The Diabetes Cure — Creating Hope

Secrets of the Sequence Video Series on the Life Sciences • Grades 9 – 12

Teaching materials developed by VCU Life Sciences.

Virginia Commonwealth University

Classroom Tested Lesson

Video Description

"Secrets of the Sequence," Show 106, Episode 3
"The Diabetes Cure – Creating Hope" Approximately 9 minutes viewing time

Dr. Aaron Vinik, of Eastern Virginia Medical School, may have found the protein that cures diabetes. By probing the gene that makes insulin, Vinik discovered INGAP which when injected into diabetic animals increased their insulin levels and lowered glucose levels. Human clinical trials have begun, creating hope for the 130 million diabetics in the world.

Ward Television
Producer: Kris Larsen
Associate Producer: Eric Wills
Featuring: Dr. Aaron Vinik, Internal Medicine, Eastern Virginia Medical School, Gary Pittenger, Internal Medicine, Eastern Virginia Medical School, Dr. Robert Ratner, MedStart Research Institute
Lesson Author; Reviewers: Beth Richert; Catherine Dahl, Dick Rezba, and Selvi Sriranganathan
Trial Testing Teachers: Kent Lewarne, Edie Andress

National and State Science Standards of Learning

National Science Education Standards Connection

Content Standard C: Life Science
As a result of their activities in grades 9-12, all students should develop understanding of

- The Cell
- Matter, energy, and organization in living systems

Content Standard F: Science in Personal and Social Perspectives.
As a result of their activities in grades 9-12, all students should develop understanding of

- Personal and community health
- Science and technology in local, national and global challenges

Selected State Science Standards Connections

Use http://www.eduhound.com (click on "Standards by State") or a search engine to access additional state science standards.

Virginia

BIO.1 The student will plan and conduct investigations in which
a) observations of living organisms are recorded in the lab and in the field

b) hypotheses are formulated based on direct observations and information from scientific literature

BIO.3 The student will investigate and understand biochemical principles essential for life. Key concepts include:
a) water chemistry and its impact on life processes
c) the nature of enzymes

BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include:
a) cell growth and division
c) cell specialization
i) exploration of the impact of DNA technologies.

Delaware

Science as Inquiry

2. Scientific investigations in many cases follow no fixed set of steps. However, there are certain features of a valid scientific investigation that are essential and result in evidence that can be used to construct explanations.

Structure/Function Relationship

4. Cells store and use information to guide their functions. DNA molecules in each cell carry coded instructions for synthesizing protein molecules. The protein molecules have important structural and regulatory functions.

Matter and Energy Transformations

1. Cells carry out a variety of chemical transformations that allow conversion of energy from one form to another, the breakdown of molecules into smaller units, and the building of larger molecules from smaller ones. Most of these transformations are made possible by protein catalysts called enzymes.

Overview

This video highlights Diabetes, a disease in which a person's pancreas does not produce sufficient insulin to break down all the glucose in the blood. With a normally functioning pancreas, glucose would be metabolized into energy. When this does not occur in a diabetic person, fatigue and hunger are the first symptoms to arise. Depending on the severity of the disease, the patient may suffer further from heart disease, nerve damage, blindness, and even death. 130 million people around the world suffer from diabetes. By the year 2025 it is predicted that approximately 350 million people will be diagnosed with this disease. The concerns arising from this major health crisis have prompted researchers to focus on the gene that produces insulin. They hope to determine how to "turn on" this gene in a diabetic patient and provide a cure instead of merely controlling the disease through insulin shots, diet, and exercise. Successful attempts have already been made in curing diabetic mice by using INGAP (Islet Neo Genesis Associate Protein) as the trigger to promote the growth of islet cells, which in turn produce the insulin. Clinical trials are now underway in humans.

Testing: A sample related multiple choice item from State Standardized Exams

A microorganism which releases water into its environment to regulate its salinity during osmosis is undergoing a process that is similar to a human being who releases moisture on a hot day. This process that helps keep both the microorganism and the human body fluids in balance is know as –

A homeostasis*
B cell division
C heredity
D mutation

Source: Virginia End of Course Biology Test, spring 2001

Video Preparation

Preview the video and make note of the locations at which you will later pause the video for discussion.

