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LESSON:

Bisphenol A and Diabetes

Summary: Students read about how bisphenol A, a component of certain plastics, may be linked to type 2 diabetes. Then they interpret a line graph of data from the study. Short Lesson—This lesson will take 20–30 minutes to implement.

***EHP* Article:** "Exploring the Roots of Diabetes: Bisphenol A May Promote Insulin Resistance" *EHP Student Edition*, April 2006, p. A48–A49
http://ehp.niehs.nih.gov/docs/2006/114-1/ss.html#expl

Objectives: By the end of this lesson, students should be able to

1. accurately summarize the data displayed in a line graph; and
2. describe how bisphenol A behaves similarly to the hormone estradiol and may contribute to type 2 diabetes.

Class Time: 20–30 minutes

Grade Level: 9–12

Subjects Addressed: General Science, Biology, Anatomy/Physiology, Health, Environmental Science/Health

Prepping the Lesson (15 minutes)

INSTRUCTIONS:

1. Download of the entire April 2006 *EHP Student Edition* at http://ehp.niehs.nih.gov/science-ed/, or download just the article "Exploring the Roots of Diabetes: Bisphenol A May Promote Insulin Resistance" at http://ehp.niehs.nih.gov/docs/2006/114-1/ss.html#expl.
2. Make copies of the article and the Student Instructions.
3. Review the Student Instructions, Background Information, and article.

MATERIALS (per student):

- 1 copy of *EHP Student Edition*, April 2006, or 1 copy of "Exploring the Roots of Diabetes: Bisphenol A May Promote Insulin Resistance"
- 1 copy of the Student Instructions

VOCABULARY:

- bisphenol A (BPA)
- diabetes, type 2
- endocrine disruptors
- estradiol
- insulin
- insulin resistance

BACKGROUND INFORMATION:

Diabetes is a disease in which there is too much sugar in the blood. When this happens the sugar can damage different parts of the body including the eyes, kidneys, nervous system, and circulatory system. Normally our bodies can handle the sugar with the help of a special protein-based hormone called insulin. Insulin helps sugar go into cells such as our muscle cells. Once the sugar is where it needs to be, it is used for energy within the cell.

There are two types of diabetes, type 1 and type 2. The difference between the two types relates to how the diabetes, or high blood sugar, occurs. With type 1 diabetes, the body does not produce enough insulin to handle the sugar. With type 2 diabetes, enough insulin is usually produced, but the body's cells ignore the insulin, leaving the sugar in the blood instead of taking it

into the cell where it can be used. "Glycemia %" is an indication of the amount of sugar that remains in the blood and relates to insulin resistance, or the body's inability to use insulin properly. It is already known that estradiol, a natural sex hormone, inhibits the body's ability to use insulin.

There are many factors that influence whether a person gets diabetes. The most significant factors include genetics, diet, and exercise. However, these factors may combine with or be exacerbated by exposure to a toxic chemical, drug, bacteria, or virus. For example, type 1 diabetes is considered to be an autoimmune disease, which means a person's immune (or protective) responses get out of control, and the body begins attacking itself. In the case of type 1 diabetes, the immune system attacks the pancreas, where insulin is produced. There are many chemicals that are known to cause autoimmune disease responses, such as mercury and polyvinyl chloride (the material in PVC pipes), but scientists do not yet know what specific environmental agent causes type 1 diabetes.

The discovery of how bisphenol A may contribute to type 2 diabetes is new and significant. This discovery may (combined with poor diet and exercise habits) help explain the rapid escalation of or susceptibility to type 2 diabetes in the U.S. population and in youth. Other environmental health contributions that are being researched include cumulative arsenic exposure (Tseng et al. 2000).

