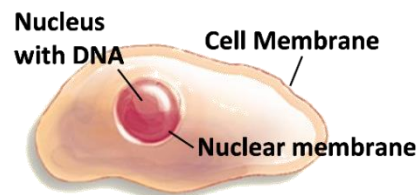


# DNA<sup>1 2</sup>

## I. Extracting DNA from Your Cells

Each cell in your body has a nucleus with multiple chromosomes. Each chromosome contains a DNA molecule.

Each cell is surrounded by a cell membrane that regulates what gets into and out of the cell. The nucleus is also surrounded by a membrane.



To extract DNA from human cells, you will need to break open the cell membranes and nuclear membranes and separate the DNA from the other types of biological molecules in human cells. You will be using the same basic steps that biologists use when they extract DNA (e.g. to clone DNA). You will follow these 3 easy steps to extract the DNA:

- Detergent
- eNzymes (meat tenderizer)
- Alcohol

### Getting Your Sample of 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. 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 (about 0.25 mL) to a test tube. 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 (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're waiting, read the information on the top of the next page and answer question 1.*

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<sup>1</sup> A bold number on the left indicates a question you should answer and an > arrowhead indicates something you should do.

<sup>2</sup>By Drs. Ingrid Waldron, Lori Spindler and Jennifer Doherty, Dept Biology, Univ Pennsylvania, © 2016. This Student Handout and Teacher Preparation Notes with instructional suggestions, background information and suggestions for alternative DNA activities are available at <http://serendip.brynmawr.edu/exchange/waldron/dna>.

### Why am I adding enzymes?

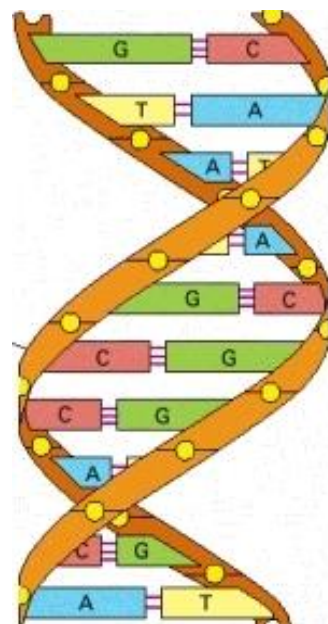
Each chromosome in the nucleus of a cell contains a very long molecule of DNA. If you stretched out the DNA found in one of your cells, it would be 2-3 meters long. To fit all of this DNA inside a tiny cell nucleus, the DNA is wrapped tightly around proteins. The enzyme in meat tenderizer is a protease,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

Each DNA molecule consists of two strands of nucleotides twisted together in a long spiral called a double helix. DNA is made up of four different types of nucleotide: **A, C, G** and **T**.

Each DNA molecule contains multiple genes. Each gene is a segment of DNA with a sequence of nucleotides that provides the instructions for making a protein.

A cell needs many different types of proteins to function. For example, a cell needs:

- protein enzymes to carry out the chemical reactions needed for life
- transport proteins to move ions and molecules into and out of the cell and to move substances around inside the cell
- structural proteins.



**1.** All living organisms, including bacteria say, plants, humans and other animals, are made up of one or more cells. Explain why all living organisms need to have DNA. Include the words genes and proteins in your explanation.

### **Step 3: Alcohol**




- Using a pipette, slowly add cold rubbing alcohol; 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 a layer of 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 at least 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're waiting for the DNA to become visible, read the information on the top of the next page and answer question 2.*

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.

Genes influence an organism's characteristics by determining which types of proteins the organism makes. The flowchart shows an example. Two different versions of a human gene give the instructions for producing either a normal or defective version of a protein enzyme which results in either normal skin and hair color or albinism.

Gene in DNA	→	Protein	→	Characteristic
	→		→	
One version of the gene provides instructions to make normal protein enzyme.	→	Normal enzyme makes the pigment molecule in skin and hair.	→	Normal skin and hair color
The other version of this gene provides instructions to make defective enzyme.	→	Defective enzyme does not make this pigment molecule.	→	Albinism (very pale skin and hair)

2. For most people, when a blood vessel is injured the clotting proteins in their blood produce a blood clot which prevents excessive bleeding. However, some people have a defective version of one type of clotting protein, so clots do not form normally. As a result, they tend to bleed excessively after even minor injuries; they have hemophilia. Explain how a person's DNA can determine whether or not he has hemophilia.

