

Food for Thought: What fuels us?

Glucose, the endocrine system, and health

Lesson 5: How does glucose dysregulation lead to disease?

I. Overview

In this lesson, students learn about the consequences of the dysregulation of blood glucose levels in type 2 diabetes. Students apply their knowledge of the insulin/glucagon model from Lesson 2 by integrating information from multiple readings that discuss risk factors for type 2 diabetes. Students learn that type 2 diabetes is preventable and is brought on by a sedentary lifestyle, poor diet, and stress. Using the information they collect, students collaborate to develop a PSA that promotes the prevention of type 2 diabetes and includes information on the dangers of stress on glucose regulation and health.

Connections to the driving question

In this lesson, students learn about the negative effects of having too much “fuel.” This lesson reveals how the body keeps glucose levels from rising too high, and how certain lifestyles can hurt this natural homeostatic response.

Connections to previous lessons

In Lesson 2, students examined the ability of the body to keep glucose levels stable when they are too low. In Lesson 4, students learned about the effects of disruption in particular homeostatic mechanisms (what happens to memory with aging as a result of fewer adrenalin receptors on liver cells). In this lesson, students explore the negative effects that can occur with prolonged high blood glucose levels. Students apply the model of glucose homeostasis they created in Lesson 2 to predict what can happen to the body when there is too much blood glucose.

II. Standards

National Science Education Standards

- 12FSPSP1.5 Selection of foods and eating patterns determine nutritional balance. Nutritional balance has a direct effect on growth and development and personal well-being. Personal and social factors - such as habits, family income, ethnic heritage, body size, advertising, and peer pressure - influence nutritional choices.
- 12FSPSP1.2 The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be

prevented, controlled, or cured. Some diseases, such as cancer, result from specific body dysfunctions and cannot be transmitted.

Benchmarks for Science Literacy

- Conditions now are very different from the conditions in which the species evolved. But some of the differences may not be good for human health. 6E/H3b
- Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. In defining a system, it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what is input and output are expected to be.

III. Learning Objectives

Learning objective	Assessment Criteria	Location in Lesson
Describe and model insulin resistance	Using their glucose homeostasis model, students can predict how cells might respond to ongoing high blood glucose: <ul style="list-style-type: none"> • Insulin resistance occurs when cells no longer respond to insulin signaling, and blood glucose does not get taken up and stored inside the cell. • Insulin resistance is a cause of type 2 diabetes. 	Activity 1 & 2
Explain how the risk factors for diabetes all increase blood glucose levels.	After evaluating and discussing articles, students will be able to explain how type 2 diabetes can be brought on by lifestyle factors such as poor diet, sedentary behavior, and or high stress. <ul style="list-style-type: none"> • Poor diet – ongoing high blood glucose • Sedentary lifestyle – blood glucose remains high as it is not being used by cells for energy. • High stress – leads to release of epinephrine which triggers the liver to release glucose into the blood. 	Activity 1, 2, & 3
Identify preventative measures against the onset of type 2 diabetes.	The onset of type 2 diabetes can be prevented by engaging in healthy eating habits that do not spike blood sugar, regular physical activity, and developing coping techniques to deal with stressful situations.	Activity 2 & 3

V. Timeframe for lesson

Opening of Lesson

- Discuss the findings of Rat Recall experiment- 5 minutes

Main Part of Lesson

- Activity 1: Insulin Resistance Jigsaw- 20 minutes
- Activity 2: Jigsaw Discussion – 20 minutes
- Activity 3: PSA – 50 minutes

Conclusion of Lesson

- Class discussion – 10 minutes

VI. Advance prep and materials

Activity 1 and 2: Insulin Resistance Jigsaw

Materials and Preparation:

- Print 1 copy per student:
 - U7_L5_Reading_InsulinResistance
 - U7_L5_StudentSheet_InsulinResistance
 - U7_L5_Reading_HyperHypoGlycemia
 - U7_L5_Reading_Diet
 - U7_L5_Reading_HighStress
 - U7_L5_Reading_DangersOfSedentaryLifestyles

Activity 3: PSA

Materials and Preparation:

- Print 1 copy per student:
 - U7_L5_StudentSheet_PSA

VII. Resources and references

U7_L5_HyperHypoGlycemia

Article taken and modified from:

- Bittman, M. (2012, September 25). Is Alzheimer’s type 3 diabetes? The New York Times. Retrieved from <http://opinionator.blogs.nytimes.com/2012/09/25/bittman-is-alzheimers-type-3-diabetes/>
- Alzheimer’s disease. In Merriam-Webster’s online dictionary. Retrieved from <http://www.merriam-webster.com/dictionary/alzheimer's%20disease>

U7_L5_HighStress

Article taken and adapted from:

- Pouwer, F., Kupper, N., & Adriaanse, M. (2010, February). Does emotional stress cause type 2 diabetes mellitus? A review from the European depression in diabetes (EDID) research consortium. *Discovery Medicine*. Retrieved from <http://www.discoverymedicine.com/Frans-Pouwer/2010/02/11/does-emotional-stress-cause-type-2-diabetes-mellitus-a-review-from-the-european-depression-in-diabetes-edid-research-consortium/>
- Goode, E. (2002, December). The heavy cost of chronic stress. *The New York Times*. Retrieved from <http://www.nytimes.com/2002/12/17/science/the-heavy-cost-of-chronic-stress.html?pagewanted=all&src=pm>

Image

- “Stress” image use given permission by Diane Cheney, www.cheneyart.com

U7_L5_Diet

Article taken and modified from the following articles:

- American Diabetes Association (2014, September 8) Diabetes Myths. Retrieved from <http://www.diabetes.org/diabetes-basics/diabetes-myths/>
- Glycemic index, glycemic load, and glycemic response definitions and consumer tip sheet. Retrieved from <http://oldwayspt.org/programs/special-custom-programs/glycemic-index-definitions-and-consumer-tip-sheet>
- Strand, R.D. (n.d.) Recommended foods. Retrieved from <https://www.raystrand.com/recommended-foods.asp>
- Thompson, R. (2012, February 16) Block sugar from your body in 7 easy ways. Retrieved from <http://www.today.com/health/block-sugar-your-body-7-easy-ways-1C9381792>

Food images from:

- <http://commons.wikimedia.org/>

U7_L5_DangersOfSedentaryLifestyles

Article taken and adapted from:

- Reynolds, G. (2012, April 28). Don't just sit there. *The New York Times*. Retrieved from <http://www.nytimes.com>
- Sedentary. In Merriam-Webster's online dictionary. Retrieved from: <http://www.merriam-webster.com/dictionary/sedentary>

Data taken from:

- Department of Health and Human Services, Centers for Disease Control and Prevention. Diabetes public health resource. Retrieved from <http://www.cdc.gov/diabetes/statistics/incidence/fig1.htm>

U7_L5_Reading_InsulinResistance

- Edelman, D. (2013, January 18) Is my blood sugar normal? Retrieved from <http://www.diabetesdaily.com/voices/2013/01/is-my-blood-sugar-normal/>

VIII. Lesson Implementation

Opening of Lesson:

Begin the class by asking students to think back to the “Rat Recall Experiment” they conducted in the previous lesson. Ask students:

- How is the adrenalin response working differently in old rats? How does this lead to memory impairment?
- Do you think that changes in hormone production and responses can explain other diseases as well?
 - Give time for students to give examples if they know any (hyper/hypothyroidism, PCOS, gigantism).

Ask students how this relates to the first endocrine model they made: the interaction between insulin and glucagon in maintaining glucose homeostasis.

For visual assistance, project the **U7_L2_Assessment_Homeostasis** (the balancing beam worksheet from Lesson 2) for the class to see. For this lesson, students will be focusing on the dysregulation of blood glucose, specifically hyperglycemia, and how it can lead to diabetes. Students will most likely already know that high blood glucose is related to diabetes. Ask students:

- What are some factors that could cause high blood glucose or Type 2 diabetes?

Inform them that in this lesson they will use the knowledge that they have developed thus far in the unit, and apply it directly to humans in a societal context.



Scientific Practices: Developing and Using Models

Developing and using models has been a major theme throughout the Unit. Lesson 5 continues this theme by providing a context for how the physiological model of glucose homeostasis can be affected by lifestyle choices. Students do not construct their scientific models in isolation from other scientific practices, but work to develop the skills to critically evaluate ideas by constantly referencing and applying their mental models.

