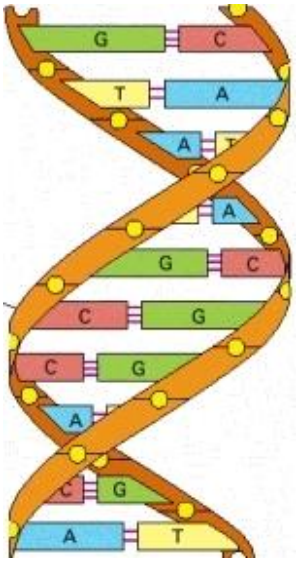
DNA Structure, Function and Replication[1]



DNA is a long molecule that 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, 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.

Genes influence an organism's characteristics by determining which types of proteins the organism makes. The flowchart shows an example in humans. Two different versions of a 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.

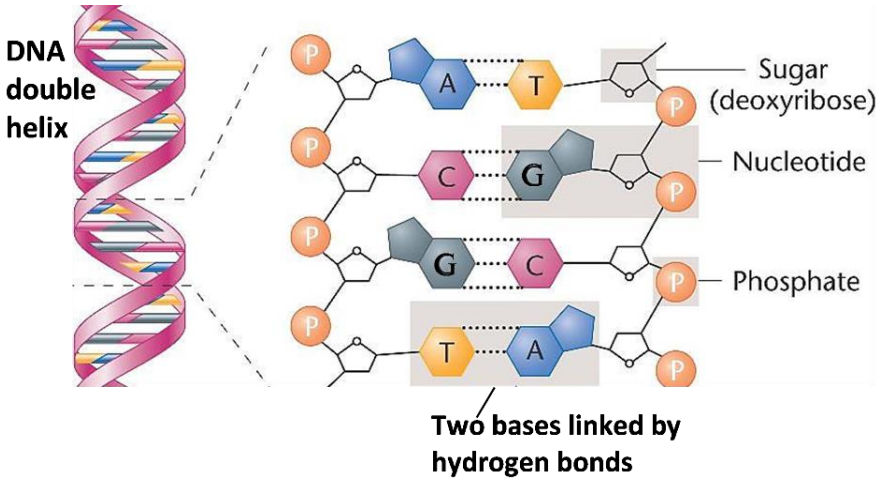
Gene in DNA	→	**Protein**	→	**Characteristic**
	→		→	
One version of the gene provides instructions to make normal protein enzyme.	→	Normal enzyme makes the pigment molecule in skin and hair.	→	Normal skin and hair color
The other version of this gene provides instructions to make defective enzyme.	→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

[1] By Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, © 2016; 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) and Teacher Preparation Notes with learning goals, instructional suggestions, and suggested alternative or follow-up activities are available at http://serendip.brynmawr.edu/exchange/bioactivities/DNA

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.

This drawing shows a short section of a DNA double helix with a diagram of four of the 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)

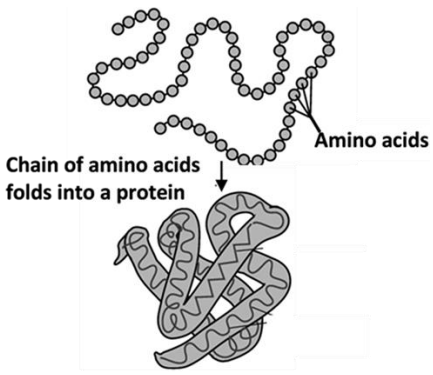


Each base in one strand of the DNA double helix pairs with a base in the other strand of the double helix. The base-pairing rules describe which bases pair together in a DNA double helix. Complete the following sentences to give the base-pairing rules.

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 determines which amino acids are joined to form a protein. Slight differences in the sequence of nucleotides in a gene can result in different versions of the protein which in turn can result in different characteristics.

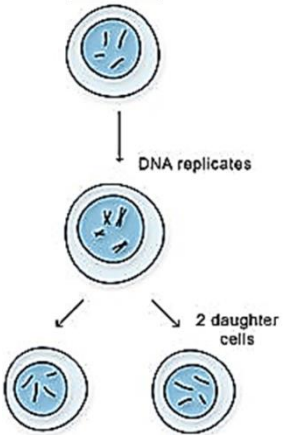
> The sequence of nucleotides in the DNA of a gene
> *determines the* sequence of amino acids in a protein which
> *determines the* structure and function of the protein which
> *influences the* characteristics or traits of the organism.