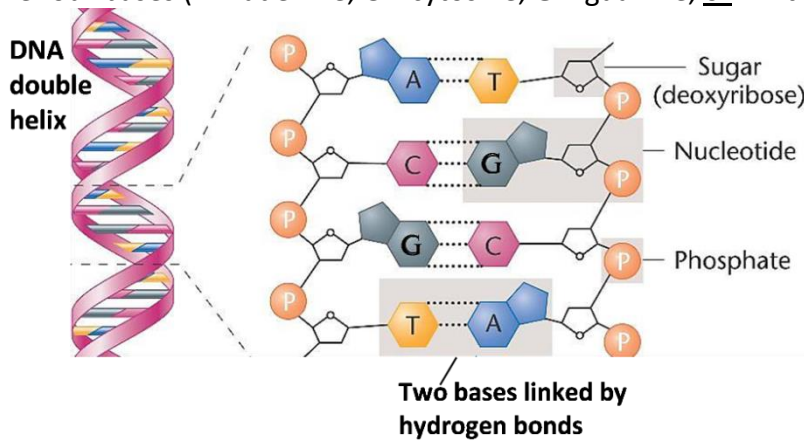
**Making Your Necklace**

- Carefully observe your DNA which should be visible as clumps of white strands floating in or just at the bottom of the alcohol layer. There may be air bubbles attached to the strands.
- Now you are ready to transfer your DNA from the test tube to your necklace. Be sure to squeeze the air out of your pipette before you put the pipette in the test tube; then gently suck up your DNA. Transfer the DNA to the small capped tube and fill it 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!

## DNA Structure and Function

This drawing shows a short section of a DNA double helix with a diagram of four nucleotides in each strand of the double helix. Each nucleotide has:

- a phosphate group (P) and a sugar molecule in the backbone of the DNA strand
- one of the four bases (**A** = adenine, **C** = cytosine, **G** = guanine, or **T** = thymine)

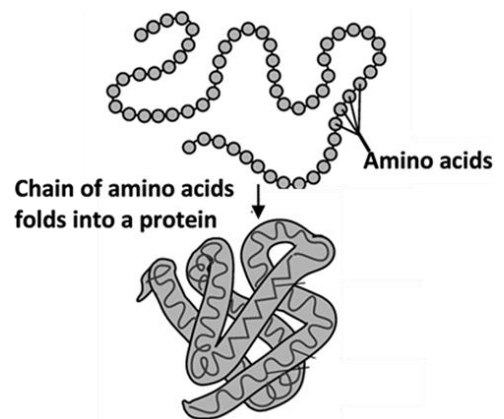


Each base in one strand of the DNA double helix pairs with a base in the other strand of the double helix. The base-pairing rules describe which bases pair together in a DNA double helix. Complete the following sentences to give the base-pairing rules.

3. **A** in one strand always pairs with \_\_\_\_\_ in the other strand.  
**C** in one strand always pairs with \_\_\_\_\_ in the other strand.

Since all the nucleotides in DNA are the same except for the base they contain, each nucleotide is given the same symbol as the base it contains (**A**, **C**, **G**, or **T**).

A polymer consists of many repeats of a smaller molecule (a monomer). For example, a protein is a polymer of amino acids.



4. DNA is a polymer of \_\_\_\_\_ .

The sequence of nucleotides in a gene in the DNA determines which amino acids are joined together to form a protein. A slightly different sequence of nucleotides in a gene can result in a different sequence of amino acids in the protein which can change the structure and function of the protein.

The sequence of nucleotides in a gene in the DNA  
*determines the sequence of amino acids in a protein which  
determines the structure and function of the protein which  
influences the characteristics or traits of the organism.*

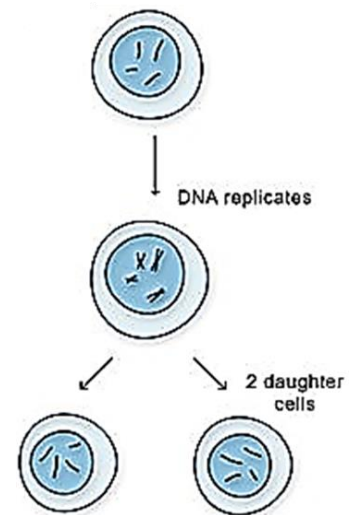
5. Explain how a difference in the sequence of nucleotides in a gene could result in one of these boys being albino and the other boy having normal skin and hair color.



### DNA Replication

Our bodies need to make new cells to grow or to replace damaged cells. New cells are formed by cell division which occurs when a cell divides into two daughter cells. Before a cell can divide, the cell must make a copy of all its DNA; this is called DNA replication.

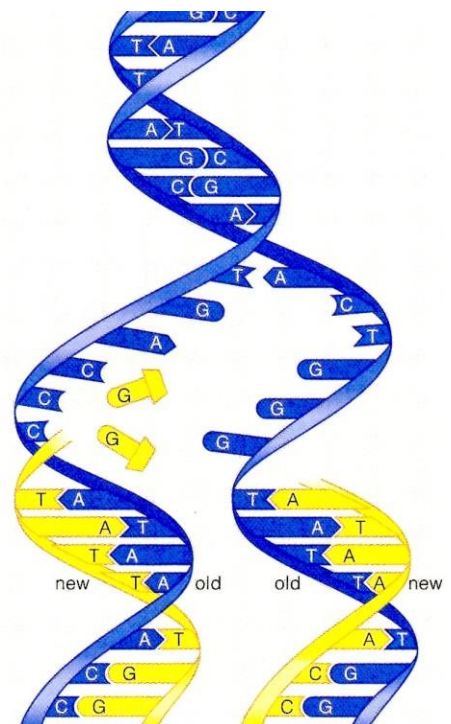
6. Explain why DNA replication is needed before a cell divides into two daughter cells.



