.

blood glucose meter: A small, handheld device used by people with diabetes to check their blood glucose concentration. The meter displays the blood glucose level as a number on the meter's digital display.

blood sugar: A popular term for glucose in the blood. This term is less accurate than blood glucose.

body mass index (BMI): A measure used to evaluate body weight relative to a person's height. For adults, BMI is used to find out if a person is underweight, normal weight, overweight, or obese. BMI is calculated differently for adults and children. For more information, go to the Centers for Disease Control Web site, http://www.cdc.gov/nccdphp/dnpa/bmi/.

borderline diabetes: A term formerly used for early type 2 diabetes or pre-diabetes. *See* pre-diabetes.

calorie: The amount of heat energy required to raise the temperature of 1 gram of water 1 degree Celsius. In this usage, calorie is spelled with a lowercase c. The food Calorie (written with a capital C) is actually a kilocalorie, or 1,000 calories. The Calorie is an indication of the amount of energy contained in food. The Calorie content written on food labels is actually kilocalories.

carbohydrate: One of the three main nutrients in food. Carbohydrates make up sugar, starch, and cellulose. Foods that provide carbohydrates include starches, vegetables, fruits, dairy products, and sugars.

certified diabetes educator (CDE): A health professional with expertise in diabetes education who has met eligibility requirements and successfully completed a certification exam. *See* diabetes educator.

coma: A sleeplike state in which a person is not conscious. In people who have diabetes, it may be caused by *hyperglycemia* (high blood glucose) or *hypoglycemia* (low blood glucose).

concentration: The amount of a substance in a specified volume of liquid or air.

deciliter (dL): A volume equal to one-tenth of a liter, or 100 milliliters. In diabetes, blood glucose concentrations are often measured as the number of milligrams of glucose in a deciliter of blood.

diabetes educator: A health professional who teaches people who have diabetes how to manage their diabetes. Diabetes educators work in hospitals, physicians' offices, managed care organizations, home health care, and other settings.

diabetes mellitus: A condition characterized by high blood glucose concentrations. Diabetes mellitus can be classified as either type 1 or type 2. Diabetes may cause serious health problems, such as heart disease, stroke, kidney failure, blindness, or amputations.

Diabetes Prevention Program (DPP): A study by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) conducted from 1998 to 2001 in people at high risk for type 2 diabetes. All study participants had impaired glucose tolerance (also called pre-diabetes) and were overweight. Basic information about the DPP and its results can be found at the NIDDK Web site, http://diabetes.niddk.nih.gov/dm/pubs/preventionprogram/.

dialysis: The process of cleaning wastes from the blood by a dialysis machine. The kidneys usually perform this function.

dietitian: A health professional who advises people about meal planning, weight control, and diabetes management. A registered dietitian (RD) has met eligibility requirements and successfully completed a certification exam.

digestion: The process of making food absorbable by mechanically and enzymatically breaking it down into simpler chemical compounds. Digestion begins in the mouth and continues in the esophagus, stomach, and intestines.

epidemic: An outbreak of disease affecting a large number of people at the same time. Or a disease that increases suddenly in numbers that exceed what is expected.

fasting blood glucose test: A medical test of the body's ability to metabolize glucose that is used to diagnose diabetes or pre-diabetes. It is also used to monitor people who have diabetes.

fat: 1. One of the three main nutrients in food. Foods that provide fat include butter, margarine, salad dressing, oil, nuts, meat, poultry, fish, and some dairy products. 2. Excess calories are stored as body fat, providing the body with a reserve supply of energy and other functions.

gestational diabetes mellitus: A type of diabetes mellitus that develops only during pregnancy and usually disappears upon delivery. Gestational diabetes increases the risk that the mother will develop diabetes later. It is managed with meal planning, activity, and, in some cases, insulin.

glucagon: A hormone produced in the pancreas. It is released in response to decreases in the blood glucose concentration. Glucagon acts to increase blood glucose by stimulating the breakdown of glycogen and the synthesis of glucose.

glucose: A simple sugar with the chemical formula $C_6H_{12}O_6$. Glucose is the main type of sugar used by cells.

glycogen: The chief carbohydrate used by animals for energy storage.

homeostasis: A fundamental characteristic of living systems; the tendency of an organism to maintain a stable, constant internal environment.

hormone: A regulatory chemical secreted by cells or glands and carried through the blood. Hormones act on specific target cells and organs elsewhere in the body to elicit a response; a chemical messenger.

hyperglycemia: Indicates excessive blood glucose.

hypoglycemia: A condition that occurs when blood glucose levels are lower than normal. Signs include hunger, nervousness, shakiness, perspiration, dizziness or light-headedness, sleepiness, and confusion. If left untreated, hypoglycemia may lead to unconsciousness.

impaired fasting glucose (IFG): A condition in which a blood glucose test, taken after an eight- to 12-hour fast, shows a level of glucose higher than normal but not high enough for a diagnosis of diabetes. IFG is one of two conditions (with impaired glucose tolerance) that are the basis for a diagnosis of pre-diabetes. *See* impaired glucose tolerance (IGT) *and* pre-diabetes.

impaired glucose tolerance (IGT): A condition in which blood glucose concentrations are higher than normal but not high enough for a diagnosis of diabetes. IGT is one of two conditions (with impaired fasting glucose) that are the basis for a diagnosis of pre-diabetes. Terms for IGT that are no longer used include borderline, subclinical, chemical, or latent diabetes. *See* impaired fasting glucose (IFG) *and* pre-diabetes.

insulin: A hormone produced by the pancreas and released in response to elevated blood glucose concentrations. Insulin decreases blood glucose by increasing the uptake and use of glucose by cells.

insulin-dependent diabetes mellitus: A term formerly used for type 1 diabetes.

insulin receptors: Specific proteins on the cell membrane that bind to insulin and trigger a series of biochemical events that result in the uptake of glucose into the cell. *See* receptor.

insulin resistance: The body's inability to respond to and use the insulin produced by the pancreas. Insulin resistance is linked to obesity, hypertension, and high levels of fat in the blood.

juvenile diabetes: The term formerly used for type 1 diabetes.

kidney failure: A chronic condition in which the kidneys do not work properly, causing the body to retain fluid and harmful wastes to build up. A person with kidney failure needs dialysis or a kidney transplant.

kidneys: The two organs that regulate water and salt levels, filter water and wastes from the blood, and get rid of the end products as urine.

liver: The body organ that changes food into energy, removes alcohol and poisons from a person's blood, and makes bile, a substance that breaks down fat and helps rid the body of wastes.

metabolism: The sum of all chemical and physical processes within a living organism. Specifically, all of the chemical changes in living cells by which energy is provided for vital processes and activities and new material are assimilated.

noninsulin-dependent diabetes mellitus: A term formerly used for type 2 diabetes.

nutritionist: A person with training in nutrition. A nutritionist may or may not have specialized training or qualifications. *See* dietitian.

obesity: A condition in which the body has a greater than normal amount of fat. Obesity is a more severe condition than being overweight. In adults, obesity is defined as a body mass index (BMI) of 30 or more.

oral glucose tolerance test (OGTT): A test used to diagnose pre-diabetes and diabetes. The oral glucose tolerance test is given by a health professional after an overnight fast. After a blood sample is taken, the patient drinks a high-glucose beverage. Blood samples are taken during the three hours after drinking the glucose beverage. Test results are compared with a standard and show how the body uses glucose over time.

overweight: Having an above-normal body weight. In adults, being overweight means having a body mass index (BMI) of 25–29.9.

pancreas: The body organ that makes the hormones insulin and glucagon, as well as some enzymes used in digestion. The pancreas is located behind the lower part of the stomach and is about the size of a hand.

pre-diabetes: A condition in which blood glucose levels are higher than normal but are not high enough for a diagnosis of diabetes. People with pre-diabetes are at increased risk for type 2 diabetes, heart disease, and stroke. Pre-diabetes is diagnosed by having impaired fasting glucose, impaired glucose tolerance, or both. *See* impaired fasting glucose (IFG) *and* impaired glucose tolerance (IFT).

protein: 1. One of the three main nutrients in food. Foods that provide protein include meat, poultry, fish, cheese, milk, dairy products, eggs, and dried beans. 2. Proteins are produced in the body for cell structure, hormones such as insulin, and other functions.

receptor: A molecule (membrane protein) that recognizes specific chemicals, including hormones, neurotransmitters, or other body chemicals. When the hormone or other body chemical binds to its receptor, a biological response is triggered in the cells. *See* insulin receptors.

sucrose: A double sugar or disaccharide composed of glucose and fructose. Known as table sugar or white sugar, it is found naturally in sugarcane and in beets.

sugar: 1. A class of carbohydrates with a sweet taste; includes glucose, fructose, and sucrose. 2. A term used to refer to blood glucose.

Adapted with permission from the *Diabetes Dictionary* by the National Institute of Diabetes and Digestive and Kidney Diseases; MedlinePlus Medical Dictionary; and *BSCS Biology: An Ecological Approach*, 10th edition (BSCS, 2006).

Resource Directory

In an effort to provide teachers with additional high-quality resources of diabetes, we offer the following list of resources.

General Information on Diabetes

1. National Diabetes Information Clearinghouse (NDIC)

http://diabetes.niddk.nih.gov

The NDIC is a service of the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). NDIC was created to increase knowledge and understanding about diabetes among patients, health professionals, and the general public. The NDIC Web site provides access to

- publications about diabetes, provided free of copyright, in varying reading levels;
- publications for health fairs and community events;
- the Combined Health Information Database;
- the diabetes subfile (which contains fact sheets, brochures, audiovisual materials, and reference materials for patients and health professionals); and
- an "A to Z list" of diabetes topics and titles.

2. U.S. Department of Health and Human Services—National Institutes of Health (NIH)

http://health.nih.gov

The National Institutes of Health (NIH), a part of the U.S. Department of Health and Human Services, is the primary Federal agency for conducting and supporting medical research. The NIH Web site provides access to

- research health topics A–Z,
- search health topics, and
- browse health categories.

3. U.S. Department of Health and Human Services—Indian Health Service

http://www.ihs.gov

The mission of the Indian Health Service (IHS) Division of Diabetes Treatment and Prevention is to develop, document, and sustain a public health effort to prevent and control diabetes in American Indian and Alaska Native peoples.

4. Food Nutrition Information Center

http://fnic.nal.usda.gov

The Food and Nutrition Information Center has been a leader in food and human nutrition information dissemination since 1971. It provides credible, accurate, and practical resources for nutrition and health professionals, educators, government personnel and consumers. The Web site provides access to

- resources for teachers,
- downloadable nutrition education,
- training materials, and
- high-resolution images for educational use.

5. National Diabetes Education Program

http://ndep.nih.gov/

This National Diabetes Education Program is a joint program of the CDC (Centers for Disease Control and Prevention), NIH (National Institutes of Health), and 200-plus partners. It provides

- resources for health professionals,
- resources for educators, and
- opportunities and information for business professionals.

6. Children with Diabetes

http://www.childrenwithdiabetes.com

Children with Diabetes is an online community for kids, families and adults with diabetes, and provides

- the latest news and information for anyone with diabetes;
- an interactive database for children to use in e-mailing pen pals;
- forums;
- a parents' section with parent-specific information on diabetes;
- a home page for parents of kids with diabetes;
- an *Ask the Diabetes Team* feature; and
- a *Diabetes Basics* section (which offers basic medical information about diabetes, insulin, and research).

7. National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention (CDC)

http://www.cdc.gov/diabetes

CDC's Diabetes Public Health Resource Web site contains information about

- the National Diabetes Education Program,
- national conferences on diabetes,
- diabetes data and trends,
- national studies, and
- *Diabetes & Me* (basic information on diabetes and its complications and on ways to be active and eat right).

8. American Diabetes Association

http://www.diabetes.org

The American Diabetes Association is the nation's leading nonprofit health organization providing diabetes research, information, and advocacy. The mission of the association is to prevent and cure diabetes and to improve the lives of all people affected by diabetes.

9. Nutrition.gov

http://www.nutrition.gov

Nutrition.gov provides easy, online access to government information on food and human nutrition for consumers. It is a service of the National Agricultural Library, USDA. The Web site provides access to

- food and nutrition information;
- physical activity requirements;
- food safety for consumers, educators, and health professionals;
- healthy choices to reduce obesity and other food related diseases; and
- specialized nutritional requirements of infants, children, teens, adult women, men, and seniors.

10. Ask the Dietitian—Joanne Larson, MS, RD, LD

http://www.dietitian.com

An interesting feature is the Healthy Body Calculator. Just type in your information, and the results are shown on the third page. A list of commonly asked questions and answers is provided.

11. Nutrition Quest

http://www.nutritionquest.com

This Web site offers an excellent tool for personal nutrition analysis, including

- fat content in your diet,
- fruit content in your diet,
- vegetable content of your diet, and
- fiber intake.

12. Joslin Diabetes Center

http://www.joslin.org

The mission of the Joslin Diabetes Center is to improve the lives of people with diabetes and its complications through innovative care, education, and research that will lead to the prevention and cure of the disease. The Web site provides current diabetes education via

- the latest news and press releases,
- an online diabetes library,
- online classes,

- discussion boards, and
- an interactive learning center (which provides a series of interactive courses on diabetes).

13. U.S. Department of Agriculture—MyPyramid.gov

http://www.mypyramid.gov/

The MyPyramid Plan offers you a personal eating plan with the foods and amounts that are right for you. Use the advice at *Inside the Pyramid* to help you

- make smart choices from every food group,
- find your balance between food and physical activity,
- get the most nutrition out of your calories, and
- stay within your daily calorie needs.

Teaching Tools

1. Discovery Kids

http://yucky.discovery.com

This interactive Web site promotes health education activities for kids, including

- games and quizzes,
- information on the endocrine system,
- information on the nervous system,
- information on the skeletal system, and
- information on the digestive system.

2. KidsHealth

http://kidshealth.org

Many topics are available, such as homework help, how the body works, information and news, and featured articles.

3. Mission Nutrition

http://www.missionnutrition.ca/missionnutrition/eng/

The Mission Nutrition Web site offers nutrition information for teachers, parents, or students. The links for educators are in the form of lesson plans and student activities.

4. Kateri Memorial Hospital Centre

http://www.ksdpp.org

This is the Web site of the Kahnawake Schools Diabetes Prevention Project. Their motto is "Healthy eating habits, daily physical activity, and positive attitude can prevent diabetes." This main Web page is oriented toward the educator and focuses on teaching elementary school children about the prevention of diabetes.

5. NIH Office of Science Education

http://science.education.nih.gov/

The Office of Science Education provides educational resources on this Web site. The NIH Curriculum Supplement Series is a package of interactive teaching units that combine cutting-edge science research discoveries from the National Institutes of Health, one of the world's foremost medical research centers, with state-of-the-art instructional materials. The educational resources are listed by topic, grade level, and resource formats.

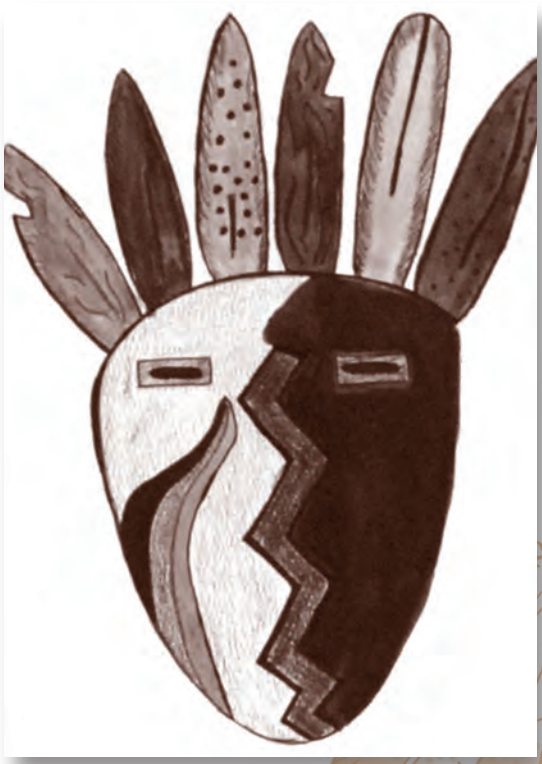
Books

American Diabetes Association. (2005). *American Diabetes Association complete guide to diabetes.* Alexandria, VA: Author.

Kaufman, F. R. (2005). *Diabesity: The Obesity-diabetes epidemic that threatens America and what we must do to stop it.* New York: Bantam Dell.

Grades 9–12

Life in Balance: Understanding Homeostasis and Diabetes



Unit Overview

The Diabetes Education in Tribal Schools (DETS) 9–12 Science Unit, *Life in Balance: Understanding Homeostasis and Diabetes*, is designed for high school biology classes. The overarching goal of this unit on diabetes is to help students understand the biology of diabetes. Knowing the biology of the disease may help individuals take actions that can reduce the chance of getting type 2 diabetes or that can help them better manage the disease.

The unit includes seven lessons that will build students' knowledge about diabetes. The big ideas that students will learn follow:

- Diabetes is a disease characterized by a blood glucose concentration that is higher than the normal range.
- There are two types of diabetes, type 1 and type 2, that have similar symptoms and impacts on a person's life, but treatment for the two types may be different.
- Blood glucose is the primary sugar used by cells of the body for producing energy. The concentration of glucose in the blood fluctuates in response to activities such as eating and exercise.
- Through homeostasis, the body regulates the blood glucose concentration within narrow ranges by the actions of insulin and glucagon.
- Diabetes is a disorder of insulin action in the body. Different problems in the mechanism of insulin action result in type 1 and type 2 diabetes. In type 2 diabetes, the body is not able to use insulin effectively, resulting in a high glucose concentration in the blood.
- Specific risk factors influence a person's risk for type 2 diabetes. Some factors are changeable, but others are not controllable by the individual. Scientific research shows that changes to an individual's lifestyle can reduce the chance for type 2 diabetes.
- Even though uncontrolled high blood glucose concentrations can cause serious health consequences, effective treatments are available. People who have type 2 diabetes can live happy and fulfilling lives.
- Science and health professionals are valuable resources for information about and treatment for type 2 diabetes. As members of the community, individuals who pursue education for one of these careers can be of service to their families and communities.

The unit emphasizes that diabetes is a problem with the body's homeostasis. Students will learn about regulation within narrow ranges that is characteristic of homeostasis, the opposing roles of insulin and glucagon to adjust the blood glucose concentration, and feedback loops. With this emphasis on homeostasis, you may be able to replace other curriculum

materials on this topic with this unit, which presents homeostasis in the context of a disease that students find interesting and relevant to their lives.

This unit complements the DETS 9–12 Health Unit, *Diabetes and American Indian/Alaska Native Health*. While this Science Unit focuses primarily on the biology of diabetes and how diabetes is an imbalance in homeostasis, the Health Unit emphasizes issues related to why type 2 diabetes is an issue for American Indian and Alaska Native populations, what factors increase people's risk for getting type 2 diabetes, and how the risks may be reduced. You may wish to coordinate with the health teacher so that students have the opportunity to experience both units. Alternatively, if your school does not offer health class in high school, you might choose to teach both units in your science class. Together, the two units provide an opportunity for students to gain a broad understanding of type 2 diabetes.

Enduring Understandings for the Unit

Project Goal 1

To increase students' understanding of health and diabetes. To help American Indian and Alaska Native children learn how to maintain balance for themselves, their families, and their communities.

9–12 Specific Goals

1. Describe elements that promote health as life in balance.

2. Explain significant physical (including biological), social, and psychological elements that contribute to type 2 diabetes.

3. Analyze major elements and risk factors contributing to type 2 diabetes that are changeable by individuals, families, and communities.

4. Design opportunities that foster maintenance of health and balance and prevention of type 2 diabetes.

Project Goal 2

To increase American Indian and Alaska Native students' understanding of and appreciation for the process of developing scientific and community knowledge with respect to health, diabetes, and maintaining balance.

9–12 Specific Goals

1. Apply scientific and community knowledge to formulate questions and make informed decisions that promote health and prevent type 2 diabetes.

2. Recognize, demonstrate, and implement successful stories and programs that promote health and prevent type 2 diabetes.

3. Analyze how scientific and community knowledge change over time and their implications for present and future health.

Project Goal 3

To improve attitudes toward and interest in entering science and health professions by developing a better understanding of how diabetes-related biomedical professionals work with communities and enhance health.

9–12 Specific Goals

1. Interact with Native American science and health professional role models.

2. Identify educational pathways to science and health professions.

3. Investigate and develop plans for career objectives.

Correlation with National Standards

The National Science Education Standards

In today's classroom, it is important that curriculum materials help teachers address the standards that have been set for various subject areas. The content of this curriculum unit ties directly to the National Research Council's *National Science Education Standards*. The chart on page 44 indicates which standards are addressed by the different lessons within this unit.

National Health Education Standards

The *Life in Balance: Understanding Homeostasis and Diabetes* curriculum unit is designed primarily for use as part of a high school biology course. As such, it addresses many of the *National Science Education Standards* (National Research Council, 1996), as indicated on the chart on page 45. However, the content of the unit also meets several of the *National Health Education Standards*, as outlined in the chart on page 45.

Content Standards: Grades 9–12

Standard A: As a result of activities in grades 9–12, all students should develop	Correlation with the DETS 9–12 Science Unit
Abilities necessary to do scientific inquiry	
■ Use technology and mathematics to improve investigations and communications.	Lessons 2, 5
■ Formulate and revise scientific explanations and models using logic and evidence.	Lessons 2, 3, 4
■ Recognize and analyze alternative explanations and models.	Lessons 1, 3, 4, 5
■ Communicate and defend a scientific argument.	Lessons 2, 3, 4, 5, 6
Understandings about scientific inquiry	
■ Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.	Lessons 3, 4, 5
Standard C: As a result of their activities in grades 9–12, all students should develop an understanding of	
The cell	
■ Cells have particular structures that underlie their functions.	Lessons 2, 3, 4
■ Most cell functions involve chemical reactions.	Lessons 2, 4
■ Cell functions are regulated.	Lessons 2, 3, 4
The behavior of organisms	
■ Organisms have behavioral responses to internal changes and to external stimuli.	Lessons 3, 4
Standard F: As a result of their activities in grades 9–12, all students should develop an understanding of	
Personal health	
■ The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism.	Lessons 1, 5
■ Personal choice concerning fitness and health involves multiple factors.	Lessons 1, 5
■ Selection of foods and eating patterns determine nutritional balance. Nutritional balance has a direct effect on growth and development and personal well-being. Personal and social factors—such as habits, family income, ethnic heritage, body size, advertising, and peer pressure—influence nutritional choices.	Lesson 5
■ Families serve basic health needs, especially for young children.	Lesson 5

Source: Reprinted with permission from *National Science Education Standards.* © 1996 by the National Academy of Sciences, National Academies Press, Washington, D.C.

Standards and Performance Indicators: Grades 9–12

Standard Number	National Health Education Standard	Correlation to the DETS 9–12 Science Unit
1	**Students will comprehend concepts related to health promotion and disease prevention to enhance health.**	
1.12.1	Predict how healthy behaviors can affect health status.	Lesson 5
1.12.2	Describe the interrelationships of emotional, intellectual, physical, and social health.	Lessons 1, 5
1.12.3	Analyze how environment and personal health are interrelated.	Lessons 1, 5
1.12.5	Propose ways to reduce or prevent injuries and health problems.	Lessons 4, 5
2	**Students will analyze the influence of family, peers, culture, media, technology and other factors on health behaviors.**	
2.12.1	Analyze how the family influences the health of individuals.	Lessons 1, 5
2.12.2	Analyze how the culture supports and challenges health beliefs, practices and behaviors.	Lessons 1, 5, 6, 7
2.12.4	Evaluate how the school and community can impact personal health practice and behaviors.	Lessons 1, 5
2.12.6	Evaluate the impact of technology on personal, family and community health.	Lesson 2
2.12.8	Analyze the influence of personal values and beliefs on individual health practices and behaviors.	Lessons 1, 5, 6
3	**Students will demonstrate the ability to access valid information and products and services to enhance health.**	
3.12.1	Evaluate the validity of health information, products, and services.	Lesson 7
4	**Students will demonstrate the ability to use interpersonal communication skills to enhance health and avoid or reduce health risks.**	
4.12.1	Use skills for communicating effectively with family, peers, and others to enhance health.	Lesson 6
8	**Students will demonstrate the ability to advocate for personal, family and community health.**	
8.12.1	Utilize accurate peer and societal norms to formulate a health-enhancing message.	Lesson 5, 6, 7
8.12.4	Adapt health messages and communication techniques to a specific target audience.	Lesson 5, 6, 7

Source: Reprinted with permission, from the American Cancer Society. *National health education standards: Achieving excellence* (2nd ed.). Atlanta, GA: American Cancer Society. 2007, www.cancer.org/bookstore.

Teacher Strategies

Timeline for the Lessons

The timeline provides a guideline for completing the seven lessons in this unit. The lessons will require approximately 12–14 class periods of approximately 45 minutes each. The actual amount of class time needed for the unit will reflect the practice of individual teachers. Some classes will spend more time on activities and discussions than others. If your class periods are either shorter or longer than 45 minutes, you will need to adjust your schedule accordingly.

Lesson 1, *What Is Diabetes?*: 2 class periods

Lesson 2, *What Is Blood Glucose?*: 3 class periods

Lesson 3, *Keeping Blood Glucose in Balance*: 2 class periods

Lesson 4, *How Does Insulin Work?*: 2 class periods

Lesson 5, *Diabetes—Why Does It Matter?:* 1 class period

Lesson 6, *Sharing Your Knowledge of Type 2 Diabetes*: 2 class periods

Lesson 7, *Pursuing a Career Related to Diabetes Education*: 2 class periods

The timeline assumes that you will teach the lessons on consecutive days. If several days separate the lessons, you may need additional time to review the previous lessons. This review will help students make stronger connections between the lessons.

Advance Preparation

2–3 Weeks Ahead

Begin reviewing lessons.

Order glucose if necessary.

Check the availability of glucose test strips at a local pharmacy; order if necessary (see Lesson 2, *Preparation*, p. 68).

Contact the local heath clinic or diabetes clinic for a loan of digital blood glucose meters (optional; see Lesson 2, *Preparation,* p. 68).

Start gathering materials.

1 Week Ahead

Make photocopies and transparencies.

Finish gathering materials.

Reserve the computer lab for student use during Lesson 7.

2–5 Days Ahead

Prepare materials for Lesson 2 (weigh chemicals, prepare solutions as appropriate, practice with glucose test strips and digital blood glucose meters; see Lesson 2, *Preparation*, p. 68).

Teacher Materials for the Unit

overhead projector

transparency pens or markers

chart paper (optional)

markers for chart paper (optional)

5 test tubes or small beakers

6 large beakers or clear containers that will hold 1 liter of water

5 stirring rods or large spoons

tape for labels

1 marker for labeling beakers

1 balance

glucose

sugar (sucrose or white table sugar from grocery store)

1,000-milliliter graduated cylinder (1 per class)

scissors

colored paper, approximately 2–3 pieces, each of 4 different colors (optional)

Teacher Resource CD (optional)

transparency copies of each of the following:

- Copymaster 1.1, *Diabetes in Native American Adolescents*, Ages *15–19*
- Copymaster 1.2, *Photographs of Nick and Kim*
- Copymaster 1.6, *Diabetes Affects the Balance in a Person's Life*
- Copymaster 1.7, *Similarities and Differences*
- Copymaster 2.1, *Summarizing Digestion and Energy Production*
- Copymaster 3.1, *Blood Glucose Concentration* (optional)
- Copymaster 3.4, *Regulating the Blood Glucose Concentration—Part 1*
- Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2*
- Copymaster 4.1, *Modeling Insulin Action—the Cell* (optional)
- Copymaster 4.8, *Type 2 Diabetes and Glucose*
- Copymaster 5.2, *Complications from High Blood Glucose Concentrations*
- Copymaster 5.4, *Revisiting the Circle of Balance*

1 copy of Copymaster 2.4, *Sample Letter Requesting Loan of Glucose Meters* (optional)

2–3 copies of Copymaster 4.2, *Modeling Insulin Action—Insulin*

2–3 copies of Copymaster 4.3, *Modeling Insulin Action—Insulin Receptors*

2–3 copies of Copymaster 4.4, *Modeling Insulin Action—Transporters*

2–3 copies of Copymaster 4.5, *Modeling Insulin Action—Glucose*

Student Materials for the Unit

For each student

notebook paper

computers with access to the Web

1 copy of Copymaster 1.3, *Summarizing Diabetes*

1 copy of Copymaster 1.6, *Diabetes Affects the Balance in a Person's Life*

1 copy of Copymaster 2.1, *Summarizing Digestion and Energy Production*

1 copy of Copymaster 2.2, *Understanding Concentration*

1 copy of Copymaster 2.3, *What Happens to the Blood Glucose Concentration during One Day?*

1 copy of Copymaster 3.1, *Blood Glucose Concentration*

1 copy of Copymaster 3.2, *Controlling the Situation*

1 copy of Copymaster 3.3, *How Does the Body Regulate Glucose?*

1 copy of Copymaster 3.4, *Regulating the Blood Glucose Concentration—Part 1*

1 copy of Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2*

1 copy of Copymaster 4.7, *Changing the System*

1 copy of Copymaster 4.9, *Cells, Glucose, and Type 2 Diabetes*

1 copy of Copymaster 5.1, *Blood Glucose and Diabetes*

1 copy of Copymaster 5.3, *Type 2 Diabetes: Can You Lower Your Risk?*

1 copy of Copymaster 5.4, *Revisiting the Circle of Balance*

1 copy of Copymaster 5.5, *Updates from Nick and Kim*

3–6 copies of Copymaster 6.1, *You Are a Diabetes Educator*

1 copy of Copymaster 6.2, *Marilyn's Story*

1 copy of Copymaster 7.1, *Science and Health Career Information*

1 copy of Copymaster 7.2, *Web Sites for Career Information*

1 copy of Copymaster 7.3, *Essay for a Diabetes-Related Career*

For each team of 3–4 students

1 envelope

1 container of glucose reagent strips for urinalysis (available at pharmacies)

1 watch or clock with second hand

1 100-milliliter graduated cylinder

6 small cups

1 digital blood glucose meter, with strips appropriate for the specific meters (optional)

1 dropping pipet (optional)

1 2-inch square of waxed paper or small dish (optional)

1 copy of Copymaster 4.1, *Modeling Insulin Action—the Cell*

1 copy of Copymaster 4.6, *How Insulin Works*

For half the class

1 copy of Copymaster 1.4, *Nick's Story,* per student

1 copy of Copymaster 1.5, *Kim's Story*, per student

Monitoring Students' Progress

Assessing what students have learned during an activity, lesson, or unit is an important part of your role as a teacher. Because assessment can play a different role at different times, this unit has a variety of assessment strategies built in to the procedures.

