TEACHER GUIDE

STRAWBERRY DNA EXTRACTION

MATERIALS PER GROUP:

- One strawberry (frozen work well)
- 50 mL tube (lysis buffer tube)
- Pipette
- 5 mL clear liquid detergent (e.g., Woo-lite®, Ivory, hand soap or other clear liquid detergent)
- 45 mL water
- 5 g salt
- 25 mL ethanol or ice-cold 91% isopropyl (rubbing) alcohol
- One quart-sized Ziploc® bag
- One coffee filter
- Funnel
- Inoculating loop (Popsicle stick, cotton swab, coffee straw or similar instrument)
- 250 mL collection cup

TOTAL DURATION:

10 min. pre-lab prep time; 40-60 min. class time

SAFETY PRECAUTIONS:

- Do not eat or drink in the laboratory. (Ethanol and rubbing alcohol may cause blindness if ingested.)
- Wear safety glasses, lab coat and gloves when performing the experiment.
- Materials should not be removed from the classroom.

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LESSON OVERVIEW:

Deoxyribonucleic acid (DNA) is a molecule that encodes genetic instructions. These instructions guide the development and functioning of all known living organisms and many viruses, and are used for building and regulating proteins which build and run an organism's body. Similar to the way a builder uses a blueprint to construct a house, cells use information from DNA to construct an organism. DNA is sometimes called the "blueprint for life."

ESSENTIAL QUESTION:

How is all life on Earth connected?

TOPICAL ESSENTIAL QUESTION:

How can DNA be extracted from cells?

LESSON OBJECTIVES:

Students will be able to:

1. Learn the simple steps to extract DNA from strawberries.
2. Construct an explanation for each step of DNA extraction.
3. Explain the importance of extracting DNA from the cells of organisms.

STANDARDS:

Middle School

MS-LS3-1
Students who demonstrate understanding will be able to:
Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure.

MS-LS3-2
Students who demonstrate understanding will be able to:
Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring.

High School

HS-LS3-1
Students who demonstrate understanding will be able to:
Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Science and Engineering Practices:

1. Asking questions
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in scientific argument from evidence
8. Obtaining, evaluating and communicating information

Crosscutting Concepts:

1. Patterns
2. Cause and Effect: Mechanisms and explanations
3. Scale, Proportion and Quantity
4. Systems and System Models
5. Energy and Matter: Flows, cycles and conservation
6. Structure and Function
7. Stability and Change

KEY VOLCABULARY:

DNA
Gene
Precipitate
Lysate
Lipids
Filtrate
LysisProtein

LAB BACKGROUND INFORMATION:

NOTE: This is background information for the teacher to assist in facilitating learning and will be explained to the students after the Explore section.

Deoxyribonucleic acid (DNA) is a molecule that encodes genetic instructions. These instructions guide the development and functioning of all known living organisms and many viruses, and are used for building and regulating proteins which build and run an organism's body. Similar to the way a builder uses a blueprint to construct a house, cells use information from DNA to construct an organism. DNA is sometimes called the "blueprint for life."

DNA instructions are divided into segments called genes. All organisms have genes that determine various biological traits. Some of these are immediately visible, such as eye color or hair color, and some are not, such as blood type or musical talent. Each gene provides the information for making a protein that carries out a specific function in the cell.

The world depends on plants and animals for food, clothing, shelter and fuel every day. These plants and animals are comprised of cells that rely on DNA for their development, functioning and reproduction. In agriculture, scientists evaluate the DNA to find genes that code for specific traits, such as disease resistance, drought tolerance and higher yield, to improve the plants. These improvements benefit you as consumers when you purchase products with improved nutrition, larger size and better taste.

In this activity, students will break open strawberry cells and extract DNA. Some fruits are especially well suited for DNA extractions due to their multiple sets of chromosomes. Strawberries are octoploid, which means they have eight copies of each chromosome. In comparison, human cells are diploid, which means they contain two copies of each chromosome.

In this activity, students will learn the simple method of DNA extraction, be able to explain the rationale of each step, and use simple household chemicals to extract DNA from a strawberry.

DNA extraction is a fairly simple process. The first step is to create the lysis buffer. Lysis is a Greek word that means to break open. The lysis buffer (water, detergent and salt) breaks open the cells by destroying the fatty membranes that enclose the cells as well as the nuclear membranes within the cells. DNA is released into the solution. The salt in the lysis buffer strips away proteins associated with the DNA molecules, and alcohol helps the DNA precipitate out of the solution. The colder the alcohol, the more DNA will precipitate. Chill the alcohol on ice for one hour prior to performing the experiment or place in the freezer overnight.

ENGAGE:

Give students a strawberry and let them observe it. On a separate sheet of paper, have students list five descriptive observations about the strawberry. Have the students do a chain note pre-assessment. At the top of the paper write “DNA ...” and have the students complete the sentence. Give the students a time limit and have them come up with as many ideas as they can to complete the sentence. This is an opportunity to uncover student misconceptions prior to the lesson.

