For Personalized Use Only — Individualized Drugs

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 130, Episode 2
"For Personal Use Only – Individualized Drugs" – approximately 9 minutes viewing time

The research in genetics promises a revolution in pharmaceuticals. Right now there are high hopes, some exciting possibilities but few real therapies. In this segment we will survey the ways in which genetic information might be able to prevent and treat disease...from vaccines to sprays to gene therapy. The ultimate dream is the ability to create specific, individualized drugs that are effective and have no side effect.

Ward Television
Producer: Naomi Spinrad,
Associate Producer: Mara Mlyn
Featuring: William Haseltine, CEO, Human Genome Sciences, Stephen Johnston, Center for Biomedical Inventions, University of Texas-Dallas, Ralph Stevenson, Diabetes and Obesity Research, Pfizer
Lesson Author; Reviewers: Catherine Dahl; Dick Rezba, Kieron Torres
Trial Testing Teachers: Brooke Williams

National and State Science Standards of Learning

National Science Education Standards Connection

Content Standard A: Life Science
As a result of their activities in grades 9 - 12, all students should develop:
Understandings about scientific inquiry;
Abilities necessary to do scientific inquiry
Content Standard F: Science in Personal and Social Perspectives
As a result of their activities in grades 9 - 12, all students should develop an understanding of:

- Personal and Community Health
- Natural and human-induced hazards;
- 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;
- c) variables are defined and investigations are designed to test hypotheses
- e) conclusions are formed based on recorded quantitative and qualitative data

BIO.5 The student will investigate and understand life functions of archaebacteria, monerans (eubacteria), protists, fungi, plants, and animals including humans. Key concepts include
- e) human health issues, human anatomy, body systems, and life functions
- f) how viruses compare with organisms

BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include
- h) use, limitations, and misuse of genetic information

Illinois

11.A.5.c. Conduct systematic controlled experiments to test the selected hypotheses.

12.A.5.a. Explain changes within cells and organisms in response to stimuli and changing environmental conditions (e.g., homeostasis, dormancy)

13.A.4.c. Describe how scientific knowledge, explanations and technological designs may change with new information over time (e.g. the understanding of DNA)

Overview

In this video, students will learn about the effects genetic research has had on the pharmaceutical industry. By studying how the body naturally defends itself against diseases and how it repairs itself, researchers are attempting to mimic these efforts using the very substances that the body produces. The ultimate goal is to create individualized drugs based on a person's own DNA and to customize vaccines as needed.

Stage 1 of this work is identifying those natural substances that act as a defense against a specific disease – this has already been successfully done using Refifermin (as illustrated in the video) that heals skin infections. Stage 2 is to conduct clinical trials in order to gain FDA approval. However, the process by which Stage 1 is accomplished is a lengthy one and the video offers students a good example of "scientific methodology" in identifying the specific gene in a pathogen (out of 4000 or more genes) that has the potential to provide immunity resulting in the development of a vaccine. Unfortunately, the dosage amounts needed to be effective in research mice are substantially smaller than those that are needed to be effective in humans so the safety issues are enormous when moving from research to clinical trials.

Pharmacogenomics also holds promise for preventing or curing diabetes. This research continues because of today's major health concerns. For example, obesity has become so prevalent in the US and the world that estimates of up to 300 million new diabetics cases will be diagnosed in the coming years. The enormous public costs associated with its treatment and care clearly justifies the costs of attempting to develop a treatment.

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

Ellen notices that she often sneezes when she visits her friend Robert, who has a cat and a parrot. Ellen wonders if she may have allergies to Robert's pets and decides to conduct a scientific investigation. What should Ellen do next?

a. Ellen should tell Robert that she cannot visit him until he gives away his pets.
b. Ellen should visit Sue who has a horse, a dog, a goldfish, and a hamster.
c. Ellen should call her doctor and insist that she needs shots for allergies
d. Ellen should visit a friend who has only cats and one who has only parrots. *

Source: Virginia Spring 2003 Released Test: Grade 8 Science

Video Preparation

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

Before Viewing

1. Provide the meaning of Pharmacogenomics to students because it will be used in the video,
   Pharmacogenomics is the study of how an individual's genetic inheritance affects the body's response to drugs. Creating individualized drugs is the ultimate goal.

2. Ask: "What is a vaccine?"
   It is a very small dose of a pathogen that is injected into the body in order to create future immunity toward that specific pathogens.

3. Ask: "What is the difference between vaccines and antibiotics?
   Vaccines create a future immunity toward a specific pathogen, while an antibiotic treats an occurring bacterial infection only.

4. Ask: "What kinds of diseases have you been vaccinated against and what is the cause of those diseases."
   Measles–virus,
   Mumps–virus,
   Chicken Pox–virus,
   Diphtheria/bordello–bacteria,
   Polio-virus,
   Typhoid – bacteria.