The Engage lessons often include a mechanism for learning more about the preconceptions that students have before new content material is presented. From research on learning, we know that it is important for students to recall and think about their current knowledge and ideas. Some of this information is likely to be accurate and correct, but often this opportunity enables students to consider what they know, what questions they have, and even what discrepancies they have in their knowledge. Only after considering their prior knowledge will they be ready to add new information or revise incorrect ideas.

Assessment is also important as students progress through the lessons in the unit. In this unit, an icon in the margin denotes an opportunity for assessment. The icon indicates stages at which you can assess students' understanding of the enduring understandings or major concepts the lesson is designed to convey. Specific strategies for evaluating students' understanding are provided with the icon. Some of the strategies are informal and quick, while others may be more in depth. Based on students' understanding at these points, you can modify your teaching practices accordingly.

The Evaluate lesson in the unit provides an opportunity for students to synthesize what they have learned during the previous lessons. By completing the Evaluate lesson, students demonstrate what they have learned and apply their understanding to new situations.

Finally, some teachers may wish to use an end-of-unit quiz to assess students' understanding of the ideas and concepts. The accompanying Teacher Resource CD (TRCD) includes a short test bank of questions that can be used for this purpose. The questions are in a variety of formats—multiple choice, true-false, short answer, and problem solving. As you design your end-of-unit quiz, select the questions from the test bank that represent the concepts you focused on and that align with the way you taught the unit.

Student Lessons

Lesson 1
What Is Diabetes?

At a Glance

Overview

In Lesson 1, *What Is Diabetes?*, students compare two case studies to learn that type 1 and type 2 diabetes are both characterized by high blood sugar (glucose) levels. Students learn that the symptoms for both types are similar but the treatments can be different. By seeing the similarities and differences, students begin to question how the biology of the two types of diabetes differs.

Enduring Understandings

- Diabetes is a disease characterized by a blood glucose concentration that is higher than the normal range.
- Although there are two forms of diabetes with similar symptoms, the treatments can be different.

Teacher Background

Consult the *Overview of Diabetes* and *Life in Balance* sections of *Introductory Information*.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to

1. begin developing an understanding of diabetes as a disease.

They will demonstrate their understanding by

- developing a list of common symptoms of diabetes,
- recognizing that diabetes is characterized by a high level of sugar (glucose) in the blood, and
- describing similarities and differences between type 1 and type 2 diabetes.

2. recognize that diabetes affects a person's life in multiple ways.

They will demonstrate this understanding by identifying ways that diabetes affects the physical, mental, spiritual, and emotional aspects of a person's life.

In Advance

Teacher Materials

overhead projector

transparency pens or markers

1 transparency of Copymaster 1.1, *Diabetes in Native American Adolescents, Ages 15–19*

1 transparency of Copymaster 1.2, *Photographs of Nick and Kim*

1 transparency of Copymaster 1.6, *Diabetes Affects the Balance in a Person's Life*

1 transparency of Copymaster 1.7, *Similarities and Differences*

Student Materials

For each student

notebook paper

1 copy of Copymaster 1.3, *Summarizing Diabetes*

1 copy of Copymaster 1.6, *Diabetes Affects the Balance in a Person's Life*

For half the class (see *Preparation*)

1 copy of Copymaster 1.4, *Nick's Story*, per student

1 copy of Copymaster 1.5, *Kim's Story,* per student

Preparation

Prepare photocopies and transparencies as specified. If making a clear transparency of the photographs in Copymaster 1.2, *Photographs of Nick and Kim*, is difficult, you can pass around the original copymaster for students to look at during Step 3.

See Step 4 about preparing Copymaster 1.4, *Nick's Story*, and Copymaster 1.5, *Kim's Story*, for half the class.

Process and Procedure

1. Display a transparency of Copymaster 1.1, *Diabetes in Native American Adolescents, Ages 15–19.* Ask students what conclusions they can make from this graph. Then ask students if they think diabetes is something that is important for them and the community to know more about.

Students should be able to state that the number of Native American adolescents who have diabetes has more than doubled between 1990 and 2004. The important information from this graph for students to recognize at this point is that more adolescents are living with diabetes now than in 1990 (the first year listed on the graph). Hopefully this will pique students' interest into why this is happening and why learning about diabetes is important. You can take this opportunity to suggest that the dramatic increase in diabetes is a reason that they should learn more about it. The more frequent it is, the more likely it will affect them or someone they know.

If students are inexperienced at reading and interpreting graphs, you can help them by asking questions such as

- "What does the height of the bars tell you?"
- "What do the different bars represent?"
- "What does the graph tell you about the number of adolescents with diabetes in 1990 compared with the number of adolescents who had diabetes in 2004?"

2. Inform students that they will be learning about diabetes over the next couple of weeks. Ask students to write three things they know about diabetes. Ask

students to think about *how* they know these things (where did they learn them, who did they learn them from). After students have had an opportunity to write their thoughts on paper, ask them to share some of their ideas with the class.

At this stage, accept all answers, regardless of whether they are correct scientifically. Also, when students think about how they know what they know (or think they know), they may think of a number of things. For example, some students may have information about diabetes because a friend or family member has diabetes. Perhaps they will remember something from a television commercial they have seen or something that they saw at the health clinic. The purpose of this step is to get students to think about their current knowledge about diabetes. Students may even recognize that some of their information about diabetes doesn't agree with other information they have heard.

Ask students to save their papers listing their personal knowledge of diabetes. Students will revisit these ideas at the end of the unit.

Figure 1:
Photographs of Nick (top) and Kim.

Note to Teacher: *At this point, some students may be familiar with the term "glucose," and some will use the term "sugar" with regard to diabetes. Accept either term at this time. In Lesson 2, students will learn that the primary sugar in the blood is actually glucose. At that time, students should begin using the more specific term.*

3. Display a transparency of Copymaster 1.2, *Photographs of Nick and Kim.* Tell students they will read about Nick's and Kim's experiences with diabetes.

The photographs of Nick and Kim should help make the stories more real to the students. Although both Nick and Kim reflect their American Indian ethnicity and culture, their stories have a great deal of similarity to the stories of people from other ethnic groups. Type 2 diabetes affects and is increasing among all ethnic groups.

Students may have heard that some women develop gestational diabetes during the late stages of pregnancy. Because this condition generally disappears after the birth of the baby, it is, for the purpose of this unit, not included as one of the major types of diabetes. See the *Overview of Diabetes* in *Introductory Information*.

4. Have students organize into teams of two. Give each student one copy of Copymaster 1.3, *Summarizing Diabetes*. Give one student in each team a copy of Copymaster 1.4, *Nick's Story*. Give the other student in each team a copy of Copymaster 1.5, *Kim's Story*.

Each student will need to read only one of the two case studies. They will then discuss their individual case study with their teammate so that both students get the information they need.

5. Instruct students to read the story they were given and fill in the blanks on Copymaster 1.3. Inform students that they should leave boxes on Copymaster 1.3 blank if the story does not give specific information (figure 2). After students answer the questions on Copymaster 1.3 for their own case study, students should share their story with their teammate and explain why they answered the questions on Copymaster 1.3 in a specific way. Instruct students to look for similarities and differences between the two stories.

   As students work, circulate around the room to monitor students' progress and to answer any questions they may have. Encourage students to help each other if they are having any difficulties with the readings or understanding the questions. Each student should complete both columns on Copymaster 1.3.

   Students may know of or have heard of other symptoms of diabetes. If students ask, explain that diabetes, like many other diseases, is characterized by a set of symptoms. Not everyone who has diabetes will have all those symptoms.

Note to Teacher: *Remind students that they are not expected to be able to answer all questions at this time.* Students should leave some boxes blank if the case studies do not provide information to answer a question. *Students will continue to refer to and add information to Copymaster 1.3 throughout this unit. By continuing to refer to and add information to this chart during the remaining lessons, students are adding to their summary and strengthening their knowledge of diabetes.*

6. Ask students if diabetes affects only a person's body or if it affects other things in a person's life. Ask students to give some examples of ways a person's life is affected by diabetes other than just the physical symptoms. Give each student a copy of Copymaster 1.6, *Diabetes Affects the Balance in a Person's Life*, and display a transparency of the same copymaster. Introduce the circle diagram and explain to the students that many Native American cultures use a circle with four quadrants to show the interaction and balance among different parts of life. Ask students to again work in their teams to identify aspects of Nick's and Kim's lives that were affected by their diabetes.

   Students may or may not have thought about the nonphysical impact of diabetes on a person's life. Students should identify and write one or two impacts of diabetes on Nick's and Kim's lives for each of the quadrants within the circle. Sample answers are shown in figure 3.

Figure 2 :
Sample answers to questions on Copymaster 1.3, *Summarizing Diabetes*.

Question	Type 1 Diabetes	Type 2 Diabetes
What are the symptoms?	thirsty, drink a lot of fluids weight loss going to the bathroom frequently flulike symptoms weak confused	thirsty, drink a lot of fluids weight loss going to the bathroom frequently weak tired
What is wrong in the body?	blood sugar (glucose) level too high	blood sugar (glucose) level too high
Who gets diabetes?	usually teens or younger get type 1	used to be only people over 40, but now young people get it also
How common is diabetes?	not common among Native Americans	frequent in Native American populations
Why is blood glucose (blood sugar) important in the body?		
Where does the glucose in the blood come from?		
What body organ isn't working correctly?		
What controls the glucose concentration in the blood normally?		
What is the problem with insulin?		
Can people with diabetes have a good life? Explain.	yes—he is healthy again, can play sports and can be an example for other kids	
What do people do to manage their diabetes?	insulin shots required healthy diet exercise monitor their blood sugar (blood glucose) levels with a meter several times a day A1c test every few months	healthy diet increase exercise monitor their blood sugar (blood glucose) level with a meter take pills get insulin shots part of time A1c test every few months
Besides physical problems, how can diabetes affect a person's life?	worst nightmare depressed scared	family members sad and scared in denial feeling hopeless
From whom can people with diabetes get information and help to keep their life in balance?	doctor nurse	nurse public health nurse dietitian certified diabetes educator doctor

The Circle of Balance

The Circle of Balance is a living and breathing metaphorical template and tool that allows for the systematic discovery of balance within self. The circle metaphor is understood by Native people, although there is no definitive circle used by all Native people as a whole. The physical, the mental, the spiritual, and the emotional parts of us move in time and space. Therefore, there is no absolute position of any of the four quadrants within the Circle of Balance. The circle conceptually divides what is interconnected in Creation and in self; the circle, which connects at the center, is always whole. This circle allows an individual the ability to grasp the complexity of self in small, manageable pieces and to reflect on how each quadrant influences the other quadrants that make the whole. The pursuit of Native knowledge and wisdom happens from the perspective of a whole person and the union of the spiritual (the essence and way of being), physical (the action we take that is dictated by our feelings about self or situations), emotional (our feelings in response to thoughts and events), and mental (our thoughts about ourselves or situations) parts of self.

The focus of the exercise is that diabetes affects all four aspects in the Circle of Balance. The placement in a specific aspect of a given characteristic is not important; students may vary in which aspect they place a given characteristic.

Students should save this diagram as they will refer to it again in Lesson 5, *Diabetes—Why Does It Matter?*

Native Spirituality

The specifics of Native spirituality vary from community to community. Native spirituality also varies from family to family and from person to person. Spirituality may vary for every teacher who will be teaching this curriculum.

Spirituality is a defining, living part of who we are as Native people. Most Native people know that their spirituality is their strength and it is a vital part of who they are. As stated in *Native American Voices: A Reader*: "Because everything in the indigenous world is interrelated, the integrity of the Native American community and an individual's sense of well-being are based on balance and holism. All forces,

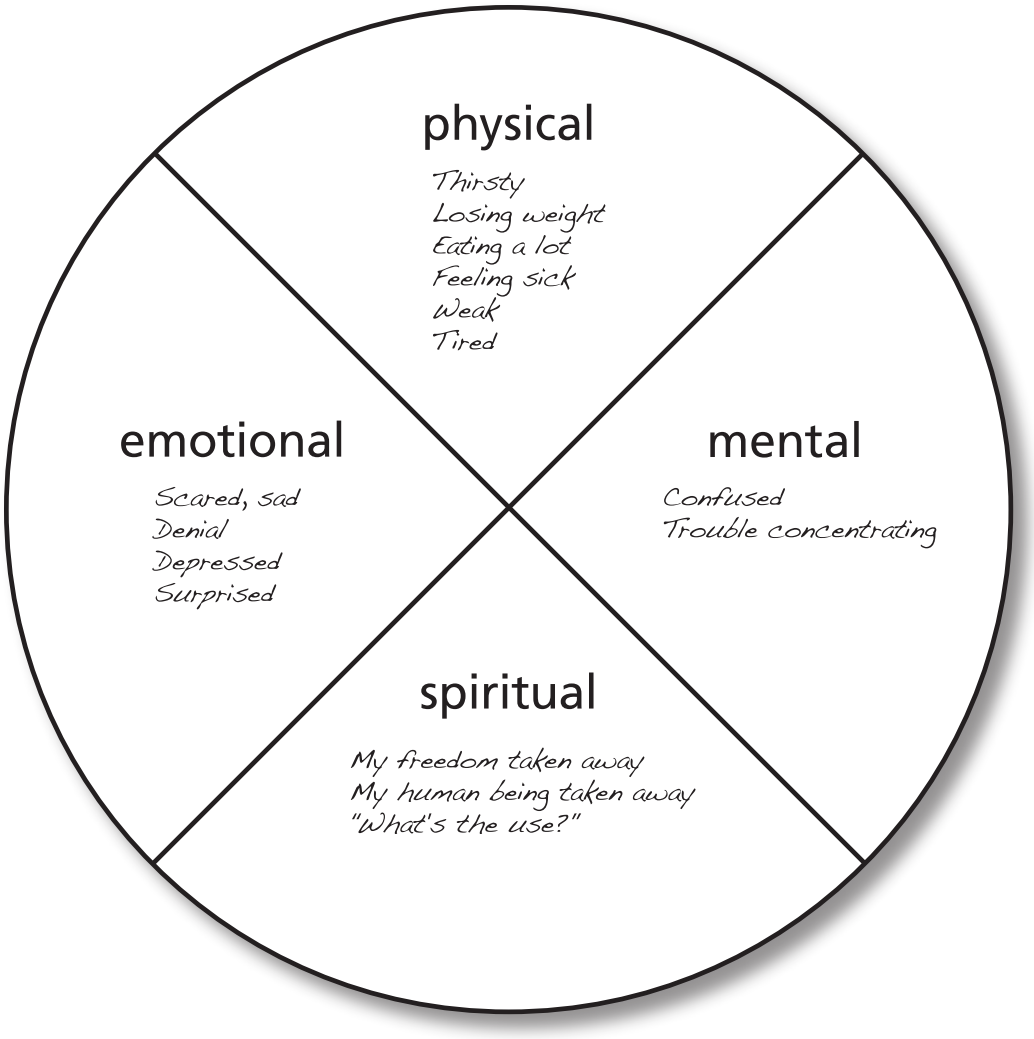


Figure 3:
Sample answers to Copymaster 1.6, *Diabetes Affects the Balance in a Person's Life.*

both animate and inanimate, must be taken into account in order for the whole person, and by extension, the entire community, to remain in good health—physically, emotionally, socially, and spiritually."* For Native people, spirituality is not simply an activity or belief that is separable from the practice of everyday life; instead, it is the context in which aspects of life are seen, defined, and given significance. Native spirituality embraces community, family, health, and education, weaving the four into each other.

*Lobo, S., & Talbot, S. (Eds.). (2001). *Native American voices: A reader* (2nd ed). Upper Saddle River, NJ: Prentice Hall.

Assessment Opportunities

If you wish, ask students to write similarities and differences between type 1 diabetes and type 2 diabetes individually before the class discussion. You can collect the students' papers to assess individual student's understanding of diabetes from the case studies. Having students write their own conclusions before the class discussion also can give students time to organize their thoughts, thereby making the discussion richer and more productive.

7. After the students finish reading and discussing their stories in their teams, reassemble the class to continue the discussion. Display a transparency of Copymaster 1.7, *Similarities and Differences.* Ask for volunteers to give one similarity or difference between type 1 and type 2 diabetes.

Students should conclude that there are many similarities in the symptoms of type 1 and type 2 diabetes. If students have any discrepancies among their answers, encourage them to give the information from the stories that support their conclusions.

Figure 4 lists conclusions about the similarities and differences between type 1 and type 2 diabetes that students could reach from the two case studies (see Copymaster 1.7). The most important conclusions that students should draw from this activity are that (1) diabetes is characterized by high blood sugar levels and (2) the symptoms of type 1 and type 2 diabetes are similar. Other answers may also be correct, but the following conclusions are of highest priority as students move toward subsequent lessons in this curriculum supplement.

Figure 4:
Sample answers to Copymaster 1.7, *Similarities and Differences*.

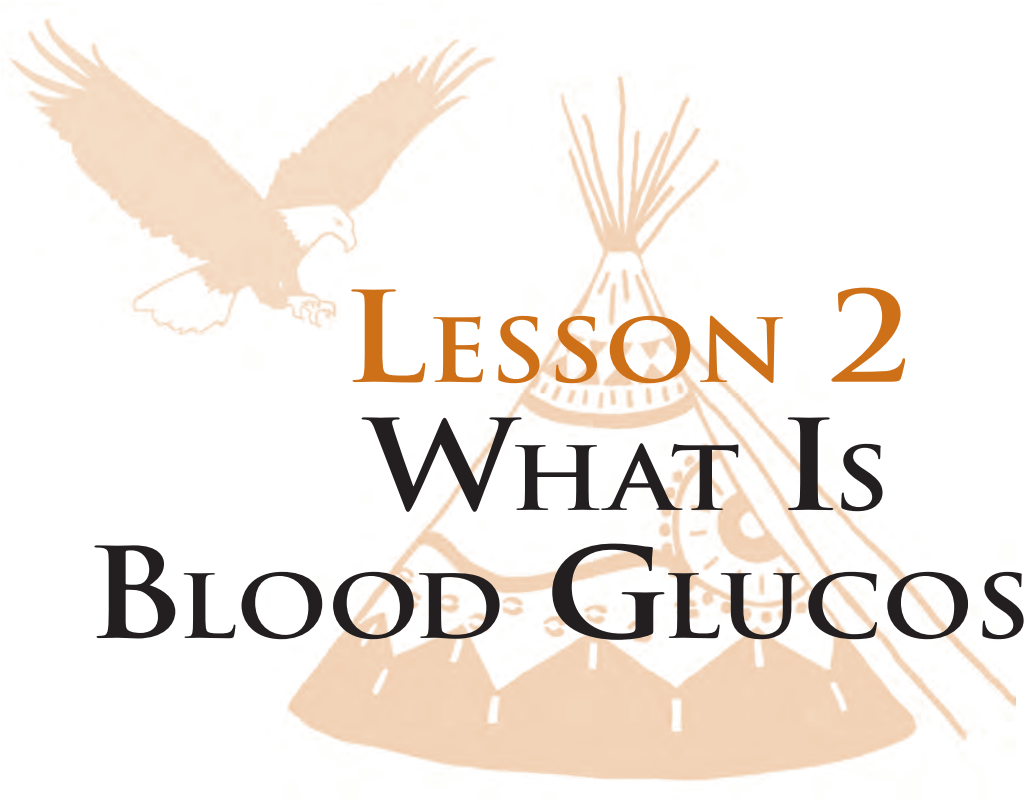
Type 1 and Type 2 Diabetes	
Similarities	Blood sugar levels are high. Symptoms are similar. Diet and exercise are important parts of treatment. People need to monitor their blood sugar levels using a meter. People should have an A1c test every few months.
Differences	People with type 1 diabetes need to take insulin, but people with type 2 may or may not take insulin. Diet and exercise are often sufficient for controlling type 2 diabetes, but are never sufficient in type 1. Some people with type 2 diabetes may need to take pills. (Some students may observe that Nick's type 1 symptoms were more severe and shorter than Kim's type 2 symptoms.)

8. Conclude the discussion by asking students to consider the question, "If both type 1 and type 2 diabetes are characterized by high blood sugar levels, how are they different in terms of what is happening in the human body?"

Students may have different ideas about how type 1 and type 2 diabetes are different in terms of how the body works. Accept reasonable ideas and inform students that during the next several lessons, they will learn more about the biology of diabetes. If students have difficulty with the idea that type 1 and type 2 diabetes represent different abnormalities or changes in the biology of blood sugar regulation, ask students

to think about why scientists and doctors would label them as type 1 and type 2 if there wasn't something different that happened in the body with each type.

Remind students to keep their copy of Copymaster 1.3, *Summarizing Diabetes*, to use in Lessons 2–5. Alternatively, collect the copies until needed in the next lesson.



Lesson 2
What Is Blood Glucose?

At a Glance

Overview

In Lesson 2, *What Is Blood Glucose?,* students recognize that "blood sugar" refers to the glucose carried in blood to all cells in the body. Students test various concentrations of glucose using test strips, and they learn how the glucose concentration changes in the blood with activity and food intake.

Enduring Understandings

- The simple sugar glucose is used to make the ATP that our body cells use for energy.
- The concentration of glucose in the blood fluctuates within a narrow range depending on food intake and activity.

Teacher Background

Consult the *Overview of Diabetes* section of *Introductory Information*.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to

1. understand that glucose is the main sugar that is carried in the blood and used by the body for energy production.

They will demonstrate their understanding by

- completing a summary statement explaining how glucose in the blood comes from the breakdown of food during digestion,
- testing for the presence and concentration of glucose by using test strips,
- calculating glucose concentrations, and
- explaining that the sucrose (white table sugar) in the food they eat is not the same as glucose and is not measured by the test strips.

2. explain fluctuations in the concentration of glucose in the blood.

They will demonstrate their understanding by

- predicting the changes in blood glucose concentration after eating, not eating, and exercise and
- developing a graph of the blood glucose concentration of a healthy person that shows fluctuations within a specific range and in response to typical daily events, such as eating and exercise.

In Advance

Teacher Materials

overhead projector

transparency pens or markers

chart paper (optional)

markers for chart paper (optional)

5 test tubes or small beakers

6 large beakers or clear containers that will hold 1 liter of water

5 stirring rods or large spoons

tape for labels

1 marker for labeling beakers

1 balance

glucose (see *Preparation*)

sugar (sucrose or white table sugar from grocery store)

1,000-milliliter graduated cylinder (1 per class)

1 transparency of Copymaster 2.1, *Summarizing Digestion and Energy Production*

1 copy of Copymaster 2.4, *Sample Letter Requesting Loan of Glucose Meters* (optional)

Student Materials

For each student

1 copy of Copymaster 1.3, *Summarizing Diabetes*, from Lesson 1

1 copy of Copymaster 2.1, *Summarizing Digestion and Energy Production* (optional)

1 copy of Copymaster 2.2, *Understanding Concentration*

1 copy of Copymaster 2.3, *What Happens to the Blood Glucose Concentration during One Day?*

For each team of 3–4 students

1 container of glucose reagent strips for urinalysis (available at pharmacies; see *Preparation*)

1 watch or clock with second hand

1 100-milliliter graduated cylinder

6 small cups

1 digital blood glucose meter, with strips appropriate for the specific meters (optional; see *Preparation*)

1 dropping pipe (optional)

1 2-inch square of waxed paper or small dish (optional)

Preparation

You can purchase glucose (in powder form) from your science supply company. The powder is the easiest and most accurate to weigh for the investigation. This is the best option.

However, an alternative is available. You can usually purchase glucose tablets in your local pharmacy. The tablets often come in a tube of 10. The tablets are usually 4 grams each and flavored. If you use the tablets, you can break them up and weigh the pieces to get the correct amount. One problem with using the tablets is that the color and flavorings in them form a film or scum on the surface of the solution that then coats the test strips. You may want to filter the solutions before use them if you use the tablets. If you elect to use the tablets, check the glucose content of the tablets by reading the label.

A week or two before starting the unit, check with your local pharmacy for the availability of the strips that students will use in Activity 2 of this lesson. The strips are designed to measure glucose concentrations through urinalysis. If you do not see the strips on the store shelf, ask the pharmacist for them. Sometimes they are kept behind the counter. If the strips are not in stock, the pharmacist can order them for you. The strips tested during development of this lesson are Diastix Reagent Strips for Urinalysis (Glucose) made by Bayer. The color chart used to read the glucose concentrations is in milligrams per deciliter (mg/dL), the preferred concentration units for this lesson. If you cannot find this brand, your scientific supply company may have another brand. Before you order, check with the company to ensure that the concentrations can be read in milligrams per deciliter.

Having one container of glucose reagent strips for urinalysis per team of students will make it easier for teams to test their solutions and read the color chart on the container. If necessary, you can make do with fewer containers and ask teams to share.

The lesson includes an optional activity during which students can use a digital blood glucose meter to test the concentration of the glucose solutions. This should not be viewed as a replacement for the use of the glucose test strips. The positive side of this option is that it enables students to use the technology that is used by people who have type 2 diabetes for testing their blood glucose. A potential negative side of including the digital meters is that students can get caught up in the technology and pay less attention to the idea being developed in the activity. You will need to weigh these factors when deciding whether to include the optional activity. If you decide to include the use of the digital meters, check with your local clinic or diabetes program at least two weeks before you begin this lesson to find out if you can get them (at least one for the class or one for each team of students) on loan. It will be easiest if each team has access to a digital blood glucose meter. However, if you cannot get enough meters, you can ask teams to each try one solution and then pass the meter to another team. You will also need the test strips appropriate for the specific meters. (Different meters use different strips.) Before beginning the lesson, make sure you understand how to use the meters yourself.

Use your own judgment about the best way to contact the health clinic to request the use of digital glucose meters. If you know someone at the clinic, a phone call may be sufficient.

Some clinics prefer you contact them in writing with your request. A sample letter (Copymaster 2.4, *Sample Letter Requesting Loan of Glucose Meters*) is included as a template for the request (a Word version can be found on the TRCD). You will need to modify the letter to include your specific information. Whether your request is via telephone or letter, reassure the clinic personnel that students will not be testing blood or body fluids.

Weigh the amounts of glucose and sucrose necessary for the activity before class begins. Put each weighed amount in a separate, labeled small beaker or test tube:

- 1.0 gram of glucose
- 2.5 grams of glucose
- 5.0 grams of glucose
- 1.7 grams of glucose
- 5.0 grams sucrose (white table sugar)

Prepare tape labels that can be put on each large beaker as follows:

- "Glucose, 0 grams per liter"
- "Glucose, 1 gram per liter"
- "Glucose, 2.5 grams per liter"
- "Glucose, 5 grams per liter"
- "Unknown glucose concentration"
- "Sucrose, 5 grams per liter"

Measure 1 liter of water into each of the six large beakers.

Prepare two of the solutions before class begins. For the first solution, add 1.7 grams of glucose to the beaker containing 1,000 milliliters of water that is labeled "unknown glucose concentration." This will be the unknown glucose concentration that students will test. This concentration was chosen because it does not match exactly with a concentration on the color chart for the glucose test strips. Because the unknown concentration doesn't match, students can realize that the strips are limited in their sensitivity to small changes. (For example, the color chart gives readings for 100 milligrams per deciliter and 250 milligrams per deciliter, but nothing in between.) If you use a brand other than Diastix, you may need to alter this concentration slightly.)

For the second solution to prepare before class, add 5 grams of sucrose to the large beaker labeled "sucrose, 5 grams/liter" that contains 1,000 milliliters of water. Stir to dissolve.

The other solutions will be mixed in class in front of the students.

Process and Procedure

Activity 1: Glucose Is Used by the Body

1. Ask students to recall what they learned about blood sugar and type 1 and type 2 diabetes from the case studies in Lesson 1.

Students should recall that blood sugar levels were high in people who had either type 1 or type 2 diabetes.

2. Ask students to write down some questions they have about the term "blood sugar." Tell them they will have two minutes to write down several questions that come to mind. After students write their questions, ask them to share their questions with the class. List their questions on a piece of chart paper or on the board. Inform students that Lesson 2 will provide answers to several of these questions.

This is intended to be a quick writing activity. By limiting the time, you are asking students to respond with what comes to mind first.

Keep students' questions focused on the term blood sugar and not on diabetes. Students will focus on diabetes later in the unit. Examples of questions include these:

- "What is blood sugar?"
- "How much sugar is in the blood?"
- "What does the body do with the sugar in the blood?"
- "Why is there sugar in the blood?"
- "Where does the sugar in the blood come from?"
- "Is sugar in the blood the same as the sugar you eat?"
- "What makes blood sugar go up?"
- "Is it normal to have sugar in the blood?"

If students don't come up with some of these questions, you can suggest them. You may not need all the questions, but these are examples of what students may suggest.

3. Inform the students that many of the questions will be answered as they move through this lesson. At the end of the lesson, they will check to see if the questions have been answered.

Save the questions so that students can check that they have been answered at the end of the lesson.

4. Ask students, "What does your body use for energy?"

Students may respond in different ways depending on what topics they have already studied in their biology course. If students have studied metabolism, they may correctly say "sugar" or "glucose." Glucose would be the more specific, correct response. If students have not studied metabolism yet, they may say "food."

5. If your students said food, ask them if there are specific kinds of foods that are best at providing energy to their bodies.

If students remember information from previous courses or from earlier topics in their current biology course, they should respond that carbohydrates, including sugars,

are used by the body for energy. If students do not know this, you can provide the information to them that the body uses carbohydrates as a source of energy.

