Lesson 3

Modeling Type 2 Diabetes

Time: 50 min

Video overview of lesson (1:39)

Student Road Map - Hyperlinked Google Doc for Lesson 3

Lesson Objectives:

Students will be able to learn:

- 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 model 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 six 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 Understandings

- 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.
- Type 2 diabetes is a serious condition with negative health consequences if left untreated.

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.

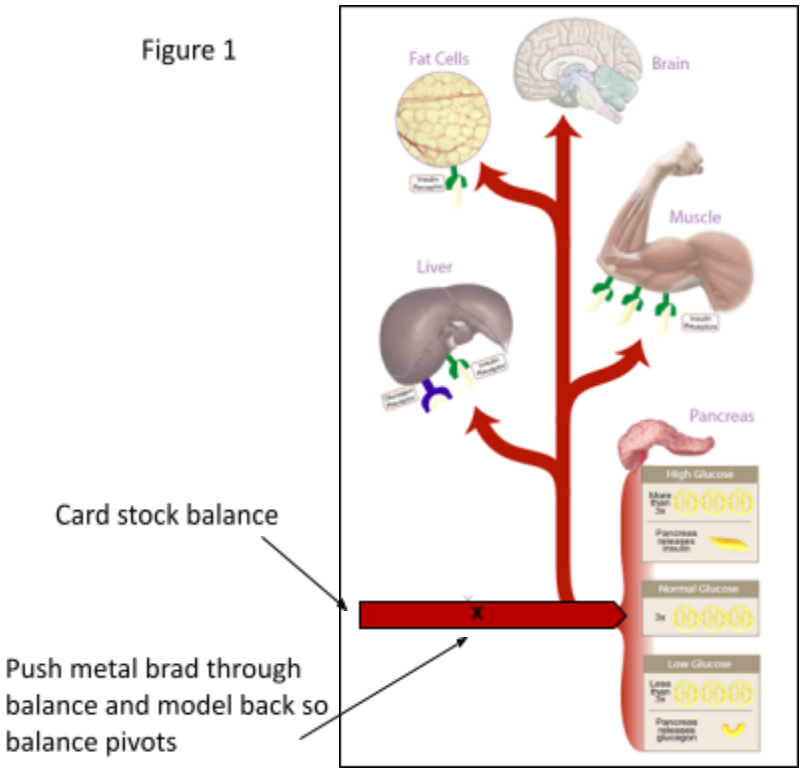
Lesson Summary with Timings

Introduction	5 min
Modeling glucose in and out of balance	35 min
Closure	10 min

This lesson has expanded to include several other modeling options, including the Blood Sugar Balance game. All options can be found here.

Materials	Quantity
Computer and projector	1 per class
Slide set for unit (Slides 63 - 76 for Lesson 3)	1 per class
Homeostasis Model Board set (see Figure 1) Each set contains: 1 11" x 17" model board or 2-page photocopy of model board pasted in to a Manilla folder 1 brad 1 balance made from red card stock, approximately 7.5 in x 1 in, and pointed at one end. Teachers can write the word "homeostasis" on the balance to underscore the concept. 30 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 For Scenario Six: 4 small marshmallows and 12 pieces of spaghetti (these can be ~4 inch pieces)	1 per group
Set of Six Scenario Cards Print card pages two-sided and cut paper in half. Digital Scenario Cards	1 set / group
Student Sheet 3—*Scenario Scaffolds*	1 per student
Lesson Summary Guide from Lesson 1	1 per student

Figure 1



Each group will need:

- a model board, assembled as shown in Figure 1
- a baggie containing the correct number of pasta pieces, marshmallows, and sticky notes
- Access to scenario cards, either printed or digitally.

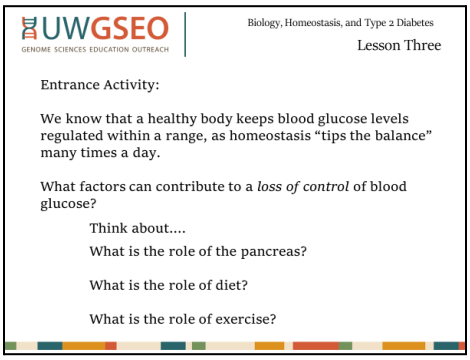
A note about the model board: Tell students that they will be learning about the biological mechanism of type 2 diabetes in this lesson by working with a model. Models can be useful to show relationships and connections within complex systems. However, every model has limitations, especially a model 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)**

Entrance activity: Students can respond to the questions posed on the entrance activity Slide 63 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 63



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 pasta pieces and sticky notes 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, or use the digital versions.

4. When students have all the materials, go through Scenarios 1 and 2 as a class, then let groups proceed at their own pace through the remaining scenarios.

5. When students finish the first 5 scenarios, hand out 4 small marshmallows and about 12 pieces of spaghetti. Have students complete Scenario Six.

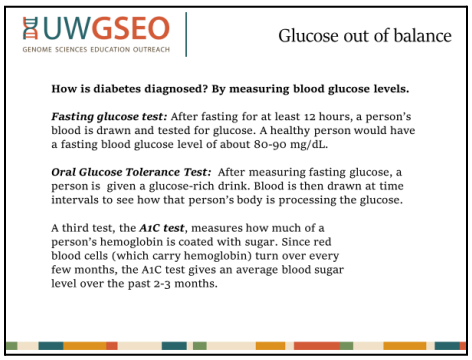
6. When students have completed the scenarios, go over the answers to Student Sheet 3 – *Scenario Scaffolds* as time allows. Possible answers can be found at the end of this lesson.

