

Do-it-yourself DNA Homework Assignment

This week you will use Molymod™ components to assemble a short section of DNA. This will consist of two paired bases (AT and GC). The A and G bases will be on one side of the spiral (attached to two repetitions of the sugar-phosphate spiral backbone units). The T and C bases, in complementary positions, will be attached to the other section of spiral backbone (the desired structure is shown below in an excerpt from Wikipedia's DNA figure).

Getting all of this right, with the bases in positions so that two strands fit together properly, is no easy task. So this time you will do the assignment in teams of three.

The parts will again be given to you in a plastic bag. The inventory of what it contains (and some hints as to assembly) are on a separate page below.

DNA is held together by "hydrogen bonds" which are not bonds in the more conventional sense. When a hydrogen atom forms a normal chemical bond, its one electron is drawn into that bond, to one side. This partially uncovers the proton of hydrogen's nucleus, leaving a net positive charge. In other atoms, such as nitrogen, pairs of unbonded electrons may form, giving that region a net negative charge. If a slightly positive hydrogen nucleus *on one molecule* finds itself close to the slightly negative pair of unbonded electrons *on another molecule*, the + and – charges will draw together forming a weaker "hydrogen bond." This combination of charge arrangement and shape (so that the charges come close enough to one another) is what holds the complementary bases of DNA (and hence the two strands) together!

So, to properly represent DNA, this time we really do have to show **all** of the valence electrons: those in conventional sigma bonds, the pi electrons (which may or may not form a second pi bond with their neighbors), and pairs of unbonded electrons.

As a resource in figuring out such details, you are encouraged to consult the "UVA Virtual Lab" webpage on DNA - close up. Scenes on this webpage download to your PC three-dimensional models of the proper length of sugar-phosphate backbone, of the individual bases (including all the details of the bonds), and the final full two base pair structure:

www.virlab.virginia.edu/VL/DNA_close_up.htm

In assembling your model, follow these rules:

- Use the standard atom color code of: Carbon = black, Hydrogen = white, Oxygen = red, Nitrogen = blue, Phosphorus = purple
- The atoms in your kit have holes for all of the valence electrons, in all of the configurations described above and every hole should now be filled!!

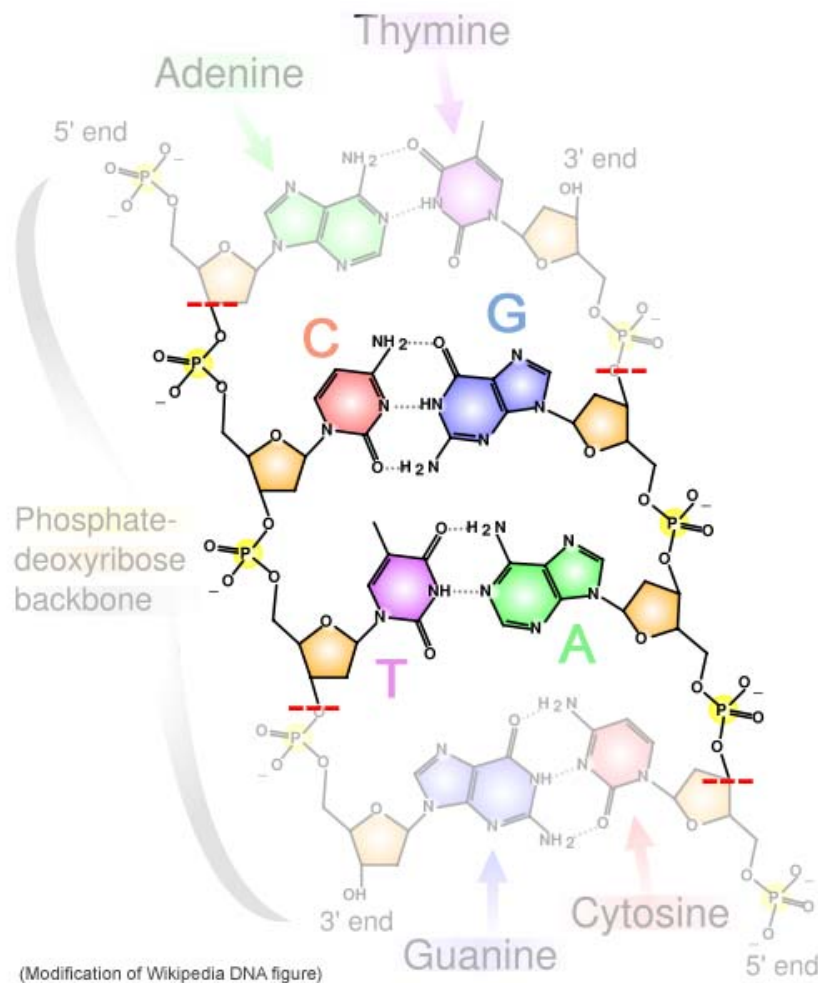
The *only* exception is the two oxygens to the side of each phosphate group in the backbone where the hole pattern in the phosphorus "atoms" won't allow for the proper bonding to all four oxygens.

