

Deoxyribonucleic Acid (DNA)

Course
Forensic Science

Unit X
Forensic
Serology/DNA

Essential Question
What is DNA and where is it found?
How can DNA be associated with crime scenes?

TEKS
§130.295(c)
(1)(A)(B)
(2)(F)(G)(H)
(3)(A)(B)(D)(E)(F)
(7)(B)
(12)(A–E)

Prior Student Learning
Structure of DNA

Estimated Time
1 ½ hour total

Rationale

Based upon its individualized characteristics, DNA is one of the most valuable tools to verify identities, exclude suspects, and ultimately solve crimes.

Objectives

The student will be able to:

1. Diagram the DNA molecule.
2. Explain the polymerase chain reaction laboratory procedure.
3. Demonstrate how to package, collect, and analyze DNA from a simulated crime scene.

Engage

Do an Internet search for the following article: The Murder Trial of O.J. Simpson by Thomas L. Jones. Read the article as a class. Discuss the role that DNA evidence played in the OJ Simpson case. Use the Discussion Rubric for assessment.

Key Points

I. Deoxyribonucleic Acid (DNA)

A. Introduction

1. Like fingerprints, DNA is unique to each individual
2. The primary unit is called a gene
3. Each gene contains DNA that controls our genetic traits

B. Structure of DNA

1. DNA is a molecule comprised of repeating units called nucleotides
2. A nucleotide consists of
 - a) Deoxyribose sugar
 - b) Phosphate
 - c) Nitrogen base (adenine, guanine, cytosine, thymine)
3. DNA is a double helix with sides consisting of alternating sugars and phosphates and the rungs representing the nitrogen bases
4. The nitrogen bases
 - a) Adenine bonds only to thymine and guanine bonds only to cytosine
 - b) Base pairing is when two DNA strands are joined by the bonding of the corresponding base pairs
 - c) The order of the bases determines the genetic code

C. DNA Typing

1. The process of DNA typing converts DNA into a series of bands that can distinguish an individual
2. Only a small percentage of DNA differs from one person to the next

3. These parts of one's DNA are used to create a DNA profile
 4. The majority of DNA is repetitive and does not code for specific proteins, repeating the same sequence over and over
- D. Polymerase Chain Reaction (PCR)
1. PCR is a technique for making many copies of a specific piece of DNA
 2. PCR can amplify very minute quantities of DNA millions of times
 3. The steps of PCR are
 - a) The DNA is heated to separate and "unzip" it
 - b) Primers are added to combine with DNA strands
 - c) DNA polymerase (enzymes) and free nucleotides are added to rebuild separated strands
 - d) The DNA is cooled
 - e) The process is repeated several times
- E. Short Tandem Repeats (STR)
1. STR is the latest method of DNA typing
 2. There are locations (loci) on a chromosome that contain short segments of 3 – 7 bases that repeat themselves
 3. STR's are less susceptible to degradation and can be recovered from bodies or stains that have been subject to extreme decomposition
 4. With the technology of PCR, one can extract and amplify a combination of different STR's
- F. Mitochondrial DNA
1. It is another method of typing used for individual characterization
 2. It is located outside a cell's nucleus and is inherited only from the mother
 3. It is not as useful as STR and is more costly than other DNA testing
- G. Visualizing DNA through Electrophoresis
1. In the lab, DNA molecules are cut by restriction enzymes into fragments of various sizes
 2. With electrophoresis, the resulting fragments are forced to move along a gel-coated plate under the influence of an electrical potential
 3. After the fragments have "migrated" across the gel, the gel can be stained to show the bands or fragments easily
 4. Comparisons can then be made such as comparing a suspect's DNA to the DNA found on a crime scene
 5. *Note:* The electrophoresis apparatus is costly, but if the budget permits, it is suggested to utilize an electrophoresis/DNA kit obtainable through most scientific supply companies. However, there are also many virtual labs available on the internet
- H. Combined DNA Information System (CODIS)
1. CODIS maintains a database of DNA profiles from convicted offenders, unsolved crime scene evidence, and profiles of

missing persons

I. Sources of DNA

1. Skin
2. Sweat
3. Blood
4. Mucus
5. Saliva
6. Tissue
7. Semen
8. Urine
9. Hair
10. Ear Wax
11. Vaginal or rectal cells

J. Collecting and Packaging Biological Evidence

1. Photograph evidence first
2. Wear gloves at all times
3. Package each stained article separately in paper or a well-ventilated box
4. Avoid using plastic or airtight containers because moisture could contribute to harmful bacteria and fungi growth
5. Remove dried blood by using a sterile swab moistened with distilled water
6. Store biological evidence in the refrigerator or a cool location until it is delivered to the lab

