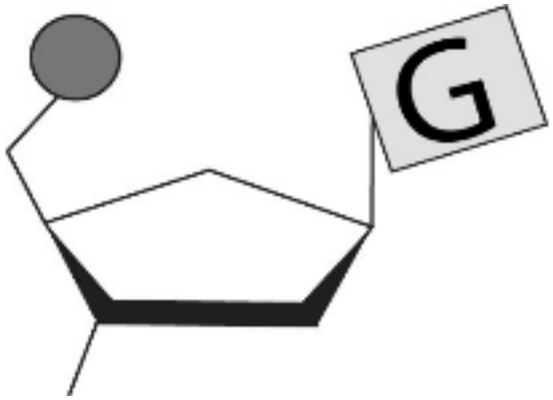
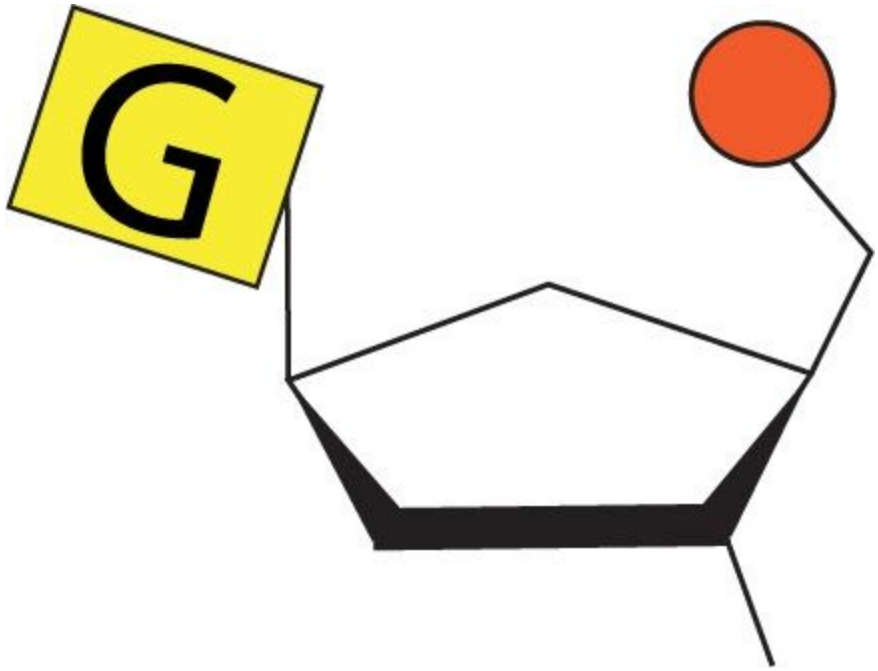
Q1. *Here is a DNA nucleotide, as shown on the previous page. What would its mirror-image look like? Is this mirror image the same as the original nucleotide? Can you rotate one to make it perfectly overlap with the other?*

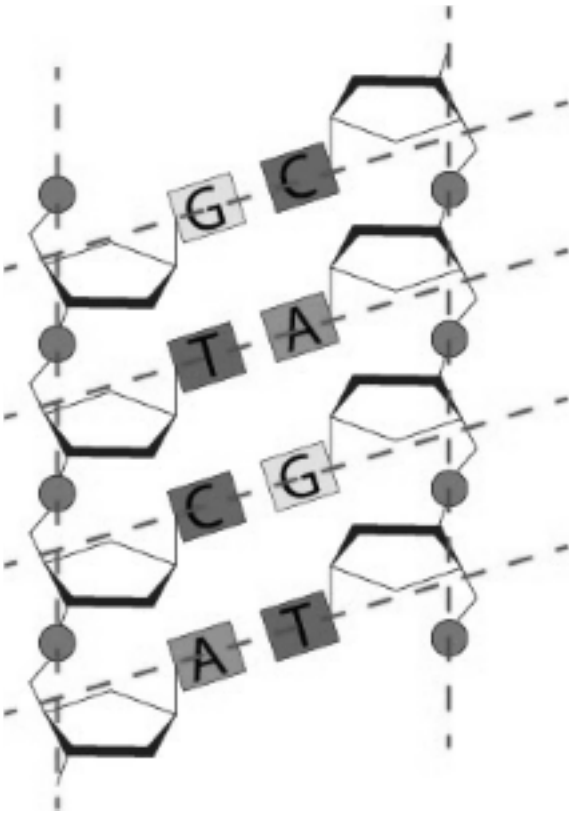


Correct Answer:

