

# Biology, Homeostasis, and Type 2 Diabetes

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Genome Sciences Education Outreach

UNIVERSITY OF WASHINGTON | VERSION 04.18



**Overview**

The increase in type 2 diabetes nationally and globally gives meaningful context for learning about the genetic and environmental contributions to this challenging disease.

In this phenomenon-driven unit, students are exposed to the complex, real-world problem of the rapid increase in diagnosed cases of type 2 diabetes across the United States in the past 20 years. Students' questions about the phenomenon drive their learning as they find out how blood glucose levels are maintained in the body, and how the failure of these mechanisms result in type 2 diabetes. Students consider genetic factors that contribute to the disease, as well as environmental factors that influence health, including social, political and economic structures. 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.

<b>Companion Unit</b>	The Enduring Understandings for this curriculum also guide a 5-lesson unit developed for high school health courses <b><i>Health, Nutrition, and Type 2 Diabetes</i></b> which can be found at <a href="https://gsoutreach.gs.washington.edu/">https://gsoutreach.gs.washington.edu/</a>
<b>Target Level</b>	Introductory high school biology courses
<b>The 5 E Model</b>	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.
<b>Assessment</b>	<p>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.</p> <p>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.</p>

**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. A detailed guide accompanies each lesson, and an overview can be found on the next page.

The following Performance Expectations are bundled in this unit:

**HS LS 1-2:** 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 LS3-3:** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

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

**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
<b>Scientific Practices</b>					
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	●	●	●		●
<b>Core Ideas: Life Sciences</b>					
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	●				●
<b>Crosscutting Concepts</b>					
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.

## Biology, Homeostasis, and Type 2 Diabetes

Lesson	Description	Activities
<b>Lesson 1</b> 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.	<ul style="list-style-type: none"> <li>• CDC slide set illustrating the dramatic increase in t2d</li> <li>• Exploration of diabetes data from CDC.gov</li> </ul>
<b>Lesson 2</b> 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.	<ul style="list-style-type: none"> <li>• Pencil/paper model of carbohydrates</li> <li>• Visual demonstration of sugar in different drinks</li> <li>• Homeostasis slide set presentation</li> </ul>
<b>Lesson 3</b> 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.	<ul style="list-style-type: none"> <li>• Game board model of glucose homeostasis using scenario cards</li> </ul>
<b>Lesson 4</b> 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.	<ul style="list-style-type: none"> <li>• Bean simulation to model genetic risk</li> <li>• Pencil/paper risk tally to determine environmental risks</li> </ul>
<b>Lesson 5</b> Evaluation 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.	<ul style="list-style-type: none"> <li>• Jigsaw or round robin of solution/treatment options</li> <li>• 4-Box evaluation and justification of own solution</li> </ul>

**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/dtdstrs/FactSheet.aspx>



## Biology, Homeostasis, and Type 2 Diabetes

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### LESSON ONE

## Lesson 1: Connecting to the *Next Generation Sciences Standards* (NGSS Lead States 2013)

Lesson 1 contributes to student competency in the following standards:

### Performance Expectations

**HS-LS2-8.** Social Interactions and Group Behavior: 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.

### DIMENSIONS

### CLASSROOM CONNECTIONS

#### Science and Engineering Practices

##### Asking Questions and Defining Problems

Students formulate and refine questions that can be answered about the rise of diabetes after viewing, sorting, and filtering national and local data from the CDC website.

##### Analyzing and Interpreting Data

Students view data from the CDC website, sort the data to reveal trends over time, geographical differences, the effects of age and education on diabetes diagnoses.

##### Constructing Explanations and Designing Solutions

Students gather evidence from the CDC website and other scientific resources that will be used to construct explanations and design solutions for the rapid rise of diabetes.

#### Disciplinary Core Ideas

HS-LS2.D: Social Interactions and Group Behavior  
Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

Social policies result from human group behavior. Social factors that influence a person's risk of t2d include access to healthy foods, their income level, and even how food is marketed.

HS-LS3.B: Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.

Students see that diabetes is a rapidly growing trait expressed in the US population, and the variation and distribution of the condition are tied to geography, age, and educational levels. Students begin to tease out how environmental factors contribute to the condition.

HS-ETS1.A: Defining and Delimiting Engineering Problems. Humanity faces major global challenges today, such as the need for clean water and food, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

Students parse data that reveal a complex set of inputs that impact diabetes diagnoses both nationally and locally. Students begin to build a foundation to address a range of solutions for this multifaceted global challenge.

#### Crosscutting Concepts

##### Patterns

Students see that the change in scale between views of the CDC data reveals patterns of diabetes incidence relative to geography, age, education, and BMI status. Students compare national and local patterns.

##### Scale, Proportion, Quantity

Students see the differences in relative magnitude of diabetes diagnoses across time and place by viewing the unit phenomenon and exploring data on the CDC website. Changes in scale reveal patterns in the data.

# Lesson 1

# Asking Questions about Diabetes

**Time:** 50 min

**Lesson Objectives:**

Students will be able to answer:

- Why should we study diabetes?
- Which is the most common type of diabetes?
- What are three factors that can lead to diabetes?

Field test question:  
Which is better—I or we? Or something else?

## Overview

In this lesson, students are introduced to the complex, real-world problem of the rapid increase in diagnosed cases of type 2 diabetes across the United States in the past 20 years. Students ask questions about the trend, filter the data in different ways to discern data shifts, analyze changes in scale, evaluate the data source, and focus on incidence in their own counties of residence. Ultimately, students figure out what they will need to know to construct an explanation about this phenomenon and pose questions that will guide their learning throughout the unit. Students are also introduced to a graphic organizer they will use throughout the unit to assess their own learning.

## Anchoring Phenomenon

The visual representation of the rapid increase of diabetes in the US over time is used as a phenomenon to anchor student learning for the unit. This phenomenon is shown through a CDC PowerPoint slide set. The slide set can be found in two ways:

- 1) It is embedded in the Biology\_Homeostasis\_T2D\_SlideSet for this unit, found at <http://gsoutreach.gs.washington.edu/> (see GEMNet Instructional Materials), or
- 2) It can be downloaded directly from the CDC at <https://www.cdc.gov/diabetes/data/center/slides.html> (See: *Maps of trends in diabetes: PPTX*). This slide set will not contain the accompanying lessons materials from this unit.

## Enduring Understandings

- 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.

## Essential Question

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

## Lesson Summary with Timings

What is going on here? Introduction to the phenomenon	10 min
CDC Data Exploration using <i>Student Sheet 1</i>	20 min
Evaluating Questions as a group	10 min
Closure and introduction to <i>Lesson Summary Guide</i>	10 min

## Materials

Materials	Quantity
Computer and projector	1 per class
Biology_Homeostasis_T2D_SlideSet PowerPoint presentation for Lesson 1, found at <a href="http://gsoutreach.gs.washington.edu/">http://gsoutreach.gs.washington.edu/</a> (see GEMNet Instructional Materials)	1 per class
The CDC slide set can be downloaded from: <a href="https://www.cdc.gov/diabetes/data/center/slides.html">https://www.cdc.gov/diabetes/data/center/slides.html</a> (see <i>Maps of trends in diabetes: PPTX</i> ).	Duplicate of above
Computers for students, with access to CDC data at: <a href="https://www.cdc.gov/diabetes/data/index.html">https://www.cdc.gov/diabetes/data/index.html</a>	1 per student or group
Student Sheet 1: <i>What is going on?</i> (two-sided)	1 per student
Lesson Summary Guide (two-sided)	1 per student

**Note:** It is ideal for students to have their own computers, if possible. Adobe Flash Player 10.0 is required to view some of the CDC data.

## Procedure

**Part I (Engage)                      What is going on here?                      (PPT Presentation; 15 min)**

1. Entrance activity: Students can respond to the questions posed on the entrance slide in a number of ways, as directed by the teacher. Suggested strategies include using a think-pair-share activity, a brief class discussion, or an individual writing exercise. Students should focus on the main question, and then choose one or more of the *think about....* options as time allows.

Slide 2

2. Without much preamble, show students the phenomenon that will drive questioning for this unit. Tell students that they will see a color-coded map that will indicate the percentage of adults in the US that have been diagnosed with diabetes between 1994 and 2015. Use Slide 3 to orient students to the scale before proceeding through Slides 4 - 26.

Slide 3

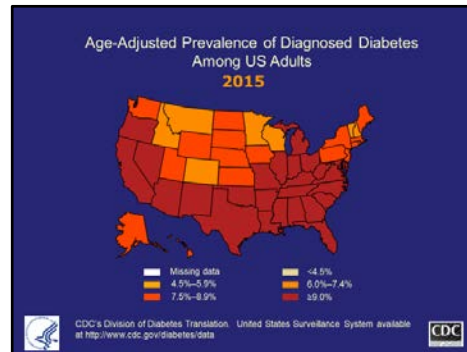
UWGSSEO | Biology, Homeostasis, and Type 2 Diabetes  
Diabetes: A Growing Concern

The following PowerPoint shows the percentage of adults who have been diagnosed with diabetes in the US between 1994 and 2015. This table shows the color key for percentages you see in the next slides.

Color	Percentage
white	No data
cream	<4.5
yellow	4.5-5.9
gold	6.0-7.4
orange	7.5-8.9
red	> 9.0

**Age-Adjusted** means that different populations (i.e. states) have been weighted to mirror the same age distributes as found in the US census data. This is done so that populations with younger or older members can be compared directly with each other.

Slide 26



**Prevalence** is the total number of people with diabetes at a certain time, divided by the population at risk.

3. Show the slide set at least one more time (by restarting at Slide 4) so that students can absorb the information.
4. Show Slide 27 to raise the issue that the data include different types of diabetes, and that it is important to understand the differences.

Slide 27

UWGSSEO | Types of Diabetes Incidence and Prevention

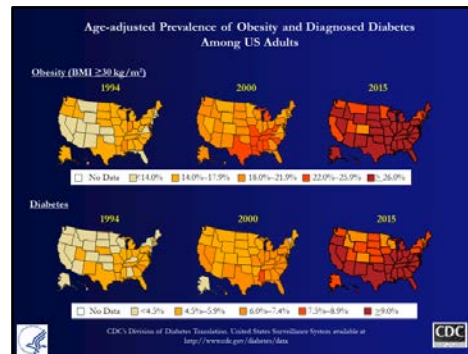
Type	Prevalence	Possible Prevention
Type 1 Diabetes	5%	none
Type 2 Diabetes	90-95%	for many, lifestyle changes
Gestational Diabetes	<1-2%	for some, lifestyle changes
other	1-5%	none

Data from the CDC

**Note:** You may have students with type 1 or 2 diabetes in your class or school who may be comfortable sharing their knowledge and experience. Background information on each type of diabetes can be found in the teacher notes in the front section of this unit. While this curriculum does not focus on type 1 diabetes, connections to that condition will be made when applicable.

5. Ask students which type of diabetes should be the focus if they want to make sense of the trend of prevalence in the country. (Students should point out that type 2 diabetes is the biggest category and is preventable for some people, so a focus on t2d has the potential to reverse the trend.)
6. Show students the summary Slide 28, which includes the prevalence of obesity over time. Point out that the scale for each condition is different. We will return to the connection between type 2 diabetes and obesity in Lesson 3.

Slide 28



7. After considering the data individually and in pairs, ask students share their ideas about what the data indicate.
8. Ask the class to work in pairs or table groups to brainstorm questions that come up for them as they watched the slide show. Ask groups to write those questions down on sticky notes.
9. Designate a Question Wall--an area in which student questions can be parked and referred back to throughout the unit. Ask students to bring their sticky notes to the wall. Focus on quickly collecting some questions at this time but not answering the questions.

**Note:** This is a nice opportunity for a student or two to lead the class in eliciting ideas about the data, brainstorming questions, and then recording or collecting questions for the Question Wall. Student leadership can increase ownership of the questioning process and shift the dynamic of the whole-class discussion, and allow the teacher to serve only as moderator.

## Part II (Explore/Explain) CDC Data Exploration (20 min)

10. Hand out Student Sheet 1 to guide student work. Ideally, each student will have access to a computer and the CDC website, found here: <https://www.cdc.gov/diabetes/data/index.html>.
11. Orient students to the CDC website using Slide 29. In Part A of Student Handout 1, students will explore national data, in Part B they will explore state/county data, and then in Part C they will explore this site or another resource for general information about diabetes.

Slide 29





**Part III (Evaluate): Evaluating Questions (10 minutes)**

12. Discuss what students learned on the CDC website, and if they found answers to any of the classes initial questions. If so, invite students to write ideas, thoughts and/or answers to a specific question on a sticky note to be placed next to the question on the Question Wall.
13. Ask students: What more would they like to learn more about? Ask them to pose additional questions. Below are a few examples of more sophisticated questions and ideas students may raise after examining the data:
- What is it about certain parts of the country/world that leads to increased incidence?
  - What changes have occurred worldwide to result in changes in type 2 diabetes incidence?
  - Does the evidence that type 2 diabetes runs in families reflect genetics, culture, society, or all three?
  - Why do some people get type 2 diabetes and others do not?
14. Do not focus on answering the questions, but continue to have students contribute to the Question Wall by adding questions on sticky notes.
15. Introduce the Driving Question, “*What can I/we do to decrease the occurrence of type 2 diabetes?*” as a broad guiding question that students will return to throughout the unit. Invite students to choose at least one additional question they would like to know more about by the end of the week.

**Part IV (Explain and Evaluate): Closure (10 minutes)**

16. Using Slide 30, go over the characteristics of type 2 diabetes.

Slide 30

UWGSEO  
GENOME SCIENCES EDUCATION OUTREACH

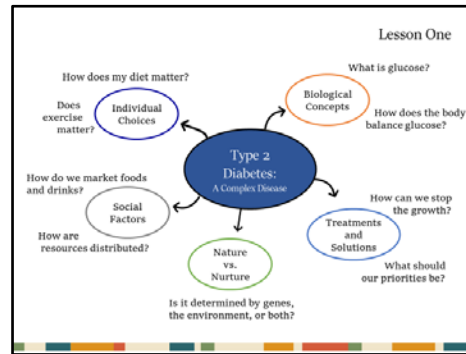
Biology, Homeostasis, and Type 2 Diabetes  
Lesson One

What are the characteristics of type 2 diabetes?

- result of chronic (long-term) high blood glucose levels
- can develop over time
- body is unable to maintain healthy ranges of glucose
- high glucose levels can damage nerves, heart, blood vessels, hands, feet, kidneys
- complications can even lead to death

17. Point out for students that type 2 diabetes is a complex condition that elicits questions about biology, social and environmental factors, choice and access, as outlined in Slide 31. We will be exploring these topics in the next few days.

Slide 31



18. Emphasize that the circles on the left of the slide—*Individual Choices* and *Social Factors*—can be in tension or conflict with this topic. Individual behaviors such as how much to eat, drinks and/or exercise, point to personal choice. Social factors include a person’s access to health care, healthy foods, and their education and income levels, and social policies include soda taxes, federal food programs, and the ways in which drinks and foods and formulated and marketed. Group behaviors form social policies which may influence a person’s risk of type 2 diabetes. Social factors and policies have the potential to both positively and negatively influence the incidence of type 2 diabetes.
19. Hand out the *Lesson Summary Guide*. The Driving Question *What can I/we do to decrease the occurrence of type 2 diabetes?* is included. Encourage students can add an additional or alternate question that interests them.
20. Exit Ticket: Students can fill out the first row of the guide as an exit ticket.

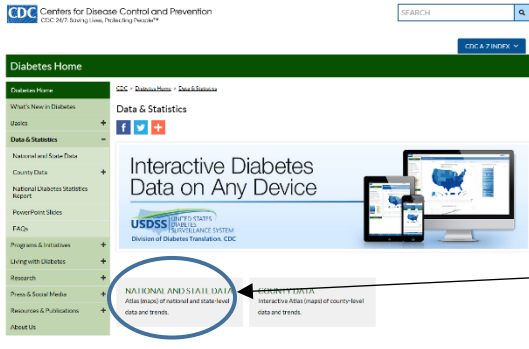
### Homework

Student should complete page 2 of the Lesson Summary Guide for homework. They are asked to provide their opinions and thoughts after Lesson 1. They will revisit this at the end of the unit.

Optional: From the CDC website, students could choose data from which to create a graph.

# Student Sheet 1: What is going on nationally?

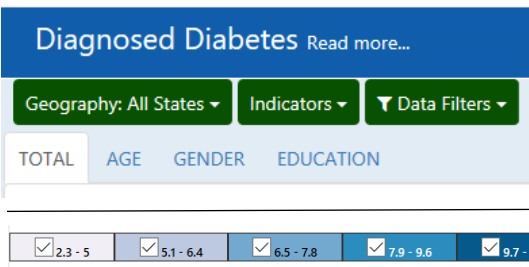
Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_



## Part A Procedures:

A. Go to <https://www.cdc.gov/diabetes/data/index.html>

B. Click on “National and State Data”  
(<https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html>)



C. Spend some time exploring the data using the map and the heat map. Using the tool bar on the upper left, you can sort the data by age, gender, and education. Using the slider bar at the bottom, you can see data from different years.

D. **Pay attention** to the scale at the bottom of the map, as it changes when you sort the data.

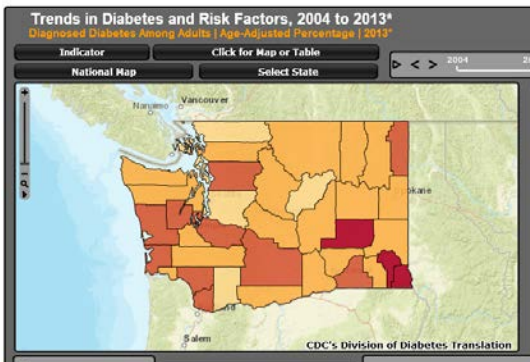
## Part A Questions:

- Is this a reputable source from which to gather information? Why or why not?
- In what way(s) did the survey methods change in 2011?
- How does geography influence diabetes diagnosis? Why?
- Under the AGE tab, find your state of residence.
  - What percentage people in each age range were diagnosed with diabetes in 2015?  
ages 18 – 44 \_\_\_\_\_ ages 45-74 \_\_\_\_\_ over 75 \_\_\_\_\_
  - What pattern do you see?
  - Can you find evidence of this pattern repeating itself in other states?
- Under the EDUCATION tab, look at the scale for darkest blue.
  - What % range does the dark blue represent for adults with **less than** a high school education?
  - What % range does the dark blue represent for adults with **more than** a high school education?
  - Why does the scale change for different maps?
  - What pattern do you notice about education and diabetes?

# Student Sheet 1: What is going on locally?

## Part B Procedures:

- A. Go to <https://www.cdc.gov/diabetes/data/index.html>
- B. Click on “County Data” (<https://www.cdc.gov/diabetes/data/county.html>)



- C. Find “All States Motion Charts.” Select your state and hit **Go**. You may need to enable Adobe Flash Player. (<https://www.cdc.gov/diabetes/data/county.html>)
- D. Spend some time exploring data on the map. Make sure to move the timeline back to the beginning to see changes over time.

## Part B Questions:

6. What percentage of adults in your **county** have been diagnosed with diabetes?
7. Look at the circle graph on the right and notice the  $x$  and  $y$  axes. What trend do you see?
8. How does your county rank for your state?
9. Write 3-4 questions and ideas that you would like to investigate in more depth based on your exploration of the data.

## Part C:

10. Return to the homepage at <https://www.cdc.gov/diabetes/data/index.html>, or one of the resources listed below to learn more about diabetes in general.
11. Write down 2 questions posed by your class earlier and look for information about those questions:
  - a. Question:  
Answer:
  - b. Question:  
Answer:

### Additional Diabetes Resources:

American Diabetes Association: <http://www.diabetes.org/diabetes-basics/type-2/>  
Mayo Clinic: Type 2 Diabetes: <http://www.mayoclinic.com/health/type-2-diabetes/DS00585>  
PubMed Health: Type 2 Diabetes: <http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001356/>

**Driving Question:** “What can I/we do to decrease the occurrence of type 2 diabetes?”

Alternate question:

Name \_\_\_\_\_ Period \_\_\_\_\_

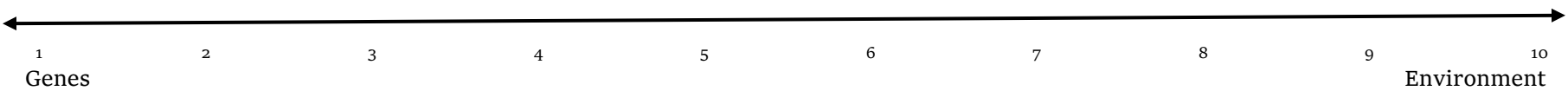
	What did I do today?	What did I find out?	How do I answer the Driving Question today?
<b>Lesson 1:</b> Asking Questions about Diabetes			
<b>Lesson 2:</b> Homeostasis: Glucose in Balance			
<b>Lesson 3:</b> Modeling Type 2 Diabetes			
<b>Lesson 4:</b> Genes and Environment			
<b>Lesson 5:</b> Evaluating Solutions	<i>Please complete the end-of-unit information on the back of this page and Student Sheet 5.2: Evaluation Solutions.</i>		

Place a mark that best represents your view on the lines below. At the beginning of the unit (i.e. Lesson 1), mark your place with a **dot**. At the end of the unit (i.e. Lesson 5), mark your place with a **star**.

I think that solutions to the growth of type 2 diabetes lie mostly with:



I think developing type 2 diabetes is mostly due to:



Date _____		<b>Why do you think the incidence of type 2 diabetes is increasing so quickly?</b>		Date _____	
Beginning of Unit			End of Unit		
<b>What do you think causes type 2 diabetes? Explain using pictures and words.</b>					
Beginning of Unit			End of Unit		

## Biology, Homeostasis, and Type 2 Diabetes

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### LESSON TWO

## Lesson 2: Connecting to the *Next Generation Sciences Standards* (NGSS Lead States 2013)

Lesson 2 contributes to student competency in the following standards:

### Performance Expectations

**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.

DIMENSIONS	CLASSROOM CONNECTIONS
<b>Science and Engineering Practices</b>	
<b>Developing and Using Models</b>	Students create paper models of poly-, di- and monosaccharide carbohydrates to illustrate where glucose comes from and how it impacts type 2 diabetes
<b>Analyzing and Interpreting Data</b>	Students analyze graphs representing blood glucose levels over time and make claims about how food choices influence blood glucose levels.
<b>Disciplinary Core Ideas</b>	
HS-LS1.A: Structure and Function <ul style="list-style-type: none"><li>Feedback mechanisms maintain a living system's internal conditions within certain limits, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage or discourage what is going on inside the living system.</li></ul>	Students see a visual representation of the average amounts of glucose in a healthy person's blood as well as the amount of glucose in a sugary drink. Students learn how the body keeps internal conditions (blood glucose) within a healthy range even as external conditions (drink choices) vary.
HS-LS1.C: Organization for Matter and Energy Flow Cellular respiration is a process in which the bonds of food molecules and oxygen molecules are broken, and new compounds are formed.	Using their paper models of glucose, students make the connection between where glucose comes from (food), what it is used for (cellular respiration), and how tightly it is regulated in the blood.
<b>Crosscutting Concepts</b>	
<b>Stability and Change</b>	Students are exposed to two examples of how feedback mechanisms maintain homeostasis (blood glucose and body temperature), and how high blood glucose is the result of disrupted homeostasis
<b>Structure and Function</b>	Students are introduced to the interconnected roles of the pancreas, liver, brain, muscles and fat tissue in blood glucose regulation.
<b>Systems and System Models</b>	Students learn the components of the model they will use in the next lesson that illustrates the interactions between and within the organs, hormones, and other factors in the system that regulates blood glucose levels.



## Lesson 2

# Homeostasis: Glucose in Balance

**Time:** 50 min

### Lesson Objectives:

Students will be able to answer:

- Where is glucose found in food?
- How do feedback mechanisms maintain homeostasis?
- What hormones and organs are involved in blood glucose regulation?