Before Viewing

1. Ask: "What do you know about diabetes and what are some of its symptoms, consequences and treatments?"
   Definition: Diabetes is a disease that occurs when the body cannot metabolize glucose in the blood as it should.

   Have students write their answers in three columns entitled "Initial Symptoms," "Long-term Consequences," and "Treatments." See sample below.

Symptoms	*Consequences*	*Treatments*
Fatigue	*Blindness*	*Diet*
Hunger	*Heart disease*	*Exercise*
Increased thirst	*Nerve damage*	*Pills*
Frequent urination	*Death*	*Insulin injections*
Weight loss		
Headaches		

2. Ask:"Can dogs and other animals get diabetes?"
   Yes, mice, dogs, and other animals can

3. Review the steps in normal metabolic activity in animals:
   Glucose is broken down from food in the digestive system.
   Glucose enters the blood stream and is the major source of energy in animals.
   To convert glucose in the blood into energy, the body needs the hormone insulin, which is produced in the pancreas.

During Viewing

1. START the video

2. PAUSE the video (5:26 minutes into the video) after the narrator describes the experiment that led to the discovery of INGAP as a possible cure for diabetes.

   Discuss the following as one example of "scientific discovery and serendipity" and record on the board.

- Healthy and diseased pancreases were studied and compared. The pancreas is the organ that produces the insulin that the body needs to convert glucose in the blood into energy. A healthy pancreas has clusters of islet cells that produce insulin. In a diabetic person with a diseased pancreas the islet cells are either missing or not working properly.
- By chance, diseased pancreases of mice stored and wrapped in plastic wrap were found to have regenerated islet cells. This confirmed the cells' ability to regenerate, although at the time the '"triggering mechanism" was not known.
- Extracts from these pancreases were injected into diabetic mice. The diabetic mice grew new islet cells and their diabetes was cured.

Note: As with many scientific discoveries, the initial event that led to the discovery of a protein that would stimulate the production of islet cells resulted by chance. It was a serendipitous discovery that mice pancreases that were wrapped in Saran wrap spontaneously grew new healthy islet cells. Subsequently, the gene associated with this regeneration was identified as INGAP, which produces the protein that makes islet cells grow.

3. RESUME the video and play to the end.

After Viewing

1. Ask: "There are 2 types of Diabetes, Type 1 and Type 2. What do you know about them, and do both types have to be treated with insulin injections?"
   Type 1 is usually diagnosed in childhood and the patient is unable to produce the insulin needed to convert glucose in the blood into energy; insulin injections are necessary.

   Type 2 is usually diagnosed in adults who are not producing sufficient insulin to convert the glucose in their blood into energy. This type of diabetes can often be treated with controlled diet and exercise. Injections are not usually necessary.

2. What does the acronym INGAP stand for?
   Islet Neo Genesis Associate Protein –it is the gene that stimulates the growth of insulin-producing cells in the pancreas.

3. By 2025, 350 million people are expected to suffer from diabetes and INGAP may perhaps be the solution for these people. Phase 1 of the clinical trials began in December 2001 and has been completed. Phase 2 is now underway. For the current status on clinical trails for this protein, go to www.gmpcompanies.com/htmlsite/products/products/ingap.html. Do a further search of the Internet using a search engine, such as Google or Yahoo, to find additional information on INGAP and its ongoing clinical trials.

Note: Most clinical trials are designated as Phase I, II, or III, based on the type of questions that study is seeking to answer: (These phases are defined by the Food and Drug Administration in the Code of Federal Regulations. See www.clinicaltrials.gov)

- In Phase I clinical trials, researchers test a new drug or treatment in a small group of people (20-80) for the first time to evaluate its safety, determine a safe dosage range, and identify side effects.
- In Phase II clinical trials, the study drug or treatment is given to a larger group of people (100-300) to see if it is effective and to further evaluate its safety.
- In Phase III studies, the study drug or treatment is given to large groups of people (1,000-3,000) to confirm its effectiveness, monitor side effects, compare it to commonly used treatments, and collect information that will allow the drug or treatment to be used safely.

Teacher Notes for the Student Activity: Learning About Diabetes

Although life expectancy has risen steadily over the last century, so have Americans' average weight and the incidence of diabetes. A recent study shows that about 12 million adults have been diagnosed with diabetes and an additional 5 million adults have the condition but do not know it.