During DNA replication, the two strands of the DNA helix are separated and each old strand provides the information needed to make a new matching strand. Each nucleotide in the new strand is matched to a nucleotide in the old strand using the base-pairing rules.

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

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

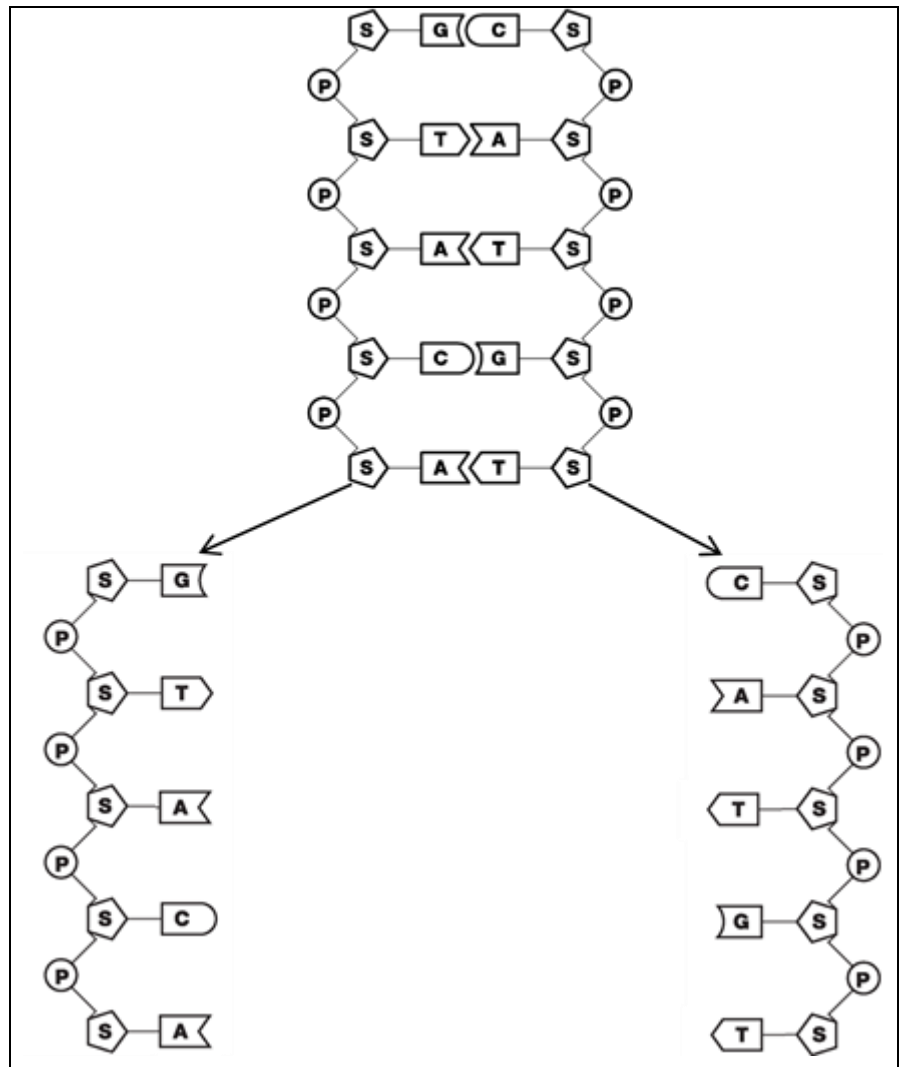


This drawing shows a short segment of DNA which separates into two strands in preparation for replication.

- Your job is to play the role of DNA polymerase and create new matching strands of DNA to produce two pieces of double-stranded DNA. Add matching nucleotides one at a time, using the base-pairing rules and the nucleotides and tape provided by your teacher.

**7a.** Are there any differences between the two new double-stranded pieces of DNA?

**7b.** Are these new double-stranded pieces of DNA the same as or different from the original piece of DNA?



**8.** Why is it important that both copies of the DNA molecule have the exact same sequence of nucleotides as the original DNA molecule?

**9.** Based on the function of DNA polymerase, explain why each part of the name DNA polymerase (DNA, polymer, -ase) makes sense.

**10.** Explain how DNA polymerase, the double helix structure of DNA, and the base-pairing rules work together to produce two identical copies of the original DNA molecule.