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COMMUNITY RESOURCES FOR SCIENCE

BASIS Lesson Plan

Lesson Name: Honey I Engineered our Food
Grade Level: 5

Presenter(s): Andrew Ng, Will Lykins, Thomas Carey, Tiama Hamkins-Indik, Max Armstrong, Zoë Steier

Standards Connection(s):

[CRS will identify standards connections & communicate with BASIS team about these]

**Note to teachers: Detailed standards connections can be found at the end of this lesson plan.*

Teaser/Overview

Farmers grow the foods that people need to eat to stay strong and healthy, and to provide ingredients that companies use to make everything from French fries to tortillia chips to canned soup and much more. Farmers face many challenges, such as keeping their crops safe from disease and pests. They also need to grow food as efficiently as possible (getting the most food from the available land and water as possible), and keep food from spoiling or getting damaged as it is travels from the farm fields to the people buying the food.

Scientists and engineers help farmers solve some of these problems.

By the end of this lesson, your students will be able to understand variation, and the role of DNA and genes in determining traits of plants.

Lesson Objectives

- What is the difference between broccoli and cauliflower?
- Students will learn how **genes** contribute to different (observable) traits
- Students will explore how all living things (organisms) contain DNA through hands-on experiment
- Students will learn that scientists are exploring ways to make changes in the genes to change a trait in plants (or animals). They are exploring ways to fight disease or solve a problem by changing something about plant or animal.

Vocabulary Words

- **Molecules:** The simplest unit of anything that exists while still being that thing. For example, if we device a molecule of DNA up into its components, it is no longer DNA.
- **Deoxyribonucleic acid (DNA):** The molecule that exists in every cell in your body and that makes you who you are – everyone has different, unique DNA. "The Words"
- **Genes:** Pieces of DNA that serve a particular function; for example, eye color is controlled by a gene, so what color your eyes are depends on what DNA is in that gene. "The Recipes"
- **Genome:** The set of all of an organism's genes and what defines an organism. "The Cookbook"
- **Cells:** The building blocks that make up all living organisms. Each part of your body is made up of different kinds of cells, like skin cells and brain cells. Cells read different parts of DNA depending on where in the body they are. Plants are also made of cells!

Materials

Scientist Volunteers will bring:

For each experiment (per group):

- Strawberries
- 1 ziplock bag
- 1 small plastic cup
- 1 paper towel
- Skewer or something with which to grab the DNA
- 7.5 ml room temperature isopropanol in a 15 ml tube
- 10 ml Extraction Buffer (EB) in a 50 ml tube
- (500 ml EB = 450 ml water + 10 g salt (1 tsp) + 50 ml dishwashing detergent)
    - *These ingredients will be pre-mixed*
- 1 Large tub for secondary containment

Materials teachers should provide:
None

Classroom Set-Up

For the DNA extraction, students should be split into groups of four. Ideally, desks or chairs could be arranged so all four students can see and participate in the experiment.

Students may need to wash their hands after the experiment.

Classroom Visit

1. Introduction (15 minutes)

Overview of lesson:
Can we use science to make broccoli taste better by changing something about the plant, rather than adding fertilizer or more water? We will focus on the idea that genes (comprised of DNA) are what give all living things their features, and we will isolate DNA from fruit to demonstrate what DNA looks like. We will show how scientists actually make changes in the genes of fruits and vegetables to get certain traits.
Questions:

- Some people like broccoli, some people don't -- how would you change broccoli to make it better?
    - We will start to discuss changes to broccoli. We anticipate ideas like making it sweeter, getting rid of the stalk, making it pink… etc.
- What makes a broccoli a broccoli and not, say, a cauliflower?
    - We will use this as a segue into **genes**. Genes provide instructions for broccoli to become a broccoli.
    - Genes and DNA explained:
        - How does a broccoli know to become a broccoli? Imagine you had to tell someone how to create broccoli. How would you do it? You decide to make a cookbook describing broccoli, with individual recipes to make the leaves, the color, the little buds, and the taste. In this example the cookbook is the **genome**, the recipes are the **genes** and the words that provide the instructions is the **DNA**.(will need some visual to support this for elementary)
        - Broccoli (and all of life!) are made up of lots of little pieces called **cells**. You can think of them as legos-- but legos that can become different colors, textures and tastes and move around by themselves to make a large lego broccoli. The way it works is each lego (aka **cell**) has its own "how to be a broccoli" cookbook in its entirety. And each lego follows

the recipes (aka genes) they need to become the leaves, the buds or the roots.
    - How could you change what the cells do, or how the legos combine together? We can give the cells a new cookbook, with some updated recipes -- let's say to make them sweeter or pink (use example generated previously).
    - There are a lot of different plants -- what makes them different? Broccoli and cauliflower have different cookbooks -- but a lot of the recipes are similar. Purple corn and yellow corn are nearly identical, but have different recipes, or genes, for what color to be. Same with different kinds of dogs. People and dogs have more different cookbooks (genomes).
    - But, of course, cells don't actually have cookbooks. They have genes, made out of DNA. DNA is actually a teeny, tiny string with specific molecules that are a code. DNA is more like a very, very long necklace, with different beads that are the like the words, and segments or sections of the necklace are genes.
  - Transition to activity:
    - Scientists have figured out how to write new recipes and put them into the cookbooks of cells. This is called genetic engineering. Scientists can use genetic engineering to make small changes to the trait of a plant. For example, they have figured out how to modify foods to grow bigger, grow faster, have a different color, taste better to people, or taste worse to insects.
    - We can look at DNA by taking it out of cells. We are going to work together to take out the DNA, the very, very long necklaces out of strawberries.

