Overview

The goal of this unit is to provide meaningful context for concepts taught in high school biology classes. The story of type 2 diabetes frames core understandings about homeostasis, feedback mechanisms, body systems, genetics, and offers a real-world problem that is in need of solutions. Students often leave high school biology with an understanding of genetics that reinforces how single-gene traits are inherited in Mendelian ratios illustrated with Punnett squares. Our aim is to provide students with an expanded understanding of genetics and other biological concepts that encompass how multiple gene-environment interactions contribute to complex health conditions that impact individuals and vary within populations.

In this phenomenon-driven unit, students are exposed to the complex problem of the rapid increase in diagnosed cases of type 2 diabetes across the United States in the past 20 years. Throughout the unit, prevention and treatment are emphasized as students learn how good nutrition, exercise, personal choice, public health policies and community engagement can contribute to positive health outcomes.

Enduring Understandings

- Most traits are determined by a combination of genetic and environmental factors, including complex diseases like type 2 diabetes.
- Type 2 diabetes is a growing concern and occurs frequently in our communities.
- Type 2 diabetes is a complex condition that is heavily influenced by environmental factors such as access to resources, personal choice, product marketing, public policy, socio-economic status, and stress.
- Blood glucose levels are regulated to stay within a healthy range. Type 2 diabetes is the result of chronic high blood glucose levels over time as regulation of blood glucose levels fail.
- Glucose, the major energy source for all human cells, is released primarily through digestion of carbohydrates. Food choices impact blood glucose levels.
- Type 2 diabetes is a serious condition with negative health consequences if left untreated.
- Type 2 diabetes can be prevented: factors contributing to a person's risk include good nutrition and exercise.
- Students can make a meaningful contribution to the prevention of type 2 diabetes.

Anchoring Phenomenon

Students experience an animated slide presentation that illustrates the rapid increase in diabetes incidence in the US between 1994 and 2015. The diabetes incidence for each state is represented by a color that gets darker over time as more people are diagnosed with the disease. The slide set is produced by the Center for Disease Control (CDC), and it supported by depth of web resources.

Essential Question

What can I/we do to decrease the occurrence of type 2 diabetes?

Gapless Explanation

Type 2 diabetes is a complex condition in which the physiological causes (inside the body) are impacted by environmental and lifestyle factors (outside the body). By understanding both the physiological and environmental factors that influence type 2 diabetes, students can consider solutions that contribution towards combatting diabetes within the students' communities. For most people, type 2 diabetes is preventable.

Physiological causes: Type 2 diabetes is a chronic disease that results when excess glucose (blood sugar) stays in the blood stream because the body is not able to let glucose into the cells to be used as energy. The pancreas makes the hormones insulin and glucagon which regulate glucose entering and exiting the body's cell through feedback mechanisms that maintain homeostasis. Type 2 diabetes happens when either cells no longer respond to insulin (due to insulin resistance) or the body does not produce enough insulin (due to beta cell damage in the pancreas). Glucose is the primary energy molecule of the body, and it is formed through the breakdown of the sugars and starches we eat. When a person is overweight, especially when fat is distributed primarily in the abdomen rather than the hips and thigh, cells become less sensitive to insulin which causes an increase in blood glucose levels. When glucose builds up in the blood, several complications associated with type 2 diabetes can occur, including damage to the heart and blood vessels, nerve damage, glaucoma (damage to the eye), and kidney disease. Poor circulation and nerve damage cause damage to the feet, including infections that can require amputation. Genetic factors also contribute to type 2 diabetes. Over 150 genes have been associated with type 2 diabetes, leading to many inheritable allele combinations. While some of these genes have a stronger effect than others, no one gene has been identified as "the cause" of type 2 diabetes.

Gapless Explanation *continued*

Environmental and lifestyle causes: While genetics plays a role in type 2 diabetes, the geographic disparities in distribution and speed at which the condition is intensifying in our communities point to environmental rather than genetic drivers. Our environments and lifestyles have changed markedly over the last generation. People sit more, move less, and have easy access to high calorie foods that are low in nutrition. This has led to more people being overweight and obese. Complex environmental and social factors that influence a person's risk of type 2 diabetes include access to healthy foods, personal choice, culture, product marketing, public policy, and socio-economic factors such as income level, educational level, and stress. The food systems and lifestyle environments currently in place may not support preventative measures such as eating a healthy diet, getting plenty of exercise, and losing weight if overweight.