Activities

1. DNA Extraction from Strawberries Lab. Students will extract and observe DNA from strawberries by mashing them and mixing them with a buffer to separate the DNA. When complete, DNA can be seen on the end of a coffee stirrer. Use the DNA Extraction from Strawberries Lab Teacher's Notes to prepare for the lab. Use the DNA Extraction from Strawberries Lab Student Response Sheet for the activity. Use the DNA Extraction from Strawberries Lab Key for the assessment.
2. Lewinsky/Clinton Activity. Have students read and then analyze the reports about the Lewinsky/Clinton scandal at law2.umkc.edu/faculty/projects/ftrials/clinton/lewinskydress.html. Then have students complete the Understanding the Steps of Polymerase Chain Reaction Lewinsky/Clinton Scandal questions. As a class, discuss the students' answers. Use the Lewinsky/Clinton Scandal Key (answers will vary) and the Discussion Rubric for assessment.

Assessments

DNA Quiz and Key

DNA Extraction from Strawberries Lab Key
Lewinsky/Clinton Scandal Key
Discussion Rubric
Individual Work Rubric
Research Rubric

Materials

DNA computer-based presentation

DNA Extraction from Strawberries Lab

- DNA Extraction from Strawberries Lab Teacher's Notes
- DNA Extraction from Strawberries Lab Student Response Sheet
- Strawberries (fresh or frozen)
- Resealable plastic freezer bags
- Small plastic cups
- Plastic pipettes
- Coffee filters (cone shaped #2 work best) or cheesecloth
- Extraction Buffer
- Ethanol
- Ice
- Coffee stirrers

Lewinsky/Clinton Scandal Activity Handout

Lewinsky/Clinton Scandal Activity Key

Computers with Internet access

Resources

Saferstein, Richard. *Forensic Science: An Introduction*. New Jersey: Pearson Prentice Hall, 2008

Saferstein, Richard. *Forensic Science: An Introduction*. 2nd ed. New Jersey: Pearson Prentice Hall, 2011

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 8th ed. Upper Saddle River, NJ; Pearson Prentice Hall, 2004

<http://law2.umkc.edu/faculty/projects/ftrials/clinton/lewinskydress.html>

Do an Internet search for the following: The Murder Trial of O.J. Simpson by Thomas L. Jones

Accommodations for Learning Differences

For reinforcement, students will construct a simple DNA model using common household items. Use the Individual Work Rubric for assessment.

For enrichment, students will research a local crime that involves DNA evidence. Use the Research Rubric for assessment.

State Education Standards

Texas Essential Knowledge and Skills for Career and Technical Education §130.295. Forensic Science (One Credit).

- (1) The student, for at least 40% of instructional time, conducts

laboratory and field investigations using safe, environmentally appropriate, and ethical practices. These investigations must involve actively obtaining and analyzing data with physical equipment, but may also involve experimentation in a simulated environment as well as field observations that extend beyond the classroom. The student is expected to:

- (A) demonstrate safe practices during laboratory and field investigations; and
 - (B) demonstrate an understanding of the use and conservation of resources and the proper disposal or recycling of materials.
- (2) The student uses scientific methods and equipment during laboratory and field investigations. The student is expected to:
- (F) collect and organize qualitative and quantitative data and make measurements with accuracy and precision using tools such as calculators, spreadsheet software, data-collecting probes, computers, standard laboratory glassware, microscopes, various prepared slides, stereoscopes, metric rulers, electronic balances, gel electrophoresis apparatuses, micropipettors, hand lenses, Celsius thermometers, hot plates, lab notebooks or journals, timing devices, cameras, Petri dishes, lab incubators, meter sticks, and models, diagrams, or samples of biological specimens or structures;
 - (G) analyze, evaluate, make inferences, and predict trends from data; and
 - (H) communicate valid conclusions supported by the data through methods such as lab reports, labeled drawings, graphic organizers, journals, summaries, oral reports, and technology-based reports.
- (3) The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions within and outside the classroom. The student is expected to:
- (A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;
 - (B) communicate and apply scientific information extracted from various sources such as current events, news reports, published journal articles, and marketing materials;