Sample student responses:
DNA ... is in cells ... is a large molecule ... makes genes ... makes up people ... codes for proteins (not makes) ... comes from my parents

Introduction

In this activity, you will learn the simple method of DNA extraction, be able to explain the rationale of each step, and use simple household chemicals to extract DNA from a strawberry.

EXPLORE:

Pre-lab Questions:

1. Do strawberries contain DNA? **Yes**
2. Where is DNA found? **DNA is found in the nucleus of each cell.**
3. What do you think the DNA will look like? **Accept all reasonable answers.**
4. What barriers must be broken to access the DNA? **Cell wall (plants), cell membrane (animals), nuclear envelope.**

PROCEDURE:

Note: Every activity could be completed by students or could be prepared ahead of time by the instructor.

Activity 1: Make Lysis Buffer

1. Add 5 g of salt (NaCl) to the empty 50 mL lysis buffer tube.
2. Add 45 mL of water (H_2O) and 5 mL of clear liquid detergent to the lysis buffer tube.
3. Place the cap securely on the tube and mix gently by swirling or inverting the tube.
4. You have made a lysis buffer.

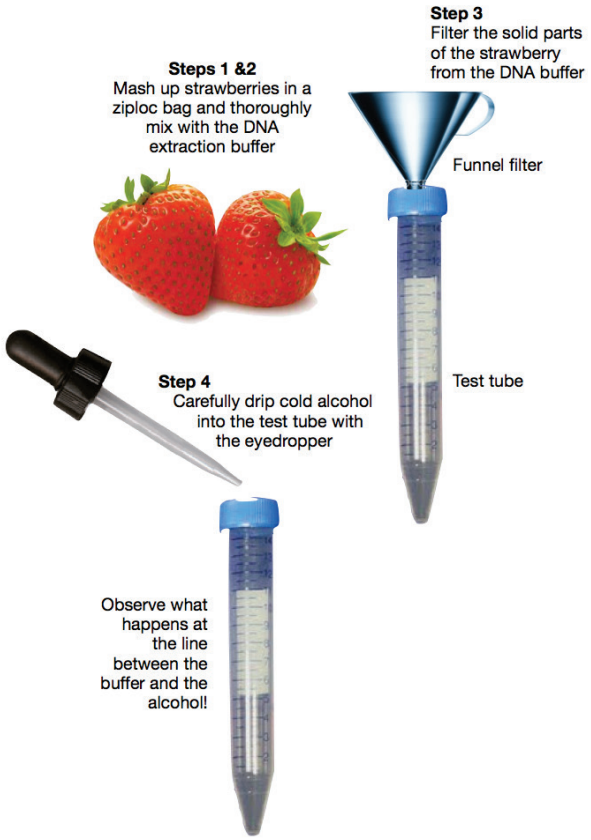
Activity 2: Make Strawberry Lysate

1. Place the strawberry in the sturdy plastic bag.
2. Remove all air from the bag and seal.
3. Mash the strawberry in the bag to a pulp. (Be careful not to break the bag!)

   **Ask the students if the cells have been broken open. Most will say no, but reinforce that the cells have not been opened or destroyed because it takes more than physical force to do this. The cells have simply been rearranged into a different form. Tell the students the definition of "lysis" (Greek for: to break open).*

4. Open the bag and add all of the lysis buffer.
5. Remove the air, seal the bag and mix the strawberry pulp with the added lysis buffer.

   **Ask the students if the cells have been broken open. Most students will say no, but reiterate the definition of lysis and that they just added a lysis buffer; ask the question again. Students should now understand that the soap has broken open the lipid membrane around the cell and nuclear membrane making the DNA accessible.*



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6. You have made a strawberry lysate, which is lysed strawberry cells, meaning that the cells have been "broken open."

   Note: As an option, the instructor can mix all of the components of the lysis buffer and the alcohol to a bag WITHOUT the strawberry to emphasize the importance of a control and to show that the extracted DNA came from the strawberry and was not due to a chemical reaction between the lysis buffer solution and the alcohol (added at Step 4).

Activity 3: Filter the Strawberry Lysate

1. Place the coffee filter into the funnel, and place the funnel into the collection cup. (Note: The instructor should demonstrate how to properly place the filter in the funnel.)
2. Pour the strawberry lysate from the bag into the filter.
3. The liquid that drips from the funnel into the collection cup is called a filtrate.
4. To speed up the process, pick up the filter from the top and gently squeeze the bottom of the filter.
5. The filtrate includes the strawberry DNA.

