

DNA¹

Today you will extract DNA from some of your cells and learn more about DNA.

★ Why is DNA so important in biology? What is the function of DNA?

★ Draw a simple diagram of a cell, showing the cell membrane and the DNA in **chromosomes** surrounded by a nuclear membrane.

Extracting DNA from Your Cells

Cells from the lining of your mouth come loose easily, so you will be able to collect cells containing your DNA by swishing a liquid around in your mouth.

To extract DNA from your cells, you will need to separate the DNA from the other types of biological molecules in your cells. You will be using the same basic steps that biologists use when they extract DNA (e.g. to clone DNA or to make a DNA fingerprint). You will follow these 3 easy steps to extract the DNA:

- Detergent
- Enzymes (meat tenderizer)
- Alcohol

Getting Your Sample of Cells

Obtain a cup with sports drink. You will need to get thousands of your cheek cells in the sports drink in order to extract enough DNA to see. Therefore you should swish the sports drink around in your mouth vigorously for at least one minute. Then spit the drink back into the cup.

Step 1: Detergent

Add a small amount of detergent to a test tube (about 0.25 mL). Put a glove on the hand you will use to hold your test tube, not the hand you will use to pour. Now carefully pour the drink containing your cheek cells into the test tube with detergent until the tube is **half full**.

Why am I adding detergent?

To get the DNA out of your cheek cells you need to break open both the cell membranes and the nuclear membranes. Cell membranes and nuclear membranes consist primarily of lipids. Dishwashing detergent, like all soaps, breaks up clumps of lipids. This is why you use detergents to remove fats

¹ Based on and adapted from the Genetic Science Learning Center's "How to Extract DNA from Any Living Thing" (<http://learn.genetics.utah.edu/units/activities/extraction/>) and BioRad's "Genes in a bottle" (http://www.biorad.com/cmc_upload/Literature/54133/4110034B.pdf), by Drs. Jennifer Doherty and Ingrid Waldron, Department of Biology, University of Pennsylvania, © 2011

Teachers are encouraged to copy this Student Handout for classroom use. A Word file (which can be used to prepare a modified version if desired), Teacher Preparation Notes, comments, and additional activities for teaching biology are available at http://serendip.brynmawr.edu/sci_edu/waldron/

(which are lipids) from dirty dishes. Adding the detergent to your cheek cell solution will break open the cell membranes and nuclear membranes and release your DNA into the solution.

Step 2: Enzymes

Add a pinch of enzyme (meat tenderizer) to your test tube. With your gloved thumb (or palm) covering the top of the test tube; gently invert the tube five times to mix. Remove your glove and throw it in the garbage. Let the mixture sit for at least 10 minutes. *While you are waiting, answer the questions on this page and the next.*

Why am I adding enzymes?

The nucleus of each of your cells contains multiple long strands of DNA with all the instructions to make your entire body. If you stretched out the DNA found in one of your cells, it would be 2-3 meters long. To fit all of this DNA inside a tiny cell nucleus, the DNA is wrapped tightly around proteins. The enzyme in meat tenderizer is a protease, which is an enzyme that cuts proteins into small pieces. As this enzyme cuts up the proteins, the DNA will unwind and separate from the proteins.

★ The protease in meat tenderizer comes from plants, but animals also make proteases. What is one reason why humans and other animals need to have protein-cutting enzymes?