### Overview

Students trace glucose molecules from the foods they eat to the starting point of cellular respiration by creating paper models of different carbohydrates, including starch, fiber, sucrose, fructose and glucose. Students then consider blood glucose regulation and learn about feedback mechanisms, homeostasis, and the role of insulin, glucagon, and organs involved in blood glucose regulation. This lesson prepares students to use the model game boards in Lesson 3 in which they work through different scenarios that illustrate how disruptions in blood glucose homeostasis contribute to type 2 diabetes.

A protocol for a lab extension: *Where is glucose in food? Using yeast respiration as a bioassay for glucose* can be found at the end of this lesson. In this lab experience, students use the CO<sub>2</sub> production by yeast as an assay for the amount of glucose in a food.

### Enduring Understandings

- Glucose, the major energy source for all human cells, is released primarily through digestion of carbohydrates. Food choices impact blood glucose levels.
- Blood glucose levels are regulated to stay within a healthy range.

### Essential Question

Where is glucose found in food, and how is it regulated?

### Lesson Summary with Timings

Modelling Carbohydrates	20 min
Feedback and Homeostasis	20 min
Closure	10 min
Lab Extension: Where is Glucose in Food?	60 min

### Alternate Lesson Timing

Lesson 2 begins with students creating a paper model of simple and complex sugars and link the glucose molecule to the process of cellular respiration.

The second half of Lesson 2 introduces students to the concepts and components they will need to use the model board in Lesson 3 and could be combined with Lesson 3 if teachers have block periods which could accommodate a longer lesson format.

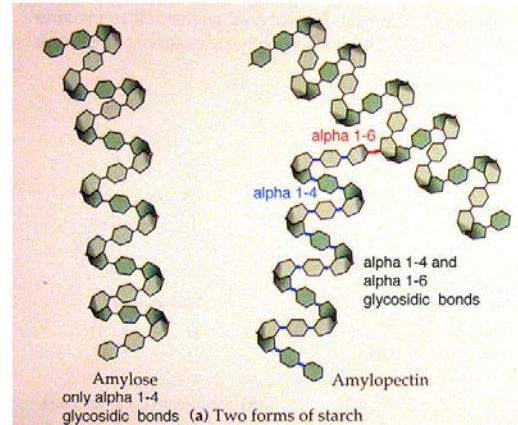
Because Lessons 2 provides the foundation for Lesson 3, they are presented in one document and use one PowerPoint slide set.

## Background on Carbohydrates

Glucose, a **monosaccharide**, is the primary energy molecule of the body. Surprisingly, much of the food we eat is not in the form of glucose. More commonly, glucose is found as part of **disaccharides** like sucrose (found in fruit) and lactose (in milk) or as a starch.

### *How is starch digested to glucose?*

**Starch**, a **polysaccharide**, is a natural **polymer** of glucose, formed in a variety of plants by the chemical linkage of hundreds or even thousands of individual glucose units. Corn, wheat, potatoes and rice are main sources of starch used in the U.S. Other plants with high starch content (*e.g., cassava, milo, sorghum*) are more abundant in other parts of the world. The common starches differ in that they contain different amounts of two types of glucose polymers. One of these polymers is **amylose** (see figure to the right), a linear chain of 500 to 2000 glucose units. The other starch polymer, **amylopectin** (see figure to the right), has a tree-like shape, with linear chains like those in amylose connected at branch points. Each branch contains about 20 to 30 glucose units and the molecule is made up of several hundred branches.



Digestion of carbohydrates begins in the mouth. Saliva contains a large amount of alpha-amylase, an **enzyme** that breaks starch into smaller fragments. With the help of additional digestive enzymes, these fragments are broken down into **glucose**. Glucose molecules are then absorbed from the small intestine into the blood stream. Once in the blood stream, glucose is transported into cells with the help of **insulin**. Insulin is a small **protein hormone** that regulates the amount of glucose in the blood by stimulating cells to transport glucose in from the blood stream. Once in our cells, glucose can be broken down for energy. In addition to alpha-amylase, other digestive enzymes that are responsible for making glucose available to cells for energy include sucrase and lactase. Sucrase (also known as invertase) digests sucrose (*table sugar*; also found in foods containing high fructose corn syrup) to glucose plus fructose, and lactase digests lactose (*milk sugar*) to glucose plus galactose. Also, some foods contain glucose without enzyme digestion.

Starch is broken down to glucose in two stages, each requiring specific enzymes that act upon different portions of the molecule. Due to the size of the starch molecule and the specificity of the enzymes, starchy foods can take longer to digest than foods containing a predominance of mono- or di-saccharides (such as foods containing high fructose corn syrup). Foods that are digested more slowly release glucose into the blood stream more slowly.

Most **fiber** is also a polysaccharide and a natural polymer of glucose. **Fiber** is plant matter such as cellulose that cannot be broken down by human digestive enzymes, though bacteria in the human digestive tract can digest some types of fiber. Fiber is important to the diet because the roughage aids in digestion, and a high fiber meal can provide a feeling of fullness without adding calories. Fiber also slows down the rate of sugar absorption by the body.

Nordqvist, C. (2013, November 4). "What is fiber? What is dietary fiber? Fiber rich foods." Medical News Today. Retrieved from <http://www.medicalnewstoday.com/articles/146935>

**Materials**

Materials	Quantity
Computer and projector	1 per class
Biology_Homeostasis_T2D_Lessons_2-3_SlideSet PowerPoint presentation for Lessons 2-3, found at <a href="http://gsoutreach.gs.washington.edu/">http://gsoutreach.gs.washington.edu/</a> (see GEMNet Instructional Materials)	1 per class
8.5 x 11 inch sheet of paper, <i>or</i> Teacher Copy Master 2	1 per class
Scissors	1 per student
Tape	1 per group
Background on Carbohydrates, optional	1 per student
Teacher Copy Master 2: Carbohydrate Chains	1 per student
Student Sheet 2: <i>Glucose in Balance</i>	1 per student
Lesson Summary Guide from Lesson 1	1 per student
<p><i>Materials for Engage activity for Part II:</i></p> <ul style="list-style-type: none"> <li>• 5 liters of liquid, preferably red, representing the approximate amount of blood adults have in their bodies.</li> <li>• 1 baggie with 4 g of sugar in it, representing the approximate amount of blood glucose a healthy adult would have when waking in the morning (80 mg/dl).</li> <li>• 1 baggie with 16 g of sugar in it, representing very high blood glucose levels of a person with diabetes (320 mg/dl).</li> <li>• 1 baggie with 65 g of sugar in it, representing the amount of sugar in one 20-ounce Coca-Cola, or one 16-ounce Caramel Frappuccino from Starbucks.</li> </ul> <p>This is intended as a teacher demonstration, but students could work in groups to calculate, weigh, and demonstrate the sugar amounts to others, if time allows.</p>	1 per class

**Note:** The PowerPoint slides for Lessons 2 and 3 are combined into one set.

**Procedures****Part I (Engage and Explain): Modelling Carbohydrates (20 min)**

1. Entrance activity: Students can respond to the questions posed on the entrance activity slide in a number of ways, as directed by the teacher. Suggested strategies include using a think-pair-share activity, a brief class discussion, or an individual writing exercise. Students should focus on the main question, and then choose one or more of the *think about....* options as time allows.

The *Background on Carbohydrates* reading is not mandatory for students but can be used at the teacher's discretion depending on the level of the class.

Slide 1

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Biology, Homeostasis, and Type 2 Diabetes  
Lesson Two

Entrance Activity:

What is glucose? Where does glucose come from in our diets?

Think about....

- What foods/drinks contain glucose?
- Where do other sugars come from?
- What is glucose used for in the body?
- Glucose can be described as both a *fuel* and a *toxin*. How can something so good also be so bad?

- Point out for students that carbohydrates, including sugar, play an important role in our diets. While the simple sugar glucose is fuel for every cell in the body through the process of cellular respiration, chronic high glucose levels can lead to glucose toxicity, debilitating illness, and type 2 diabetes.
- Hand out a blank 8.5 x 11 inch piece of paper to each student.
- Have students fold the paper down about an inch along the short side. “Accordion” the paper by folding it back and forth to the end (Figure 1).
- Once flat, have students cut the paper into squares (Figure 2).
- Lastly, have students snip the corners off the top and bottom of each square to create connected 6-sided shapes to represent single-ring sugars such as **glucose** (Figure 3). **Be careful** to leave the midsection intact.

If time is short, print and cut out strips of simple sugars using Teacher Resource 2, then jump to Step 7.

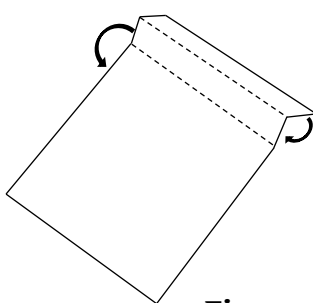


Figure 1

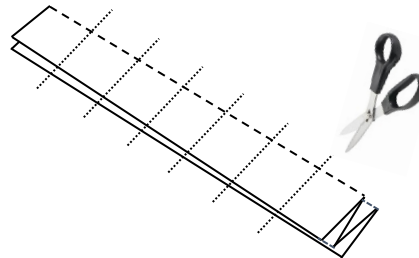


Figure 2

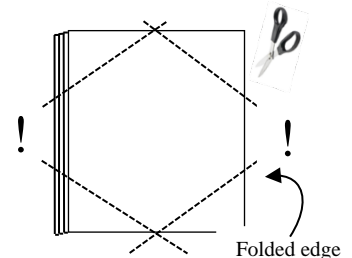
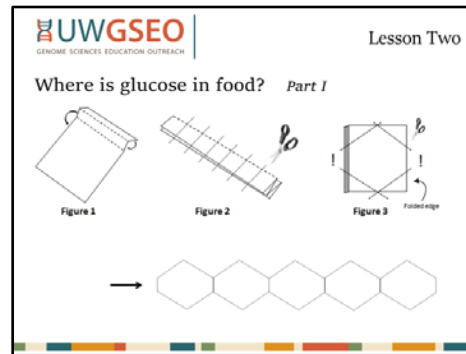


Figure 3

- Have students unfold their paper models into chains. Tell students that these chains represent **carbohydrates** in the form of **polysaccharides** (poly = many; saccharide = sugar). Slide 2 can help instruct students in folding and cutting.

Slide 2



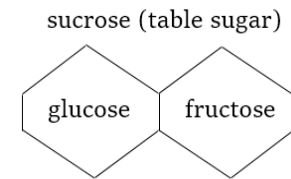
8. Have students tape a few of the chains together to make longer chains. Encourage them to join chains with other individuals or groups to make both straight chains and branched chains.
9. These longer, more complex polysaccharide chains represent large carbohydrates such as **starch** and **cellulose**. The starches in our diets are found in foods such as *corn*, *rice*, *wheat*, and *potatoes*. These can be made up of hundreds or even thousands of individual units.
10. Explain that each individual unit (hexagon) represents one **glucose** molecule. Glucose is released through digestion and the work of **enzymes** in the body. Enzymes are the “molecular scissors” that break the large carbohydrates and sugars apart so that the body can get energy from the individual units such as glucose.
11. Choose one group of students to draw colored lines using a marker between the single units of one of the larger chains. The chains with colored lines between units represent dietary **fiber**. Fiber is plant matter such as cellulose that cannot be broken down by human digestive enzymes—we don’t have the molecular scissors to cut the colored bond—though bacteria in the human digestive tract can digest some types of fiber. Fiber is important to the diet because the roughage aids in digestion, and a high fiber meal can provide a feeling of fullness without adding calories. Fiber also slows down the rate of sugar absorption by the body.
12. Ask each student to take *one* of his or her chains and cut or tear it into individual hexagons, or **glucose** units. Each glucose is a single sugar, or **monosaccharide**, (mono = one) when detached from the chain. Have students label a few monosaccharide pieces as **glucose**.
13. Explain that **fructose** is also a monosaccharide and have students label a few more monosaccharide pieces as **fructose**. Fructose is a very sweet sugar found in some plants such as fruits and berries. It is metabolized differently than glucose by the body. [Teacher note: fructose is a 5-ring sugar but will be represented the same way as glucose in this activity.]

**Polysaccharides** are often referred to as **complex carbohydrates**.

**Mono-** and **disaccharides** are often referred to as **simple carbohydrates**.

## Lesson 2

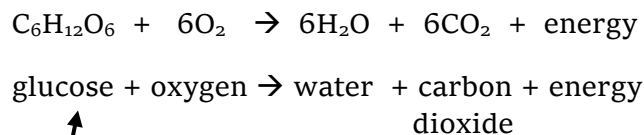
14. Ask students to break another chain into groups of two hexagons. Each of these represents a **disaccharide** (di = two). **Sucrose** (table sugar) is a disaccharide.
15. **Sucrose** is made of two monosaccharides, **fructose** and **glucose**. These two monosaccharides are often found together. Have students label a few disaccharides sucrose and label the individual monosaccharides as fructose and glucose. Slide 3 provides an overview.



Slide 3

**Lactose**, the sugar found in milk, is also a disaccharide. It is made up of the monosaccharides **glucose** and **galactose**. This sugar is not as sweet as sucrose. People who are lactose intolerant are lacking the enzyme that breaks apart the double-ring sugar into the two single-ring sugars.

16. Return to a single glucose hexagon. If students are already familiar with photosynthesis and cellular respiration, this is a good place to reinforce the equation below.



Energy released through cellular respiration pathways is in the form of ATP. One glucose molecule in combination with oxygen can generate 38 ATP molecules.

17. Glucose, our monosaccharide, is the input fuel for cellular respiration—the way the body gains energy from food. Remind students that most of the starches in our diets (corn, wheat, rice, potatoes) are long chains of glucose, made by plants through the process of photosynthesis.
18. Have students label a few glucose hexagons with its chemical formula:  $\text{C}_6\text{H}_{12}\text{O}_6$ .
19. Have student tear up a few glucose molecules to show that bonds of the glucose molecule itself (in the presence of oxygen) are chemically broken to form new compounds. One of the products of this chemical reaction is energy, which is used for everything from organ function to keeping our bodies warm.
20. Before moving to Part II, instruct students to clearly label their models of glucose, fructose, sucrose, and chains of starch and fiber, and tape the models in their notebooks.

**Part II (Engage and Explain)      Feedback and Homeostasis      (20 min)**


21. Show student the 5 liters of colored water and bags of sugar described in the **Materials** section. This provides a helpful and concrete visual for this lesson. As students just learned, the sucrose in the baggies will be digested into glucose and fructose, both of which have metabolic pathways in the body. If time allows, students could be given the materials and asked to calculate and demonstrate the activity to others.
22. Ask students how their bodies might accommodate all the extra sugar that does not end up as blood glucose. Where does it go? What happens if a person drinks a lot of soda? Or none? How do our bodies balance this?
23. Introduce **homeostasis** as the way our bodies maintain balance by regulating internal conditions (keeping blood glucose within a range), even as the external environment (how many sodas a person drinks) changes. This is an important theme in biology, and we will look closely at the mechanisms for regulating blood glucose.
24. Tell students that the glucose molecules we ingest enter the bloodstream through digestion. Keeping blood glucose within a healthy range is an important balancing act our bodies go through many times a day. Type 2 diabetes results when blood glucose levels become too high for long periods of time. Slide 4 reinforces this concept and introduces the pasta wheel that represents glucose in the model students will work with in Lesson 3.

## Slide 4

What does glucose have to do with type 2 diabetes?

Type 2 diabetes develops when blood glucose levels are too high for too long. The body is not maintaining blood glucose within a healthy range.

For the model we will be using next, glucose is represented by a pasta wheel.



Paper model of Glucose      Pasta model of Glucose


$C_6H_{12}O_6$

**Note:** The purpose of Part II of this lesson is to prepare students to use the model boards in Lesson 3. Students are introduced to homeostasis, feedback mechanisms, the role of insulin and glucagon, and the body organs and tissues that are part of the system. Students will need to have a good understanding of these components before using the model boards.

25. Tell students that **feedback mechanisms** are responsible for maintaining homeostasis. This occurs when different components of a system regulate each other. In our model, the hormones insulin and glucagon regulate blood glucose levels. Slides 5 and 6 reinforce this concept.

Slide 5

**Homeostasis:**  
Maintaining balance by regulating internal conditions



A balancing act happens many times a day—every time you have a meal or consume a drink with sugar. The ability of the body to maintain balance and regulate internal conditions is called **homeostasis**.


Slide 6

**Homeostasis** allows organisms to maintain balance (stability) even as the external environment changes.

You may have high blood glucose levels after eating a large meal, or low blood glucose levels between meals. Your body responds to how often you eat and what you eat in order to keep blood glucose levels within a healthy range.

**Feedback mechanisms** maintain homeostasis

Balance is maintained when different components of a system regulate each other.



26. Show Slides 7 through 12, which illustrate the feedback mechanism that maintains blood glucose homeostasis.

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How does the body balance blood glucose levels?

A **feedback mechanism** relying on two hormones:

**Insulin**  
Allows glucose to leave the blood and enter some cells

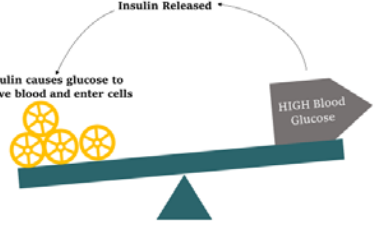
**Glucagon**  
Allows glucose to leave some cells and enter the blood

3 pasta wheels represent a balanced amount of blood glucose



Insulin Released

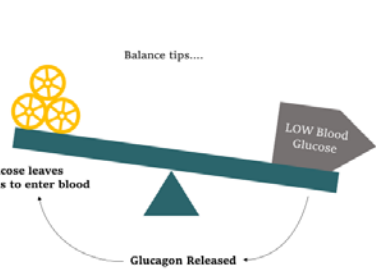
Insulin causes glucose to leave blood and enter cells



Feedback Mechanism

Balance tips....

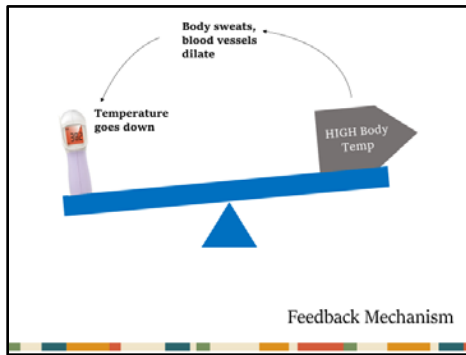
Glucose leaves cells to enter blood



Feedback Mechanism

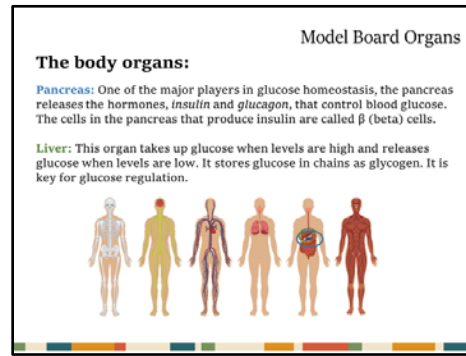
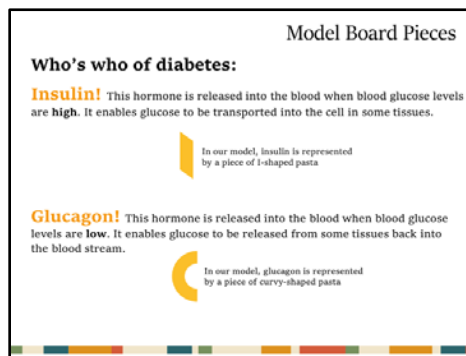
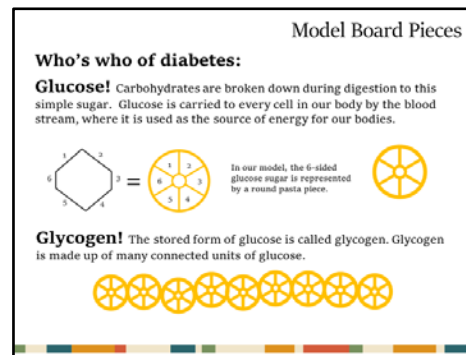
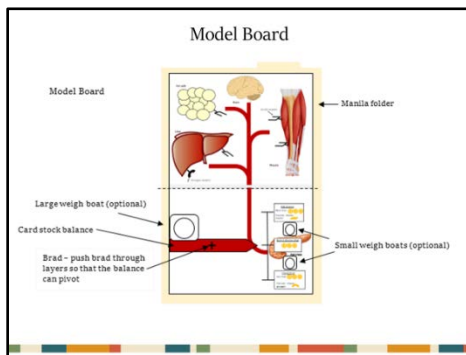
27. Slides 13 - 17 apply the concept to body temperature regulation to illustrate that feedback mechanisms are prevalent in other body systems.

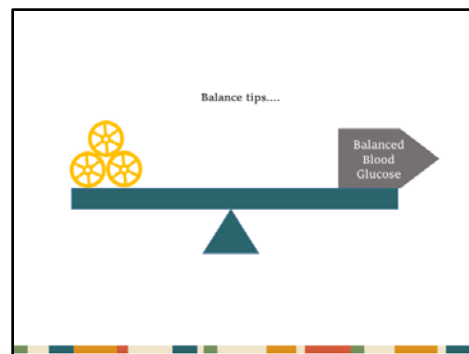
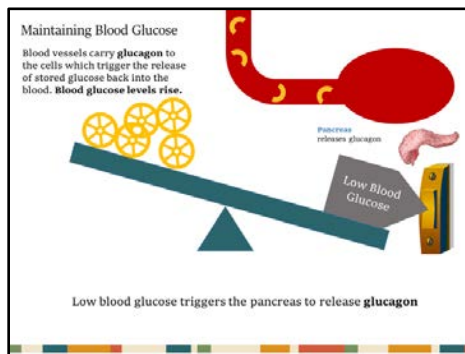
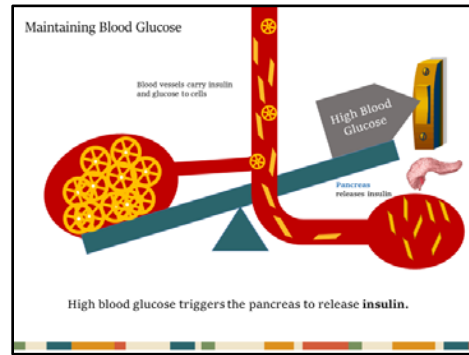
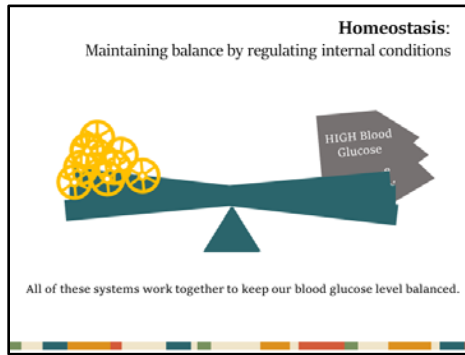




**Note:** Feedback mechanisms that maintain homeostasis are ubiquitous in biology. As an extension or homework assignment, students could find additional examples which exist at every level of biology, from cells to ecosystems.

28. Hand out Student Sheet 2—*Glucose in Balance*. Ask students to fill out the first section as Slides 18 – 28 are presented. These slides orient students to the model board used in Lesson 3, the game pieces, and the organs involved in the model. Selected slides are shown below.





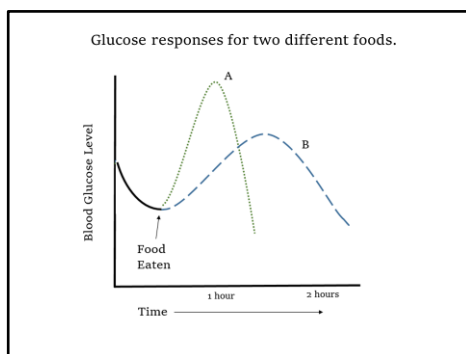
**Part III (Evaluate)**

**Closure**

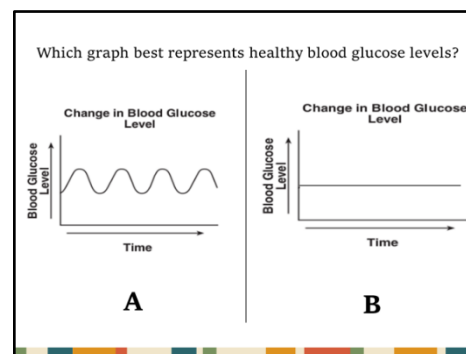
**(10 min)**

29. Let students finish Student Handout 2—*Glucose in Balance*. A completed sheet can be used as an exit ticket, or assigned as homework depending on time.
30. Show students Slide 29 - 31. Have them talk with a neighbor and decide which graph best represents healthy glucose levels maintained through homeostasis in slide 30.

