Biochemistry Literacy for Kids Lesson 1: NGSS Alignment and Lesson Plan

Grade: Grades 3-12	**Topic:** Chemistry and biochemistry intro	**Lesson # 1 in a series of 25 lessons**

Brief Lesson Description: Students learn how to interpret the periodic table and become familiar with bonding behavior of hydrogen, carbon, nitrogen, oxygen, and fluorine. Students explore the structure of hemoglobin and atmospheric gases using computer modeling software and physical model building. The lesson gives an atomic foundation for the study of the physical and life sciences which will be applied in future Biochemistry Literacy for Kids lessons.

Performance Expectations: Students will view animated presentations, discuss chemical concepts, build molecular models individually and in groups, and use molecular modeling software to explore the structure of macromolecules.

Specific Learning Outcomes:

Students will use computers to examine and explore 3D protein structures to deduce bonding rules and periodic trends for several common elements.

Students will clarify and revise their understanding of the concepts of atom, molecule, and cell.

Students will use visual models to theorize and argue how hemoglobin transports oxygen gas molecules within the body.

Students will perform hand-held chemical reactions with model kits and predict reaction products of simple combustion reactions.

Students will be able to discuss and demonstrate with models and drawings how several elements bond together to make commonplace molecules and materials, connecting the molecular world to the reality that we experience.

Narrative / Background Information

Prior Student Knowledge: The lesson is designed for students with a science background at floor level.

Science & Engineering Practices:	**Disciplinary Core Ideas:**	**Crosscutting Concepts:**
Asking Questions and Defining Problems Developing and Using Models Engaging in Argument from Evidence	**From Molecules to Organisms: Structures and Processes** LS1.A Structure and Function 4-LS1-1; MS-LS1-1; MS-LS1-2; MS-LS1-3; HS-LS1-1; HS-LS1-3; HS-LS1-6; HS-LS1-7 **Matter and Interactions** PS1.A Structure and Properties of Matter 2-PS1-1; 2-PS1-2; 2-PS1-3; 5-PS1-1; 5-PS1-2; MS-PS1-1; MS-PS1-2; MS-PS1-3; MS-PS1-4; HS-PS1-1; HS-PS1-2; PS1.B: Chemical Reactions 5-PS1-4; 5-PS1-2; MS-PS1-; MS-PS1-3; MS-PS1-5; HS-PS1-2; HS-PS1-7	Patterns Scale, Proportion, and Quantity Systems and System Models Structure and Function Stability and Change

Possible Preconceptions/Misconceptions:

Belief that chemistry is a subject mainly about making explosions.

Belief in the four classical elements: earth, wind, water, fire.

Confusion about the differences between the concepts of atom, molecule, and cell

LESSON PLAN – 5-E Model

ENGAGE: Opening Activity – Access Prior Learning / Stimulate Interest / Generate Questions:

The class begins with students coloring a periodic table worksheet to remember the color-coding for hydrogen, carbon, nitrogen, and oxygen, the most common elements in biology. Students then begin viewing an interactive 3D model of hemoglobin, the protein found in red blood cells responsible for oxygen transport. The structure is accessed from the Biochemistry Literacy website, and is viewed on the free molecular modeling software PyMol. If laptops are available, each student can use a mouse to rotate and zoom into the structure, viewing the almost 10,000 atoms that make up the molecule. The instructor guides the class by asking students to find bonding patterns in the structure; for example, does carbon (gray atoms) follow any bonding patterns? Students construct a table of bonding rules based on what they observe in the hemoglobin structure, and begin to notice patterns of bonding based on the element's position in the periodic table (periodic trends). Students can begin to predict the bonding behavior of other elements, based on what they have discovered, and begin to ask questions about why these patterns exist.

EXPLORE: Lesson Description – Materials Needed / Probing or Clarifying Questions:

The animated presentation used to guide classroom discussion is available on the program website.

The lesson presentation first orients students to the tiny scale of molecules like hemoglobin by zooming into a microscopy image of a red blood cell. Animated visualizations help students see that over a quarter billion hemoglobin molecules are squeezed into each red blood cell. Students then view animated presentations showing how hemoglobin binds four oxygen gas molecules, and how the oxygen is carried from the lungs to other parts of the body. If enough model kits are available, students can physically bind an oxygen molecule to the central iron of the heme molecule. A photographed version of this model is also viewable in the presentation.