2. Learning Experience (30 minutes)

Students will be divided into groups and will extract DNA from strawberries. To get DNA out of cells, first we need to break the cells with soap (pulverize strawberries, use detergent and salt solution). Then we strain the mush through a paper towel to get rid of everything except DNA– the clear liquid has DNA dissolved in it. Now to see the DNA we can "undissolve" it – we can do this by adding isopropanol – this disturbs the DNA and we can see it come out of solution. This needs to be done slowly and carefully. Look at the DNA! To extract the DNA, each component of the extraction solution plays a part. The soap helps to dissolve the cell membranes. The salt is added to break up protein

chains that hold nucleic acids together, releasing the DNA strands. Finally, DNA is not soluble in isopropyl alcohol, and even less so when the alcohol is ice cold.

1. Take a strawberry in a ziplock bag
2. Squeeze out air, seal bag and then carefully crush until there are no large pieces.
3. Add 10 ml of extraction buffer
4. Seal bag again and mix gently
    a. Avoid creating bubbles from the soapy detergent – a possible technique is to gently tilt back and forth while crushing the strawberry pulp
5. Set up a paper towel in a small cup for filtering the solution
    a. Moisten the paper towel with some water
    b. Wrap the towel around your finger and then insert it into the cup, creating a well
6. Pour the solution into the towel and let it filter
    a. Do not squeeze the towel or bubbles will be created
    b. This step may take up to 5 minutes
7. Transfer 5 to 7.5 ml of the strawberry solution from the cup to the empty falcon tube that had the extraction buffer
8. Slowly add 2 ml of the room temperature isopropanol to the tube by pouring down the side of the tube
    a. DNA will precipitate at the interface
9. Add the rest of the isopropanol to the tube and mix the two layers together by either shaking or inversion
10. DNA will precipitate in the 50% isopropanol solution at room temperature and form a big jellyfish like blob. Fibres are still visible at this stage though not as pretty as at the interface, but you see a lot more DNA.
11. Optional: After 2-3 minutes, insert a skewer into the tube and spool the DNA (this can be transferred to any remaining isopropanol and left with the students)- the DNA should easily stick to the blunt end of a skewer
12. Collect cups and remaining ml falcon tubes (for reuse)

Discussion of experimental results (whole class). Did we see DNA in strawberries? (yes). What do you think our DNA would look like if we got it out of our own cells? (same). Why does it look like fluffy white stuff? (Really long molecules that fold together – kind of like a plate of spaghetti. Can show the class a poster of what a DNA molecule looks like).

3. Wrap Up: Review and Discuss the Learning Experience (10 minutes)

All living things contain DNA. The DNA contains the "recipe" for making that specific living thing.
DNA acts as a blueprint, why a broccoli isn't a cabbage isn't a carrot.
Understanding that DNA is a physical object, and something that scientists can manipulate or change.

Review: What does DNA look like up close, what does DNA feel like (will be safe to touch)
Following protocols, sequential steps that lead to a product
Concluding with connection between DNA extraction and question of what makes a broccoli a broccoli. Could you turn a broccoli into a cauliflower?

4. Connections & Close (5 minutes)

Becoming a scientist: More difficult than not doing it, but significantly more rewarding
Time for Q&A

Follow Up: After the Presentation

This section is background information for teachers:
Genetic modification of plants, "GMOs", have become a social and political topic of discussion. Scientists are focused on "what science CAN do" while the larger society may have some questions concerning "what science SHOULD do". To learn more about the background of genetic engineering and "GMO" in food, visit the sources listed below.
Scientists have been exploring ways to alter the genetic material of living things to address specific problems. Similar techniques for DNA engineering are also going to make big changes in medicine in the next 10 years, and cure diseases that we can't even treat right now. You can learn more by visiting:
http://www.yourgenome.org/facts/what-is-genetic-engineering
http://tiki.oneworld.org/genetics/home.html
https://www.amgenbiotechexperience.com/

Exercise
Maybe change this to start with a problem. If you are a scientist and a farmer asked you to help solve the problem of (molding, or getting bugs, etc.) what would you try to change about the plant? The leaves? Flowers? Scent? Color? Why? Draw your modified plant – does it look any different than the regular one?

Further Reading for teachers (From last year's DNA group)

- Genetics: From DNA to Designer Dogs by Kathleen Simpson. Illustrated with photographs from various sources. National Geographic Society. 64pp. Trade ISBN 978-1-4263-0361-6, $17.95; Library ISBN 978-1-4263-0327-2, $27.90. (I, A) Portraying the work of scientists in the quickly advancing field of genetics, the stories in this book tell about researchers sequencing a mummy's DNA and investigating the use of human stem cells. It includes an interview with a DNA investigator and superb photographs. http://www.nsta.org/recommends/ViewProduct.aspx?ProductID=18798
- Genes and DNA by Richard Walker - Explores modern genetics, from an investigation of genes and their function, to forensics, therapy, and cloning. http://www.amazon.com/Kingfisher-KnowledgeGenes-Richard-Walker/dp/0753456214/
- DNA is Here to Stay by Frances Balkwill - From the moment of conception, the DNA strands contained in the chromosomes of our cells are hard at work duplicating themselves, so that the body can make and maintain all the different parts it needs to function efficiently. What DNA does and how it does it is explained by Dr Balkwill's straightforward text and Mic Rolph's illustrations. This is the third book in a series which introduces microbiology to young readers. The first two titles, "Cells Are Us" and "Cell Wars", won the 1991 Copus Science Book Prize. http://www.amazon.com/DNA-Here-Stay-Cells-Things/dp/0876146388

Standards Connections

Scientific and Engineering Practices:
1. Asking questions and defining problems
3. Planning and carrying out investigations
6. Constructing explanations and designing solutions

Crosscutting Concepts:
6. Structure and function