# Student Guide: DNA Structure
# DNA Simulation BioKit®

**Name** ______________________

**Date** ______________________

In most living organisms the carrier of the genetic information is deoxyribonucleic acid (DNA). The intricate structure of the DNA molecule carries the genetic code for inherited characteristics from one generation to the next.

The DNA molecule consists of thousands to millions of nucleotides bonded together in an interconnected chain. Nucleotides have three components: a sugar molecule, a phosphate group, and a nitrogenous base. In DNA the sugar is a five-carbon molecule called deoxyribose. The deoxyribose sugars are linked together by phosphate groups at the number three and number five carbons of the sugars. The number three carbon end, or three-prime (3′) position, of one sugar is bonded by the phosphate group to the number five carbon, or 5′ position, of another sugar. This process is repeated to form very long polynucleotide chains. The DNA molecule has as its structural backbone two antiparallel sugar-phosphate chains. The two single strands of DNA are interconnected via hydrogen bonds between nitrogenous bases. Of the four nitrogenous bases, adenine (A) and guanine (G) are classified as purines and cytosine (C) and thymine (T) as pyrimidines. Because of their molecular structure, the nitrogenous bases bond very specifically: adenine bonds only with thymine and cytosine only with guanine. It is this strict base pairing between strands that dictates the spiraling DNA structure known as the double helix.

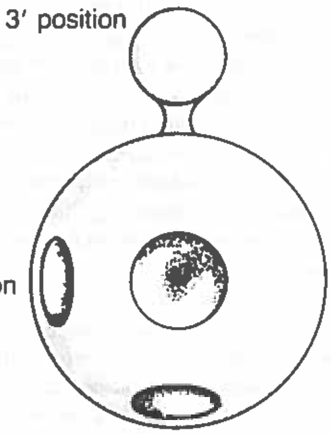



**Figure 1** Carbon positions on the deoxyribose sugar (white) bead.

ASSEMBLY

Each team needs the materials listed below. Note the designation of each component at this time.

| Quantity per team | Kit component | Component designation |
|---|---|---|
| 60 | White beads | Deoxyribose sugar |
| 60 | Red beads | Phosphate group |
| 15 | Orange beads | Adenine (A) |
| 15 | Green beads | Guanine (G) |
| 15 | Blue beads | Cytosine (C) |
| 15 | Yellow beads | Thymine (T) |
| 30 | Clear connectors | Hydrogen bonds |

Assemble 60 nucleotides by attaching a phosphate group (red bead) to the 5′ position of the deoxyribose sugar (white bead) and by attaching any one of the four nitrogenous bases (adenine, orange; guanine, green; cytosine, blue; or thymine, yellow) to the 1′ position of the same sugar (Fig. 1). Separate the 60 nucleotides into 4 groups of 15 according to their nitrogenous bases (orange, green, blue, yellow).

Construct a single-stranded polynucleotide chain by attaching the phosphate group (red bead) of one nucleotide to the 3′ peg of the sugar (white bead) of another nucleotide (Fig. 1). Use eight nucleotides with adenine, eight with guanine, seven with cytosine, and seven with thymine. Attach the nucleotides in any order of color but maintain the phosphate group to 3′ attachment form.

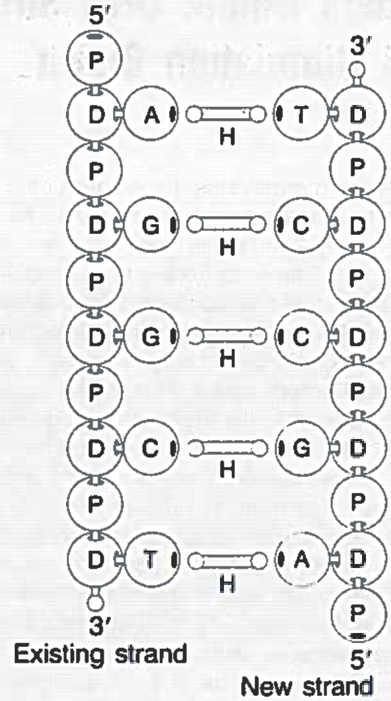
To form the typical double-stranded DNA molecule, a complementary, antiparallel single strand of DNA nucleotides must now be constructed to bond with the initial strand. The remaining 30 nucleotides must be linked together in the following manner: the 3′ pegs of the new strand should be aligned in the opposite direction of the initial strand; the nucleotides should be attached so that cytosine on the initial strand pairs with guanine on the new strand and vice versa; thymines on the initial strand should be matched to new adenine nucleotides and vice versa (Fig. 2).

When positioned next to the initial DNA single strand, the nitrogenous bases of the oppositely aligned new strand should always pair adenine with thymine and cytosine with guanine. These nitrogenous base pairs should now be connected with hydrogen bonds (clear connectors) to form a double-stranded DNA molecule (Fig. 2). The order of the nitrogenous bases in the DNA molecule codes for specific hereditary information. Rearrangement of the sequence of base pairs in the chain changes the interpretation of the genetic code.

Grasp the completed DNA molecule by the base pair at each end of the double strands. Gently twist the molecule into the form of a spiraling rope ladder, being careful not to separate the hydrogen bonds between base pairs. This represents the double helical structure of the DNA molecule.

Equal amounts of adenine and thymine are present within the cell nucleus; equal amounts of cytosine and guanine are also present. When constructing new codes, do not link more than 15 combined adenine and thymine nucleotides or 15 combined cytosine and guanine nucleotides on the same single strand, or proper base pairing will not be possible when constructing new complementary strands because of the limited number of beads in the kit.

Disassemble your DNA molecule. Rearrange the nucleotide order and change the DNA code. Remember to oppositely align your two new strands of nucleotides. Check for proper base pairing: adenine with thymine and cytosine with guanine. Repeat the construction procedure until you are familiar with the DNA molecule.




D: deoxyribose sugar
P: phosphate group
A: adenine
T: thymine
C: cytosine
G: guanine
H: hydrogen bond

**Figure 2** A simulated segment of double-stranded DNA.

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