6. **Ask, "Does the food you eat provide energy to your body directly or is the food changed to make the energy available to the body?" Then ask, "What specific substance do the cells in your body need to produce energy?"**

   If students understand the fundamentals of metabolism, they should recognize that the food must be digested before it can be used by the body. Carbohydrates and sugars taken into the body are broken down into glucose. During the process of cellular respiration, glucose is then used by cells to make ATP, a molecule that stores energy that the body needs to function.

7. **Display a transparency of Copymaster 2.1, *Summarizing Digestion and Energy Production.* Ask students to fill in blanks to complete the sentences.**

   This is an opportunity for students to summarize what they know or remember about metabolism and cellular respiration. The important things for students to recall are that glucose is the form of sugar that the body cells need to generate ATP and that glucose in the blood comes from the breakdown of carbohydrates taken in through the diet.

   If you wish, you can give each student a copy of Copymaster 2.1, *Summarizing Digestion and Energy Production*, to fill in at the same time the class works together to fill in the blanks on the transparency.

   Sample Responses to Copymaster 2.1, Summarizing Digestion and Energy Production

   People eat foods that are broken down by a process called **digestion**. This process begins with enzymes in the saliva and continues as foods pass through the stomach and intestines. A main type of nutrient that the human body can use for energy is **carbohydrates**. After they are eaten, **carbohydrates** are broken down into smaller molecules, including **glucose**. This is the main type of sugar that circulates in the blood for cells to use. The cells use **glucose** to produce ATP, a chemical compound that stores energy the body can use. Calories are a measurement of the amount of energy that a food contains.

   Most students will have had this information at some point in their education, but because glucose is such an important part of the remainder of the lessons, it is critical that they understand that glucose is the main type of sugar that the body uses for fuel. If students have already covered metabolism in your curriculum, this should simply be a review. If this is new material for them, you may need to prompt

them by giving them some choices for each blank or you may simply need to tell them what goes in a blank.

8. Ask the students to consider the question, "Based on this information, when we refer to 'blood sugar,' what is it we really mean?" After students acknowledge that the sugar in blood really is glucose, explain to them that from this point on, you will refer to "blood glucose" instead of "blood sugar."

   If students understand that glucose is the form of sugar that the cells need, they should recognize that when people use the term blood sugar, they are really referring to blood glucose. Blood glucose is the more accurate term. If students have difficulty with this idea, another approach to helping them understand this point will come in Activity 2, Step 10.

Note to Teacher: *From this point onward, refer to blood glucose instead of blood sugar. Blood glucose is a more accurate term. Moreover, many people have misconceptions based on the term blood sugar.*

Activity 2: Measuring Glucose in Solution

Note to Teacher: *In this activity, students will use test strips and digital glucose meters (optional) to measure the concentration of glucose in several solutions. Be aware that students might want to try "diagnosing" themselves or others because they have access to these tools. This is not appropriate and would not yield meaningful results. If students have concerns about their health and type 2 diabetes, encourage them to speak with their parents or guardians and then contact a local health professional.*

1. Ask students, "How much glucose is in the blood?" Tell students that you will do a demonstration to help them understand these concentrations.

   Students should probably already have some familiarity with the term "concentration." If necessary, remind students that concentration is a measure of the amount of something (mass) per unit of volume. In other words, if a glucose solution is 2 grams per liter, there are 2 grams of glucose dissolved in 1 liter of solvent. In the solutions used in this activity, the solvent is water.

2. Set four large beakers each containing 1 liter of water on the desk or table at the front of the classroom. Tell students that each beaker contains the same amount of water. Next to each beaker, place the container of glucose that will be added to the large beaker in Step 3. Point out the amount of glucose in each of the small containers.

One beaker will have no glucose added to it. The other small beakers have different amounts (1.0, 2.5, or 5.0 grams) of glucose in them. If students need to practice skills related to experimental design, ask them why they would need a beaker that will not have glucose added to it. This solution will serve as a control.

3. **Ask three students to come forward and add the weighed samples of glucose to the appropriate beakers of water. Have them stir to dissolve the glucose.**

   As students add the glucose to each beaker, put a label on the beaker indicating the glucose concentration. For example, the last beaker is 5.0 grams glucose per liter of water.

4. **Discuss the concentrations of glucose in each beaker. Make sure students understand how the concentration is determined.**

   Students should determine that the concentrations of the beakers are 0 grams per liter, 1.0 gram per liter, 2.0 grams per liter, and 5.0 grams per liter.

5. **Point out to students that the concentrations in the beakers are given as grams per liter, but that in the blood the concentration of glucose is expressed as milligrams per deciliter. Ask if students remember what a deciliter is from their knowledge of the metric system of measure.**

   Students should know that a deciliter (dL) is 1/10th of a liter, or 100 milliliters. There are 10 deciliters in 1 liter. Remind them that the prefix "deci-" means 1/10th. A deciliter is not a common unit of measure, but it is the standard when discussing the concentration of glucose in the blood. For this reason, it is important for students to understand the term. It may be helpful to hold up a graduated cylinder holding 100 milliliters of water and explain that it would take 10 of these amounts to equal 1 liter that is in each of the beakers.

6. **Tell students that they will work in teams of three or four to learn more about how the concentrations in grams per liter compare with the concentrations expressed in milligrams per deciliter. Assemble the students into teams and give each student one copy of Copymaster 2.2, *Understanding Concentration*. Have them follow the directions on the copymaster for Part 1 only and complete the questions.**

   At this time, put the beaker containing the unknown glucose concentration solution that you prepared before class on the table next to the other beakers for students to use.

   If you feel it would help, go over the instructions on Copymaster 2.2 with the students before they begin the investigation. Circulate around the room as students work through the instructions on Copymaster 2.2 and answer any questions that may come up.

Note to Teacher: *Remind students that they should never taste, drink, or eat anything in the biology lab.*

After teams have completed their investigations, discuss the results as a class. Ask each team to share their result for the unknown solution.

Beaker Number	Concentration in Grams per Liter (g/L)	Color of Glucose Test Strip*	Concentration in Milligrams per Deciliter (mg/dL)
1	*0.0*	*Light blue*	*0*
2	*1.0*	*Light green*	*100*
3	*2.5*	*Darker, olive green*	*250*
4	*5.0*	*Brown*	*500*
5	Unknown	*(An intermediate shade of green between the colors for 100 and 250 mg/dL)*	*175*

Figure 5:
Sample answers to Copymaster 2.2, *Understanding Concentration.*

** The sample answers for color are expected if using the Diastix test strips for glucose. Other brands may have a different color scale.*

Sample Responses to Copymaster 2.2, Understanding Concentration

Students should fill in column 2 by reading the labels off the beakers prepared in class. They will describe the color after comparing the color chart on the container. The readings that students make (column 4) by comparing their test strips with the color chart will not match exactly with the concentration of the solution, but they should be close.

7a. How does the concentration in grams per liter compare with the concentration in milligrams per deciliter?

The concentration is the same but the units of measure are different.

7b. What are some possible sources of error when measuring glucose concentrations this way?

Possible sources of error include waiting too long to read the color chart after dipping the test strip, reading the color chart incorrectly, and color of strip not matching the chart exactly.

7c. Did the color of the test strip used on the unknown concentration exactly match the color chart? If not, how did you determine the concentration of that solution?

For the solution containing the unknown glucose concentration, students will need to interpolate the concentration. The color that the test strip turns should be between the two colors on the color chart on the

bottle. Students' responses to the concentration of this solution will vary, but they should be between 100 and 250 milligrams per deciliter. The use of this intermediate concentration should reinforce the idea that not all concentrations will match exactly with the concentrations on the test strips' color chart. Also, often when you test a concentration, you don't know what it should be before you test it.

7. Students may have noticed that the test strips are designed for use in urine tests. Explain to students that these test strips are used because in people with diabetes whose blood glucose is high, some glucose is excreted in the urine.

The important aspect of this investigation is that the test strips are a way to make a quantitative measurement of the glucose concentration in a solution.

8. Tell the students that the concentrations of glucose in the solutions represent glucose concentrations that are in blood. A normal range for glucose in the blood when a person has not eaten for eight hours is 70–100 milligrams per deciliter. A glucose concentration of 200 milligrams per deciliter and higher would be characteristic of diabetes, and a concentration of 500 milligrams per deciliter would be a very high glucose concentration for someone with diabetes.

The students don't need to memorize the numbers, but should have some idea of the range.

9. To help students understand that the concentrations are the same and just the units of measure are different, work through the calculations to convert grams-per-liter concentrations to milligrams-per-deciliter concentrations.

This is good practice for students and may help them understand that the concentration is the same—just the units are different. Depending on your students' comfort level with the math, you may wish to do the first calculation as a class exercise and then let students work through the other conversions independently.

$$\left(\frac{1.0\,\cancel{g}}{\cancel{L}} \times \frac{1{,}000\,mg}{\cancel{g}} \times \frac{\cancel{L}}{10\,dL}\right) = \frac{100\,mg}{dL}$$

$$\left(\frac{2.5\,\cancel{g}}{\cancel{L}} \times \frac{1{,}000\,mg}{\cancel{g}} \times \frac{\cancel{L}}{10\,dL}\right) = \frac{250\,mg}{dL}$$

$$\left(\frac{5.0\,\cancel{g}}{\cancel{L}} \times \frac{1{,}000\,mg}{\cancel{g}} \times \frac{\cancel{L}}{10\,dL}\right) = \frac{500\,mg}{dL}$$

10. Ask students if glucose is the same as the sugar they eat in things like candy bars, soda, or cookies. Reassemble the teams to test an additional solution. Place a beaker of sucrose solution at a concentration of 5 grams per liter on the table.

Point out to students that sucrose is the kind of sugar that they buy at the grocery store as table sugar. It is also the kind of sugar in many other kinds of food that they buy.

11. Working in their teams, students should complete Part 2 on their worksheets (Copymaster 2.2).

If appropriate, go over the directions with students before they begin. The procedure that they will follow is very similar to what they did previously.

12. After students complete Part 2, review the results as a class.

Students should find that the test strips will not work for sucrose and give a negative result. They may conclude that either the test strips don't work on sucrose or they may say that the strips won't work on this concentration of sucrose solution. If students suggest that the concentration of sucrose isn't high enough, remind them that the sucrose concentration is the same as the highest glucose concentration that they tested. Ask them to consider whether they think that concentration is the most likely explanation given that the glucose concentration is not close to the low limit for the test strips. Confirm for students that the strips don't work on sucrose solutions because the chemical reaction that happens when the strip is dipped into the solution is specific for glucose. If students wanted to continue this investigation to confirm that the concentration of sucrose is not the reason for the lack of reaction by the test strips, they could design and conduct an experiment where they vary the concentration of sucrose in solution.

Prompt students to think about how this finding compares with what they reviewed in Activity 1 of this lesson and the answers they used to complete the blanks on Copymaster 2.1. Students should remember that the major type of sugar that body cells use is glucose, and that glucose is the type of sugar that is at high concentrations in people who have diabetes.

13. (Optional) Explain to students that most people don't use test strips like the ones students used in the investigation to measure their blood glucose concentrations. Now, because of advances in science and technology, people can use digital meters to measure their blood glucose concentrations. If you have access to a digital blood glucose meter and test strips, demonstrate its use with the glucose solutions used earlier.

You can do this activity in different ways depending on the availability of glucose meters. If you have access to one meter, you can do this as a demonstration. It is

Figure 6:
Digital glucose meter.

probably best to use a dropping pipet to place a small amount of the glucose solution on a piece of wax paper or in a small dish. The test strip should then be carefully touched to the solution. It is important not to get too much liquid on the test strip, and you do not want the solution getting into the body of the meter.

14. (Optional) If you have access to enough meters so that each team of students can use one, allow each team to work with a meter and test at least one concentration of glucose solution. Have them compare the readings from the meter with the results from their test strips.

    This will likely be engaging for students because they may have seen these meters used before. It also will help reaffirm for them that the reading on the meter is approximately the same as what they measured using the test strips. The advantages of the digital meter include ease of use and more accuracy.

Note to Teacher: *This is an area where you may wish to point out how technological advances have helped solve problems. One likely result is that the meters will give a very specific number whereas the concentration determined by the strips is less accurate. You may wish to discuss this point with students. It is also likely that the reading from the meter won't match exactly with the concentration determined by weighing the glucose and measuring the water. You can use this as an opportunity to discuss reasons for these differences and the possible sources of error in the activity.*

Activity 3: The Concentration of Glucose in the Blood Increases and Decreases

1. Remind students of the glucose solutions that they tested that had concentrations of 100 milligrams per deciliter and 250 milligrams per deciliter. Inform students that the concentration of glucose in a person's blood changes during the day. A blood glucose concentration of 70 milligrams per deciliter is actually at the low end of the normal range for a healthy person. Tell students that a blood glucose concentration of around 140 milligrams per deciliter is at the upper end of the normal range for a healthy person. A blood glucose concentration of 250 milligrams per deciliter is higher than normal for a healthy person. Ask students to suggest things that might cause the concentration of glucose in the blood to change.

    Students are likely to suggest that altering the amount or types of food that a person eats could affect the blood glucose concentration. Reinforce that it is the intake of carbohydrates and their subsequent breakdown into glucose that causes an increase in the blood glucose concentration. Students are also likely to correctly say that physical activity or exercise is another way to change the blood glucose concentration.

2. Give each student a copy of Copymaster 2.3, *What Happens to the Blood Glucose Concentration during One Day?* Ask students to predict how a *healthy* person's blood glucose concentration changes during a day. Students should draw what they think a graph of a person's blood glucose concentration looks like, and they should provide reasons why they predict those changes.

Students should work independently but they can discuss their ideas with teammates before drawing their graphs.

Note that the concentration of blood glucose is on the vertical axis of the graph, and the time, in two-hour increments, is listed along the horizontal axis of the graph. The horizontal axis spans a 24-hour period. Students can assume that they start at a blood glucose concentration of 85 milligrams per deciliter (midpoint in the normal fasting range). As you circulate around the room observing students' work, you may need to remind them that they should be thinking about fluctuations in the blood glucose concentration of a healthy person—not one who has diabetes.

3. Ask students to share their ideas with the class.

You can facilitate this sharing in different ways. You might display a transparency of Copymaster 2.3 and have several students draw their graphs on the transparency. Different students could use different colored pens. This would allow everyone to compare several predictions. Students could also share their ideas about what causes blood glucose to either go up or go down.

A graph of what happens to the blood glucose concentration in a healthy person actually looks something like the sample graphs shown in figures 7–9. The important thing to notice is that the concentration of glucose in the blood fluctuates during the day. The graphs should show that the concentration of blood glucose stays within a relatively narrow range (figure 7). The concentration should also not be too high. The graph in figure 8 represents a healthy person who does not have diabetes but one of the peaks is a bit high. This graph does correctly show that the blood glucose concentration varies during the day. Remind students if necessary that a normal blood glucose concentration fluctuates usually between 70 and 140 milligrams per deciliter. The graphs should not show a blood glucose concentration that is too low either—the concentration will not go near zero (as in figure 9). The important thing for all the graphs to show is an increase and decrease in blood glucose concentration within this range. The concentration should increase after a meal and then fall again. There will be differences in how high or low the peaks and valleys on the graphs are and in how far apart the peaks and valleys are spread. These types of differences are to be expected.

Figure 7:
Examples of student graphs—example 1.

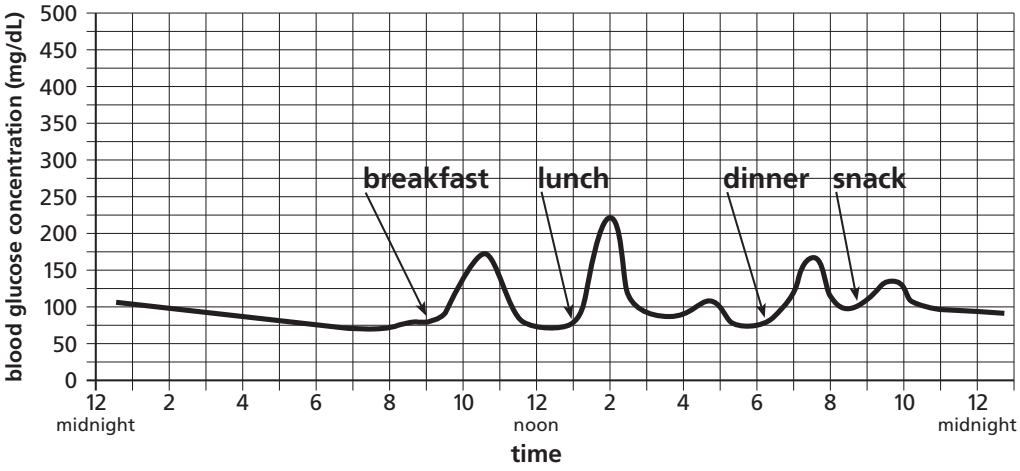


Figure 8:
Examples of student graphs—example 2.

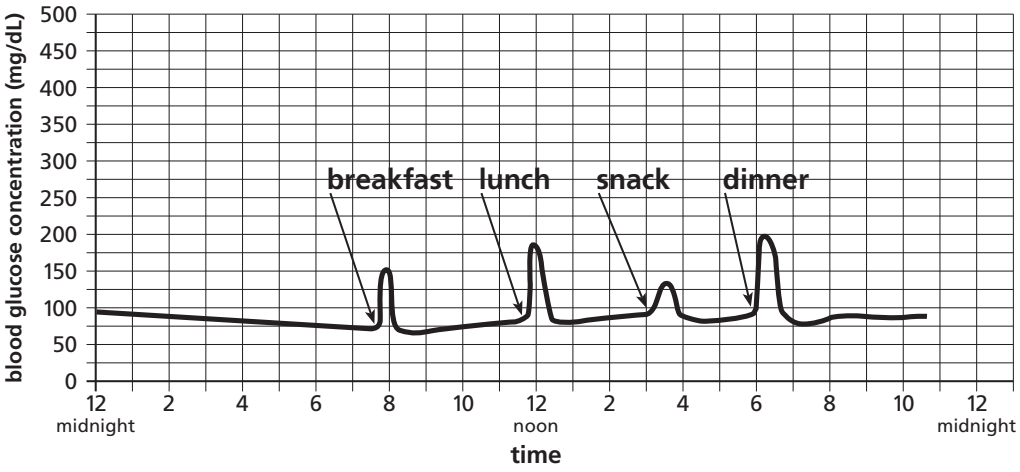
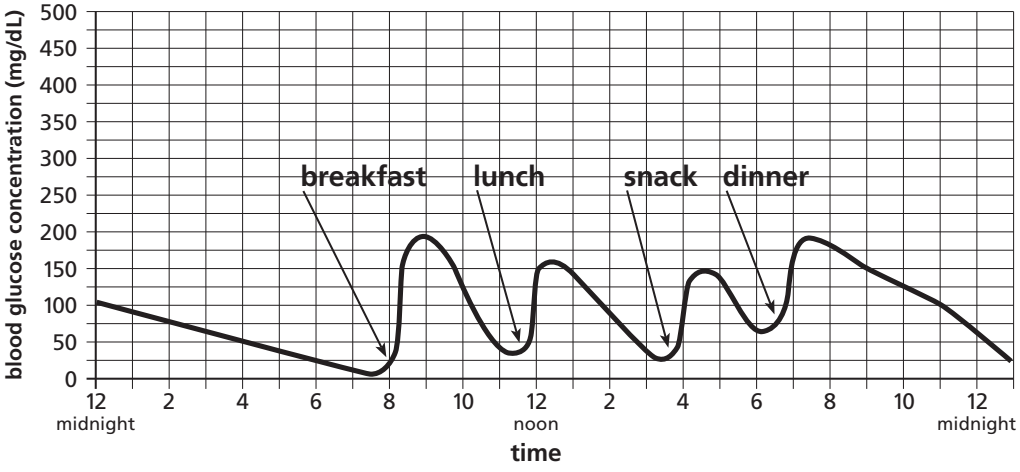


Figure 9:
Examples of student graphs—example 3.



Students should propose that the concentration of blood glucose rises after a person eats and decreases when a person engages in physical activity. Other things that affect the concentration of blood glucose include passing time (time between meals either during the day or while sleeping). If students have difficulty with the idea of changes in blood glucose, have them review the responses to Copymaster 2.1.

4. After the class has reached a consensus about what the graph should look like, ask them to predict how a person's blood glucose concentration would change if he or she ate one cookie compared with a person who ate five cookies and drank a can of soda.

If students understand what causes blood glucose to rise, they should predict that eating more carbohydrates (many kinds of simple and complex sugars) will lead to a bigger change in blood glucose concentration.

Note to Teacher: *This question asks students to make a connection between the amount of carbohydrate ingested and the resultant change in blood glucose in general terms. There is not a direct correlation between the amount of carbohydrate eaten (in grams) and the specific change in blood glucose concentration. For example, each time a person eats 1 gram of carbohydrate, his or her blood glucose concentration will not increase by the same specific amount. Metabolism is too complicated for this type of direct correlation. At this point, it is important for students to know that eating will cause the blood glucose concentration to increase. Students should also know that the body uses energy from food so that when a person doesn't eat, the blood glucose concentration will decrease to a point, after which the body's homeostasis mechanisms respond to keep the concentration of glucose within a normal range. (Students will learn more about homeostasis and regulation in upcoming lessons.) This may be another opportunity to remind students that sucrose is not the type of sugar that is in the blood and that carbohydrates are broken down into glucose that is used by the body's cells.*

5. Return to the questions that the students proposed at the beginning of this lesson. Ask students to work in teams of three or four to answer the questions. Ask students to identify the activity they did that helped them answer each question.

Students should be able to answer most of the questions. If there are questions that they still cannot answer, keep the list and see if they can be answered after completing the rest of the lessons in this curriculum unit.

6. Wrap up this lesson by asking students to get out their copy of Copymaster 1.3, *Summarizing Diabetes*. Give students an opportunity to add any new information they feel is appropriate.

The new information that students can gain from Lesson 2 to add to or supplement their answers is shown in the table in figure 10. The information that students could have written during the previous lesson is shown in italics. As before, students will have questions that they do not yet have answers for. Students should leave those spaces blank.

Figure 10:
Sample answers to questions on Copymaster 1.3, *Summarizing Diabetes* after Lesson 2.

Question	Type 1 Diabetes	Type 2 Diabetes
What are the symptoms?	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *flulike symptoms* *weak* *confused*	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *weak* *tired*
What is wrong in the body?	*blood sugar (glucose) level too high*	*blood sugar (glucose) level too high*
Who gets diabetes?	*usually teens or younger get type 1*	*used to be only people over 40, but now young people get it also*
How common is diabetes?	*not common among Native Americans*	*frequent in Native American populations*
Why is blood glucose (blood sugar) important in the body?	the main type of sugar used for energy production in cells	the main type of sugar used for energy production in cells
Where does the glucose in the blood come from?	Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.	Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.
What body organ isn't working correctly?		
What controls the glucose concentration in the blood normally?		
What is the problem with insulin?		
Can people with diabetes have a good life? Explain.	*yes—he is healthy again, can play sports and can be an example for other kids*	
What do people do to manage their diabetes?	*insulin shots required* *healthy diet* *exercise* *monitor their blood sugar (blood glucose) levels with a meter several times a day* *A1c test every few months*	*healthy diet* *increase exercise* *monitor their blood sugar (blood glucose) level with a meter* *take pills* *get insulin shots part of time* *A1c test every few months*
Besides physical problems, how can diabetes affect a person's life?	*worst nightmare* *depressed* *scared*	*family members sad and scared* *in denial* *feeling hopeless*
From whom can people with diabetes get information and help to keep their life in balance?	*doctor* *nurse*	*nurse* *public health nurse* *dietitian* *certified diabetes educator* *doctor*

Lesson 3
Keeping Blood Glucose in Balance

At a Glance

Overview

Students use a model in Lesson 3, *Keeping Blood Glucose in Balance*, to understand blood glucose regulation in the body. Using graphs, students will develop an understanding of regulation, feedback loops, and homeostasis.

Enduring Understandings

- Homeostasis is the process the body uses to maintain a consistent internal environment.
- The body regulates blood glucose concentration by using the hormones insulin and glucagon.
- Feedback loops are part of the method of regulation in homeostasis to keep life in balance.

Teacher Background

Consult the *Overview of Diabetes* section of *Introductory Information*.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to

1. develop an understanding of the body's regulation of the blood glucose concentration.

They will demonstrate their understanding by

- correctly interpreting a graph that illustrates the body's ability to maintain the blood glucose concentration within a relatively narrow range and
- recognizing how insulin and glucagon affect the blood glucose concentration in the body.

2. explain how the regulation of blood glucose concentration is an example of homeostasis.

They will demonstrate their understanding by

- defining homeostasis,
- explaining how insulin and glucagon exert opposite effects to regulate the blood glucose concentration, and
- listing examples of other body functions maintained by homeostasis.

In Advance

Teacher Materials

overhead projector

transparency pens or markers

1 transparency of Copymaster 3.4, *Regulating the Blood Glucose Concentration—Part 1*

1 transparency of Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2*

Student Materials

For each student

1 copy of Copymaster 1.3, *Summarizing Diabetes*, from Lessons 1 and 2

1 copy of Copymaster 3.1, *Blood Glucose Concentration*

1 copy of Copymaster 3.2, *Controlling the Situation*

1 copy of Copymaster 3.3, *How Does the Body Regulate Glucose?*

1 copy of Copymaster 3.4, *Regulating the Blood Glucose Concentration—Part 1*

1 copy of Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2*

Process and Procedure

1. Ask students to recall what they learned about blood glucose concentration and what things can cause the amount of glucose in the blood to either increase or decrease.

Students should recall that eating, especially eating foods high in carbohydrates, causes the glucose concentration to rise. The blood glucose concentration falls between eating episodes or with increased activity.

2. Explain to students that they will be learning more about the increases and decreases in the blood glucose concentration. Give each student a copy of Copymaster 3.1, *Blood Glucose Concentration*. Organize students into their teams of three or four to work together to answer the questions on the copymaster.

If appropriate, go over the instructions for Copymaster 3.1 with the students. You may want to specifically point out the times when the person eats and when he or she begins and ends exercising.

3. After students complete the questions on Copymaster 3.1, go over the responses during a class discussion.

Students should be able to explain points A and B on the graph (figure 11a) easily based on what they learned in Lesson 2, *What Is Blood Glucose?* For points C–F, students should recognize when the blood glucose concentration is increasing or decreasing, but they may not have an explanation for what is happening to cause the changes. Accept any reasonable ideas, but, if appropriate, challenge students to admit that they can't be sure of their ideas (figure 11b).

Sample Responses to Copymaster 3.1, Blood Glucose Concentration

1. Use what you have learned about blood glucose to explain what is happening at each of the points indicated on the graph on page 87. Keep in mind that the only time that the person eats is shown on the graph. When the person starts and stops exercising is also shown on the graph. Keep these facts in mind as you analyze the graph.

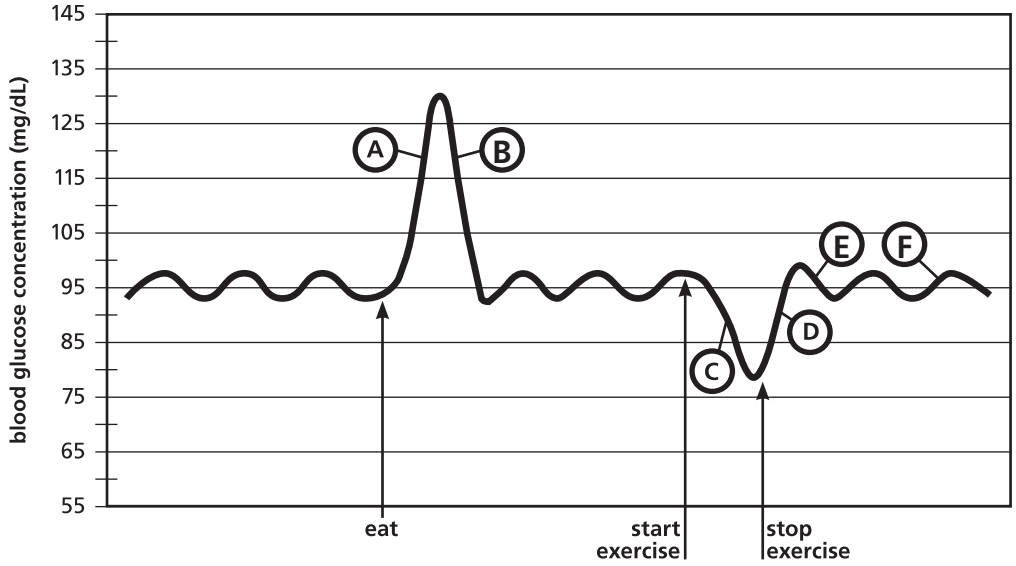


Figure 11a:
Graph from Copymaster 3.1, *Blood Glucose Concentration.*

2. What is the highest concentration of blood glucose shown on the graph?

   The highest concentration is about 130 milligrams per deciliter.

3. What is the lowest concentration of blood glucose shown on the graph?

   The lowest concentration is about 80 milligrams per deciliter.

4. Do you think the blood glucose concentration would ever get close to 0 in a healthy person, even one who goes for a long time (maybe even a couple of days) without eating? Explain your answer.

   The correct answer is that blood glucose would never become extremely low even if the person doesn't eat for an extended period of time. Students may speculate here. (The answers to this question may provide you with some information about their understanding of how the human body works in general.)

5. What is the concentration around which the blood glucose is fluctuating?

   The middle of the concentration range is about 95 milligrams per deciliter.

6. Based on the information shown on the graph, does the blood glucose ever stay at one specific concentration or is it always changing?

   The graph shows that the concentration is always rising or falling. Sometimes the changes are large, and other times they are small.

Figure 11b:
Table from Copymaster 3.1, *Blood Glucose Concentration.*

Point	Is Blood Glucose Concentration Increasing or Decreasing?	What Causes the Change in the Blood Glucose Concentration?
A	Increasing	Blood glucose concentration increases because food is broken down into glucose during digestion.
B	Decreasing	Blood glucose decreases because cells of the body use glucose to produce energy.
C	Decreasing	Blood glucose decreases because cells use glucose to produce energy.
D	Increasing	Answers will vary or students may be unsure.*
E	Decreasing	Blood glucose decreases because cells use glucose to produce the energy that they need. However, students may be unsure because the glucose concentration was previously slightly high for a reason they may not understand.
F	Increasing	Answers will vary or students may be unsure.*

**Students have not received the information yet in this lesson to be sure of the answer to this question. See the sample answers and the Note to Teacher that follow.*

7. Think about points D–F on the graph. Would you say that there is something inside the body or outside the body that is causing these small fluctuations in the blood glucose concentration? Explain your answer.

