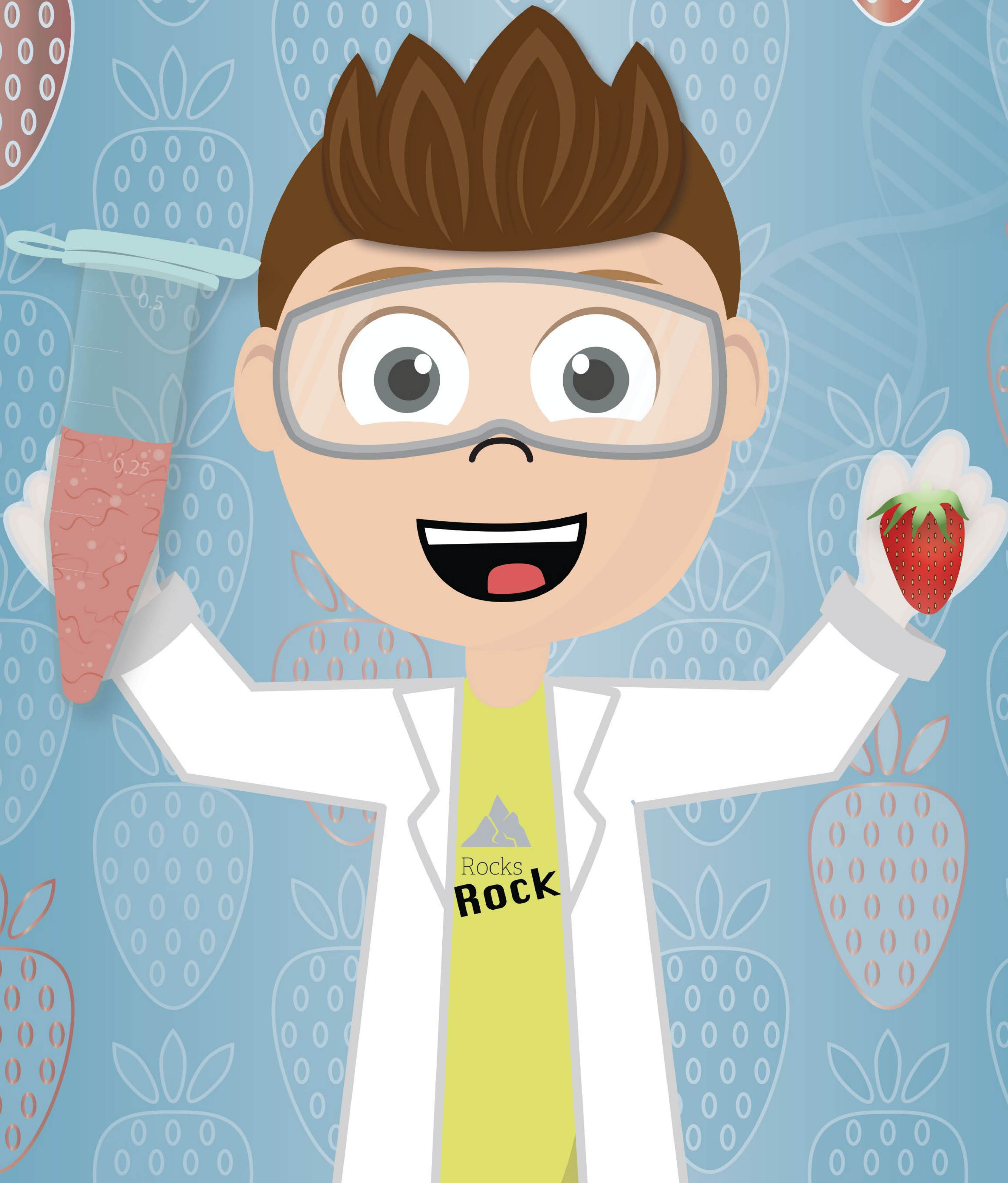
BIOLOGY

Fruitful DNA



NGSS

MS-LS3-1; MS-LS4-5

Objective

The student will understand and reason that every cell in each plant and animal has DNA, just like all human cells (except red blood cells) contain DNA.

The student will be able to explain what DNA is and what it looks like, after successfully isolating it from a banana or strawberry.

Vocabulary

DNA/Deoxyribonucleotide: The genetic instructions for an organism

Genome: An organism's genetic material encoded by DNA

Chromosome: Structure composed of DNA, RNA, and protein that carries genetic material in the form of genes

Background

DNA is the genetic material that provides the blueprint, or genetic instructions, for how an organism will develop and function. Each cell has the exact same copy of DNA housed in the nucleus. This DNA is turned into protein, which then performs a specific function.

All plants and animals have DNA, and today this experiment will demonstrate that all living things have DNA. The students will be divided into two groups and at the end will compare their experiments. We can extract the strawberry and banana genomes and even sequence them if we want. Strawberries are a convenient fruit to use because they have large genomes that are easily visible when extracted. Strawberries are octoploids, which means they have 8 chromosomes in each cell.

To get to the genetic material, a detergent is needed to disrupt the phospholipid bilayer of cell membranes and organelles. Detergents, such as soap, have a head that is attracted to water (hydrophilic) and a tail that is attracted to grease (hydrophobic). This makes it possible to disrupt the hydrophobic and hydrophilic regions of phospholipid bilayers.

To release the DNA strands, we then use salt to break up the protein chains that bind around the nucleic acids.

Because DNA is not soluble in isopropyl alcohol, it will precipitate, and then the DNA can be scooped up.

Materials

Supplies (per student group of 2-3 students multiply by number of groups as needed)

- Strawberries (1 per student)
- Bananas (1/2 or 1/3 per student)
- Isopropyl alcohol (100% and 70%; keep chilled)
- Distilled water (sink water can also work, but may have contaminants)
- Dish soap
- Salt
- Quart sized resealable plastic bags (1 per student)
- Plastic cups (2 per student)
- Spoons or stir sticks (non-metal) (1 per student)
- Plastic Pasteur pipettes or turkey basters (1 per student)
- Coffee filters (1 per student)
- Measuring spoon set
- Rubber bands (1 per student)
- Microcentrifuge tubes and string
- Colored gumdrops/mini-marshmallows (or other type of candy or material that has 4 different colors; 2 boxes per group)
- Box of toothpicks
- Twizzlers
- 1 paper plate per student
- Pens or Pencils

Procedure

1. Introduce topic, go over concepts and background
2. Start the experiment
    a. Split students into groups. Groups get to choose whether they'll extract DNA from a banana or from a strawberry.
        i. This is so the students can compare afterwards and see that everything has a genetic makeup and that it looks the same!
    b. Within each group, students will work individually to extract DNA from their fruit, but ultimately together in their small group
    c. Pass out to each student:
        i. ¼ cup of distilled H_2O
        ii. 2 plastic cups
        iii. Rubber band
        iv. Spoon
        v. Pinch of table salt
        vi. Coffee filter paper
        vii. Plastic pipette

NOTE: When you conduct each step of the extraction procedure, be sure to explain the scientific reason for each step using the information in the background section of the lesson. (Soap to break cells open, salt to bind DNA, etc.)

Strawberry Group:

Instructor: Give 1 strawberry per student along with one bag.

Students (individually):

1. Place strawberry (without the leaves) in the bag.
2. Add ¼ cup of distilled H_2O to the bag.
3. Mash up the strawberries so there are no large chunks left.
4. Place the mashed up strawberry mixture aside.
5. In one of the plastic cups:
    a. Fill cup roughly 1 centimeter high with soap
    b. Dump salt for a count of 3 seconds
    c. Add ¼ cup of distilled H_2O
6. Pour all of the mashed banana solution from the bag into the cup.

7. Stir for about 5 minutes. Stir slowly to avoid producing too many bubbles.
8. Strain the contents of this cup through the coffee filter into another clean cup.
    a. Make sure coffee filter is resting on the top of the cup. The filter paper should not be too tight over the top of the cup... you do not want the paper to rip when you filter the solution. Use the rubber band to secure the filter.
9. Once all the mixture has been filtered into a new cup, slowly pour cold isopropyl alcohol down the side and into the cup (add about ½ inch of isopropyl alcohol into the cup). This should precipitate the DNA and make it float to the top.
10. Gather the precipitated DNA at the surface of the fluid using the plastic pipette. You can put the DNA in the micro-centrifuge tubes to hold on to!

Banana Group:

This is the same procedure as strawberry group)

Instructor: Give 1 banana per student along with one bag.

Students (individually):

1. Place banana (without the peel) in the bag.
2. Add ¼ cup of distilled H_2O to the bag.
3. Mash up the banana so there are no large chunks left.
4. Place the mashed up banana mixture aside.
5. In one of the plastic cups:
    a. Fill cup 1 centimeter high with soap
    b. Dump salt for a count of 3 seconds
    c. Add ¼ cup of distilled H_2O
6. Pour all of the mashed banana solution from the bag into the cup.
7. Stir for about 5 minutes. Stir slowly to avoid producing too many bubbles.
8. Strain the contents of this cup through the coffee filter into another clean cup.
    a. Make sure coffee filter is resting on the top of the cup. The filter paper should not be too tight over the top of the cup... you do not want the paper to rip when you filter the solution. Use the rubber band to secure the filter.
9. Once all the banana mix has been filtered into a new cup, slowly pour cold isopropyl alcohol down the side and into the cup (add about ½ inch of isopropyl alcohol into the cup). This should precipitate the DNA and make it float to the top.
10. Gather the precipitated DNA at the surface of the fluid using the plastic pipette. You can put the DNA in the micro-centrifuge tubes to show it off.

11. Compare results of the student groups
    a. How does the DNA extraction compare between groups? Were all successful? What does it look like?
        i. The students should be able to observe what the DNA extractions look like via a white mucousy substance!

Build a Candy DNA Model of the Product:

1. Each student group will build a candy DNA model and will need the following:
    a. 2 Twizzlers (the backbone)
    b. ~10-12 toothpicks
    c. Colored gumdrops/mini-marshmallows (~20 total, but in a mixture of 4 different colors)
        i. Each different color will represent a nucleotide base (A,T,G,C)
    d. DNA Handout
2. Each student will decide which color of candy represents each base. They must indicate their choices when they share out their designs. When they build their model, the bases must pair properly (A-T & C-G).
3. Have the students assist with cleanup.

Guiding Questions

- Does every cell within an organism contain the exact same DNA sequences?
- What is the name of an organism's complete set of genes or genetic material encoded by DNA?
- Do you think if you isolated DNA from another organism that it would look the same? Why or why not?

Career/Future Application

DNA can help to identify people, even better than a fingerprint! Crazy, right? Being able to extract DNA helps a lot of professionals. Biomedical researchers use DNA all the time as a tool for discovering new things about diseases – their discoveries help develop new and better treatments and cures for diseases. Forensic scientists use DNA analysis to determine whether samples from crime scenes match suspects' DNA. Doctors use DNA to help diagnose genetic illnesses. Genetic engineers study the mechanisms of DNA replication. There are even scientists who conduct genetic research on our food!

Sources

https://www.youtube.com/watch?v=23jSj-B18gM

https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_biomed/cub_biomed_lesson09_activity2.xml