7. Playing the game Blood Sugar Balance reinforces the concepts from the model board.

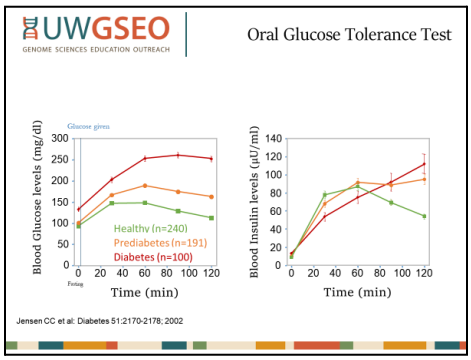
8. Use Slides 64 and 65 to help answer the last question on the student sheet. These slides go over how diabetes is diagnosed in different ways by measuring blood glucose levels.

9. Ask students to predict blood glucose curves for people with and without diabetes before showing them Slide 65.

Slide 64



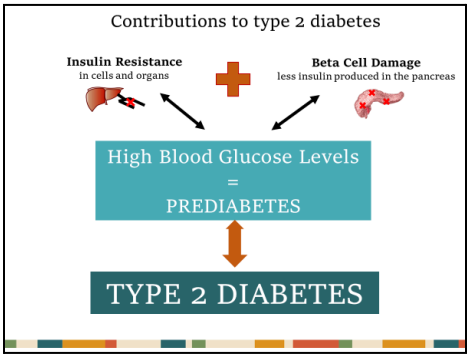
Slide 65



Part III (Evaluation): Closure (10 minutes)

10. 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 66

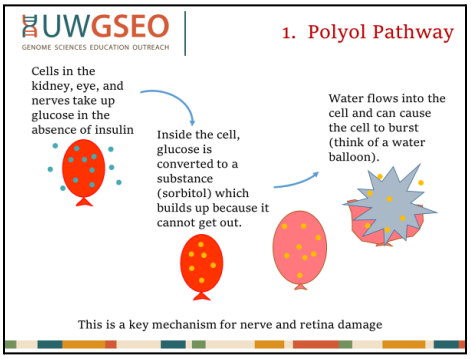


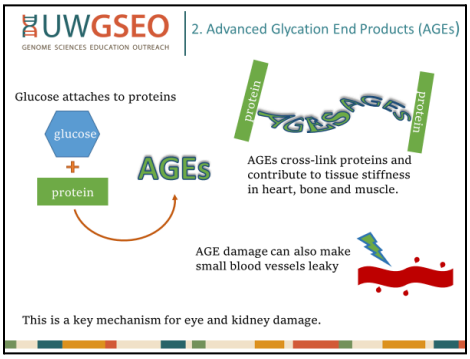
11. Ask students to get out their *Lesson Summary Guide* from Lesson 1 and fill in the third row.

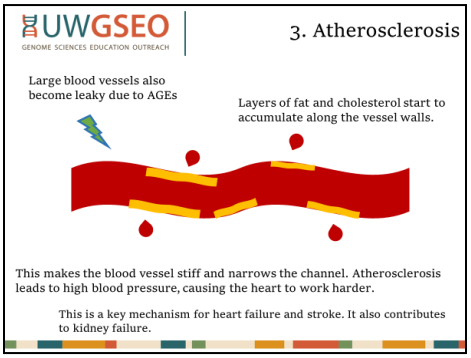
12. Exit Ticket: Students can fill out the third row of the guide as an exit ticket.

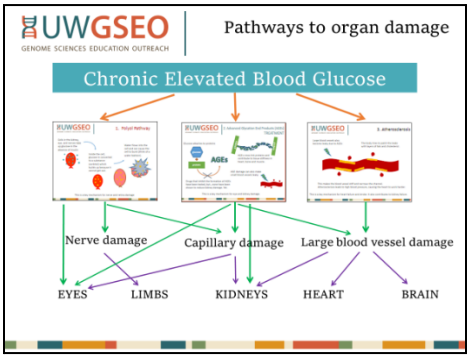
Extension

Slides 67 through 76 provide physiological details on how high blood glucose affects 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.

Possible Answers to Student Sheet 3

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 what 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

a. How does the pancreas respond when blood glucose levels are low?
The pancreas releases glucagon.

b. What is the role of glucagon?
Glucagon binds to receptors on the liver which allows the liver to release glucose into the blood.

c. 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.

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. 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.

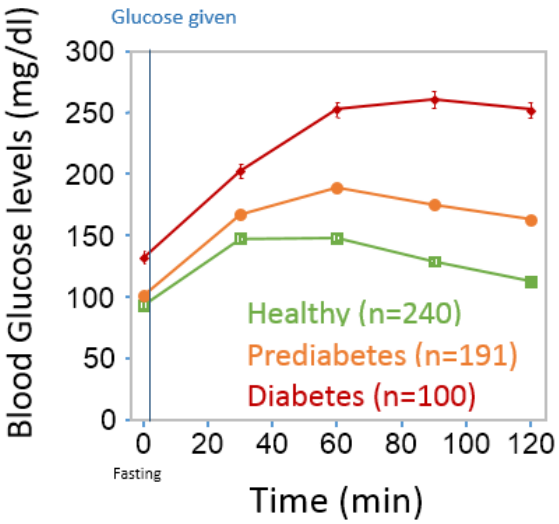
Scenario Six—Couch Potato

a. How can excess glucose lead to body fat?
If not needed for immediate energy, glucose can be converted to both fatty acids and glycerol through different pathways. Fatty acids and glycerol are the building blocks of triglycerides, which are stored in fat cells and are the main component of body fat.

Summary Questions

a. 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).

b. How is type 2 diabetes diagnosed? By measuring blood glucose levels. One type of test is 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