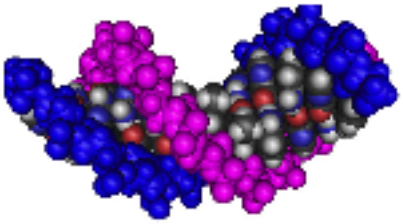
# DNA Structure Worksheets

## Major and Minor Grooves

Label the major and minor grooves in the image on the below.



## Investigate interactions between DNA and other molecules

1. Name of structure file:

2. Is the other molecule bound to the major groove or minor groove? Explain your answer.

3. Do you think the other molecule is a protein or something else? Explain your answer.

## Compare the orientation of the two DNA strands

Two strands of DNA are represented as straight lines in the drawing below.

5′ ––––––––––––––––––––––––––––> 3′

3′ <––––––––––––––––––––––––––– 5′

1. Write out the rainbow colors for each strand, ROYGBIV, in the order that you see them, on the drawing above, for both strands.

2. Label the 5′ and 3′ ends on the bottom strand.

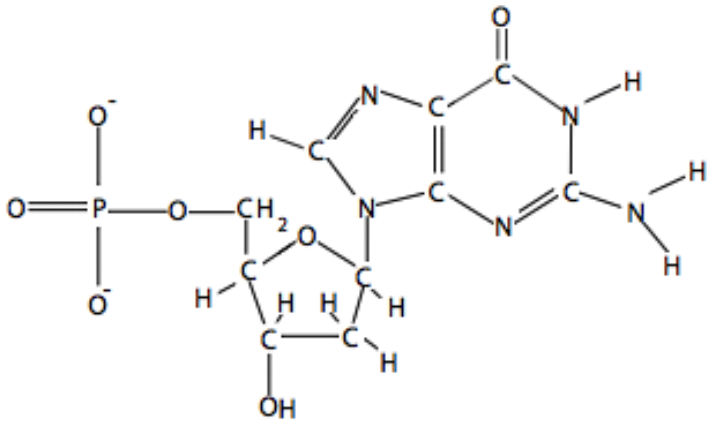
3. Draw an arrowhead on the bottom strand to indicate the direction (orientation). Typically, the strands are drawn with an arrow pointed in the 5′ to 3′ direction

4. How would you describe the orientation of the two DNA strands relative to each other? Explain your reasoning.

# The building blocks of DNA

1. The drawing below shows a nucleotide with a single phosphate group. Write the Cn3D element colors in the table below.

Note: a. Some hydrogens are missing from the drawing below.
b. A solid line represents a covalent bond.
c. Two solid lines represent a covalent, double bond.



| | |
|---|---|
| Phosphorus | |
| Oxygen | |
| Carbon | |
| Nitrogen | |
| Hydrogen | |

2. In the drawing above, find, circle and label the following:
   a. the phosphate group
   b. the deoxyribose
   c. the base
   d. Add the numbers (1' to 5') to the carbons in the deoxyribose.

3.What charge is shown on the oxygens?

4. How would you expect DNA to be charged, given the charge on the oxygens?

5. How does a phosphate group differ from phosphorus?

6. Refer to the drawing of double-stranded DNA. Find, circle, and label the following:
   a. a phosphate group
   b. the deoxyribose groups at both ends of the DNA strands
   c. the guanines
   d. Add the numbers (1' to 5') to the carbons in the deoxyribose groups at the ends of both strands.
   e. the 3' and 5' ends of both strands

# The DNA backbone

1. Which element appears in the backbone, but not in the bases?

2. Which element appears in the center, but not in the backbone?

3. Examine the drawing of double-stranded DNA. Find an example of each of the chemical groups or atoms, listed below, in the drawing. If you haven't done so already, label, and circle an example of each group or atom.

a. a deoxyribose
b. a phosphate
c. a phosphorus
d. an ester bond
e. a phosphodiester bond
f. a 5′ carbon at the end of a DNA strand
g. a 3′ hydroxyl (OH) group at the end of a DNA strand
h. a 3′ carbon

4. What charge do the phosphate groups give to the outside of the DNA molecule?

5. How are the sugars in the DNA backbone positioned relative to the bases? Describe how this looks.

6. Describe how the deoxyribose groups from the two strands are oriented with respect to each other. Explain your answer.

7. Phosphodiester bonds hold _____ together.

# How are the two DNA strands held together?

1. Refer to the drawing of double-stranded DNA (last page). Find, circle, and label the following:

a. cytosine
b. adenine
c. guanine
d. thymine

2. What base became highlighted when a base within 2.5 angstroms, of cytosine, was selected? What is the nucleotide position of this base?

3. Sketch a cytosine paired with its complementary base.

4. Complete the the table below

| Base | Complementary base | Number of hydrogen bonds between the two bases |
|---|---|---|
| Adenine | | |
| Guanine | | |
| Cytosine | | |
| Thymine | | |

7. Use the information from your table to calculate the number of hydrogen bonds that would form between the DNA sequence below and its complementary strand.

5' AATAGATCTACT 3'

8. Give the type of bond that functions in each of the roles described for a and b, and answer questions about these bonds.

a. Holds nucleotides together within a single strand of DNA.

b. Holds two strands of DNA together.

c. Which of these two kinds of bonds is *not* covalent?

d. Which kind of bond is harder to break, the bonds within a strand of DNA or the bonds that hold two strands together?

e. How might bond strength be important in copying a strand of DNA?

# Transmitting genetic information to the next generation

1. Write out the sequence for 1LAI_A, from left to right, in a 5’ to 3’ direction.

2. Write the complementary sequence, in a 3’ to 5’ direction, left to right, below the **1LAI**_
**A**. sequence

3. Write the same sequence below, of the complementary strand, that you wrote above, but reverse the direction and write it in a 5’ to 3’ direction, from left to right.

Compare this sequence to the 1LAI_B sequence in the Sequence/Alignment Viewer window. Does this match the sequence of 1LAI_B?

4. For the sequence below, write the complementary sequence, in a 3’ to 5’ direction, directly below.

5’ ACTCTATGA 3’

# Base pairing in double-stranded DNA

Cn3D presents all DNA and RNA sequences in a 5′ to 3′ direction, however, in a cell, the two strands are joined to each other, and oriented in the opposite direction. Biologists, accordingly, often write DNA sequences with a top strand, in a 5′ to 3′ direction (left to right) and a bottom strand in 3′ to 5′ direction as shown below.

5′ GACTGA 3′
3′ CTGACT 5′

1. A list of nine structure files containing double-stranded DNA sequences is shown below.

| | | |
|---|---|---|
| 1AWC.cn3 | 1K2Z.cn3 | 1R0O.cn3 |
| 1HCR_A.cn3 | 1K61.cn3 | 1R4R.cn3 |
| 1I3J_A.cn3 | 1PUF.cn3 | 3CRO.cn3 |

2. Choose one of the files listed above, or use the structure file assigned by Dr. Bob. All of these structures are located inside the Structures the folder, in another folder labeled, "DNA paired." Note, some of these structures may include proteins.

File name:

3. Write out the sequences of both the top strand and the bottom strand, in a double- stranded form, showing how the two strands are paired with each other. The two strands should also be in the opposite orientation.

## Double-Stranded DNA