Biological Chemistry: Nucleic Acids, Building DNA

Nucleic acids are composed of subunits or monomers called nucleotides. Each nucleotide is made of a sugar, a phosphate group and a nitrogen-containing base. The sugar found in DNA is deoxyribose and the bases are adenine, thymine, guanine and cytosine. The sugar serves as the linchpin. The sugar deoxyribose is covalently bonded to both the phosphate group and the base. The backbone of the DNA molecule is the sugar and phosphate component of the nucleotide. The bases face 'inward' toward the center of the double-stranded DNA molecule. A ladder is a commonly used analogy to the structure of DNA. A DNA molecule is composed of two strands which connected via hydrogen bonds between the nitrogen containing bases. The rungs of the ladder represent the bases and the hydrogen bonds. The rails of the ladder represent the sugar phosphate backbone.

Materials

Gum drops – 6 different colors

Tooth picks

Procedure

1. Divide the gum drops by color.

2. Within your group decide which color of gumdrop will represent each component of a nucleotide. Enter that information here.

	Gum Drop Color
Phosphate	
Deoxyribose	
Adenine	
Thymine	
Guanine	
Cytosine	

Keep in mind that the sizes of all of these nucleotide components differ. The phosphate is small, deoxyribose is larger, guanine** and adenine** are larger than deoxyribose and approximately twice the size of cytosine and thymine. The gumdrops used for the modeling done in this activity are all approximately the same size.

** If there are enough gum drops you may want to use 2 gumdrops for the adenine and guanine bases.

3. Use a tooth pick to connect a phosphate gumdrop to a deoxyribose gumdrop.

4. Use another toothpick to connect an adenine** gumdrop to the deoxyribose gumdrop. Add the gum drop at right angles to the phosphate.

5. Repeat steps 3 and 4 to create another adenine nucleotide.

6. Repeat steps 3, 4 and 5 to create 2 thymine, guanine** and cytosine nucleotides.

7. You should now have 8 nucleotides, 2 adenine, 2 cytosine, 2 guanine and 2 thymine.

8. Create a nucleotide strand using 1 adenine**, 1 cytosine, 1 guanine** and 1 thymine. Use a toothpick to connect the phosphate group of one nucleotide to the sugar group of another. Connect them in any order you choose. Continue connecting the sugar phosphate units until you have a four-base strand of DNA.

9. Place the strand on your desk and identify the order of bases. Write the order below.

Base position	Base identification
First Nucleotide	
Second Nucleotide	
Third Nucleotide	
Fourth Nucleotide	

The bases in DNA bond to specific partner bases via hydrogen bonds. Adenine forms 2 hydrogen bonds to thymine. Guanine forms 3 hydrogen bonds to cytosine.

10. Keep in mind the A-T, G-C bonding paradigm, and align your remaining nucleotides next to their partner bases, e.g., place the remaining adenine nucleotide next to the thymine nucleotide. The adenine base is complementary to the thymine base. Remember the 'ladder rungs' are composed of the bases, so the bases should be toward the inside of the ladder and the sugar-phosphate component should be outward (rails of the ladder).

11. Once all the bases have been placed double check your order and record it here.

Base position	Base identification	Complementary base identification
First Nucleotide		
Second Nucleotide		
Third Nucleotide		
Fourth Nucleotide		

12. Use toothpicks to connect the complementary bases in the newly formed DNA strand.

13. Take 5 toothpicks and break them evenly in half. These represent hydrogen bonds.

14. Insert toothpick pieces into the complimentary base pairs to complete the 'ladder'. Remember the A-T has 2 hydrogen bonds and the G-C pair forms 3 hydrogen bonds.

Take a photo of your DNA molecule and insert it here.

Why is it important that the bases in the DNA molecules connect via hydrogen bonds as opposed to covalent bonds?