DNA: The Foundation for YOU

GRADE LEVELS:
Grades 9th - 12th

CONCEPT:

- Explore the structure of DNA and how it relates to the cellular structure and expression of characteristics.

OBJECTIVES: Participants will be able to:

- Learn about the early research on genetics and DNA.
- Learn about current research on genetics.
- Extract actual DNA.

ACADEMIC CONTENT STANDARDS:

- Science: Life Science: 10.5, 10.6, 10.7, 12.1, 12.4, 12.5, 12.6

VOCABULARY WORDS:
Chromosome - Any of several threadlike bodies that carry the genes in a linear order: the human species has 23 pairs, designated 1 to 22 in order of decreasing size, and X and Y for the female and male sex chromosomes respectively.
DNA (Deoxyribonucleic acid) - an extremely long macromolecule that is the main component of chromosomes; it is the material that transfers genetic characteristics in all life forms.
Dominant - The member of a pair of alleles that masks the effect of the other when both are present in the same cell or organism.
Double Helix - The spiral arrangement of the two complementary strands of DNA.
Enzyme – A protein, such as pepsin, originating from living cells and capable of producing certain chemical changes in organic substances by catalytic action, as in digestion.
Genetics - The science of heredity; deals with resemblances and differences of related organisms resulting from the interaction of their genes and the environment.
Natural Selection - The process by which organisms having traits that better enable them to adapt to specific environmental pressures tend to survive and reproduce in greater numbers than others of their kind, thus ensuring the perpetuation of those favorable genetic traits in succeeding generations.
Photo-sensitive - Sensitive to light or similar radiation.

Recessive – The member of a pair of alleles whose effect is masked by the activity of the second when both are present in the same cell or organism.
Traits - A distinguishing characteristic or quality.
X-ray crystallography - The determination of the structure of a crystal by bombarding it with x-rays and deciphering the pattern made by the scattering of the waves.

ADDITIONAL RESOURCES:

National Human Genome Research Institute
http://www.genome.gov/Education/
Human Genome Project
http://www.ornl.gov/sci/techresources/Human_Genome/education/education.shtml
Center for Disease Control-Genomics
http://www.cdc.gov/genomics/resources/e.htm

SAMPLE TEST QUESTIONS:

1. What does DNA stand for?
   a. Denatured Nucleic Acid
   b. Deoxyribonucleic Acid
   c. Double Nucleic Acid
   d. None of the above

2. In base pairing, purines form hydrogen bonds with pyrimidines. What are the 4 nucleobases that are in DNA?
   a. adenine, guanine, cytoplasm, terra
   b. adenine, guanine, cytosine, thymine
   c. adenine, gene, covalent, thymine
   d. acridine, gene, cytosine, trait

3. The shape of DNA is:
   a. A spiral
   b. A helix
   c. A double helix
   d. Parallel strands

DNA Pre Visit Activities

Candy Dish Selection

Objective: Students participate in a demonstration of natural selection.

Materials:

- Variety of candies, including popular ones and unpopular ones. You should have at least two candies per person plus plenty of unpopular ones. Possibly include candies with different colors, sizes, brand names, etc. (avoid candies with nuts for kids who are allergic).
- A large bowl

Procedure:

1. Make the candy dish accessible in advance so students can pick candies over a period of time, or the dish can be passed around the room a couple times. You can avoid commenting about it at all, or you can make very innocent remarks about providing a treat for the students.
2. After more than half of the candy has been removed, gather the class together. Start the discussion by pointing out that there is often great variation among individuals of animal species. For example, students can look around the room and list the characteristics that vary among humans. Then, ask the students why variation is significant. (One reason variation is important is that variation allows for differential survival of individuals.)
3. Show them the candy bowl and the remaining candies. Count the candies that remain and list them on the board. Ask the students if they remember which candies were originally available. Make a list on the board of the original types of candies.
4. Now ask them to list the traits of the candy they *selected* from the candy dish (examples include: chocolate flavor, large size, favorite brand, etc). These are the traits that led to the removal of certain candies.
5. Make a list now of the traits of the candies that were *not selected* (examples: bad flavor, small size). These are the traits that allowed the candies to survive being passed around the room.
6. So, the fact that there were different candies with different traits resulted in some candies being eaten and others surviving. This is what natural selection does with individuals in a population. Each individual has unique traits; some traits will help an individual survive and some traits do not.

What Happened?

This activity provides a model for natural selection. It is, of course, artificial both in the sense that the selecting is done by people and that the "organisms" being selected are nonliving entities with no genetics and no ability to reproduce. Charles Darwin, in modeling natural selection, used the artificial selection of pigeons to illustrate how selection can over time modify populations of living things. This activity is at least one additional step removed from the reality of natural selection, but it provides one way to illustrate the mechanism. The concept of natural selection should be pursued in many other ways in order to help students understand its centrality to evolutionary theory.

Extension:

A teacher could continuously add candy into the candy bowl according to the proportions left in the candy bowl. For example, if after the first round all the Hershey kisses disappeared but there were a lot of yellow Starbursts remaining, then add more yellow Starbursts but do not add any more kisses. This will accentuate the loss of favorite candies and the proliferation of the remaining ones. In addition, this extension will simulate the production of new generations, similar to the evolution of populations over time. Another possibility is that you will see students taking their second choice of candies, simulating the natural situation where predators will start consuming another prey item when their favorite prey item is eliminated.

Academic Standards:

- Life Sciences: 10.13, 10.21, 10.22

String Genome

Objective: Students will observe that DNA is very long, very skinny, and packs well into cells. They will learn that only a small fraction of the DNA in our cells encodes the approximately 23,000 genes. Students will be able to discuss the usefulness and limitations of this model.

Materials:

- 2 meters of black yarn
- 10 cm length of sticky-backed labels (in blue to represent "blue genes")
- Optional - 10 cm red sticky-backed labels
- scissors

Instructions:

1. Tell the students to cut the labels into 23,000 pieces to represent the 23,000 genes in our genome.
2. If their scissors are not sharp enough to do this, they may cut the labels into about a dozen pieces.
3. These are then stuck onto the string in a distributed fashion.

What's Going On?

The human genome contains about 3 billion nucleotides, about the same number of nucleotides possessed by mice, apes and most other mammals. If you were to unravel the DNA packed into all 23 pairs of chromosomes in just one of your cells, how long would that stretch of DNA be? It would be 2 meters long! Two meters multiplied times 10 trillion cells in your body is enough DNA to stretch to the sun and back almost 70 times! This string is mostly black, with a little red and a little blue. The blue region represents genes. The red represents control genes or regulatory elements that regulate when genes are turned on or off. The black represents the so called "dark matter" or junk in our genes.

Academic Content Standards:

- Science: Life Sciences: 10.6

DNA Post Visit Activities

Multifactorial Inheritance

Objective: Using the example of a common disease, students will learn that disease progression has many factors, including a combination of genetics and environment.

Materials:

- 1 die
- pencil
- paper

Procedure:

1. Roll the die as instructed. Record the points awarded in the spreadsheet.
2. Add up your score to find out if this fictional person will develop heart disease.

Roll 1: Genetic Contribution

Using the following scale ranging from 1-6 (1 being No Family History of heart disease and 6 being Strong Family History of heart disease), roll the die and start a total with your current roll number:

1	2	3	4	5	6
No family History					Strong Family History

Roll 2: Blood Pressure

High blood pressure can increase risk for developing heart disease because blood vessels can become weak and/or prone to blockage.
Roll the die and add the points to your starting number.
1, 2 or 3: No points (normal blood pressure)
4, 5 or 6: Add 2 (high blood pressure)

Roll 3: Smoking

People who smoke or are exposed to smoke tend to develop more blood clots in their arteries, reduced blood oxygen levels and elevated blood pressure.
Roll the die and add the points to your running total.