Activity 4: Visualize the Strawberry DNA

1. Remove the funnel from the collection cup.
2. Add 25 mL of ethanol slowly to the collection cup by pouring down the side.
3. Observe the interface between the ethanol and strawberry lysate layer. The DNA will begin to precipitate out of the strawberry lysate. Note the appearance and texture of the DNA. A "precipitate" is an insoluble compound that forms when two solutions interact.
4. Collect the strawberry DNA using the inoculating loop.

EXPLAIN: (SEE LAB BACKGROUND)

The Lab Background information from the Teacher Guide is repeated in the Explain section of the Student Guide. Below is additional information to help aid explanations.

In order to improve plants and animals, agriculturalists have been studying genes and DNA for many years. The process of choosing the best or most desirable traits from each generation and selecting those individuals to breed together is the basis of agriculture. It has allowed scientists to create plants and animals that are more disease resistant and drought tolerant; produce more offspring; have better mothering ability; and have higher quality meat, eggs or wool.

ELABORATE:

Optional Extension Activities

- Use varying concentrations of alcohol (50 percent to 100 percent) to determine how ethanol concentration affects the yield of DNA.
- Calculate the yield of DNA isolated, relate it to the mass of the strawberry, and express yield as mg DNA/gram tissue.

- Using the procedure above, try extracting DNA from other fruits or vegetables.
- Try extracting your own DNA by using the following procedure:
  - To an empty collection cup, add 15 drops (2.5 mL) of clear liquid detergent and 5 g (1 tsp.) of salt (NaCl)
  - Gently chew the inside of the cheek for 30 seconds.
  - Put approximately 25 mL (1.5 Tbsp.) of clear Gatorade in your mouth and swish it around for 30 seconds.
  - Spit the Gatorade into the collection cup containing the detergent and salt.
  - Gently stir with a plastic spoon.
  - Slowly add 15 mL of ethanol to the collection cup by pouring it down the side of the cup.
  - Wait a few minutes for the DNA to precipitate out of the solution.
  - Collect your DNA using the inoculating loop.

EVALUATE:

1. Use this acrostic device to list words related to DNA and GENES. Add words that contain at least one of the following letters:

   Example: in**D**ividuals

   N

   A

   G

   E

   N

   E

   S

   Students will do a First Word/Last Word Activity (Keely, 2008). Students will use this as an acrostic device to describe what they know about DNA and GENES. This can be done in student groups or pairs. Students can share these with the class and compare the words they used to describe DNA and GENES.

   Example: inDividuals

   Nucleus

   LAdder

   Genome

   hElix

   plasma membraNe

   protEins

   traitS

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2. "DNA" is a shorthand version of: **DeoxyriboNucleicAcid**

3. DNA is the _____**blueprint**_____ for life.

4. DNA forms a double _____**helix**_____.

__**C**__ 5. The fruit used in this experiment is:

A. Diploid

B. Haploid

C. Octoploid

D. Tetraploid

6. The nucleus contains _____**DNA**_____.

7. It is important that you understand the steps in the extraction procedure and why each step was necessary. Each step in the procedure aided in isolating the DNA from other cellular materials.

Match the procedure with its function:

PROCEDURE	FUNCTION
A. Filter strawberry slurry through coffee filter	__**A**__ Precipitate DNA from solution
B. Smash the strawberry in the plastic bag	__**D**__ Separate components of the cell
C. Mix strawberry with salt/soap solution	__**B**__ Break open the cells
D. Add alcohol to the filtered solution	__**C**__ Break up proteins and dissolve cell membranes

8. DNA is often referred to as the "blueprint for life." Why?
DNA contains the code to construct the molecules for all living organisms.

9. From what other fruits or vegetables could we extract DNA? Accept a range of answers. Why?
The cells of all living organisms contain DNA.

10. There are approximately 10 feet of DNA in a single plant cell. We eat an average of 50 million cells in a single meal. How many miles of DNA do we eat in a single meal (hint: a mile equals 5,280 feet)?
Approximately 100,000 miles – it could stretch around the Earth about four times.

11. Why is it important for scientists to be able to extract DNA from an organism? List two reasons.
To study DNA to identify organisms, to solve crimes, to manipulate DNA in research, to sequence DNA, to detect mutations, for personalized medicine, etc.

12. What factors could affect the success of extraction of DNA from strawberries or other plants?
Answers may include: amount of DNA in a particular fruit, the number of cells in the fruit, ripeness of the fruit, following procedures, etc.

13. A person cannot see a single cotton thread 100 meters away, but if they wound thousands of threads together into a rope, it would be visible. Is this statement analogous to our DNA extraction? Explain.
By extracting condensed DNA from multiple cells and collecting it together, we are able to see DNA with the naked eye.

References:
Keeley, P. (2008). *Science formative assessment: 75 practical strategies for linking assessment, instruction and learning:* SAGE.