- (D) evaluate the impact of scientific research on society and the environment;
 - (E) evaluate models according to their limitations in representing biological objects or events; and
 - (F) research and describe the history of science and contributions of scientists.
- (7) The student recognizes the methods to process and analyze trace evidence commonly found in a crime scene. The student is expected to:
- (B) process trace evidence such as soil, grass, glass, blood, fibers, and hair collected in a simulated crime scene;
- (12) The student analyzes deoxyribonucleic acid laboratory procedures in forensic science. The student is expected to:
- (A) diagram the deoxyribonucleic acid molecule, including nitrogen bases, sugars, and phosphate groups;
 - (B) explain base pairing of adenine, thymine, cytosine, and guanine as they relate to deoxyribonucleic acid fingerprinting;
 - (C) extract deoxyribonucleic acid from food such as peas and strawberries;
 - (D) explain the polymerase chain reaction laboratory procedure for forensic deoxyribonucleic acid typing; and
 - (E) collect and package deoxyribonucleic acid from a simulated crime scene.

College and Career Readiness Standards

Science Standards

II. Foundation Skills: Scientific Applications of Mathematics

F. Scientific measurement

1. Select and use appropriate Standard International (SI) units and prefixes to express measurements for real world problems.

III. Foundation Skills: Scientific Applications of Communication

B. Scientific reading

2. Set up apparatuses, carry out procedures, and collect specified data from a given set of appropriate instructions.

Name: _____ Date: _____

DNA Quiz

Short Answer

1. There are _____ different nitrogen bases found in DNA.
2. The national database of DNA that stores profiles from convicted offenders, unsolved crime scene evidence, and profiles of missing persons is called _____.
3. DNA evidence should be packaged in a _____ bag or well-ventilated box.
4. _____ is a technique used for making many copies of a specific piece of DNA.
5. _____ DNA is only inherited from the mother.
6. _____ always bonds to thymine and _____ always bonds to cytosine in DNA.
7. _____ are less susceptible to degradation and can be recovered from badly decomposed circumstances.
8. A dried blood stain must be removed by using a _____.

True or False

9. _____ Always photograph evidence before collecting it.
10. _____ The PCR technique can make many, many copies of DNA.

DNA Quiz Key

- 1) 4
- 2) CODIS – Combined DNA Information System
- 3) Paper
- 4) PCR – Polymerase Chain Reaction
- 5) Mitochondrial
- 6) Adenine, guanine
- 7) STR's – Short Tandem Repeats
- 8) Sterile swab (moistened with distilled water)
- 9) True
- 10) True

DNA Extraction from Strawberries Lab – Teacher’s Notes

Rationale

This lab is an excellent resource to allow students to extract, spool, and see DNA. Strawberries are an excellent source for extracting DNA because they are easy to work with and have lots of DNA to isolate. They actually have 8 copies of each chromosome which makes them octoploid.

Materials

- Student worksheets
- Strawberries (frozen can be used but they must be thawed to room temperature)
- Resealable plastic freezer bags
- Small plastic cups
- Plastic pipettes
- Coffee filters (cone shaped #2 work best)
- Extraction Buffer (see below)
- Alcohol (95% ethanol or 100% isopropyl)
- Ice (to keep the ethanol cold)
- Coffee stirrers

The following should be completed in advance of the lab:

DNA Extraction Buffer

- 50 mL of clear shampoo without conditioner
- 1 tsp non-iodized salt
- 450 mL water

Mix the materials gently in a container so as not to create many bubbles.
This amount is enough for 50 groups of students working in pairs.

Make sure the alcohol is ice cold!

Freezer bags work better than regular plastic bags because they are thicker.

Fill 50 test tubes with approximately 15 mL of ethanol (one for each group). Cap the test tubes and keep them on ice until students are ready for them.

