**Structure of DNA**

*Paper Model Lab, Part 1*

**Objective:** The purpose of this lab/activity is to gather a better understanding of the structure and function of DNA. (Indiana State Academic Standards: Biology, 1.11, 1.12, 1.15, 1.18, & 1.21)

**Background:**

Deoxyribonucleic acid (DNA) is a complex molecule found in all living organisms. DNA is the chemical of which genes are composed. An understanding of the organization of tiny molecule has answered many questions. Scientists now know how chromosomes can duplicate during cell division and transfer their genetic information to new chromosomes. Scientists also understand how chromosomes in the cell nucleus can direct the formation of specific proteins outside the nucleus.

In 1954, James Watson and Francis Crick discovered a probable structural format of the DNA molecule, and in 1962 they received the Nobel Prize for their theory about the structure of DNA—the molecule that controls everything in a living organism. It is essentially a very simple molecule as far as structure is concerned. In fact, James Watson once said, “If I had known it was so simple, I would have discovered it a long time ago.” (Ha ha! very funny.)

Two important molecules, which made up DNA are deoxyribose (6-sided sugar) and a phosphate group (phosphoric acid). In addition to these two molecules, there are four different molecules called nitrogenous bases. For DNA they are adenine, thymine, guanine, and cytosine. These nitrogenous (nitrogen containing) bases are divided into two groups: purines and pyrimidines. Purines have two rings in their structures, whereas pyrimidines have one ring. A molecule of deoxyribose joins with phosphoric acid and any one of the four possible nitrogen bases. This makes a monomer of DNA called a nucleotide. A nucleotide is named for the base that joins with the deoxyribose. For example: if thymine bonds to deoxyribose, the molecule is called a thymine nucleotide. A DNA molecule is “ladder-like” in shape. Deoxyribose and phosphoric acid molecules join to form the sides or uprights of the ladder. Nitrogenous base molecules join to form the rungs of the ladder. The bases form complimentary pairs with only one other base. Adenine bonds with thymine, and cytosine bonds with guanine. In order for the rungs of the ladder to all be the same length, a purine must join with a pyrimidine. The molecule then twists creating a double helix shape.

**Materials:**
- Paper models

**Procedure:**

1. Collect 12 nucleotide pieces. You should have:
   - 2 pink thymine pieces
   - 2 green adenine pieces
   - 4 blue cytosine pieces
   - 4 yellow guanine pieces

2. Join six nucleotides together in puzzle like fashion to form a column in the following sequence from top to bottom.
   - Cytosine nucleotide
   - Thymine nucleotide
   - Guanine nucleotide
   - Adenine nucleotide
   - Guanine nucleotide
   - Cytosine nucleotide
3. Tape these nucleotides together using a small piece of tape (you will have to take them apart later). Let this arrangement represent the LEFT half of a ladder molecule.

4. Complete the right side of the DNA ladder by matching the bases of other nucleotides to form complete "rungs" (steps of the ladder). Start at the TOP of the left side of the ladder and add nucleotides one at a time in the correct order. Tape (bond) each to the above nucleotide as you add it. Be careful when you bond the nitrogen bases of the 'rungs' to each other. Use a VERY small piece of tape. This represents the weaker hydrogen bonds that keep the nitrogen bases together. (This will become important in the second half of this activity). NOTE: It is necessary to turn the nucleotides upside down in order to join the base pair combinations.

5. Besides being shaped like a ladder, a DNA molecule is twisted. Gently, twist your model as if you were winding it around a rod. The effect you should get is a double helix.

6. Using your DNA molecule, answer the analysis questions that follow.

Analysis and Conclusion:
1. DNA stands for ________________________________.  

2. If four guanine bases appear in a DNA model, how many cytosine bases should there be? Does your model represent your prediction?  

3. The two scientists credited with describing the structure of DNA are ______________________ and _______________________.

4. According to complementary base pairing rules, Adenine always bonds to _______________________ and cytosine always bonds to _______________________.

5-7. Identify the following structures (hint: Structure X is made up of 3 components and #6 & #7 are types of bonds)

5. X = __________________  

6. __________________

7. __________________

8. Where is DNA located in the cell? _________________________

9. Describe the difference between purines and pyrimidines?

10. List the 3 parts of a nucleotide.
DNA Replication

*Paper Model Lab, Part 2*

**Objectives:** The purpose of this lab/activity is to gather a better understanding of the structure and function of DNA. (Indiana State Academic Standards: Biology, 1.11, 1.12, 1.15, 1.18, & 1.21)

**Instructions:** Follow the procedures and complete the analysis questions that follow.

**Background:**

The major concentration of DNA is found in the cell nucleus. We know that the nucleus of the cell is the “control center”. It is the nucleus, which controls all cell activity. DNA is the molecule in the cell nucleus that sends chemical signals to the cell instructing it to conduct the thousands of chemical reactions necessary each minute for life to be sustained. Since every cell needs the instructions about how to stay alive, there must be a way to make sure every new cell gets these instructions. A new cell is made by already existing cells, therefore, there is a mechanism to copy these “life instructions” into new cells. DNA has the instructions for life coded by the order in which the nucleotides occur in a chromosome. Every cell inherits the same sequence of nucleotides that its parent received. The method DNA uses to make an exact copy of its nucleotide sequence is called **DNA replication**.

**Procedure:**

_____1. Open your DNA model by ‘breaking’ the hydrogen bonds between the bases along the middle of the ‘rungs’ and separate into halves.

_____2. Using the LEFT half of your model as a pattern, add new nucleotides (you will need to collect more) to form a **new right side.** (Do NOT mark this side.) Tape the upright phosphoric acid and deoxyribose molecules using a ‘covalent’ bond. Tape the nitrogen bases together using ‘hydrogen’ bonds (a very small piece of tape).

_____3. Again, using the free nucleotides, add nucleotides to the other side of the DNA. Add these nucleotides one at a time and tape as above.

_____4. You should have **TWO** short strands of DNA, each six nucleotides long containing a total of twelve nucleotides each.

_____5. Using both of the DNA stands, complete the analysis and conclusion questions.

**Analysis and Conclusion:** *(Complete sentences are required)*

1. List the base pairs of the **first strand** and **second strand**. What do they have in common?

   **STRAND 1:**

   **STRAND 2:**

   How are they similar?
2. The type of replication demonstrated in this lab is called semi-conservative replication. What does this mean?

3. Draw and label diagrams that show the progression of DNA replication. (Use the three boxes as a guide.) Hint: use the diagrams in your notes to help you.

<table>
<thead>
<tr>
<th>Replication Fork</th>
<th>Replication (Use arrows to show the direction.)</th>
<th>Separation (Draw the new strands of DNA. Use colored pencils to show the “old” strand and “new” strand in each molecule of DNA.)</th>
</tr>
</thead>
</table>

4. What is the role of DNA polymerase in DNA replication?

5. What does the enzyme helicase do? What type of bond is affected by its action?

6. Explain why DNA replication is necessary before cell division takes place.

7. Where does DNA replication take place in the cell?