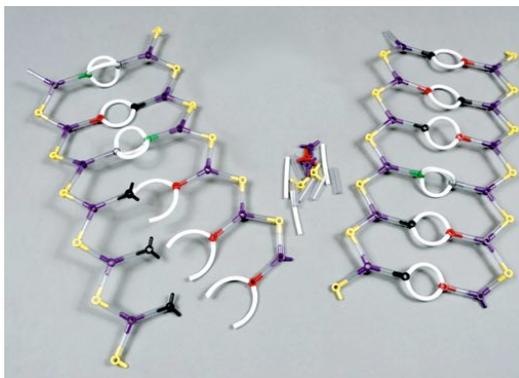


Super Models



Deoxyribonucleic Acid (DNA)

Molecular Model Kit

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Recommended for ages 10-adult

⚠ Caution: Atom centers and vinyl tubing are a choking hazard. Do not eat or chew model parts.

Kit Contents:

25 purple 3-peg sugar (1 spare)
25 yellow 2-peg phosphate (1 spare)
9 red 3-peg adenine (1 spare)
9 black 3-peg thymine (1 spare)
5 green 4-peg cytosine (1 spare)
5 silver 4-peg guanine (1 spare)
75 clear, 1.25" covalent bonds (3 spares)
30 white, 2" hydrogen bonds (2 spares)

Related Kits:

Nucleic Acid Bases Molecular Model Kit
Nucleotides Molecular Model Kit

Replacement and Expansion Parts Customized Kits

Phone: (806) 438-6865

E-Mail: etishler@rylerenterprises.com

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Address: 5701 1st Street, Lubbock, TX 79416

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GENERAL INFORMATION

Three features of DNA can be seen after making the model. First, there are two kinds of bonds. The clear, thicker tubes represent strong-chemical bonds that can occur between almost any two types of atoms. The longer, white tubes are for hydrogen bonds that are weaker and involve the sharing of hydrogen atoms. Hydrogen bonds can easily be broken by heat, radiation or chemical agents. Second, there are two hydrogen bonds between A and T, while three hydrogen bonds occur between C and G. Organisms that live in hot springs have more C and G in their DNA, as you can imagine. And finally, the molecule resembles a ladder with the “rungs” represented by the bases and the “sidepieces” or “backbones” are made of alternating sugar-phosphate molecules (-s-p-s-p- and so on).

The hydrogen bonding between the bases of the nucleotides forces the DNA to take on the form of a **helix** (spiral). Since DNA is made of two strands, we call the molecule a **double helix** (sometimes it is called a duplex). Below, in Fig. 1, there is a metal spring (not supplied) on the left and a portion of a DNA molecule on the right. A helix may be right-handed or left-handed. It is left-handed if, when seen from the top, it turns in a counter-clockwise direction. It is right-handed if, when seen from the top, it turns in a clockwise direction. Observe that the metal spring and the DNA double helix are right-handed. This form of DNA is called B-DNA, and it is one of several forms of the molecule.

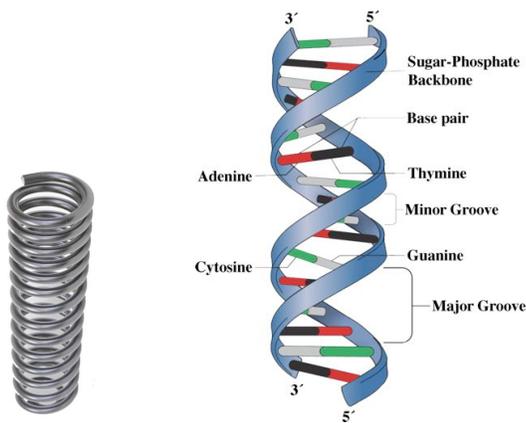


Fig. 1 A right-handed metal helix and a part of a right-handed DNA molecule.

Two new features of DNA become obvious when you examine Fig. 1. One is the double helix which is similar to a spiral staircase, not a twisted ladder, and second, there are two sizes of grooves in the molecule. The larger is known as the **major groove**, while the smaller is called the **minor groove**.