Name: _____ Date: _____

DNA Extraction from Strawberries Lab

Introduction

Wouldn't it be great to be able to see DNA with your own eyes? In this lab activity, you will be able to do so by extracting DNA from the nucleus of strawberry cells. Strawberries are an excellent source of DNA because they have multiple copies of each chromosome.

Materials

- 1 resealable plastic bag
- 1 – 3 strawberries (depending on the size; total volume needs to be around golf-ball size)
- 1 coffee filter
- 1 plastic cup
- 1 plastic pipette
- 10mL DNA extraction buffer
- 1 test tube
- 1 test tube with 15mL ice cold alcohol
- Coffee stirrer

Procedure

1. Remove any stem, leaves, or sepals from the strawberries
2. Place the strawberries in the plastic bag and seal it
3. Mash the strawberries for about 2 minutes, smashing them completely
4. Add 10mL of DNA extraction buffer to the bag and reseal it
5. Mash for about 2 more minutes, trying not to get it too bubbly
6. Place the coffee filter into the cup, folding the top over the edges of the cup. Make sure the filter does not touch the bottom of the cup
7. Pour the strawberries and buffer into the filter and let them drip into the cup. This may take a few minutes.
8. Using the pipette, add about 3mL to the empty test tube
9. Slowly pour the alcohol into the strawberry solution by pouring down the side of the tube so it forms a separate layer on top of the strawberry liquid
10. You should see the precipitate form as a white cloud between the two layers. The cloudy substance is DNA!
11. Slowly spin and stir the coffee stirrer in the DNA to wrap it around the stirrer

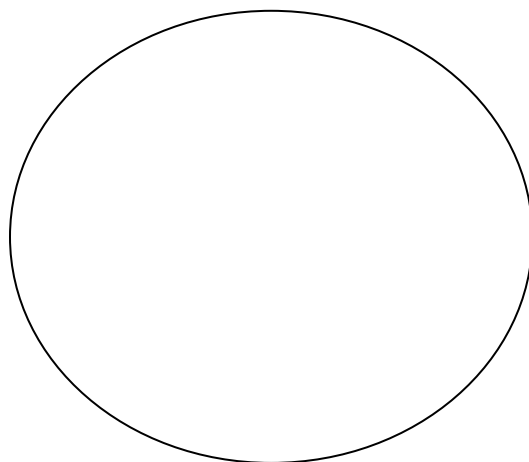
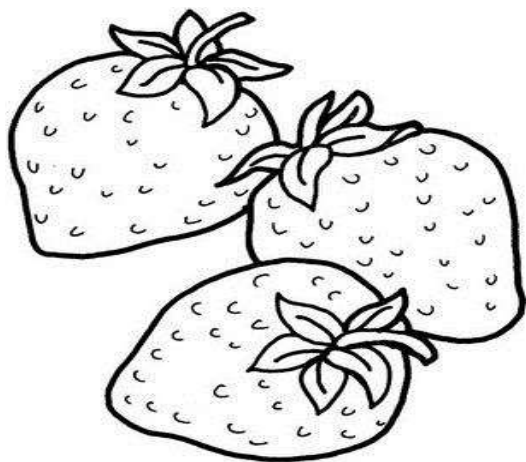
You have now extracted DNA from strawberries. Clean up your lab area and complete the post lab questions.

Post-Lab Questions

1. Why were the strawberries mashed?
2. What is the purpose of the filter?
3. What does the DNA extraction buffer do?
4. What happened when you added the ethanol to the strawberry filtrate?
5. What does the DNA look like? Is a microscope needed? Explain.

Extension Activity

Take the coffee stirrer with DNA attached and remove some of the DNA onto a clean glass microscope slide. Gently stretch it apart using 2 toothpicks. Observe with the microscope. Draw what you see in the field of view below.



DNA Extraction from Strawberries Lab Key

Answers to the Post-Lab Questions

1. To break down the cell wall and to separate the cell components.
2. It removes larger particles from the solution. It is selectively permeable, allowing only smaller cell parts such as DNA and proteins to pass.
3. The buffer helps to remove the DNA from the rest of the strawberry's cell components.
4. The different solutions separated and the DNA precipitated out of the strawberry solution.
5. DNA looked like a white, cloudy substance or perhaps a white, stringy material. In mass, it can be seen without the use of a microscope although specific parts of the DNA cannot be viewed.