Students can make a meaningful contribution to the prevention of type 2 diabetes. Solutions exist along the range from the individual level (such as a person's choice to treat sugar-sweetened beverages as an occasional treat rather than a daily practice, choosing high-fiber foods, and increasing exercise) to the societal level (addressing access to healthy foods, food policies, product labeling and marketing) and will address both prevention and treatment. By understanding the complex set of both physiological and environmental inputs that impact diabetes diagnoses, students can begin to address a range of solutions to this multifaceted global challenge.

Companion Unit

The Enduring Understandings for this curriculum also guide a 5-lesson unit developed for high school health courses ***Health, Nutrition, and Type 2 Diabetes*** which can be found at https://gsoutreach.gs.washington.edu/

Target Level

Introductory high school biology courses

The 5 E Model

The unit is designed around the 5E Learning Cycle Model developed by the Biological Sciences Curriculum Study. The 5E model provides a scaffold for guiding and assessing student inquiry and learning through the following stages: Engage; Explore; Explain; Elaborate; and Evaluate.

Assessment

Each lesson provides opportunities to assess student learning through opening and closing activities and questions. In addition, students reflect on each lesson by completing a Lesson Summary Guide.

As a summative assessment, students evaluate possible solutions to the complex problem of type 2 diabetes. Using evidence gathered throughout

the unit, students engage in argumentation to support their position on the best treatments and preventative measures that address this complex condition. This sets the stage for leadership opportunities, in which students could implement direct, meaningful, and relevant contributions towards combatting diabetes within their community.

Next Generation Science Standards

The unit fully integrates the three dimensions woven together through the Next Generation Science Standards. Student engage in science and engineering practices while explore crosscutting concepts that contribute to understanding of the disciplinary core ideas. An overview can be found on the next page. ***A detailed guide accompanies each lesson.***

The following Performance Expectations are bundled in this unit:

HS LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS LS1-7: Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

HS LS2-8: Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.

HS LS3-3: Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

HS ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS ETS 1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

Contributions to the Next Generation Science Standards

	Lesson One	Lesson Two	Lesson Three	Lesson Four	Lesson Five
Scientific Practices					
1. Asking Questions and Defining Problems	●			●	●
2. Developing and Using Models	●	●	●	●	
3. Planning and Carrying out Investigations			●	●	
4. Analyzing and Interpreting Data	●	●	●	●	●
5. Using Mathematics and Computational Thinking	●			●	
6. Constructing Explanations and Designing Solutions	●		●	●	●
7. Engaging in Argument from Evidence	●				●
8. Obtaining, Evaluating, and Communicating Information	●	●	●		●
Core Ideas: Life Sciences					
HS-LS1: From Molecules to Organisms: Structure and Processes		●	●		
HS-LS2: Ecosystems: Interactions, Energy, and Dynamics	●			●	●
HS-LS3: Heredity: Inheritance and Variation of Traits	●			●	
HS-ETS1: Engineering Design	●				●
Crosscutting Concepts					
1. Patterns	●		●	●	●
2. Cause and Effect: Mechanism and Explanation	●		●	●	●
3. Scale, Proportion and Quantity	●			●	
4. Systems and System Models	●	●	●	●	●
5. Energy and Matter: Flows, cycles, and conservation		●	●		
6. Structure and Function		●	●		
7. Stability and Change	●	●	●	●	●

Black dots represent connections explained in detail on the one-page summary that accompanies each lesson. Gray dots represent valid connections to NGSS not described in detail due to space limitations.

Source: NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Lesson	Description	Activities
Lesson 1 Asking Questions about Diabetes	Students are exposed to the anchoring phenomenon for the unit through a slide animation from the CDC that shows the rapid increase in diagnosed cases of type 2 diabetes in the past 20 years. Students ask questions about the phenomenon and explore how diabetes diagnoses are impacted by age, educational level, geography and other factors.	• CDC slide set illustrating the dramatic increase in t2d • Exploration of diabetes data from CDC.gov
Lesson 2 Homeostasis: Glucose in Balance	Students trace glucose molecules from carbohydrates they eat to cellular respiration. They are then introduced to glucose homeostasis through a model that shows how organs and systems interact through feedback mechanisms to maintain balance. As an extension, students use yeast as an indicator for cellular respiration.	• Pencil/paper model of carbohydrates • Visual demonstration of sugar in different drinks • Homeostasis slide set presentation
Lesson 3 Modeling Type 2 Diabetes	Students collect evidence for the causes of type 2 diabetes by using the homeostasis model board to figure out how blood glucose homeostasis is affected by diet, exercise, insulin resistance, and pancreatic function.	• Game board model of glucose homeostasis using scenario cards
Lesson 4 Genes and Environment	Students learn about environmental, genetic and social factors that influence type 2 diabetes by simulating how high risk and low risk gene variants may be distributed through a population and looking for patterns in their own environments and eating habits.	• Bean simulation to model genetic risk • Pencil/paper risk tally to determine environmental risks
Lesson 5 Evaluating Solutions	Students evaluate solutions to the complex problem of type 2 diabetes by evaluating and communicating information about four different prevention and treatment options for people with, or at risk for, type 2 diabetes. Using evidence gathered throughout the unit, students engage in argumentation to support their position on the best treatments and preventative measures that address this complex condition.	• Jigsaw or round robin of solution/treatment options • Evaluation and justification of own solution