Slide 29



Slide 30



31. Slides 29 - 31 illustrate that blood glucose levels fluctuate throughout the day, as do many biological processes maintained by homeostasis. When a person is becoming pre-diabetic or diabetic, blood glucose levels are not as well maintained and blood glucose levels begin to rise.

32. Lastly, have students consider what they did today, what they learned, and how it might apply to the question, “*What can I/we do to decrease the occurrence of type 2 diabetes?*” (or alternate question) by filling out the second row of the **Lesson Summary Guide**.

### Extension

A protocol for a lab extension: *Where is glucose in food? Using yeast respiration as a bioassay for glucose* can be found at the end of this lesson. In this lab experience, students use the CO<sub>2</sub> production by yeast as an assay for the amount of glucose in a food. The assay measures the amount of bubbles collected in an inverted conical tube. The protocol for the first experiment is included. At the end of this lesson there are some ideas for other foods students can test and how the glucose that is found in them might be released.

### Glossary

**Beta cell ( $\beta$  cell):** A type of cell in the pancreas that makes and secretes insulin.

**Carbohydrate:** Types of sugar, starch, and cellulose that are made of carbon, hydrogen and oxygen, usually in a ratio of 1:2:1.

**Cellulose:** The main component of cell walls and fibrous plant products. As it is insoluble and cannot be broken down by human digestive enzymes, it provides fiber in the diet.

**Complex Carbohydrate:** Another name for polysaccharides, or starches made of longer saccharide chains. These take longer to break down than simple carbohydrates.

**Disaccharide:** di- (two) + saccharide (sugar). A sugar composed of two single sugars (monosaccharides) bound together. Examples are sucrose, lactose and maltose.

**Dietary Fiber:** A carbohydrate found in plant matter (such as cellulose) that cannot be broken down by human digestive enzymes. Fiber can be soluble and insoluble in water, and is sometimes referred to as roughage.

**Enzyme:** A biological molecule (a protein) that speeds up the rate of a chemical reaction.

**Fructose:** A simple, single-ringed sugar found in many plants that often bonds with glucose to make up the two-ringed sugar sucrose (table sugar).

**Galactose:** A simple, single-ringed sugar often found bonded with glucose to make up the two-ringed sugar lactose, found in milk.

**Glucagon:** A hormone made by the pancreas in response to a fall in blood glucose levels.

**Glucose:** A simple, single-ring sugar that is the main source of energy for living organisms through the process of cellular respiration. It also is the building block of many carbohydrates.

**Glycogen:** A storage form of glucose produced mainly in the liver and muscle cells.

**Homeostasis:** The ability to maintain a living system's internal conditions within certain limits even as external conditions change within some range, often involving feedback mechanisms.

**Insulin:** A hormone made by the beta cells of the pancreas to regulate the amount of glucose in the blood.

**Lactose:** A two-ringed (disaccharide) sugar made of glucose + galactose sugars. It is the major sugar in milk. It can be broken down by the enzyme lactase.

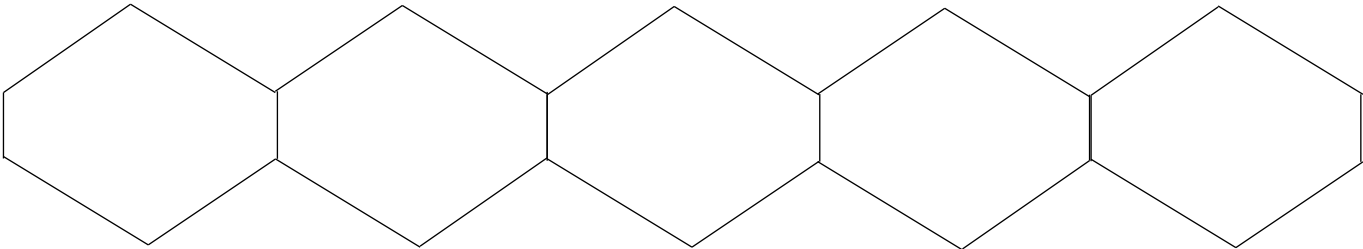
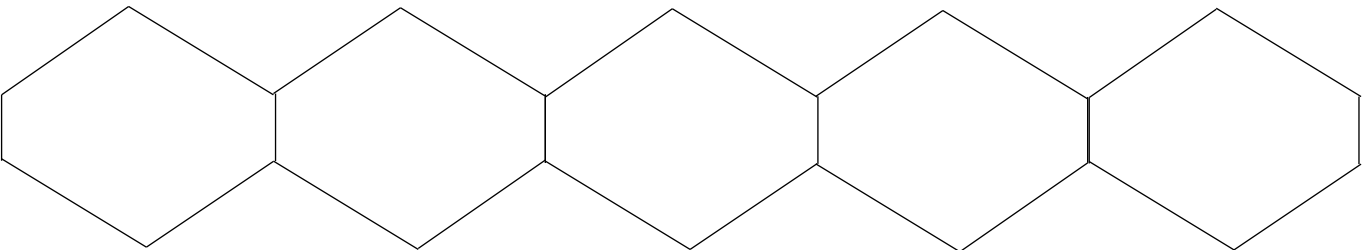
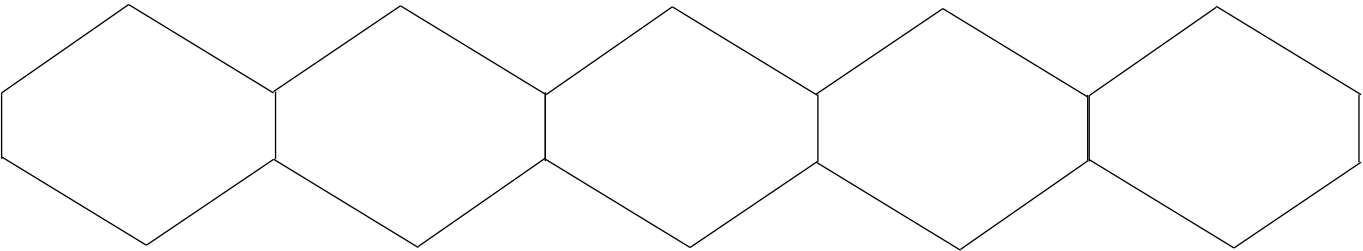
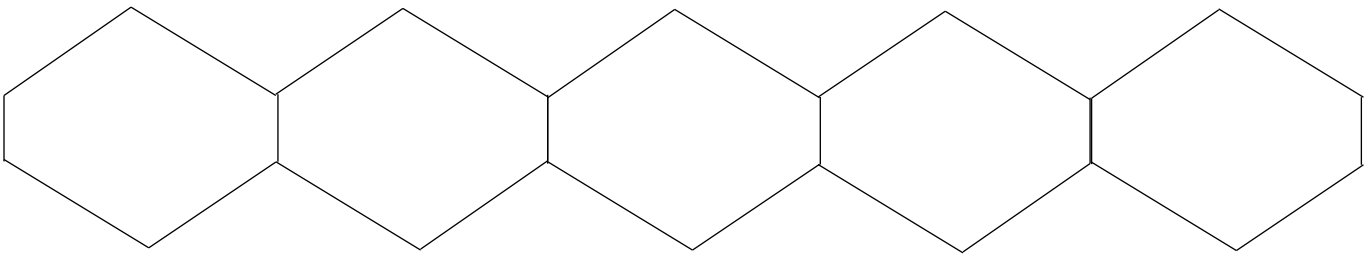
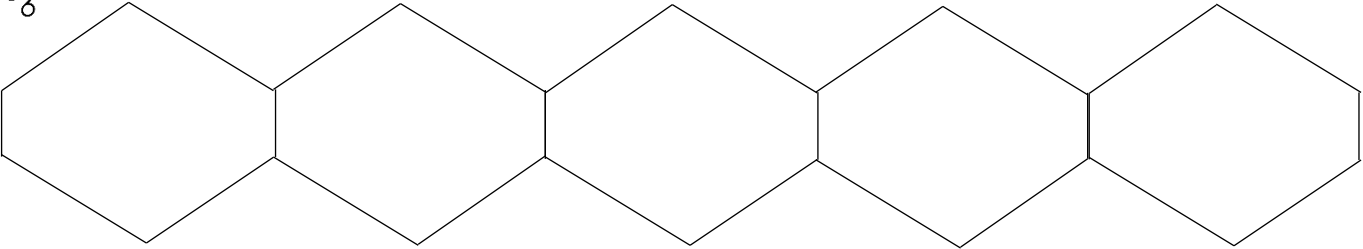
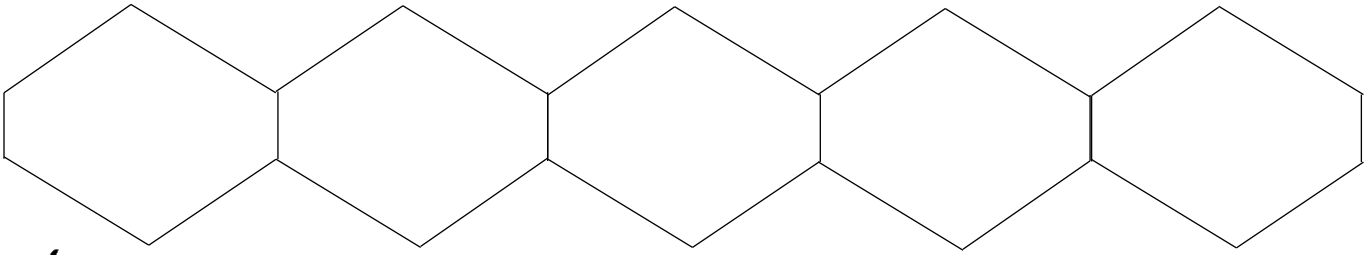
**Monosaccharide:** mono- (one) + saccharide (sugar). A simple, one-ring sugar such as glucose or fructose. Monosaccharides are the building blocks of more complex sugars.

**Polysaccharide:** poly- (many) + saccharide (sugar). A carbohydrate made by repeating units; a complex sugar made of a chain of monosaccharides joined together by bonds.

**Simple Carbohydrate:** Another name for monosaccharides and/or disaccharides, (single or double ringed sugars).

**Starch:** A carbohydrate made of many glucose units joined together.

**Sucrose:** A two-ringed sugar (disaccharide) that is made up of glucose + fructose. It is used widely as a sweetener and made from sugar beets and sugar cane. It can be broken down by the enzyme sucrase.





## Student Sheet 2: Glucose in Balance

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

### Model Board Pieces and Organs:

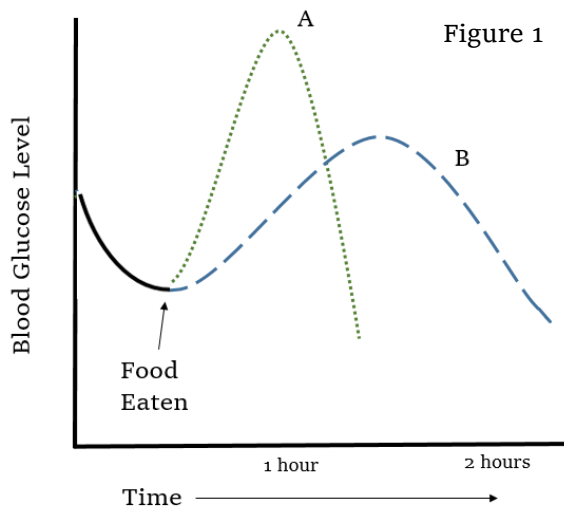
Player	Game piece	Function
Glucose		
Glycogen		
Insulin		
Glucagon		
Organ	Role	
Pancreas		
Liver		
Muscles		
Fat cells		
Brain		

### Glucose in Balance

1. When our blood glucose is high, the \_\_\_\_\_ releases \_\_\_\_\_.
2. When our blood glucose is low, the \_\_\_\_\_ releases \_\_\_\_\_.
3. Define homeostasis:

Using Figure 1, answer the following questions:


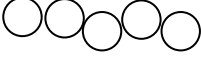


4. What kind of food might be represented by Line A?
5. What kind of food might be represented by Line B?
6. How would insulin release be different for Lines A and B?



## Student Sheet 2: Glucose in Balance

### POSSIBLE ANSWERS to Student Sheet 2

#### Model Board Pieces and Organs:

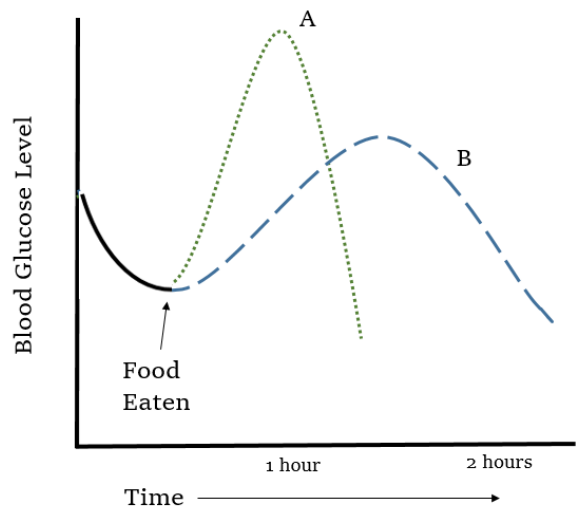
Player	Game piece	Function
Glucose		Blood sugar, used as energy
Glycogen		Stored glucose, made of many units of glucose
Insulin		Hormone allows glucose storage
Glucagon		Hormone allows glucose to be released
Organ	Role	
Pancreas	Makes and releases insulin and glucagon. Has $\beta$ cells, which make insulin.	
Liver	Regulates glucose levels in blood by both taking up and releasing glucose	
Muscles	Can take up lots of glucose from the blood, use glucose, and store glucose	
Fat cells	Can take glucose into the fat cell when glucose is present	
Brain	Uses glucose for fuel; does not need insulin	

#### Glucose in Balance

- When our blood glucose is high, the pancreas releases insulin.
- When our blood glucose is low, the pancreas releases glucagon.
- Define homeostasis:  
*The ability of the body to maintain balance and regulate internal conditions.*

Using Figure 1, answer the following questions:

- What kind of food might be represented by Line A?  
*A sugary food or drink that releases glucose into the blood quickly, such as soda, candy, or cookies. White bread, white rice and other starches without much fiber can also release glucose quickly.*
- What kind of food might be represented by Line B?  
*A food with a higher fiber content, such as whole grains, whole fruit, and legumes.*
- How would insulin release be different for Lines A and B? *Line A foods would trigger more insulin.*





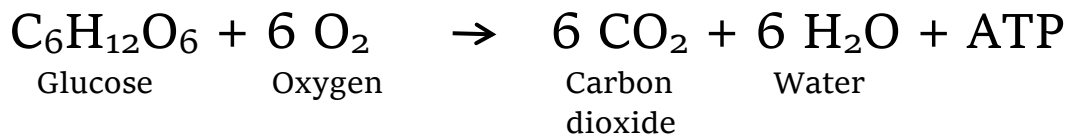
# Where is glucose in food? Using yeast respiration as a bioassay for glucose

## LAB EXTENSION

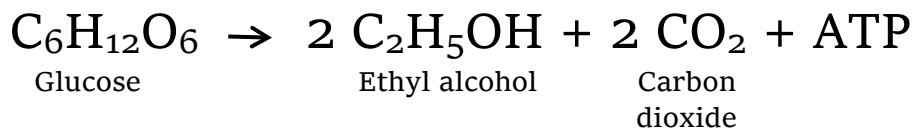
### Background

Like mammalian cells, the single-celled organism, yeast, uses the single-ring sugar glucose as a source of energy through the following reactions:

In presence of oxygen:



In absence of oxygen:



In this experiment, we're going to use the CO<sub>2</sub> production by yeast as an assay for the amount of glucose in a food. The assay measures the amount of bubbles and the ability to displace liquid from the yeast/food mixture. The protocol for the first experiment is given. At the end of this lesson there are some ideas for other foods you can test and how you might release the glucose that is found in them.

### Materials and Reagents

15 ml conical tubes with 3-4 holes in cap (made with a tack or 21 gauge needle)

Waterbath set to 37°C

Plastic beakers

Waterproof felt tip pens

Labeling tape

Yeast solution made by mixing 1 pkg Fleischman's active dry yeast (1/4 oz) in 100 ml tap water

1% glucose solution in tap water

1% sucrose solution in tap water

Tap water (use hot water from water dispenser in kitchen, and cool to 37°C)

Mashed kidney bean solution

Mashed kidney bean solution incubated with 1 Walgreen's antigas tablet (α-galactosidase)

Mashed kidney bean solution incubated with 1 Enzymedica Digest complete enzyme mixture

### Directions

Prior to setting up the yeast respiration experiment, prepare the test food.

Beans: Mash 10-15 mls of beans with a glass rod, adding about 30 mls of tap water to get a slurry the consistency of gravy. Divide into 3 tubes. To tube 1, add nothing; to tube 2 add one Walgreen's antigas tablet, and to tube 3, add one Enzymedica tablet. Incubate tubes 2 and 3 at 37°C for 1-2 hours. Spin each tube to collect supernatant.

# Where is glucose in food? Using yeast respiration as a bioassay for glucose

## Respiration assay

1. Label 15 ml conical tubes with strips of lab tape along the length of the tube right beside the gradations. Write the name of the sample at the edge of the tape furthest from the markings on the tube.
2. Pour 8 ml sample food into each 15 ml conical tube. Set up all samples, and incubate them right side up in the water bath.
3. Invert container of yeast solution to mix; then pour into sample tube 1, filling to top so meniscus goes over the top.
4. Screw on a lid with holes on top of tube, making sure that a little bit of liquid extrudes from the holes. Cover the holes with your finger, and invert twice to mix.
5. Place the tube into a beaker containing water warmed to the same temperature as the water bath. To do so, keep your finger on the holes in the cap and invert the tube, then place cap down into the beaker of water. Up to 2 tubes can be placed in each beaker.
6. Repeat with all sample tubes, starting them at 1 minute intervals so you have time to make measurements on each throughout your experiment.
7. About 10 seconds BEFORE each of the measurement times on the table below, place your finger over the bottom of the tube, remove it from the water bath, and invert 2-3 times to mix and allow the bubbles caught at the bottom of the tube to rise to the surface.
8. Record the volume of gas given off by the yeast by drawing a line on the tape at the position of the gas bubble, including the froth at the top of the liquid. Record the volume on the data table. Invert so the cap is down and put back in the water bath.
9. When all measurements are complete, record the volume of gas using your markings and the gradations on the conical tube.
10. Graph data on the graph provided.

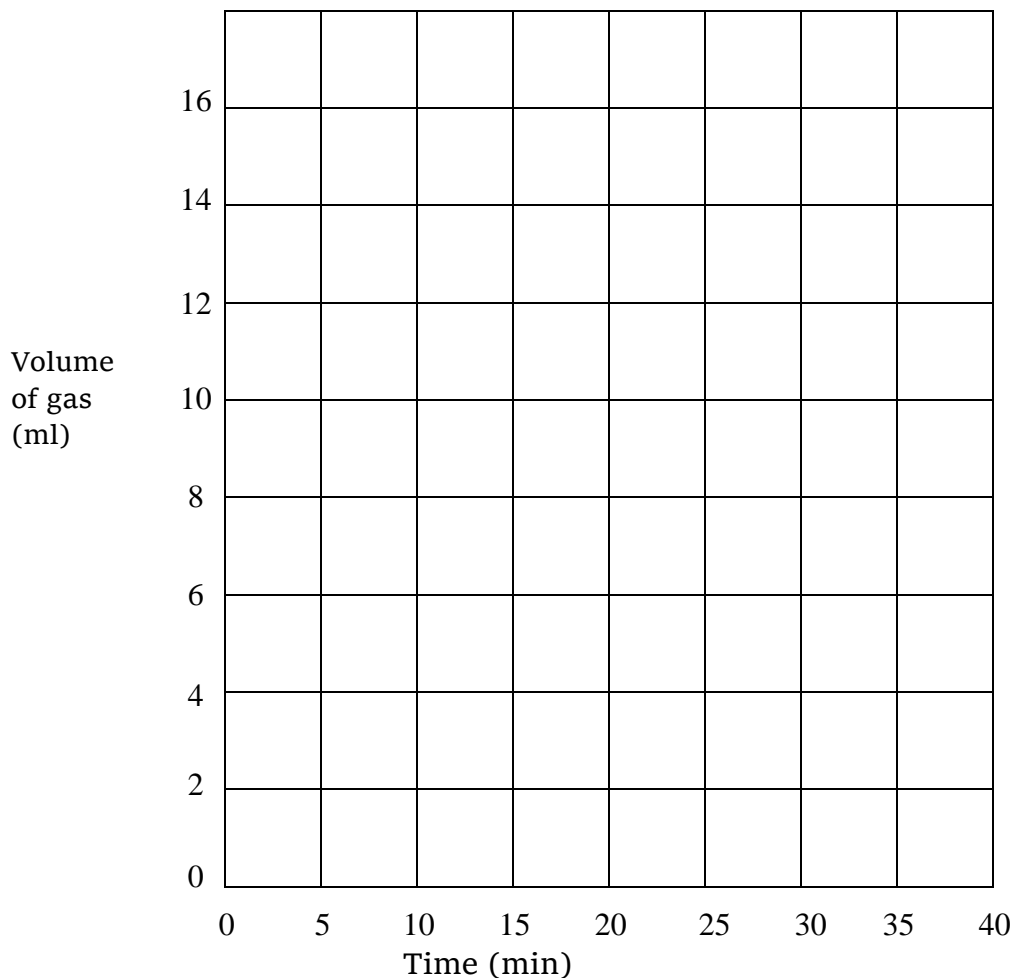
## Results

Table 1: Data

	Volume CO <sub>2</sub> (ml)				
Tube #	Contents	5 min	10 min	15 min	20 min
1					
2					
3					
4					

# Where is glucose in food? Using yeast respiration as a bioassay for glucose

Graph of results



## Discussion

1. What patterns do you observe in your data?
2. Why do these patterns occur? What do the data tell you about the amount of glucose in the food you are studying?
3. How do you account for differences in gas production with glucose compared to sucrose?

## Other experiments to try

Many of the foods we eat do not contain free glucose but can be used as a source of glucose after digestion. Below are some digestive aids that can be purchased at a pharmacy and that contain different digestive enzymes. Try incubating test foods with different digestive aids to test which ones release glucose in the food. First, research each enzyme to see what substrate it works on and what product it makes. Then, make a prediction for each food you are testing and the digestive aid(s) you use. Don't forget to use appropriate controls in your experiment.