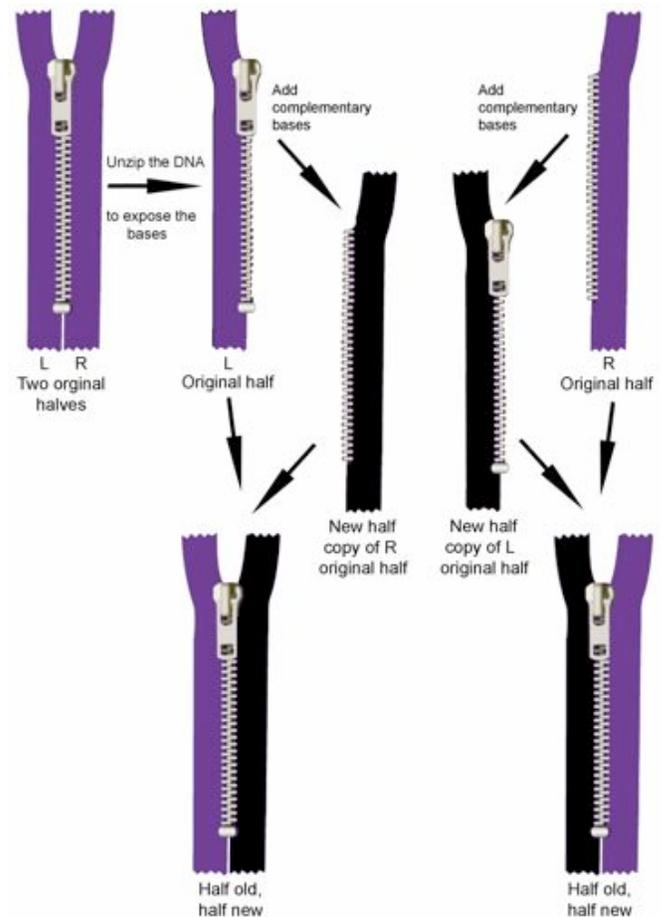
You will also notice that the two halves of the molecule run in opposite directions, that is the bottom half starts at

3' on the left and proceeds to 5' on the right. The top half is arranged with 5' on the left and 3' on the right. This alignment is important to the functioning of the DNA molecule, and it is called an **antiparallel** arrangement.

In a living cell, DNA has two functions: 1) Make exact copies of itself prior to cell division or for other purposes, and 2) Control the development and the operation of the cell from its birth until its death.

This kit will be helpful in understanding the first of the two functions. A separate kit is available for studying the second function.

As an aid to understanding replication you might try using zippers, to see the overall plan for the steps used to make two exact copies of a DNA molecule.



Assembly Instructions

Color Guide for Molecules & Bonds

<u>Molecule</u>	<u>Color</u>	<u>Number of Pegs</u>
Deoxyribose	Purple	3
Phosphate	Yellow	2
Adenine	Red	3
Thymine	Black	3
Cytosine	Green	4
Guanine	Silver	4

<u>Bond</u>	<u>Color</u>
Covalent	Colorless (clear)
Hydrogen	White

DNA is a double stranded polymer of nucleotides. A nucleotide is made of a sugar (deoxyribose), a phosphate, and one of the following nitrogenous bases: adenine, thymine, cytosine, or guanine.

This kit provides you with enough molecules and bonds to make a DNA model containing 24 nucleotides.

YOUR TEACHER WILL SIGN YOUR CHECK LIST AS YOU COMPLETE EACH PART OF THIS LAB.

PART I: MAKING A DNA MOLECULE.

BEFORE YOU ASSEMBLE THE MODEL, IDENTIFY AND SHOW YOUR TEACHER THE PARTS THAT REPRESENT MOLECULES OF SUGAR, ADENINE, GUANINE, CYTOSINE, AND THYMINE, AND AN ION OF PHOSPHATE. (1)

Step I: Making a nucleotide.

Assemble one nucleotide by placing a clear tubing bond on the purple sugar molecule peg that is at the top of the 130° angle farthest away from the other two pegs as pictured in Fig. 2.