What is diabetes? Diabetes is a group of diseases marked by high levels of blood glucose resulting from defects in insulin production, insulin action, or both. Diabetes can lead to serious complications and premature death, but people with diabetes, working together with their support network and their health care providers, can take steps to control the disease and lower the risk of complications.

Type 1 diabetes Type 1 diabetes was previously called insulin-dependent diabetes mellitus (IDDM) or juvenile-onset diabetes. Type 1 diabetes develops when the body's immune system destroys pancreatic beta cells, the only cells in the body that make the hormone insulin that regulates blood glucose. To survive, people with type 1 diabetes must have insulin delivered by injection or a pump. This form of diabetes usually strikes children and young adults, although disease onset can occur at any age. In adults, type 1 diabetes accounts for approximately 5% of all diagnosed cases of diabetes. Risk factors for type 1 diabetes may be autoimmune, genetic, or environmental. There is no known way to prevent type 1 diabetes.

Type 2 diabetes Type 2 diabetes was previously called non–insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes. In adults, type 2 diabetes accounts for about 90% to 95% of all diagnosed cases of diabetes. It usually begins as insulin resistance, a disorder in which the cells do not use insulin properly. As the need for insulin rises, the pancreas gradually loses its ability to produce it. Type 2 diabetes is associated with older age, obesity, family history of diabetes, history of gestational diabetes, impaired glucose metabolism, physical inactivity, and race/ethnicity. African Americans, Hispanic/Latino Americans, American Indians, and some Asian Americans and Native Hawaiians or Other Pacific Islanders are at particularly high risk for type 2 diabetes and its complications. Type 2 diabetes in children and adolescents, although still rare, is being diagnosed more frequently among American Indians, African Americans, Hispanic/Latino Americans, and Asians/Pacific Islanders.

Gestational Diabetes This is a form of glucose intolerance diagnosed during pregnancy. Gestational diabetes occurs more frequently among African Americans, Hispanic/Latino Americans, and American Indians. It is also more common among obese women and women with a family history of diabetes. During pregnancy, gestational diabetes requires treatment to optimize maternal blood glucose levels to lessen the risk of complications in the infant.

Other types Other types of diabetes result from specific genetic conditions (such as maturity-onset diabetes of youth), surgery, medications, infections, pancreatic disease, and other illnesses. Such types of diabetes account for 1% to 5% of all diagnosed cases.

Fact Sheet

What is type 2 diabetes (t2d)?

It is a chronic condition resulting from the body either not producing enough of the hormone insulin or cells no longer responding to insulin. Normally, insulin is the signal that controls the uptake of glucose by cells. Glucose is the primary energy molecule of the body, and it is formed through the breakdown of the sugars and starches we eat. When glucose builds up in the blood, several complications associated with type 2 diabetes can occur, including damage to the heart and blood vessels, nerve damage, glaucoma (damage to the eye), and kidney disease. Poor circulation and nerve damage cause damage to the feet, including infections that can require amputation.

What are the symptoms of t2d?

Symptoms include thirst and increased urination, hunger, fatigue, weight loss, blurred vision, and slow-healing sores.

What are the causes/risk factors for t2d?

Type 2 diabetes is caused by the body's inability to make insulin or to respond to it. Factors that increase risk for developing it include being overweight, having body fat distributed primarily in the abdomen rather than the hips and thighs, age, family history, having pre-diabetes (increased blood sugar that is greater than normal but not at the level of diabetes), and having gestational diabetes (developing diabetes during pregnancy)

How is it treated?

Treatment can include monitoring blood sugar daily, losing weight, eating a healthy diet, getting daily exercise, and sometimes taking drugs and/or insulin.

Can type 2 diabetes be prevented?

Prevention measures include eating a healthy diet, getting plenty of exercise, and losing weight if overweight.

The points are from the Center for Disease Control (CDC) Fact Sheet found at http://www.nccd.cdc.gov/ddtstrs/FactSheet.aspx