

Testing Zygoty: Are They Identical or Not?

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

Teaching materials developed by VCU Life Sciences.

V i r g i n i a C o m m o n w e a l t h U n i v e r s i t y

Classroom Tested Lesson

Video Description

“Secrets of the Sequence,” Show 110, Episode 2

“Testing Zygoty: Are they identical or not?” – Approximately 9 minutes viewing time

Joe and Jason are so-called identical or monozygotic twins – or so they thought. But the two brothers seem to have major differences. One is right-handed, the other is a lefty. We'll give them the DNA testing that will determine once and for all whether they're fraternal or identical.

Ward Television

Producer: Kip Prestholdt

Featuring: Dr. Geoff Machin, Kaiser Permanente Oakland Medical Center; Dan Demeres, Fairfax Identity Laboratories

Teacher Author; Reviewers: Peggy Deichstetter; Catherine Dahl, Dick Rezba

Trial Testing Teachers: Josie Stratton

National and State Science Standards of Learning

National Science Education Standards Connection

Content Standard A: Science as Inquiry

As a result of activities in grades 9-12, all students should develop:

- abilities necessary to do scientific inquiry and
- understandings about scientific inquiry

Content Standard C: Life Science

As a result of their activities in grades 9-12, all students should develop an understanding of:

- the cell,
- molecular basis of heredity,
- biological evolution,
- interdependence of organisms, and
- behavior of organisms.

Content Standard E Science and Technology

As a result of activities in grades 9-12, all students should develop:

- understandings about science and technology

Content Standard F Science in Personal and Social Perspectives

As a result of activities in grades 9-12, all students should develop an understanding of

- personal and community health,

- population growth, and
- natural and human-induced hazards.

Selected State Science Standards Connection

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

Illinois

Standard 11: Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

Standard 12: Understand the fundamental concepts, principles, and interconnections of the life, physical and earth/space sciences.

Standard 13: Understand the relationship among science, technology, and society in historical and contemporary contexts.

Virginia

BIO.1 The student will plan and conduct investigations in which:

- a) observations of living things are recorded in the lab and in the field;
- b) hypotheses are formulated based on observations;
- d) graphing and arithmetic calculations are used as tools in data analysis;
- e) conclusions are formed based on recorded quantitative and qualitative data;
- g) validity of data is determined; and
- j) research is used based on popular and scientific literature.

BIO.3 The student will investigate and understand biochemical principles essential for life. Key concepts include

- b) the structure and function of macromolecules.

BIO.5 The student will investigate and understand life functions of monerans, protists, fungi, plants, and animals, including humans. Key concepts include:

- a) how their structures are alike and different;
- b) comparison of their metabolic activities;
- c) analyses of their responses to the environment; and
- e) human health issues, human anatomy, body systems, and life functions.

BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include:

- b) sex cell formation;
- e) effects of genetic recombination and mutation;
- f) events involved in the construction of proteins; and
- g) exploration of the impact of DNA technologies.

BIO.7 The student will investigate and understand bases for modern classification systems. Key concepts include:

- a) comparison of DNA sequences in organisms.

Overview

Joe and Jason seem like identical twins. But are they? They chose the same occupation - banking, and they often know what the other is thinking. But they are opposite in some other ways; Jason is right handed and Joe is left handed. They are called Mirror Twins. There are some other

differences; Jason is one inch taller and weighs 20 lbs. more, and Joe has had Crohn's disease for ten years. Crohn's Disease appears to have a genetic link. In this video Joe and Jason decide to take a DNA test to see if they are identical (monozygotic) twins. The goals of this lesson are:

1. To learn about Crohn's Disease
2. To introduce an autoimmune disease and the role the environment plays in its development
3. To examine the role of genetics in an autoimmune disease.

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

The Human Genome Project was begun in 1988 by scientists from 13 nations as a worldwide effort to understand the sequencing of all of the DNA in the human body. What is one potential scientific benefit of this research?

1. It will help to explain human cultural differences.
2. It will create communication between research centers
3. It will help find the genes responsible for many diseases*
4. It helps to classify man most accurately in the animal kingdom.