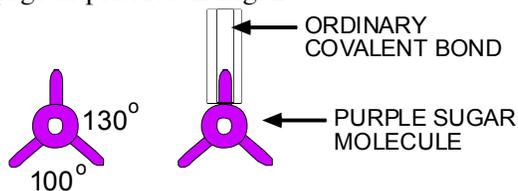


Fig. 2 Attaching a bond to a deoxyribose.

Next, insert a peg of any one of the bases into the bond you just put on the sugar molecule. In order to complete the nucleotide, put clear tubing bonds on the sugar molecule pegs that are closest together, and place a yellow phosphate peg into either of these clear bonds. The phosphate is now on the 5' carbon of the nucleotide that you have just made, and it should look like Fig. 3.

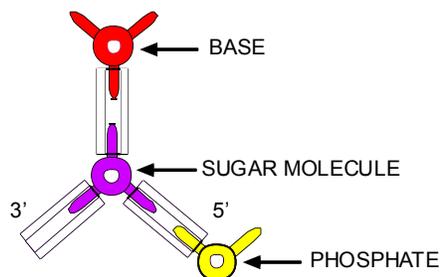


Fig. 3 A 5' phosphate deoxyribonucleotide.

HAVE YOUR INSTRUCTOR CHECK YOUR NUCLEOTIDE MODEL. (2) POINT TO THE 3' AND 5' ENDS OF THE NUCLEOTIDE. (3)

Step II: Making more nucleotides

Construct 23 more nucleotides from the remaining molecules and clear plastic bonds.

Step III: Making a strand of 12 nucleotides.

Connect the yellow phosphate of one nucleotide to a 3' bond on a sugar of another nucleotide. You have just made a dinucleotide which should resemble the one in Fig. 4.

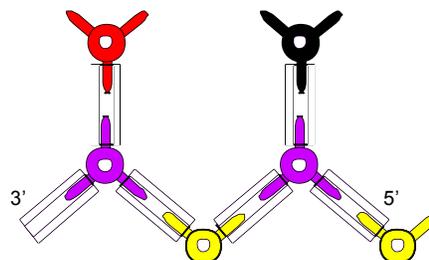


Fig. 4 A dinucleotide.

HAVE YOUR INSTRUCTOR CHECK YOUR DINUCLEOTIDE MODEL. (4)

Continue to attach additional nucleotides to each other until you have a strand of 12. Your model should now closely resemble the five nucleotide chain shown in Fig. 5.

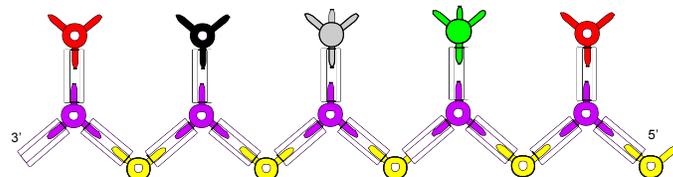


Fig. 5 A five nucleotide segment of a single strand of DNA.

HAVE YOUR MODEL CHECKED AGAIN. (5)

Step IV: Making a double stranded DNA molecule.

To complete a DNA molecule, you will now attach the remaining nucleotides to their complements on the strand that you just made. Put hydrogen (white) bonds on all of the unattached pegs of the base of the first nucleotide (on the 3' end) of the chain. Connect the base of an unattached nucleotide to these hydrogen bonds according to the following scheme: Red is bonded to Black; Green is bonded to Silver. The 5' end of the nucleotide should be on the left side as you can see in Fig. 6.

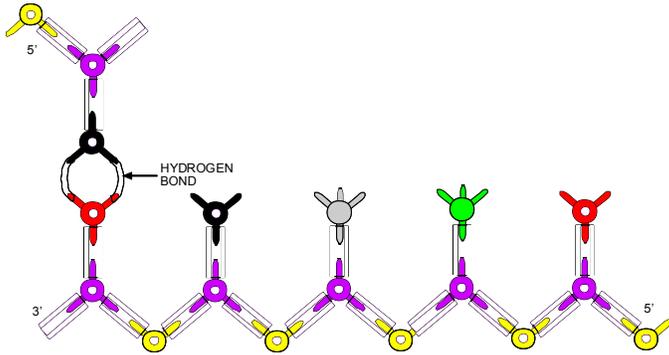


Fig. 6 Attaching complementary nucleotides to an original single strand of DNA.