REFERENCE:

Tseng CH, Tai TY, Chong CK, et al. 2000. Long-term arsenic exposure and incidence of non-insulin-dependent diabetes mellitus: a cohort study in arseniasis-hyperendemic villages in Taiwan. Environ Health Perspect 108:847–851. Available: http://ehp.niehs.nih.gov/members/2000/108p847-851tseng/tseng-full.html

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, http://ehp.niehs.nih.gov. Choose Autoimmune Disease, Endocrine Disruptors, Environmental Disease

Alonso-Magdalena P, Morimoto S, Ripoll C, et al. 2006. The estrogenic effect of bisphenol A disrupts pancreatic-cell function *in vivo* and induces insulin resistance. Environ Health Perspect 114:106–112. Available: http://ehp.niehs.nih.gov/members/2005/8451/8451.html

American Diabetes Association, http://diabetes.org/home.jsp

Kraine MR, Tisch RM. 1999. The role of environmental factors in insulin-dependent diabetes mellitus: an unresolved issue. Environ Health Perspect 107(suppl 5):777–781. Available: http://ehp.niehs.nih.gov/members/1999/suppl-5/777-781kraine/kraine-full.html

Implementing the Lesson

INSTRUCTIONS:

1. Hand out the article and the Student Instructions.
2. Although this lesson is capable of standing alone, you may want to provide a brief description of diabetes (see the Background Information) and/or discussion on its becoming an epidemic in the United States. Although most diabetes is controllable through a strict diet and exercise, it is also a very dangerous disease that can damage almost every major organ system, as well as eyesight.
3. Depending on your students' level of experience, you may want to provide an example of how to read and interpret a graph. Be prepared to assist students, but encourage them to figure it out themselves by asking them questions.
4. When students are finished, and if time permits, you may want to ask the class the question "why are the results of this research important?" Answers may include:
   - Bisphenol A and other estrogen mimickers may be a significant contributor to the diabetes epidemic that is occurring in this nation (it could compound or exacerbate the effects of poor diet and exercise habits in the United States).
   - Understanding the contribution of bisphenol A to insulin resistance and diabetes may impact how plastics are made and/or used.
   - This research brings scientists one step closer to understanding the biochemical mechanisms for insulin resistance, which could lead to a cure for type 2 diabetes.

NOTES & HELPFUL HINTS:

- You may want to copy the original research publication for students to read and study. They could check their interpretation of the graph against the description given in the article. See http://www.ehponline.org/members/2005/8451/8451.html.

Aligning with Standards

SKILLS USED OR DEVELOPED:

- Communication (note-taking, oral, written—including summarization)
- Comprehension (listening, reading)
- Critical thinking and response
- Experimentation (data analysis)
- Graph reading
- Observation

SPECIFIC CONTENT ADDRESSED:

- Bisphenol A
- Diabetes
- Estradiol

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Science Content Standards

Unifying Concepts and Processes Standard

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function

Science As Inquiry Standard

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Life Science Standard

- The cell

Science in Personal and Social Perspectives Standard

- Personal and community health
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

History and Nature of Science Standard

- Science as a human endeavor
- Nature of scientific knowledge

Assessing the Lesson

Step 2: After reading the article, answer the following questions regarding the experiment. Note: Corn oil is the delivery vehicle for the estradiol and bisphenol A.

a) What are the treatments in this experiment, and what is the control?

Although students are not explicitly told the methods for this experiment, they should be able to deduce by looking at the graph what the treatments are. Corn oil is the delivery vehicle for the estradiol and bisphenol A, so corn oil is used by itself to control for any effects it may have separate from the treatments.

Control: corn oil

Treatments: estradiol and bisphenol A

b) Can you identify and explain why one of the treatments would be considered a positive control? (A positive control is a procedure that is very similar to the actual experimental test but which is known from previous experience to give a positive result.)

Estradiol is a positive control because it is known to inhibit the body's ability to use insulin. This allows the researchers to see how bisphenol A behaves compared to a known.

Step 3: At the right is a graph from the actual research paper on which this news article was based. Answer the following questions about the graph.

a) Which is the x-axis, and which is the y-axis?

x-axis: time (minutes)
y-axis: glycemia %

b) Which is the dependent variable? Explain.