Diabetes increases an individual's risk of heart disease, kidney failure, blindness, infection and amputation. Because diabetes can cause such serious complications, it is important for all of us to be on the lookout for signs that we may have diabetes. Some of these signs are:

- Increased thirst
- Increased hunger (especially after eating)
- Dry mouth
- Frequent urination
- Unexplained weight loss (even though a person is eating and feels hungry)
- Fatigue (weak, tired feeling)
- Blurred vision
- Headaches
- Loss of consciousness (rare)

Note: Remind students that these symptoms can also be for many other minor or severe conditions.

In Part I of this activity, students will summarize their knowledge of diabetes from a) the initial discussion before watching the video, b) viewing the video, c) the follow-up questions after viewing the video, and d) using the Internet to research current status of diabetes treatments. This will prepare them to conduct the laboratory activity in Part II.

Part I: Diabetes – Summarizing the Basics

1. Write the following on the board:
    A. Description of diabetes
    B. Types of diabetes
    C. Causes
    D. Complications
    E. Risks and prevention
    F. Treatments
2. Have students fold a piece of notebook paper horizontally into three equal sections. This will give them six areas (using the front and back of the paper) in which to label and write about each of the six diabetes topics listed above (and written on the board).
3. If time is short, assign different topics to different student groups.
4. Have students use the library and/or the Internet to research any topic for which they may need additional information. Ask them to write key information in the labeled sections of their folded paper.

    Note: If you do not have Internet access in your classroom, provide copies of relevant materials and distribute them to your class. See the Additional Resources listed at the end

5. When students have completed their summaries, have them share their information with the class.
6. Answer questions and clear up any misconceptions students have about the disease.

Part II Activity: Why Diabetics Often Have Frequent Thirst and Urination

Before beginning this activity, you should review the physiological process of how sugar gets into the blood stream through the digestion of carbohydrates. See *Teacher Background Information: Digestion of Carbohydrates* that follows.

The following activity will simulate how high amounts of sugar in the bloodstream extract water from body tissues, thus leading to increased thirst and urination.

Note: The concepts of osmosis and diffusion should be reviewed and discussed before starting this lesson.

Materials Needed

High water-content vegetables such as zucchini, yellow squash, cucumber, or beet (about 1 cm thick slices)
Honey, maple syrup, or thick simple sugar syrup
Paper Towels
Balances
Student Handout

Procedure

1. Purchase honey, maple syrup or 'simple sugar syrup' and a high water-content vegetable.
2. Provide each student or group with two pieces of the same high water-content vegetable.
3. Have students blot the vegetable pieces dry with a paper towel.
4. Students will mass both vegetable slices and record their masses on their handout.
5. Students should create an "experimental sample" by drizzling approximately 1 mL (1/4 tsp.) honey (representing sugar) onto one of the vegetable slices.
6. Students should create a "control sample" by not treating one of the vegetable slices.
7. Students should record their visual observations at 5-minute interval for 20 minutes.
8. At the end of the 20 minutes, students should *gently* wipe or blot both vegetable slices dry with paper towels. *Note: Caution them not to squeeze the vegetable slices that would remove water still inside the vegetable.*
9. Students should then mass the vegetables again to determine the quantity of water lost by each.
10. Students should complete the analysis/conclusion questions on the student handout.
11. Students should clean up their lab area and return all materials.

Post Lab Activity Discussion

Have students share their qualitative and quantitative results.

Note: One trial test teacher reported that students could easily relate the loss of vegetable mass to weight loss and thirst symptoms in people with diabetes, but needed coaching to make the connection to frequent urination.

Discuss their responses to the analysis/conclusion questions.

Teacher Background Information: Digestion of Carbohydrates

One of the primary goals of the digestive process is to provide each body cell with sufficient amounts of energy to sustain itself and remain alive. Many of the vital chemical reactions that take place in the cell require energy, which is derived from the oxidation of the glucose, within the cell. Glucose is carried to the cell as the end product of carbohydrate metabolism. There, in the presence of enzymes and oxygen, the *glucose* is converted into *carbon dioxide, water* and *energy*. The carbon dioxide and water are non-essential by-products of this reaction; the important product is the heat energy, which is derived from the glucose.