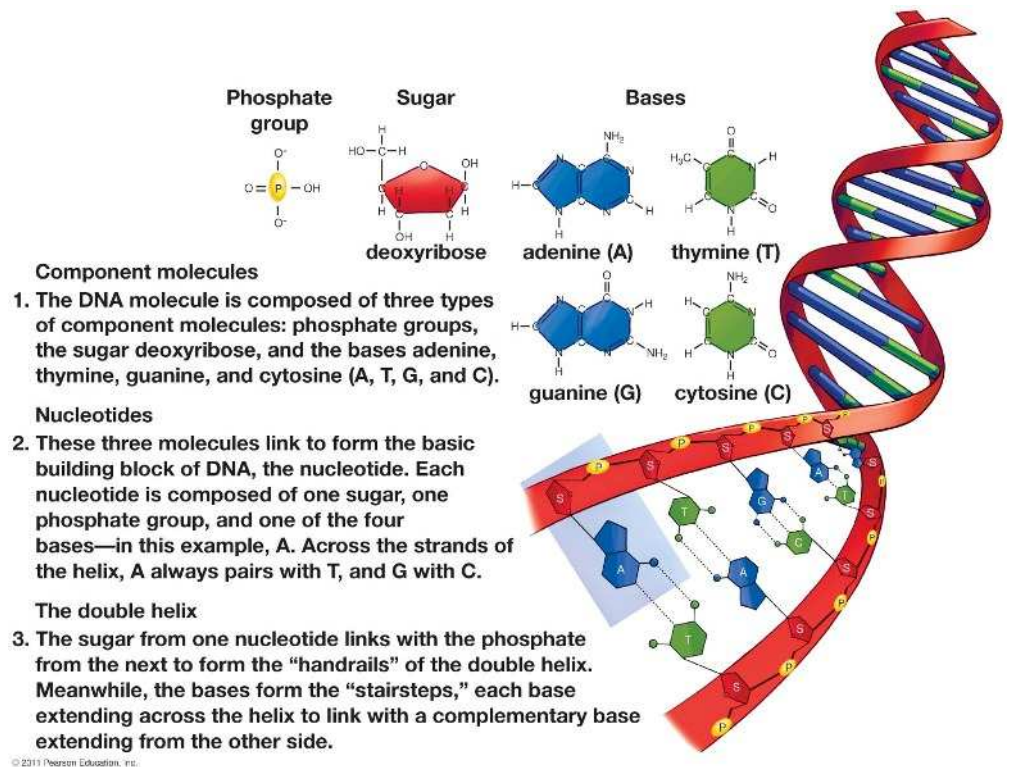
DNA Structure

DNA consists of two strands of **nucleotides** wound together in a spiral called a **double helix**. Read the explanation in the figure before answering questions 1 and 2.

1. The three components of each nucleotide are:

Draw a rectangle around a single nucleotide in the double helix.

2. The complete name for DNA is **deoxyribonucleic acid**. Which component of each nucleotide accounts for the "deoxyribo" part of this name?



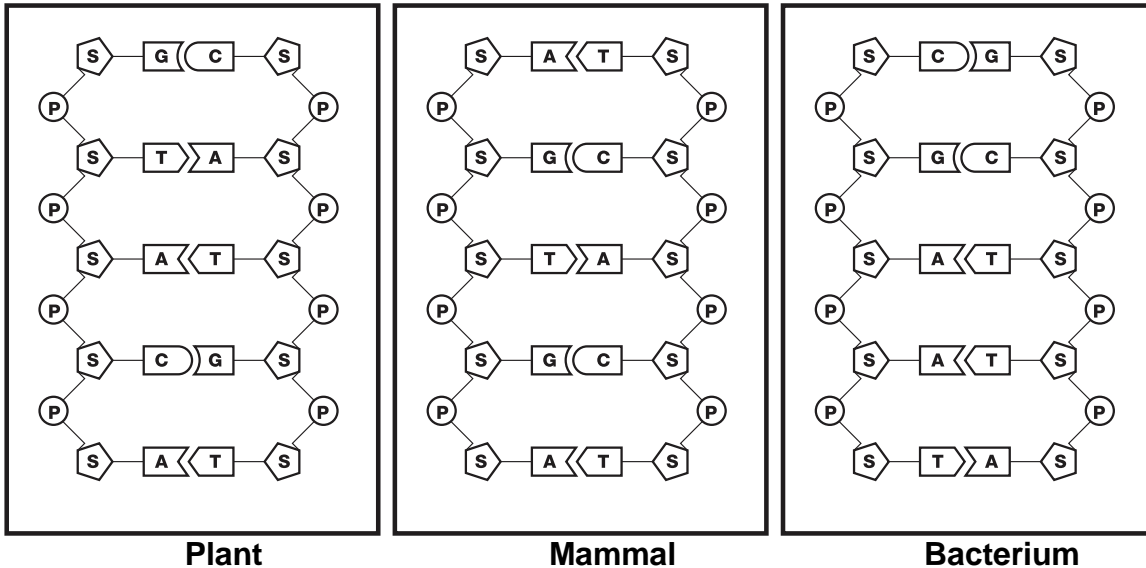
(Figure from [Biology -- A Guide to the Natural World](#) by Krogh)

