



YOUNG VOICES:

Life With Diabetes

Lesson 3: Blood glucose

Inquiry Focus: How does the body deliver the energy in food to its parts?

Student Learning Objectives: By the end of the lesson, students will be able to do the following:

- Describe why glucose in the blood is important
- Explain the idea of feedback in terms of glucose levels in the body
- Describe the actions of insulin and glucagon within the framework of feedback

Time Frame: 1-2 class periods

Materials:

- Yeast and Energy (for each group of students)
 - 2 100ml graduated cylinders
 - Access to warm water
 - 1 packet of active yeast
 - 1 packet of sugar
- Regulating the Energy Flow
 - Multiple student computers connected to the internet
 - Video segments from the web site: “The Pancreas, Insulin, Glucose, and Diabetes” and “The Pancreas.”
 - Video segment from the web site: “Carbohydrates and Fat: Fueling the Body” from the video program *Human Body: Pushing the Limits: Strength*.

Teacher Background Information:

- The main form of usable energy in our bodies is a kind of sugar called “glucose.” Sugars are a kind of simple carbohydrate. Glucose gets transported to the cells in the blood; the amount of glucose in the blood is called the “blood glucose” or, less precisely, the “blood sugar.” It might help to think of the body as a vending machine full of every function a cell or tissue can do; this vending machine normally takes only quarters, which are glucose. Does a muscle cell need energy to contract? It will take a few glucoses. A neuron has to send a signal to the brain?

Another handful of glucoses. A skin cell needs to split into two cells to help heal a cut? More glucose.

- What happens when you start to run short on glucose quarters? The first thing that happens is the liver starts releasing its stored form of glucose, which is called “glycogen,” like cashing in \$5 bills for glucose quarters.
 - When your body has a sustained need for glucose and it is not being replaced fast enough in the diet, then your body will start using your other types of fuel: fats and proteins.
 - Several kinds of amino acids can be used to make glucose in a process called “gluconeogenesis,” which is like changing some different coins for glucose quarters to use in the vending machine. Some parts of fats, specifically the glycerol, and fat byproducts can also be turned into glucose through gluconeogenesis.
 - When your body is starving for glucose, it can break its preference for only accepting glucose in order to survive. Fatty acids can be used by some tissues like muscle for energy, but the brain cannot use fatty acids. To keep the brain functioning when blood glucose is low, some fatty acids can be converted by the liver to something that the brain can use called “ketone bodies.”
- The body has a system of signals to tell cells when blood glucose is high (“hyperglycemia”) and therefore glucose needs to be picked up by cells, and when it is low (“hypoglycemia”) and glycogen needs to be released from the liver along with beginning gluconeogenesis and fat mobilization.
 - The pancreas, which is also involved in digestion, has groups of cells called the “Islets of Langerhans” that produce and release into the bloodstream chemicals called “hormones” that are largely responsible for the body’s response to blood glucose levels.
 - “Insulin” is made by the beta-cells of the pancreas and is released in response to high blood glucose levels, like those that occur after a carbohydrates-rich meal. Insulin is necessary for tissues like muscle and fat to effectively take up glucose from the blood. Insulin also signals the liver to take up glucose and store it as glycogen, and inhibits the breakdown of fat. Insulin has the effect of lowering blood glucose levels.
 - “Glucagon” is made by the alpha-cells of the pancreas and is released in response to low blood glucose levels. Its effects are opposite those of insulin: it signals the liver to release glycogen to increase the blood glucose levels. Glucagon has the effect of raising blood glucose levels.
 - Blood glucose levels are kept in a narrow range through the actions of insulin and glucagon. Much like a seesaw, the amount of insulin on one end is constantly adjusted by the body to balance out the blood glucose on the other end.

Instructional Activities:

Review with students what they’ve learned up to now about food and how it is converted through digestion into chemicals that the body can use. Proteins are broken down into amino acids that are

used to build or repair tissue. Carbohydrates are broken down into a sugar called glucose, which is stored as glycogen and used as a power source for cells. Fats are stored as fat and can be broken down for energy. The body tends to store fat as a reserve power source, so it does not draw on the fat for energy as much. The body uses up the glycogen molecules first.

Yeast and Energy

To see how glucose is used for energy, have students conduct a simple yeast experiment. Yeast consists of simple cells that use sugar energy to grow, reproduce, and respire. When they respire, they give off carbon dioxide gas. This is why they are used to make bread rise. Explain to students that, in the body, sugar in the form of glucose is used as energy to carry out the functions of the body, including growth and respiration (taking in oxygen and giving off carbon dioxide). Yeast cells also utilize sugar.

Provide each student group with two 100ml graduated cylinders and a packet of yeast. Have students add half a yeast packet to each cylinder, then fill the cylinders with 20ml of very warm, but not boiling water. To one cylinder, they should add the sugar packet. Swirl to ensure that the yeast and sugar are evenly distributed. Observe what happens in each of the cylinders over a period of 10 – 25 minutes. (Typically, yeast within the cylinder with sugar added will rapidly begin to respire and replicate, forming a foam on the surface that will rise over time.)