- Beano and Walgreen's antigas: Contain  $\alpha$ -galactosidase and other compounds (check ingredient list)
- Rainbow light advanced enzyme system and EnzymedicaDigest complete enzyme form: Contain amylase, glucoamylase, lipase, protease, invertase, maltase, cellulase, lactase, and other compounds

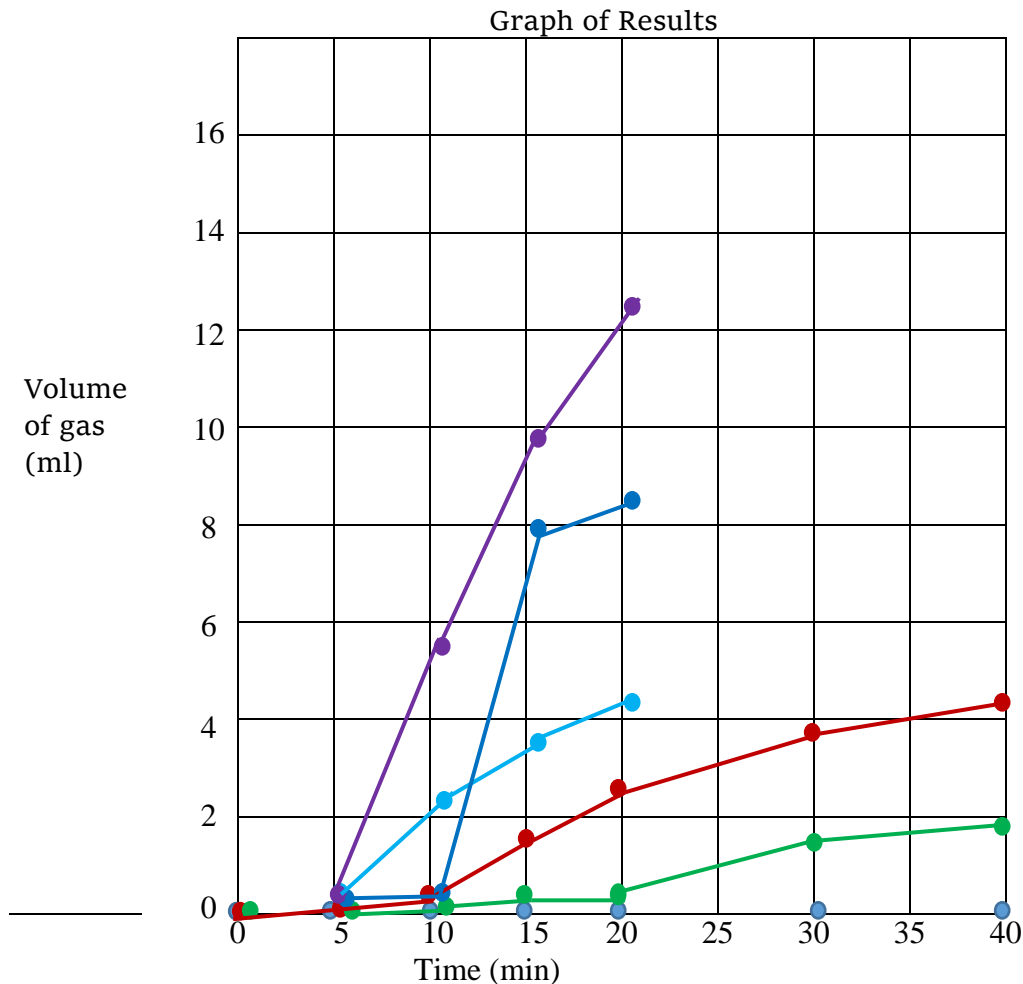
Protocol: based on paper by Reinking, Reinking and Miller and classroom activity by Griswold

# Where is glucose in food? Using yeast respiration as a bioassay for glucose

Table 1: Sample Data

		Volume CO <sub>2</sub> (ml)					
Tube #	Contents (8 ml) + yeast	5 min	10 min	15 min	20 min	30 min	40 min
1	Water ●	0	0	0	0	0	0
2	Glucose ●	0.04	0.5	1.5	2.5	3.8	4.4
3	Sucrose ●	0.07	0.22	0.4	0.5	1.5	1.8

		Volume CO <sub>2</sub> (ml)			
Tube #	Contents	5 min	10 min	15 min	20 min
1	Water ●	0	0	0	0
2	Bean supernatant ●	0.3	2.4	3.5	4.4
3	Bean sup+ antigas table ●	0.25	0.4	8.0	8.5
4	Enzymedica tablet ●	0.3	5.3	9.7	12.6



## Biology, Homeostasis, and Type 2 Diabetes

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### LESSON THREE

## Lesson 3: Connecting to the *Next Generation Sciences Standards* (NGSS Lead States 2013)

Lesson 3 contributes to student competency in the following standards:

### Performance Expectations

**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.

DIMENSIONS	CLASSROOM CONNECTIONS
<b>Science and Engineering Practices</b>	
<b>Developing and Using Models</b>	Students use a model to show the mechanistic relationship between interacting systems made of organs (liver, muscle, pancreas, fat, brain) and the hormones insulin and glucagon.
<b>Analyzing and Interpreting Data</b>	Students use their models to make sense of data showing blood glucose curves for a person who has normal blood glucose, a person who is pre-diabetic, and a person with diabetes.
<b>Constructing Explanations and Designing Solutions</b>	Students construct an explanation for the mechanistic causes of type 2 diabetes based on evidence gathered using the model.
<b>Disciplinary Core Ideas</b>	
<p>HS-LS1.A: Structure and Function</p> <ul style="list-style-type: none"> <li>Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.</li> <li>Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system.</li> </ul>	<p>Students model an interconnected system in which the physiological processes of one component affects other components in that system, contributing to blood glucose balance.</p> <p>Students model blood glucose homeostasis, in which high blood glucose levels trigger the release of insulin, and low blood glucose levels trigger the release of glucagon. Students then perturb the system to see how homeostatic control can fail over time.</p>
<b>Crosscutting Concepts</b>	
<b>Cause and Effect</b>	Students make changes to components in their models and predict the effect this has on the relationships between components.
<b>Stability and Change</b>	Students model homeostatic control within limits, then perturb the system to illustrate how stability can be disrupted.
<b>Systems and System Models</b>	Students simulate blood glucose homeostasis using a model and predict how changes in the system will affect other components that interact in that system.

# Lesson 3

# Modeling Type 2 Diabetes

**Time:** 50 min

**Lesson Objectives:**

Students will be able to answer:

- What is the role of insulin in blood glucose regulation?
- How do insulin resistance and beta cell damage contribute to type 2 diabetes?
- How is type 2 diabetes diagnosed?

## Overview

Students model blood glucose homeostasis using a game board and pasta pieces to illustrate the feedback mechanisms that maintain blood glucose, insulin, and glucagon levels. Students also explore the interacting roles of liver, fat, muscle and brain cells in blood glucose homeostasis. Students are presented with five different scenarios to carry out using the model board, allowing them to figure out how blood glucose levels are impacted by eating, fasting, insulin resistance, beta cell damage, and exercise.

## Enduring Understanding

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.

## Essential Question

How is blood glucose regulated, and what factors contribute to insufficient blood glucose regulation?

## Prerequisite Knowledge

Students will need a good understanding of the following concepts, introduced in Lesson 2:

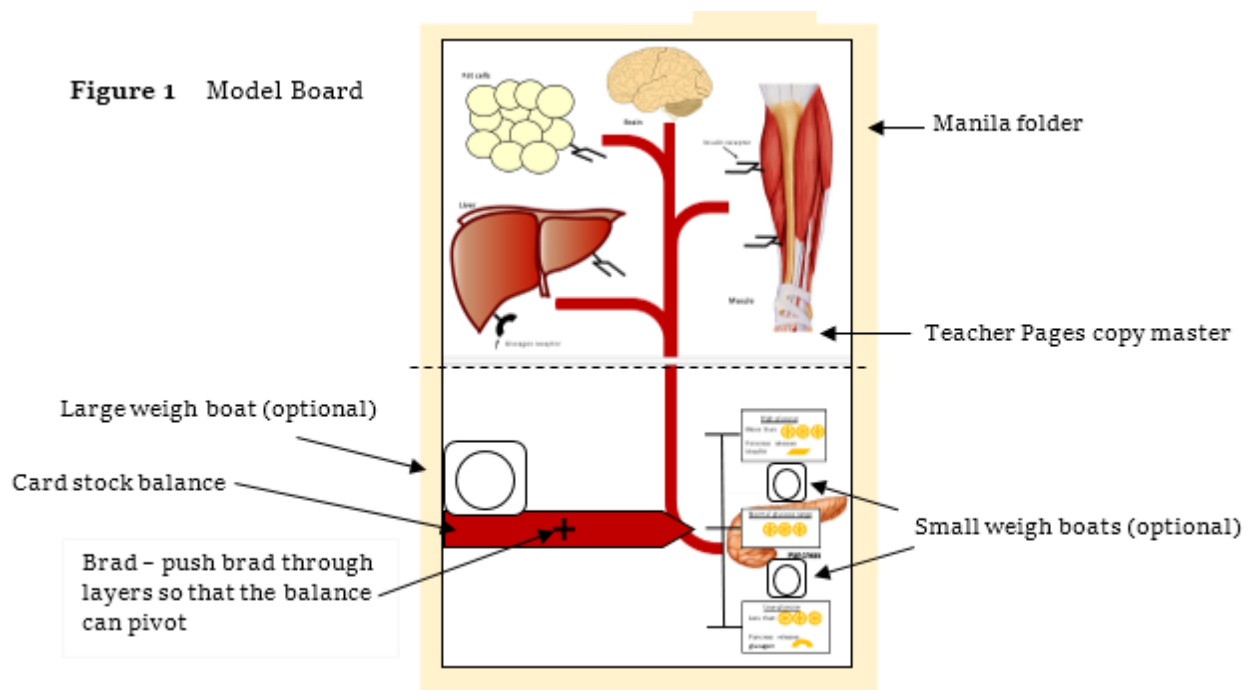
- Model board pieces
- Homeostasis and feedback mechanisms
- Role of insulin
- Role of glucagon
- Body organs and tissues in the system.

## Lesson Summary with Timings

Introduction	5 min
Using the model boards with scenarios	35 min
Closure	10 min

Materials	Quantity
Computer and projector	1 per class
Biology_Homeostasis_T2D_L2_3_SlideSet PowerPoint presentation for unit, found at <a href="http://gsoutreach.gs.washington.edu/">http://gsoutreach.gs.washington.edu/</a> (see GEMNet Instructional Materials)	1 per class
Homeostasis Model Board set (see Figure 1) Each set contains: 1 Manila folder 1 2-page photocopy of model board showing organs 1 brad 1 balance made from red card stock, approximately 7.5 in x 1 in, and pointed at one end. Teachers may wish to write the word “homeostasis” on the balance to underscore the concept. 20 pieces of wheel-shaped (rotelle) pasta to represent glucose 20 pieces of I-shaped (penne) pasta to represent insulin 10 pieces of curvy-shaped (macaroni) pasta to represent glucagon 1 small sticky note cut into 4 strips, each with a sticky end Optional: 2 small weigh boats and 1 large weigh boat to hold pasta	1 per group
Model Board Scenario Cards + Model Orientation Cards	1 set / group
Student Sheet 3— <i>Scenario Scaffolds</i>	1 per student
Lesson Summary Guide from Lesson 1	1 per student

**For each group:** 1) a model board, assembled as shown in Figure 1; 2) a baggie containing the correct number of pasta pieces and sticky notes; and 3) set of cards





**A note about the model board:** Tell students that they will be learning about the biological mechanism of type 2 diabetes in this lesson by working with a model. Models can be useful to show relationships and connections within complex systems. However, every model has limitations, especially a model that works to simplify a very complex system. Some limitations of this model are that it focuses on only a few cell types even though every cell can use glucose for energy. In addition, the role of fats and triglycerides is not well-addressed, nor are the model pieces to scale. Tell students that they will have a chance to address any other limitations of the model at the end of the lesson.

## Procedures

### Part I (Engage):

(5 min)

1. Entrance activity: Students can respond to the questions posed on the entrance activity Slide 32 in several ways, as directed by the teacher. Suggested strategies include using a think-pair-share activity, a brief class discussion, or an individual writing exercise. Students should focus on the main question, and then choose one or more of the *think about....* options as time allows.

Slide 32

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GENOME SCIENCES EDUCATION OUTREACH

Biology, Homeostasis, and Type 2 Diabetes  
Lesson Three

Entrance Activity:

We know that a healthy body keeps blood glucose levels regulated within a range, as homeostasis “tips the balance” many times a day.

What factors can contribute to a *loss of control* of blood glucose?

Think about...

- What is the role of the pancreas?
- What is the role of diet?
- What is the role of exercise?

**Note:** The PowerPoint slides for Lessons 2 and 3 are combined into one set. Lesson 2 uses Slides 1-31.

### Part II (Elaborate):

### Glucose in and out of balance

(35 minutes)

1. Handout Student Sheet 3 – *Scenario Scaffolds*. Student groups will answer questions as they work through the model board scenarios.
2. Hand out the model boards and baggies containing the three types of pasta pieces, sticky notes and weigh boats (if available) to each group of 2-3 students. Orient students to model boards and let students explore the balance mechanism.
3. Hand out the Orientation Cards and Scenario Cards, one set per group.
4. When students have all the materials, let groups proceed at their own pace through the five scenarios.
5. When students have completed the scenarios, go over the answers to Student Sheet 3 – *Scenario Scaffolds* as time allows. Possible answers can be found at the end of this lesson.

- Use Slides 33 and 34 to help answer the last question on the student sheet. These slides go over how diabetes is diagnosed in different ways by measuring blood glucose levels.
- Ask students to predict blood glucose curves for people with and without diabetes before showing them Slide 34.

Slide 33

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**Glucose out of balance**

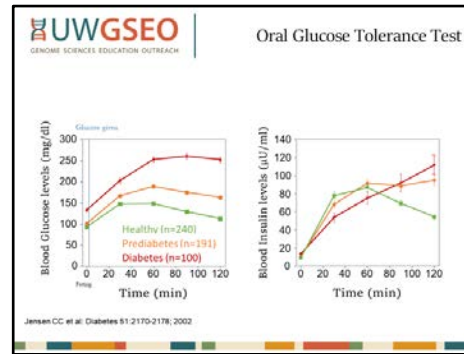
**How is diabetes diagnosed? By measuring blood glucose levels.**

**Fasting glucose test:** After fasting for at least 12 hours, a person's blood is drawn and tested for glucose. A healthy person would have a fasting blood glucose level of about 80-90 mg/dL.

**Oral Glucose Tolerance Test:** After measuring fasting glucose, a person is given a glucose-rich drink. Blood is then drawn at time intervals to see how that person's body is processing the glucose.

A third test, the **A1C test**, measures how much of a person's hemoglobin is coated with sugar. Since red blood cells (which carry hemoglobin) turn over every few months, the A1C test gives an average blood sugar level over the past 2-3 months.

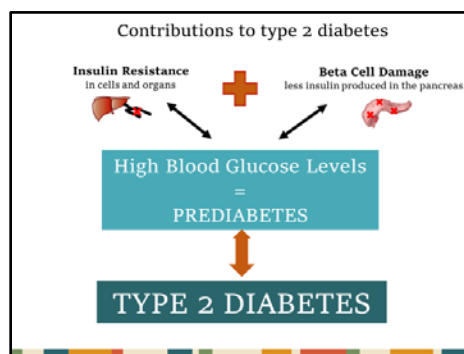
Slide 34



**Part III (Evaluation):** **Closure** **(10 minutes)**

- Show students the next slide which illustrates the two main factors that contribute to type 2 diabetes: **insulin resistance at the cells**, and **beta cell damage** in the pancreas. Point out that the first set of arrows are bi-directional showing that diabetes is reversible at this point. As a person's blood glucose levels rise over time, the condition becomes harder (and more expensive) to reverse. At a certain point, treatment is the only option.

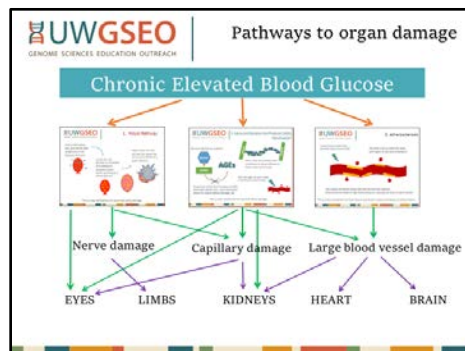
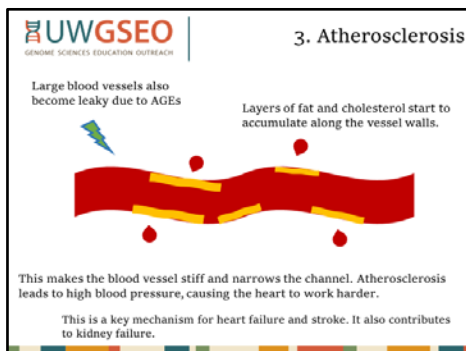
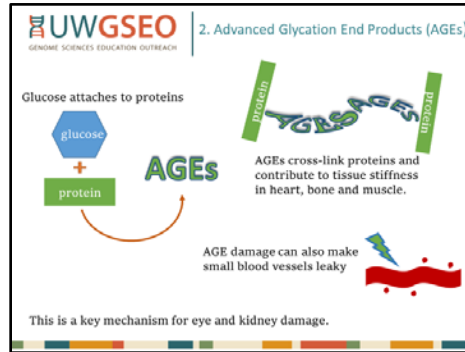
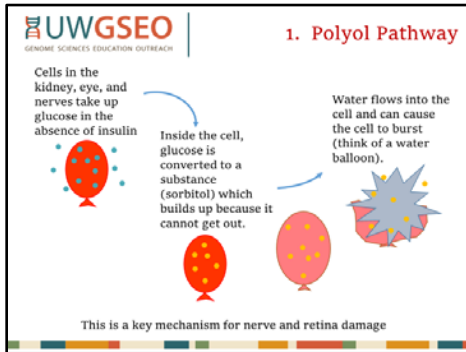
Slide 35



- Ask students to get out their *Lesson Summary Guide* from Lesson 1 and fill in the third row.
- Exit Ticket: Students can fill out the third row of the guide as an exit ticket.

**Extension**

Slides 36 through 45 provide physiological details on how high blood glucose effects our systems in three distinct ways. For each pathway, a possible treatment is also included. Students then think about downstream impacts of living with chronic high blood glucose levels and consider where money for treatment and/or prevention is best spent.



**Glossary**

**Glucose:** A simple, single-ring sugar that serves as the main source of energy for most living things.

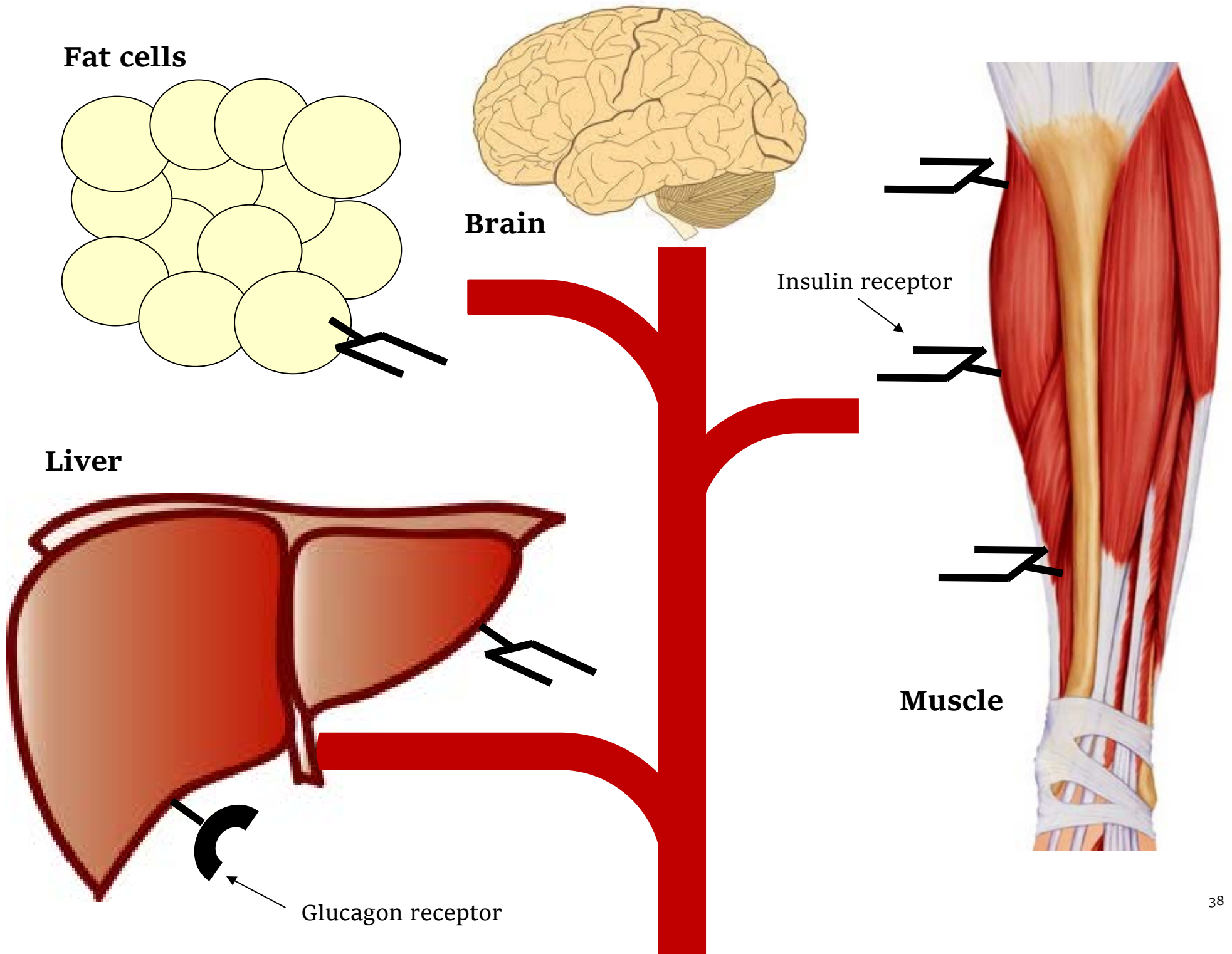
**Insulin:** A hormone made by the beta cells of the pancreas to regulate the amount of glucose in the blood.

**Glycogen:** A storage form of glucose produced mainly in the liver and muscle cells.

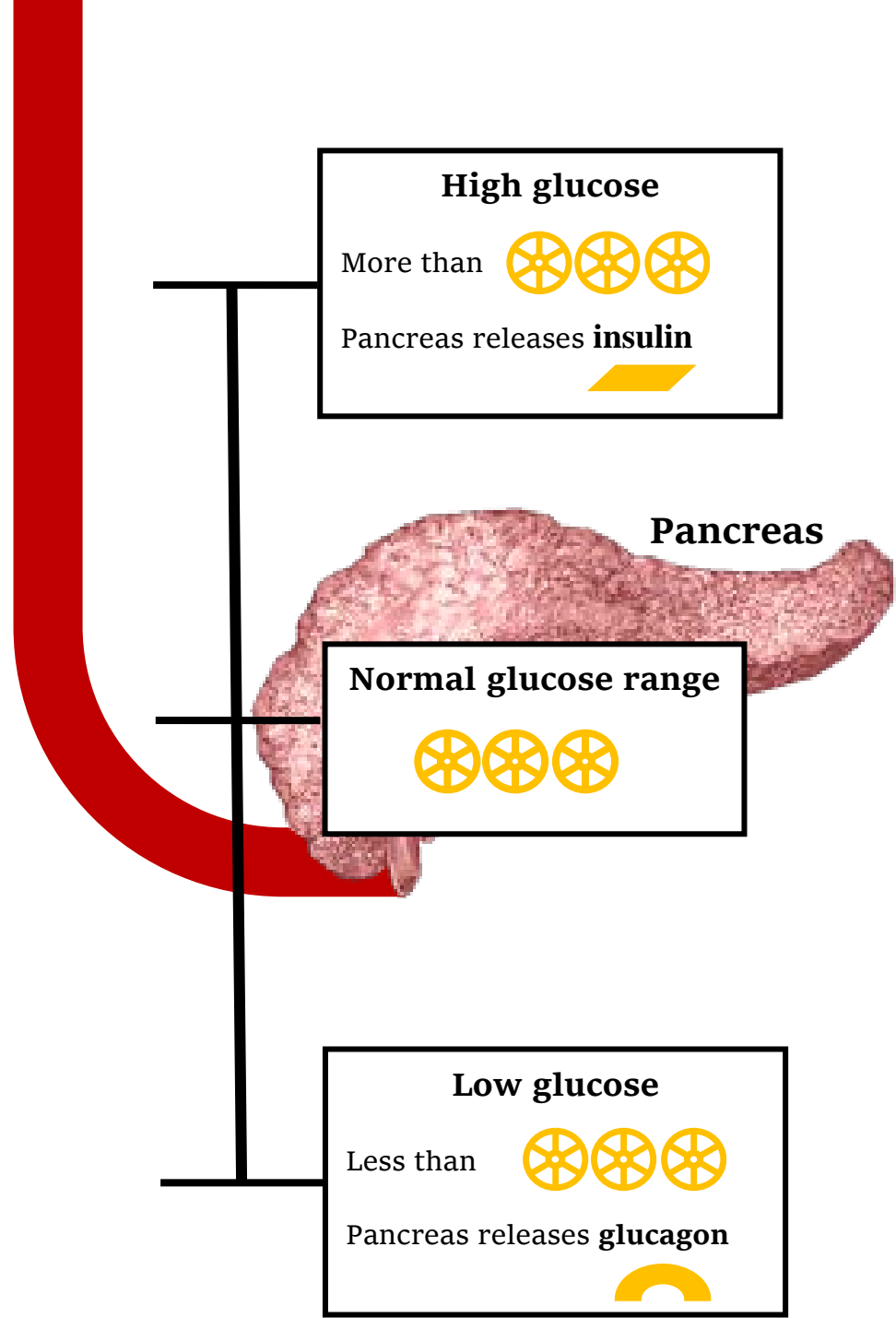
**Glucagon:** A hormone made by the pancreas in response to a fall in blood glucose levels.