There must be something inside the body that is causing the small changes because the person isn't actively doing anything (eating or exercising) that would explain the changes.

Note to Teacher: *Question 7 is an important transition. The most important ideas for students to recognize from this graph are that the blood glucose concentration fluctuates around a certain concentration (approximately 95 milligrams per deciliter) and that the body must have some internal mechanism for regulating the blood glucose concentration. At this point, students will not be able to explain what causes some of the changes in blood glucose concentration because the changes are not triggered by eating or exercise. This will set the stage for students asking how the body does this. If students have trouble understanding that the graph suggests that the body has a mechanism to regulate blood glucose and keep it at a specific*

concentration, ask them to consider what else could explain it if it isn't something happening inside the body. They most likely won't be able to suggest any alternatives that are probable. The fact that they can't think of anything external that is feasible should suggest to them that the regulatory mechanism is internal.

4. If students think that the body has a way to control the concentration of blood glucose, ask if they can think of other examples of things that the body regulates.

Examples of things that the body regulates include the following:

- Body temperature
- The amount of water in the body
- pH
- The amount of respiratory gases (oxygen and especially carbon dioxide)

If students are unable to answer this question and provide an example, suggest that temperature is something that the body can control. This is something that they would be familiar with. Knowing that there are other things that the body regulates will reinforce the idea that the body has a mechanism to regulate blood glucose.

5. Tell students that before they think about how the body controls glucose, they will consider a different example of how something is controlled. The example that they will consider is driving a car. Give each student a copy of Copymaster 3.2, *Controlling the Situation*. For Part 1 of the copymaster, ask students to fill in the answers as you go through a class discussion. Guide the discussion using the following questions:

- **"What is the fuel for the car?"** Answer: Gasoline.
- **"What part of the car uses the fuel?"** Answer: Engine.
- **"What part of the car carries the fuel to the engine?"** Answer: Gas line.
- **"What part of the car makes it go faster?"** Answer: Accelerator.
- **"What part of the car makes it slow down?"** Answer: Brakes.
- **"What decides if the car is going too fast or too slow?"** Answer: Driver.
- **"What is the driver doing right before making a decision?"** Answer: Observing and assessing the surroundings.
- **"What does the driver do after making a decision?"** Answer: Adjust speed.

Desired answers to the questions are provided next to the questions above. (Obviously, the questions and answers suggest you are talking about a typical gasoline-powered car, not one that runs on an alternative fuel.)

6. Ask students to now complete Part 2 on Copymaster 3.2. They can either work individually or discuss their ideas with a classmate. After students complete the graph, ask for two to three volunteers to sketch their graphs on the board.

Figure 12:
Regulating the body.
iStockphoto/Julián Rovagnati

Figure 13:
Driving a car.
Dreamstime/Kathy Wynn

The graphs that different students create may look slightly different in terms of how far apart on the *x*-axis events occur. Some graphs may have sections indicating a constant speed between events. The important thing is that the graph should reflect changes in speed shown by a curve that has ups and downs.

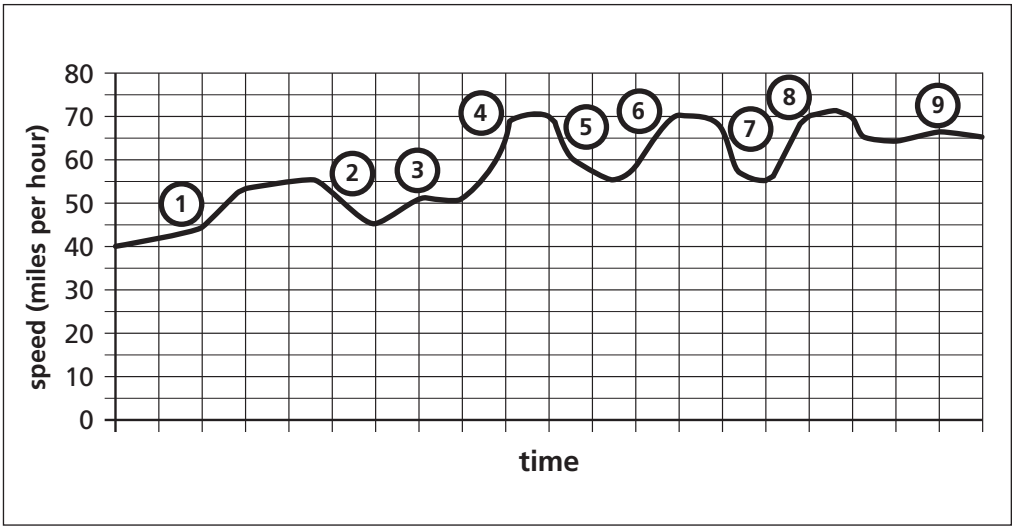


Figure 14:
Sample answer to Copymaster 3.2, *Controlling the Situation, Part 2*.

7. Ask students if their graphs show control of the car's speed in response to changes in the surroundings.

   Students should recognize that the graph, drawn in response to certain events described in the reading, indicates a control over the car's speed.

8. Explain to students that the car example actually has some similarities to how blood glucose is regulated. Ask students to look at Part 1 on Copymaster 3.3, *How Does the Body Regulate Glucose?*, and fill in the table as they participate in a class discussion. Use the following questions to guide the discussion. As you work through the questions, students won't have the information to answer some questions. Leave them blank at this point. In the next step, students will get additional information that will help them answer the questions:

   - "What is the fuel that the body uses? Answer: Glucose.
   - "What part of the body uses that fuel?" Answer: Cells.
   - "What carries the fuel to different parts of the body?" Answer: Blood.*
   - "What substance gets more fuel to the parts of the body that need it?"
   - "What substance helps the body store fuel for later use?"
   - "How does the body know if it has the right amount of fuel?"

   Responses that students should know at this time are provided next to the appropriate question. The * indicates an answer that students are likely to know;

if not, the information will be clarified in the next step. The missing answers represent information the students haven't been exposed to yet in this lesson, so they probably will not be able to answer these questions yet.

9. Ask students to organize into teams of three students. Ask them to read the information in Part 2 to learn more about how the body controls the blood glucose concentration. After students read the information in Part 2, ask them to add any appropriate information to Part 1.

Students should work together to read and understand the information provided. As students work, circulate around the room to make sure they understand the analogy between the car example and regulation of the blood glucose concentration.

10. Conduct a class discussion to ensure that students understand how insulin and glucagon regulate the concentration of glucose in the blood. Give students an opportunity to ask any questions about the car analogy or glucose regulation.

Car	The Body
Gasoline	Glucose
Engine	Cells
Gas line	Blood
Accelerator	Insulin
Brakes	Glucagon
Driver	Feedback system or pancreas

Figure 15:
Sample answers to Copymaster 3.3, *How Does the Body Regulate Glucose?*

This is likely to be a challenging activity for many students. It is possible that some students will interpret the "accelerator" and the "brakes" in the model differently. In this model, insulin represents the accelerator in that insulin gets more "fuel" (glucose) into the cells where it is used. To elaborate the analogy further, glucose can only be used by the cells when it gets into them—cells can't use glucose for energy production when it is in the blood. That compares with the fact that the engine of the car can't use the gas that is in the gas line—it has to get to the engine before it can go faster. The accelerator causes more gas to be available for use by the engine, somewhat like insulin enables more glucose to move into the cells where it can be used.

However, students may think that insulin is the brake because it lowers the amount of glucose circulating in the blood. (When glucose moves from the blood into the cells, the concentration of glucose in the blood decreases and the concentration of glucose

inside the cells increases.) Glucagon in this interpretation would be the accelerator because its action is opposite that of insulin on the blood glucose concentration and causes more glucose to be in the blood. This interpretation is based on the level of glucose in the blood, not in the cells. If students identify these two hormones differently in the model, you can be sure that they are working hard to understand it—just make sure their explanations are consistent with the information provided. Like most models, this one has strengths and limitations but can still be a helpful way to help students put several pieces of information together. It is probably helpful if, before moving on, everyone agrees with the roles for insulin and glucagon listed in figure 15.

11. Explain to students that scientists often construct models to help them understand a phenomenon. Models can help by providing a comparison to a situation they already understand. However, models are not perfect. Sometimes, most comparisons work, but there are others that don't fit so well. In this activity, students have been comparing a car and its speed with the body's use of glucose. Ask students to "brainstorm" ways in which this comparison works well and to identify ways in which it doesn't work as well.

You can conduct this brainstorming session in one of two ways. You can either do it as a full class discussion or you can give students about five minutes to discuss ideas with a partner before sharing with the entire class.

Possible responses include the following:

Strengths of the Model

- Regulation of blood glucose and a person driving a car both involve responding to the environment.
- Both systems involve components that have opposite effects from each other.

Limitations of the Model

- A person makes conscious decisions when driving. Control over the blood glucose concentration is not under a person's voluntary control.
- Depending on how you define the roles, insulin could be either analogous to the accelerator or the brakes. The same is true for glucagon. This could lead to confusion.
- The body doesn't have a "driver" in a tangible way. (Exactly how the body senses changes in the glucose concentration is a complicated process.)
- The body maintains the blood glucose concentration in a relatively narrow range. Unlike a car that can slow down to zero or just a few miles per hour, the blood glucose concentration will never drop near zero under normal conditions.

12. Remind students that at the beginning of this lesson, they looked at a graph that suggested that the body has a way of keeping the blood glucose concentration within a narrow range. Students should now be able to define what that mechanism is. Ask students, "What does the body use to keep the blood glucose concentration from going too high or too low?"

If helpful, ask students to look again at the graph on Copymaster 3.1. Point out that the blood glucose concentration fluctuated around 95 milligrams per deciliter. Students should respond that both insulin and glucagon are important for keeping blood glucose within a normal range. You may want to remind students that this is how glucose is regulated in a person who is healthy.

Note to Teacher: *If students question the size or amplitude of the fluctuation in blood glucose concentration, you can simply point out that our bodies can respond to both small and larger fluctuations—just as a driver can make either a small or large adjustment to speed. The amount of insulin or glucagon needed varies with the degree of fluctuation in the blood glucose concentration.*

13. Ask students to return to their teams. Give each student a copy of Copymaster 3.4, *Regulating the Blood Glucose Concentration—Part 1*. Instruct students to work with their team members to complete the lower part of the diagram.

Although it may not seem intuitive to start with the bottom part of the diagram, this may be the easier part of the diagram for students to complete.

14. Review the diagram as a class. To aid the discussion, display a transparency of Copymaster 3.4. Work with the class to complete the lower part of the diagram. Ask students to explain what should be added to each box. (See Figure 16 on page 94.)

Copymaster 3.4 is designed for students to summarize the sequence of events that happen when the blood glucose concentration decreases. When class members reach agreement about what belongs in each box, write the responses in (or next to) each box.

15. Give each student a copy of Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2*. Ask students to work individually to complete the information in the diagram. Instruct students to also complete the summary at the bottom of the page.

On Copymaster 3.5, students will summarize the sequence of events that occur when a person's blood glucose concentration increases. Students should complete this copymaster in a similar fashion to how they completed the previous one. Having students work individually will enable you to assess each individual's understanding of the process.

Assessment Opportunities
As written, students work in small teams on part of the activity, but then work independently to complete the worksheet. However, having students complete Copymaster 3.5 individually before a class discussion may provide an assessment opportunity for you and enable you to assess each student's understanding.

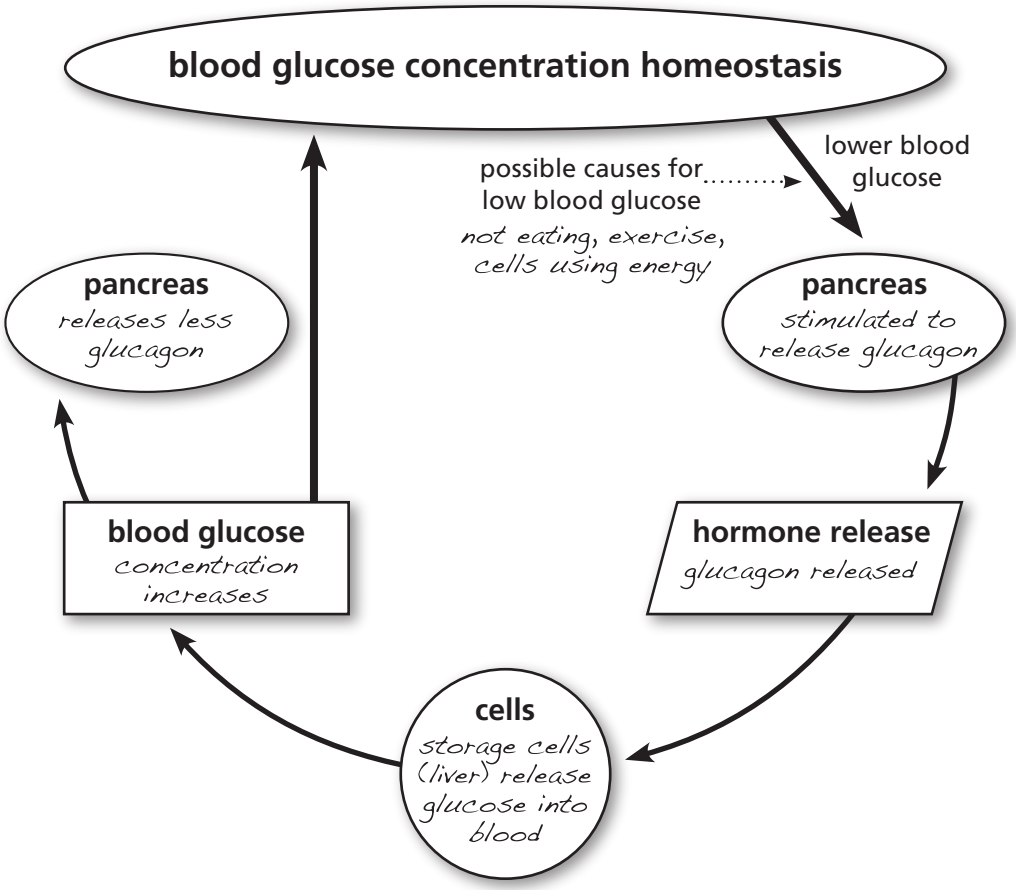


Figure 16:
Sample answers to Copymaster 3.4, *Regulating the Blood Glucose Concentration—Part 1.*

16. Display the transparency of Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2.* As before, ask students to share their ideas about what information should be added to each box.

As students reach a consensus about what belongs in each box, write their responses on the transparency.

17. Following the discussion of Copymaster 3.5, have students put Copymasters 3.4 and 3.5 together, overlapping at "blood glucose concentration homeostasis." Overlap the transparency copies of each copymaster to show students how they should be aligned.

Having both parts of this diagram put together should reinforce the dynamic feedback nature of blood glucose regulation in the body. Students may need to fold one side of Copymaster 3.4 so that it doesn't cover up information on Copymaster 3.5.

18. Ask students to look at their diagrams (Copymasters 3.4 and 3.5 together) and write two to three sentences summarizing the role of insulin and glucagon in the regulation of the blood glucose concentration. You may need to assist students in starting with their summary statements.

The goal is not for students simply to restate what is in the diagram in words.

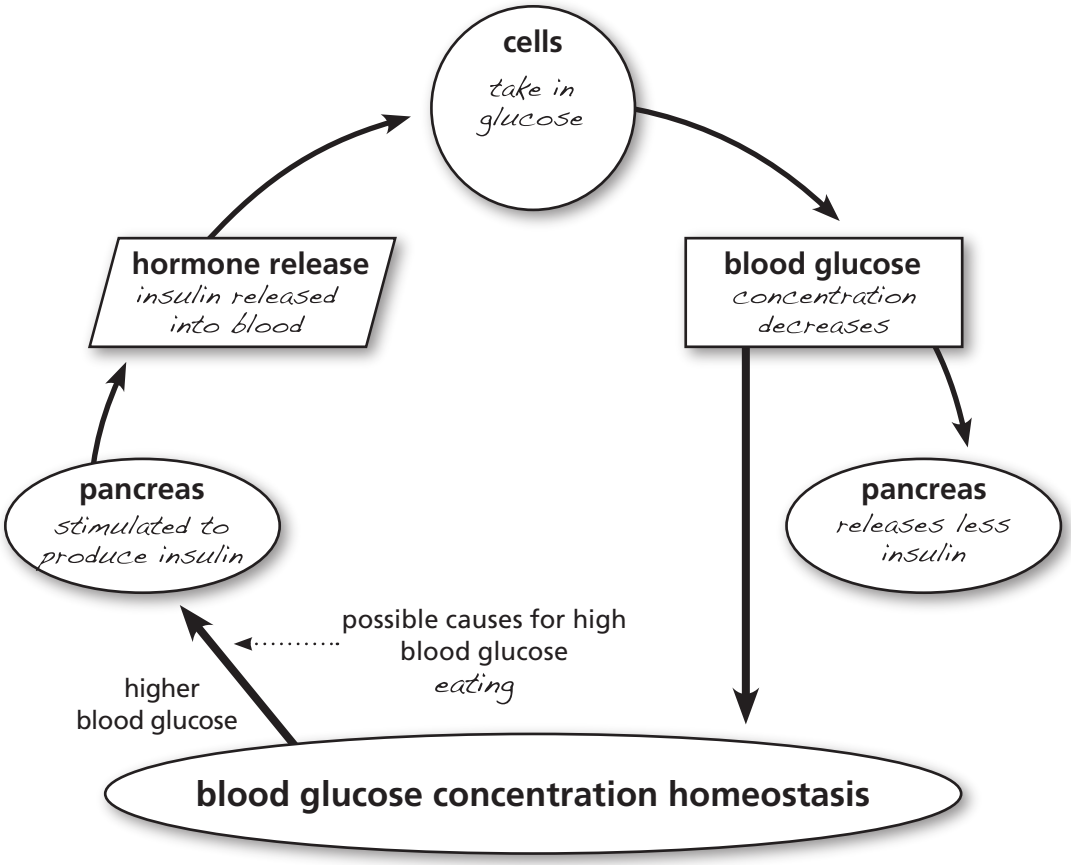


Figure 17:
Sample answers to Copymaster 3.5, *Regulating the Blood Glucose Concentration—Part 2*.

Rather, try to help students think of conclusions they can make about blood glucose, insulin, glucagon, homeostasis, and feedback. Examples of summary statements may include the following:

- "The blood glucose concentration in the body is regulated by two hormones that have opposite functions."
- "Insulin and glucagon respond to changes to the concentration of glucose in the blood to keep the glucose concentration within a narrow range."
- "Two hormones, insulin and glucagon, are released from the pancreas to keep the blood glucose concentration relatively constant."

19. Explain to students that the ability of the body to keep the internal environment stable with only small fluctuations is called homeostasis. Homeostasis is very important to our survival. Other examples of homeostasis in the body include these:

- Body temperature (Body temperature in humans is normally 98.6 degrees Fahrenheit or 37 degrees Celsius and fluctuates by about 1 degree during the day in a healthy person.)
- The amount of water in the body (Kidneys adjust the amount of water reabsorbed in the kidneys, which affects the concentration of the urine.)

- pH (The pH of the body is maintained within a narrow range.)
- The amount of respiratory gases (Carbon dioxide is more narrowly regulated; the amount of carbon dioxide in the blood also affects pH.)

Homeostasis is one of the fundamental concepts in biology. Students should be able to define homeostasis and explain why the regulation of blood glucose by insulin and glucagon is an example of homeostasis. Hormones are important in many homeostatic systems, while the nervous system plays the primary role in maintaining homeostasis in other systems (e.g., body temperature).

20. Ask students if they can think of another word to describe homeostasis.

Students may or may not think of the word "balance." If they do, explain that by keeping the internal environment within narrow ranges, the body is staying in a balanced state. If students don't think of balance, you can prompt them by asking what it means that the body doesn't let things like blood glucose concentrations or temperature get too high or too low before making corrections.

21. Wrap up the discussion by asking students if homeostasis is something a person can control or make choices about.

Students should recognize that in all the examples of homeostasis, the body has mechanisms that keep its internal environment relatively constant and within a fairly narrow range. The body does this without a person's conscious control or even awareness. This is true for blood glucose concentrations as well as body temperature, water balance, pH level, or respiratory gas levels.

22. Ask students to get out their copy of Copymaster 1.3, *Summarizing Diabetes*. Allow students a few minutes to answer any additional questions on the copymaster or to add information to any of their answers.

The new information that students can gain from Lesson 3 to add to or supplement their answers is shown in figure 18. The information that students may have written during the previous lessons is shown in italics.

Figure 18:
Sample answers to Copymaster 1.3, *Summarizing Diabetes*, after Lesson 3

Question	Type 1 Diabetes	Type 2 Diabetes
What are the symptoms?	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *flulike symptoms* *weak* *confused*	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *weak* *tired*
What is wrong in the body?	*blood sugar (glucose) level too high*	*blood sugar (glucose) level too high*
Who gets diabetes?	*usually teens or younger get type 1*	*used to be only people over 40, but now young people get it also*
How common is diabetes?	*not common among Native Americans*	*frequent in Native American populations*
Why is blood glucose (blood sugar) important in the body?	*the main type of sugar used for energy production in cells*	*the main type of sugar used for energy production in cells*
Where does the glucose in the blood come from?	*Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.*	*Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.*
What body organ isn't working correctly?	The pancreas isn't working correctly.	The pancreas isn't working correctly.
What controls the glucose concentration in the blood normally?	The hormones insulin and glucagon are part of a body system that regulates blood glucose levels. Insulin lowers the blood glucose concentration, and glucagon increases the blood glucose concentration.	The hormones insulin and glucagon are part of a body system that regulates blood glucose levels. Insulin lowers the blood glucose concentration, and glucagon increases the blood glucose concentration.
What is the problem with insulin?		
Can people with diabetes have a good life? Explain.	*yes—he is healthy again, can play sports and can be an example for other kids*	
What do people do to manage their diabetes?	*insulin shots required* *healthy diet* *exercise* *monitor their blood sugar (blood glucose) levels with a meter several times a day* *A1c test every few months*	*healthy diet* *increase exercise* *monitor their blood sugar (blood glucose) level with a meter* *take pills* *get insulin shots part of time* *A1c test every few months*
Besides physical problems, how can diabetes affect a person's life?	*worst nightmare* *depressed* *scared*	*family members sad and scared* *in denial* *feeling hopeless*
From whom can people with diabetes get information and help to keep their life in balance?	*doctor* *nurse*	*nurse* *public health nurse* *dietitian* *certified diabetes educator* *doctor*

Lesson 4
How Does Insulin Work?

At a Glance

Overview

In Lesson 4, *How Does Insulin Work?*, students develop a model to understand how the body uses insulin to regulate the concentration of glucose in the blood. Students then consider how blood glucose is affected if one of the components is abnormal.

Enduring Understandings

- Insulin controls the uptake of glucose into the cells of the body through a multistep process that includes the binding of insulin to its receptor.
- Type 1 diabetes results from a lack of insulin, whereas type 2 diabetes results from an inability of the insulin to stimulate glucose uptake as efficiently.
- In type 2 diabetes, the body requires a higher frequency of binding between insulin and the insulin receptor to elicit glucose transport.

Teacher Background

Consult the *Overview of Diabetes* section of *Introductory Information*.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to

1. understand how insulin functions to lower the blood glucose concentration.

They will demonstrate their understanding by

- modeling how insulin functions in a healthy individual and
- predicting how changes in the components of the insulin pathway would alter the blood glucose concentration.

2. explain how the insulin function is disrupted in diabetes.

They will demonstrate their understanding by

- comparing and contrasting insulin action and blood glucose regulation in type 1 and type 2 diabetes and
- summarizing how glucose gets into body cells in someone who has type 2 diabetes compared with someone who does not have type 2 diabetes.

In Advance

Teacher Materials

overhead projector (optional)

scissors

colored paper, approximately 2–3 pieces, each of 4 different colors (optional)

transparency copies of the following:

- Copymaster 4.1, *Modeling Insulin Action—the Cell* (optional)

- Copymaster 4.8, *Type 2 Diabetes and Glucose*

2–3 copies* of Copymaster 4.2, *Modeling Insulin Action—Insulin*

2–3 copies* of Copymaster 4.3, *Modeling Insulin Action—Insulin Receptors*

2–3 copies* of Copymaster 4.4, *Modeling Insulin Action—Transporters*

2–3 copies* of Copymaster 4.5, *Modeling Insulin Action—Glucose*

*(see *Preparation*)

Student Materials

For each student

1 copy of Copymaster 1.3, *Summarizing Diabetes*, from Lesson 1

1 copy of Copymaster 2.3, *What Happens to the Blood Glucose Concentration during One Day?*, from Lesson 2

1 copy of Copymaster 4.7, *Changing the System*

1 copy of Copymaster 4.9, *Cells, Glucose, and Type 2 Diabetes*

For each team of 3–4 students

1 envelope

1 copy of Copymaster 4.1, *Modeling Insulin Action—the Cell*

1 copy of Copymaster 4.6, *How Insulin Works*

Preparation

Prepare the pieces of the model that student teams will need for the activity. Photocopy Copymasters 4.2–4.5, *Modeling Insulin Action*. If you wish, you can copy each copymaster on a different color of paper. To make the model pieces more durable, you may wish to laminate them. Cut out the pieces of the model and put the pieces that each team will need into an envelope. Include approximately 10 of each model piece (insulin, insulin receptor, transporter, and glucose) in each team's envelope.

Process and Procedure

1. Review with the class the graphs that they drew of changes in the concentration of blood glucose over time (Copymaster 2.3) and of the changes in insulin and glucagon that occur in response to blood glucose changes.

You can either ask students to look at the copies of the graphs they constructed or you can draw a graph template on the board and ask students to draw the appropriate curves. Students should also remember that increases in the blood glucose concentration stimulate more insulin production and release whereas decreases in the concentration of glucose in the blood stimulate the release of glucagon from the pancreas. This discussion will give you an opportunity to assess their recall of earlier information.

2. In diabetes, there is a problem with insulin in the person's body. Although both

insulin and glucagon are important in regulating blood glucose, inform students that for the rest of Lesson 4 they will focus on insulin.

A person who has diabetes may also have some irregularities in glucagon, but the primary problem is with insulin.

3. Challenge the students to answer the question, "What happens to the glucose that is in the blood when insulin is released into the blood?" Focus the discussion on the glucose itself and not on the concentration of glucose in the blood.

This will perhaps cause students to think more fully about what they know. Students may just think that the insulin destroys the glucose somehow or causes it to be eliminated from the body through the urine. If students have difficulty with this question, ask them what the body does with glucose. Make sure that students understand that all cells in the body need glucose for energy production (ATP production).

Note to Teacher: *This is an opportunity to reinforce concepts that you may have covered in other sections of your course. During their biology course, students should learn that ATP is the "energy currency" of cells and that glucose is an important starting point in the production of ATP in the body.*

4. Inform students that they will work in teams to investigate how insulin works in the body. Divide the class into teams of three to four students. Give each team a copy of Copymaster 4.1, *Modeling Insulin Action—the Cell*, and one envelope containing the other pieces of the model.

Students will manipulate the pieces that represent parts of the insulin and glucose metabolism mechanism in the body. The pieces of the model are not to scale; they are simply shapes that students can manipulate to understand how insulin works.

5. Give each team a copy of Copymaster 4.6, *How Insulin Works*. Explain to students that one team member will read the information on Copymaster 4.6 while the other students model the process using the pieces.

As students work, circulate around the room and ask questions to probe their understanding of the reading or to identify teams that are having difficulties in manipulating the pieces in accordance with the reading.

6. After teams work through the model by manipulating the pieces, ask them to work with their teams to construct some type of graphic that summarizes how insulin works to regulate the blood glucose concentration. (See figure 19)

The nature of the graphic is up to each team, but should show a summary of the main steps involved. Teams can compare their graphic with those of other teams.

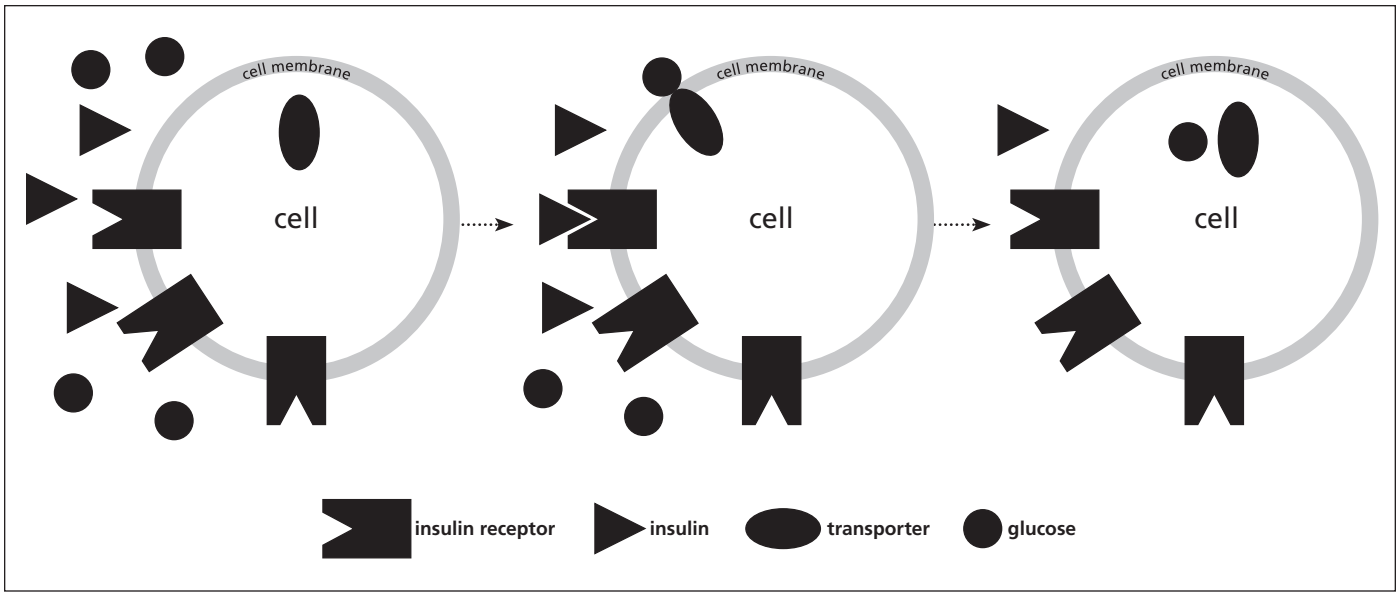


Figure 19:
Insulin and the regulation of glucose. In someone who does not have diabetes, when insulin binds to the insulin receptor, a change happens inside the cell. A series of biochemical reactions cause the transporter protein to move to the cell membrane, where it allows glucose to be carried into the cell. The insulin does not enter the cell or carry glucose into the cell directly.