Source: Virginia Standards of Learning Assessments Spring 2003, End of Course Biology, Question 42

Video Preparation

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

Before Viewing

1. Have students view the Power Point presentation of Crohn's disease at <http://www.nlm.nih.gov/medlineplus/crohnsdisease.html>. Click on Crohn's disease to learn about the disease.
Alternatively, use pictures, transparencies or a torso model to talk about the disease and give brief notes.
2. Write the following questions on the board and ask students to think about them and listen carefully to the video as they will be asked to give their responses later in the lesson (see point 3 under During Viewing)
 - If identical twins are identical, how can one twin, Jason, be one inch taller and 20 lbs. heavier?

This is an opportunity for students to form a hypothesis. Good responses include Joe having had better nutrition because he doesn't suffer from Crohn's disease. Good nutrition leads to reaching optimum height and weight. Another hypothesis is that they are NOT identical, hence the differences. The important thing is that students can use data to develop a viable hypothesis.

- Are all monozygotic twins identical?

No, you can have monozygotic twins who are very different due to level of nutrition and other factors received in the womb. This concept was illustrated in the movie,

"Twins" with Arnold Schwarzenegger and Danny DeVito. Surprisingly, it is also possible to have identical twins that are different sexes.

During Viewing

1. **START** the video.
2. **PAUSE** the video (3:55 minutes into the video) when the narrator says, "It was ten years ago when Jason was diagnosed with Crohn's disease...Joe hasn't shown any signs of Crohn's yet..."
Ask, "Do you think Joe and Jason are monozygotic or dizygotic? Why?"
This is an opportunity for a pre-assessment of whether students understand the differences between monozygotic and dizygotic twins. At this point, their responses are largely guesses by students.
3. Refer students to the questions on the board.
4. **RESUME** the video and play to the end.

After Viewing

1. Why do you need 13 positions or sites to determine the zygosity of Joe and Jason?
This number of sites provides sufficient statistical data to determine similarity with a high degree of confidence.
2. How can one identical twin have a genetically-based disease and the other twin not have it?
You must have the gene and you must also get a triggering infection (the effect of environment on genetics).
3. What is an autoimmune disease?
The immune system attacks the body as if it were a foreign invader. In the case of Crohn's disease it is suggested that the NOD2 protein, which fights off some bacterial diseases, is not working properly. The individuals with the mutated gene (Joe and Jason) may be unable to fight an infection. The immune system then overreacts and attacks the intestines.
If time allows, for more information on auto-immune diseases, have students do a Web search.
4. Why does only Jason have Crohn's disease?
Jason became infected with bacteria that he couldn't fight because of his mutated gene. Joe may never have come into contact with bacteria that trigger the disease.
5. Conduct Student Activity: What Are the Chances?
Using paper, pencil, and a die or number cube, students learn the effects of genes and the environment on phenotype.

Teacher Notes for the Student Activity: What are the Chances? - Genes and Environmental Factors

Materials

- 1 copy of the Student Handout, What are the Chances? - Genes and Environmental Factors, for each student
 - 1 die or number cube for each pair of students
- Note: In some school districts, the use of dice is discouraged or not permitted. If that is the case, borrow number cubes from mathematics teachers.

Procedure

1. Distribute copies of the student handout
2. Divide the class into pairs and tell each pair they are siblings.
3. Students will first roll one die to determine their exact relationship.
4. Students will then roll the die to determine their genotypes and phenotypes.
If lab partners are identical twins, they only roll one die to determine their genotype because they have the identical genotype for both of them. If they are siblings or fraternal twins, each rolls and records his or her results separately.
5. To have a Crohn's disease phenotype students must have at least one gene for Crohn's and have been infected with a bacteria. Exposure to a bacterial infection without the Crohn's gene will not result in getting Crohn's disease.

Student Handout: What Are the Chances? - Genes and Environmental Factors

Materials for each pair of students:

- 1 die or number cube.