**Beta cell (β cell):** A type of cell in the pancreas that makes and secretes insulin.

**Homeostasis:** The ability to maintain a living system’s internal conditions within certain limits even as external conditions change within some range, often involving feedback mechanisms.



X





## Student Sheet 3: Scenario Scaffolds

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

*Using the scenario cards and the model board and pieces, complete each scenario and respond to the following prompts.*

### **Scenario One – Role of Insulin**

- a. How does the pancreas respond when glucose digested from food enters the blood?
  
  
  
  
  
  
  
  
  
  
- b. What is the role of insulin?
  
  
  
  
  
  
  
  
  
  
- c. Summarize when happens in the body in Scenario One.

### **Scenario Two – Role of Glucagon**

- a. How does the pancreas respond when blood glucose levels are low?
  
  
  
  
  
  
  
  
  
  
- b. What is the role of glucagon?
  
  
  
  
  
  
  
  
  
  
- c. Summarize what happens in the body in Scenario Two.

### **Scenario Three – Insulin Resistance**

- a. What happens if cells are no longer responsive to insulin?
  
  
  
  
  
  
  
  
  
  
- b. How does insulin resistance lead to type 2 diabetes?
  
  
  
  
  
  
  
  
  
  
- c. Summarize when happens in the body in Scenario Three.

## Student Sheet 3: Scenario Scaffolds

### Scenario Four – Beta Cell Damage

- What happens if beta cells in the pancreas become damaged?
- How does beta cell damage lead to type 2 diabetes?
- What happens to the body with constant high blood glucose levels?
- Explain how insulin shots work as a treatment for type 1 or type 2 diabetes.

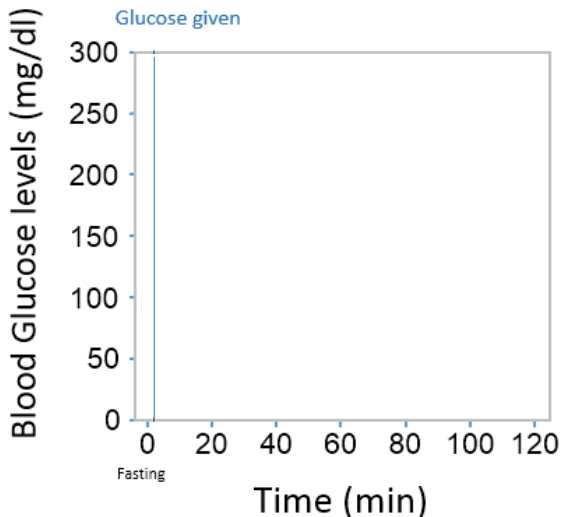
For people with type 1 diabetes, the pancreas produces little or no insulin. The beta cells have been mistakenly destroyed by the body's immune system.

### Scenario Five—Exercise

- What are two ways that exercise can help with blood glucose homeostasis?
- How would adding muscle mass help with type 2 diabetes?

**How is type 2 diabetes diagnosed?** By measuring blood glucose levels.

One type of test is called an *Oral Glucose Tolerance Test*. After measuring fasting glucose, a person is given a glucose-rich drink. Blood is then drawn at time intervals to see how that person's body is processing the glucose. What would you expect to happen?



On the graph to the left, draw the line that you think best represents **blood glucose** levels after eating for:

- a person who is healthy
- a person who is prediabetic
- a person who is diabetic



Using the scenario cards and the model board and pieces, complete each scenario and respond to the following prompts.

**Scenario One – Role of Insulin**

- a. How does the pancreas respond when glucose digested from food enters the blood?  
*The pancreas releases insulin.*
- b. What is the role of insulin?  
*Insulin binds to receptors on some tissues, which allows blood glucose to enter those cells.*
- c. Summarize when happens in the body in Scenario One.  
*Glucose levels become high, so the pancreas releases insulin. Insulin in receptors allows muscle, liver and fat to take up and store glucose.*

**Scenario Two – Role of Glucagon**

- d. How does the pancreas respond when blood glucose levels are low?  
*The pancreas releases glucagon.*
- e. What is the role of glucagon?  
*Glucagon binds to receptors on the liver which allows the liver to release glucose into the blood.*
- f. Summarize what happens in the body in Scenario Two.  
*Low blood glucose levels trigger the release of glucagon from the pancreas. The liver receives the glucagon message and releases stored glucose into the blood.*

**Scenario Three – Insulin Resistance**

- a. What happens if cells are no longer responsive to insulin?  
*Insulin resistant cells cannot bind insulin at lower concentrations. It takes more and more insulin to let blood glucose into the cells.*
- b. How does insulin resistance lead to type 2 diabetes?  
*If insulin is not able to let blood glucose into cells, blood glucose levels continue to rise. Type 2 diabetes is due to chronic (long-term) high blood glucose levels.*
- c. Summarize when happens in the body in Scenario Three.  
*The resistant insulin receptors cannot bind insulin at lower concentrations. Muscle, liver and fat do not take up much glucose. This leads to high levels of glucose in the blood.*

**Scenario Four – Beta Cell Damage**

- a. What happens if beta cells in the pancreas become damaged?  
*The pancreas is not able to make enough insulin, if any.*
- b. How does beta cell damage lead to type 2 diabetes?  
*Without enough insulin glucose cannot enter the cells, so it stays in the blood.*
- c. What happens to the body with constant high blood glucose levels?  
*Excess glucose in the blood binds to proteins, cells and tissues and they no longer work the way they should. This can lead to constant thirst and urination, blindness, infection in the toes, legs and feet, and heart failure. (See Scenario Four Card for more information).*
- d. Explain how insulin shots work as a treatment for type 1 or type 2 diabetes.  
*Insulin shots replace the insulin the body can no longer make. This insulin binds to receptors on the liver, fat and muscle cells to allow glucose to enter the cells.*

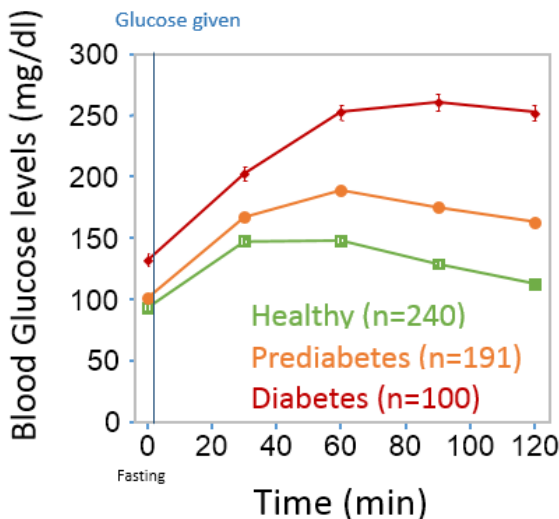
For people with type 1 diabetes, the pancreas produces little or no insulin. The beta cells have been mistakenly destroyed by the body's immune system.

**Scenario Five—Exercise**

- a. What are two ways that exercise can help with blood glucose homeostasis?  
*Exercise decreases blood glucose levels because 1) muscles can take up and store lots of glucose, 2) muscles can use glucose during exercise even if no insulin is present, and 3) and muscles burn glucose for fuel during exercise.*
- b. How would adding muscle mass help with type 2 diabetes?  
*Since muscle can store a lot of glucose, building more muscle builds more places for glucose storage. Adding muscle also helps burn calories which can control weight.*

**How is type 2 diabetes diagnosed?** By measuring blood glucose levels.

One type of test is called an *Oral Glucose Tolerance Test*. After measuring fasting glucose, a person is given a glucose-rich drink. Blood is then drawn at time intervals to see how that person's body is processing the glucose. What would you expect to happen?



On the graph to the left, draw the line that you think best represents **blood glucose** levels after eating for:

- a) a person who is healthy – lower line
- b) a person who is prediabetic –middle line
- c) a person who is diabetic – upper line

## ORIENTATION CARD

Print back to back and cut out, 1 set per group. Cards can be laminated for future use.

### Model Board Pieces

### Orientation Card



#### Glucose

- Fuel to make energy for the cell
- Must be kept within a healthy range
- Too much glucose leads to type 2 diabetes



#### Glycogen

- Stored form of glucose
- Made up of connected units of glucose
- Stored mostly in the liver and muscles



#### Insulin

- Hormone released when blood glucose is **high**
- Needed for glucose to enter the cells in some tissues



#### Glucagon

- Hormone released when blood glucose is **low**
- Needed to release glucose back into the blood in some tissues

## ORIENTATION CARD

Print back to back and cut out, 1 set per group. Cards can be laminated for future use.

### Model Organs

### Orientation Card



#### Brain

- Uses glucose as main source of energy
- Does not need insulin for glucose to enter the cells



#### Liver

- Takes up glucose when blood levels are high
- Releases glucose when blood levels are low
- Stores glucose in chains as glycogen



#### Pancreas

- Makes and releases both hormones insulin and glucagon
- Cells that produce insulin are called  $\beta$  (beta) cells



#### Fat Cells

- Take up glucose when insulin is present
- Fat cells use glucose to make more fat



#### Muscles

- Can take up and store a lot of glucose
- Often needs insulin to let glucose into the cells
- Use glucose during exercise

## SCENARIO CARDS

Print back to back and cut out, 1 set per group. Cards can be laminated for future use.

### Scenario One

### Role of Insulin

You have just eaten a meal of pancakes and maple syrup. What happens?

1. **Pour about 15 glucose pieces** on the balance and tilt the balance. Respond as directed.
2. **Release 5 insulin into the blood stream.**
3. Insulin is carried to the cells. **Place insulin onto each receptor on the liver, fat and muscle.** The insulin/receptor combination activates a channel for the glucose to move into the cell in muscle and fat cells. In the liver, the channel is always active.
4. **Move glucose into the liver, fat and muscle.** The muscles can take up lots of glucose, so move more glucose into the muscles.
5. Don't forget to feed the brain! Without insulin receptors, glucose can move freely into the brain. **Give the brain one glucose.**
6. **Continue moving glucose into organs** until blood glucose is back to the normal level (3 glucose remain on the balance).
7. **Arrange the glucose in the muscle and liver into chains** to represent stored glucose in the form of glycogen.
8. Once glucose in the blood is decreased, **insulin can be removed from the receptors.**

This is the end of Scenario One. Keep your board as it is to begin Scenario Two.

### Scenario Three page 1

### Insulin Resistance

A person has become overweight and eats a meal of pancakes and maple syrup. What happens?

**Insulin Resistance:** When our bodies are overweight, especially around the middle, our insulin receptors become changed and do not bind insulin as well.

1. **Place a small sticky note on each insulin receptor to show that it is insulin resistant.**
2. **Pour about 15 round pasta pieces into the pan on the balance, tip the balance, and respond as directed.**
3. **Release 5 insulin into the blood stream.**
4. The resistant insulin receptors cannot bind insulin at this concentration. **Show that muscle, liver and fat do not take up glucose.**
5. The blood glucose levels are still high, and the balance is still tipped. The pancreas releases more insulin. **Release 5 more insulin into the blood stream.**

## SCENARIO CARDS

Print back to back and cut out, 1 set per group. Cards can be laminated for future use.

### Scenario Two

### Role of Glucagon

You've been sitting in school and haven't eaten in hours! What happens?

1. Start with three glucose on the balance.
2. Your brain is hungry! **Feed it one glucose from the balance** and move the balance accordingly.
3. **Release 5 glucagon into the blood stream.**
4. **Place a glucagon on its receptor on the liver.** The glucagon/receptor combination results in glucose being released from the liver by breaking down glycogen.
5. **Move 2 glucose out of the liver into the blood stream.**
6. Your brain needs energy again. **Give it another glucose.**

This is the end of Scenario Two. Please answer the questions about Scenarios One and Two on Student Sheet 3. Clear your board for the next scenario.

### Scenario Three, continued

### Insulin Resistance

6. At this higher insulin level, some insulin receptors bind insulin. **Remove the sticky notes from two receptors and put insulin on those receptors.**
7. Liver, fat and muscle can take up some of the glucose in the blood. **Move 5 glucose molecules into the tissues with insulin on the receptors.**
8. Blood glucose is still high, so the pancreas releases more insulin. **Release 5 more insulin in the blood stream.**
9. More receptors bind insulin. **Remove the sticky notes from the remaining receptors and put insulin on all its receptors.**
10. Liver, muscle and fat take up more glucose from the bloodstream. **Move glucose out of the blood and into the liver, muscle and fat.**

Clear the model board. Please answer the questions about Scenario Three on your Student Sheet.

## SCENARIO CARDS

Print back to back and cut out, 1 set per group. Cards can be laminated for future use.

### Scenario Four

### Beta Cell Damage

A person has been insulin resistant for years and has high levels of blood glucose. What happens?

**Beta Cell Damage:** High levels of blood glucose trigger the  $\beta$  (beta) cells in the pancreas to release lots of insulin, as you saw in the previous scenario. When a person becomes insulin resistant, the  $\beta$  cells must work hard to release enough insulin. Over time, the  $\beta$  cells become damaged and cannot make enough insulin. Once the damage has been done, diabetes becomes a life-long condition that will always require management.

1. **Place a small sticky note on the pancreas** to represent  $\beta$  cell damage.
2. **Pour about 15 glucose pieces on the balance, tip the balance, and respond as directed.**
3. **Release one insulin into the blood stream. Show that muscle, liver and fat cannot take up very much glucose.**
4. **Add more small sticky notes on the pancreas to represent more  $\beta$  cell damage.**

### Scenario Five page 1

### Exercise

A person goes from a sedentary lifestyle to one that includes daily exercise. What happens?

**Hint:** Muscles can take up about five times as much glucose as liver and fat, and can use glucose during and after exercise even if no insulin is present. Muscles also burn glucose for energy.

1. **Pour about 15 glucose pieces on the balance, tip the balance, respond accordingly.**
2. **Release five insulin into the blood stream.**
3. **Place insulin onto each receptor on the liver, fat and muscle.**
4. **Move 12 glucose into the liver, fat and muscle.** The muscles can take up lots of glucose, so move more glucose into the muscles.
5. **Arrange the glucose in the muscle and liver into chains** to represent stored glucose in the form of glycogen.

## SCENARIO CARDS

Print back to back and cut out, 1 set per group. Cards can be laminated for future use.

### Scenario Four, *continued*

### Beta Cell Damage

5. ***Pour 5 glucose pieces on the balance and tip the balance.***
6. ***Release NO insulin into the blood stream.***

Excess glucose in the blood binds to proteins, cells and tissues and they no longer work the way they should. This can lead to:

- Constant thirst and urination, as the kidneys are unable to cope with high blood glucose levels. Other mechanisms can eventually lead to kidney failure.
- Blindness, as the small blood vessels in the back of the eye become broken.
- Infection in the toes, legs and feet, caused by poor circulation and a lack of feeling due to nerve damage.
- Heart failure as large blood vessels become clogged and small blood vessels become fragile and leaky.

Clear the model board. Please answer the questions about Scenario Four on your Student Sheet.

### Scenario Five, *continued*

### Exercise

6. ***Use two sticky notes to cover some of the insulin receptors*** to represent insulin resistance.
7. ***Use a sticky note to cover up some of the pancreas*** to represent minor beta cell damage.
8. ***Pour about 15 more glucose pieces on the balance, tip the balance, respond accordingly.***
9. ***Release two insulin into the blood stream.***
10. ***Move most of the glucose into the muscle.*** During and after exercise, glucose can enter muscles *even without insulin* present.
11. The muscles are working hard and use glucose for energy during exercise. ***Remove glucose from the muscle.*** You may break apart one glucose piece to illustrate that it is involved in a chemical reaction during cellular respiration.

Clear the model board. Please answer the questions about Scenario Five on your Student Sheet.



## Biology, Homeostasis, and Type 2 Diabetes

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### LESSON FOUR

## Lesson 4: Connecting to the *Next Generation Sciences Standards* (NGSS Lead States 2013)

Lesson 4 contributes to student competency in the following standards:

### Performance Expectations

**HS-LS2-8.** Social Interactions and Group Behavior: 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.

DIMENSIONS	CLASSROOM CONNECTIONS
<b>Science and Engineering Practices</b>	
<b>Developing and Using Models</b>	Students use two bean colors and an egg carton model to simulate their genetic risk score, which reinforces concepts of independent assortment, probability, and the distribution of alleles in a population.
<b>Analyzing and Interpreting Data</b>	Students collect data on their own environmental risk factors, and then analyze their own risks in terms of choice and access. Students also interpret a conceptual schematic about allele distribution in a population.
<b>Constructing Explanations and Designing Solutions</b>	Students take an environmental risk survey and learn how both choice and access influence risk for t2d. This supports students in explaining the increase in t2d, and provides potential targets for solutions.
<b>Disciplinary Core Ideas</b>	
HS-LS2.D: Social Interactions and Group Behavior Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	Social policies result from human group behavior. Social factors that influence a person's risk of t2d include access to healthy foods, safe places to exercise, and even how food is marketed.
HS-LS3.B: Environmental factors also affect expression of traits, and hence affect the probability of occurrences of traits in a population. Thus the variation and distribution of traits observed depends on both genetic and environmental factors.	Students calculate the probability of drawing different allele combinations from a population. They look at data to reinforce how gene variants lead to variation within a population and figure out how environmental factors can shift distribution of traits in a population.
<b>Crosscutting Concepts</b>	
<b>Cause and Effect</b>	Students search for the underlying genetic and environmental causes of type 2 diabetes. They find out that allele distribution is only part of the cause, and environmental factors have a large influence on t2d.
<b>Stability and Change</b>	Students consider food and social systems that have changed over time and impact our environmental risk for t2d, such as access to foods and drinks, product marketing, and sleep and stress levels.
<b>Scale, Proportion, and Quantity</b>	Students learn that independent assortment of alleles in just a few genes can lead to variations in a population. Students then scale up the "few genes" to over 150 known genes that contribute to diabetes.

# Lesson 4

# Genes and Environment

**Time:** 55 min

**Lesson Objectives:**

Students will be able to answer:

- How do allele combinations lead to variations within a population?
- What are three environmental *risk factors* you have for type 2 diabetes?
- What are three environmental *protective factors* you have for type 2 diabetes?

## Overview

Students are introduced to environmental, genetic and social factors that influence type 2 diabetes through two activities. Students simulate how high risk and low risk gene variants may be distributed through a population and look for patterns in their own environments and eating habits.

## Enduring Understandings

- Most traits are determined by a combination of genetic and environmental factors, including complex diseases like type 2 diabetes.
- Type 2 diabetes can be prevented: factors contributing to a person’s risk include good nutrition and exercise.
- 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.

## Essential Question

How do environmental and genetic risk factors influence a person’s risk of developing type 2 diabetes?

## Prerequisite Knowledge

Students should understand the following terms: inheritance, risk, protein, allele.

## Lesson Summary with Timings

Entrance Activity	10 min
Simulating Genetic Risk	15 min
Assessing Environmental Access and Choice	15 min
Putting it all Together	10 min
Closure	5 min

**Materials**

Materials	Quantity
Computer and projector	1 per class
Biology_Homeostasis_T2D_L4_SlideSet PowerPoint presentation for unit, found at <a href="http://gsoutreach.gs.washington.edu/">http://gsoutreach.gs.washington.edu/</a> (see GEMNet Instructional Materials)	1 per class
The Bigger Picture video <i>A Taste of Home</i> by Monica found at <a href="https://www.youtube.com/watch?v=yuhhxTj5odo">https://www.youtube.com/watch?v=yuhhxTj5odo</a>	
Class stock mixture of dry beans in the following amounts and colors: 5 pounds of white beans (i.e. navy or great northern beans) 5 pounds of red beans (i.e. red or kidney beans)  Any two colors of dry beans <b>of similar size and shape</b> can be used. Alternately, tan beans can be spray painted on one side or Pony beads of two different colors can be used. Beans may be reused for multiple classes over many years.	Per class
Small opaque bag, such as a paper sack	1 per pair
From class stock mixture (above) make the following combinations: <b>Standard Mix:</b> Make most student groups a bag containing 1/2 cup white beans and 1/2 cup red beans. <b>Risk Mix:</b> About 2/3 cup white beans to 1/3 cup red beans. <b>Protective Mix:</b> About 2/3 cup red beans to 1/3 cup white beans. Make 2 bags each of the Risk and Protective mixes. Make a subtle mark on each bag so that you can tell the bags apart but students cannot.	1 per pair
Egg carton for 12 eggs	1 per pair
Student Sheet 4.1: <i>Genetic risk factors</i>	1 per student
Student Sheet 4.2: <i>Environmental influences and options</i>	1 per student
Extension: <i>Environmental and genetic risk cards</i>	1 set per class
Optional homework: Reading packets for Lesson 5 Student Sheet 5.1: <i>Options Organizer</i>	1 per student

**Lesson Preparation**

Prepare the bean bags for each student group, as described above.

Photocopy Student Sheets 4.1 and 4.2 one per student.

Optional extension: Photocopy environmental and genetic risk cards

**Procedure****Part I (Engage)****Entrance Activity****(10 min)**

- As students settle in, begin class by showing them the 5-minute video produced by Youth Speaks as part of the The Bigger Picture campaign found here:

<https://www.youtube.com/watch?v=yuhhxTj5odo>

- After watching the video, students can respond to the questions posed on the entrance slide in a number of ways, as directed by the teacher. Suggested strategies include using a think-pair-share activity, a brief class discussion, or an individual writing exercise. Students should focus on the main question, and then choose one or more of the *think about...* options as time allows.

Slide 1

Biology, Homeostasis, and Type 2 Diabetes  
Lesson Four

Entrance Activity:  
A Taste of Home  
By Monica

<https://www.youtube.com/watch?v=yuhhxTj5odo>

What are some environmental risk factors for type 2 diabetes in Monica's family?

To think about...

- How does culture impact risk?
- How does product marketing impact risk?
- How have these changed over time?

- Tell students that both genetic and environmental factors impact their risk for type 2 diabetes. In this lesson, students will first simulate their **genetic risk** in an activity, and then evaluate their own **environmental risk**.

**Part II (Explore and Explain): Simulating genetic risk (15 minutes)**

- Tell students that they will now assess their *simulated* genetic predisposition for type 2 diabetes by doing an activity that will give them a hypothetical genetic risk score. During this exercise, we are assuming that some of the gene variants (alleles) associated with type 2 diabetes increase susceptibility to the disease, and some offer a protective effect.
- Show student the colored beans in the bag and the egg cartons. The beans in the bag represent the gene pool of the population. The egg carton represents 12 possible genes that contribute to a person's chance of getting type 2 diabetes. Each pair of beans indicates a different pair of alleles, one inherited from mother, and one from father. Show students the next two slides.