Note to Teacher: *Tell students they will use the pieces of the model again in later parts of this lesson.*

7. Ask students to recall what they learned in the opening case studies in Lesson 1 about the problem that someone with either type of diabetes has. If students do not recall, prompt them to remember that, in both cases, the person's blood glucose concentration was too high.

   You may want students to get out their copies of Copymaster 1.3, *Summarizing Diabetes*, to jog their memories.

8. Students know about the basic process of how insulin reduces the amount of glucose in the blood in a healthy person. They will now use what they know to consider how the process may be working differently in someone with diabetes.

9. Ask students to continue working in their teams to suggest ways that a component of the system may change and the effect that the change would have on the concentration of glucose in the blood. Tell students to continue to use the model as a tool to help them think about the options and possible consequences. Give each student a copy of Copymaster 4.7, *Changing the System,* for them to record their ideas. Have them leave the third column blank at this point.

   For example, one component of the system is the cell. A student could say that there are fewer cells that have insulin receptors (see figure 20 on page 105). Because there are fewer cells to take in glucose, the concentration of glucose in the blood would be higher. Obviously, this isn't a very logical change because the number of cells in the body is not likely to decrease. However, at this point, students can speculate about any

changes; the main point is for them to demonstrate an understanding that changing a component of the system leads to specific consequences. Students can use the pieces of the model to help them simulate the changes they consider.

10. After students have an opportunity to think about changes to the system, hold a class discussion to let students compare their ideas. Add their ideas to the chart. At this point, ignore the third column on the chart.

You can use a transparency of Copymaster 4.1, *Modeling Insulin Action—the Cell*, on the overhead projector and the different shapes for the other parts of the system to illustrate how changes would affect the blood glucose levels. As students suggest changes, ask them to manipulate the pieces and explain how the changing one component of the system would affect blood glucose.

Students may not suggest all of the possible changes given in the sample responses. As students give changes and the effect that the change has on the blood glucose concentration, ask other members of the class if they agree with the effect. If there are

Figure 20:
Sample answers to Copymaster 4.7, *Changing the System*.

Change to Part of System	Effect on Blood Glucose (Including Reason)	Is This Something That Really Happens?
Not as many cells	Blood glucose would increase because fewer cells take it in.	
Less insulin made in the body	Blood glucose would increase because there would be less transport of glucose into cells.	
Fewer insulin receptors	Blood glucose would increase because insulin needs to bind to a receptor before glucose can be taken into the cells.	
Fewer glucose transporter proteins	Blood glucose would increase because the transporters are needed to take glucose into the cells.	
Insulin doesn't bind to insulin receptor properly	Blood glucose would increase because insulin must bind to its receptor before transporters can take glucose into the cells.	
Insulin binds to receptor but doesn't cause changes inside the cell that result in glucose entering the cell	Blood glucose would increase because less glucose moves into the cells.	
No insulin	Blood glucose would increase because insulin must bind to its receptor before glucose can enter cells.	
Less glucose in blood	The concentration of glucose in the blood remains low.	
Insulin receptors not on cell membranes	Blood glucose would increase because receptors would not be active if they aren't on the cell membrane.	

different opinions, work through them as a class to reach a consensus. Don't worry at this point that some of the changes suggested are not likely.

11. Now that the class has a list of changes to the system, ask students to think about which changes to the parts of the system are likely to occur and whether some of the changes are unlikely.

Depending on the list that students have developed, some changes may be unlikely. Changes such as a decrease in the number of cells or having receptors somewhere other than on cell membranes aren't likely to occur in a real situation.

12. After students have listed all of the options that they have thought of, work through the list and complete the third column on the table (see figure 21).

If students suggest an option and you don't know if it represents something that actually happens in the body, you can tell the students that you aren't sure, but that it probably doesn't represent something that actually happens in the body.

Figure 21:
Answers for column 3 of Copymaster 4.7, *Changing the System*.

Change to Part of System	Effect on Blood Glucose (Including Reason)	Is This Something That Really Happens?
Not as many cells	Blood glucose would increase because fewer cells take it in.	This is not a likely situation in a person's body. The number of cells in a person's body generally does not decrease (at least by any significant amount).
Less insulin made in the body	Blood glucose would increase because there would be less transport of glucose into cells.	In type 2 diabetes, the body makes less insulin than the body needs to keep the blood glucose concentration in the normal range.
Fewer insulin receptors	Blood glucose would increase because insulin needs to bind to a receptor before glucose can be taken into the cells.	This is not something that scientific studies have found to cause diabetes.
Fewer glucose transporter proteins	Blood glucose would increase because the transporters are needed to take glucose into the cells.	This is not something that scientific studies have found to cause diabetes.
Insulin doesn't bind to insulin receptor properly	Blood glucose would increase because insulin must bind to its receptor before transporters can take glucose into the cells.	This is not something that scientific studies have found to cause diabetes.
Insulin binds to receptor but doesn't cause changes inside the cell that result in glucose entering the cell	Blood glucose would increase because less glucose moves into the cells.	This is what happens in type 2 diabetes.
No insulin	Blood glucose would increase because insulin must bind to its receptor before glucose can enter cells.	This is what happens in type 1 diabetes.
Less glucose in blood	The concentration of glucose in the blood remains low.	This doesn't really consider the mechanism of insulin and glucose regulation.
Insulin receptors not on cell membranes	Blood glucose would increase because receptors would not be active if they aren't on the cell membrane.	This is not something that scientific studies have found to cause diabetes.

13. Point out to students that in this activity they have modeled some of the ways that scientists think about questions they want to investigate. Scientists often start by identifying the parts, such as the types of cells or the types of proteins or chemicals, involved in a system. Scientists then design experiments to find out which part does a specific job or which part is not working normally in a disease.

Although students are using a paper model, the general process has similarities to how a scientist approaches his or her work. Scientists want to know what parts of the body are affected and what the roles of specific cellular proteins or signaling molecules are in both a healthy person and in someone who has a disease.

14. Ask students to respond to the question, "Does the fact that scientists haven't found a certain situation mean that it never occurs?"

The fact that scientists have not found a decrease in the number of transporter proteins as a cause of diabetes doesn't mean that it never happens. This points out that scientists continue to learn and find out more about how our bodies and living systems work. Science is a continually changing body of knowledge, and there are opportunities for people to pursue science and work to find answers to these questions.

15. Display a transparency of Copymaster 4.8, *Type 2 Diabetes and Glucose*. Have students continue thinking about the way insulin works by discussing the following questions:

- "For people who have type 2 diabetes, do their cells still need glucose to function properly?"
- "If the cells need glucose, and the movement of glucose into cells doesn't work normally, how does glucose get into the cells?"

If students understand how insulin works with insulin receptors and transporter proteins to move glucose from the blood into the cells, these questions should set up a discrepancy for them to figure out in the next steps of the lesson.

16. Give each student a copy of Copymaster 4.9, *Cells, Glucose, and Type 2 Diabetes*. Have students continue to work in their teams to complete the steps on the worksheet.

Students will use the pieces of the model to complete this copymaster. One student will read the information aloud to teammates while the other team members manipulate the pieces to work through the steps.

17. After students have completed their work on Copymaster 4.9, briefly review the material as a class. Ask several teams to share their responses to the final questions. Ask if other teams agree or disagree with the responses. If there is disagreement among teams, encourage teams to ask questions for responding teams to answer.

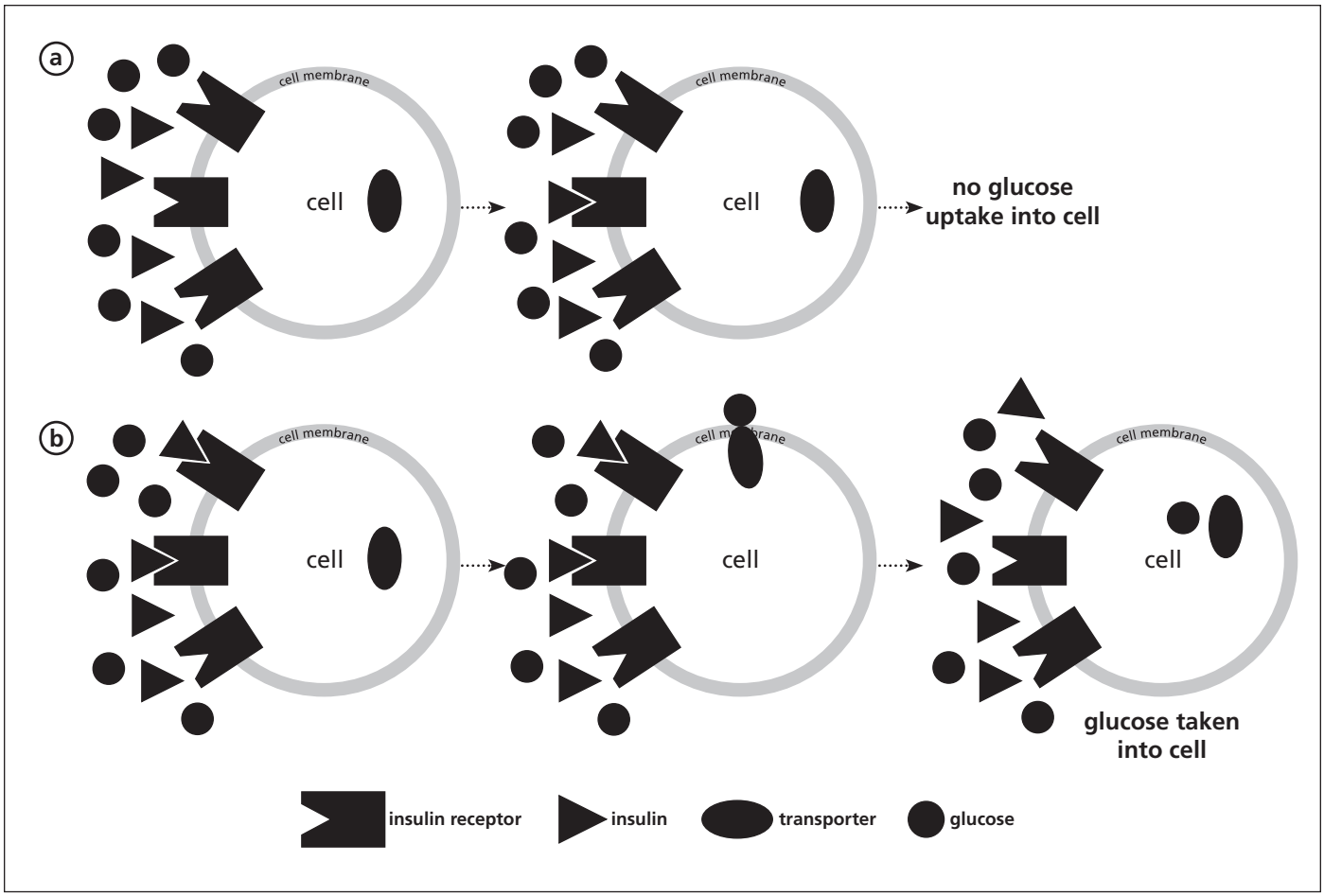


Figure 22:
Glucose transport in type 2 diabetes. In someone who has type 2 diabetes, some insulin can bind to the insulin receptor (a). However, because of some biochemical defect, the binding may not cause glucose to be taken into the cell. If more insulin receptors bind insulin, this can cause the transporter protein to be activated, move to the cell membrane, and carry glucose into the cell (b). In other words, it takes more insulin binding to more insulin receptors before glucose can be taken up into the cell. At some point, the body may not be able to produce enough insulin to meet this increased demand.

Sample Responses to Copymaster 4.9, Cells, Glucose, and Type 2 Diabetes

6a. The body can only make a certain amount of insulin. At some point, the body can't make enough. In Step 5, you modeled taking three times as much insulin binding to insulin receptors to get one molecule of glucose into the cell. What would happen if the body can only make two times as much insulin?

If it takes three times as much insulin binding to insulin receptors to cause glucose uptake into the cell, but three times as much insulin is not available, some glucose will not move from the blood into the cells.

6b. Write a few sentences summarizing how glucose gets into cells when someone has type 2 diabetes. Also explain how that differs from how it works in people who do not have type 2 diabetes.

Students' summary statements will vary, but should discuss how it takes more insulin binding to more receptors to cause glucose entry into cells. The insulin–insulin receptor interaction is less effective in type 2 diabetes than normal. (See figure 22)

Note to Teacher: *You may want to point out to students that this activity used a model that, like most models, has limitations. A major benefit of models in science is that they make a complicated process simpler. In this model, students used one or a few pieces representing insulin, receptors, transporters, and glucose. In reality, there are hundreds or thousands of molecules of insulin and glucose in the blood, receptors on cells, and transporters inside cells. Students should not take the low numbers of each of these components in the model as representative of the numbers that occur in the body. The principles demonstrated in the model are accurate, but the scale is simplified.*

18. Ask students to get out their copies of Copymaster 1.3, *Summarizing Diabetes*. Allow students time to add any new information to answer the questions on the copymaster.

The new information that students can gain from Lesson 4 to add to or supplement their answers is shown in figure 23 on page 110. The information that students could have written during the previous lessons is shown in italics.

Figure 23:
Sample answers to questions on Copymaster 1.3, *Summarizing Diabetes*, after Lesson 4.

Question	Type 1 Diabetes	Type 2 Diabetes
What are the symptoms?	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *flulike symptoms* *weak* *confused*	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *weak* *tired*
What is wrong in the body?	*blood sugar (glucose) level too high*	*blood sugar (glucose) level too high*
Who gets diabetes?	*usually teens or younger get type 1*	*used to be only people over 40, but now young people get it also*
How common is diabetes?	*not common among Native Americans*	*frequent in Native American populations*
Why is blood glucose (blood sugar) important in the body?	*the main type of sugar used for energy production in cells*	*the main type of sugar used for energy production in cells*
Where does the glucose in the blood come from?	*Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.*	*Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.*
What body organ isn't working correctly?	*The pancreas isn't working correctly.*	*The pancreas isn't working correctly.*
What controls the glucose concentration in the blood normally?	*The hormones insulin and glucagon are part of a body system that regulates blood glucose levels. Insulin lowers the blood glucose concentration, and glucagon increases the blood glucose concentration.*	*The hormones insulin and glucagon are part of a body system that regulates blood glucose levels. Insulin lowers the blood glucose concentration, and glucagon increases the blood glucose concentration.*
What is the problem with insulin?	In type 1 diabetes, the pancreas produces little or no insulin.	In type 2 diabetes, the body can't use insulin efficiently. It takes more insulin to cause glucose uptake into cells. At some point, the body can't make enough insulin to keep up with the body's needs for glucose.
Can people with diabetes have a good life? Explain.	*yes—he is healthy again, can play sports and can be an example for other kids*	
What do people do to manage their diabetes?	*insulin shots required* *healthy diet* *exercise* *monitor their blood sugar(blood glucose) levels with a meter several times a day* *A1c test every few months*	*healthy diet* *increase exercise* *monitor their blood sugar (blood glucose) level with a monitor* *take pills* *get insulin shots part of time* *A1c test every few months*
Besides physical problems, how can diabetes affect a person's life?	*worst nightmare* *depressed* *scared*	*family members sad and scared* *in denial* *feeling hopeless*
From whom can people with diabetes get information and help to keep their life in balance?	*doctor* *nurse*	*nurse* *public health nurse* *dietitian* *certified diabetes educator* *doctor*

Lesson 5
Diabetes—Why Does It Matter?

At a Glance

Overview

During Lesson 5, *Diabetes—Why Does It Matter?*, students apply their knowledge of the problem with glucose regulation to consider how the blood glucose concentration in a person who has type 2 diabetes is different from normal. Students then learn the consequences that can result from not regulating the blood glucose concentration in type 2 diabetes. They then consider how type 2 diabetes can affect many parts of a person's life, and they analyze case histories to discover examples of how a person's entire life is affected.

Enduring Understandings

- Type 2 diabetes has consequences that can be serious to a person's health.
- Maintaining a healthy weight and increasing activity can bring the blood glucose concentration within a normal range in people with diabetes. A lower blood glucose concentration reduces the chance of serious consequences.
- For people who do not currently have type 2 diabetes, maintaining a healthy weight and increasing physical activity reduces the chance of developing type 2 diabetes.
- Diabetes affects many aspects of a person's life, including the physical, mental, emotional, and spiritual.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to

1. understand that uncontrolled high blood glucose concentrations can result in physical consequences that adversely affect a person's health.

They will demonstrate their understanding by giving examples of the consequences of not managing type 2 diabetes.

2. recognize that individuals may take steps to reduce their chance of developing type 2 diabetes.

They will demonstrate their understanding by

- analyzing data from a scientific study and
- using their knowledge of blood glucose and homeostasis to explain why lifestyle changes may affect a person's risk of getting type 2 diabetes.

3. add to their understanding of how diabetes affects the balance in a person's life, including the physical, mental, emotional, and spiritual aspects.

They will demonstrate this understanding by

- considering case studies of individuals who are living with diabetes and
- assessing how individuals can take steps to restore balance in their lives, including interactions with family and community.

In Advance

Teacher Materials

overhead projector

transparency pens or markers

transparency copies of the following:

- Copymaster 3.1, *Blood Glucose Concentration* (optional)
- Copymaster 5.2, *Complications from High Blood Glucose Concentrations*
- Copymaster 5.4, *Revisiting the Circle of Balance*

Student Materials

For each student

1 copy of Copymaster 1.3, *Summarizing Diabetes,* from Lesson 1

1 copy of Copymaster 1.4, *Nick's Story,* from Lesson 1

1 copy of Copymaster 1.5, *Kim's Story*, from Lesson 1

1 copy of Copymaster 2.3, *What Happens to the Blood Glucose Concentration during One Day?*, from Lesson 2

1 copy of Copymaster 5.1, *Blood Glucose and Diabetes*

1 copy of Copymaster 5.3, *Type 2 Diabetes: Can You Lower Your Risk?*

1 copy of Copymaster 5.4, *Revisiting the Circle of Balance*

1 copy of Copymaster 5.5, *Updates from Nick and Kim*

For half the class

1 copy of Copymaster 1.4, *Nick's Story*, from Lesson 1

1 copy of Copymaster 1.5, *Kim's Story*, from Lesson 1

Process and Procedure

1. Ask students to look at their copies of Copymaster 2.3, *What Happens to the Blood Glucose Concentration during One Day?*, which they completed in Lesson 2. Remind students that the blood glucose concentration graph that they drew represents the blood glucose concentration in a person who does not have diabetes.

If students can't locate this graph from Lesson 2, you can display a transparency of Copymaster 3.1, *Blood Glucose Concentration*, from Lesson 3, *Keeping Blood Glucose in Balance.*

2. Give each student a copy of Copymaster 5.1, *Blood Glucose and Diabetes*. Have students return to their teams of three and work through the questions on the copymaster.

As you circulate among the teams, check their understanding from previous lessons and ask them to explain the reasoning behind their answers to the questions.

3. After teams have had the chance to work through the questions on the copymaster, reassemble the class for a discussion. Ask for two or three volunteers to sketch their graphs on the board. Go over the questions from Copymaster 5.1.

If there are different ideas, try to build consensus among students as to what is correct.

Sample Responses to Copymaster 5.1, Blood Glucose and Diabetes

1. Look at your graph of blood glucose concentration that you drew in Lesson 2. That graph showed how blood glucose concentration changes in someone who does not have diabetes. What part of the graph would be different in someone who has untreated type 2 diabetes?

   In someone who has uncontrolled type 2 diabetes, the blood glucose concentration is elevated compared with a person who does not have diabetes.

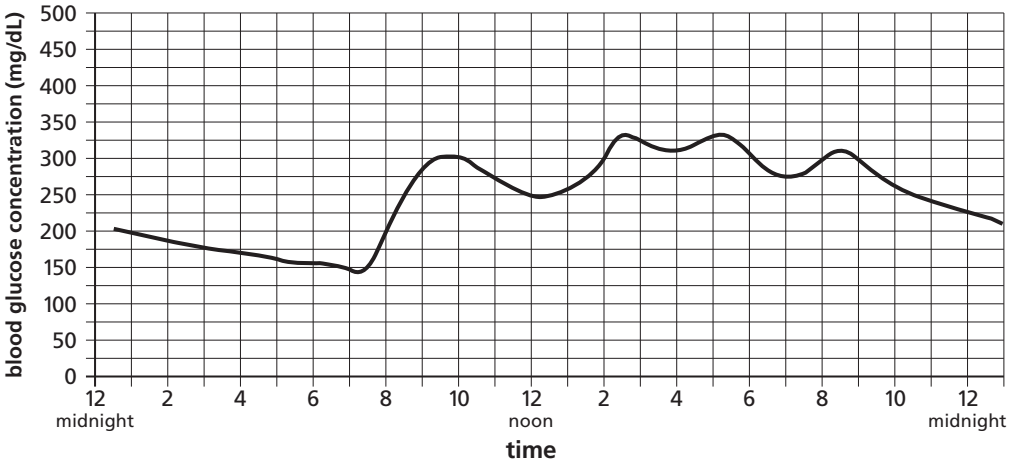


Figure 24:
Examples of student graphs—example 1.

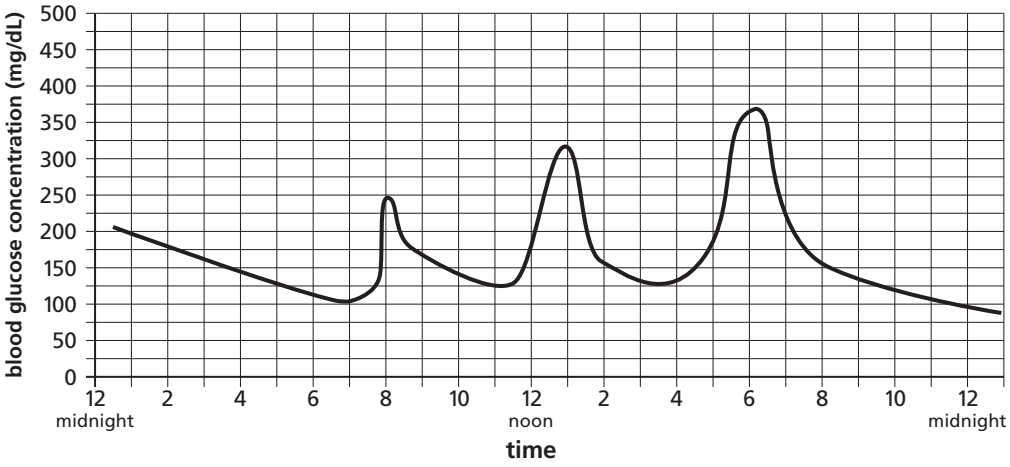


Figure 25:
Examples of student graphs—example 2.

2. Use what you have learned about type 2 diabetes to draw a graph of blood glucose concentration in someone who has untreated type 2 diabetes.

Students will likely draw graphs with different shapes. The important things to look for are (1) the glucose concentration for someone who has type 2 diabetes is higher than that of someone who does not have type 2 diabetes and (2) the concentration increases after eating and usually decreases during and after exercise. (The shape of the fluctuations does not have to be identical to those seen in the blood glucose concentration of people without diabetes.)

3. Explain why you think this graph represents the blood glucose concentration in someone who has untreated type 2 diabetes.

The blood glucose concentration is higher in people who have type 2 diabetes than for people without diabetes. In type 2 diabetes, when insulin binds to insulin receptors, it does not cause as much change in the cell as it usually does to result in glucose entering the cell. (Although the glucose concentration increases by eating and decreases by exercise in people with type 2 diabetes, students' graphs should show a slower response to insulin secretion by the pancreas.)

Note to Teacher: ***Students may think that glucose concentrations stay elevated at a constant level. In actuality, the blood glucose concentration increases after eating and decreases during and after exercise. Remind students that even in type 2 diabetes, the person's cells need and use glucose. Insulin does lower the blood glucose concentration somewhat, but more slowly and not as strongly. As you discuss the graph with the class, you can point this out.***

4. **Ask students if they think any problems occur as a result of a person's blood glucose concentrations being high. If so, what might they be? List students' responses on the board.**

This step asks students to recall information they learned from the case studies in Lesson 1. The consequences would be the symptoms that Kim and Nick had. (Because the symptoms are caused by high blood glucose concentrations, the symptoms are quite similar in type 1 and type 2 diabetes. That is, the causes of type 1 and type 2 diabetes are different, but the consequences of each due to high blood glucose concentrations are similar.) If students can't recall symptoms, ask them to look at their summary chart, Copymaster 1.3, *Summarizing Diabetes*.

5. Display a transparency of Copymaster 5.2, *Complications from High Blood Glucose Concentrations*. At this point, display only the top half of the copymaster (short-term signs). Discuss any items that are not on the list students generated in Step 4.

   Many of the consequences should be similar to the ones students listed before. If students wonder why there are some symptoms or consequences listed here that they didn't learn earlier, explain that not everyone will have all of the symptoms. Some symptoms, such as tiredness, irritability, and lack of concentration, may affect some people more than others.

6. Inform students that these symptoms and consequences occur when someone gets type 2 diabetes. Doctors use their knowledge of these symptoms to diagnose diabetes, which they then confirm with a blood test. Now ask students if they think that there might be additional problems if someone doesn't take care of his or her diabetes and the concentration of glucose in the blood remains high for a long period, such as years.

   The purpose of this question is to get students to think about blood glucose concentration remaining out of balance for a longer period of time. They may not have the factual knowledge to respond to this, but they should speculate that being out of normal range for a period of time would lead to more severe problems.

7. Reveal the bottom part of Copymaster 5.2 (long-term consequences). You can tell students that the biological explanations for some of these consequences may be complicated. In general, they occur because high concentrations of glucose over several years can actually harm or damage organs of the body.

   This is an opportunity to present the idea that high blood glucose concentrations are really the cause of the serious health problems that people with uncontrolled type 2 diabetes frequently have. It is the prolonged high concentration of glucose in the blood that leads to problems such as blindness and circulation problems. If a person controls his or her blood glucose concentration, he or she is much less likely to experience serious complications.

   The specific details for why some of these consequences occur aren't important for students to know and are outside the intent of this curriculum. While it is important to present these facts to students, don't dwell on them because they could reinforce a fatalistic view of diabetes.

8. Ask students to write down their answers to the following questions:
   - "What things can cause the blood glucose concentration to decrease in someone who does not have type 2 diabetes?"

- **"What things can cause the blood glucose concentration to decrease in someone who has type 2 diabetes?"**

Allow students just a couple of minutes to write their answers. Then ask students to share their ideas with the class. Some of the responses will be the same for both questions. For example, exercise, which increases the use of glucose, will cause a decrease in the blood glucose concentration. This would be true for people who do and for people who do not have type 2 diabetes. Insulin also causes the blood glucose concentration to decrease, but more strongly and more quickly in people who do not have type 2 diabetes. In people who have type 2 diabetes, insulin doesn't function properly or as well to cause a decrease in blood glucose.

Another thing that students could appropriately suggest is eating less food. In the short term, food with lower carbohydrates tends to prevent the high rise of blood glucose after a meal. In the long term, lowering total calories to decrease body weight has been proven to lower blood glucose concentrations in people with diabetes.

9. Ask students whether a person can do anything to reduce the chance of getting type 2 diabetes. Ask students if they can suggest anything that might be effective at reducing a person's risk.

A person doesn't have control over whether insulin functions in his or her body. Things that a person does have control over include the amount and type of food that enters the body and how much energy is burned through exercise.

10. Inform students that scientists have done studies to find out if there are things people can do to lower their chance of getting type 2 diabetes. Tell students that they will now review the results of one study. Give each student a copy of Copymaster 5.3, *Type 2 Diabetes: Can You Lower Your Risk?* Have students divide into their teams of three to four to work together to complete this worksheet.

As students work, circulate around the room to check students' understanding. Make sure teams recognize that the scientific study only included people who did not currently have type 2 diabetes.

11. Discuss the students' responses as a class. If different teams have reached different conclusions, ask them to explain their reasoning and work toward a consensus for the correct response.

Sample Responses to Copymaster 5.3, Type 2 Diabetes: Can You Lower Your Risk?

1. Write at least three conclusions you can make from the information in the tables.

- *About one-third of the people in the control group got type 2 diabetes before the study ended.*
- *Fewer people in the lifestyle-change group got type 2 diabetes than people in the control group.*
- *Some people in each group got type 2 diabetes before the study ended.*
- *Not all the people in any group got type 2 diabetes before the study ended.*
- *The results for Native American participants were similar to the results for all ethnic groups.*

2. Based on the data, can people who do not currently have type 2 diabetes lower their chance of getting it if they lose weight and become more active? Explain your answer.

The data indicate that people who do not currently have type 2 diabetes can lower their chances of getting diabetes by making lifestyle changes. The data show that fewer people who made specific types of changes to their lifestyles developed type 2 diabetes over a three-year period than people who did not change their lifestyles.

3. Use your knowledge of the biology of type 2 diabetes to explain why changes in lifestyle may change a person's chance of getting type 2 diabetes.