Students begin to apply the bonding rules discovered in the opening activity to interpret chemical formulas, and build molecular models of simple gas molecules such as hydrogen, oxygen, and nitrogen gas. As these gases contain one, two, or three bonds, the class can discuss and experience differences in bonding strength for different gas molecules. This has implications for the stability or reactivity of the gases. For example, triple bonded nitrogen is much more stable than single bonded hydrogen. Students then experience their first hand held chemical reaction by simulating the combustion of hydrogen gas in oxygen. This experience lays the ground work for the concepts of stoichiometry and balancing equations. Real world connections with the gases are then explored. The concept of allotropy is introduced with carbon. Physical or virtual models of diamond, graphite, and fullerine are explored, and students debate how the different bonding patterns of each allotrope determine each material's properties. The lesson concludes by showing students the composition of Earth's atmosphere in terms of percentages of nitrogen and oxygen gas, and reviews the new nomenclatures learned during the lesson.

EXPLAIN: Concepts Explained and Vocabulary Defined:

The periodic table displays all the elements, and patterns in atomic bonding are connected with the element's position in the periodic table.

Scientists use colors white, black, blue, and red to code for hydrogen, carbon, nitrogen, and oxygen, respectively.

Molecules are extremely small, and cells contain billions of them.

Hemoglobin protein is a molecule found in red blood cells that is responsible for carrying oxygen around the body. Oxygen binds to the central iron if hemoglobin's heme.

Atoms can be combined into molecules. Each molecule has different functions and properties, based on its structure.

Common gas molecules obey bonding rules, and single, double, or triple bonds allow atoms to conform to those bonding rules.

The atmosphere is made up of mostly nitrogen and oxygen.

Vocabulary:

Periodic table: A chart that organizes and presents the different types of atoms that make up the universe

Atoms: very small entities that bond together to make molecules.

Molecules: assemblies of two or more atoms.

Cells: living structures that are large enough to view in a microscope. Cells are made of billions of molecules.

Bond: a connection between to atoms. Bonds can be single, double, or triple.

Hemoglobin: a very large molecule made of almost 10,000 atoms, whose function is to transport oxygen in red blood cells.

Heme: a component of hemoglobin that contains an iron atom, which is responsible for binding inhaled oxygen gas.

Chemical reaction: a reorganization of the atoms of one or more molecules that can be accompanied by a release of energy.

Allotrope: a form of a material that has a particular bonding pattern. Some elements like carbon have several allotropes that have different properties, depending on their structures.

ELABORATE: Applications and Extensions:

Research an atom or molecule mentioned in the lesson to explore additional chemical behaviors, occurrences, or applications. For example, carbon dioxide, one of the gases studied in the lesson, is a greenhouse gas. Its sources can be explored, and how it contributes to global warming can be discussed.

Give students a creative building project. Ask them to work together to build large molecules and draw them using the nomenclatures learned in the course.

Discuss the role of oxygen in aerobic respiration. Why do animals need oxygen?

Research the atmospheres of other planets and moons. How similar or different from Earth's are they?

EVALUATE: Formative Monitoring (Questioning / Discussion):

Can you theorize how many bonds third row elements can make, based on the rules observed for second row elements?
The elements of each column can bond the same way. Sulfur is expected to form 2 bonds, like oxygen, for example.

Why is such a complicated molecule, hemoglobin, required to bind only four small oxygen molecules?
(Students usually bring up this question themselves. The answer requires some more advanced lessons, but it can get students thinking about biochemistry right away.)

Why is a triple bond stronger than a double bond? And why is a double bond stronger than a single bond?
Students can physically try to pull a triple bonded molecule apart and experience the extra force required.

Why is diamond such a strong material?
A built structure of diamond allows students to experience the stability of a carbon crystal.

Summative Assessment (Quiz / Project / Report):

1. What are living things made of?

2. What is an element?

3. What is an atom?

4. Can you give an example of a kind of element or atom?

5. What is a molecule?

6. Can you give an example of a kind of molecule?

7. What is a cell?

8. Can you give an example of a kind of cell?

9. Project: Construct your own molecule based on the bonding rules learned in class. Draw the structure using the element symbols learned in the lesson.

Materials Required for This Lesson			
Quantity	**Description**	**Potential Supplier (item #)**	**Estimated Price**
1	Biochemistry Literacy for Kids Curriculum License	Biochemistry Literacy for Kids	$150/ teacher
1 per 2-3 students	Molymod Molecular Modeling Kit	Molymod	$30/kit
1 per 2 students	PyMol molecular modeling software	Schrödinger Labs	Free
1 per 2 studnets	Computers (optional)	-	-
1 per 2 students	3-button mice (required to operate PyMol correctly)	-	-
1 per 2 students	Colored pencil sets gray, black, red, blue, green	-	-
1 per student	Printed guided note sheets	Biochemistry Literacy for Kids	-