Procedure:

1. Work in pairs. You and your lab partner are siblings. Each of you should roll one die to determine your relationship to your partner. Record your results in the Summary Chart below.
 - If you both roll an even number = Identical twins
 - If you both roll an odd number = Fraternal twins
 - If one is even & the other is odd = Just siblings (brothers or sisters)

2. What is your genotype?
 If you and your lab partner are identical twins, you only roll one die this time to determine your genotype and record the same result in the Summary Chart below. Why?
 If you are fraternal twins or siblings, each of you rolls and records your results in the Summary Chart below.
 - 1-2 on the die = One mutated gene for NOD2 protein
 - 3 = Two mutated genes for NOD2 protein
 - 4-5-6 = Normal genes for NOD2 protein

3. The environment sometimes affects a phenotype type. Each of you must roll the die to see if you were exposed to a viral or bacterial infection of the gastrointestinal tract.
 - Even number = Infected
 - Odd number = Not infected

4. Evidence suggests that in Crohn's the disease phenotype appears only if an infection, such as a mycobacterium, attacks the digestive tract. One of the genes related to Crohn's disease makes a defective protein so an infection can't be overcome. The immune system then overreacts to the infection, attacking not only the bacteria but also the lining of the digestive tract. This type of disease is called an autoimmune disease because the immune system attacks the body. Do you or your partner have Crohn's Disease based on the results recorded below?

Summary Chart: Crohn's Disease

	Relationship Disease	Genotype	Infection	Crohn's
	Identical Yes	One mutated gene	Infected	
	Fraternal No	Two mutated genes	Not infected	
	Just siblings	Normal genes		
Partner 1				
Partner 2				

Analyzing the Data

Answer the following questions by yourself based on the data you and your partner recorded in Part 1.

1. Are you a twin? _____
2. If so, identical or fraternal? _____
3. What is your genotype? _____
4. What is your phenotype? _____
5. Do you have Crohn's disease? _____.

a. If you have Crohn's disease, write a few sentences about the factors that contributed to you having the disease. If you have the disease and your partner (twin/sibling) does not, explain how this can happen.

b. If you do not have Crohn's disease, write a few sentences about the factors that contributed to you not having the disease. If you *do not* have the disease and your partner (twin/sibling) does, explain how this can happen.

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.

Hope for Crohn's Disease ABC News

Researchers say they have identified the first genetic abnormality associated with Crohn's disease, a finding that could help doctors better understand the devastating gastrointestinal disorder and lead to new drugs to treat it.

<http://abcnews.go.com/sections/living/DailyNews/crohnsgene010521.html#1>

Genetic Diseases/ Crohn's Disease

Information about genetic diseases such as Crohn's. <http://www.mazornet.com/genetics/chronsdisease.asp>

The Human Genome Project

The Human Genome Project (HGP) was one of the great feats of exploration in history, an inward voyage of discovery rather than an outward exploration of the planet or the cosmos. An international research effort to sequence and map all of the genes -- together known as the genome -- of members of our species, *Homo sapiens*, the HGP was completed in April 2003. Now we can, for the first time, read nature's complete genetic blueprint for building a human being.

<http://www.genome.gov/10001772>

Center for Genome Research

Crohn's disease is a so-called "complex" disorder, with a tendency to cluster in families, suggesting that several genes play an important role, but that environment is also a key component. Scientists had previously identified a gene on chromosome 16 as a culprit, but this gene could only account for a fraction of the IBD cases. http://www.broad.mit.edu/media/archive/pr_01_crohns.html

National Center for Biotechnology Information

Two papers report a clear-cut identification by linkage mapping of a gene involved in a common human disorder — Crohn's disease (CD). Importantly, they also indicate how the innate immune system might be involved in the etiology of CD, because the identified gene — *NOD2* — encodes an intracellular receptor for bacterial lipopolysaccharides (LPS) that activates NF- κ B, a target of the innate immune signaling pathway and a transcriptional regulator of inflammatory genes.

http://www.ncbi.nlm.nih.gov/Coffeebreak/CB21_Crohns/page.html

Online Mendelian Inheritance in Man

This is a database, a catalog of human genes and genetic disorders authored and edited by Dr. Victor A. McKusick and his colleagues at Johns Hopkins and elsewhere, and developed for the Web by NCBI, the National Center for Biotechnology Information. The database contains textual information and references. It also contains copious links to MEDLINE and sequence records in the Entrez system, and links to additional related resources at NCBI and elsewhere. This site is for Inflammatory Bowel Disease/Crohn's Disease.

<http://www.ncbi.nlm.nih.gov/entrez/dispomim.cgi?id=266600>

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/sosg