Glucose + Oxygen + Many enzymes = Carbon dioxide + Water + Heat + Energy

The oxygen used in this chemical reaction is brought from the lungs to the cells by the red blood cells, containing hemoglobin. The hemoglobin and oxygen combine chemically until enzymes in the cell separate them for the oxidation process. Glucose is one of literally hundreds of chemical compounds called *carbohydrates* or *saccharides*. The molecules of all carbohydrates are made up of building blocks called simple sugars. Carbohydrates may be subdivided into three groups:

- *Monosaccharides*, like glucose, consist of a single sugar building block.
- *Disaccharides*, like common table sugar (sucrose) consist of two simple sugar building blocks.
- *Polysaccharides*, like starch and cellulose, consist of many simple sugar building blocks joined together in a long line in daisy-chain fashion.

It appears that the only carbohydrate of any chemical value to the body is the simple sugar or monosaccharide called glucose. Therefore, one of the major goals of the digestive process is to extract the glucose from the various carbohydrates that we ingest every day. Carbohydrate sources are primarily starches (like grains) and sugars (like cane sugar, milk sugar, fruit sugar). The enzyme *ptyalin* or *amylase* in the saliva begins to break down the food in the mouth. Food does not stay in the mouth long enough for ptyalin to complete the breakdown of starches. Yet the action of ptyalin continues for several hours after food has entered the stomach...until the food is mixed with the stomach secretions. Once the pH of the food's environment falls below approximately 4.0, as will occur in the second portion of the stomach, ptyalin becomes inactive. But, before this happens, 30 to 40 percent of the starches will have been changed into *maltose* and *isomaltose*. They are now ready to enter the small intestine as part of the chyme.

After the chyme enters the duodenum and mixes with pancreatic juice, starches that are not yet split will be immediately digested by amylase. Like saliva, pancreatic secretions contain large amounts of amylase, acting identically to the amylase in saliva, splitting the starches into maltose and isomaltose. Carbohydrates that have been split into simple sugar combinations (disaccharides), lactose, sucrose, maltose and isomaltose, are then split even further into just simple sugars (monosaccharides) by enzymes from the cells lining the small intestine. These simple sugars (galactose, glucose, and fructose) are then absorbed into portal blood...that is, on their way to the liver. About 80 percent of the final product of carbohydrate digestion is glucose. Blood sugar is glucose.

Absorption of Carbohydrate

Most carbohydrates are absorbed as simple sugars. Transport through the intestinal membrane is selective; each type of simple sugar has its own maximum rate of transport. Competition for transport can exist between certain sugars, and transport can be blocked by numerous processes. A complex but impressively efficient system.

Source: AskJeves.com, http://www.tuberose.com/Digestion.html

Student Handout: Learning About Diabetes

Although life expectancy has risen steadily over the last century, so have Americans' average weight and the incidence of diabetes. A recent study shows that about 12 million adults have been diagnosed with diabetes and an additional 5 million adults have the condition but do not know it.

Diabetes increases an individual's risk of heart disease, kidney failure, blindness, infection and amputation. Because diabetes can cause such serious complications, and a cure is not yet available, it is important for all of us to be on the lookout for signs that we may have diabetes. Here are some of those signs:

- Increased thirst
- Increased hunger (especially after eating)
- Dry mouth
- Frequent urination
- Unexplained weight loss (even though a person is eating and feels hungry)
- Fatigue (weak, tired feeling)
- Blurred vision
- Headaches

Note: If you have one or more of these symptoms, it does not mean that you have diabetes. Many of these symptoms are related to other conditions, both minor and severe.

In Parts I and II of this activity you will learn why diabetics may have frequent thirst and urination. Before you complete the laboratory activity, it is important that you have a basic knowledge of diabetes, including the types of diabetes, causes, complications, risks and prevention, and treatments. In Part I of this lesson you will summarize what you learned about diabetes. Be prepared to share what you learned and to ask questions about things you do not understand.

Part I: Diabetes – Summarizing the Basics

1. Fold a piece of notebook paper horizontally into three sections. This will give you 6 areas (the front and back of the paper) in which to label and write about each of the diabetes topics given below.

A. Description of diabetes
B. Types of diabetes
C. Causes

2. Label each of the sections as:
   - A. Description of diabetes
   - B. Types of diabetes
   - C. Causes
   - D. Complications
   - E. Risks and prevention
   - F. Treatment

3. Use the library and the Internet to research any of these topics for which you may need additional information. Write key information about each topic in the labeled sections of your folded paper.

