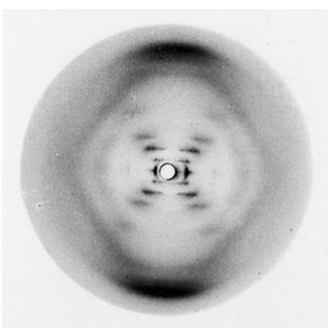
Student Guide

The discovery of the structure of DNA by James Watson and Francis Crick in 1953 was one of the most momentous scientific advances of the last century. This discovery has had far-reaching implications for modern molecular science and society. You will explore the importance of this discovery through a study of **DNA STRUCTURE**, **FUNCTION**, and **BIOINFORMATICS** using the *Dynamic DNA Kit*©.

Part 1 - DNA Structure: Nucleotides as Building Blocks of DNA

Questions to jumpstart your thinking:

1. What have you heard about DNA? Where have you heard about DNA?
2. Where is DNA located in your cells?
3. Why is DNA important to your cells?
4. How do your cells use DNA?
5. Why do you think determining the structure of DNA was so important for the progress of the biological sciences?

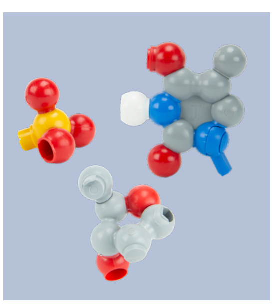
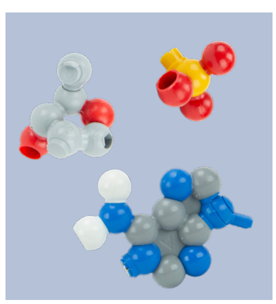
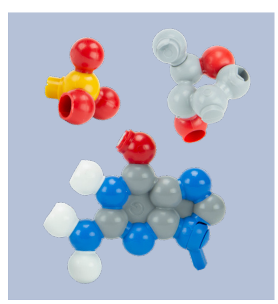
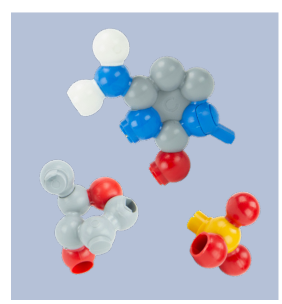


https://www.bbc.com/news/health-18041884

The *Dynamic DNA*© model is based on X-ray crystallographic data (illustrated at left by Rosalind Franklin's famous "Photo 51") and is built to scale (approximately 80,000,000 times actual size). For clarity in the model, hydrogen atoms are not shown except for the hydrogens forming the hydrogen bonds between the base pairs (shown in white) and the magneted hydrogen of the hydroxyl group on the 3' carbon of the sugar at the end of each DNA strand. The remaining colors used in the model are standard CPK colors and are as follows:

Carbon atoms: **Grey**
Oxygen atoms: **Red**
Nitrogen atoms: **Blue**
Phosphorus atoms: **Orange**

Examine the three component pieces that have been given to you. You should have one of the groupings pictured below.

Identify the phosphate group, deoxyribose sugar and nitrogen base in your collection of parts.
Answer PART 1 questions 1-2 on the student answer sheet.

Compare and contrast your three pieces with that of another student or group.
Record your observations in PART 1 question 3 of the student answer sheet.

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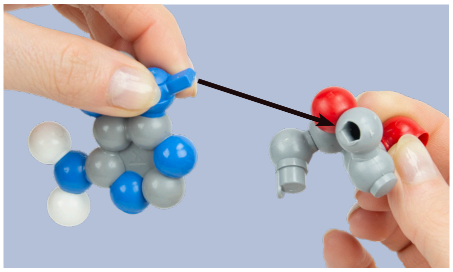
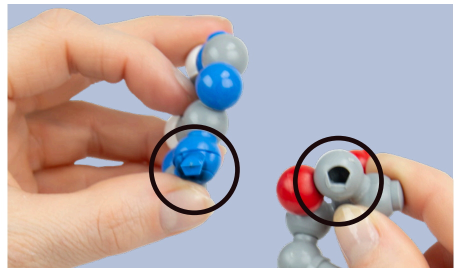
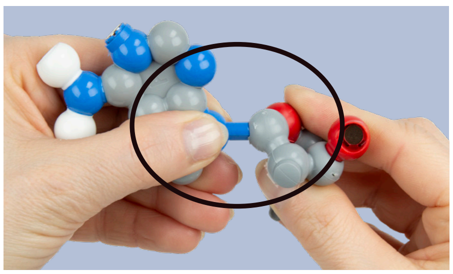
Assemble the three parts given to you by your instructor by inserting the posts into the appropriate holes to form a **DNA nucleotide**. Nucleotides are the building blocks of DNA molecules. **Assemble using post and hole fittings. Don't connect any magnets at this time. Refer to the photos below.**



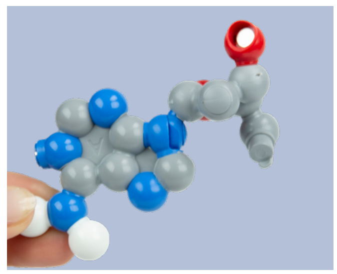
Hold the swivel post tightly.



