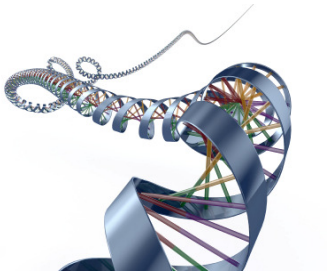
South Florida Science Museum
DNA & Heredity Program Curriculum



PROGRAM DESCRIPTION

This hands-on science lab allows students to explore cells and DNA in an easy-to-understand, engaging manner. Students will use cell models to explore the different parts of an animal cell, as well as look at their very own cells. Students will also be amazed as they work like actual genetic scientists and isolate DNA from cells by using real world technology!

BIG IDEAS

1, 4, 15, 16

SUNSHINE STATE STANDARDS

Grades 4-8:

SC.4.L.16.2 Explain that although characteristics of plants and animals are inherited, some characteristics can be affected by the environment.
SC.4.L.16.3 Recognize that animal behaviors may be shaped by heredity and learning.
SC.4.L.17.4 Recognize ways plants and animals, including humans, can impact the environment.
SC.5.L.15.1 Describe how, when the environment changes, differences between individuals allow some plants and animals to survive and reproduce while others die or move to new locations.
SC.5.L.17.1 Compare and contrast adaptations displayed by animals and plants that enable them to survive in different environments such as life cycles variations, animal behaviors and physical characteristics.
HE.6.C.1.4: Recognize how heredity can affect personal health.
HE.6.B.1.7: Investigate a variety of technologies to gather health information.
HE.6.C.1.8: Explain how body systems are impacted by hereditary factors and infectious agents.
SC.6.L.14.2: Investigate and explain the components of the scientific theory of cell (cell theory): all organisms are composed of cells (single- celled or multi- cellular), all cells come from pre-existing cells, and cells are the basic unit of life.
SC.7.L.16.1: Understand and explain that every organism requires a set of instructions that specifies its traits, that this hereditary information (DNA) contains genes located in the chromosomes of each cell, and that heredity is the passage of these instructions from one generation to another.
SC.8.N.2.2: Discuss what characterizes science and its methods.

MATERIALS

Animal Cell Parts Description Sheet
Foam animal cell models
DNA Model
Test tubes (one per student)
Test tube holders
Stirrer/ glass rod (one per student)
1 liter bottle of water
Laminated paper with period

Laminated photos of cheek cells
Plastic droppers (optional)
Disposable cups (30 or one per students)
70-95% isopropyl or ethyl alcohol (kept EXTREMELY cold in test tubes)
Cooler with ice packs
Detergent solution (Prepare 25 % solution - 1 pt detergent/ 3 pt water) – poured into large test tubes
Salt solution (2 t. dissolved in 1 L of water)

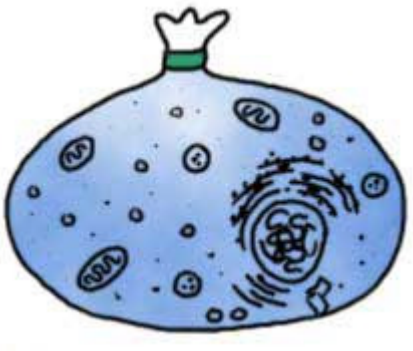
VOCABULARY
Cell- smallest LIVING building block
Chromosomes- made up of DNA and make organisms what they are
DNA- also known as Deoxyribonucleic Acid; carries characteristics from the parents to the offspring; instructs cells how to put together materials to produce certain traits
Double Helix- twisted ladder shape
Genes- segments of DNA in specific patterns
Nucleus- controls many of the functions of the cell (the 'commander' of the cell); contains the genetic code of the cell (DNA)
Genetic- relating to, or produced by, the genes
Heredity- the passing of traits from parents to offspring
Trait- characteristic that is passed through genes

SCRIPT FOR CLASS
What is the smallest living this that exists? *A cell!* Everyone say 'I'm made up of cells.' That is one of the rules that scientists use to determine if something is living. A **cell** is the basic unit of structure and function of life. Cells make up living things and carry out activities that keep a living thing alive. A cell is itself a living unit. So, cells are able to make more cells like themselves. In fact, new cells can come only from existing cells. Some organisms, like bacteria, are made up of one cell while other organisms, like earthworms, trees, and humans are made up of many cells. As you grow larger and larger and larger, that means your body is making more and more and MORE cells. Most cells are microscopic, or so tiny you need a microscope to see them.