Slide 2

Student Sheet 4.1: Genetic risk factors

The beans in the bag represent the gene pool of the population.

For each gene you will draw from 2 possible alleles

You could draw...

Color Combinations	Probability	Term
2 white beans	25% or 1/4	Homozygous
1 of each color (2 combinations) 1W 1R or 1R 1W	50% or 1/2	Heterozygous
2 red beans	25% or 1/4	Homozygous

Slide 3

Student Sheet 4.1: Genetic risk factors

Egg carton represents 12 genes that contribute to type 2 diabetes

Each gene contains 2 alleles

Possible Allele Combinations:

- Two white beans increase RISK → + 1
- or One of each color is neutral → 0
- Two red beans are PROTECTIVE → - 1 (decrease risk)


**Note:** The terms *homozygous* (having two identical alleles), *heterozygous* (having two different alleles) and *genotype* (the paired combination of alleles) can be introduced and/or reinforced here, but students are not required to know this vocabulary for this lesson.

6. Explain that each student will randomly draw two beans from the bag at a time to be placed in one of the egg spaces in the carton. When one person has drawn and recorded a total of 24 beans (2 beans x 12 egg spaces), they should return the beans to the bag and the next person will draw 24 beans. Although students will be working independently, they will share supplies with a partner.
7. White beans increase risk for developing t2d, and red beans offer a protective effect, decreased the risk for developing t2d. Inheriting one of each color bean confers neutral risk.
8. Pass out Student Sheet 4.1 *Genetic risk factors* and the bean bags and egg cartons to each group. Give most student groups the **Standard Mix**, but give 1-2 groups the **Protective Mix**, and 1-2 groups the **Risk Mix**. Do not tell students which mix they have.
9. Let students complete the activity using Student Sheet 4.1: *Genetic risk factors*.
10. Have students tally their genetic risk score and record it on Student Sheet 4.1, as this number will be used at the beginning of the next section.
11. When students are finished tallying their risk scores, ask them to report back on their genetic risk scores as a class. Most of the scores should fall in a middle range (-3 to +3), as most of the students received the Standard Mix of beans. The scores for the student groups who received either the Protective Mix or the Risk Mix, however, will be lower or higher than the norm.
12. Allow student to open their bags and look at the allele mix from their bags. How did the allele mix contribute to their (simulated) higher or lower risk scores? Will they take any actions based on this information?
13. The next slide shows how the **high risk** population bag changes the probability for drawing a white bean or red bean. In the high-risk group, 2/3 of the beans are white, and 1/3 of the beans are red. The numbers would be reversed for the low risk population.

**Note:** The term **risk** is used here as it is in the field of public health. A person with an increased risk for t2d will not automatically develop t2d. Rather, risk is a measure that compares an individual to population data. In other words, a person's risk of developing a disease given x, y, and z, is based on how many other people who have x, y, and z get the disease of concern.

Slide 4




Student Sheet 4.1: Genetic risk factors



The beans in the high **risk** bag represent the gene pool of the **high risk** population.

You can still draw a red bean or a white bean, but the probability for each has changed.

If 2/3 (~.67) of the beans are white and 1/3 (~.33) are red, you could draw....

Color Combinations	Probability	Term
 2 white beans	$.67 \times .67 = 45\%$	Homozygous
 1 of each color (2 combinations) 1W 1R <b>or</b> 1R 1W	$(.67 \times .33) + (.33 \times .67) = 44\%$	Heterozygous
 2 red beans	$.33 \times .33 = 11\%$	Homozygous

14. Using the questions on the bottom of the Student Sheet, ask students to calculate the probability of drawing two white beans, two red beans or one of each color for the normal 50:50 mix (as shown on slide 2).

**Note:** The commonly-used terms *dominant* and *recessive* are not generally used to describe genes related to type 2 diabetes. For many genes of interest, the exact mechanism is not well understood at this time.

15. As an illustration of how probability and independent assortment of alleles can lead to variation of traits, use the next two slides to show students how unlikely it would be for a person to inherit ALL risk or ALL protective alleles for the 12 genes represented by the egg carton. If the probability for either RR or WW is 25% (1/4), the probability of inheriting that allele combination in *each* of the 12 egg cups is:

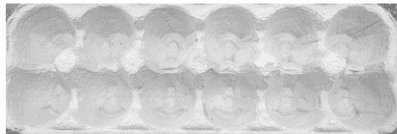
$$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = 1/16,777,216$$

or ~0.000006% chance

16. The number of genes that have been associated with type 2 diabetes illustrates how possible allele combinations contribute to variation of traits in a population.

Slide 5

What is the probability of inheriting ONLY risk alleles (white beans) for these 12 genes?



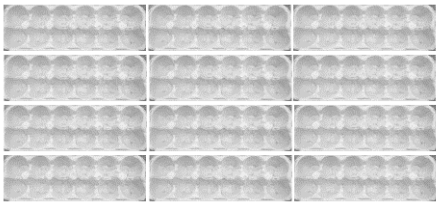
For each cup, the chance of drawing two white beans is  $\frac{1}{4}$ , or 25%.  
To get two white beans in two cups, the probability is  $\frac{1}{4} \times \frac{1}{4}$   
For all 12 cups...

$$\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} =$$

1 in 16,777,216 or ~0.000006% chance

Slide 6

Over 150 genes have been associated with type 2 diabetes.  
That is a lot of different allele combinations!  
These combinations lead to tremendous **variation of traits** in a population.



Limitations in the model: 1) Each allele associated with type 2 diabetes is present in the population at the same frequency (50:50), and alleles vary in frequency in a population. 2) Alleles don't always sort independently of each other. 3) Environmental impacts on genes are not addressed.

17. Make sure to go over the limitations of this model, many of which spring from the model's simplicity. Ideally, students would be drawing from 12 different bags for 12 egg cups, and each bag would have different colored beans in different frequencies. Specific limitations include: 1) Each allele associated with type 2 diabetes is present in the population at the same frequency (50:50), and alleles vary in frequency in a population. 2) All genes are equally weighted (+1, 0, -1) when some have a stronger effect on type 2 diabetes, 3) For the probabilities to be accurate, students would need to return the beans to the bag for every draw. 4) Alleles don't always sort independently of each other, 5) The same allele colors are used for all 12 genes, whereas different allelic variants would contribute to each gene.

**Part 3 (Explore): Assessing environmental access and choices (15 minutes)**

18. Tell students that they will now be assessing their environmental risks for acquiring type 2 diabetes. If students don't feel comfortable assessing their own environmental risks, they may choose a fictional representative character to assess.

- Pass out Student Sheet 4.2: *Environmental influences and options* for students to fill out. Allow students to tally their scores and answer the questions.
- Students may need support in filling out the survey. Go over a few examples, as shown on the following slide.

Slide 7

Environmental and Genetic Risk Factors

Student Sheet 4.2: Environmental Risk Factors

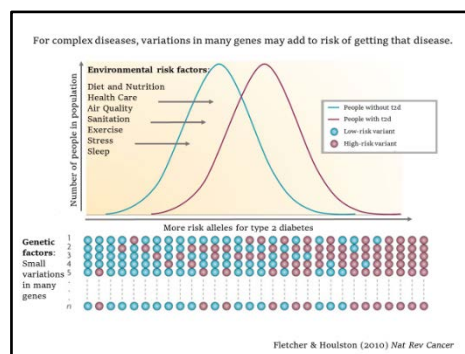
Environmental Factor	Range	Score	My Score
1. Number of fast food establishments (such as McDonald's or Burger King) or convenience stores that are in your community.	0-4	0	4
2. Number of times you eat a meal at a fast food restaurant over the course of the week.	0-4	0	2
3. Number of servings of fruit juice you drink per day.	0-4	0	
4. Number of 12-ounce sugar-sweetened sodas you drink on an average day (one 16-ounce drink = 1.33-ounce drinks).	0-2	0	
5. Number of grocery stores in your community.	0-2	0	
6. Number of Farmer's Markets, community gardens, or neighbors who share fresh produce in your community.	0-2	0	
7. Number of servings of fruits and vegetables you have on an average day.	0-5	0	5
8. Number of times per week you eat red meat (beef, pork, lamb).	0-4	0	
9. Number of times per week you eat whole grains.	0-4	0	
10. Number of times per week you eat dessert, cookies and other sweets.	0-4	0	
11. Number of local gyms or sports clubs such as the Boys & Girls Club or YMCA in your neighborhood.	0-4	0	

- Assist students in calculating their Total Risk Score, which is a combination of their genetic and environmental risk scores. As a class, discuss the questions on the survey.
- Help students determine which environmental factors are issues of *access*, and which are issues of *choice*. For example, students may live in neighborhoods with good parks (providing access to exercise) but choose not to visit the park to walk, run, play Frisbee or otherwise exercise (an issue of choice). Conversely, students may not have access to a gym, but choose to run on a road.
- Be aware that not all the factors on the sheet are easily sorted into *access* or *choice* and be prepared to discuss areas of gray. If lack of time is a contributing factor to not exercising, is that an issue of choice or access? How does age factor into acquiring type 2 diabetes? Are high levels of stress a matter of access or choice?

### Part IV (Elaborate) Putting it all together (10 minutes)

- The next slide illustrates how genes and environment influence complex disease traits like type 2 diabetes. Show the slide without the animation and make sure that students understand the label, and *x* and *y* axes, and what a distribution curve is. Ask the first two questions, below, before advancing the animation.

Slide 8





**x axis: More risk alleles for type 2 diabetes:** Just as with the egg carton model, a person may inherit a low-risk or high-risk allele (variant) for each gene. If there are 150 genes associated with type 2 diabetes, the  $n$  would be 150.

**y axis: Number of people.** The more people in the sample population, the smoother the curve will be.

**Distribution curve:** The blue and purple lines show distribution curves, or the number of people in the population with a trait measured. Point out that most traits distributed through a population would make a similar curve. A height distribution curve, for example, would show a low number of people on the very short end, and a low number of people on the very tall end, many people towards the middle and most people in the middle.

25. Ask student questions such as:

**Question:** “Can a person *without* many risk alleles get type 2 diabetes?”  
(alternately, “Can a person with many risk alleles *not* get type 2 diabetes?”)

**Answer:** Yes. The left edge of the purple curve represents a person without many risk alleles who has type 2 diabetes. (The right edge of the blue curve represents a person with many risk alleles and no diabetes.)

**Question:** “There are a lot of people in the overlapping area of the two curves. What might affect whether or not they have type 2 diabetes?”

**Answer:** Environmental factors. (Animate the slide to show some risk factors from the environmental survey.) These factors can “push” the curve over.

**Question:** “Is this graph only accurate for type 2 diabetes?”

**Answer:** No. Many complex diseases (t2d, heart disease, cancer, obesity, high blood pressure) would follow a similar pattern. Student may notice that the graphic is from a cancer periodical. We have altered the slide for type 2 diabetes.

### Closure (Evaluate)

(5 minutes)

26. Ask students to write down five factors that appear to be associated with an *increase* in type 2 diabetes. Have them then turn to a neighbor and compare lists. If time allows, create a class list on the board.
27. Ask students to write down five factors that contribute to the *prevention* of type 2 diabetes. Again, have students turn to a neighbor and compare lists, and then create a class list if time allows.
28. Review with students that both genetic and environmental exposures may increase an individual’s risk of acquiring type 2 diabetes. Likewise, there are genetic and environmental protective factors that influence likelihood of acquiring type 2 diabetes.
29. Hand out the *Lesson Summary Guide*. The Driving Question *What can I/we do to decrease the occurrence of type 2 diabetes?* is included. Encourage students can add an additional or alternate question that interests them.
30. As an Exit Ticket, students can fill out the fourth row of the Lesson Summary Guide.

## Homework (optional)

Lesson 5 includes four one-page descriptions of proposed solution options for the rise in diabetes. Students could read these for homework and fill out Student Sheet 5.1 in preparation for Lesson 5.

## Extensions

### A. Environmental and Genetic Risk Cards

Each item found on the Environmental Risk Survey is supported by evidence. More information can be found on the *Environmental and genetic risk cards* found at the end of this lesson. Six gene cards are included.

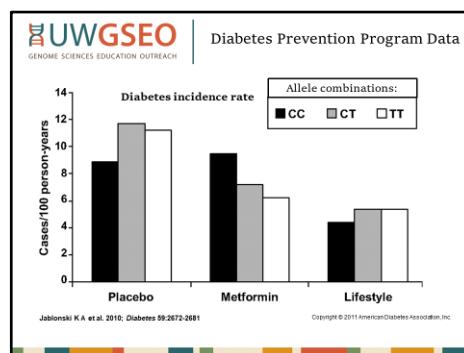
These cards can be used in a variety of ways depending on class time and teacher direction. Some examples include:

- Each student could be asked to provide more research about his or her card, possibly as a homework assignment, using the source information on the card.
- Students could share the information on the card in a round-robin exercise.
- Students could meet in groups of four to share information the cards, and then regroup with new students until students have heard from a range of their peers.

### B. Additional Data—How do allele combinations affect our health?

Show students the **Extension Slide** for Lesson 4. The Diabetes Prevention Program (DPP) was a long-term research study involving over 3000 people in the United States. At the beginning of the DPP, participants were all overweight and pre-diabetic. They were divided into three treatment groups and followed for several years. Researchers looked at common allele variants in 34 genes for each participant. This graph shows data from one of those variants.

Slide 9



1. Make sure that students understand the title, x and y axes, and labels.

**Incidence rate:** Number of new cases within a time period.

**Cases/100 person-years:** These units measure rate of incidence over time. A bar reaching 8 means that 8 people for every 100 in the population developed diabetes in one year. Researchers can convert different population sizes and time periods to these units for comparison.

**Placebo Group** received placebo pills with an inactive substance instead of Metformin.

**Metformin Group** received a drug that controls blood glucose levels twice a day.

**Lifestyle intervention group** received intensive training in diet, physical activity, and behavior modification with the goal of losing 7% of their body weight.

**Allele combinations:** At this particular location (on chromosome 17) there are three allele variations found in the population.

2. Ask students questions such as:

*Question:* “Is one allele combination always better than another?”

*Answer:* No, it depends on the circumstance. While the CC combination seems to reduce risk if there is no intervention, the relative risk compared to the other two genotypes is much higher with Metformin. CT and TT both respond well to Metformin.

*Question:* “Which intervention is the most successful for all groups of people?”

*Answer:* Lifestyle interventions reduce risk of becoming diabetic for people with all allele combinations.

*Question:* “In this graph, which appears to have the most impact on getting type 2 diabetes—genetic or environmental factors?”

*Answer:* Environmental factors, as diet, physical activity, and behavior modifications associated with intensive lifestyle changes are all environmental factors. These show the most impact on keeping people from NOT having new diabetes diagnoses.



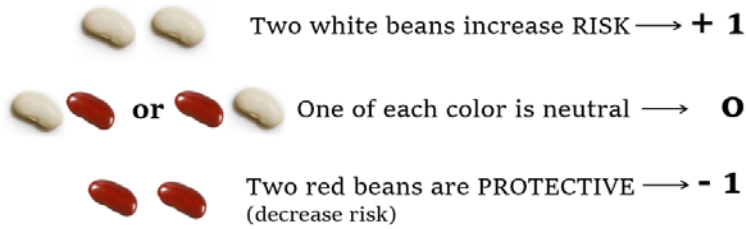
## Student Sheet 4.1: Genetic risk factors

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

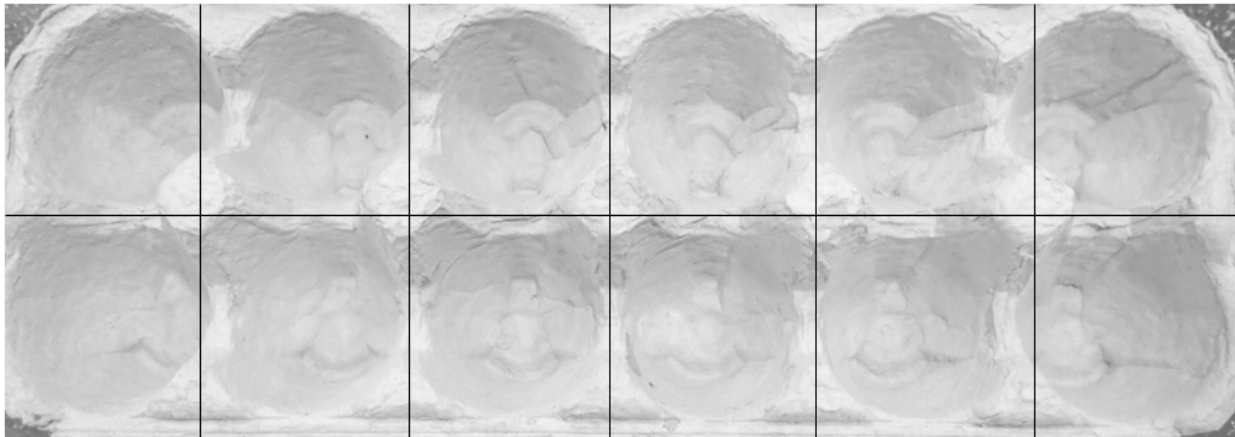
*This activity simulates a genetic predisposition for getting type 2 diabetes. The egg carton represents 12 genes that are known to contribute to type 2 diabetes. The beans represent alleles (variations) for that gene. For each gene, you will inherit two alleles—one from your mother, and one from your father.*

**Directions:**

1. One person selects two beans from the bag and places them in the first egg carton slot.
2. Continue drawing two beans until each egg carton slot has two beans, for a total of 24 beans.
3. Record your bean combinations on the egg carton below using a +1, 0 or -1 in each space.



4. Put the beans back into the bag and let your partner draw beans and record.



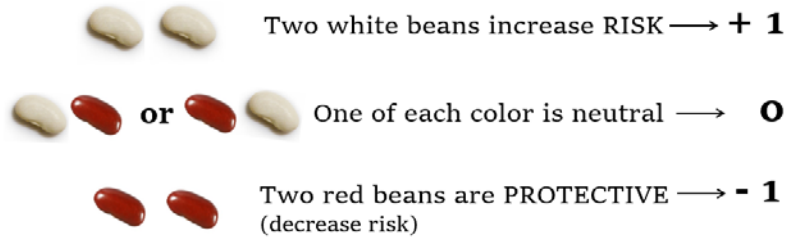
*A high number indicates an increased risk, a neutral number indicates no change, and a low or negative number indicates the possibility of a protective effect.*

5. Tally your simulated genetic risk score and record it here: \_\_\_\_\_
6. What is the **probability** of drawing:
  - a) Two white beans?
  - b) Two red beans?
  - c) One of each color?
7. How might knowing your genetic risk score impact your behavior?
8. No model is 100% accurate. What are some limitations of this model?

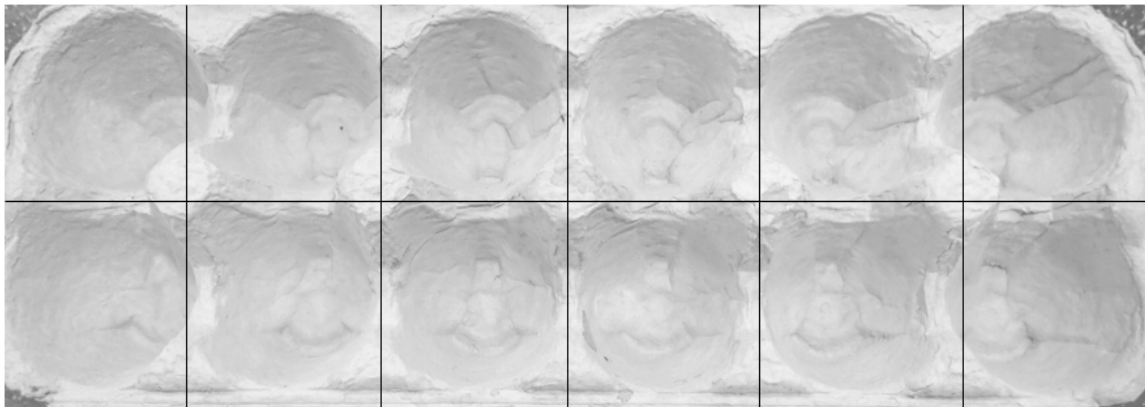
*This activity simulates a genetic predisposition for getting type 2 diabetes. The egg carton represents 12 genes that are known to contribute to type 2 diabetes. For each gene, you will inherit one allele (variation) from your mother, and one from your father.*

**Directions:**

1. One person selects two beans from the bag and places them in the first egg carton slot.
2. Continue drawing two beans until each egg carton slot has two beans, for a total of 24 beans.
3. Record your bean combinations on the egg carton below using a +1, 0 or -1 in each space.



4. Put the beans back into the bag and let your partner draw beans and record his or her combinations.



*A high number indicates an increased risk, a neutral number indicates no change, and a low or negative number indicates the possibility of a protective effect.*

5. Tally your simulated genetic risk score and record it here:     answers will vary
6. What is the **probability** of drawing:
  - b) Two white beans?  $\frac{1}{4}$  or 25%
  - b) Two red beans?  $\frac{1}{4}$  or 25%
  - c) One of each?  $\frac{1}{2}$  or 50%

(RW or WR)
7. How might knowing your genetic risk score impact your behavior?  
*Answers will vary*
8. No model is 100% accurate. What are some limitations of this model?  
*Answers could include: Not all genes are present in the population at the same frequency (50:50), not all genes contributing to t2d should be equally weighted, beans should be replaced after each draw for the probabilities to be accurate, genes don't always sort independently of each other, different colors of beans should be used for each gene.*

## Student Sheet 4.2: Environmental influences and options

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

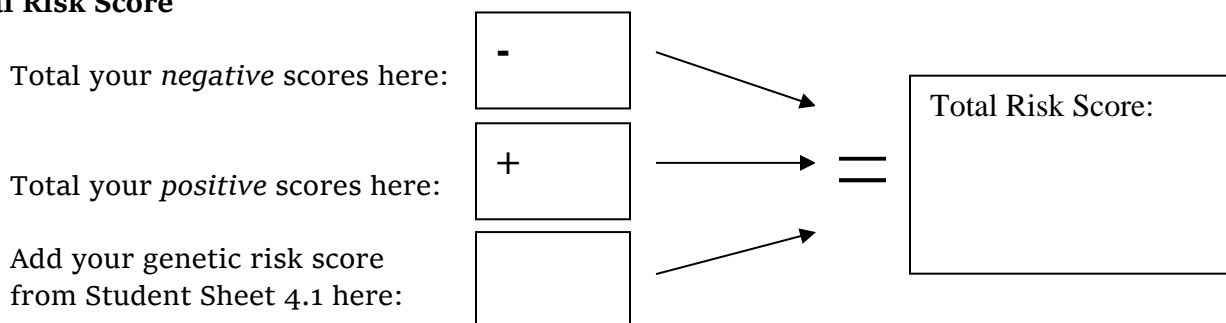
**Directions:** Fill in the following table to the best of your ability. You will not be required to share your score unless you choose to. “In your community” means the distance you can walk in 15-20 minutes, or the area you drive through frequently.