CHECK YOUR MODEL AGAIN WITH YOUR INSTRUCTOR. (6)

Continue to attach nucleotide bases to their complements with hydrogen bonds as you just did. When you are finished adding the remaining 11 nucleotides, insert the phosphates into the clear tube bonds on the sugar next to each phosphate. The double stranded DNA is called a duplex. Compare the diagram of a DNA duplex in Fig. 7 with your model.

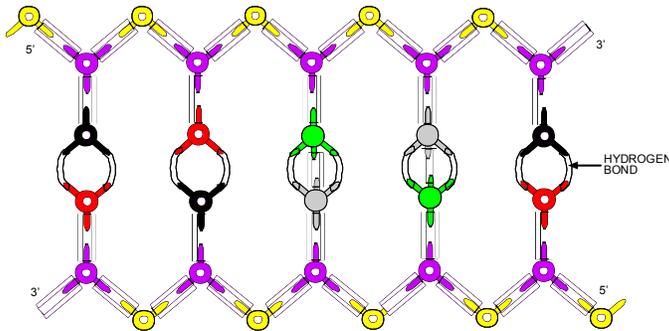


Fig. 7 A segment of a completed DNA

Congratulations! You have completed construction of a molecule of DNA.

SHOW YOUR TEACHER: THE DNA. (7) THE 3' AND 5' ENDS OF THE DNA. (8) A HYDROGEN BOND. (9) A NUCLEOTIDE PAIR . (10)

PART II: REPLICATING A DNA MOLECULE.

Step I. Unzipping the DNA.

Separate the DNA duplex by removing the hydrogen bonds from all of the bases on one side of the model from all of the bases on the complementary strand. In Fig. 8 all but base pair have been separated.

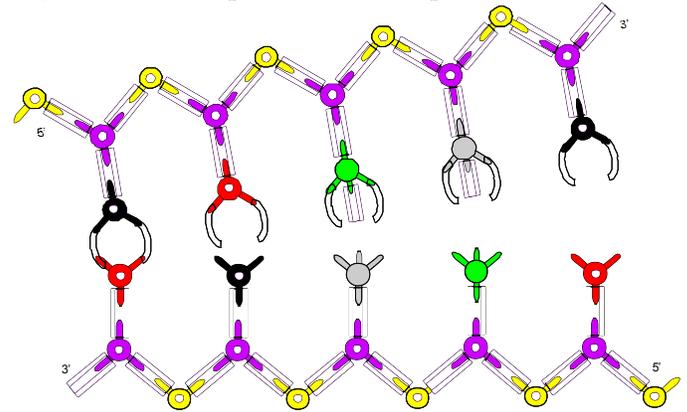


Fig. 8 Separating the duplex into two halves.

HAVE YOUR MODEL CHECKED. (13)

Step II. Replication.

Your teacher will tell you how to obtain additional nucleotides from another group. Add these to both of the separated halves of your original DNA molecule.

HAVE YOUR MODEL CHECKED. (15)

PART III: A POINT MUTATION.

One of the common genetic conditions in people that populate areas of the globe where malaria is a problem is sickle cell hemoglobin. Possessing two genes (being homozygous) for the condition can be life threatening. The gene calls for the amino acid glutamate to be replaced in the sixth position of a β -polypeptide chain by valine. Two β -chains are incorporated into a hemoglobin molecule. When valine is present in hemoglobin, red blood cells containing the molecules become distorted into a sickle shape. These cells break easily, plugging small vessels, and the blood fails to carry oxygen normally. The ensuing sickle cell anemia can then be fatal.

The triplet in DNA that codes for glutamate is CTT. A point mutation that changes the triplet to CAT causes valine to be substituted for glutamate. Your DNA kit can be used in two ways to demonstrate this type of mutation.

First make sure that you have a CTT triplet somewhere in the 3'—5' side of the completed DNA model. Then choose Simulation I or II and proceed.

Mutation simulation I.

Mutate (change) your completed DNA model so that the original sequence has a new triplet in the third position from the 3' end. An example is given in Fig. 9.