5. Ask: "Which is a simpler organism - a virus or a bacteria- and what does that mean for the research involved in developing a vaccine.
   A *virus is a simpler organism and has fewer genes so there would be fewer genes to test in determining the specific gene that produces immunity.*

During Viewing

1. START the video.
2. PAUSE the video (3:30 minutes into the video) after the "computer voice" says, "It's even easier with a virus since they have fewer genes."

   Review the steps involved in developing a gene vaccine:

   • Select a pathogen that has been sequenced. (A virus has fewer genes than a bacterium and therefore will be easier to analyze.)
   • Break down the genes of the chosen pathogen) into groups of 40 (the video illustrates a pathogen with 4000-5000 genes.
   • Inject these genes into mice and see which mice survive. (The assumption is that if the mouse survives, one of those 40 genes has provided a sufficient level of immunity to fend off the pathogen.)
   • Break down those 40 genes individually and inject into 40 more mice. (The mouse that survives received the gene that becomes the gene "vaccine".)
   • Determine how these results fare with primates. (Note: a major concern is that there are still safety issues to be addressed. In order to provide protection to humans and other primates, approximately 1000 times the amount of gene vaccine given to a mouse needs to be administered to humans.)

3. RESUME the video and play to the end.

After Viewing

1. Ask and discuss the following question: "What are the present limitations of genetically engineering a vaccine?"

2. Pharmacogenomics' role in preventing or curing diabetes is also mentioned in the video. While the exact treatment is not yet known, it is likely to be a treatment that changes how cells function without changing an individual's genetic background.

   Ask:"Why is gene research on diabetes so important for Americans as well as for the world population?"
   Recent information indicates that half of all Americans are considered to be overweight and more than 300 million people worldwide are in danger of developing diabetes.

Teacher Notes for the Student Survey and Activities 1 and 2

Part I: Conduct a student survey about allergies
Part II: Choose one of the two following activities, or have students do both
1. Cold tolerance
2. Sandpaper and your sense of touch

Both activities are designed to develop the concept of "specificity of reaction" and help students recognize "sensitivity".

Background

The sequencing of the human genome has shown that 99.9% of human genes are identical. One

would therefore assume that in any treatment, dosages and specific drugs would react the same way. However, it is that 0.1% of our genetic makeup that reflects significant differences and is associated with traits that call for some modifications and adjustments on medications. Researchers have shown that some individuals as well as entire ethnic and racial groups are more sensitive to certain drugs and it is these differences in response that are leading scientists to develop personalized medicine. There are numerous ways in which humans react differently but whether we study these overt responses or look at the internal chemical makeup of how enzymes work in our bodies, the concept is the same – the "specificity of reaction".

Part I: Conducting an Allergy Survey

1. On the board or an overhead transparency, construct an allergy survey chart with 4 columns. (*See sample below*)
2. Have students form groups of 3 - 4 to brainstorm kinds of allergies with which they are familiar. *(See column 1 for a sample list)*
3. Have a member of each group add their list of allergies to column 1 on the board or overhead transparency omitting any that have already been listed by other groups.
4. Survey the students to find out which students 1) have an allergy, and 2) know someone outside of the class with one of these allergies. A*dd responses to columns 2 and 3 of the chart.*
5. Ask students, "How do people know if they have an allergy?" *Add responses to column 4 of the chart.*
6. Ask students, "Is it is possible for a person to be allergic to something and not know it? *Some students, for example, may never have eaten shellfish nor had penicillin, yet be allergic to them.*

SAMPLE ALLERGY SURVEY CHART

Column 1 Allergy	Column 2 Number of students with that allergy	Column 3 Number of people known by students to have that allergy	Column 4 Symptoms of the allergy
1. Dairy products			
2. Mold, dust, pollens			
3. Cat or dog hair			
4. Shellfish			
5. Aspirin			
6. Penicillin			
7. Peanuts			
8. Sun			
9. Insect Bites			
10. Bee Stings			
11. Preservatives			
12. Laundry detergents			
13. Cleaning products			
14. Soaps			
15. Moth balls			
16. Chocolate			
17. Strawberries			
18. Band-Aids			

Part II Specificity of Reaction Activities

Purpose: In these two activities students will explore differences in their levels of sensitivity. Exploring differences in their sensitivities to cold and roughness will help them better understand that they may react differently to medicines and dosages.

Activity 1: Cold Tolerance

Materials

- Ice Cubes
- Stop watch or clock with a second hand

1. Divide students into groups of two. Have one student place an ice cube on the palm of his or her hand while the other student times how long it takes in seconds for the first student to report his or her discomfort.
2. On an overhead transparency or on the board, construct a table for students to record their data:

Student	Seconds until "discomfort time"
1	
2	

3. Have students record their times in the table.
4. Have students calculate one or more measures of central tendency – mean, median, or mode.
5. Ask: "What is the range of discomfort times?" If students are familiar with Box and Whisker Plots, have them construct one for the data to show the dispersion/spread of the data.
6. Discuss their responses to the handout question, "What are some reasons that might explain why there are variations in discomfort times?"