4. During the follow-up discussion your teacher will ask you to share your summary with the class.

5. During the discussion be sure to ask questions to clarify any misconceptions you might have about the disease before beginning Part II, which is a laboratory activity. Be sure you understand the process of how sugar gets into the blood stream. Recall also the processes of diffusion and osmosis.

Name_____

Part II: Why Diabetics Often have Frequent Thirst and Urination (A Demonstration of Osmosis).

Introduction

In this lab activity you will observe how high amounts of sugar help to extract water from plant tissues. In some ways this activity simulates how high amounts of sugar in the bloodstream extract water from body tissues, thus leading to increased thirst and urination.

Materials

1 cm thick slices of high water-content vegetables such as zucchini, yellow squash, cucumber, or beet
1 mL (¼ tsp.) of honey or syrup
Paper Towels
Digital or triple beam balance

Procedure

1. What do you think will happen if you coat a slice of a vegetable with honey or sugar syrup? If you have a prediction, record it below.
2. Obtain two slices of the same high water-content vegetable.
3. Gently blot (do not squeeze!) the vegetable slices dry with a paper towel.
4. Mass each vegetable slice and record their masses below.
5. Create an "experimental sample" by drizzling approximately 1 mL (¼ tsp.) of honey or syrup onto one of the vegetable slices.
6. Create a "control sample" by not treating one of the vegetable slices.
7. Record your visual observations at 5-minute intervals for 20 minutes.
8. At the end of the 20 minutes, use a paper towel to gently remove the honey or syrup and any visible surface water. *Do not squeeze* the vegetable slices because that would remove water still inside the vegetable.
9. Mass the vegetable slices again to determine the quantity of water lost by each.
10. Answer the analysis/conclusion questions below.
11. Clean your lab area and return all materials.

Prediction _____

_____

Qualitative Data (Observations)

0 Minutes

_____

5 Minutes

_____

10 Minutes

_____

15 Minutes

_____

20 Minutes

_____

Quantitative Data

Vegetable	Initial Mass	Final Mass (after 20 minutes)	Difference in Mass (final – initial)
Control			
Experimental			

Analysis/Conclusion

1. How did the syrup or honey affect the vegetable?

2. How do you know if it was the syrup or honey that caused the water loss?

3. What did the honey represent in this experiment?

4. How might excess sugar in a diabetic's bloodstream affect the water content of some of that person's tissues?

5. What do you think excess sugar in the blood stream might do to a diabetic?

6. Using what you learned in the library, from the Internet, and in this lab activity, explain why diabetics often have frequent thirst and urination.

Additional Resources

Because Web sites frequently change, some of these resources may no longer be available. Use a search engine and related key words to locate new Web sites.

The Physiology of Blood Sugar
http://www.simplystated.com/info/answers/diabetes_main.jsp?checked=y

http://www.bodybuilding.com/fun/matt55.htm

Diabetes Basic Information Sites:
Detailed information and support from WebMD.
http://my.webmd.com/condition_center/dia

Children with Diabetes
http://www.childrenwithdiabetes.com/d_0n_000.htm

Youth Zone - American Diabetes Association
http://www.diabetes.org/wizdom/basics/index.shtml

What is Diabetes?
http://www.lifeclinic.com/focus/diabetes/about_it.asp

Diabetes Diagnosis and Symptoms Information by lifeclinic.com
http://www.lifeclinic.com/focus/diabetes/diagnosis.asp

Diabetes Basics
http://my.webmd.com/content/article/56/65911?z=4203_00101_2600_in_26

Diabetes Basics from WebMD
http://my.webmd.com/content/Article/46/1667_50911.htm

Diabetes Basics
http://healthlink.mcw.edu/article/967584797.html

Free Diabetes Booklet
http://www.daref.org/booklet.html

Diabetes Basics
http://www.orthop.washington.edu/arthritis/types/diabetes

Genomic Revolution
http://www.ornl.gov/sci/techresources/Human_Genome/education/education.shtmL
This Web site of the government-funded Human Genome Project has links about genomics, the history of the project, and more.

Secrets of the Sequence Videos and Lessons
This video and 49 others with their accompanying lessons are available *at no charge* from www.vcu.edu/lifesci/sosq