**EPGENETICS: INVESTIGATING THE STRUCTURE AND FUNCTION OF DEOXYRIBONUCLEIC ACID (DNA)**

The term Epigenetics has had a variety of meanings to scientists, until relatively recently when it was agreed that the term be defined as a “stably heritable phenotype resulting from changes in a chromosome without alterations in the DNA sequence”. In other words **Epigenetics** is the study of cellular and physiological trait variations that are caused by external or environmental factors that switch genes on and off and affect how cells read genes instead of being caused by changes in the DNA sequence. To better understand Epigenetics as well as to continue to improve the ability to use VSEPR to predict shapes of molecules, we will take an in depth look at the structure and shape of the DNA molecule. More specifically, in this activity we will investigate the parts of a DNA molecule, important bonds present in the molecule, the double helix structure and encounter an introduction to DNA replication and transcription. You will also be asked to participate in an “interdisciplinary thinking” challenge as a means to better prepare you for your future as a deep thinker and scientist. To accomplish this, we will progress through the following parts of this project:

**Part 1:** Part of the DNA molecule and Connections to Biology (Day 1 in class, pre-lab outside)
**Part 2:** Pre-Drawing Challenge (Day 1 in class)
**Part 3:** Seminar (prepare outside class between Days 1 & 2, discussion in class on Day 2)
**Part 4:** IDI-Challenge (Day 2 in class)
**Part 5:** Post-lab Assignment (outside class)

**Part 1: Parts of the DNA Molecule**
The deoxyribonucleic acid (DNA) of a typical mammalian cell contains about $3 \times 10^9$ repeating units that are composed of three parts: a *phosphate group*, a *pentose sugar* (a sugar with five carbon atoms), and a *nitrogenous base* (a base containing nitrogen atoms). In this section, we will explore each part of a DNA molecule and apply VESPER theory to gain a better understanding of the shape of this large molecule.
A. Nitrogenous bases
DNA is composed of four nitrogenous bases (shown below). Explore the structure of each of these bases by completing the following tasks:
1. Use the ball and stick model kit to build the Cytosine base (C).
2. Add lone pairs of electrons to each structure to the right to complete the Lewis structure for all four bases.
3. Use VSEPR theory to name the molecular shape and indicate bond angles around the carbon and nitrogen atoms in the cytosine molecule.
4. Add partial charges or a dipole arrow to the cytosine molecule to indicate molecular polarity.
5. Draw the expanded Lewis Structure for cytosine that has the same bonding pattern as the structure shown above. Now draw one resonance structure for this molecule. Add formal charges to both structures and select the best structure by circling it.
B. Deoxyribose sugar
Deoxyribose is a 5-carbon sugar molecule and forms the backbone of the DNA molecule. Four of the carbons reside in the ring along with an oxygen atom and one carbon is outside of the ring. Explore this sugar molecule by completing the following tasks:
6. Circle the carbon atom located outside of the ring.
7. Add hydrogen atoms to the carbon atoms that are needed to complete the structure (there are no double bonds).
8. Add lone pairs of electrons to the structure to complete the Lewis structure.
9. Use VSEPR theory to name the molecular shape and bond angles around each carbon and oxygen atom.

C. Phosphate group
The other part of the repeating unit in the DNA backbone is a phosphate group. The phosphate group attaches to two deoxyribose molecules linking the backbone together. Explore phosphate by completing the following tasks:
10. Add lone pairs of electrons to the structure to complete the Lewis structure.
11. Use VSEPR theory to name the molecular shape and bond angle around the phosphorus atom.
12. Place two circles on the structure where you think the phosphate group might attach to the sugar molecule to form the backbone of the DNA molecule.
D. Linking Through Chemical Bonds
The two images below represent a nucleotide (the repeating unit that makes up DNA molecules that is composed of sugar, base and phosphate groups). Use these two images to understand how the three pieces “bond” together.

13. Draw a circle around the phosphate group
14. Draw a square around the sugar group
15. Draw a rectangle around the nitrogenous base
16. Use arrows to point to the bonds that link the three pieces together. Next to each arrow indicate which two atoms are involved in the bond.

17. Use the DNA model set provided to connect the three parts of the DNA molecule together. Notice the chemical bonds that links them together as you carry out this task.
18. The backbone of the DNA molecule is further constructed by the formation of another bond between a phosphate group and a second sugar group. This linkage is referred to as a **phosphodiester bond**. Review the image below to observe the phosphodiester bonds shown and draw circles around these linkages.

19. Use DNA model kits to construct the DNA molecule. You may need to combine at least two groups to have all the pieces needed.
E. Functions of DNA and Methylation

20. Briefly describe the two major functions of DNA.

21a. Do all your cells have the same DNA?

b. Do all your cells use all their DNA? Why or Why not?

22. What happens chemically and structurally when DNA is methylated? Use your model of cytosine that you built to explore where the methyl group is added. Draw cytosine again, but this time show the methyl group on your molecule.
Part 2: Pre-Drawing Challenge
On your white board, make a group drawing that represents your thinking about how methylation of DNA silences a gene. Be creative and use ideas from both chemistry and biology to respond.

Once your drawing is finished, be prepared to tell the class about it and be sure that we capture your drawing as a photograph for future reflection.

Part 3: Seminar Preparation (outside class between Days 1 and 2)
1. Read these two articles:
   “A New Kind of Inheritance”, Scientific American, 2014
   “Ancestral dichlorodiphenyltrichloroethane (DDT) exposure promotes epigenetic transgenerational inheritance of obesity” BMC Medicine, 2013.
2. Write a summary of the articles.
3. Write three questions that you still have after reading the articles.
4. Bring the summary and questions with you to class and be prepared to participate in an in-class seminar.

You will also be asked to submit your summary and questions to your instructor after the seminar.

Part 4: IDI Challenge (Day 2 in class discussion, include in postlab)
In this Challenge, you are asked to combine what you have learned during this investigation to produce a second white board group drawing about how methylation is involved in Epigenetics.

Again, be prepared to share your drawing and to capture your work as a photograph. You will need this for your postlab assignment.

Part 5: Post-lab (complete after Day 2)
Complete the postlab assignment on a separate piece of paper and submit to your instructor along with your Part 1 handout that was completed in class.

1. Provide images of both in-class group white board drawings. Be sure to label which drawing was completed first and which was completed second.
2. From observing your drawings, discuss the following:
   a. How did your group use both chemistry and biology to produce your model?
   b. How did you as an individual progress in your understanding of epigenetics from the first drawing to the second?
   c. Do you have a better understanding of VSEPR and molecular shape as a result of working through this activity?
   d. What questions do you still have about epigenetics or the structure of DNA?
3. Write a summary describing the model you came up with in your second drawing for how methylation impacts gene expression.