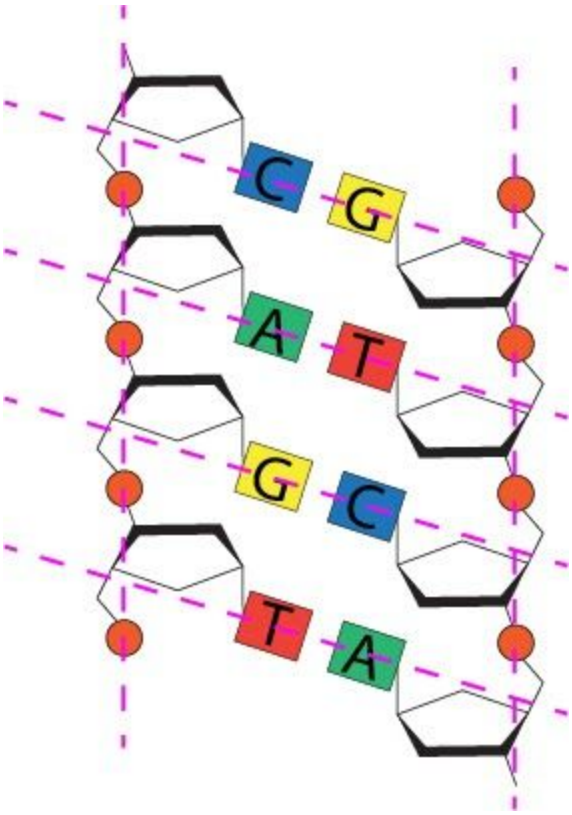


Nucleotides are chiral, so a nucleotide and its mirror-image are not the same molecule, and cannot be rotated to overlap perfectly.

Q2. *Here are two D-DNA strands, base paired together; lines have been added between the phosphates in each strand, and connecting each of the base pairs, showing the "ladder" structure that will twist into a double helix. Draw the same structure using L-DNA (use the L-DNA nucleotide structure shown previously as a reference), and add the same connecting lines. How are the two ladders for D-DNA and L-DNA related?*



Correct Answer:



The two ladders from D-DNA and L-DNA are mirror-image reflections of each other.

Q3. *Is the origami sheet you have been provided D-DNA or L-DNA? Use your answers to Q1 and Q2 to determine the answer.*

Correct Answer: determine from list of which hand out student received.

Q4. *A double helix can be chiral, just like smaller molecules. To determine the "handedness" of a helix, imagine it is a spiral staircase, and you are walking from the top to the bottom - as you move down these stairs, would you turning left or right? Whichever direction you need to turn as you move down a helix is the handedness.*

Correct Answer: If the student received a D-DNA origami sheet, the helix should be right-handed. The L-DNA origami sheet should yield a left-handed helix.

Q5. *Compare your helix with other students' - are all the helices the same handedness, or different? Compare the helix handedness of D-DNA and L-DNA - which handedness of DNA leads to a right-handed helix?*

Correct Answer: D-DNA forms a right-handed helix, L-DNA a left-handed helix.

Q6. *Carefully stretch out and cut one of the L-DNA helices in half, so that you have a single "strand" of L-DNA. Try to lay this strand onto a D-DNA helix, so that the bases in the L-DNA strand pair correctly to D-DNA. Is this possible without bending the L-DNA out of its original helical shape? Do you think an L-DNA and D-DNA strand could pair with each other?*

Correct Answer: It should not be possible to form all ten base pairs between the L-DNA and D-DNA strands without bending the L-DNA out of its natural coil - the L-DNA should tend to coil in the opposite direction as the D-DNA strand, preventing more than a few bases from being paired at the same time. This demonstrates that L-DNA and D-DNA strand can't base pair with each other.

Q7. *Proteins in our cells bind to DNA to read and copy it. Proteins are made of amino acids, which like DNA nucleotides, are also chiral. Unlike DNA, amino acids found in living things are left-handed. Imagine your left hand is a protein: curl your hand and rest a D-DNA helix in it so that one edge is touching your palm and thumb, and the tips of your fingers are touching the other edge. Hold your hand in that position, remove the D-DNA helix, and try to place an L-DNA helix in the same position - can it fit, or do you have to move your fingers? Based on these results, would L-proteins in our cells be able to interact with L-DNA in the same way that they interact with D-DNA?*

Correct Answer: It should not be possible to grab L-DNA and D-DNA strands with your left hand in the same way without changing the shape your hand makes or bend the origami out of shape. If you take the shape your left hand makes while gripping D-DNA and make the mirror image shape with your right hand, you should be able to grab L-DNA in the same way. Natural enzymes made of left-handed amino-acids aren't able to interact with non-natural L-DNA, but scientists have made mirror-image enzymes out of right-handed amino acids and shown they can work on L-DNA.

Q8. *Imagine an organism that wasn't homochiral, and had equal mixtures of D-DNA and L-DNA nucleotides in its DNA strands. What problems would this cause? Would the organism be able to use this kind of DNA to store genetic information?*

Correct Answer: DNA strands with random mixtures of left- and right-handed nucleotides wouldn't be able to base pair with other strands, and wouldn't be able to form a double helix. Without this, DNA wouldn't be able to store genetic information, which is one of many examples of why homochirality is important for living things.