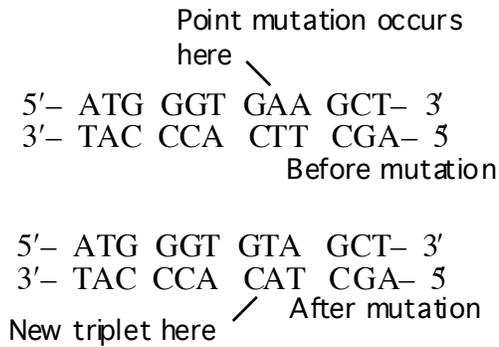


Fig. 9 A point mutation in the third triplet.

Mutation simulation II.

A second method of showing the mutation can be done during replication. As you add nucleotides to the 5'–3' side of the separated duplex, make a mismatch so that the third triplet reads CAT. Also make a mismatch of the 3'–5' original side in the third triplet so that GTA replaces GAA, although both errors would not necessarily take place simultaneously in a cell. You do not have to hydrogen bond the mismatched bases. See Fig. 10 for an example.

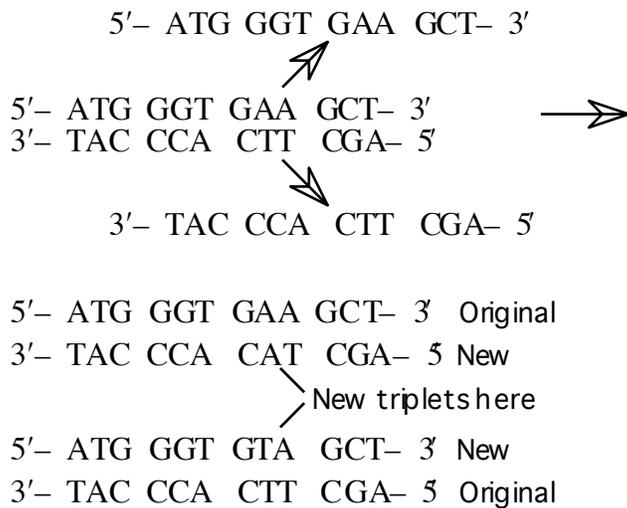


Fig. 10 Point mutations during DNA replication.

Notice that the CAT error in the gene is expressed immediately, while the DNA carrying GTA will have to be replicated one more time to have an effect.

PART IV: THE DNA HELIX.

Two students holding a DNA model can demonstrate the primary coiling of the molecule in the B-DNA conformation with 10 base pairs per turn. Using the model this way shows the staircase-like twisting of both backbones of the B-DNA double helix around a common axis, rather than a twisted ladder arrangement.

DNA MODEL KIT-ANSWERS TO QUESTIONS

Part I: Making a DNA molecule.

10. How many nucleotide pairs are in your model? **answer: 12**
11. Consult a dictionary of the genetic code, and then write the names of the amino acids in the polypeptide coded for by the gene 3'—TAC CCA CTT—5'. **answer: Methionine—Glycine—Glutamic acid**
12. What does the triplet ACT code for?
answer: This is a stop or nonsense triplet that stops the process of protein synthesis.

Part II: Replicating a DNA molecule.

14. What type of bond did you just break? **answer: Hydrogen**
16. How are the two new DNA molecules the same?
answer: They should be exact duplicates of each other and of the original DNA.

Part III: a point mutation.

17. Consult a dictionary of the genetic code, and determine whether the following DNA mutations will result in a change in the amino acid content of a protein.
answer:

	CHANGE	
	YES	NO
GAG ⇒ GAT	<input type="radio"/>	<input checked="" type="radio"/>
AAA ⇒ AAG	<input type="radio"/>	<input checked="" type="radio"/>
GGT ⇒ GTT	<input checked="" type="radio"/>	<input type="radio"/>

18. Why are some point mutations harmful, while others are not?

answer: Some point mutations cause a change in the type of amino acid inserted at a location in a protein which has no affect on the function of the protein.

Some point mutations do not cause a change in the amino acid coded for by the original base triplet, e.g. GAG in question 17.