Environmental Factor	Range	Score	My Score
1. Number of fast food establishments (such as McDonald’s or Burger King) or convenience stores that are in your community.	0 – 3 4+	0 +1	
2. Number of times you eat a meal at a fast food restaurant over the course of the week.	0 – 1 2 – 4 5 +	0 +2 +4	
3. Number of servings of fruit juice you drink per day.	0 – 1 2 – 4	0 +2	
4. Number of 12-ounce sugar-sweetened sodas you drink on an average day (one 36-ounce drink = 3 x 12-ounce drinks).	Add 2 points per 12 oz.		
5. Number of grocery stores in your community.	0 1 2+	+1 0 -1	
6. Number of Farmer’s Markets, community gardens, or neighbors who share fresh produce in your community.	0 1 2+	+1 0 -1	
7. Number of servings of fruits and vegetables you have on an average day	Subtract 1 point per serving		
8. Number of times per week you eat red meat (beef, pork, lamb)	0 – 1 2 – 4 5 +	0 +2 +4	
9. Number of times per week you eat whole grains	0 – 1 2 – 4 5 +	+4 0 -4	
10. Number of times per week you eat dessert, cookies and other sweets	0 – 1 2 – 4 5 +	0 +2 +4	
11. Number of local gyms or sports clubs such as the Boys & Girls Club or YMCA in your neighborhood.	0 1 2+	+1 0 -1	
12. Number of times you exercise for 30 minutes or more over the course of the week.	0-1 2-4 5+	+4 0 -4	
13. Number of safe, free places to be physically active, such as parks, trails, skate parks, etc., within walking distance of where you live.	0 1-2 3+	+1 0 -1	
14. Number of days a week you spend more than 2 hours watching TV.	0-1 2-4 5-7	-2 0 +2	
15. Number of days per week you spend more than 4 hours playing video games or being on a computer or on your smart phone.	0-1 2-4 5-7	-2 0 +2	
16. Are the sidewalks in your neighborhood in good repair and/or do you see other people walking?	Yes No	-1 +1	
17. Are there bike lanes, paved shoulders of roads, or other safe places to ride a bike, near where you live?	Yes No	-1 +1	
18. Number of times you bike or walk to a destination over the course of a week, 1/2 a mile or more.	Subtract 1 point per time		

## Student Sheet 4.2: Environmental influences and options

19. Do you have bus access in your neighborhood or within walking distance of where you live?	Yes No	-2 +1	
20. Number of times you drive to a destination less than 2 miles away from your home over the course of a week.	0-5 6+	0 +1	
21. Number of times per day you drink out of an older, hard plastic water bottle that is not BPA-free.	Add 1 point per time		
22. How many hours of sleep do you usually get every night?	Less than 5 5-9 >9	+1 -1 +1	
23. Do you live along a busy road?	Yes No	+1 -1	
24. What is your age?	Up to 45 46-64 65+	0 +2 +4	
25. How are your stress levels, on an average day? (Circle a number)	1      2      3      4      5 Not much      Moderate      Very stressed	Add the number you circled	

### Total Risk Score



### Assessment of Risk Score:

1. Do you consider your risk to be high, low, or average? Why?
  - C. What total risk score would you list as “high risk?” What about “low risk?” Explain your answer.
  - D. What item(s) on the survey surprised you the most? Why?
  - E. Given your risk score, how would you alter or improve environment risk factors contributing to your risk score?

### Access and Choice:

Look back at the environmental factors table. Some of the factors are issues of **access** (do you have access to many fast food restaurants in your neighborhood?) and some are issues of **choice** (how often do you eat at fast food restaurants?). Put a STAR next to the factors that represent a **choice**.



Photocopy the following cards back to back, one set per class. Cards can be cut out along the lines.

<p><b>Environmental Factor 1</b>          Number of fast food establishments (such as McDonald’s or Burger King) or convenience stores that are in your community.</p> <p>Abby G. Ershow, Sc.D. 2009. Environmental Influences on Development of Type 2 Diabetes and Obesity: Challenges in Personalizing Prevention and Management in Journal of Diabetes Science and Technology, Diabetes Technology Society, 3, 727-734.</p>	<p><b>Environmental Factor 2</b>          Number of times you eat a meal at a fast food restaurant over the course of the week.</p> <p>Farah Naja, Hwalla N, Itani L, Salem N, Azar ST, Zeidan MN, 2012. Dietary patterns and odds of Type 2 diabetes in Beirut, Lebanon: a case control study. Nutrition and Metabolism 9: 111-122</p>
<p><b>Environmental Factor 3</b>          Number of servings of fruit juice you drink per day.</p> <p>Harvard School of Public Health. The Nutrition Source: Simple Steps to Preventing Diabetes:  <a href="http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/">http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/</a></p>	<p><b>Environmental Factor 4</b>          Number of 12-ounce sugar-sweetened sodas you drink on an average day (one 36 ounce drink = 3 x 12-ounce drinks).</p> <p>Harvard School of Public Health. The Nutrition Source: Simple Steps to Preventing Diabetes:  <a href="http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/">http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/</a></p>
<p><b>Environmental Factor 5</b>          Number of grocery stores in your community.</p> <p>Curry, Andrew. “Bringing Healthy Fare to Big-City ‘Food Deserts.’” Diabetes Forecast. December 2009.  <a href="http://forecast.diabetes.org/magazine/your-ada/bringing-healthy-fare-big-city-food-deserts">http://forecast.diabetes.org/magazine/your-ada/bringing-healthy-fare-big-city-food-deserts</a></p>	<p><b>Environmental Factor 6</b>          Number of Farmer’s Markets, community gardens, or neighbors who share fresh produce in your community.</p> <p>Curry, Andrew. “Bringing Healthy Fare to Big-City ‘Food Deserts.’” Diabetes Forecast. December 2009.  <a href="http://forecast.diabetes.org/magazine/your-ada/bringing-healthy-fare-big-city-food-deserts">http://forecast.diabetes.org/magazine/your-ada/bringing-healthy-fare-big-city-food-deserts</a></p>
<p><b>Environmental Factor 7</b>          Number of servings of fruits and vegetables you have on an average day</p> <p>Harding, AH, Wareham, NJ, Bingham SA et al (2008) Plasma vitamin C level, fruit and vegetable consumption, and the risk of new-onset type 2 diabetes mellitus: the European prospective investigation of cancer—Norfolk prospective study. Arch Intern Med 168:1493-1499.</p>	<p><b>Environmental Factor 8</b>          Number of times per week you eat red meat (beef, pork, lamb)</p> <p>Harvard School of Public Health. The Nutrition Source: Simple Steps to Preventing Diabetes:  <a href="http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/">http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/</a></p>

*Back of cards*

<p>A study from Beirut, Lebanon showed that people with type 2 diabetes are 2.80 times more likely to eat a high fast food diet than people without type 2 diabetes.</p>	<p>A study in Portland, OR showed that an increase in fast food outlets is associated with a 7% increase in being overweight and obese.</p> <p>Li F, Harmer PA, Cardinal BJ, Bosworth M, Acock A, Johnson-Shelton D, Moore JM. Built environment, adiposity, and physical activity in adults aged 50–75. <i>Am J Prev Med.</i> 2008; 35 (1):38–46.</p>
<p>Based on data from several studies, for every 12 oz. serving of a sugary drink per day, diabetes risk increases by 25%.</p> <p>Research on the effects of artificially-sweetened beverages is still unclear about association with t2d, but one large study of men showed that drinking one 12 oz can of diet soda per day does not affect t2d risk.</p>	<p>Drinking 2 or more servings per day of fruit juice is associated with a 31% increase in t2d risk compared to drinking less than 1 serving per month. There is growing evidence that daily drinking of sugary drinks also results in chronic inflammation, high triglycerides, decreased HDL (“good” cholesterol) and increased insulin resistance.</p>
<p>There is a strong correlations between increased rates of type 2 diabetes and people who live in areas without access to affordable, healthy food options within a convenient travelling distance.</p>	<p>A study of Chicago neighborhoods found that people who did not have access to affordable, healthy food options within a convenient travelling distance died from diabetes at twice the rate as people from areas offering access to grocery stores.</p>
<p>Eating red meat (beef, pork, or lamb) or processed red meat daily, even a small serving about the size of a deck of cards, increases diabetes risk by 20%.</p> <p>Replacing red meat with a daily serving of fish, poultry, nuts, or whole grains results in a 35% reduction in diabetes risk.</p>	<p>A 12-year study showed that people with higher levels of vitamin C were less likely to develop diabetes. Vitamin C is a good indicator of fruit and vegetable consumption because fruits and vegetables are the main source of vitamin C in the western diet. Even small amounts of them may be beneficial, and protection against diabetes increases with the amount of fruits and vegetables consumed.</p>

Front of cards

<p><b>Environmental Factor 9</b> Number of times per week you eat whole grains.</p> <p>Harvard School of Public Health. The Nutrition Source: Simple Steps to Preventing Diabetes: <a href="http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/">http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/</a></p>	<p><b>Environmental Factor 10</b> Number of times per week you eat dessert, cookies and other sweets</p> <p>Farah Naja, Hwalla N, Itani L, Salem N, Azar ST, Zeidan MN, 2012. Dietary patterns and odds of Type 2 diabetes in Beirut, Lebanon: a case control study. Nutrition and Metabolism 9: 111-122</p>
<p><b>Environmental Factor 11</b> Number of local gyms or sports clubs such as the Boys &amp; Girls Club or YMCA in your neighborhood.</p> <p>Auchincloss AH, Roux, A, Mujahid MS, et al. (2009) Neighborhood resources for physical activity and healthy foods and incidence of type 2 diabetes mellitus: the multi-ethnic study of atherosclerosis. Arch Intern Med. 12(18):1698-1704.</p>	<p><b>Environmental Factor 12</b> Number of times you exercise for 30 minutes or more over the course of the week.</p> <p>Gill JM and Cooper AR. Physical activity and prevention of type 2 diabetes mellitus. Sports Med. 2008; 38(10):807-24.</p> <p>Harvard School of Public Health. The Nutrition Source: Simple Steps to Preventing Diabetes: <a href="http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/">http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/</a></p>
<p><b>Environmental Factor 13</b> Number of safe, free places to be physically active, such as parks, trails, skate parks, etc., within walking distance of where you live.</p> <p>Li F, Harmer PA, Cardinal BJ, Bosworth M, Acock A, Johnson-Shelton D, Moore JM. Built environment, adiposity, and physical activity in adults aged 50–75. Am J Prev Med. 2008; 35 (1):38–46.</p>	<p><b>Environmental Factor 14</b> Number of days a week you spend more than 2 hours watching TV.</p> <p>Harvard School of Public Health. The Nutrition Source: Simple Steps to Preventing Diabetes: <a href="http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/">http://www.hsph.harvard.edu/nutritionsource/preventing-diabetes-full-story/</a></p>
<p><b>Environmental Factor 15</b> Number of days per week you spend more than 4 hours playing video games, being on a computer or on a phone.</p> <p>Owen N, Healy GN, Matthews CE, Dunstan DW. Too Much Sitting: The population-Health Science of Sedentary Behavior. Exerc Sport Scien Rev. July 2010; 38(3): 105-113.</p>	<p><b>Environmental Factor 16</b> Are the sidewalks in your neighborhood in good repair and/or do you see other people walking?</p> <p>Auchincloss AH, Roux, A, Mujahid MS, et al. (2009) Neighborhood resources for physical activity and healthy foods and incidence of type 2 diabetes mellitus: the multi-ethnic study of atherosclerosis. Arch Intern Med. 12(18):1698-1704.</p>

*Back of cards*

<p>A study from Beirut, Lebanon showed that people with diabetes are 3.85 times more likely to eat a diet high in refined grains and dessert, than people without type 2 diabetes.</p>	<p>In one study of women followed over 18 years, women who ate 3 or more servings of whole grains per day had a 30% lower risk of t2d than those who ate little or no whole grains. Based on several large studies, eating an extra 2 servings of whole grains per day reduces risk by 21%.</p>
<p>Vigorous physical activity is associated with a 20-30% reduction in diabetes risk, and brisk walking for 3.5-5 hours/week can improve risk of not developing type 2 diabetes by 30%.</p> <p>Active muscles involved in physical activity are able to take up increased amounts of glucose. This is balanced by the liver producing more glucose.</p>	<p>A study following people over 5 years found that better neighborhood resources, such as those that offered opportunities to be physically active and access to healthy food, were associated with a 38% lower incidence of type 2 diabetes.</p>
<p>One study found that for every two hours a day spent watching television instead of doing something more active resulted in a 20% increase in diabetes risk.</p>	<p>A Portland, OR study found that a mix of more street intersections interspersed with green spaces and parks was associated with more neighborhood walking. A 10% increase in land-use mix resulted in a 25% reduction in the prevalence of people being overweight and obese, which affects type 2 diabetes.</p>
<p>A study following people over 5 years found that better neighborhood resources, such as those that offered opportunities to be physically active and access to healthy food, were associated with a 38% lower incidence of type 2 diabetes.</p>	<p>One study found that the more time a person sits per day correlates to higher levels of blood glucose and fasting glucose, even in active adults.</p> <p>This study coined the term “Active Couch Potato” to describe adults who got enough physical activity to meet healthy guidelines, but still sat for long periods of time each day</p>

Front of cards

<p><b>Environmental Factor 17</b> Are there bike lanes, paved shoulders of roads, or other safe places to ride a bike, near where you live?</p> <p>Auchincloss AH, Roux, A, Mujahid MS, et al. (2009) Neighborhood resources for physical activity and healthy foods and incidence of type 2 diabetes mellitus: the multi-ethnic study of atherosclerosis. Arch Intern Med. 12(18):1698-1704.</p>	<p><b>Environmental Factor 18</b> Number of times you bike or walk to a destination over the course of a week, 1/2 a mile or more.</p> <p>Gill JM and Cooper AR. Physical activity and prevention of type 2 diabetes mellitus. Sports Med. 2008; 38(10):807-24.</p>
<p><b>Environmental Factor 19</b> Do you have bus access in your neighborhood or within walking distance of where you live?</p> <p>Li F, Harmer PA, Cardinal BJ, Bosworth M, Acock A, Johnson-Shelton D, Moore JM. Built environment, adiposity, and physical activity in adults aged 50–75. Am J Prev Med. 2008; 35 (1):38–46.</p>	<p><b>Environmental Factor 20</b> Number of times you drive to a destination less than 2 miles away from your home over the course of a week.</p> <p>Gill JM and Cooper AR. Physical activity and prevention of type 2 diabetes mellitus. Sports Med. 2008; 38(10):807-24.</p>
<p><b>Environmental Factor 21</b> Number of times per day you drink out of an older, hard plastic water bottle that is <i>not</i> BPA-free.</p> <p>Alonso-Magdalena P, Morimoto S, Ripoll C, Fuentes E, Nadal A. Effect of Bisphenol A Disrupts Pancreatic B-Cell Function <i>In Vivo</i> and Induces Insulin Resistance. Environmental Health Perspectives. 2006; 114(1):106-112.</p>	<p><b>Environmental Factor 22</b> How many hours of sleep do you usually get every night?</p> <p>Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, Rundle AG, Zammit GK, Malaspina D. Sleep duration as a risk factor for diabetes incidence in a large US sample. Sleep. 2007; 30(12):1667–1673.</p>
<p><b>Environmental Factor 23</b> Do you live along a busy road?</p> <p>Ursula Krämer, Christian Herder, Dorothea Sugiri, Klaus Strassburger, Tamara Schikowski, Ulrich Ranft, Wolfgang Rathmann, 2010. Traffic-Related Air Pollution and Incident Type 2 Diabetes: Results from the SALIA Cohort Study. Environ Health Perspect 118:1273-1279 (2010).</p>	<p><b>Environmental Factor 24</b> What is your age?</p> <p><a href="http://www.diabetes.org/diabetes-basics/statistics/">http://www.diabetes.org/diabetes-basics/statistics/</a></p>

*Back of cards*

<p>Vigorous physical activity is associated with a 20-30% reduction in diabetes risk, and brisk walking for 3.5-5 hours/week can improve risk of not developing type 2 diabetes by 30%.</p> <p>Active muscles involved in physical activity are able to take up increased amounts of glucose. This is balanced by the liver producing more glucose.</p>	<p>A study following people over 5 years found that better neighborhood resources, such as those that offered opportunities to be physically active and access to healthy food, were associated with a 38% lower incidence of type 2 diabetes.</p>
<p>Vigorous physical activity is associated with a 20-30% reduction in diabetes risk, and brisk walking for 3.5-5 hours/week can improve risk of not developing type 2 diabetes by 30%.</p> <p>Active muscles involved in physical activity are able to take up increased amounts of glucose. This is balanced by the liver producing more glucose.</p>	<p>A study in Portland, OR found that more public transit stations in an area were associated with people walking more for transportation.</p>
<p>Routinely getting 5 hours or less sleep per night as an adult is associated with developing type 2 diabetes. This effect is attributed to weight gain and chronic stress due to low sleep.</p> <p>There is also an association between getting more than 9 hours sleep per night as an adult and type 2 diabetes. This association may be due to increased release of small proteins which cause sleepiness, and disrupt glucose balance and <math>\beta</math> cell function.</p>	<p>Bisphenol A (BPA) is used in making polycarbonate plastics and leaches from plastics. BPA is found in the urine of most Americans, and higher levels of BPA in the urine are associated with type 2 diabetes.</p> <p>In studies of mice with higher levels of BPA, beta cells produced and released more insulin, which increased insulin resistance.</p>
<p>As people get older, their risk for type 2 diabetes goes up. About 11% of the people between the ages of 20 and 64 have diabetes. After the age of 65, almost 27% of people in this age group have diabetes. As in other age groups, type 2 diabetes is associated with obesity.</p>	<p>In a longitudinal study of women in an industrialized section of Germany, risk of type 2 diabetes was increased by 15% for each doubling in exposure to particulate matter such as that found in air pollution near busy roads.</p>

Front of cards

<p><b>Environmental Factor 25</b> How are your stress levels, on an average day?</p> <p>Diabetes.co.uk (2013). Diabetes warning for stressed men. <a href="http://www.diabetes.co.uk/news/2013/Feb/type-2-diabetes-warning-for-stressed-men-96045737.html">http://www.diabetes.co.uk/news/2013/Feb/type-2-diabetes-warning-for-stressed-men-96045737.html</a></p>	
<p><b>Gene 1</b> Melanocortin-4 (MC4) Receptor</p> <p><a href="http://www.diabetes.org/news-research/research/research-database/molecular-genetics-of-human-obesity.html">http://www.diabetes.org/news-research/research/research-database/molecular-genetics-of-human-obesity.html</a></p>	<p><b>Gene 2</b> Leptin (LEPR) Receptor</p> <p><a href="http://ghr.nlm.nih.gov/condition=leptin-receptor-deficiency">http://ghr.nlm.nih.gov/condition=leptin-receptor-deficiency</a></p>
<p><b>Gene 3</b> PPAR Gene Family</p> <p><a href="http://www.diabetesselfmanagement.com/Articles/Diabetes-Definitions/ppar_agonists/">http://www.diabetesselfmanagement.com/Articles/Diabetes-Definitions/ppar_agonists/</a></p> <p>Marie-France Hivert et al., Updated Genetic Score Based on 34 Confirmed Type 2 Diabetes Loci is Associated with Diabetes Incidence and Regression to Normoglycemia in the Diabetes Prevention Program. 2011. Diabetes, 6, 1340-1348.</p>	<p><b>Gene 4</b> <i>TC7L2</i></p> <p>Marie-France Hivert et al., Updated Genetic Score Based on 34 Confirmed Type 2 Diabetes Loci is Associated with Diabetes Incidence and Regression to Normoglycemia in the Diabetes Prevention Program. 2011. Diabetes, 6, 1340-1348.</p> <p><a href="http://www.ncbi.nlm.nih.gov/omim">http://www.ncbi.nlm.nih.gov/omim</a> <a href="http://www.ncbi.nlm.nih.gov/SNP/">http://www.ncbi.nlm.nih.gov/SNP/</a></p>
<p><b>Gene 5</b> <i>FTO</i></p> <p>Frayling, T. M., Timpson, N. J., Weedon, M. N., Zeggini, E., Freathy, R. M., Lindgren, C. M., Perry, J. R. B., Elliott, K. S., Lango, H., Rayner, N. W., Shields, B., Harries, L. W., and 30 others. A common variant in the FTO gene is associated with body mass index and predisposes to childhood and adult obesity. Science 316: 889-894, 2007.</p> <p><a href="http://www.ncbi.nlm.nih.gov/omim">http://www.ncbi.nlm.nih.gov/omim</a> <a href="http://www.ncbi.nlm.nih.gov/SNP/">http://www.ncbi.nlm.nih.gov/SNP/</a></p>	<p><b>Gene 6</b> <i>CDKAL1</i></p> <p>Marie-France Hivert et al., Updated Genetic Score Based on 34 Confirmed Type 2 Diabetes Loci is Associated with Diabetes Incidence and Regression to Normoglycemia in the Diabetes Prevention Program. 2011. Diabetes, 6, 1340-1348.</p> <p><a href="http://www.ncbi.nlm.nih.gov/omim">http://www.ncbi.nlm.nih.gov/omim</a> <a href="http://www.ncbi.nlm.nih.gov/SNP/">http://www.ncbi.nlm.nih.gov/SNP/</a></p>

Back of cards

	<p>From a 35 year longitudinal study of 7000 Swedish men, it was found that chronically stressed men had a 45% higher risk of developing type 2 diabetes.</p> <p>Stress results in the release of the hormone cortisol, which raises blood pressure, and raises blood glucose by causing insulin resistance.</p>
<p>Leptin is a hormone produced by fat cells that manages appetite and metabolism. Binding of leptin to leptin receptors reduces the amount of glucose released into the blood by the liver and increases glucose uptake from the blood into the muscle.</p> <p>A mutation to the LEPR (leptin receptor) is a rare cause of obesity.</p>	<p>The MC4 receptor is expressed in the brain and helps match food intake to energy expenditure.</p> <p>Mutations in the MC4 receptor can predispose an individual to severe obesity. Mutations in the MC4 receptor gene account for 1 to 6% of cases of severe obesity cases</p>
<p>The protein coded for by the gene TC7L2 is involved in maintaining glucose homeostasis. Risk alleles in this gene have been shown to be associated with impaired <math>\beta</math> cell function and type 2 diabetes in European populations</p>	<p>This gene family regulates the body's breakdown of fatty acids, the generation of fat cells and affects blood glucose control.</p> <p>A variation in the PPAR-gamma gene is associated with a <i>reduction</i> in the risk for type 2 diabetes as it predisposes people to having less fat.</p> <p>A group of anti-diabetic drugs targets the PPAR-gamma gene</p>
<p>The gene CDKAL1 is expressed the most in skeletal muscle and the brain. The protein from this gene may be involved with insulin release, and certain allele combinations decrease insulin levels by 20%. It is thought to be associated with decreased <math>\beta</math> cell function.</p>	<p>The gene FTO is involved in hunger control, and people with the risk alleles are associated with increased body mass indexes and rates of obesity, both of which are linked to type 2 diabetes.</p>



## Biology, Homeostasis, and Type 2 Diabetes

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### LESSON FIVE

## Lesson 5: Connecting to the *Next Generation Sciences Standards* (NGSS Lead States 2013)

Lesson 5 contributes to student competency in the following standards:

### Performance Expectations

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

**HS-ETS1-3.** 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.

DIMENSIONS	CLASSROOM CONNECTIONS
<b>Science and Engineering Practices</b>	
<b>Engaging in Argument from Evidence</b>	Students evaluate four competing design solutions to the real-world problem of diabetes based on societal and economic factors and ethical considerations. Students also make and defend a claim of their own.
<b>Obtaining, Evaluating and Communicating Information</b>	Students critically read scientific information containing graphs and data, and evaluate the information based on set criteria.
<b>Constructing Explanations and Designing Solutions</b>	Students evaluate four solutions to the growth of diabetes, and design their own solution based on the knowledge they have gained in the unit plus other criteria and tradeoff considerations.
<b>Disciplinary Core Ideas</b>	
HS-LS2.D: Social Interactions and Group Behavior Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.	One of the criteria students use to evaluate competing solutions is whether it is driven by individual choices and actions or social/group behavior. Students consider how social policies may contribute to health.
HS-ETS1.B: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	Students evaluate four potential solutions to combat the rise in t2d and consider constraints such as cost, scope of impact, potential harms and benefits, and cultural factors.
<b>Crosscutting Concepts</b>	
<b>Patterns</b>	Students look for patterns in data from different options that address the growth of t2d and ask questions about the relationships and factors that influence them.
<b>Cause and Effect</b>	After exploring the multifaceted causes of t2d during the unit, students evaluate four ways of effecting the mechanisms that drive t2d. Students also rely on their knowledge of causes of t2d to propose their own way of effecting change.
<b>Nature of Science</b>	
<b>Science is a Human Endeavor</b>	Students have learned that the causes of t2d are multifaceted, and solutions will reside at the intersection of science and society and will be impacted by their influence on each other.