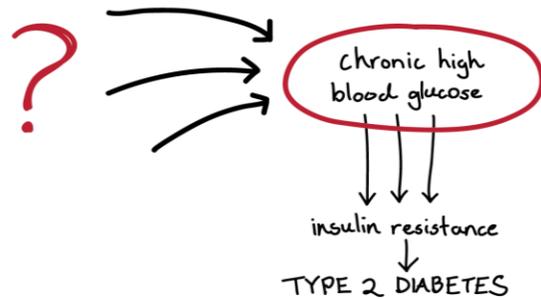
Main Part of Lesson

Activity 1: Insulin Resistance Reading

Split the class into groups of 4, pass out **U7_L5_StudentSheet_InsulinResistance**, and tell them to just answer question #1.

When all groups have finished question #1 initiate class discussion. What is diabetes? What causes type 2 diabetes? (Insulin resistance) What causes insulin resistance? (Chronic levels of high blood sugar)

Draw this process on the board for to students to see. Next ask students what they think can contribute to chronic levels of high blood sugar?



Activity 2: High Blood Sugar Culprits

Inform students that they will be reading articles that address factors that lead to chronic levels of high blood sugar. With the information that students gain from the article they just read and the articles they are about to read and discuss, they will be creating a Public Service Announcement (PSA) on prevention of diabetes and high blood sugar.

Once students have completed question #1, pass out the jigsaw articles to each group:

- U7_L5_Reading_HyperHypoGlycemia
- U7_L5_Reading_HighStress
- U7_L5_Reading_Diet
- U7_L5_Reading_DangersOfSedentaryLifestyles

This is a jigsaw activity. Each member of the group must choose an article to be responsible for reading and become an “expert” on the content of the article. Together, students will collaborate to complete the remaining questions on the **U7_L5_StudentSheet_InsulinResistance**, each bringing in a different slice of knowledge from the readings.

Below are quick summaries of what each article discusses.

Hyperglycemia and Hypoglycemia: Both are bad for brain function.

The body attempts to keep blood glucose levels at a range of 70-100 mg/dL. Both hypoglycemia and hyperglycemia impair brain function. Although modest increases in blood glucose can improve memory, when blood glucose rises too high, cognitive deficits can occur. The high blood glucose that is a part of type 2 diabetes can cause damage to the brain and increase the likelihood of developing Alzheimer’s disease. It seems an overconsumption of simple carbohydrates may be linked to both diseases. People with diabetes are at least twice as likely to get Alzheimer’s.

Can Our Psychological State Affect Our Physical Health? The Cost of Chronic Stress

A multitude of studies reveal how important psychological well-being is to our physical health. Depression, low amounts of sleep, anger, and chronic stress all greatly increase the risk of diabetes. Stress causes adrenalin to elevate blood glucose levels. Constant high blood glucose during times of non-activity can have very similar effects to eating poorly.

Diet: Type 2 diabetes is a preventable (and reversible?) disease!

Eating certain types of carbohydrates (simple carbohydrates) are likely to spike blood sugar, and if continued, over time can lead to insulin resistance. Eating complex carbohydrates such as vegetables and whole grains will lead to slow release of glucose into the blood and will prevent

the onset of insulin resistance. Eating a well-balanced meal with proteins, carbohydrates, and fats will slow the absorption of glucose into the bloodstream. The way food is prepared will also change the speed at which glucose gets absorbed into the blood. For instance, overcooking foods speeds the digestion and absorption of glucose into the bloodstream. Eating a high fiber diet can greatly reduce the onset of type 2 diabetes, and has also been shown to decrease (and possibly reverse) hyperglycemia in type 2 diabetics.

The Dangers of a Sedentary Lifestyle; Don't Just Sit There

Living an active lifestyle is a great way to maintain normal blood glucose levels and prevent diabetes. Sitting for long periods of time increases circulating blood glucose which causes insulin levels to spike. This can lead to insulin resistance. To reduce blood glucose levels, it is beneficial to break up long periods of sitting around with some type of movement.