- For a simple single sigma bond between atoms, use a single (short fat) bond

- For a double sigma + pi bond, loop two (long skinny) bonds between the atoms (this is not quite accurate, and not quite the way that it is depicted on the webpage, but it works well with these models).
- For an unbonded pi electron, place a half bond in each of the holes on opposite sides of atom (representing its "8" like configuration)
- For an unbonded PAIR of electrons, place a half bond in one hole of an atom (it really should be fatter than the preceding single pi electron, but we don't have extra fat bonds)
- Assemble the two strands so that you can show how the bases properly fit together allowing "hydrogen bonds" to form between the complementary bases (this is not as easy as it sounds).

Additional Requirements:

- 1) These kits are even more costly, so when you submit the assignment we will again count or weigh what you return to make sure nothing has been lost (expecting you to replace any such losses out of your own pocket).
- 2) Submit the assignment with the Honor Code pledged sheet below.



Do-it-yourself DNA Homework Assignment

Homework Team Member 1)

Printed Name: _____

Check one:

_____ We all contributed significantly to the construction of this model

_____ I did all or almost all the work

_____ I did little or no work

Signature (backed by the Honor Code) _____

Homework Team Member 2)

Printed Name: _____

Check one:

_____ We all contributed significantly to the construction of this model

_____ I did all or almost all the work

_____ I did little or no work

Signature (backed by the Honor Code) _____

Homework Team Member 3)

Printed Name: _____

Check one:

_____ We all contributed significantly to the construction of this model

_____ I did all or almost all the work

_____ I did little or no work

Signature (backed by the Honor Code) _____

DNA kit contents:

Backbone (2 units x two helices) =

- 20 4-bond (sp³) black carbon atoms
- 4 4-bond purple phosphorus atoms
- 20 2-bond red oxygen atoms
- 28 1-bond white hydrogen atoms
- 80 Short grey bonds

Adenine:

- 5 4-bond black carbon atoms
- 4 4-bond blue nitrogen atom (3 in rings + side group)
- 1 5-bond blue nitrogen atoms (1 in 5-ring)
- 0 2-bond red oxygen atoms
- 4 1-bond white hydrogen atoms
- 14 Short grey bonds (3 of which are cut in half to represent pi electrons or pi pairs in 90degree positions of the nitrogens)
- 8 Long grey bonds (four double bonds in rings)

Cytosine:

- 4 4-bond black carbon atoms
- 1 4-bond blue nitrogen atom (w/ double bond in ring)
- 2 5-bond blue nitrogen atoms (1 in ring, 1 in side group)
- 1 2-bond red oxygen atoms
- 4 1-bond white hydrogen atoms
- 12 Short grey bonds (two of which are cut in half to represent pi electrons in 90degree positions of the nitrogens)
- 6 Long grey bonds (2 double bonds in ring + double bond to oxygen)

Guanine:

- 5 4-bond black carbon atoms
- 3 4-bond blue nitrogen atom (1 in each ring + side group)
- 2 5-bond blue nitrogen atoms (1 in each ring)
- 1 2-bond red oxygen atoms
- 4 1-bond white hydrogen atoms
- 16 Short grey bonds (four of which are cut in half to represent pi electrons or pi pairs in 90degree positions of the nitrogens)
- 6 Long grey bonds (three double bonds in rings)

Thymine:

- 4 4-bond black carbon atoms
- 0 4-bond blue nitrogen atoms
- 2 5-bond blue nitrogen atoms
- 2 2-bond red oxygen atoms
- 3 1-bond white hydrogen atoms
- 10 Short grey bonds (two of which are cut in half to represent pi electrons in 90degree positions of the nitrogens)

6 Long grey bonds (1 double bonds in ring + 2 double bonds to oxygen)

Yielding totals for DNA kit

4-bond (sp3) black carbon atom:		38
4-bond purple phosphorus atoms:		4
4-bond blue nitrogen atoms:	8	
5-bond blue nitrogen atoms:	7	
2-bond red oxygen atoms:		24
1-bond white hydrogen atoms:		43
Short grey bonds:		132
Long grey bonds:		26