Explain that although this is a different kind of sugar, cells in our bodies utilize glucose in the same way. When they need to reproduce or perform some other function, our cells need to have glucose delivered to them. High energy activities, such as athletics or emergencies, require more glucose be delivered to the cells. Low energy activities require less glucose.

Regulating the Energy Flow

But how does the body know when to deliver glucose and when not to?

Explain that the body is able to utilize an amazing system of controls on this energy coming into the body. As different foods are brought into the body, they provide glucose at different rates. Simple sugars are converted quickly and immediately add glucose energy to the bloodstream. Carbohydrates take more time and are slowly converted to glucose. The body has different needs for energy at different times.

If you have access to student computers with internet access, divide students into two groups and assign a different video from the web site to each group. One group should view, “The Pancreas,” while the other should view, “The Pancreas, Insulin, Glucose, and Diabetes.” Have both groups respond to the following questions:

1. What is the main source of energy flowing through the bloodstream?
2. What does the pancreas do when too much of this sugar energy gets into the bloodstream?
3. What does the pancreas do when too little sugar is in the bloodstream to do the tasks the body needs to do?
4. What is the “feedback” mechanism of the body for maintaining an energy balance in the bloodstream?

Have groups come back with their answers. Pair up students who saw a different video and have them share answers. Then bring the class together to discuss.

Extension: "Hitting the Wall"

Following the discussion, explain that some food energy that comes into the body is too much even for the liver to store. Some is also stored in muscles. Many fats and extra sugars are stored by the body in fat cells. These occur throughout the body. When the human body is pushed to extremes, it will run out of the quick glucose energy that is in the blood and liver. It will begin to use up reserve stores in the muscles and, finally, fat.

The video from *Human Body: Pushing the Limits* contains a segment entitled, "Carbohydrates and Fat: Fueling the Body" which illustrates the point at which the body runs out of glucose and begins to convert fat into useable energy.

Before showing it, ask students who have been in athletic competitions if they have ever "hit the wall" or know someone who has used that expression. Ask them to explain what it feels like. Then view the video and follow with a discussion.

Lesson Assessment:

Use the questions for the two videos as a means to assess student understanding of the main ideas of this lesson.

Have students respond to this application level question: In World War II, soldiers who went into combat were issued candy bars. The army would not normally just give soldiers treats for fun, even soldiers going into combat. So why did the army do this? (The candy contained simple sugars that would give the soldiers a quick, but brief, energy boost when the fighting began.)

Vocabulary:

- Hyperglycemia- when the blood glucose is too high
- Hypoglycemia- when the blood glucose is too low
- Hormone- a chemical made by the body that signals specific cells with the receptor to do something
- Pancreas- an organ whose functions include producing insulin and glucagon
- Insulin- a hormone made by the pancreas that signals the body to take in glucose from the blood when blood glucose is high
- Glucagon- a hormone also made by the pancreas that signals the liver to release glucose when blood glucose is low
- Glycogen- a stored form of glucose in the liver that can quickly be released when blood glucose is low

NSES Standards Addressed:

Scientific Inquiry: Formulate and revise scientific explanations and models using logic and evidence.



Life Science: The Cell: Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts called enzymes.

Life Science: Matter, Energy, and organization in living systems: The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken and new compounds with lower energy bonds are formed.

Personal and Community Health: Personal choice concerning fitness and health involves multiple factors; selection of foods and eating patterns determine nutritional balance; many diseases can be prevented, controlled, or cured; some diseases . . . result from specific body dysfunctions and cannot be transmitted.

Historical perspectives: Usually, changes in science occur as small modifications in extant knowledge; scientific knowledge evolves by changing over time, almost always building on earlier knowledge.





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Bibliography

1. American Dietetic Association. www.eatright.org. 2008.
2. American Diabetes Association. www.diabetes.org. 2008.
3. Centers for Disease Control and Prevention. www.cdc.gov. 2008.
4. Dietary Guidelines for Americans. www.health.gov/dietaryguidelines. 2006.
5. Juvenile Diabetes Research Foundation International. www.jdrf.org. 2008.
6. Kids Health. www.kidshealth.org. 2008.
7. Medline Plus. www.medlineplus.gov. 2008.
8. Miller, Kenneth. R. and Levine, Joseph. Prentice Hall Biology: Teachers Edition. Upper Saddle River. Pearson Education. 2002.
9. My Pyramid. www.mypyramid.gov. 2008.
10. National Diabetes Education Program. <http://ndep.nih.gov>. 2008.
11. National Digestive Diseases Information Clearinghouse. <http://digestive.niddk.nih.gov>. 2008.
12. The National Academies Press. www.nap.edu/html/nse. 1996.
13. Nutrition.gov. www.nutrition.gov. 2008.
14. USDA National Nutrient Database. www.nal.usda.gov/fnic/foodcomp/search. 2008.

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