As students work through the readings and student sheet, walk around the room to assist them if they need help. Make sure that students complete the questions associated with the readings on **U7_L5_StudentSheet_InsulinResistance** before continuing on to Activity 3.

Activity 3: Type 2 diabetes Public Service Announcement (PSA)

The PSA covers the same learning objectives as **U7_L5_StudentSheet_InsulinResistance**, therefore, it can be used to reinforce student learning or it can be considered optional. Activity 3 further engages students in the scientific practice of obtaining, evaluating, and communicating information.



Scientific Practices: Obtaining, Evaluating, and Communicating Information

Thus far students have read a collection of scientific articles taken and modified from popular and scientific magazines. Students must not only read the articles, but also apply them to the insulin model to understand how certain lifestyle factors lead to hyperglycemia. The variety of articles in this lesson give students multiple perspectives on human health for the purpose of developing a more holistic understanding of diabetes. Finally, to solidify these skills students must communicate their analysis of the articles through the creation of a PSA.

With the knowledge students have on the endocrine system, the insulin model, and the jigsaw articles, students will make a Public Service Announcement discussing the negative effects high stress, a sedentary lifestyle, and a poor diet have on blood glucose regulation and the development of diseases such as Diabetes and Alzheimer's Disease.

The PSA can be made as a document or pamphlet. However, also consider allowing students to have the freedom in presenting the risks of high blood sugar in other creative ways. Other option might include a PowerPoint, video, skit, song, prezzi, story, bus advertisement, poster, etc.

Students should use the **U7_L5_StudentSheet_PSA** for planning their PSA. Students PSA's should include:

- 1) Explanation of why type 2 diabetes is detrimental and preventable.
- 2) Relate the lifestyle factors (diet, sedentary lifestyle, and high stress) to the insulin model and how each one may disrupt normal blood glucose levels.
- 3) Relate the lifestyle factors to the development of health disorders such as Alzheimer's disease, depression, and diabetes.
- 4) Include suggestions for lifestyle changes that would decrease the likelihood of developing health disorders. These suggestions must include specific examples for how a person's lifestyle can be altered to prevent the onset of type 2 diabetes.



Teacher Content Knowledge: How do high glucose levels affect other organ systems?

The Brain:

Because the brain has glucose transporters that are insensitive to insulin, it is always able to take up glucose from the blood, whether the individual has insulin resistance or not. In the case of an insulin resistant individual, since blood glucose levels are perpetually high, the brain takes up more and more glucose. High glucose uptake in the brain can damage the brain by creating high levels of metabolic stress during cellular respiration in mitochondria. Over many years, this metabolic stress can damage proteins and cause the brain to work less efficiently on glucose. This reduction in glucose metabolic efficiency can lead to mild cognitive impairment and eventually Alzheimer's Disease. In fact Alzheimer's disease is also known as type 3 diabetes, because the brain is inefficiently utilizing glucose leading to decrements in cognition. In fact, many diabetics are more likely to develop Alzheimer's disease.

The Kidneys:

Because the kidneys function as the blood filtration organ, high levels of glucose in the blood lead to damage to the kidney's filtration network. The increased blood glucose leads to glucose attaching to proteins on the cell membrane which in turn leads to dysfunctions in the kidney cells. Overtime, this increase in blood glucose wears away at kidneys and they can eventually fail. Many diabetics suffer from kidney failure during aging.

The Eye:

The blood vessels in the eye are very small and fine. When blood glucose levels are perpetually high, the increase in glucose in these tiny capillaries leads to capillary death. Many diabetics will go blind in old age due to prolonged high blood glucose levels and damage to the capillaries in the eye.

Conclusion of Lesson

To conclude the lesson and summarize the theme of the unit, ask the question, “What fuels us?”

- What fuels us? Where do we get energy? Our body, our cells?
- Where does the body get extra fuel during exercise, starvation, a stressful event?
- How does the body “know” how to store or release this fuel?
- What fuels us? What fuels our choices? For living a healthy lifestyle?

Homework and Assessments

U7_L5_StudentSheet

- Student groups should have their student sheets completed by the end of the lesson.

Public Service Announcements

- Student groups should have completed the necessary PSA prep questions on the U7_U5_StudentSheet. The final assessment will be decided by the students and teacher.