Type 2 diabetes occurs when the body can't use insulin correctly for regulation of the blood glucose concentration. Eating a healthy diet would keep the blood glucose concentration more stable without as many high spikes. Exercising helps the body use glucose for energy and thus lower the blood glucose concentration. A healthy diet plus exercise would help keep the blood glucose concentration closer to the normal range.

12. Give each student a copy of Copymaster 5.4, *Revisiting the Circle of Balance*, and also display it as a transparency. Remind students that they completed a similar diagram in Lesson 1 when they read in the case studies how diabetes affected many parts of Nick's and Kim's lives. Ask students to recall the purpose of this diagram.

This diagram is intended to help students recognize that many aspects of a person's life are affected by diabetes.

13. Tell students that they will be working with this diagram again to add new information to it. Remind students of the case studies they read during Lesson 1.

Have students get out their copies of Copymasters 1.4, *Nick's Story*, and 1.5, *Kim's Story*. Now give each student a copy of Copymaster 5.5, *Updates from Nick and Kim*. Explain that students will work in teams of two and use the information in both the initial case studies and the updates to identify at least one way that each aspect (physical, mental, emotional, and spiritual) positively affected Kim's and Nick's life with diabetes.

Nick and Kim drew strength from all four aspects of their lives. Improving their physical health improved their diabetes. Their improved diabetes improved the mental and emotional areas of their lives, which in turn helped them control and manage their diabetes better. (Nick was no longer depressed; Kim was no longer in denial.) Their spiritual life was a major contributor to their positive lives. The role of their families is striking in both stories. They not only received support from their families, but their desire to help their families (preventing and controlling diabetes in family members and friends for Nick, ensuring the health of her daughter for Kim) was itself a major motivator.

The Circle of Balance diagram (Copymaster 5.4) is intended to help students recognize how many areas of a person's life may be positively affected by diabetes, and how those areas can positively affect diabetes in turn. Students may relate personal anecdotes from family or friends as they discuss this diagram.

14. Point out the outer circle in the diagram that represents family and community. Explain that community can include many things, such as people, facilities, and other resources. Ask students to think about diabetes and one's family and community.

In the updates, both Nick and Kim discussed how their families and community provide support that has helped them deal with their diabetes. In addition, both Nick and Kim give information about how they can help others in their community who are dealing with diabetes. See figure 26.

15. Ask students to summarize what they have learned in this lesson about diabetes and the effect of diabetes on the balance in a person's life. You can guide the discussion by prompting students with the following questions:

- "How are Nick and Kim creating balance in their lives?"
- "Is this different than the way people who don't have diabetes create balance in their lives?"
- "What evidence has been presented that people who have diabetes can live successful and happy lives?"

16. Again, ask students to look at their copy of Copymaster 1.3, *Summarizing Diabetes*. Allow a few minutes for students to answer any additional questions based on what they learned in this lesson.

The new information that students can gain from Lesson 5 to add to or supplement their answers is shown in figure 27 on page 122. Some of the information in this lesson reinforces information from Lesson 1. The information that students may have written during the previous lessons is shown in italics.

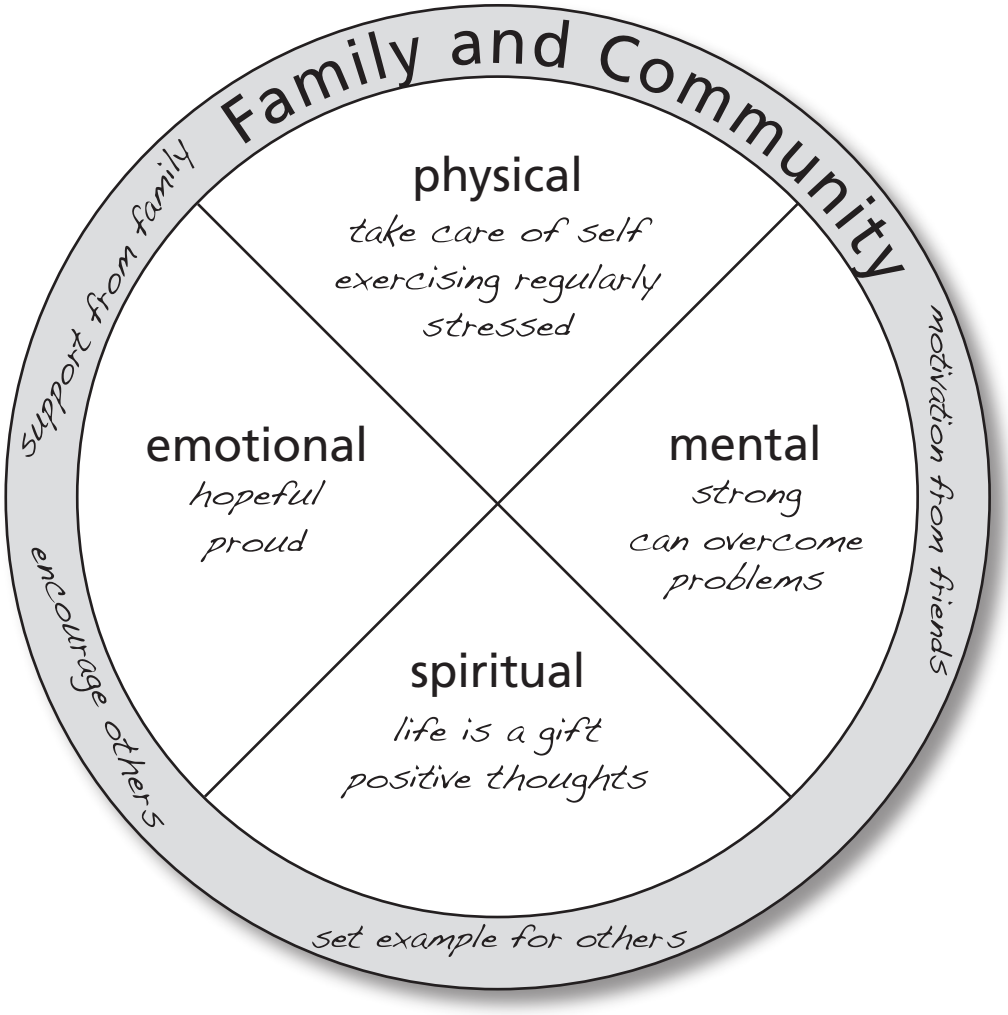


Figure 26:
Sample answers to Copymaster 5.4, *Revisiting the Circle of Balance*.

Figure 27:
Sample answers to questions on Copymaster 1.3, *Summarizing Diabetes*, after Lesson 5.

Question	Type 1 Diabetes	Type 2 Diabetes
What are the symptoms?	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *flulike symptoms* *weak* *confused* blurred vision headaches irritability long-term consequences if blood glucose concentration is not controlled	*thirsty, drink a lot of fluids* *weight loss* *going to the bathroom frequently* *weak* *tired* blurred vision headaches irritability long-term consequences if blood glucose concentration is not controlled
What is wrong in the body?	*blood sugar (glucose) level too high*	*blood sugar (glucose) level too high*
Who gets diabetes?	*usually teens or younger get type 1*	*used to be only people over 40, but now young people get it also*
How common is diabetes?	*not common among Native Americans*	*frequent in Native American populations*
Why is blood glucose (blood sugar) important in the body?	*the main type of sugar used for energy production in cells*	*the main type of sugar used for energy production in cells*
Where does the glucose in the blood come from?	*Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.*	*Glucose in the blood comes mainly from the foods a person eats, especially carbohydrate-rich foods that break down into glucose during digestion.*
What body organ isn't working correctly?	*The pancreas isn't working correctly.*	*The pancreas isn't working correctly.*
What controls the glucose concentration in the blood normally?	*The hormones insulin and glucagon are part of a body system that regulates blood glucose levels. Insulin lowers the blood glucose concentration, and glucagon increases the blood glucose concentration.*	*The hormones insulin and glucagon are part of a body system that regulates blood glucose levels. Insulin lowers the blood glucose concentration, and glucagon increases the blood glucose concentration.*
What is the problem with insulin?	*In type 1 diabetes, the pancreas produces little or no insulin.*	*In type 2 diabetes, the body can't use insulin efficiently. It takes more insulin to cause glucose uptake into cells. At some point, the body can't make enough insulin to keep up with the body's needs for glucose.*
Can people with diabetes have a good life? Explain.	*yes—he is healthy again, can play sports and can be an example for other kids* A person with diabetes can exercise, go to school, and do other activities with family and friends.	Yes; a person with diabetes can go to school, be a parent, and plan for a future career.
What do people do to manage their diabetes?	*insulin shots required* *healthy diet* *exercise* *monitor their blood sugar (blood glucose) levels with a meter several times a day* *A1c test every few months*	*healthy diet* *increase exercise* *monitor their blood sugar (blood glucose) level with a meter* *take pills* *get insulin shots part of time* *A1c test every few months* Lose weight
Besides physical problems, how can diabetes affect a person's life?	*worst nightmare* *depressed* *scared* can affect the person physically, mentally, emotionally, and spiritually	*family members sad and scared* *in denial* *feeling hopeless* can affect a person physically, mentally, emotionally, and spiritually
From whom can people with diabetes get information and help to keep their life in balance?	*doctor* *nurse*	*nurse* *public health nurse* *dietitian* *certified diabetes educator* *doctor*

Lesson 6
Sharing Your Knowledge of Type 2 Diabetes

At a Glance

Overview

In Lesson 6, *Sharing Your Knowledge of Type 2 Diabetes*, students read a case history and role-play a diabetes educator who explains the changes that occur in a person's body when he or she has type 2 diabetes. Students must employ the knowledge of the biology of type 2 diabetes that they have gained over the last five lessons.

Enduring Understandings

- Type 2 diabetes is a disease characterized by a blood glucose concentration that is higher than the normal range.
- It affects a person in many ways, but can be managed through diet and exercise.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to synthesize their understanding of diabetes.

They will demonstrate their understanding by

- explaining the biological changes that type 2 diabetes causes to a person's blood glucose concentration,
- describing the actions a person can take to get his or her blood glucose concentration closer to normal, and
- listing reasons why it is important for someone with type 2 diabetes to closely monitor his or her blood glucose concentration and keep it in balance.

In Advance

Teacher Materials

3–6 copies of Copymaster 6.1, *You Are a Diabetes Educator* (see *Preparation*)

Student Materials

For each student

notebook paper

1 copy of Copymaster 6.2, *Marilyn's Story*

Preparation

Prepare photocopies as indicated. To reduce the number of photocopies needed, Copymaster 6.1, *You Are a Diabetes Educator*, repeats the necessary information three times. Before class begins, cut the copymaster on the dotted lines. Each student in the class will get one part.

Process and Procedure

1. **Inform students that for the next activity they will play the role of a diabetes educator. Before the students can role-play the diabetes educator, they need to learn a little about what a diabetes educator does and what training that person must have.**

   Role-playing a diabetes educator is intended to give students another idea of career options involving diabetes. The primary goal for this lesson is for students to use their new understanding of the biology of diabetes as a method for you to evaluate their progress; but the information about diabetes educators will also raise students' awareness about a career opportunity.

2. **Give each student a copy of the information on Copymaster 6.1, *You Are a Diabetes Educator*. Allow time for students to read the information about a diabetes educator.**

   You can choose the most appropriate method for having students read the information on Copymaster 6.1. Students can individually read the information silently or you can ask for volunteers to read portions of the information aloud to the class while the other students follow along.

3. **Give each student a copy of Copymaster 6.2, *Marilyn's Story*. Give students time to read the story.**

   You may want to have students read the story silently or you can ask for volunteers to read it aloud to the class. Use the strategy that you think will be most helpful to your students.

4. **Inform the students that they will use what they have learned about diabetes, especially type 2 diabetes, to help Marilyn understand what is happening in her body. Explain to the students that they will need to use what they have learned in the previous lessons for their explanations to Marilyn. At this time, reinforce to students that the science content of the explanations will be the primary focus for assessment.**

   As a way to help students start thinking about their explanations, you can ask them to suggest general topics that they should include in their explanations. The discussion should not include a complete review of the specific science concepts, just some general topics that students will elaborate on in their explanations. Examples of general topics include information about

   - how insulin and glucagon are hormones (chemicals) in the body that work to keep blood glucose in balance,
   - how the insulin level in a person's body is different in type 1 and type 2 diabetes,

- what mechanism the body uses to keep blood glucose in balance, and
- what happens if the body can't keep blood glucose in balance.

Make sure students understand that they should include other points if they believe those ideas are important in explaining diabetes to Marilyn. Encourage students to include drawings if they would be helpful. Emphasize to students that they should choose the most important ideas to include in their explanations.

5. **Give students approximately 10 minutes to organize their ideas for their explanation. Ask students to outline their thoughts on paper.**

   It may be helpful to have students work with a partner for this initial organizational session as they decide what they wish to include in their explanations. As students work on their outlines, circulate around the room to monitor students' progress. If necessary, help students focus their ideas about what to include. Because this is the Evaluate activity, students should be synthesizing their own ideas. However, it may be helpful to ask them why they have selected specific points to include or exclude.

6. **After students have outlined their thoughts, allow time for them to add detail to their explanations.**

   For purposes of assessment, it is preferable for students to work individually on their explanations. For most classrooms, it is probably more feasible for students to create written explanations. However, if you wish, you could give students the option of videotaping themselves giving their explanations orally.

7. **After students have finished writing their explanations, ask them to share their ideas and explanations. Ask volunteers to each share one part of their explanation with the class. Ask if other class members included a similar idea in their explanations. Ask if all class members agree with the explanation.**

   If there are any disagreements, ask the students with discrepant views to further explain their thinking. Resolve any discrepancies and make sure that the class agrees on the scientific explanations before moving on to listen to other students' explanations.

8. **Collect each student's written explanation.**

   Each student's written explanation will be your main assessment opportunity to evaluate the student's overall understanding of diabetes and its impact on an individual's life. Students should include specific facts about the biology of diabetes in their explanations.

Assessment Opportunities

By collecting students' written explanations, you can assess how well they have learned

- the biology of blood glucose concentration regulation,
- homeostasis,

- diabetes as a disruption in homeostasis,
- the consequences of uncontrolled high blood glucose concentrations, and
- the impact of diabetes on many aspects of a person's life.

Lesson 7
Pursuing a Career Related to Diabetes Education

At a Glance

Overview

In Lesson 7, *Pursuing a Career Related to Diabetes Education*, students will perform Web research on science and health careers related to diabetes. Students will organize their material and write an essay demonstrating their understanding of both type 2 diabetes and the career of their choice.

Enduring Understandings

- Native American students are able to enter science and health careers.
- Doing a Web search for information and writing an accurate, well-supported, and organized essay are valuable skills.

Outcomes and Indicators of Success

By the end of this lesson, students should be able to

1. appreciate that many careers in science and health relate to diabetes.

They will demonstrate their understanding by

- completing a Web research project to find out more about a science or health career that interests them and
- explaining how that career can help individuals or communities learn about, manage, or reduce the risk of type 2 diabetes.

2. appreciate that they could pursue a career in health or science related to diabetes.

They will demonstrate their understanding by writing an essay explaining their interest in a given career. The essay meets requirements for a generic college application.

In Advance

Student Materials

For each student

computers with access to the Web

1 copy of Copymaster 7.1, *Science and Health Career Information*

1 copy of Copymaster 7.2, *Web Sites for Career Information*

1 copy of Copymaster 7.3, *Essay for a Diabetes-Related Career*

Preparation

If necessary, reserve the computer lab so students can do Web research.

Process and Procedure

1. **Explain to students that many careers in science or health relate to diabetes. Inform students that they will choose a career and do some brief research on the Web to learn more about it. Also, inform students that they will use the information from their Web research to write an essay about their chosen career.**

   Many science and health careers are related to diabetes. Individuals in these careers may help individuals and communities learn about diabetes so that they can reduce the risk of getting type 2 diabetes or they may treat and manage diabetes. Other careers involve doing research to discover the new ways to reduce the risk of getting diabetes and to treat and manage diabetes.

   Students don't need to be too concerned about the essay at this point. Students should focus their efforts on identifying a career that they think might be interesting to them and on learning about that career. Students will receive more information about the essay in Step 3.

2. **Give each student a copy of Copymaster 7.1, *Science and Health Career Information*, and a copy of Copymaster 7.2, *Web Sites for Career Information*. Briefly review the information on Copymaster 7.1 and make sure that students understand the nature of the research they will be conducting.**

   Students may select from a wide range of careers related to science or health. The questions on the chart should help focus students' research about their chosen career to include information such as the education or degree required, the duties and responsibilities for that career, the type of business or organization where a person in that occupation works, and how a person in that profession can serve individuals with diabetes, their communities, or both. However, inform students that they can add other career-related information that is interesting to them.

   The Web sites listed on Copymaster 7.2 provide information about science and health careers that is reliable and accurate. Students may visit other Web sites as well, but they should consider whether the other sites provide high-quality information. If your students have not done much Web research where they need to consider the quality of the material, you may need to discuss this issue with them.

3. **After students have researched a career, point out that part of becoming qualified for that profession is getting the education. The first step in getting the education is to apply for college. One of the most important parts of applying to colleges is writing an essay. Inform students that they will write an essay explaining why they are interested in going to college to become a member of their chosen diabetes-related profession.**

You may want to help students understand more about the general process of college application and selection. Many students may be unaware of the process, what information they will need for completing an application, or even where to find out about colleges.

4. Give each student a copy of Copymaster 7.3, *Essay for a Diabetes-Related Career*. Briefly go over the instructions on the copymaster with the students.

For the purposes of this unit, students will write about their interest in a diabetes-related career and education experience. Help students understand that an essay of this type is done in stages. Most people begin by writing brief ideas or an outline of what they wish to say. Then they add more detail and add examples that illustrate the point they want to make. Finally, they make revisions to make their writing clearer and to make sure that things like grammar and spelling are correct.

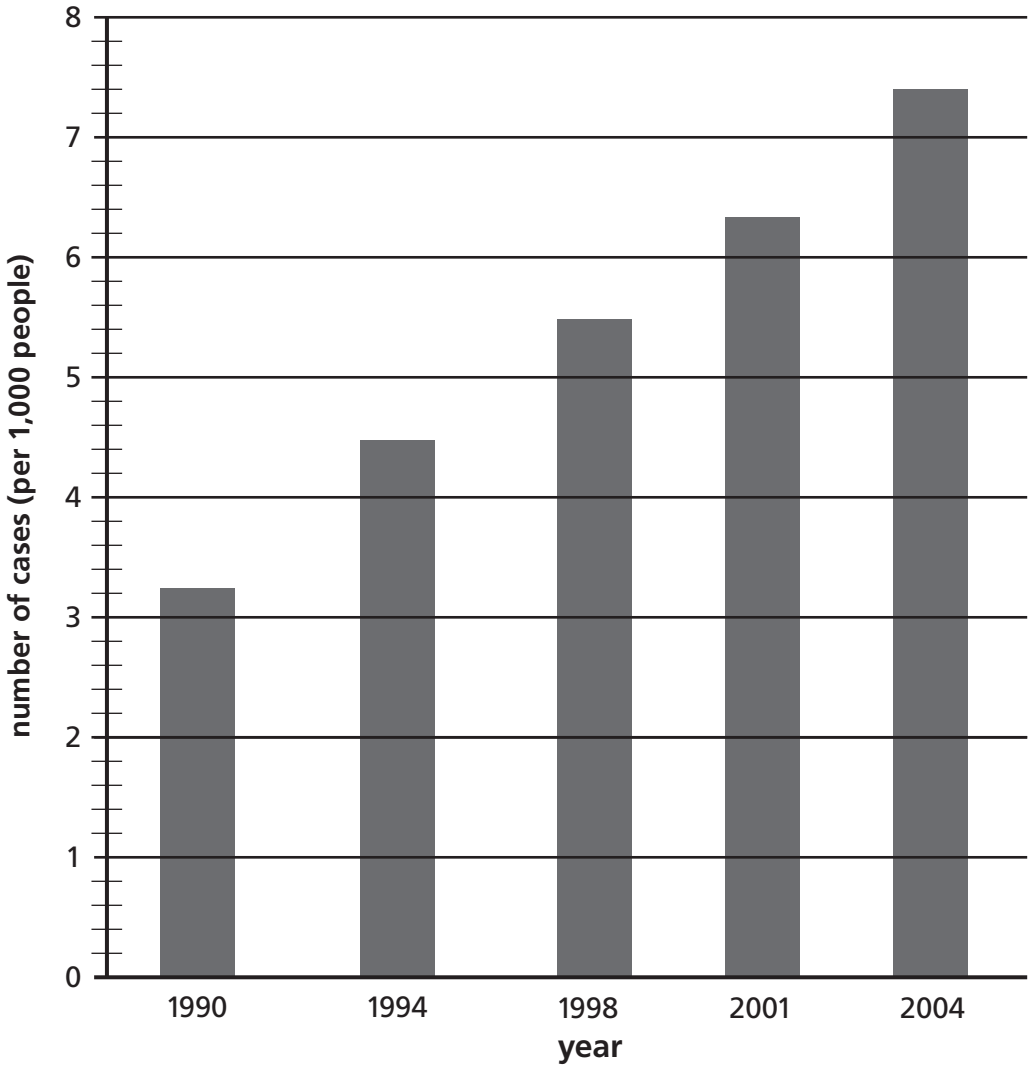
Note to Teacher: *The essay can be used for college and scholarship applications. This is an opportunity to encourage students to think about attending college. Tell students that in order to be considered for college, every student must submit an application. All applications require an essay. Usually the student is given some freedom to select the topic of the essay. This assignment will provide good experience for writing such an essay, and it could serve as the basis for the essay students actually write on their college applications.*

5. After students have completed their essays, you may wish to speak with the class or with each student individually about their essays and how they can use this experience on a real college application.

Students are likely to have varying degrees of comfort with this writing process. You may also wish to speak with a school counselor and let him or her know that students may have questions about the college application process. Some students may benefit from knowing that there are individuals in the school community who can help them go through the college application process.

Copymasters

Diabetes in Native American Adolescents, Ages 15–19



Photographs of Nick and Kim

Nick

Kim

Photos provided by Bill Freeman.

1.3

Summarizing Diabetes

Directions: For each question, write a short answer for both type 1 and type 2 diabetes. You will start completing this chart in Lesson 1 and continue in later lessons. You will not be able to answer all questions during Lesson 1—just leave those blank for now.

Question	Type 1 Diabetes	Type 2 Diabetes
What are the symptoms?		
What is wrong in the body?		
Who gets diabetes?		
How common is diabetes?		
Why is blood glucose (blood sugar) important in the body?		
Where does the glucose in the blood come from?		

1.3

Question	Type 1 Diabetes	Type 2 Diabetes
What body organ isn't working correctly?		
What controls the glucose concentration in the blood normally?		
What is the problem with insulin?		
Can people with diabetes have a good life? Explain.		
What do people do to manage their diabetes?		
Besides physical problems, how can diabetes affect a person's life?		
From whom can people with diabetes get information and help to keep their life in balance?		

1.4

Nick's Story

My name is Nicholas Scott. I'm 18 years old and I attend Northwest Indian College. I am from the Lummi Indian Reservation, located near Bellingham, Washington.

I was diagnosed with type 1 diabetes when I was 12 years old attending elementary school. Becoming a diabetic at such a young age was a child's worst nightmare. In my case, I did not know what was wrong with me. I came down with the most unbearable dehydration and flulike symptoms. I could not get enough fluids in my body so I kept on drinking glass after glass of water and juice. This process continued for about two weeks and, as I was at school, I always told my teacher that I needed to go to the bathroom and that I needed a drink of water. By the time my family took me to the doctor's office, I had lost about 20 pounds because of my lack of appetite and how many fluids were going in and out of my body.

My body was at the point in which I could no longer walk or comprehend what was going on. No one really said anything about my strange habits of going to the bathroom and drinking so much water and how tired and down I was. Then by the time I went to my family doctor, my blood sugar was so high it was unreadable by a blood sugar meter. I was rushed to the hospital where I was admitted and stayed for a week, not knowing that I was pretty much in a diabetic coma.

When I was able to get up out of the hospital bed, the first thing that the doctors and nurses did for me was teach me how to give my insulin shots in my arms and in my lower stomach, also how to regulate my diet and check my blood sugar. Over the years, I have learned how to change the amount of insulin I need and what different types of food are the best for my body. I've also learned that most of the people who get type 1 diabetes are mostly young—between when they are born and their teenage years. The one thing I learned that shocked me the most was that diabetes is most commonly found among Native Americans and I don't know why this is, but it just shows that Native Americans should take diabetes more seriously and be aware if it runs in your family. Most Native Americans get type 2 diabetes, but no matter what type of diabetes someone has, it is important to take it seriously.

After I had learned enough information about the disease, the hospital sent me home. I then went into diabetic depression. I no longer wanted to live because I thought there was no point in being part of this world if I was going to be stuck with this disease. Being the young kid I was, I felt that everything was being taken away from me, like my freedom to be a kid, and even a regular human being!

As life went along, I learned how to deal with my diabetes. I started to learn how to stay on a healthy diet and keep a well-organized schedule so I could manage my blood sugar level. The person who has helped me through my diabetes the most is my doctor, who I visit every three months. He has me on timed schedules for checking my blood sugar and, by the time the day is over, I usually check up to five times a day and give shots with every meal and every blood sugar check if needed. When I am playing sports or being more active than usual, I check my blood sugar beforehand because if my blood sugar is over 300*, I can't be active until it comes down because my body is too low on energy at that point and I could pass out or become very dehydrated. Every time I visit my doctor, I get my A1c checked to see how my diabetes is doing and how my blood sugar levels are. An A1c check is to see what my average blood sugar is for a three-month period.

Being healthy again is unbelievable. I never thought I could control the disease this well. To help my diet, I add in exercise daily. I play basketball to keep my body in shape, and to set an example for other kids who go through the same tasks that I do every day.

**300 milligrams / deciliter (mg/dL)*

1.5

Kim's Story

My name is Kimberly Marie Thiele. (My Dakota name is "Mahpiya Duta Winyan" which translates as "Red Cloud Woman." This name had been given to me by my grandmother from Canada.)

My life began on a summer day on July 17, 1987. I was born early, weighing only 3 pounds and 7 ounces. I developed yellow jaundice a couple of days later so I stayed for an extra week. Other than that, I was healthy and went home after two weeks. It took me awhile to catch up to the other kids my age but after awhile I caught up and grew up to be a healthy and happy little girl.

As I grew into my teen years, my life was good; I came from a two-parent family, had good friends, and enjoyed school. In January of 2003, I noticed that something was wrong. I was always thirsty, like really thirsty to the point where I started bringing a glass with a pitcher of water to my bedroom at night, and then of course, I was also urinating a lot, especially at night, maybe two, three times a night. I lost a lot of weight. It didn't really dawn on me to think that I may have some type of disorder like diabetes.

On April 26, 2003, in school, I had a headache, was tired, and weak. I called my father, and he came after me. We went to the clinic, and I signed up as a walk-in and waited. My name was called. They took my temp and blood pressure, etc., etc. My father asked if they could check my sugar. In the past weeks, little did I know, my father would wake up every time I went to the bathroom during the night. (He noticed how frequently I was visiting the restroom.) He suspected diabetes but didn't really think that could be it, after all, I was only 16 years old. The nurse did a blood sugar test, and my blood sugar was 670* that day. I was given a dose of insulin and was prescribed diabetes pills. (A year later, I was switched from pills to insulin.)

**670 milligrams / deciliter (mg/dL)*

I had been diagnosed with type 2 diabetes. After the doctor informed me I had diabetes, I was sent to talk to a dietitian and a public health nurse. Both of these people are also certified diabetes educators. They explained to me that the type of diabetes I had was usually found in older people but was increasingly being diagnosed in young children and teenagers. They also explained to me that I would have to do A1c testing every three to six months. (What an A1c test does is monitor the glucose control of diabetics over time; it also aids in treatment decisions.) They also taught me how to check my blood sugar and how often (twice a day), and explained that I could control my diabetes with diet and exercise.

When I was diagnosed, I never thought too much about it. It didn't really matter because I didn't know what diabetes was all about. On the other hand, my parents were heartbroken. It was heartbreaking for them because I was just 16, and they had seen what effects diabetes had on the human body and also the pain that it causes emotionally and physically.

After learning all about diabetes and that it is a lifelong disease with severe consequences if not taken care of, I went into denial big time. I told myself, "I don't have diabetes, how can I? I am only 16 years old." I wouldn't test my blood sugar, on some days I didn't take my insulin, and I ate whatever I wanted and whenever I wanted. My parents enrolled us in an educational counseling program taught by a nurse, but I wouldn't cooperate and didn't believe I needed to be there.