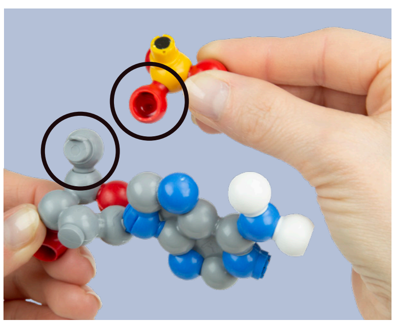
Note the distinct shapes of the post and hole and line them up before insertion.



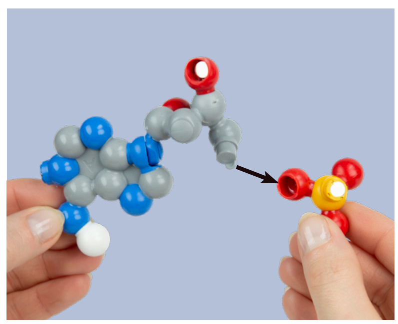
Push firmly to insert the post.



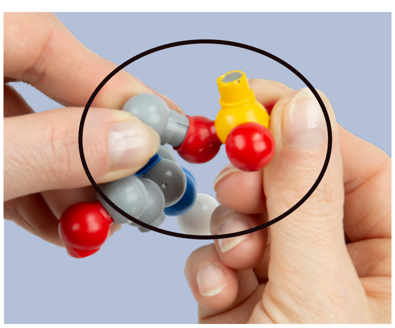
Finished connection



Look for the paddle on the post.



Note the distinct shapes of the paddle and hole and line them up before insertion.



Push firmly to insert the post.

Finished connection

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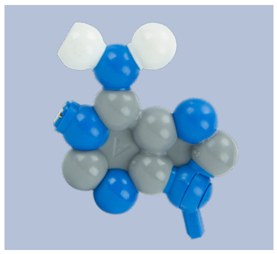
Answer PART 1 question 4 on the student answer sheet.

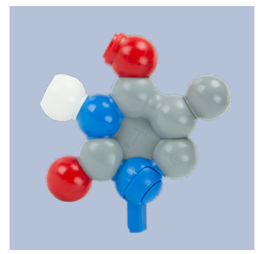
Examine the nitrogen bases in each of the assembled nucleotides. The bases marked **C (cytosine)** and **T (thymine)** have a common structural feature and are classified as **pyrimidines.** Likewise, the bases marked **G (guanine)** and **A (adenine)** have a different common structural feature and are classified as purines.

Answer PART 1 questions 5-7 on the student answer sheet.

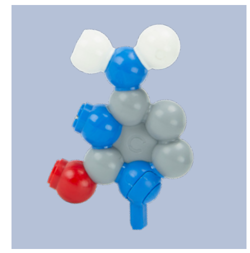


adenine (A)

guanine (G)



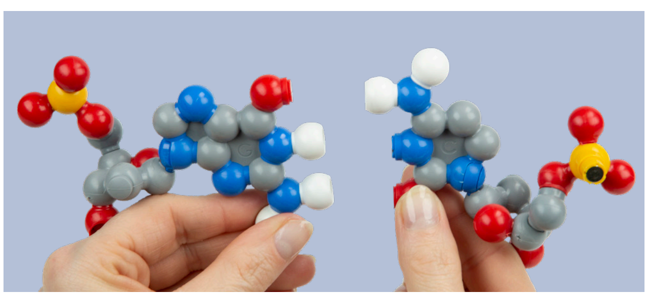
thymine (T)

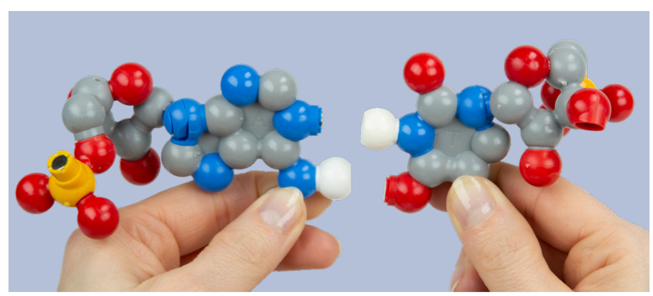


cytosine (C)

In 1949 Erwin Chargaff discovered that within any one species the amount of adenine is equal to the amount of thymine and the amount of guanine is equal to the amount of cytosine. The ratio of A-T to G-C is not equal and varies between species.