Noble Academy would like to thank the following people for their contributions to this lesson:
- Quentin Biddy
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- Susie Edens
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- Kay Gamble
- Julie Smiley-Foster

STUDENT GUIDE

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SAFETY PRECAUTIONS:

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LESSON OVERVIEW:

Deoxyribonucleic acid (DNA) is a molecule that encodes genetic instructions. These instructions guide the development and functioning of all known living organisms and many viruses, and are used for building and regulating proteins which build and run an organism's body. Similar to the way a builder uses a blueprint to construct a house, cells use information from DNA to construct an organism. DNA is sometimes called the "blueprint for life."

ESSENTIAL QUESTION:

How is all life on Earth connected?

TOPICAL ESSENTIAL QUESTION:

How can DNA be extracted from cells?

LESSON OBJECTIVES:

You will be able to:

1. Learn the simple steps to extract DNA from strawberries.
2. Construct an explanation for each step of DNA extraction.
3. Explain the importance of extracting DNA from the cells of organisms.

ENGAGE:

Look closely at the strawberry in front of you. On a separate sheet of paper, list five descriptive observations you can make by just looking at the strawberry. After you have listed your descriptions, use complete sentences to complete the phrase "DNA..." to write everything you know about DNA.

INTRODUCTION:

In this activity, you will learn the simple method of DNA extraction, be able to explain the rationale of each step, and use simple household chemicals to extract DNA from a strawberry.

EXPLORE:

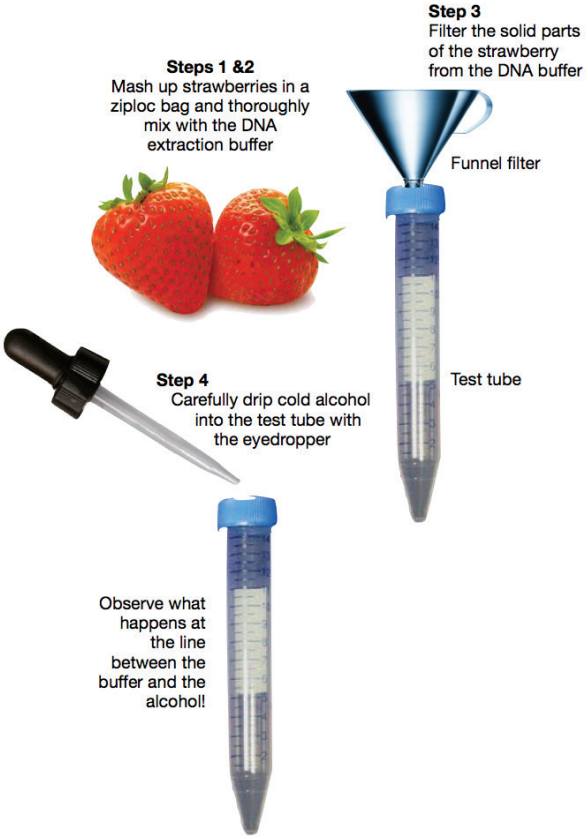
Pre-lab Questions:

1. Do strawberries contain DNA?

2. Where is DNA found?

3. What do you think the DNA will look like?

4. What barriers must be broken to access the DNA?



PROCEDURE:

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EXPLAIN:

Deoxyribonucleic acid (DNA) is a molecule that encodes genetic instructions. The instructions coded into the DNA guide the development and functioning of all known living organisms and many viruses. Similar to the way a builder uses a blueprint to construct a house, cells use DNA to construct an organism. DNA is therefore often considered the "blueprint for life."

DNA instructions are divided into segments called **genes**. All organisms have genes that determine various biological traits. Some are immediately visible, such as eye color or hair color, and some are not, such as blood type or musical talent. Each gene provides the information for making a protein that carries out a specific function in the cell.

The world depends on plants and animals for food, clothing, shelter and fuel every day. These plants and animals are comprised of cells that rely on DNA for their development, functioning and reproduction. In agriculture, scientists evaluate the DNA to find genes that code for specific traits, such as disease resistance, drought tolerance and higher yield, to improve the plants. These improvements benefit you as consumers when you purchase products with improved nutrition, larger size and better taste.

ELABORATE:

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◦ Wait a few minutes for the DNA to precipitate out of the solution.
◦ Collect your DNA using the inoculating loop.

EVALUATE:

Name: _____

Use knowledge gained from this lesson to complete the questions.

1. Use this acrostic device to list words related to DNA and GENES. Add words that contain at least one of the following letters:

Example: in**D**ividuals

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A

G

E

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2. "DNA" is a shorthand version of: D_____ N_____ A_____

3. DNA is the _____ for life.

4. DNA forms a double _____.

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8. DNA is often referred to as the "blueprint for life." Why?

_____

_____

9. From what other fruits or vegetables could we extract DNA? Accept a range of answers. Why?

_____

_____

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