market science

Genes, Genomes, and GMOs

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Session Goals:

1. Lead visitors through genetic concepts including:
    a. the physical structure of DNA
    b. DNA function in living beings
    c. human manipulation of DNA in the past and present.
2. Provide visitors with a fun and hands-on activity that generates excitement for science.

Activities

Activity #1 – DNA origami

Desired Learning outcomes:

1. Visualize the basic double-helix structure of DNA
2. Learn that DNA contains genetic information
3. Learn that DNA strands are complementary

Materials:

1. Paper template (~40X) and instruction sheet (http://www.yourgenome.org/activities/origami-dna)
2. Scissors

Lesson:

Set up:

Cut off the borders of the templates. A subset of templates can be pre-folded or partially folded to accommodate younger visitors or those in a hurry.

Content:

DNA (deoxyribonucleic acid) is a molecule found in all living beings and it contains the genetic information that determines an organism's traits. This activity is a hands-on approach that allows visitors to visualize the physical structure of DNA. As visitors follow the instruction sheet to fold the DNA, point out the four letters on the borders of the paper (ATCG), which represent the four types of nucleotides. Genetic information is determined by the specific sequence of these nucleotides. Once folded, visitors can see that DNA has complementarity, meaning that Adenine always pairs with Thymine, and Cytosine always pairs with Guanine. When the two strands separate for DNA replication, each strand contains all the information necessary to create its complement, and allows the specific sequence of nucleotides to be copied during cell duplication and to be inherited from one generation to the next.

Activity #2 – DNA extraction from strawberries

Desired Learning outcomes:

1. Understand that all living beings have DNA (including the food we eat)
2. Learn that physical properties of DNA allow us to separate it from other cell contents
3. Create enthusiasm for science among visitors

Materials:

1. Ziploc bags
2. Salt
3. Strawberries
4. Dish detergent
5. Water
6. Coffee filters
7. Disposable cups
8. Rubbing alcohol
9. Ice in a cooler
10. Toothpicks
11. Measuring spoons and cups
12. Water bottle to store lysis solution
13. Wet towelettes for sticky hands
14. Bucket to collect waste

(https://www.genome.gov/pages/education/modules/strawberryextractioninstructions.pdf)

Lesson:

Set up:

Prepare the lysis solution, containing water, detergent and salt, beforehand. Cool the rubbing alcohol and keep on ice for the duration of the session.

Content:

This activity was popular among kids and adults alike, with many commenting on how fun it was and how impressed they were with the results. Young visitors were excited to be 'scientists' for the day. Before starting, give a brief introduction about DNA, explaining that it is a substance found in the cells of all living beings, including the fruits and vegetables we can buy at the market. You can give specific examples of strawberry traits that are determined by DNA, such as the fruit's shape, its red color and its sweet taste. As visitors mash up the strawberry within the ziploc bag and lysis solution is added, you can explain that this step allows the DNA to be released from the inside of the cells. Specifically, the detergent will help disrupt the cell membranes. This mixture is gently filtered into a cup using a coffee filter in order to separate the cell wall material and other solids from the dissolved DNA. For the final step, it is important to note that the DNA, which is soluble in water, is not soluble in alcohol. When alcohol is added, DNA precipitates/becomes a solid and we are able to observe it as white strings floating in the alcohol. Using a toothpick, visitors are able to pick up the DNA and even touch it.

Activity #3 – Introduction to DNA-controlled traits

Desired Learning outcomes:

1. Understand that DNA controls traits (or observable characteristics) in living beings
2. Learn the concept of 'trait' by examples of these in dogs and humans
3. Learn that these traits can be inherited because DNA is transmitted from generation to generation

Materials:

1. Paper printouts of trait charts:
   http://learn.genetics.utah.edu/content/inheritance/activities/pdfs/A%20Recipe%20for%20Traits_Public.pdf (Page 10 and 11)
   http://learn.genetics.utah.edu/content/inheritance/activities/pdfs/Traits%20Trivia_Public.pdf (Page 2)

Lesson:

DNA controls genetic traits, some of which are easily observable. Variations in the DNA sequence of a gene leads to differences between individuals, and these can be inherited. Using the paper printouts, ask visitors to classify the traits they observe in their family pet, or in themselves. Explain that these types of characteristics are inherited and determined by DNA. Others traits, such as the ability to read or tricks that you teach your dog, are learned traits and are not heritable.

Activity #4 – GMO sorting game

Desired Learning outcomes:

4. Understand that many crops on the market are genetically modified
5. Relate the previous DNA-centered activities to the concept of genetic modification
6. Learn examples of genetic modifications and why they are implemented

Materials:

2. Cardboard poster with two halves labeled "GMO" and "Non-GMO"
3. Color printed images of GMO crops, GMO crops that are currently undergoing FDA approval and other non-GMO examples

Lesson:

Though the topic is controversial, the objective of this activity is to simply inform visitors what we mean by Genetically Modified Organism or GMO, and which GMO crops at the time of the session are available to consumers. The volunteer can transition from the topic of DNA extraction or DNA origami by explaining that DNA contains genetic information that controls traits in living beings. Changes in the DNA of a crop can lead to trait changes that benefit farmers or consumers. It is worth mentioning that humans have already altered the DNA of crops over thousands of years, through breeding and selection, but GMO technology allows a more controlled approach to crop modifications. After the visitors have sorted the images as GMO or Non-GMO, the volunteer can show them the correct answers. If the visitor is interested, the volunteer can explain each of the crops' specific modifications, and explain whether they benefit consumers or farmers. Crops like apples and potatoes are undergoing FDA inspection

and approval, and are different from other GM crops on the market because they will benefit consumers.

Pre-session trivia:

1. How big is the human genome? How many genes do humans have?

Answer: The human genome has an estimated 20,000 - 25,000 genes in 3 billion base pairs. This amount of information would take up 3 gigabytes of space in your computer!

2. Where in the cell is DNA located?

Answer: Primarily in the nucleus, but mitochondria and chloroplasts (in plants) also contain genetic information.

3. What is the genetic distance between humans and chimpanzees?

Answer: Human and chimpanzee genomes as greater than 98% identical.

4. True or False. Genes are defined as regions of DNA that are the basic unit of heredity.

Answer: True (for now). The concept of a gene has kept evolving as we learn more about genetics! For example, some viral genomes are made entirely of RNA.

5. What are the four most common GMO products sold in the U.S.?

Answer: Soybean, corn, cotton, and sugar beets.

6. What species has the largest known genome?

Answer: The amoeba *Polychaos dubium* may have the largest genome at 670 billion base pairs. It is over 200 times larger than the human genome, showing that genome size does not necessarily imply higher species complexity.

Links to references or background materials

http://www.yourgenome.org/activities/origami-dna
https://www.genome.gov/pages/education/modules/strawberryextractioninstructions.pdf
https://drive.google.com/file/d/0BwX19Sxq44XGNmcxZWJkNnpNQm8/view?usp=sharing
http://learn.genetics.utah.edu/content/inheritance/activities/
http://learn.genetics.utah.edu/content/inheritance/activities/pdfs/A%20Recipe%20for%20Traits_Public.pdf
http://www.bio.bg.ac.rs/materijali_predmeta/med-eng-griffiths-an-introduction-to-genetic-analysis.pdf (page 130)

Recommended age range

4 +

Optional Handouts

https://drive.google.com/file/d/0BwX19Sxq44XGZlpqMU9LU2JnYzA/view?usp=sharing

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