DNA Blueprint for Life

Objective

Students conduct an experiment with fruit to isolate DNA and research online to learn more about the reasons for isolating DNA.

Background

A blueprint is a detailed drawing or map which identifies and directs the construction and development of a building or an object. DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA. DNA is the blueprint that guides the construction and development of living organisms. If the 46 DNA molecules from the chromosomes of one cell were placed end-to-end, they would be up to eight feet long but so thin you couldn't see them.

In the nucleus of each cell, the DNA molecule is packaged into thread-like structures called chromosomes. Each chromosome is made up of DNA tightly coiled many times around proteins that support its structure. Human DNA consists of about 3 billion bases, or nucleotides, and more than 99 percent of those bases are the same in all people. The order, or sequence, of these bases determines the information available for building and maintaining an organism. When the cell is not dividing, chromosomes are not visible in the cell's nucleus, not even under a microscope. However, the DNA that makes up chromosomes becomes more tightly packed during cell division and is then visible under a microscope. Most of what researchers know about chromosomes was learned by observing chromosomes during cell division.

DNA isolation is the process of extracting DNA from a cell. It involves separating DNA from other cellular components. DNA is isolated by placing the cells in a tube containing a special solution and mechanically or chemically breaking the cells open. This causes the cell to release its contents into the solution, which may contain enzymes, chemicals, and salts. Enzymes are used to chew up the proteins; chemicals to destroy any rnA present and salts to help pull the DNA out of solution. The DNA will exist in long strands that form a mucous-like glob.

Oklahoma Academic Standards

GRADE 6
Physical Science: 1-4. Life Science: 1-1,2,3

GRADE 7
Physical Science: 1-1,2. Life Science: 3-1

GRADE 8
Physical Science: 1-3,5. Life Science: 1-7

Materials Needed

(for each student)

strawberries or 1/2 banana
a knife
a coffee filter
two normal sized plastic cups
one small test tube (or clear film canister or medicine bottle.)
15 ml 91% alcohol (Prior to activity place test tubes with alcohol in freezer.)
a teaspoon of salt
1 tablespoon clear shampoo
1 eye dropper or pipette
fork for mashing
small shallow bowl for mashing
tooth picks or swizzle sticks

CAUTION: Rubbing alcohol is POISONOUS!

Vocabulary

blueprint—a detailed drawing or map which identifies and directs the construction or development of a building or an object **cell**—the basic unit of living systems

chromosome—the tiny rod-shaped bodies in a cell's nucleus that carry the hereditary information; Humans have 23 pairs of chromosomes. Each chromosome is a single long, thin DNA molecule

DNA (deoxyribonucleic acid)—molecule that contains genetic information and is located in the nucleus of every cell inside an organism

DNA extraction—the separation of DNA from the unwanted substances of the cell

enzyme—protein controlling biochemical reactions; any complex chemical produced by living cells that is a biochemical catalyst

gene—the basic unit of heredity that serves as a blueprint for each protein product produced in the human body; Humans have over 30,000 genes.

molecule—the smallest physical unit of a substance that can exist independently, consisting of one or more atoms held together by chemical forces

nucleotide—building blocks of DNA (G,A,T,C) also called "bases"

nucleus—the central body, usually spherical, within a eukaryotic cell, that is a membrane encased mass of protoplasm containing the chromosomes and other genetic information necessary to control cell growth and reproduction

Science

1. Read and discuss background and vocabulary.
2. Follow the steps on the worksheet that follows to demonstrate DNA isolation.
3. Try different fruits and veggies, shampoos, and other experimental variables; iodized vs. non-iodized salt; bottled vs. tap water.
4. Meat tenderizers contain DNA cutting enzymes. Try adding meat tenderizer to the solution. Do any of these variables change the experiment outcomes?
5. Research DNA extraction on the internet to learn why scientists are interested in isolating DNA.
6. Make DNA Fruit Smoothies from the leftover fruit puree used in the demonstration.
   —To the leftover fruit puree add 1 banana, 1 cup orange juice, 4-8 tablespoons honey (to taste), and 5-10 ounces. frozen strawberries. If desired you may add tofu (12.3 oz) or yogurt.
   —Blend to desired consistency, and pour into small cups. Can you taste the DNA?
7. Students will use this experiment to extract their own DNA:
   —Mix 500 ml bottled water with 1 T salt.
   —Stir until salt is dissolved.
   —Transfer 3 T of the salt water mixture into a clear cup.
   —Rinse your mouth with the salt water for 1 minute.
   —Spit the salt water back into the cup. Your cheek cells are now suspended in the cup.
   —Gently stir in 1 drop of clear dish soap.
   —In a separate cup mix 100 ml isopropyl alcohol (70 percent) with 3 drops of food coloring.
   —Tilt the salt water cup and gently pour in the food coloring/alcohol moisture so it forms a layer on top.
   —Wait 2.5 minutes. You will see white clumps and strings forming. That is your DNA. (Source: NOVA Education)
8. Hand out the instructions for DNA Bracelets, included with this lesson. Students will follow the instructions to make models of the DNA codes of common animals by following the instructions.