Understanding the Steps of Polymerase Chain Reaction (PCR) Lewinsky/Clinton Scandal

- 1) Explain the PCR procedure for DNA typing.

- 2) Go to <http://law2.umkc.edu/faculty/projects/ftrials/clinton/lewinskydress.html> and read the article on the "The Stained Blue Dress". Summarize it below.

- 3) Explain what evidence was found and how it was collected.

- 4) What was the FBI's conclusion regarding the analysis of the dress?

- 5) Explain the statistics of the report. What are the chances the stain belonged to anyone else but Bill Clinton?

Understanding the Steps of Polymerase Chain Reaction (PCR) Lewinsky/Clinton Scandal Key

Note: This assessment should be based on accuracy and details at the teacher's discretion. The following list suggests items that should be mentioned. No set rubric is provided.

1) Steps of the PCR procedure:

PCR, or polymerase chain reaction, is where small quantities of DNA or broken pieces of DNA found in crime scene evidence can be copied with the aid of a DNA polymerase. Once DNA copies are produced, they can be analyzed by the various types of molecular biology testing. The steps are

- Heat the DNA to about 94 degrees Celsius, which causes it to separate
- Add the primers to the separated strands and allow the primers to combine with the strands by lowering the test tube to about 60 degrees Celsius
- Add DNA polymerase and a mixture of free nucleotides to the separated strands then heat again to about 72 degrees Celsius allowing for the rebuilding of the double-stranded DNA molecule

This cycling of heating and cooling allows for the DNA to be doubled and is repeated several times. In the Lewinsky/Clinton situation, a Restriction Fragment Length Polymorphism (RFLP) test was performed.

- 2) The article discusses the blue dress worn by Monica Lewinsky which reportedly had a semen stain on it from President Bill Clinton. It mentions the FBI's acknowledgement of the receipt of the blue dress as evidence as well as the drawing and the receipt of a liquid blood sample from President Clinton. It finally gives a report of the examination.
- 3) See answer above
- 4) A seven-probe RFLP match was obtained between the president's DNA and the semen stain.
- 5) The chances of the stain belonging to anyone else but President Bill Clinton was nearly one in eight trillion, an undeniable statistic.

Name_____

Date_____

Discussion Rubric

Objectives	4 pts. Excellent	3 pts. Good	2 pts. Needs Some Improvement	1 pt. Needs Much Improvement	N/A	Pts.
Participates in group discussion						
Encourages others to join the conversation						
Keeps the discussion progressing to achieve goals						
Shares thoughts actively while offering helpful recommendations to others						
Gives credit to others for their ideas						
Respects the opinions of others						
Involves others by asking questions or requesting input						
Expresses thoughts and ideas clearly and effectively						
Total Points (32 pts.)						

Comments:

Name_____

Date_____

Individual Work Rubric

Objectives	4 pts. Excellent	3 pts. Good	2 pts. Needs Some Improvement	1 pt. Needs Much Improvement	N/A	Pts.
Follows directions Student completed the work as directed, following the directions given, in order and to the level of quality indicated						
Time management Student used time wisely and remained on task 100% of the time						
Organization Student kept notes and materials in a neat, legible, and organized manner. Information was readily retrieved						
Evidence of learning Student documented information in his or her own words and can accurately answer questions related to the information retrieved						
*Research/Gathering information (if relevant) Student used a variety of methods and sources to gather information. Student took notes while gathering information						
Total Points (20 pts.)						

Comments:

Name_____

Date_____

Research Rubric

Objectives	4 pts. Excellent	3 pts. Good	2 pts. Needs Some Improvement	1 pt. Needs Much Improvement	N/A	Pts.
Question/goal Student identified and communicated a question or goal of the research						
Research/Gathering information (if relevant) Student used a variety of methods and sources to gather information. Student took notes while gathering information						
Conclusion/Summary Student drew insightful conclusions and observations from the information gathered. Information is organized in a logical manner						
Communication Student communicated the information gathered and summary or conclusions persuasively. Student demonstrated skill in the use of media used to communicate the results of research						
Reflection Student reflected on the importance of the research and its potential application						
Total Points (20 pts.)						

Comments: