Justice DNA – Freeing the Innocent

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 115, Episode 1
"Justice DNA" – approximately 12 minutes viewing time

Forensics is the application of science to legal problems. In 1984, British geneticist Alec Jefferies developed DNA profiling, and it has been shaking up the process of solving crimes ever since.

Ward Television
Producer: Julie James
Featuring: Kirk Bloodsworth, former death row inmate, Dr. Paul Ferrara, Chemistry and Forensics Science, Virginia Commonwealth University, and Director, Virginia Division of Forensic Science, and George Li, Virginia Division of Forensic Science
Lesson Author; Reviewers: Stephanie Estes; Marilyn Elder, Cathie Alder, Revabeth Russell, Catherine Dahl, Dick Rezba and Kieron Torres
Trial Testing Teachers: Leigh Dougherty, Beth Richert

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 an understanding of:

- the molecular base of heredity.

Content Standard E: Science & Technology
As a result of their activities in grades 9-12, all students should develop:

- abilities of technological design and
- understandings about science and technology.

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
Goal 13 - Understand the relationships among science, technology and society in historical and contemporary contexts. They will examine, research, analyze, compare, contrast and evaluate the products, policies, and processes of science in current and future contexts. Students will investigate, hypothesize, infer, predict, critique and create informed opinions about local, regional, national and global connections to the world of science.

Oregon
Life Science CIM (Certificate of Initial Mastery, 10th grade)
Heredity:
Explain laws of heredity and their relationship to the structure and function of CAN.
Science & Technology:
Understand the process of technological design to solve problems and meet needs.

Overview

This lesson is designed to teach students the origins of DNA profiling and its current and projected uses in solving crimes. The video's core example concerns the case of Kirk Bloodsworth. Kirk was exonerated of his accused crime because his DNA did not match the DNA from the crime scene. In 1995 O.J. Simpson was exonerated due to 'contamination' of DNA samples.
Other concepts germane to class discussion are:

- DNA profile – list of unique characteristics of an individual.
- Biological remnants – sweat, blood, semen, hair, etc.
- PCR – Polymerase Chain Reaction – Test that allows small amounts of biological remnants to be analyzed by copying DNA repeatedly. http://www.dnalc.org/shockwave/pcranwhole.htmL offers an interactive animation that explains PCR in more detail.
- Contaminants – 'Other' DNA samples, pollutants. Doesn't change the original DNA.
- Distinction between DNA samples – 13 places on DNA (markers) used for differentiation of samples. STR's – Short Tandem Repeats.
- CODIS – Convicted criminal DNA database.

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

DNA is a polymer consisting of repeating units known as

a. Dipeptides
b. amino acids
c. nucleotides *
d. organic salts

Source: New York State Education Department, Regents Examination, Biology, 1998

Video Preparation

Preview the video and make note of the locations you will need later to pause the video for discussion.

Before Viewing

Use *Inspiration* software to create a concept map, or create one on the board called "Who's Been Here?" to summarize what the class knows about types of crime scene evidence.
Note: A free trial download of Inspiration software can be obtained at http://www.inspiration.com/

1. Ask: "What are some examples of things people might leave behind that could be used as evidence to show that they were in a certain place at a certain time?"
   hairs, fibers from clothing, tissues, napkins, gum, candy wrappers, soda containers, straws, paper, fingerprints, ATM receipts, and store receipts.

Note: A trial test teacher suggested using a scenario or a drawing of a crime scene and asking the students what they would collect from it as evidence.

2. Ask: "Does anyone know of any scientific means by which hair (especially the root) could be used to identify people?"
   Physical characteristics such as color, texture, and length; also results from DNA analysis.
   Note: See *Popular Science*, December 2003, p. 16, "DNA and a New Kind of Racial Profiling" by Jessica S. Sachs.
   Ask: "Is color of hair always accurate?"

3. Ask: "How do you think a straw could be used to identify the person who used it?"
   physical characteristics such as lipstick or tooth marks; also DNA analysis of saliva or lip cells.

4. Ask: "How can we use hats to identify a person?"
   sweat from the sweat band, strands of hair

5. Inform students that since 1984 forensic scientists have been using DNA left on evidence at crime scenes to convict guilty suspects and to free prisoners who have been wrongly convicted of a crime.
   Ask: "Explain how you think DNA could free a person who did not commit a crime."

During Viewing

1. START the video. The case of Kirk Bloodsworth is discussed. Kirk was an inmate on Maryland's Death Row despite his innocence in the case of the rape and murder of a young girl.

2. PAUSE 3.50 minutes into the video, after Kirk says, "I can't even begin to articulate the anguish one endures during that process."

   Ask: "How is it possible for someone who is innocent to be convicted of a crime and sentenced to death?"
   Remind them that our criminal justice system relies on evidence available at the time of the trial and that juries consist of citizens who make the best judgments they can, based on the evidence shown to them. As technology advances, more precise methods of interpreting evidence are being developed. Therefore, all evidence gathered at the scene of the crime is important and should be protected from contamination. Additionally, items once overlooked as evidence, such as a cigarette or straw, may later be important in a case.

3. RESUME the video.

4. PAUSE 4.43 minutes into the video after the computer narrator says, "This is called a DNA profile."
   Ask the following questions:
   - Explain in your own words how a DNA profile is like a fingerprint.
   - Do you think a DNA profile would be a better or worse identifier than a fingerprint?
     DNA would typically be better.
   - Why do you think so?"
     fingerprints can be partial; fingerprints degrade faster over time, etc
   - Would fingerprints ever be <u>better</u> than DNA?"
     fingerprints are easier, faster, and cheaper to test.

5. RESUME video and play to the end.
   Ask: "Can you think of disadvantages to the development of a database such as CODIS, where genetic profiles are used to identify unknown perpetrators based on their DNA?
   Right to privacy; victims' and alleged perpetrator's rights.

After Viewing

1. Look at the concept map again. What changes would you make to it? What additions? Circle the areas that you still are unsure about.
2. Tell your students that extracting DNA from anything living does not need to be conducted in special laboratories. We will be extracting DNA in our own classroom today!
3. Conduct the Student Activity: How to Extract DNA from Anything Living.

Teacher Notes for the Student Activity: How to Extract DNA from Anything Living

Note:
A trial test teacher suggests reminding students that despite the title of this activity, not only "alive" things have DNA. Dried blood cells or hair (dead tissue) also contain DNA.

Materials

- Copies of the student handout, *How to Extract DNA from Anything Living*
- Blender
- Dried green split peas
- Table salt
- Cold water
- Strainer
- Graduated cylinder
- Test tube
- Dawn or other liquid dishwashing detergent
- Powdered meat tenderizer
- 70-95% ice cold isopropyl alcohol
- Wooden skewer or toothpicks
- Computers with Internet access

Preparation

1) Prepare split pea homogenate prior to students' arrival to class:
2) Measure 250 mL (1 cup) of dry split peas into a blender.
3) Add one or two pinches (about ¼ teaspoon) table salt.
4) Add 500 mL (2 cups) water. (Note: Some sources say the DNA will clump together better if cold water is used; others use warm water for adequate separation of DNA from proteins, fats, and carbohydrates.)
5) Blend on high for 15 seconds.
6) Pour the blended peas through a large strainer into a large beaker.
7) Pour homogenate into individual test tubes of ~20mL each.
8) This procedure should make enough homogenate for 16 student samples of 20-30 mL each.

Procedure

1. Distribute copies of the Student Handout: *How to Extract DNA from Anything Living*.
2. Tell students to begin the activity by completing Part I: Tour of the Basics.
   Students type the following URL into the address bar on their computer's browser:
   http://gslc.genetics.utah.edu/units/basics/tour
3. Read through the Flash videos, "What is DNA?" and "What is a Chromosome?" as a class.
4. Students start the wet lab Part II: *How to Extract DNA from Anything Living* by following the procedure in the handout or by typing the following URL into the address bar on their computer's browser:
   http://gslc.genetics.utah.edu/units/activities/extraction/
5. Tell students to complete the steps required to extract DNA from peas (some teachers prefer onions, bananas, broccoli, apples, or strawberries.)
6. Tell students to prepare discussion questions on the student handout.

Note: It helps students to understand what each step is for. The blending and filtering removes the cell walls and most organelles, such as chloroplasts. The dishwashing detergent takes the grease out of the way. The meat tenderizer predigests the meat by breaking apart the proteins.

Extensions

- For advanced students visit the following URL site:
  http://library.thinkquest.org/19037/dna_extraction.htmL?tqskip1=1&tqtime=1119
- Use other homogenates to see which provides the best DNA extraction.
- Vary the brand of detergent used or source of enzymes such as pineapple juice or contact lens cleaning solution.
- Because all of the materials required for this activity are readily available at home, students can repeat this activity for their families, or use this initial activity as a starting point for designing other experiments.
- This DNA can be used for electrophoresis. Restriction enzymes are needed to cut the DNA into smaller pieces.

Adapted from the activity "How to Extract DNA from Anything Living," Genetic Science Learning Center at the Eccles Institute of Human Genetics, University of Utah, 2003. http://gslc.genetics.utah.edu/units/activities/extraction/
Use this Web site to troubleshoot any problems with the extraction technique that may arise.

Answer Key

1. What was the purpose of each of the following in the DNA extraction?

Peas: (*source of DNA*)

Salt (*Salt provides the DNA with a favorable environment; it contributes positively charged atoms that neutralize the normal negative charge of DNA.)*

Water *(Water provides an environment for releasing the DNA from the nuclei of the cells.)*

Detergent *(The enzymes in the soap are breaking down the lipid molecules of the cell and nuclear membranes, releasing the contents of the cell, including the DNA. These enzymes in the soap are what break down grease while washing dishes.)*

Meat tenderizer *(The meat tenderizer contains enzymes that speed up reactions. The enzymes cut proteins around the DNA just like a pair of scissors. The DNA in the nucleus of the cell is molded, folded, and protected by proteins. The meat tenderizer cuts the proteins away from the DNA.)*

Alcohol *(DNA will not dissolve in alcohol, so the DNA comes out of the solution, or precipitates. It is less dense than both water or 'cell scum'--which is what*

settles to the bottom of the glass--so it floats up into the alcohol layer, where it is seen as a mucous, string-like substance with small bubbles formed on it.)

2. What part of the cell did the DNA come from? (*99% is from the nucleus.)*

3. From what part of the body can crime scene investigators obtain DNA? (*All cells with nuclei contain DNA in their nuclei.)*

4. How many membranes have to be broken to extract DNA? (*Two, the cell membrane and the nuclear membrane.)*

5. According to the video segment, what are STR's? *(Short tandem repeats, used to identify differences in DNA between individuals.)*

Student Handout: How to Extract DNA

Because DNA is the blueprint for life, all living things contain DNA in the nuclei of their cells. For this activity, we will use split peas, but other common food items such as strawberries, broccoli, onions, spinach, or raw chicken liver could be used. This procedure actually took scientists many years to discover, but can now be done safely at school or at home.

Materials

- Safety goggles
- 20-30 mL split pea homogenate in test tube
- Skewer
- Test tube for alcohol
- Dawn liquid dishwashing detergent
- 50 mL graduated cylinder
- Ice cold isopropyl alcohol
- Test tube rack
- Meat tenderizer

Safety Precautions

- Safety eyewear should be worn at all times.
- Possible hazards:
- Broken glassware
- Isopropyl alcohol is poisonous
- Sharp skewers

Procedure

1. Obtain a test tube, test tube rack, and a graduated cylinder from your instructor.
2. Obtain a 20-30 mL sample of split pea homogenate.
3. Rinse the graduated cylinder with tap water. Using the graduated cylinder, measure 5 mL liquid dishwashing detergent and pour into the test tube containing the homogenate. Stir gently to avoid making bubbles. Let stand in the test tube rack for 5 to 10 minutes.
4. Add a small pinch of meat tenderizer (an enzyme) to the test tube and gently swirl to mix. If mixture is swirled too hard, the DNA will break up, making it difficult to see.
5. Using the graduated cylinder, measure 30 mL ice cold isopropyl alcohol. Holding the test tube at an angle, slowly pour the alcohol into the test tube containing the homogenate mixture. Pour until there is about the same amount of alcohol in the tube as pea mixture. DNA will rise into the alcohol layer from the pea layer. Use the wooden skewer or toothpick to draw the DNA into the alcohol.
6. Lift the DNA strands out of the alcohol by winding them around the skewer.
7. Dispose of all liquids in the sink, put skewers in the trash, and wash, dry and put away all glassware.
8. Answer the questions on the following page.

This activity was adapted from "How to Extract DNA from Anything Living," Genetic Science Learning Center at the Eccles Institute of Human Genetics, University of Utah, 2003.
http://gslc.genetics.utah.edu/units/activities/extraction/

Name_____

Questions:

1. What was the purpose of each of the following in the DNA extraction?

   - Peas_____
   - Salt _____
   - Water_____
   - Detergent _____
   - Meat tenderizer _____
   - Alcohol _____

2. What part of the cell did the DNA come from?

3. From what part of the body can crime scene investigators obtain DNA?

4. How many membranes have to be broken to extract DNA?

5. According to the video segment, what are STR's?

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.

http://library.thinkquest.org/19037/dna_extraction.htmL?tqskip1=1&tqtime=1119
The purpose of this lab is to extract DNA from a variety of cells and see DNA molecules. This lesson shows that DNA is found in a variety of tissues.

http://gslc.genetics.utah.edu/units/activities/extraction/
How to Extract DNA from Anything Living. A basic How-to lab that can be done at home or school.

http://www.sciencenetlinks.com/lessons.cfm?BenchmarkID=5&DocID=98
This site develops understanding of DNA by modeling the process of DNA extraction.
(Detailed description of the procedure used in the laboratory activity above.)

http://www.interpol.int/Public/Forensic/dna/dnafaq.asp
Frequently asked questions regarding DNA profiling from the International Police website.
(Interpol's frequently asked questions site)

http://www.biotechnology.gov.au/biotechnologyOnline/human/h_DNA.htm
Australia's official biotechnology Web site used by secondary science educators. Interactive DNA profiling case examines crime scene and paternity/maternity identification.
(Biotechnology Australia, A Commonwealth Government Initiative: Explains the use of DNA profiling in forensics.)

http://www.biorad.com Life Science Education. DNA extraction kit #166-2300 Edu. Genes in a Bottle.

http://www.dnalc.org/shockwave/pcranwhole.htmL
An interactive animation that explains PCR. Requires shockwave (available through a link where the animation should be if you don't have it).

http://www.crime-scene-investigator.net/searchingandexamining.htmL - article about examining a crime scene.

http://www.cyberbee.com/whodunnit/crimescene.htmL An interactive crime scene simulation.

http://www.planet-science.com/whodunit/go/Default.htmL
Planet Science offers a free Whodunit kit online. The contest is over, but there are still links for games and activities.

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