Extra Reading

Balkwill, Frances R., and Mic Rolph, *Have a Nice DNA (Enjoy Your Cells, 3)*, Cold Springs Harbor Laboratory, 2002.

Edom, Helen, *Science With Plants*, Usborne, 2007.

Hesser, Leon, *The Man Who Fed the World: Nobel Prize Laureate Norman Borlaug and His Battle to End World Hunger,* Durban House, 2006.

Simpson, Kathleen, *Genetics: From DNA to Designer Dogs*, National Geographic, 2008.

Somervill, Barbara A., *Food Scientist (Cool Careers)*, Cherry Lake, 2009.

DNA Blueprint for Life

1. Measure 2 teaspoons (10 ml) shampoo into a small cup.
   WHY? The cell membrane and nuclear membrane are broken down by soaps such as those found in shampoo and dish soap. When you wash dishes, the fats (grease) are removed from your dishes by the dish soap. When you wash your hair the shampoo removes the grease and oils.

2. Add 2-3 pinches of salt (naCl) to the shampoo.
   WHY? The positively-charged sodium ions (na +) are attracted to the negative charge of the DNA. This creates a "shield" around the DNA molecules and causes them to stick together (coalesce). This enables the DNA to precipitate out of the solution when added to alcohol in a later step. Add 4 teaspoons (20 ml) tap water. Mix with a spoon, but try to avoid creating bubbles in the solution.

3. Place fruit on a paper plate or in a bowl and mash with a fork. Add approximately the same volume ofwater. The mixture should be the consistency of a smoothie (not too thick or too thin). Add fruit or water as needed.
   WHY? Blending or mashing the fruit with water causes some of the cells in the fruit to break open. Because DNA has a negative charge, it is able to dissolve in the water. Many other cell parts will not be soluble in water.

4. Add 4 teaspoons (20 ml) of the fruit puree to the cup containing the shampoo/salt solution. Gently mix with a spoon until the mixture develops a uniform consistency. Try not to create too much foaming. This will interfere in the filtration step and may damage the long, fragile DNA molecules.

5. Save the remaining fruit puree. This may be used to make a smoothie.

6. Place a cone-shaped coffee filter into a cup. The bottom of the filter must not touch the bottom of the cup. Fold the edge of the filter over the cup.

7. After the fruit-shampoo mixture has been mixed for several minutes, pour it into the coffee filter. Filter the mixture until there are at least 2 teaspoons or 10 ml of filtrated liquid in the cup.
   WHY? Filtering the soapy fruit solution through a coffee filter removes extra cell debris (cell membranes, precipitated proteins, and excess fruit pieces that didn't get completely pureed). The DNA molecules are soluble in the water, which enables them to pass through the filter.

8. Pour 4 teaspoons (20 ml) of ICE COLD 91% isopropyl rubbing alcohol into the test tube (approx. 1/2 full).

9. Pick up filtered fruit extract in eye dropper or pipette (10 ml). Gently squirt the extract into the chilled alcohol. To get a good yield of DNA it is important to keep the tube still. Do not shake it. The DNA will slowly come out of the solution and coagulate. After a few minutes, you should see a white "glob" forming in the solution. This is DNA!

10. The DNA can be scooped out and dried on a card. Spool out the DNA with a toothpick or swizzle stick.

Oklahoma Ag in the Classroom is a program of the Oklahoma Cooperative Extension Service, the Oklahoma Department of Agriculture, Food and Forestry and the Oklahoma State Department of Education.

11. Place the DNA on a black or blue card to create a DNA blueprint. Once the DNA dries, students will begin to identify its stringy, spider-web type structure.

    WHY? DNA molecules are soluble in water but not in an alcohol solution. When the fruit DNA solution comes in contact with alcohol, the long, stringy DNA molecules precipitates into the alcohol. You can see this long, stringy precipitated DNA. What you see is thousands of DNA molecules that are stuck together. Pure DNA is a colorless molecule. Fruit pigment molecules that got trapped in the stringy DNA cause any color that you may see in your DNA.