Humans have about <u>one hundred trillion cells</u> (100, 000, 000, 000, 000), and more than 200 different types of cells all working together to control our body and keep us alive. That number is more than 15, 000 times the number of people that live here on Earth!

A cell is the smallest LIVING* unit known (the smallest unit known is an atom), and is often called the "building block" of the body. This is because cells make up everything in the body! While your cells keep making more cells, you also have about 300 million cells in the human body that die and are replaced EVERY MINUTE. It is important to keep them all healthy with optimal nutrition.

Structure of a Cell
Pass out the foam animal cell models so the youth can find the parts as you discuss them.



A cell is completely contained within a cell (plasma) membrane. This keeps all of the cell's contents neatly inside, while attempting to keep harmful substances out (*draw a big circle on the board*). It's like the cell's skin. Everyone say CELL MEMBRANE.

Cytoplasm is the fluid that fills the cell. Everyone say CYTOPLASM.

The **nucleus** (*draw a circle inside the circle*) is the "brain" of the cell or the commander. It controls eating or movement. The nucleus knows everything happening in the cell. It's not always in the center, but it won't ever be near the sides because that could be dangerous. It contains the **chromosomes** which make organisms what they are. Chromosomes are made up of **DNA.** Segments of DNA in specific patterns are called **genes**. Your genes make you who you are. **Red blood cells have no nucleus and no DNA.

Introduction to DNA
DNA stands for a big word known as *deoxyribonucleic acid*. Have the students repeat the word. See if they can say it five times fast. DNA is found in segments, called **genes.** Everyone say genes. Then genes make up something called **chromosomes.** Each type of organism has a fixed number of chromosomes. Human beings have 46 chromosomes (23 pairs) in each of our cells.

-DNA is one of the **nucleic acids**, information-containing molecules in the cell (**ribonucleic acid**, or RNA, is the other nucleic acid).
-DNA is what carries characteristics from the parents to the offspring. DNA acts like a blueprint for the cells of an organism, instructing them how to put together materials to produce certain traits.
- Every organism has a set of genes that determines its traits. Traits acquired during your lifetime, such as dyed hair or the shape of a nose that has been altered by surgery, cannot be inherited.
-Twins: Identical twins have exactly the same genes (but they do have different fingerprints); fraternal twins are no more genetically similar than any other two children from the same parents.

Structure of DNA
Show the model of DNA structure.

DNA is a very large molecule with a shape similar to a twisted ladder. This twisted ladder shape is called a **double helix**. Everyone say double helix! The rungs of the ladder are made up of molecules called bases. Human DNA has about 6,000,000,000 'rungs' of DNA. The sides of the ladder are made up of phosphate and sugar molecules. A DNA molecule may contain millions of base pairs. It is the arrangement of these base pairs that determines whether the organism is a rose, a robin, a fish, or a fruit fly.

Although it may look complicated, the DNA in a cell is really just a pattern made up of four different parts called **nucleotides**. Imagine a set of blocks that has only four shapes, or an alphabet that has only four letters. DNA is a long string of these blocks or letters. Each letter on the rung of the ladder represents a base:

A is for adenine (add-uh-neen)
G is for guanine (gwa-neen)
C is for cytosine (site-oh-seen)
T is for thymine (thy-meen)
The steps are formed by the nitrogen bases of the nucleotides where adenine pairs with thymine and cytosine with guanine. Sugar (**deoxyribose**) and phosphates make up the sides of the ladder.

DNA Isolation Introduction
Now you all are going to be genetic scientists and isolate DNA from your very own cheek cells!

Who or what contains DNA? *All living things.* Individual strands of DNA are too small to be visible to the eye. (One million threads of DNA fit onto the period at the end of a sentence using Times New Roman, font 12 in WORD – show laminated paper with period). The reason why we are able to see DNA in this activity is that there are so many of them, clumped together.

DNA Isolation Activity
1. Begin by passing around laminated photos of cheek cells. Point out the nucleus as the organelle where the DNA is located.

Students can either perform the extraction individually/with their partner following their worksheet or teacher can model the extractions while the whole class follows along step by step. Directions for the extraction (also see attached worksheet).