The drawings below show a very small section of the DNA double helix from three very different organisms: a plant, a mammal, and a bacterium. Each strand of DNA shown contains five nucleotides. Each nucleotide has:

S = sugar molecule called deoxyribose

P = phosphate group

plus one of the four bases: **A** = adenine, **C** = cytosine, **G** = guanine, or **T** = thymine



(From BioRad's "Forensic DNA fingerprinting kit" http://www.bio-rad.com/cmc_upload/Literature/12525/4006096G.pdf)

3. Complete the following sentences to describe the structure of DNA.

In the backbone of each strand in the DNA double helix molecule, the sugar of one nucleotide is bonded to the _____ in the next nucleotide.

The _____ of the nucleotides in each strand of DNA extend toward each other in the center of the DNA double helix molecule.

A in one strand always pairs with _____ in the other strand, and **G** in one strand always pairs with _____ in the other strand. These are the **base-pairing rules**.

4. DNA has the same double helix structure in all living organisms. However, we know that a plant, mammal and bacterium must have different genes in their DNA to result in the very different characteristics of these different organisms. So, the question is: What is different in the DNA of these different organisms? Complete the following table to identify what is different between the DNA of the plant, mammal and bacterium.

	Compare the plant and mammal DNA.	Compare the mammal and bacterium DNA.
Is the arrangement of the sugar and phosphate groups the same in each type of DNA?		
Does each type of DNA contain the same four bases (A, C, G, T)?		
Is the sequence of bases the same in each type of DNA?		
Are the base-pairing rules the same in each type of DNA?		

What is the only characteristic that differs between these segments of DNA from a plant, a mammal and a bacterium?

Step 3: Alcohol

Using a pipette, slowly add cold rubbing alcohol into the test tube; let the alcohol run down the side of the test tube so it forms a layer on top of the soapy liquid. Add alcohol until you have about 2 cm of alcohol in the tube. Alcohol is less dense than water, so it floats on top. **Do not mix or bump the test tube for 10 minutes.** DNA molecules will clump together where the soapy water below meets the cold alcohol above, and you will be able to see these clumps of DNA as white strands. *While you are waiting for the DNA to become visible, answer the questions in the section on DNA replication (this page and the next).*

Why am I adding alcohol?

The cold alcohol reduces the solubility of DNA. When cold alcohol is poured on top of the solution, the DNA precipitates out into the alcohol layer, while the lipids and proteins stay in the solution.

DNA Replication

New cells are formed when a cell divides into two daughter cells. For example, cell division in the lining of your mouth makes the new cells that replace the cells that are rubbed off whenever you chew food. Before a cell can divide, the cell must make a copy of all the DNA in each chromosome; this process is called **DNA replication**.

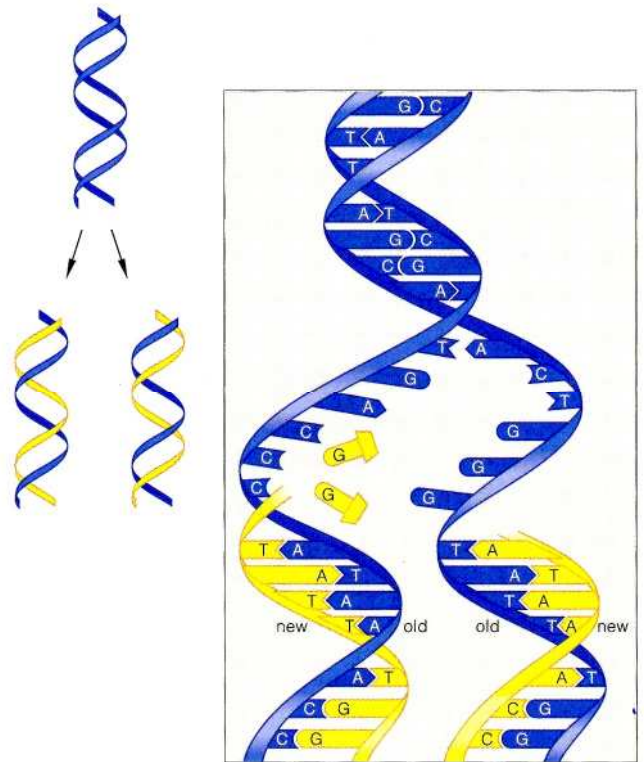
1. Why is DNA replication necessary before each cell division?