# Lesson 5

# Evaluating Solutions

**Time:** 50 min

**Lesson Objectives:**

Students will be able to answer:

- How are solutions to the growth of t2d driven by individuals and/or society?
- What is my solution to help decrease the occurrence of t2d?
- What is one benefit and one cost for my solution to this problem?

## Overview

In this lesson, students evaluate solutions to the complex problem of type 2 diabetes in our communities 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.

## Enduring Understandings

- 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.
- Students can make a meaningful contribution to the prevention of type 2 diabetes.

## Essential Question

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

## Lesson Summary with Timings

Entrance Activity	5 min
Looking at Four Options	20 min
Your Solution	20 min
Closure	5 min

## Materials

Materials	Quantity
Computer and projector	1 per class
Biology_Homeostasis_T2D_SlideSet PowerPoint presentation for Lesson 5, found at <a href="http://gsoutreach.gs.washington.edu/">http://gsoutreach.gs.washington.edu/</a> (see GEMNet Instructional Materials)	1 per class
Options Packet Option 1: Medications Option 2: Food Labeling and Marketing Option 3: Surgery Option 4: Lifestyle changes	1 per group or student, depending on strategy
Student Sheet 5.1: <i>Options Organizer</i>	1 per student
Student Sheet 5.2: <i>Evaluating Solutions</i> (two-sided)	1 per student
Lesson Summary Guide from Lesson One (two-sided)	1 per student

## Procedure

## Part I (Engage)

## Entrance Activity

(5 min)

1. Entrance activity: Students can respond to the questions posed on the entrance slide in several ways, as directed by the teacher. Suggested strategies include using a think-pair-share activity, a brief class discussion, or an individual writing exercise. Students should focus on the main question, and then choose one or more of the *think about....* options as time allows.

Slide 1

**UWGSEO** | Biology, Homeostasis, and Type 2 Diabetes  
GENOME SCIENCES EDUCATION OUTREACH | Lesson Five

Entrance Activity

**If current trends continue, 1 in 3 U.S. adults will have diabetes by 2050.**

How would you distribute money and resources towards **prevention** and/or **treatment** of diabetes?

To think about....

- How old will you be in 2050?
- Will you be at risk for type 2 diabetes?
- How and when should your future self take steps to prevent you from developing type 2 diabetes?

**Note:** Teachers could give students a hypothetical \$1 million to combat the trends for type 2 diabetes and ask students what percentage of the money they would spend on prevention, what percentage on treatment, and how the money would be used.

2. Use the next slide to show students the financial burden that diabetes places on individuals, families, communities, and health care systems.

Slide 2

**Part II (Explore/Explain)****Looking at Four Options****(20 min)**

- Tell students that they will consider 4 options to the growing diabetes problem and then recommend their own solutions. The next slide shows students the options they will be presented with. For each option, students will read a description of the option and be asked to think about a few factors. Make sure students understand the types of questions asked, but don't answer the question at this point.

**Prevention or Treatment?** Is the goal of this option prevention (keeping people from becoming diabetic) or treatment (providing interventions for people already living with type 2 diabetes)? Or both?

**Individual or Social?** Is the option driven by the choices and decision-making of individuals, or at a societal policy level in which people need to work together to create change? Are there ways social policies and group behaviors contribute to health in this option?

**Who benefits? What is the cost? Who is harmed?** What kinds of harms and benefits might come from different options? Costs associated are not only monetary but could be harm to some groups or people.

Slide 3



- Hand out the reading packets and Student Handout 5.1: *Options Organizer* to students. Suggested reading and discussion strategies include:
  - Jigsaw:** Each group gets one of the four options to read, discuss and record on the Options Organizer. Students then are re-arranged so that new groups are



**Part IV (Evaluate):                      Sharing Solutions and Closure                      (5 minutes)**

9. Students should return to the *Lesson Summary Guide* before class is over and complete the “end of unit” questions on the back page. The next slide can be used as an informal check-in to see if student ideas have changed from the beginning of the unit to the end, by asking students to hold up their fingers to show where they stood at the beginning and end of the unit for each question.

Slide 4

**UWGSEO**  
GENOME SCIENCES EDUCATION OUTREACH

Back to the Beginning

I think that solutions to the growth of type 2 diabetes lie mostly with:

1 2 3 4 5 6 7 8 9 10  
Individuals Society

I think developing type 2 diabetes is mostly due to:

1 2 3 4 5 6 7 8 9 10  
Genes Environment

**Extension**

Students could present and defend their solutions to their classmates. Competing student design solutions could be respectfully evaluated by their peers and, if a school-based solution exists, that solution could be enacted by the class. Student solutions may also lend themselves to Call to Action Projects (see below).

**Looking Forward: Call to Action Projects**

Type 2 diabetes is a complex condition that brings together issues of health care, scientific research, environmental influences, personal choice, access to resources, diet and exercise, social justice, public policy, and more. The nature of this complex topic lends itself well to extended learning through student projects. If students have a leadership/project component to their education, they could be encouraged to create a type 2 diabetes-themed Call to Action project, in which they synthesize and apply their learning throughout the unit by creating a product that demonstrates their understanding of type 2 diabetes, addresses a specific diabetes-related problem, and contributes to a solution. Successful Call to Action projects implement direct, meaningful, and relevant actions to make a contribution towards combatting diabetes within the students’ communities.

**Project Ideas**

Ideas for projects may include:

- Educate peers and others on sugar content of common drinks
- Survey and analyze foods typically given at food banks
- Create a media literacy lesson for peers using food and drink marketing
- Develop a cookbook for a person who is prediabetic or living with diabetes
- Enroll a team/create an educational table for a *Tour de Cure* or other event
- “Do This, Not That” (in parallel to book “Eat This, Not That”)
- Develop a script for a “living room focus group”
- Propose public policy at local or state level to improve health

- Develop a monthly healthy menu plan for a family of four given a budget
- Assess the nutritional quality of school lunch programs
- Use a personal tracking device or health app to analyze one's own practices

### Resources for Options Packet:

#### Medications:

##### References

American Diabetes Association: What Are My Options?

<http://www.diabetes.org/living-with-diabetes/treatment-and-care/medication/oral-medications/what-are-my-options.html>

Diabetes.co.uk: The Global Diabetes Community

<https://www.diabetes.co.uk/treatment-for-type2-diabetes.html>

Joslin Diabetes Center: Oral Diabetes Medications Summary Chart

[http://www.joslin.org/info/oral\\_diabetes\\_medications\\_summary\\_chart.html](http://www.joslin.org/info/oral_diabetes_medications_summary_chart.html)

List of Medications Available for Diabetes

Last reviewed Mon 27 June 2016

By Markus MacGill

Reviewed by [Alan Carter, PharmD](#)

<https://www.medicalnewstoday.com/articles/311300.php>

Background on the DPP

<https://www.niddk.nih.gov/about-niddk/research-areas/diabetes/diabetes-prevention-program-dpp>

#### Food Labeling and Marketing Resources

Morbid obesity in a developing country: the Chilean experience

Claudia Bambs, Jaime Cerda, Alex Escalona

Bulletin of the World Health Organization

<http://www.who.int/bulletin/volumes/86/10/07-048785/en/>

Nutrition Reviews Special Article

June 2001: 170-176

Nutrition Transition in Latin America: The Case of Chile

Cecilia Albala, M.D., M.P.H., Fernando Vio, M.D., M.P.H., Juliana Kain, M.P.H., and Ricardo Uauy, M.D., Ph.D.

In sweeping war on obesity, Chile slays Tony the Tiger

By Andrew Jacobs, Feb 7, 2018

<https://www.nytimes.com/2018/02/07/health/obesity-chile-sugar-regulations.html>

#### Surgery Resources

Abbasi, J. (2017). Unveiling the “Magic” of Diabetes Remission After Weight-Loss Surgery. *JAMA*. 317 (6), 571-574. <https://jamanetwork.com/journals/jama/fullarticle/2601499>

Galchen, R. (2016) Bariatric Surgery: The Solution to Obesity? The New Yorker [September 26, 2016 Issue](#). <https://www.newyorker.com/magazine/2016/09/26/bariatric-surgery-the-solution-to-obesity>

Keider, A., (2011). Bariatric Surgery for Type 2 Diabetes Reversal: The Risks. *Diabetes Care* 34 Supplement 2, S361-S366. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3632208/>

Obesity Coverage Staff (2013). Weight Loss Surgery Coverage and Costs. In *Insurance and Costs, Pre-approval Process*. <https://www.obesitycoverage.com/weight-loss-surgery-insurance-coverage-and-costs/>



Yska, J. P., van Roon, E. N., de Boer, A., Leufkens, H. G. M., Wilffert, B., de Heide, L. J. M., de Vries, F. and Lalmohamed, A. (2015). Remission of Type 2 Diabetes Mellitus in Patients After Different Types of Bariatric Surgery: A Population-Based Cohort Study in the United Kingdom. *JAMA Surg.* 150 (12) 1126-1133. <https://jamanetwork.com/journals/jamasurgery/fullarticle/2446843>

### Other Surgery Resources

American Diabetes Association. Bariatric Surgery. <http://www.diabetes.org/living-with-diabetes/treatment-and-care/bariatric-surgery.html>

Kolata, G. (2016). After Weight-Loss Surgery, A Year of Joys and Disappointments. *New York Times* December 27, 2016 issue. <https://www.nytimes.com/2016/12/27/health/bariatric-surgery.html>

National Institute of Diabetes and Digestive and Kidney Diseases. Bariatric Surgery. <https://www.niddk.nih.gov/health-information/weight-management/bariatric-surgery>

### **Lifestyle Changes Resources**

Updated Genetic Score Based on 34 Confirmed Type 2 Diabetes Loci Is Associated With Diabetes Incidence and Regression to Normoglycemia in the Diabetes Prevention Program  
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3064108/>

The Diabetes Prevention Program (DPP): Description of lifestyle intervention  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1282458/>

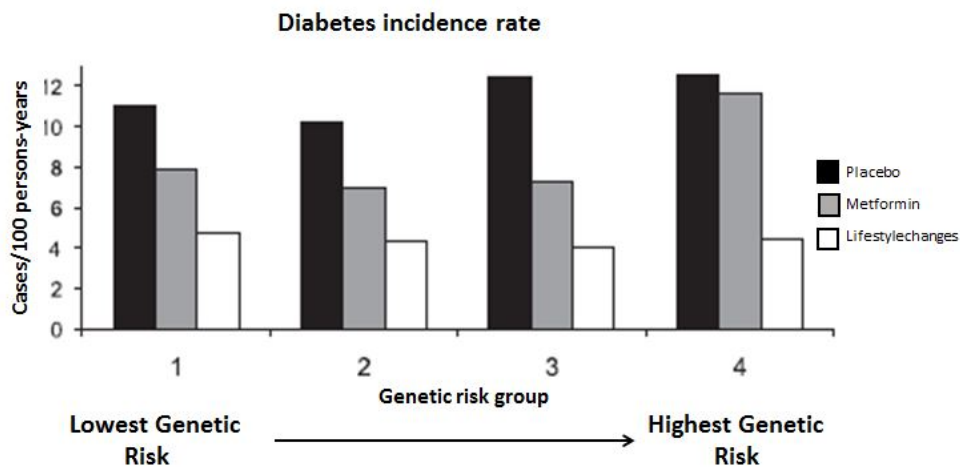


## Option 1: Medications

A person who is diagnosed with type 2 diabetes may be prescribed one or more drugs to control their condition. There are many classes of oral drugs that use different tactics to control blood glucose levels, including those that help the body to respond better to insulin, those that stimulate insulin release from the pancreas, and those that slow down digestion. In addition, people with type 2 diabetes are sometimes given medication to help them lose weight.

The most commonly prescribed oral medication (and generally first to be prescribed) is called Metformin. It helps the body respond better to insulin, mainly by decreasing the release of glucose by the liver.

The graph below shows results from a long-term research study involving over 3000 people who were pre-diabetic at the start of the study. People in the study were randomly divided into three treatment groups. The Lifestyle changes group received extensive coaching on diet and exercise. The Metformin group was prescribed Metformin twice a day for the duration of the study. The placebo (control) group did not get the drug or Lifestyle coaching. All participants in this study had their DNA analyzed to measure their genetic risk for developing type 2 diabetes based on their alleles for 34 risk genes. The graph below compares the rate of progression to type 2 diabetes for people in the study. How effective do you think Metformin is compared to the other groups? Does it have a similar effect for all genetic risk groups?



Hivert, M-F et al., 2011; *Diabetes* 60:1340-1348

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Overall, participants who took metformin lowered their chances of developing type 2 diabetes by 31 percent compared with participants who took a placebo. Metformin was most effective for younger people, people with a body mass index over 35, and women with a history of diabetes during pregnancy.

Like all drugs, Metformin has side effects. These include loss of appetite, upset stomach, bloating, gas, and diarrhea. If it does not work well enough at reducing a person's blood glucose, then sometimes an additional drug is given.

Insulin may be prescribed if a person's beta cells in the pancreas are not functioning well enough and oral medications and lifestyle interventions are not lowering blood glucose sufficiently. Although insulin is very effective at lowering blood glucose, it needs to be administered carefully so that a person's blood glucose does not get too high or too low. According to the American Diabetes Association, the cost of insulin has tripled in the past ten years, which is cause for concern for insulin-dependent diabetics.

## Option 2: Food Labeling and Marketing

### Reversing the obesity trend in Chile through a national nutritional labeling law

In the three decades between the late 1960s to the late 1990s, Chile, like many other Latin American countries, made great improvements in socio-economic status, literacy, infant mortality, life expectancy, and gross national product. However, as malnutrition and undernutrition decreased during this period, Chile saw a significant increase in obesity and the chronic diseases associated with obesity (see Figure 1). This

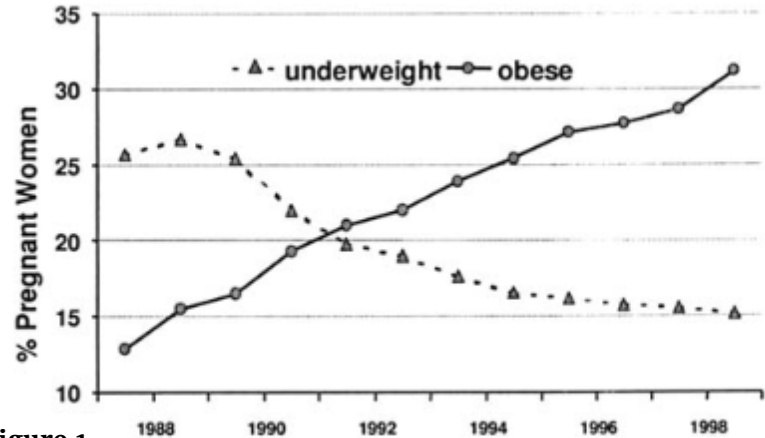


Figure 1

increase in obesity is associated with increased intake of foods high in saturated fats, a decrease in consumption of cereals and legumes, and a more sedentary lifestyle.

In 2016, the Chilean government adopted a sweeping nation-wide war on obesity through policies directed at unhealthy food, including changes in how foods are labeled, a ban on junk foods in and around schools, and prohibition of advertising for junk food on TV programs and websites viewed by children. Foods that are high in salt, sugar, fats, or calories are required to show a black stop sign label for each—and based on their ingredients, some foods are required to show all four. In addition, manufacturers are no longer allowed to use cute mascots or symbols that appeal to children, like Tony the Tiger or Chester Cheetah.

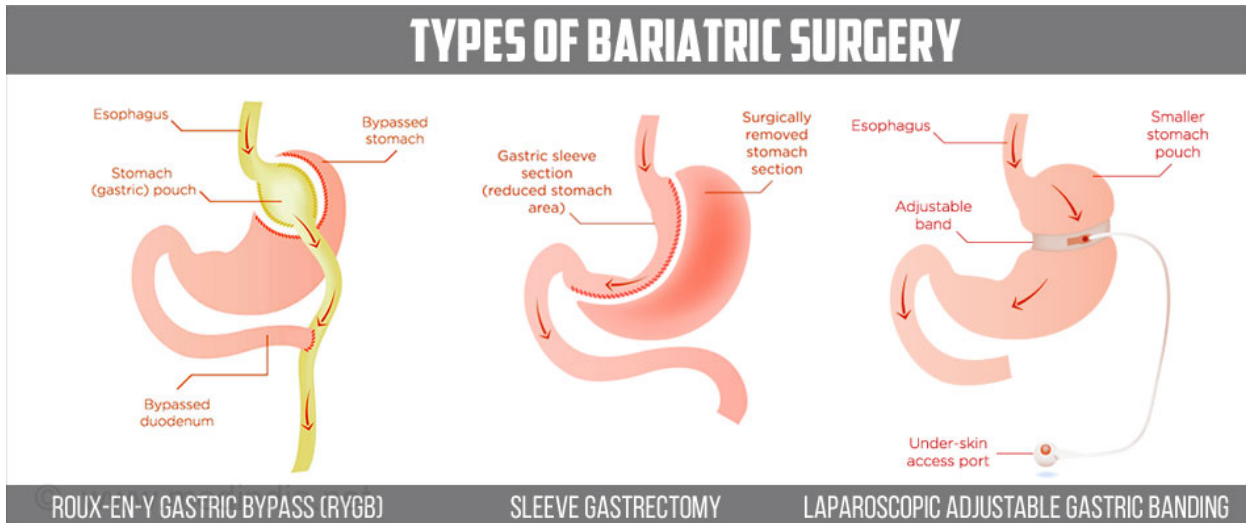
There has not been sufficient time in the last two years to see changes in the obesity rates. However, the new laws are having effects on products being sold, which in many cases have been re-formulated to get rid of one or more of their black labels. Furthermore, children are advising their parents about which products not to buy because of their labels. Two other South American countries, Ecuador and Brazil, are now considering adopting similar rules.



## Option 3: Surgery

### Bariatric surgery: A Magic Bullet to cure type 2 diabetes?

‘Bariatric’ means ‘weight treatment,’ and bariatric surgeries are designed to help very obese people to lose weight. There are three common types, all of which either bypass or constrict the stomach. In the most effective type of surgery (RYGB, below) the bypassed portion of the stomach is sealed surgically, and the bypassed duodenum is attached to the lower part of the small intestine so digestive juices from the stomach can enter the small intestine.



As well as losing weight, people with type 2 diabetes who have bariatric surgery are much more likely to have their diabetes go into remission than matched controls who do not get surgery. In one study in the United Kingdom, people having bariatric surgery were 43 times (for gastric bypass), 17 times (for sleeve gastrectomy), and 7 times (for gastric banding) more likely to have their t2d in remission within 6 months of treatment, as compare to controls.

There are risks associated with bariatric surgery, including a small risk of death within 30 days of the operation (a rate similar to other surgeries), the need for subsequent surgery to repair the initial surgery or treat other GI conditions, increased depression, increased use of drugs and alcohol, and nutritional deficiencies. In addition, diabetes remission can reverse over time. For example, in one study conducted in Sweden, the rates of remission decreased from 72% after two years to 30% after 15 years.

Who qualifies for bariatric surgery? The criteria were set in the 1991 National Institutes of Health Consensus Conference Guidelines and are as follows: patients must have a body mass index (BMI) of 40 or greater, or a BMI greater than 35 and a condition such as type 2 diabetes, hypertension, or heart disease. Additional criteria might be set by the hospital offering the surgery, such as length of time being obese, whether the patient has tried other methods to lose weight, psychological factors, and willingness to eat a healthy diet.

Who typically gets bariatric surgery, and how much does it cost? Typically, patients able to get surgery are middle to upper class. The costs vary depending on type of surgery, from \$23,000 for gastric bypass surgery to about \$15,000 for gastric sleeve and gastric banding surgery. Some, but not all health insurance policies will cover some or most of the cost, but it depends on the patient’s insurance policy. Gastric bypass surgery is covered by Medicaid in 48 states.

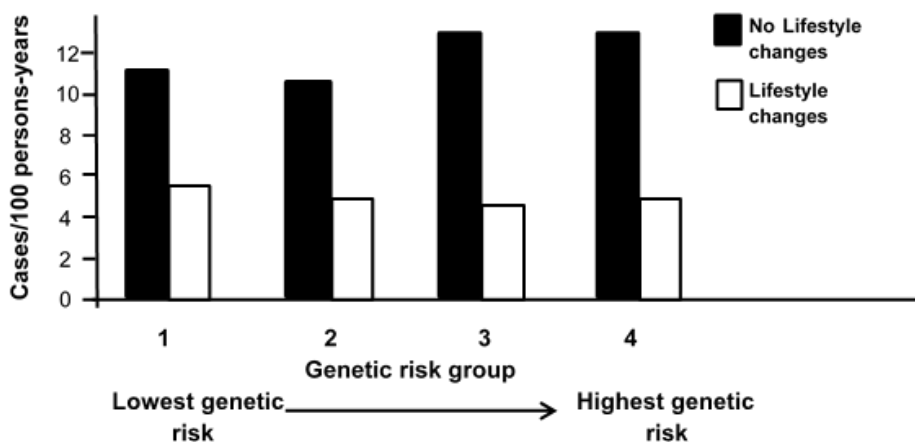
## Option 4: Lifestyle Changes

The Diabetes Prevention Program (DPP) was a long-term research study involving over 3000 people in the United States. At the beginning of the DPP, participants were all overweight and had prediabetes, but not diabetes. The participant group was composed of 45% racial and ethnic minorities.

In the DPP, participants were randomly divided into different treatment groups. The first group, called the **lifestyle** intervention group, received intensive training in diet, physical activity, and behavior modification. By eating less fat and fewer calories and exercising for a total of 150 minutes a week, they aimed to lose 7 percent of their body weight within six months and maintain that loss.

Related studies identified 34 different allele combinations (gene variants) associated with type 2 diabetes. Each of the 34 risk alleles was weighted according to its effect on the development of type 2 diabetes. DPP participants were genotyped, and the weights of their risk alleles were added together to give the participant a Genetic Risk Score between 1 and 4.

The graph below compares the rate of progression to type 2 diabetes for people in all four genetic risk groups with or without lifestyle interventions. There was a 58% reduction in the incidence of type 2 diabetes in the lifestyle group compared to the control group over an average follow-up time of about 3 years. The Program was effective for all participating racial and ethnic groups and both men and women. The Program worked particularly well for participants ages 60 and older, lowering their chances of developing type 2 diabetes by 71 percent.



Modified from Hivert, M-F et al., 2011; *Diabetes* 60:1340-1348

The cost of the lifestyle intervention in the original DPP study was \$1400 per participant for the first year. The costs included an individualized goal-based approach that included weight loss and exercise goals. Each participant was assigned an individual lifestyle coach, who taught a 16-session core curriculum and follow-up sessions to help the participant achieve their goals. Although the cost of the intervention seems high, it is much lower than the average health care cost for one person with type 2 diabetes, which in 2009 was \$11,700.

**Student Sheet 5.1 Options Organizer**

Description of Option	How is this a prevention, treatment, or both?	How is this option driven by individuals, society, or both?	Who benefits? What is the cost, or what is the harm?
Option 1: Medications			
Option 2: Food Labeling and Marketing			
Option 3: Surgery			
Option 4: Lifestyle Interventions			





## Student Sheet 5.2: Evaluating Solutions

**FACTS:** What have you learned about type 2 diabetes during the unit that your solution will address?

**BENEFITS:** What good could your solution bring?  
Does this benefit people from all levels of society?  
Who does it benefit most?

Your Solution(s):

**COSTS:** What are the tradeoffs for your solution? What harm could your solution bring? Who might be harmed?

**DRIVERS:** Who or what is responsible for making your solution happen? Does it rely on individual choices, social systems, or a combination?

## Student Sheet 5.2: Evaluating Solutions

Page 2

In the space below, write a justification for your solution. A strong justification will include:

- A clearly stated solution (claim)
- Facts about diabetes that will be addressed by your solution (evidence)

Logically reasoned arguments regarding:

- The benefits and costs associated with your solution
- The importance of your solution as a prevention, a treatment or both
- How individuals and/or social groups (drivers) can put your solution into practice

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