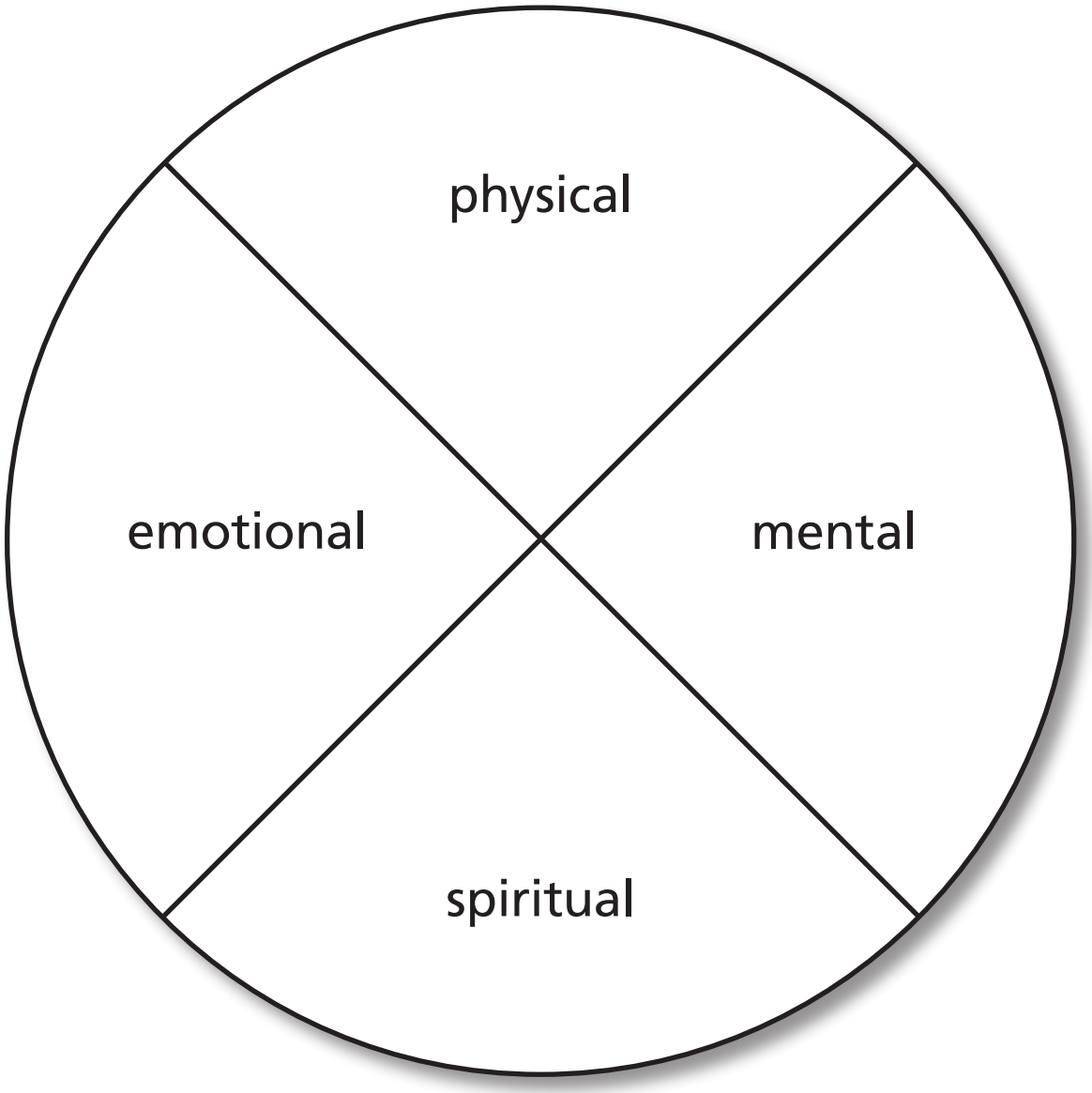
One day in school, my blood sugar became so low that I got a headache and was shaky, tingly, and confused. I got the scare of my life. After that incident, I was determined to take care of myself, and it went well for a while. Then I was back in denial and fell back into not taking care of myself again. I didn't want to be treated any different than anyone else. I figured at one point, what's the use? My death will have something to do with diabetes anyway.

1.5

In the spring of 2005, I suspected that I was pregnant, and in May it was confirmed. I didn't want to tell my parents and break their hearts again. I tried to wait a couple of more months to July when I would be turning 18 years old. I was told by my school counselor that, because of my health, if I didn't tell my parents that day that she would. I couldn't face them so I e-mailed my mom. (Yes, I know that sounds crazy but you just had to be there to understand the situation I was in.) We all went through accepting the fact, that yes, I was pregnant, and went from there. My parents supported me, especially my dad, who drove me once a month and then twice a week to the special prenatal clinic which was a 180-mile round-trip. Thank you, Dad, I love you.

1.6

Diabetes Affects the Balance in a Person's Life



1.7

Similarities and Differences

	Type 1 and Type 2 Diabetes
Similarities	
Differences	

2.1

Summarizing Digestion and Energy Production

People eat foods that are broken down by a process called _____. This process begins with enzymes in the saliva and continues as foods pass through the stomach and intestines. A main type of nutrient that the human body can use for energy is _____. After they are eaten, _____ are broken down into smaller molecules, including _____. This is the main type of sugar that circulates in the blood for cells to use. The cells use _____ to produce ATP, a chemical compound that stores energy the body can use. Calories are a measurement of the amount of energy that a food contains.

2.2

Understanding Concentration

Part 1

Directions: Work in your groups and follow the directions.

1. Decide who will get supplies from the supply table in the room.

You will need

- 5 plastic or paper cups
- 1 100-milliliter graduated cylinder
- 1 container of glucose testing strips
- 1 watch or clock with a second hand

2. Label each cup with the concentration of one of the solutions at the front of the room. The labels should read

- "0 grams per liter"
- "1.0 grm per liter"
- "2.5 grams per liter"
- "5.0 grams per liter"
- "Unknown glucose concentration"

3. Send one team member to get a sample of each solution from the large beakers at the front of the room. Use the graduated cylinder to measure 100 milliliters and pour it into the labeled cup. Rinse the cylinder with water between measurements.

4. For the next part of the investigation, you will take turns with the rest of your team members. One student will dip the test strip into one solution, another team member will time 30 seconds starting when the strip is pulled out of the solution, and all students will look at the color chart to determine the concentration. Team members should change roles for each test so everyone has a chance to do one of the tests.

5. Now get the container of glucose testing strips. Notice that there is a color chart on the side of the container. The test strips will change color depending on how much glucose is in the solution. When it is your turn to test one of the solutions, take one test strip from the container and dip the end of it into one of the solutions in your cups. Just dip it in and pull it out. Don't hold the strip in the solution. As soon as the strip is removed from the solution, begin timing for 30 seconds.

6. After 30 seconds, compare the color on the test strip with the chart on the side of the container. Determine what the concentration of the glucose solution is for each cup. Write your answers in the chart below.

Beaker Number	Concentration in Grams per Liter (g/L)	Color of Glucose Test Strip	Concentration in Milligrams per Deciliter (mg/dL)
1			
2			
3			
4			
5	Unknown		

7. Discuss the following questions with your team members. Write your answers in the space provided.

a. How does the concentration in grams per liter compare with the concentration in milligrams per deciliter?

b. What are some possible sources of error when measuring glucose concentrations this way?

c. Did the color of the test strip used on the unknown concentration exactly match the color chart? If not, how did you determine the concentration of that solution?

Part 2

1. Collect the materials that you will need for this part of the investigation.

You will need

- 1 plastic or paper cup
- 1 100-milliliter graduated cylinder
- 2 test strips
- 1 cup of 5 grams per liter glucose solution used in Part 1

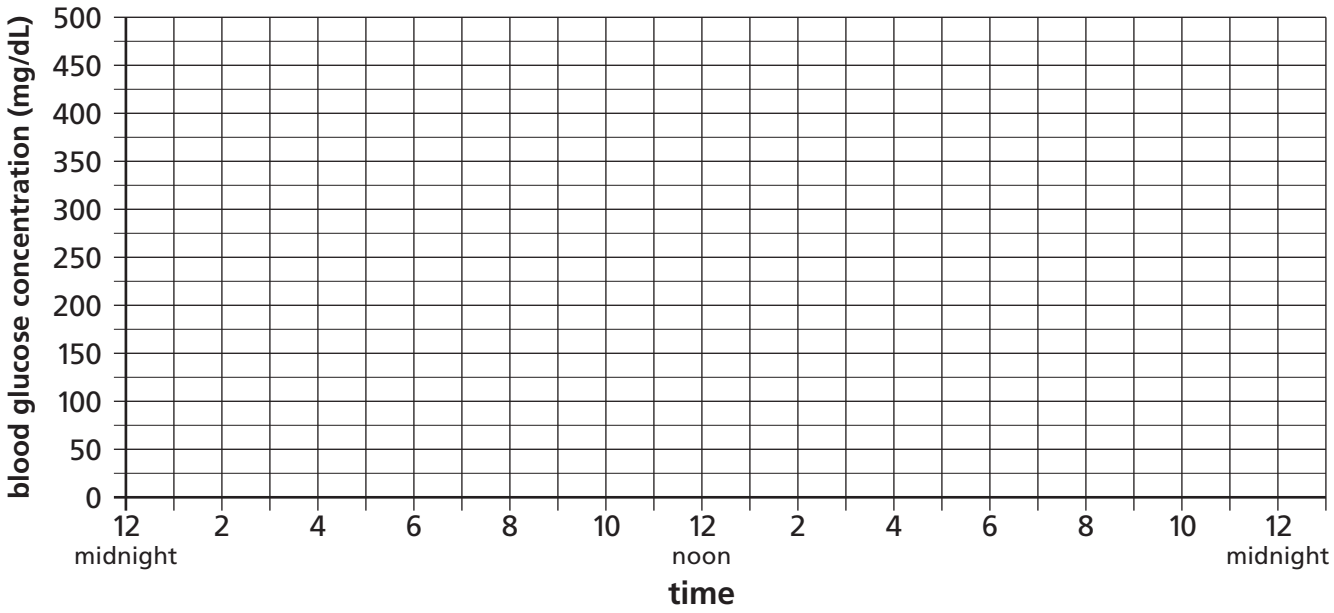
2. Have one team member get 100 milliliter of the sucrose solution that your teacher has at the front of the classroom.

3. Use the test strips again to measure the concentration in both cups. Write your results below.

4. What conclusions can you make based on your results?

2.3

What Happens to the Blood Glucose Concentration during One Day?



2.4

Sample Letter Requesting Loan of Glucose Meters

Dear Clinic Administrator or Diabetes Program Coordinator:

I teach high school biology at . I am currently planning to begin teaching a unit on type 2 diabetes to my students in about three weeks. As part of this unit, students do an experiment to measure glucose concentration in water solutions. This experiment will help them understand the concept of concentration. It will also help them understand the units of mg/dL, which are used to measure glucose concentration in humans.

I would like to borrow electronic glucose meters for my class to use. I anticipate needing a total of five meters and approximately 30 test strips for my class. Please be assured that students will not be testing any blood or body fluids. They will not be using lancets. The solutions that they will test are simply glucose and table sugar (sucrose) dissolved in water.

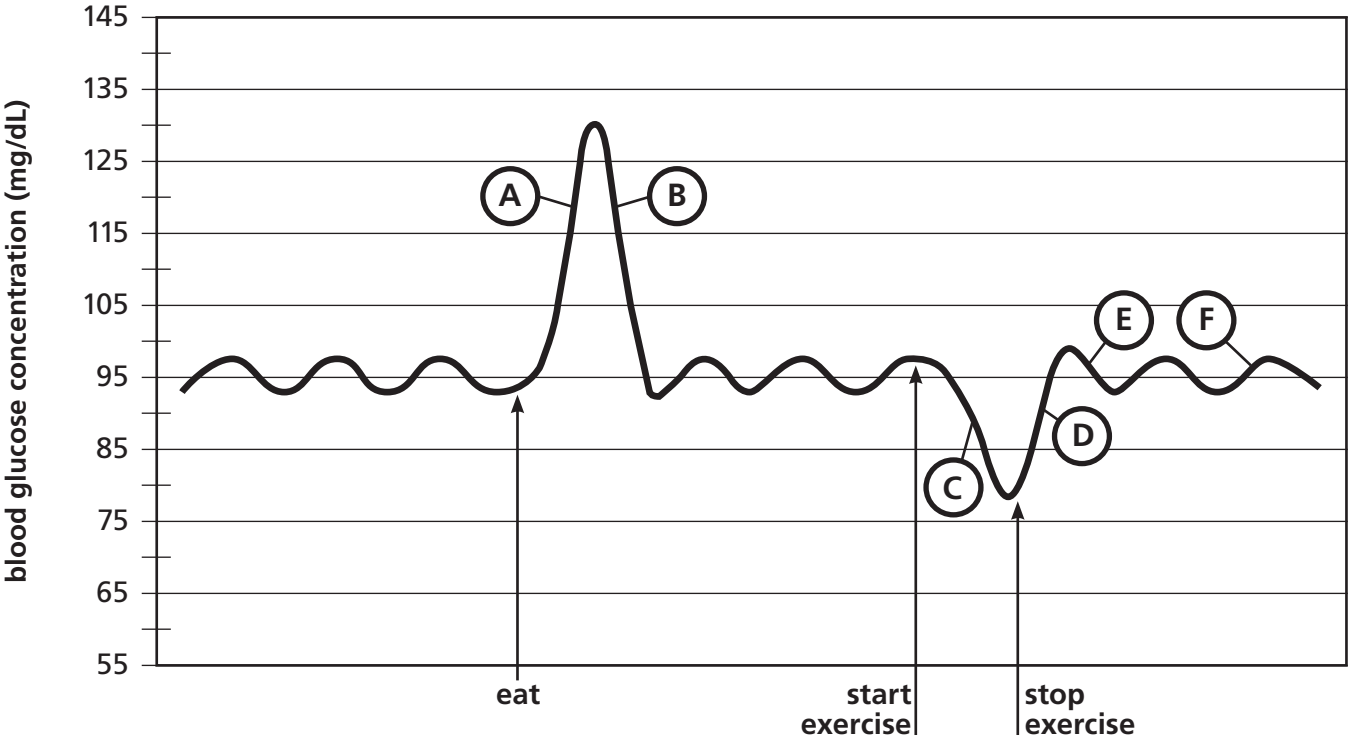
I hope that you will be able to help me with this request. If necessary, I can conduct the activity using a single meter, but fewer students will be able to actively participate. As you know, type 2 diabetes is a significant health issue, and I think this unit should help students understand more about what diabetes is and how it can be prevented or managed.

Thank you for considering this request. Please let me know if you need any additional information.

Best wishes,

3.1

Blood Glucose Concentration



1. Use what you have learned about blood glucose to explain what is happening at each of the points indicated on the graph. Keep in mind that the ***only*** time that the person eats is shown on the graph. When the person starts and stops exercising is also shown on the graph. Keep these facts in mind as you analyze the graph.

Point	Is Blood Glucose Concentration Increasing or Decreasing?	What Causes the Change in the Blood Glucose Concentration?
A		
B		
C		
D		
E		
F		

3.1

2. What is the highest concentration of blood glucose shown on the graph?

3. What is the lowest concentration of blood glucose shown on the graph?

4. Do you think the blood glucose concentration would ever get close to 0 in a healthy person, even one who goes for a long time (maybe even a couple of days) without eating? Explain your answer.

5. What is the concentration around which the blood glucose is fluctuating?

6. Based on the information shown on the graph, does the blood glucose ever stay at one specific concentration or is it always changing?

7. Think about points D–F on the graph. Would you say that there is something inside the body or outside the body that is causing these small fluctuations in the blood glucose concentration? Explain your answer.

3.2

Controlling the Situation

Part 1

Directions: As you take part in the class discussion, answer the following questions:

a. What is the fuel for the car? _____

b. What part of the car uses the fuel? _____

c. What part of the car carries the fuel to the engine? _____

d. What part of the car makes it go faster? _____

e. What part of the car makes it slow down? _____

f. What decides if the car is going too fast or too slow? _____

g. What is the driver doing right before making a decision? _____

_____

h. What does the driver do after making a decision? _____

Part 2

Directions: Use the information provided to draw a graph of the speed of the car.

1. You turn from a city street where the speed limit is 40 miles per hour onto a highway where the speed limit sign says 55 mph. What do you do?

2. You see something on the road in front of you. Because it is far away, you can't tell what it is, so you make a decision about your speed. What do you do?

3. When you get closer, you see that it is just a big piece of tire from a semitruck. You again make a decision about your speed. What do you do?

4. Next you see a sign saying that the speed limit is 70 miles per hour. What do you do?

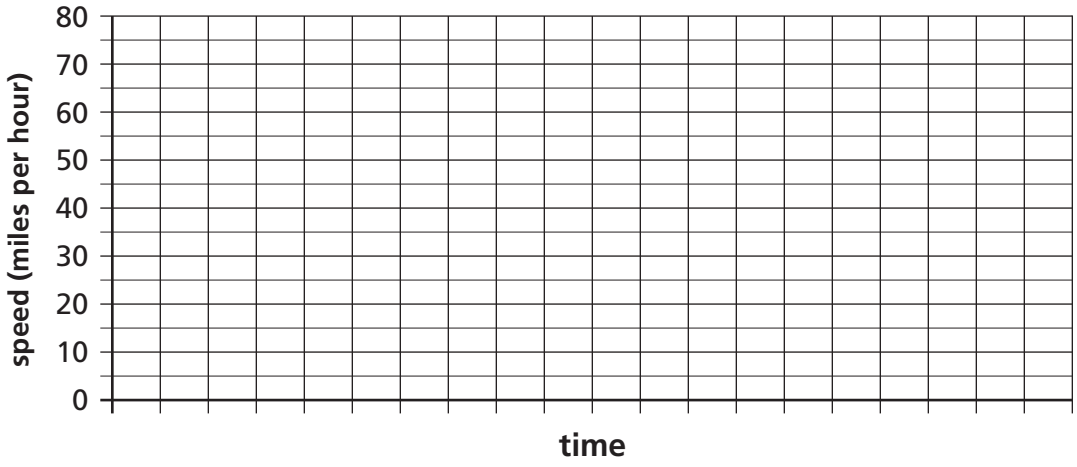
5. Then you see a state police car up ahead. The police officer is standing next to the road talking to someone who has car trouble. How do you adjust your speed?

6. You get past the police car, and the road ahead is clear. What do you do?

7. Up ahead, you see several cars and notice that you are coming up behind them quickly. What do you do?

8. After a little while, you notice that the cars in front of you are moving faster again. What do you do?

9. You see a sign telling you the speed limit is 65 miles per hour. It is a clear day, and the road is good. What do you do?



3.3

How Does the Body Regulate Glucose?

Part 1

Directions: Complete the second column of the table as you take part in the class discussion. What parts of the body have some similarity to the car scenario?

The Car	The Body
Gasoline	
Engine	
Gas line	
Accelerator	
Brakes	
Driver	

Part 2

The body normally keeps the blood glucose concentration between about 70 and 140 milligrams per deciliter. To do this, your body has to have a way to determine when the amount of glucose in the blood is either low or high. Two hormones play important roles in keeping the glucose concentration in this normal range. Hormones are a type of chemical messenger in the body. They are released from specialized cells or glands into the blood.
The blood carries them to other cells where they cause a specific response. The two hormones that regulate glucose in the body are insulin and glucagon. Both hormones are made by cells in the pancreas.

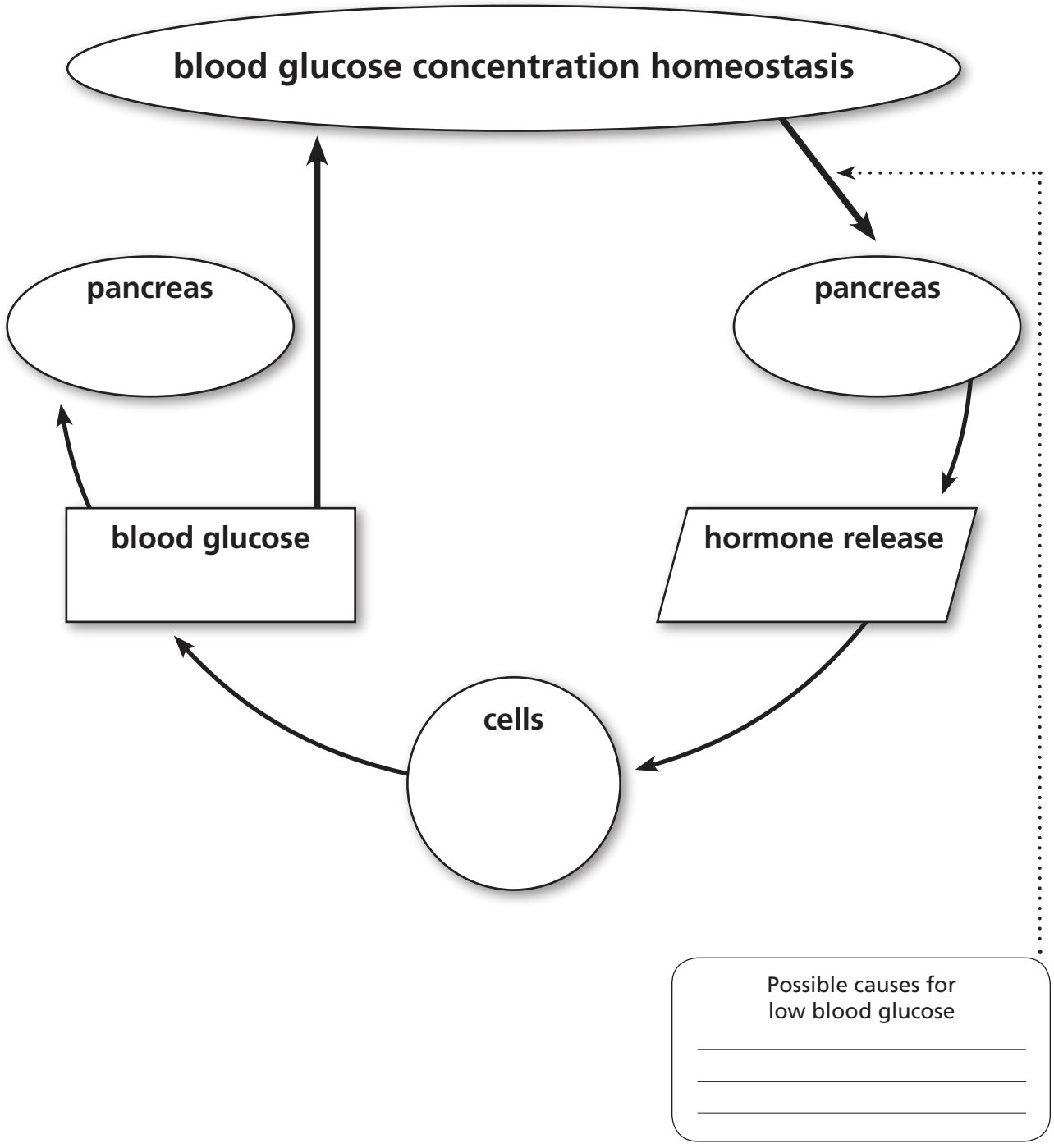
Insulin and glucagon have opposite effects to control the concentration of glucose in the blood. The pancreas always makes and releases small amounts of insulin and glucagon. As you have learned, when a person eats carbohydrates, they are broken down into glucose, and the amount of glucose in the blood increases. The body detects this increase in blood glucose and triggers specific cells in the pancreas to release insulin. The insulin acts on many other cells in the body so they can take up the glucose. This lowers the concentration of glucose in the blood. Glucagon is released from the pancreas when the concentration of glucose in the blood is low. Glucagon stimulates primarily the cells of the liver to release stored glucose into the blood. This makes the blood glucose concentration increase.

It is the controlled release of both of these hormones that keeps the blood glucose concentration within the normal range. Eating carbohydrates stimulates the release of insulin from cells of the pancreas. The glucose inhibits or "turns off" the release of glucagon from the pancreas. Insulin in the blood also inhibits the release of glucagon. When the concentration of glucose in the blood is low, the cells in the pancreas that produce glucagon are stimulated and they release their hormone into the blood. This coordinated release of insulin and glucagon and is an example of a feedback system. A feedback system can be defined as a situation in which one activity of a body system affects another, which in turn affects the first. Feedback systems are important ways in which the body maintains balance. A high blood glucose concentration triggers the release of insulin. When the blood glucose concentration decreases, it signals the pancreas to stop releasing insulin. When the blood glucose concentration is low, cells in the pancreas are stimulated to release glucagon. When the blood glucose concentration increases, the cells release much less glucagon.

The cells of the pancreas can sense small changes in blood glucose concentration. Because they are so sensitive, the cells of the pancreas can respond to changes before the blood glucose concentration can increase or decrease much. This is also a constant process. If a person eats a meal with a lot of carbohydrates, a larger amount of insulin will be released. If a person eats a meal with less carbohydrates, the pancreas releases a smaller

amount of insulin. In the same way, the amount of glucagon that is released depends on how close or how far below normal the blood glucose concentration is.

The actions of insulin and glucagon to control the amount of glucose in the blood, along with feedback mechanisms that can either turn on or turn off the release of these hormones into the blood, are all part of homeostasis. Homeostasis refers to the processes used by the body to maintain conditions within a narrow range. For example, the body normally maintains blood glucose concentrations at around 95 milligrams per deciliter (mg/dL) in a healthy person. After a person eats and the blood glucose concentration is high, insulin works to lower the level to around 95 milligrams per deciliter (mg/dL). If the blood glucose concentration is low, glucagon released into the blood functions to increase the concentration. Therefore, by making adjustments to raise or lower the blood glucose concentration, the body can maintain a relatively stable environment.



Directions: Use your knowledge of homeostasis, insulin, and glucagon to fill in the blanks on the diagram below.

3.5

Possible causes for high blood glucose

_____

_____

_____

cells

hormone release

blood glucose

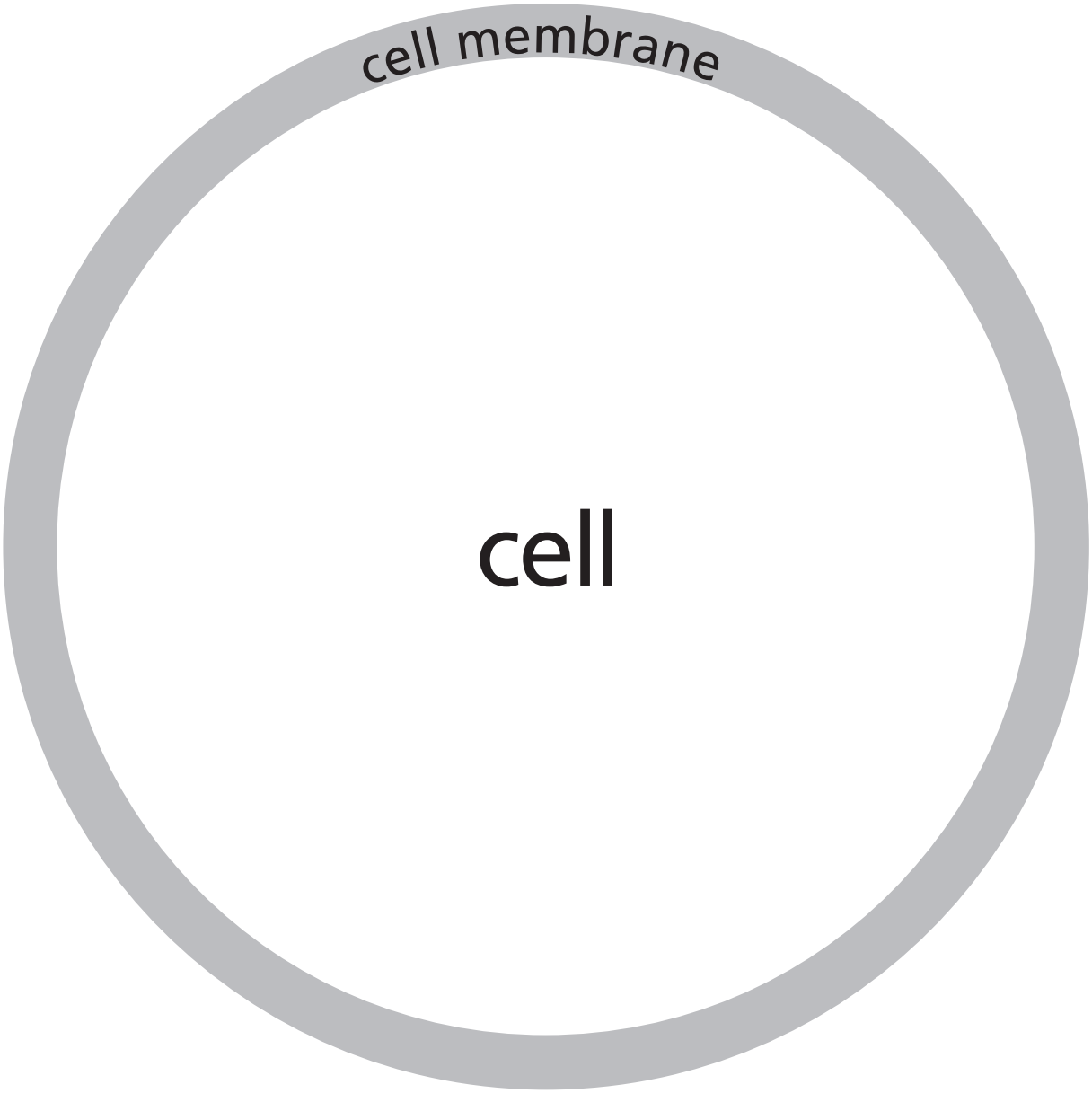
pancreas

pancreas

blood glucose concentration homeostasis

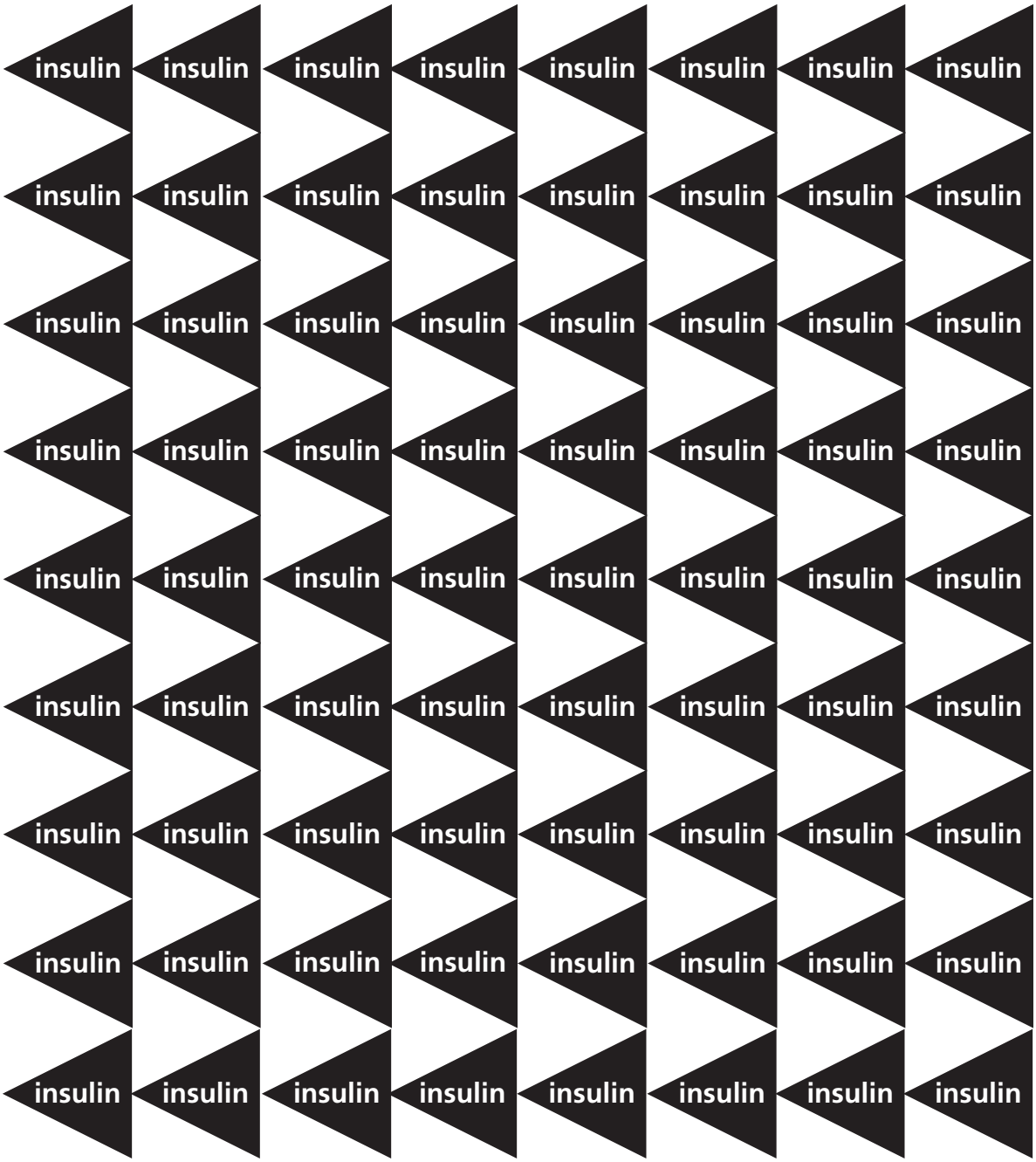
4.1

Modeling Insulin Action—the Cell



4.2

Modeling Insulin Action—Insulin



4.3

Modeling Insulin Action—Insulin Receptors

insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor
insulin receptor	insulin receptor	insulin receptor	insulin receptor

4.4

Modeling Insulin Action—Transporters

transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter
transporter	transporter	transporter	transporter

4.5

Modeling Insulin Action—Glucose

glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose
glucose glucose glucose glucose glucose glucose glucose

4.6

How Insulin Works

Part 1

The pancreas is always releasing a very small amount of insulin into the blood. When the concentration of glucose in the blood goes up, the pancreas releases more insulin into the blood. Insulin in the blood attaches or binds to a special protein on the membrane of a cell called the insulin receptor. Many cells in the body have insulin receptors. The insulin receptor can only bind to insulin, not any other type of hormone or protein. When insulin binds to the insulin receptor, things inside the cell change. A different protein inside the cell called glucose transporter (or just transporter) moves from inside the cell, where it is stored, to the cell membrane. When it reaches the cell membrane, it embeds in the membrane. Once it is in the membrane, the transporter carries glucose inside the cell. This is how glucose gets from the blood into the cell where it can be used to make energy in the form of ATP.