The process of DNA replication is shown in the figure on the right. During DNA replication, the two strands of the DNA helix are separated and each old strand provides the instructions for making a new matching strand. The nucleotides in the new strand are added one at a time. Each new nucleotide is matched to a nucleotide in the old strand using the base-pairing rules.

DNA replication results in two new DNA molecules that are identical to the original DNA molecule. Thus, each of the new DNA molecules has the same genetic information as the original DNA molecule.

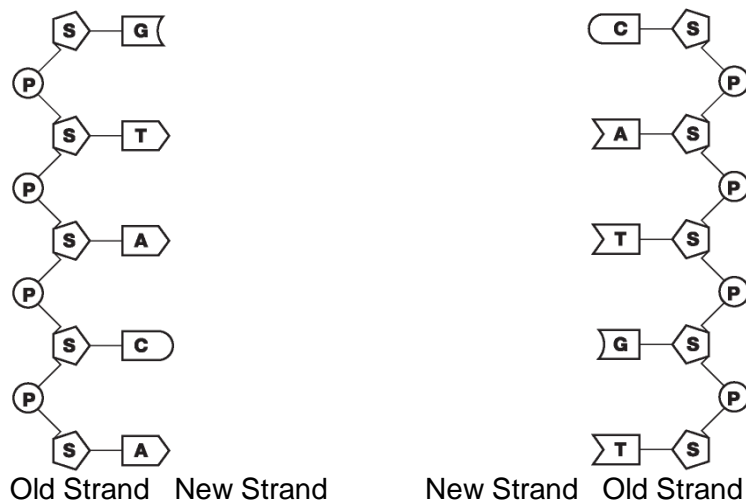
DNA polymerase is an enzyme that helps to make the new matching DNA strand by adding nucleotides one at a time and joining each new nucleotide to the previous nucleotide in the growing DNA strand.

2. Each new nucleotide added by the enzyme DNA _____ matches the corresponding nucleotide in the old strand of DNA, in accord with the _____ rules.



(From *Biology -- A Human Emphasis*, Sixth Edition by Starr)

3. In the drawing below, the small segment of plant DNA from page 3 is shown after the two strands of the DNA molecule have been separated. Your job is to play the role of DNA polymerase and create the new matching strands of DNA to make two pieces of double-stranded DNA in the drawing below. Use the base-pairing rules to write in the nucleotides for both new strands of DNA.



Look at both of the double-stranded pieces of DNA you have created. Are there any differences between these two pieces of DNA?

Are these new double-stranded pieces of DNA the same as or different from the original piece of plant DNA (shown on page 3)?

Making Your Necklace

By now your DNA should be visible as clumps of white strands floating in the alcohol layer. There may be air bubbles attached to the strands.

Use a pipette to suck up your DNA from the test tube and transfer it to the small capped tube. Be careful to squeeze the air out of the pipette before you put the pipette in the test tube; then gently suck up your DNA. Fill the small capped tube the rest of the way with alcohol. Close the cap of the tube around a piece of string. Now you have a necklace with your very own DNA!

Questions

1. Which cells in your body contain DNA?

Why do these cells need DNA?

2. Which of the following do you think will contain DNA?

bananas ___ concrete ___ fossils ___ meat ___ metal ___ spinach ___ strawberries ___

Explain your reasoning.

3. Describe the function of DNA polymerase.

Explain why each part of the name DNA polymerase (DNA, polymer, -ase) makes sense.

Bonus Question

What is wrong with the figure on the right? Why would the type of DNA replication shown in the bottom part of the figure be biologically impossible?

(Hint: Compare this figure with the figure on page 4 and think about how the new strands are formed when a DNA molecule is replicated.)