1 or 2: No points (non-smoker)
3 or 4: Add 1 (some smoke exposure)
5 or 6: Add 3 (heavy smoker)

Roll 4: Nutrition

A diet high in fat can cause the arteries to become narrow, which makes it harder for the blood to circulate.
Roll the die and add the points.
1, 2 or 3: No points (low fat diet)
4, 5 or 6: Add 3 (high fat diet)

Add up all of your points. If the score is 10 or more, the fictional person will develop heart disease.

What happened?

Many of the common diseases in developed countries like Canada fall into the multifactorial inheritance category, examples being diabetes, MS, and heart disease. Basically, multifactorial means there are many factors involved in disease progression, and a combination of genetics and environment.

We will use the example of heart disease to illustrate the many factors that can cause multifactorial diseases. In Canada, heart disease and stroke account for up to 1/3 of all deaths. It does run in families but not in a nice, neat pattern like a single gene disease. The risk of developing heart disease increases if you are related to someone with heart disease and/or you are exposed to certain environmental factors.

Additional Facts about Heart Disease

- Heart disease is an umbrella term for multiple conditions including: coronary artery disease, heart attacks and congestive heart failure.
- The risk for developing heart disease is increased in relatives of people with heart disease (genetic factors).
- Heart disease increases in the presence of certain environmental events. These include smoking, lack of exercise, and poor nutrition.

REMEMBER: This activity does not predict your actual risk of developing heart disease. It is a model to show how genetic and environmental events can interact to produce disorders.

Academic Standards:

- Science: Life Sciences: 11.1, 12.5

To Taste or Not to Taste

Objective: Students will be able to determine whether they are 'tasters' or 'non-tasters', test selected individuals from their families and peer group for the trait, and chart all findings from all students to determine which trait is dominant.

Materials:

- Large sheet of butcher paper
- PTC Taste Paper
- Sodium Benzoate Taste Paper*
- Thiourea Taste Paper*
- Control Taste Paper*
- Envelopes containing three complete sets of Taste Papers, numbered to match the sequence of the activity
- Notebook paper
- pencil
- paper cup of water

* Test papers are available through scientific supply stores and catalogues.

Procedure:

1. Students will discuss traits that they know are dominant in their immediate families and peer groups (i.e., hair and eye color, right/left handedness). List traits and post.
2. Students will number a sheet of notebook paper from 1-5.
3. Distribute paper cups of water to "cleanse the palate."
4. Distribute PTC taste paper, one to each student with instructions to taste the paper and write down what it tasted like. Tell them not to share their results with anyone yet. It is OK if it tastes like nothing, or like paper (that would be the control). It could also taste salty, sweet, bitter, hot, etc.
5. Continue with the other taste papers, and have the students record how each paper tasted.
6. Collect results and graph the data on a large sheet of butcher paper.
7. Using the chart, predict which trait (taster or non-taster) is dominant in their families, and in the general population.
8. Assignment: Each student will take three complete sets of taste papers home to test parents and one friend. Test papers are to be numbered to correspond with the sequence of the previous activity. (If a student has one parent or is living with a relative, he may go ahead and test that person or persons.)

What's Going On?

Phenylthiocarbamide, also known as PTC, or phenylthiourea, is an organic compound that either tastes very bitter or is virtually tasteless, depending on the genetic makeup of the taster. The ability to taste PTC is a dominant genetic trait. The test to determine PTC sensitivity is one of the most common genetic tests on humans.

About 70% of people can taste PTC, varying from a low of 58% for Indigenous peoples of Australia and New Guinea to 98% for Indigenous peoples of the Americas. One study has found that non-smokers and those not habituated to coffee or tea have a statistically higher percentage of tasting PTC than the general population. PTC does not occur in food, but related chemicals do, and food choice is related to a person's ability to taste PTC. There is conflicting evidence as to whether a higher percentage of women than men can taste PTC.