Part 2

All the cells in the body need glucose to function and work properly. They all need glucose so they can make ATP for energy. Some types of cells in the body can store glucose for use later. Cells in the liver take up glucose using the process described in Part 1. After the glucose is in the liver cells, however, it is changed to glycogen. Glycogen is many glucose molecules linked together. Muscle cells need a lot of glucose to function. But they also can change some of the glucose to glycogen. Liver cells change excess glucose into fat, which is then stored in fat cells in the body. Glycogen and fat are ways that the body can store glucose for later use. Glycogen and fat can be converted back to glucose if a person doesn't take in more glucose by eating.

4.7

Changing the System

Change to Part of System	Effect on Blood Glucose (Including Reason)	Is This Something That Really Happens?

4.8

Type 2 Diabetes and Glucose

- For people who have type 2 diabetes, do their cells still need glucose to function properly?
- If the cells need glucose, and the movement of glucose into cells doesn't work normally, how does glucose get into the cells?

4.9

Cells, Glucose, and Type 2 Diabetes

Directions: As you learned in the last part of this lesson, in type 2 diabetes, the movement of glucose from the blood into the body's cells doesn't happen normally. However, the body's cells still need to take in glucose from the blood. How can this happen in type 2 diabetes?

Use the pieces of the model that you used before. Select one of your team members to read the information in Steps 1–5 aloud to the team while other team members move the pieces of the model into the correct places.

1. The glucose, insulin, insulin receptors, and transport proteins start in the same places they did before. The receptors are in the cell membrane. The transport proteins are inside the cell. Glucose and insulin are in the blood outside the cell. Put pieces for each of these parts in the appropriate place.

2. Normally, when an insulin molecule binds to the insulin receptor, it triggers the movement of the transporter protein from inside the cell to the cell membrane. The transporter then carries a glucose molecule into the cell. Move the pieces to show this process.

3. In type 2 diabetes, insulin doesn't work as well. Insulin binds to its receptor, but there is something different about this interaction. It doesn't work normally. In type 2 diabetes, it isn't that insulin can't result in the entry of glucose into cells; it just doesn't work as well.

4. Instead of insulin binding to its receptor and causing glucose uptake into cells, it takes more insulin binding to more receptors. For example, it may take two insulin molecules binding to two insulin receptors to activate one transporter protein to carry one glucose molecule into the cell. Move the pieces of the model to show this situation.

5. There is a limit to what the body can do. You might ask if it might take three times as much insulin binding to insulin receptors to get one molecule of glucose into the cell. Move the pieces in your model to show this possibility.

6. ***Work with your team members to answer the following questions. Write your answers in the space below.***

a. The body can only make a certain amount of insulin. At some point, the body can't make enough. In Step 5, you modeled taking three times as much insulin binding to insulin receptors to get one molecule of glucose into the cell. What would happen if the body can only make two times as much insulin?

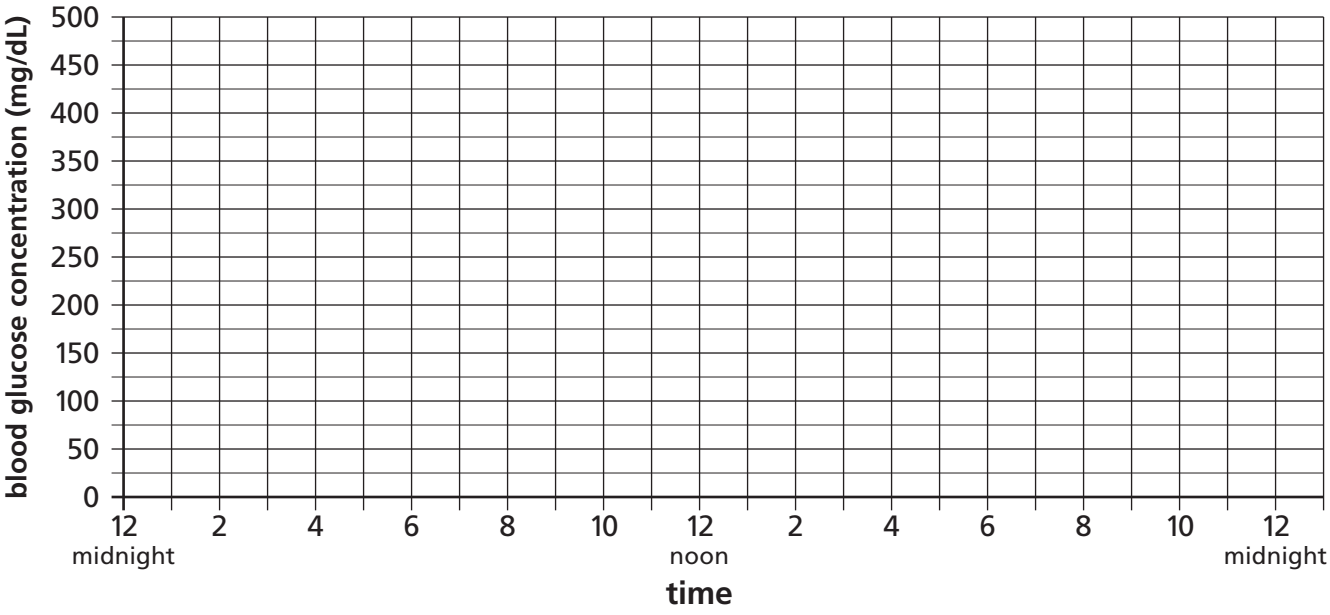
b. Write a few sentences summarizing how glucose gets into cells when someone has type 2 diabetes. Also explain how that differs from how it works in people who do not have type 2 diabetes.

5.1

Blood Glucose and Diabetes

1. Look at your graph of blood glucose concentration that you drew in Lesson 2. That graph showed how blood glucose concentration changes in someone who does not have diabetes. What part of the graph would be different in someone who has untreated type 2 diabetes?

2. Use what you have learned about type 2 diabetes to draw a graph of blood glucose concentration in someone who has untreated type 2 diabetes.



3. Explain why you think this graph represents the blood glucose concentration in someone who has untreated type 2 diabetes.

5.2

Complications from High Blood Glucose Concentration

Short-Term Signs of Having a High Blood Glucose Concentration and Being Out of Balance (Diabetes)

- Tired
- Thirsty
- Going to the bathroom a lot
- Weight loss
- Irritability
- Feeling sick
- Blurred vision
- Headaches

Long-Term Consequences of Having a High Blood Glucose Concentration (Uncontrolled Diabetes)

- Damage to nerves (especially of the eyes, leading to blindness)
- Damage to blood vessels (resulting in poor circulation that can lead to heart attack, stroke, or amputation of limbs)
- Damage to body organs, including kidneys and heart
- Wounds that won't heal or heal very slowly

5.3

Type 2 Diabetes: Can You Lower Your Risk?

A scientific study, called the Diabetes Prevention Program, or DPP for short, asked the question, "Do positive changes in lifestyle reduce the chance that a person will get type 2 diabetes?"

The people who volunteered to be part of this scientific study did not have type 2 diabetes when the study began. Even though they didn't have type 2 diabetes when the study began, all the volunteers had a high risk for getting it. The study lasted for almost three years. At the end of the three years, scientists recorded the number of people in each group who got type 2 diabetes. People were randomly put into one of two groups for the study.

Group Name	What They Did in the Study
Positive change in lifestyle	Individuals in this group ate a diet lower in fat and calories, lost at least 7 percent of their initial body weight, and moderately exercised for 30 minutes per day, five days per week.
Control	Individuals in this group received only their usual health care. They also received information about healthy living.

Directions: The results of the DPP are summarized in the following tables. Work with your team members to analyze the data and answer the questions that follow.

Results for All Participants of All Ethnic Groups

Group	Number in Group	Number Who Developed Type 2 Diabetes	Percent of People with Type 2 Diabetes at End of Study
Lifestyle	1,079	142	13%
Control	1,082	336	31%

Results for American Indian Participants

Group	Number in Group	Number Who Developed Type 2 Diabetes	Percent of People with Type 2 Diabetes at End of Study
Lifestyle	60	7	12%
Control	59	20	34%

5.3

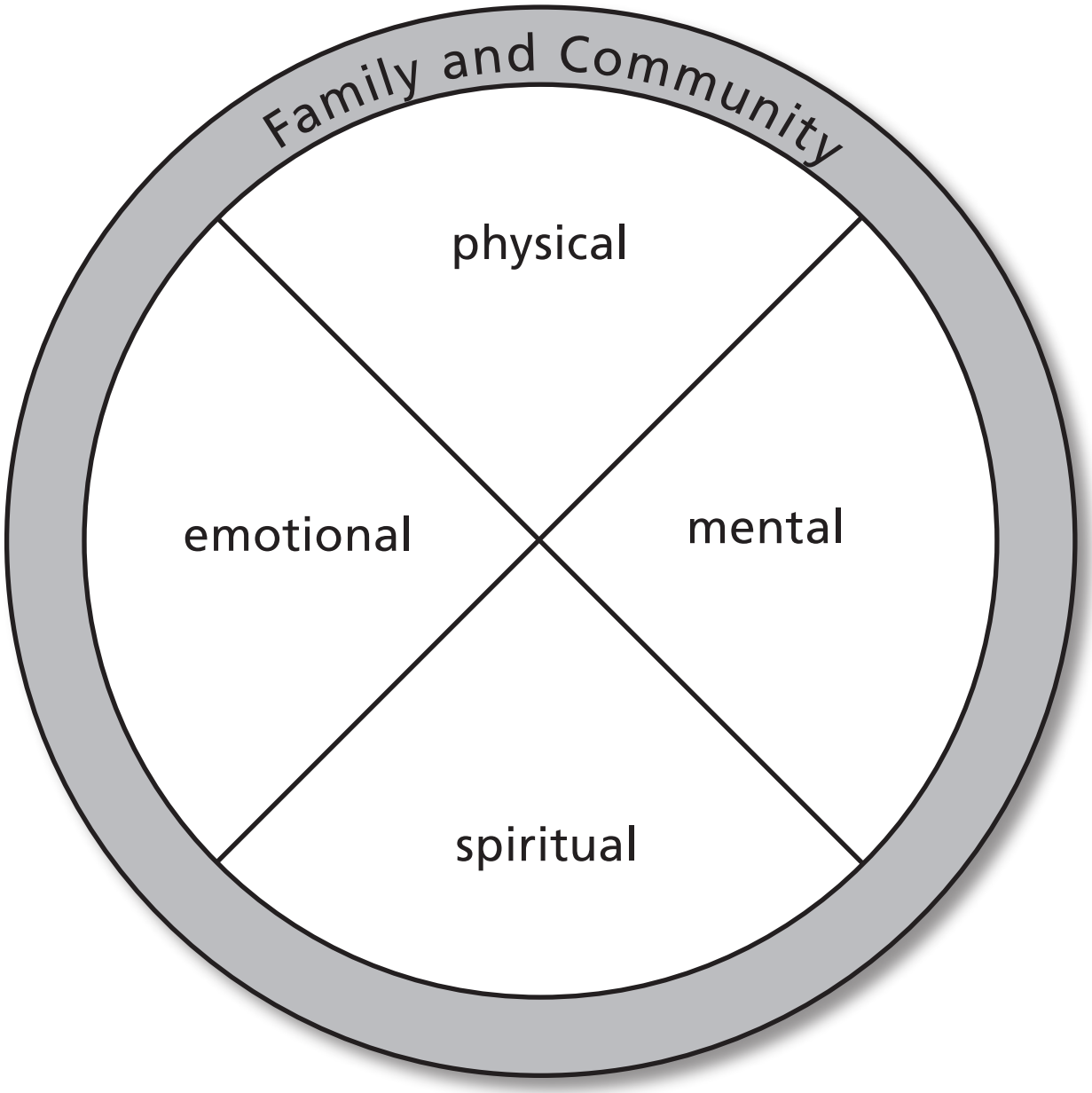
1. Write at least three conclusions you can make from the information in the tables.

2. Based on the data, can people who do not currently have type 2 diabetes lower their chance of getting it if they lose weight and become more active? Explain your answer.

3. Use your knowledge of the biology of type 2 diabetes to explain why changes in lifestyle may change a person's chance of getting type 2 diabetes.

5.4

Revisiting the Circle of Balance



5.5

Updates from Nick and Kim

Nick's Story

In the many years of living with type 1 diabetes, I've learned to listen and soak in different types of motivation to keep myself healthy.

I talk with my grandpa who is 69 years old and living with type 2 diabetes. He is constantly exercising every day, and I keep in touch with him to discuss diet plans and exercise routines. Doing this helps me keep my head on my shoulders—knowing that if my grandpa can stay healthy, eat right, and still exercise every day, then I am capable of doing it, too.

Another way I get motivation is from one of my friends. He is always asking me how my diabetes is doing. He constantly questions me if my blood sugar is at the right level. The thing that I like best about the questioning is just the fact that people are concerned about my health, and it makes me feel positive inside. I know now that you need to have someone close to you that you can talk to because diabetes can drag you down at times, and when you are down that close person will always tend to have positive thoughts to bring you back up.

My spirituality is the reason that, I believe, I am here today. Growing up with diabetes was very hard, especially at such a young age. When I first got diabetes, I thought I wasn't going to be the same person. I wanted to give up. My parents and I are religious and we always went to church every Sunday morning. When I was diagnosed with diabetes, I almost died. My blood sugar was 600* or more. My Mom prayed for me, but she said she stopped because she felt God was not helping her. I didn't know what to think. I was going through this hard time. I prayed and prayed. Then, when I was able to drive, I started to go to church again by myself, and still do to this day. The feeling of being in church made me think straight and kept my thoughts positive. Just having something to believe in, I think, pushed me to keep on trying and to realize that there is too much to live for.

Having type 1 diabetes for over six years has put a lot of stress on my body, and fighting the disease can be tough, but with all my friends and family pushing me and keeping me on track, it gives me a lot of motivation. Now that I am on a good diet and good exercise plan, I can give back to my friends and family by setting examples of exercising and eating healthy. I seem to help my friends out a lot by telling them how I count my carbohydrates with every meal and how I stay in shape by exercising in the Lummi gym. Having family members on both sides of my family with type 2 diabetes is tough for me because I don't like seeing others with the problem I have. It is working out, though, as a kind of advantage, because I have others who know what I am going through and also I can always talk to them and give them advice on what I am doing to make myself better and healthier. I give back to my friends and family by showing, not only those who have diabetes but also the ones who do not, how to prevent diabetes by great eating habits and lots of exercise.

**600 milligrams / deciliter (mg/dL)*

5.5

Kim's Story

Because I was pregnant, I now had an extra good reason to straighten up and take care of myself and my baby. It was not only about me anymore but my baby, too. I took my insulin, checked my sugar, exercised, and ate right. I prayed that nothing would happen to my baby and that she would be healthy and normal.

On November 15, 2005, my baby girl was born. She was 10 pounds and 11 ounces. I was not shocked that I had a huge baby because I was told during my first prenatal visit that women with diabetes usually had large babies due to the insulin. She required insulin at first and had to be weaned off the insulin. I felt bad about that. I named her Derikah Marion Starr Whiteshield; she is my pride and joy. I never realized how giving birth can change a person's outlook on life.

I went back to school second semester and had to get caught up and it was hard trying to go to school and taking care of a baby. My health suffered and it got the best of me, and I ended up in the hospital. I got back on track taking care of myself, and in May 2006, I graduated from Warwick High School. Along with my parents and family, I was so proud of myself. My dad is on the school board and he was the person giving the diplomas at this graduation, so I received my diploma from my father.

I look to the future now, and want to make a better life for myself and daughter. I take care of myself; I don't want my daughter pushing me around in a wheelchair due to me losing my eyesight or because my feet are amputated.

Today, I am a full-time student at the Candeska Cikana Community College. I want to continue on and go into the medical field. I have learned that I am a strong person who can overcome problems and learn from them.

I would like to encourage others to eat healthy and exercise, and don't take your health for granted—especially the children, because when you are young it's that much harder to accept diabetes. I blamed so many people and was angry for a long time for having diabetes.

Life is not fair sometimes, but it is a gift from God, and I plan on living it to the fullest.

6.1

You Are a Diabetes Educator

You Are a Diabetes Educator

A diabetes educator is someone who has learned a great deal about diabetes and who works with people to help them learn to live with diabetes, both for the individual and the family. A diabetes educator is someone who has a college degree in nursing, nutrition, health education, exercise science, or another field related to health. A person who wants to be a diabetes educator then gets special training about diabetes. A diabetes educator can help someone who has type 2 diabetes learn about healthy eating behaviors, ways to be more active, how to use a meter to check his or her blood glucose concentration, and many other things. Mainly, a diabetes educator helps people understand their disease and practice diabetes self-care behaviors.

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6.2

Marilyn's Story

Marilyn packed her shawl and moccasins. She and her parents and her little brother were going to her tribe's annual summer powwow.

At last, they all arrived at the powwow grounds. She waited anxiously for her cousins and other members to get ready in time for Grand Entry. As usual, Marilyn's family found seats in the woodland bowl to watch the Grand Entry. This powwow was a big intertribal event. Tribes from Canada to Mexico were there.

After the Grand Entry, Marilyn liked to stroll among the vendors. The jewelry at some of the booths was colorful and sparkling. Other booths were selling a lot of different kinds of beads, feathers, and shells for use on regalia. The booths selling food were her favorites. The smell of fry bread and hamburgers made everyone hungry. Of course, she could not come to the powwow without buying a fry bread with honey and soda! The taste of fry bread brought back memories of the first time she helped her grandmother make it. She remembered all the times she would watch her grandmother making fry bread and listen to her grandmother's stories about growing up on the reservation. From the stories, Marilyn knew her life was very different from her grandmother's.

After Marilyn walked around all the booths, she headed back to the entrance of the powwow grounds. Her older sister, Peggy, was sitting at the Health Department's diabetes screening booth. Peggy was a nurse at the Tribal Clinic. Peggy called for Marilyn to come over and get tested. Marilyn laughed and said, "I don't need to get tested. I'm just 18—I'm too young to get diabetes!"

Peggy kept saying that Marilyn should be tested, and Marilyn finally gave in. Marilyn said that she didn't think that the finger stick test for blood glucose would work because she just ate fry bread with honey and a soda.

Peggy kept pushing Marilyn to do the test. She said, "Let's give it a whirl anyway." Marilyn agreed to the test. The two sisters chatted while they waited for the machine to give the results. The results finally started to print. Marilyn asked, "Well, what does it say?" Peggy told Marilyn that her blood glucose level was much higher than normal. Marilyn's blood glucose level was 200 milligrams per deciliter (mg/dL), and normal is between 70 and 100 milligrams per deciliter of blood.

Peggy told Marilyn that the food and soda could have raised her blood glucose to go that high, but that it could also mean that Marilyn had a problem. Peggy told Marilyn that she should go to the Tribal Clinic the next day for another test. Only this time, Marilyn should not eat anything for breakfast before the test.

Marilyn was sure that she did not have diabetes. After all, she was only 18. As far as she knew, only old people got diabetes. And none of her sisters or brothers had diabetes. Neither did her parents. But she told her sister that she would come to the clinic for another test. This time, she followed her sister's instructions and didn't eat before the test. At the clinic, they repeated the test, and the results showed Marilyn's blood glucose was 164. Marilyn knew that was high. Peggy

Photo provided by: Carolee Dodge Francis, author
Oneida Nation of Wisconsin

told Marilyn that she didn't need to worry. Before the doctor could say whether Marilyn had diabetes, they would need to repeat the test one more time—again without eating for eight hours before the test.

Marilyn didn't want to make the appointment. But she did make one for the next week. Marilyn knew that type 2 diabetes was serious—her best friend's mother had it and Marilyn had seen how it had caused problems in her life. Marilyn was worried about the second test. She didn't want to be told that she had type 2 diabetes. She even worked out really hard and tried to avoid French fries and candy during the week before the next test. When it came time to go to the clinic again, Marilyn almost didn't go. But she did. When the doctor came in with the results, she had a serious look on her face. Marilyn knew she had diabetes.

Marilyn felt sad and overwhelmed. She knew that type 2 diabetes had something to do with insulin and that she needed to lower her blood sugar, but she didn't really understand what was going on in her body. She needed to know more.

7.1

Science and Health Career Information

You will have a chance to find out about how to enter a science or health care profession. You need to select a career to explore and complete the chart below with information you find on the Web about the qualifications for, and responsibilities of, that career.

Careers in science and health that you may wish to explore include scientist researching diabetes and its treatment, physician, nurse, pharmacist, physical therapist, mental health counselor, exercise physiologist, dietitian, and nutritionist. You should look for the education or degree required, the duties and responsibilities for that career, the type of business or organization where a person in that occupation works, what happens during a typical work day, and how a person in that profession can help individuals, communities, or both learn about or manage diabetes.

Science or health career to investigate:

_____

Web sites used for research (at least three):

_____

_____

_____

Question	Information about Career Choice	Your Own Questions or Additional Information
Why is this career a good choice for you? Explain.		
What are some duties and responsibilities of people in this career?		
How can this career help Native American communities?		
What education is required? (What degree and skills are needed?)		

7.2

Web Sites for Career Information

The following Web sites contain information about some careers related to science and health.

http://www2.sacnas.org/biography/listsethnicity.asp
This site will give you a chance to read about Native American/ Alaska Native/ Hawaii Native professionals working in science and medical careers.

http://science.education.nih.gov/LifeWorks
At this general site, you can find all of the sites listed below.

http://science.education.nih.gov/women/careers/index.html
This site gives information about women in cancer research, heart research, and neuroscience research.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Frank+GrayShield
This site is about a health educator.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Health+Educator
This site is about being a health educator.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Antoinette+Colbert
This site is about a dietetic technician.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Dietetic+Technician,+Registered
This is about being a dietetic technician.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Egda+M.+Morales-Ramos
This site is about a high school biology teacher.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Biology+Teacher,+Secondary
This is about being a biology teacher.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Barbara+Biesecker
This site is about a genetic counselor.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Genetic+Counselor
This is about being a genetic counselor.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Angi+M.+Christensen
This site is about a forensic scientist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Forensic+Science+Technician
This is about being a forensic scientist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Darryl+Lowery
This site is about a paramedic and emergency medical technician.

7.2

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Emergency+Medical+Technician+and+Paramedic
This is about being an emergency medical technician and paramedic.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Lynne+Haverkos
This site is about a pediatrician, a doctor working with kids.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Pediatrician
This site is about being a pediatrician.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Karoline+Harvey
This site is about an occupational therapist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Occupational+Therapist
This site is about being an occupational therapist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Patricia+Diaz
This site is about a microbiologist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Microbiologist
This site is about being a microbiologist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Matthew+Scherer
This site is about a physical therapist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Physical+Therapist
This site is about being a physical therapist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Keisha+Potter
This site is about a nurse.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Nurse,+Registered
This site is about being a nurse.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Leslie+Adams
This site is about a pharmacist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Pharmacist
This site is about being a pharmacist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Gloria+Stables
This site is about a dietitian and nutritionist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Dietitian+and+Nutritionist
This site is about being a dietitian and nutritionist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Chris+King
This site is about a medical and clinical laboratory technologist.

7.2

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Medical+and+Clinical+Laboratory+Technologist
This site is about being a medical and clinical laboratory technologist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Barry+Weidner
This site is about a fitness trainer and aerobics instructor.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Fitness+Trainer+and+Aerobics+Instructor
This site is about being a fitness trainer and aerobics instructor.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Byron+Ford
This site is about a medical scientist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Medical+Scientist
This site is about being a medical scientist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Jason+Sacks
This site is about a biological technician.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Biological+Technician
This site is about being a biological technician.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Julie+Hoehl
This site is about a recreational therapist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Recreational+Therapist
This site is about being a recreational therapist.

http://science.education.nih.gov/LifeWorks.nsf/Interviews/Victoria+Cargill
This site is about an epidemiologist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Epidemiologist
This site is about being an epidemiologist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Family+and+General+Physician
This site is about being a general doctor or physician.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Biologist
This site is about being a biologist.

http://science.education.nih.gov/LifeWorks.nsf/Alphabetical+List/Internist
This site is about being an internist (special doctor).

http://science.education.nih.gov/LifeWorks.nsf/education.htm
This site gives information about education required.

7.3

Essay for a Diabetes-Related Career

This essay will help us become acquainted with you and your educational goals. This information is different from what we learn about you from grades, test scores, and other objective data. It will demonstrate your ability to organize your thoughts and express yourself. Please write an essay at least 250 words long about the diabetes-related science or health career that you have selected. Include information related to *one or two* of the following areas:

- Explain why you became interested in this career.
- Discuss why you think this career can be important either to your community or to an individual.
- Provide reasons why you think you would be good at this career.
- Explain why diabetes is an important issue for Native Americans, and all people, to know about.
- Discuss specific facts about diabetes and how a person in this career would use those facts.

Directions: Follow these suggestions for writing this essay.

- Organize your thoughts and write an outline with categories you want to make sure to include in your essay. Arrange your categories in a logical order.
  - The opening paragraph might include your own goal for a job and the career you are exploring.
  - The second paragraph might explain what a person who is in the career of your choice does during a workday. You might give a description of what working in this job is like, what you might like, and what might be hard to do.
  - The third paragraph might present information about the education required and why you think this professional job would be interesting to you. What might you like about working in this job? You could also write how this person could work in your own community.
  - Think about how you can include what you know about diabetes.
  - In the ending paragraph, you might say why this career is of value to your community and how you could help other people. You can also say why you would be good at this kind of job.
- Review your outline and talk about it with a classmate.
- Write a draft of your essay. Check to see how long it is. Avoid using unnecessary words just to meet the length requirements. Be concise. (One page is about 250 words. This is the minimum.)
- Use a strong and informative topic sentence (the first sentence) for each paragraph so the reader knows what you plan to discuss in the paragraph.
- Writing large or using a large font size to make your essay look longer, or using a small font to give you more space on the page, should not be done. The font size should be 11 or 12.
- If you write your essay using a computer word processing program, use the software's tool to check spelling and grammar.
- When you finish your draft, exchange papers with one or two other people. Read each others' drafts and offer suggestions to each other to help make each essay the very best it can be. It is OK to help each other during the draft stage.
- Check your work against the rubric. (This is the tool that will be used to grade your essay.) Make sure you have met the requirements stated in the rubric.

7.3

Rubric for Grading the Essay

The chart lists the categories that will be used to evaluate your essay. When the reviewer scores your essay, he or she will circle the number of points to assess each of the criteria. This information will help you know which areas may need additional work.

Criteria for Evaluation	Score				
The essay includes accurate information about type 2 diabetes.	5	4	3	2	1
The essay includes sufficient information about type 2 diabetes, including ways to prevent or manage the disease to stay healthy.	5	4	3	2	1
The essay explains the connection between the chosen career, type 2 diabetes, and community needs.	5	4	3	2	1
The essay discusses the writer's reasons for interest in this career choice.	5	4	3	2	1
The essay is clearly written, with correct spelling, grammar, and sentence structure.	5	4	3	2	1
Other	5	4	3	2	1

Score	Definition
5	Exceeds minimum requirements, is accurate and well written
3	Meets requirements
1	Does not meet requirements

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