Activity 2: Sandpaper and Your Sense of Touch

Materials

- 2 sheets each of 5 grades of sandpaper
- Plastic sandwich bags
- Stop watch or clock with a second hand
- Blindfolds

In this activity students will use their sense of touch to order five different grades of sandpaper while blindfolded and to time how long it took them to order the pieces.

1. Cut each grade of sandpaper into 8 equal size pieces. Two sheets of each grade of sandpaper will provide enough pieces for 16 pairs of students. Be sure to write the grade of sandpaper on the back of each piece; the grade is normally printed on the back of the sheets. Place one piece of each grade of sandpaper into a plastic sandwich bag.
2. Divide the students into pairs.
3. Give a bag of pieces of different grades of sandpaper to each pair of students. While blindfolded, have one student order the pieces from smoothest to roughest, while the other student times how long in seconds it takes the first student to put the pieces in order. Reverse roles so each student orders the pieces of sandpaper
4. On an overhead transparency or on the board, construct a table for students to record their data:

Student	Correct Order (Yes or No)	Time to order the pieces (sec)
1		
2		
…		

5. Have students record their data in the table.
6. Have students calculate one or more measures of central tendency for the times needed to order the pieces– mean, median, or mode.
7. Ask: "What percent of the class were able to put the sandpaper pieces in the correct order?"
8. Discuss students' responses to the handout question, "Why do you think some people are more sensitive to touch than others?

Adapted from Neuroscience Ideas at http://faculty.washington.edu/chudler/chtouch.html

Student Handout

Part I Conducting an Allergy Survey

1. In groups of 3 or 4 brainstorm a list of allergies that people have.
2. Be prepared to answer the following questions:
    - Do you have one of these allergies?
    - Do you know anyone outside of class with one of these allergies?
    - How do people know if they have an allergy?
    - What are the symptoms for a particular allergy?
    - Is it possible for someone to be allergic to something and not know it?
3. As a class, complete the following table that your teacher will have on the board or on an overhead transparency.

Column 1	Column 2	Column 3	Column 4
Allergy	Number of Students with that allergy	Number of people known by students to have that allergy	Symptoms of the allergy

4. Have a member of your group add your list of allergies to the table on the board omitting any that have already been listed by other groups.

Part II Specificity of Reaction Activities

Purpose: In these two activities you will explore differences in your levels of sensitivity. As you explore differences in your sensitivities to cold and roughness, you may better understand how people react differently to medicines and the size of the dosage.

Activity 1: Cold Tolerance

Materials:

- Ice Cubes
- Stop watch or clock with a second hand

1. In groups of two, place an ice cube on the palm of your partner's hand while you time how long it takes in seconds for your partner to report his or her discomfort. Then reverse your roles.

2. Record your data in the table your teacher will have on the board or on a transparency.

Student	Seconds until "discomfort time"
1	
2	

3. As a class, calculate one or more measures of central tendency for the data – mean, median, or mode.

4. What is the range of discomfort times? If you are familiar with Box and Whisker Plots, construct one for the data to show the dispersion/spread of the data.

5. What are some reasons that might explain why there are variations in discomfort times?

Activity 2: Sandpaper and Your Sense of Touch

Materials

- 5 grades of sandpaper in a plastic sandwich bag
- Stop watch or clock with a second hand
- Blindfold

In this activity you will use your sense of touch to order five different grades of sandpaper (blindfolded) while timing how long it took to order the pieces.

1. While blindfolded, one student will order the pieces of sandpaper from smoothest to roughest, while the other student times how long in seconds it takes him or her to put the pieces in order. When one student finishes, reverse roles. The roughness grade of the sandpaper is written on the back of the pieces – the lower the number, the rougher the grade.
2. Record your data below and in the class data table.

Student	Correct Order (Yes or No)	Time to order the pieces (sec)
1		
2		

3. As directed by your teacher, calculate one or more measures of central tendency for the times needed by the class to order the pieces– mean, median, or mode.

4. What percent of the class was able to put the sandpaper pieces in the correct order?

5. Why do you think some people are more sensitive to touch than others?

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.

Information on Pharmacogenomics

Pharmacogenomics: Medicine and the New Genetics
www.ornl.gov/sci/techresources/Human_Genome/medicine/pharma.shtml
http://www.ncbi.nlm.nih.gov/About/primer/pharm.html

Information on Repifermin

Genomics-Based KGF-2 (Repifermin) and Its Receptors Function ...
Human Genome Sciences: Repifermin (KGF-2)

Calculating the Cost

FORTUNE - Intro - Can Personalized Drugs Pay Off?
ARTICLE: Meeting discusses gene therapy, personalized drugs

Genomic Revolution

http://www.ornl.gov/sci/techresources/Human_Genome/education/education.shtml

The Web site to the government-funded Human Genome Project with 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