Base pair your nucleotide with that of another student or group, **USING ONLY MAGNETS ON THE NITROGEN BASES**, in a way to support Chargaff's discovery

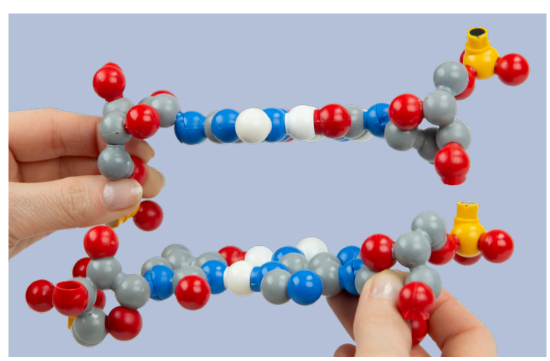




Answer PART 1 questions 8-9 on the student answer sheet.

Join your base pair with another base pair from another group and continue joining until you have formed a 6 base-pair double helix.

Answer PART 1 questions 10-11 on the student answer sheet.



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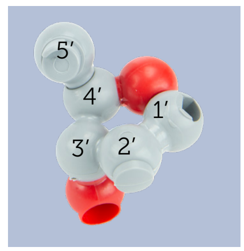
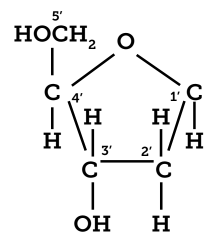
When joining the nucleotides to form your initial base pairs, you may have noticed that it is possible to pair the bases in combinations that do NOT support Chargaff's findings. Non-standard base pairing can occur; however, these base pairs are not compatible with the double stranded helical structure of DNA for two reasons. First, base pairs formed with two purines or two pyrimidines will have a different diameter than the standard A-T and G-C base pairs. Second, when the non-standard hydrogen bonded base pairs form, the polarity of the strands of DNA will be parallel, not the anti-parallel structure consistent with DNA structure.

Discover the polarity of the DNA strands by observing the ends of each strand of the DNA double helix.

Answer PART 1 questions 12-13 on the student answer sheet.

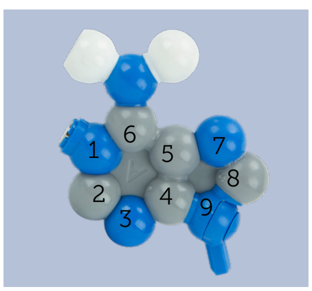
The carbons in the sugar group are numbered 1 through 5 with a prime (') in order to distinguish them from the atoms in the rings of the nitrogen bases. Please see the diagrams below for numbering of these atoms.

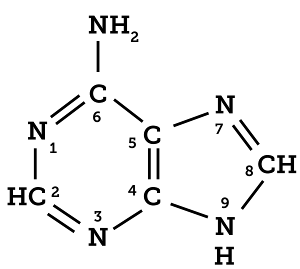




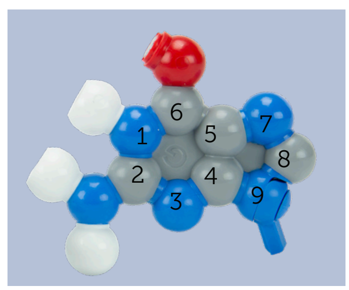
deoxyribose

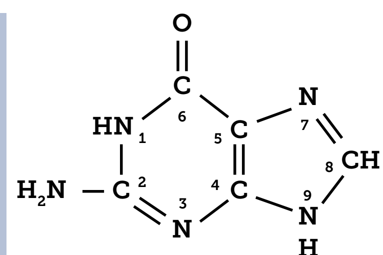
Purines





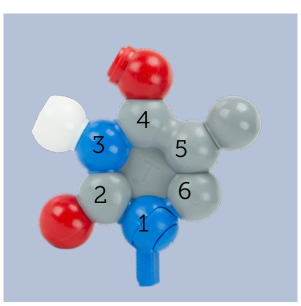
adenine (A)