2. FIRST ENSURE THE STUDENTS HAVE NOT JUST EATEN SO THAT NO FOOD PARTICLES END UP IN THE SOLUTION. Have students swirl the 10ml of salt solution in their mouths for 30 seconds. <u>This will remove dead cells lining the mouth</u>.
3. Have students spit their solution back into their cup and then pour it into the large test tube containing the detergent solution.
4. Students should then cap the test tube and GENTLY rock it on its side for 2-3 minutes. IMPORTANT: Don't shake the test tube or mix it too vigorously. DNA will break into smaller fragments and will be harder to see later on.
5. While you are rocking it, let's discuss why we are using the dish soap. What do we normally use dish soap for? To break the fats and grease on our dishes. The plasma and nuclei membrane of a cell is also made up of fatty acids, so the dish soap will help us break through the two membranes to get to the DNA inside the nucleus.
6. DURING THESE THREE MINUTES, you can also discuss why scientists might want to extract DNA. (Try and get the students to say the reasons below). Extraction of DNA is important because of many reasons. With the ability to remove DNA from an organism, scientists can observe, manipulate, and classify the DNA. Scientists can identify genetic disorders or diseases from studying DNA. Scientists can possibly find cures for these causes by manipulating or experimenting with this DNA. They can accurately sort organisms into classes because of DNA uniqueness. If we didn't have DNA extraction, it would be a lot harder to decide which organisms are different from each other.

   Scientists can genetically engineer some organisms to produce beneficial things. A common example is that of insulin. Scientists can genetically engineer insulin production so that

people with diabetes can live longer.

7. After 3 minutes, have students uncap their tube, slightly tilt it and carefully pour the chilled alcohol down the side of the test tube (you can use a dropper to do this as well). The alcohol and the detergent should form two distinct layers with the alcohol sitting on top. It should be almost as much alcohol as detergent. Why is the alcohol just sitting on top of the detergent? *It is less dense.*
8. Have students let the tube stand for one minute. First, have them look for clumps of white stringy stuff where the water and alcohol layers meet.

9. Then, have them CAREFULLY use the stirring rod to slowly move some of the ethanol into the soap layer. DNA will start to precipitate out of the soap solution. DNA is a long, stringy molecule. The salt that you swished in your mouth helps the DNA stick together. So what you see are clumps of tangled DNA molecules!
10. DNA normally stays dissolved in water, but when salty DNA comes in contact with alcohol it becomes undissolved. This is called precipitation. The physical force of the DNA clumping together as it precipitates pulls more strands along with it as it rises into the alcohol. **Make sure they understand that they would NOT be able to see one individual strand of DNA. The white strands that are becoming visible contain many DNA strands clumped together.

My Traits

Living things reproduce to make more organisms like themselves (green mold can only make green mold; humans can only make humans). When organisms reproduce, many traits, or characteristics, of the parents are passed to the new organism.

A **trait** is a characteristic that has been passed from one generation (i.e. your parents) to another (i.e. you). You can receive your traits from either one or both parents. If neither of your parents carry a certain trait, it is likely that you will not have that trait either. What do you think are some examples of a trait? *Curly hair, cleft chin, or dimples*

We are going to see who has the taster trait. Make sure your tongue has plenty of saliva on it because saliva helps you taste. Hand out the "control" paper. Instruct the students to place the control paper on their tongue and leave it there for several seconds to experience what it tastes like. Now hand out a PTC paper strip to each student. Again, place this test strip on the tongue and allow it to remain for approximately 30 seconds. If a student tests positive for the taster trait, a bitter taste will result sooner or later within that time period. IT IS RECCOMENDED TO HAVE SOME PAPER CUPS OR SOURCE OF WATER AVAILABLE for students that test positive for the trait. (*The chemical ingredients of the test strips are safe for the user.) The students which do not detect the bitter taste are non-tasters and should represent about 1/3 of the group tested. Tater traits are found to be approximately 70% of a population or gene pool. *Optional:* The student can also try the thiourea or sodium benzoate test strips. If they did not test positive with PTC paper, they may test positive with one of these two.

About Heredity

What are segments of DNA called? *Genes.* **Genes** are segments of DNA that carry instructions for the traits of an organism from parents to offspring. A **chromosome** may contain thousands of

genes. GENES CONTROL TRAITS. The passing of traits from parents to offspring is called **heredity.** (The Austrian monk Gregor Mendel is often called the 'Father of Genetics.' Mendel did many early experiments with heredity, setting the stage for genetics, the study of heredity.)

Imagine a cat with black and white fur. The genes in the nuclei of this cat's cells direct the production of proteins that cause black or white fur to grow on certain parts of its body. The petals of a sunflower are bright yellow because its genes direct the production of proteins that specify a yellow color.

You don't look exactly like with parents because you receive only some genes from each parent. Your genes determine your skin color, hair texture, and whether or not your can roll your tongue into a U-shape. *Humans* have thousands of different genes. They are located on the 23 pairs of chromosomes in the nuclei of our body cells. Taken together, ALL THESE GENES MAKE UP THE HUMAN **GENOME.**