12. To save the DNA, remove it from the container and place it in another container containing only alcohol.

Review

1. The shampoo breaks up the fatty membranes of the cell, allowing the DNA to come out of the cell (cutting the fruit into pieces, blending or mixing and mashing the mixture breaks down the cell walls as well).

2. Filtering the fruit "goo" gets rid of the debris you no longer need.

3. Salt can dissolve in water, but not in alcohol.

4. In the fruit 'goo' the salt binds to the DNA.

5. When the DNA and the salt are put into alcohol, the salt solidifies into the solution and can be visibly seen along with the DNA. The salt falls to the bottom of the test tube. The solution is kept cold to help the precipitation of the salt and the DNA.

Discussion

1. DNA coagulates in the top of the test tube, what is the substance that precipitates to the bottom of the test tube?

2. Examine the DNA blueprint on your card? What do you see? What do you think it is?

3. What do you know about DNA? What do you still need to learn?

Sources: University of Illinois extension (2003), Biotechnology Curriculum; national 4-H Council (1997), Field of Genes (http://fog.n4h.org); Iowa State University Biotechnology

DNA Bracelet

Materials Needed

Pony beads in the following colors: purple, yellow, green, pink
Extra Long Chenille sticks or bracelet string from a craft store

1. Choose one DNA code from the chart provided by your teacher. You will need this chart to follow the DNA pattern to make your bracelet.

2. Thread a bead onto your first Chenille stick. Then on the second Chenille stick thread the matching bead. Use the guide below to help. Example would be if your first bead on the first Chenille stick is Pink (T) then on your second Chenille stick the bead would be Green (A), because T always pairs with A.

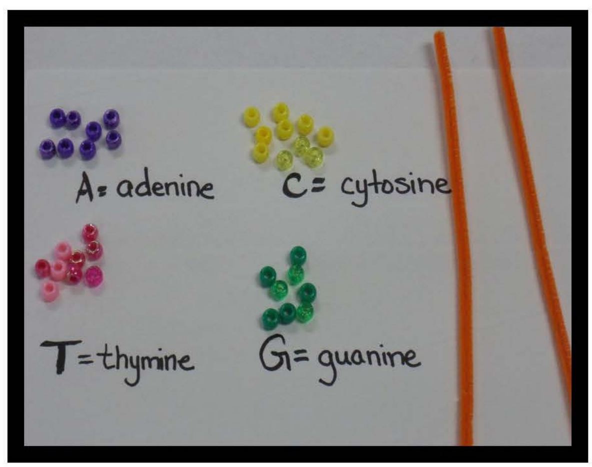
3. Finish out both sides of your DNA strands following the pattern provided by your teacher.

4. Once all your beads have been placed on their Chenille sticks, twist them into the form of a Helix (sometimes referred to as the DNA ladder)

5. Tie the Chenille sticks together to form a bracelet to fit your wrist. See if your friends can figure out what plant or animal you are based on your DNA.

BASE PAIR CHART

A (purple) pairs with **T**
T (pink) pairs with **A**
C (yellow) pairs with **G**
G (green) pairs with **C**



Thanks to Illinois Ag in the Classroom for the DNA bracelet activity.

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DnA Codes for Common Animals

Monarch Butterfly (Danaus Plexippus)
gaggctaccaagtttccgatctgcaggagatgcattgaaagatcgtttcg

Grizzly Bear (Ursus Arctos)
atgaccaacatccgaaaaacccacccattagctaaaatcatcactacte

Sunflower (Helianthus Annuus)
tgagatgctagaaggtgcaaaatcaatagggcccggagctgctacaattg

Chimpanzee (Pan Troglodytes)
tgaccccgacacgcaaaattaacccactaataaaattaattaatcactca

Human (Homo Sapiens)
tgaccccaatacgcaaaattaacccccctaataaaattaattaaccgctca

African Elephant (Loxodonta Africana)
atcaccgacattcgaaaatctcatccttcactcaaaatgatgaataaatc

Apple Tree (Malus Domestica)
gaattcggcacgagaagaaacgaagagagagagagagag-caaaaatggtt

Red Flour Beetle (Tribolium Castaneum)
cacaacctcggggatcgccttcgccatcctctgcctggccgagaatccca

Brown Trout (Salmo Trutta)
ctttggctcactcttaggcttgtgtctagccacccaaatcttaccggac

Human Heart
gttgctggtacaatctcataaaatcgggctccagtgtttagagaaggacag

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