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.

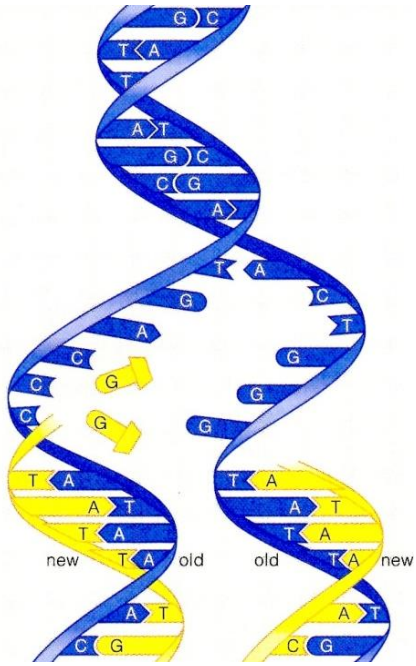
6. Explain why DNA replication is needed before a cell divides into two daughter cells.



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.

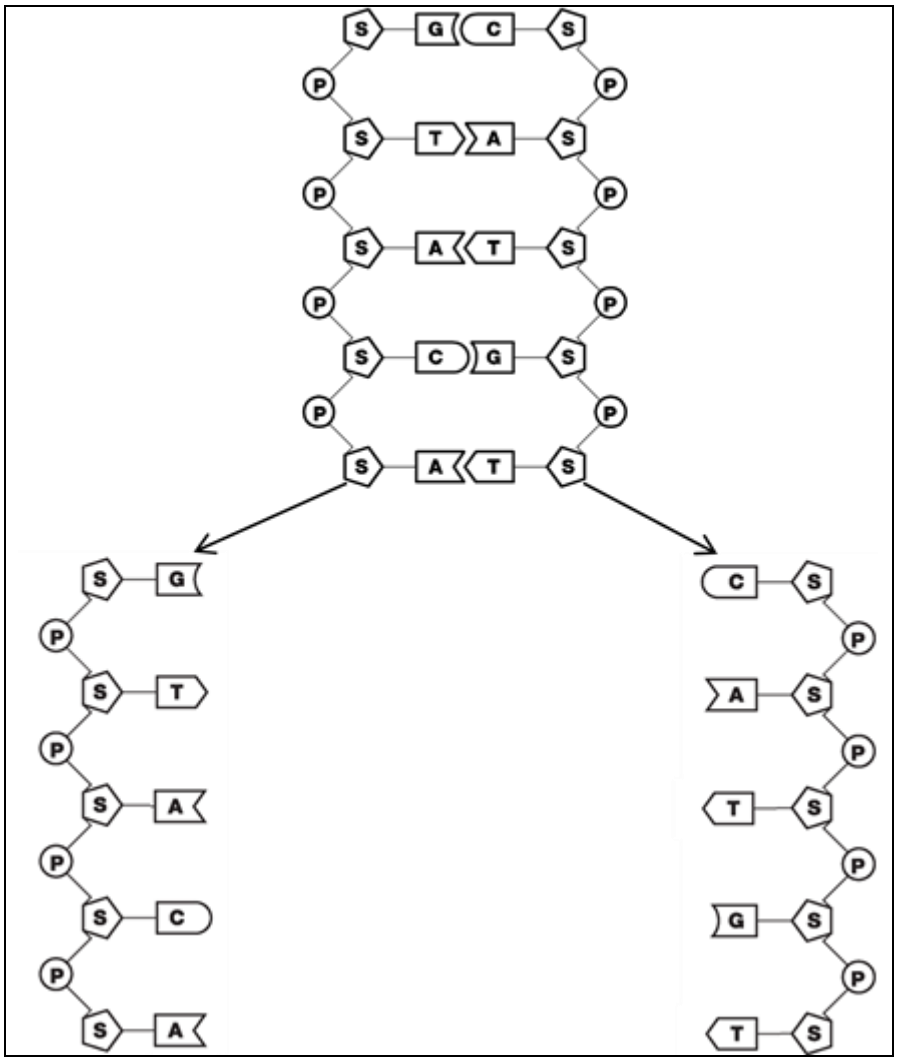
The enzyme DNA polymerase helps to make the new matching DNA strand by adding the matching nucleotides one at a time and joining each new nucleotide to the previous nucleotide in the growing DNA strand.

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 the 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.