Glycemia is the dependent variable because it responds to the treatments. The glycemia % depends on the treatment type and the time.

c) The graph refers to data from a part of the experiment where the mice were fed and blood sugar was high. Then they were given insulin to help their body properly handle the sugar. Insulin helps sugar go into cells where it can be used. When sugar does not make it into the cells because either the insulin stops working (type 2 diabetes) or there is not enough insulin (type 1 diabetes), a high blood sugar level occurs. In this case, the mice were given insulin so there would be enough insulin to do its job.

"Glycemia %" is an indication of the amount of sugar that remained in the blood after the insulin injection. Describe what the graph shows and how it relates to insulin resistance, or the body's inability to use insulin properly. The asterisks (*) mean that there is a significant difference compared to the corn oil.

The graph shows the percentage of sugar (glycemia %) that remained in the blood over a period of approximately 45 minutes after the insulin injection was given to the mice. The mice that had been given the corn oil control showed the greatest response to the insulin—that is, the blood sugar levels were reduced. The bisphenol A responded similarly to the estradiol in that both prevented the body's ability to properly use the insulin and remove sugar from the blood. There was a significant difference between the glycemia % of the two treatments and the corn oil control. It appears that bisphenol A may have inhibited insulin's ability to work even more so than the estradiol; however, the difference appears not to be significant (except perhaps at the 15-minute reading). All of the responses showed a sharp decrease in the glycemia %, with the lowest reading at 30 minutes (approximately 70% for the corn oil, and 85% for the estradiol and bisphenol A). Then the blood sugar began increasing again. The mice treated with the bisphenol A ended up with the highest glycemia % (approximately 96%) after 45 minutes.

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STUDENT INSTRUCTIONS: Bisphenol A and Diabetes

Step 1: Read the April 2006 *EHP Student Edition* article "Exploring the Roots of Diabetes: Bisphenol A May Promote Insulin Resistance."

Step 2: After reading the article, answer the following questions regarding the experiment. Note: Corn oil is the delivery vehicle for the estradiol and bisphenol A.

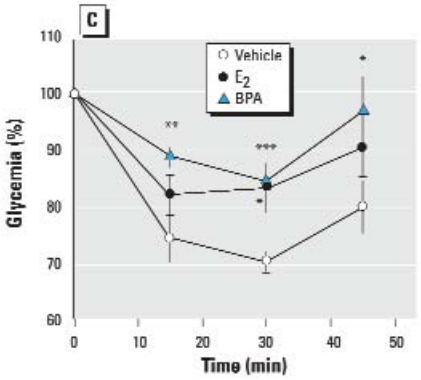
a) What are the treatments in this experiment, and what is the control?

b) Can you identify and explain why one of the treatments would be considered a positive control? (A positive control is a procedure that is very similar to the actual experimental test but which is known from previous experience to give a positive result.)

Step 3: At the right is a graph from the actual research paper on which this news article was based. Answer the following questions about the graph.

a) Which is the x-axis, and which is the y-axis?

b) Which is the dependent variable? Explain.



Source: Alonso-Magdalena P, Morimoto S, Ripoll C, Fuentes E, Nadal A. 2006. The estrogenic effect of bisphenol A disrupts pancreatic-cell function *in vivo* and induces insulin resistance. Environ Health Perspect 114:106–112.

c) The graph refers to data from a part of the experiment where the mice were fed and blood sugar was high. Then they were given insulin to help their body properly handle the sugar. Insulin helps sugar go into cells where it can be used. When sugar does not make it into the cells because either the insulin stops working (type 2 diabetes) or there is not enough insulin (type 1 diabetes), a high blood sugar level occurs. In this case, the mice were given insulin so there would be enough insulin to do its job.

"Glycemia %" is an indication of the amount of sugar that remained in the blood after the insulin injection. Describe what the graph shows and how it relates to insulin resistance, or the body's inability to use insulin properly. The asterisks (*) mean that there is a significant difference compared to the corn oil.

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