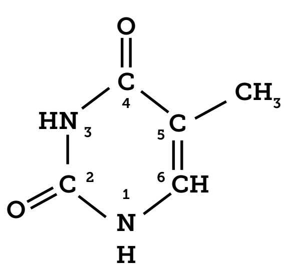




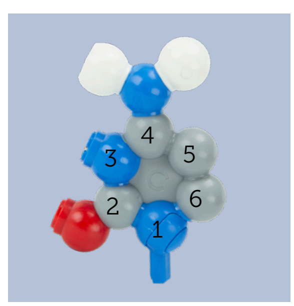
guanine (G)

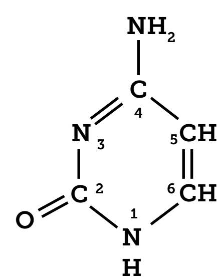
Pyrimidines





thymine (T)





cytosine (C)

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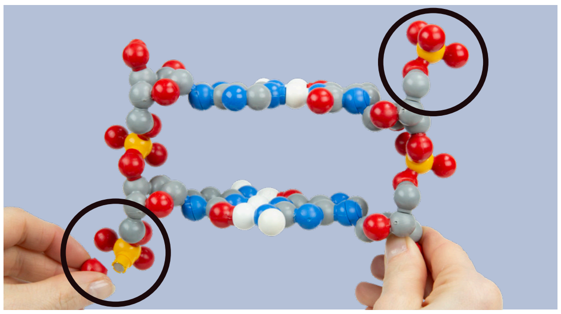
Note where phosphate groups attach to sugar groups in the DNA backbone.

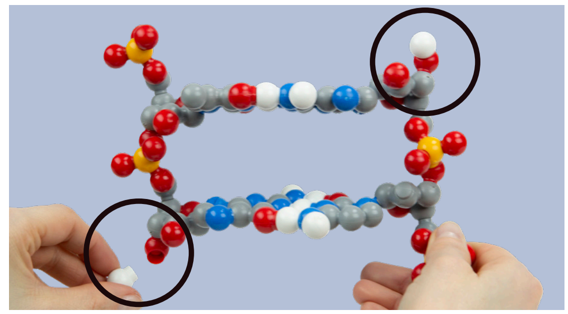
Answer PART 1 question 14 on the student answer sheet.

To complete each phosphate group, add a red oxygen cap over the magnet.



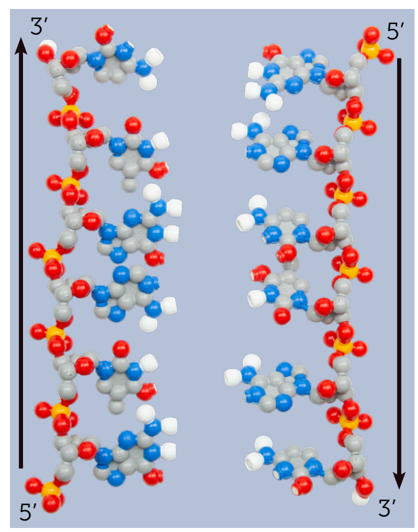
Attach 2 red oxygen caps.

Complete the end hydroxyl groups by adding a hydrogen to the 3’ oxygen in the sugar ring.



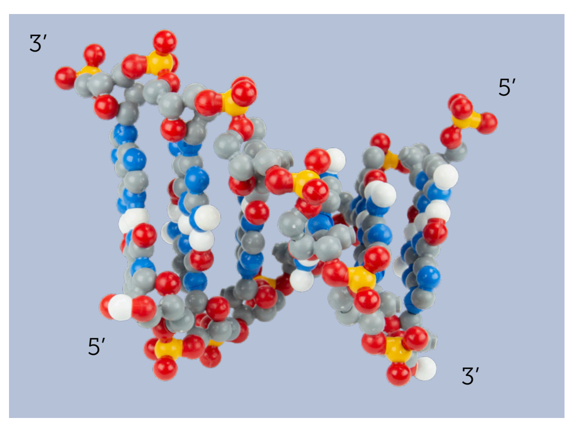
Attach 2 white hydrogen caps.

Compare the position of the phosphate group on one strand to the position of the phosphate group on the complementary strand. Each DNA strand has **directionality**. The two sugar-phosphate backbones run in opposite 5’→3’ directions from each other. In order to see this more clearly, you may want to “unzip” the two strands at the nitrogen bases to make a comparison.



Answer PART 1 question 15 on the student answer sheet.

Molecules are not static, rigid structures! **Molecular dynamics** simulations allow exploration of the interaction and physical movement of atoms and molecules resulting in fluctuation and conformational changes. Model the ***dynamic nature*** of DNA by carefully twisting and untwisting 4-6 base pairs.



Answer PART 1 question 16 and 17 on the student answer sheet.