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| **Lesson Title** | Scientific Method – Enzyme Activity |
| **Length of Lesson** | 180 minutes |
| **Created By** | David Wilson |
| **Subject** | Physical Science (PS) / Chemistry (Chem) |
| **Grade Level** | 9-12$^{th}$ Grade |
| **State Standards** | PS-1(a,b,c,e,f) / Chem-1(b,c,e,f), 5(a) |
| **DOK Level** | DOK2 and DOK3 |
| **DOK Application** | Investigate, Theorize, Analyze, Use, Explain |
| **National Standards** | K-12 / 9-12: A: Science as Inquiry, B: Physical Science, C: Life Science, G: History and Nature of Science |
| **Graduate Research Element** | Investigation of Enzyme Activity |

**Student Learning Goal:**

*State Standards:* (Physical Science)

1) Apply inquiry-based and problem-solving processes and skills to scientific investigations.

a. Use appropriate laboratory safety symbols and procedures to design and conduct a scientific investigation. (DOK 2)

b. Identify questions that can be answered through scientific investigations. (DOK 3)

c. Identify and apply components of scientific methods in classroom investigations. (DOK 3)

e. Analyze procedures and data to draw conclusions about the validity of research. (DOK 3)

f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)

*State Standards:* (Chemistry)

1) Apply inquiry-based and problem-solving processes and skills to scientific investigations.

b. Clarify research questions and design laboratory investigations. (DOK 3)

c. Demonstrate the use of scientific inquiry and methods to formulate, conduct, and evaluate laboratory investigations (e.g., hypotheses, experimental design, observations, data analyses, interpretations, theory development). (DOK 3)

e. Evaluate procedures, data, and conclusions to critique the scientific validity of research. (DOK 3)

f. Formulate and revise scientific explanations and models using logic and evidence (data analysis). (DOK 3)

5) Compare factors associated with acid/base and oxidation/reduction reactions.

a. Analyze and explain acid/base reactions. (DOK 2)

*National Standards:* (K-12)

Unifying Concepts and Processes:

As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:

- Systems, order, and organization
- Evidence, models, and explanation
- Constancy, change, and measurement
- Evolution and equilibrium
- **Form and function**

*National Standards:* (9-12)

A: Science as Inquiry: Abilities Necessary to do Scientific Inquiry

- IDENTIFY QUESTIONS AND CONCEPTS THAT GUIDE SCIENTIFIC INVESTIGATIONS. Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment. They should demonstrate appropriate procedures, a knowledge base, and conceptual understanding of scientific investigations.
- DESIGN AND CONDUCT SCIENTIFIC INVESTIGATIONS. Designing and conducting a scientific investigation requires introduction to the major concepts in the area being investigated, proper equipment, safety precautions, assistance with methodological problems, recommendations for use of technologies, clarification of ideas that guide the inquiry, and scientific knowledge obtained from sources other than the actual investigation. The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers. Regardless of the scientific investigation performed, students must use evidence, apply logic, and construct an argument for their proposed explanations.

B: Physical Science: Chemical Reactions

- Chemical reactions occur all around us, for example in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.

C: Life Science: The Cell

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.
- Most cell functions involve chemical reactions. Food molecules taken into cells react to provide the chemical constituents needed to synthesize other

molecules. Both breakdown and synthesis are made possible by a large set of protein catalysts, called enzymes. The breakdown of some of the food molecules enables the cell to store energy in specific chemicals that are used to carry out the many functions of the cell.

G: History and Nature of Science: Nature of Scientific Knowledge

- Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world.

**Materials Needed (supplies, hand-outs, resources):**
[Any quantities of supplies listed are per each class.] One fresh, unpasteurized papaya fruit. One fresh, unpasteurized pineapple fruit. One bottle of powdered meat tenderizer. A few boxes of unflavored gelatin. One hotplate per group. A package of small Styrofoam or Dixie cups. (These cups will hold very hot water. Test their integrity before using them.) Several small dropper bottles containing buffer solutions of various pH. Several 100-250 mL beakers. Several table spoons (or some other tool to crush fruit pieces in the small beakers to extract the juice.) OPTIONAL: a fruit juicer (This is cleaner than having students juice their fruits.) and gloves (The fruit enzymes will slowly react with your students' skin, so have them wash up after.)

**Lesson Performance Task/Assessment:**

1) Students will proceed through the steps of the scientific method with the assistance of the teacher.
2) Students will design an experiment to investigate the effects of pH and heat upon enzyme activity.

**Lesson Relevance to Performance Task and Students:**
In this lesson the students will not only review but apply the scientific method to a real-world scientific investigation. Students will also infer the effects and benefits of pasteurization. Finally, students will explain the effect of pH and heat on enzyme structure, and the effect of enzyme structure change on enzyme function.

**Anticipatory Set/Capture Interest:**
The teacher will explain that fruit jello must be made with pasteurized fruit (depending on the fruit), and ask the students to brainstorm why that is?

**Guided Practice:**
The teacher will guide the students through the steps of the scientific method in designing the procedure for investigating the effect of heat on the fruit enzyme function.

**Independent Practice:**

The students will independently design the procedure for investigating the effect of pH on the fruit enzyme function.

**Remediation and/or Enrichment:**
Remediation: Individual IEP.
Enrichment: Students will be encouraged to elaborate on their investigation by evaluating their procedure after analyzing their data and implementing a revised procedure to optimize their investigation.

**Check(s) for Understanding:**
The quality of the students' independently drawn up procedure.

**Closure:**
"How important is pasteurization? How exactly does pasteurization work?"
"What is the effect of the heat on the function of the protein? Why?"

**Possible Alternate Subject Integrations:**
Biology

**Teacher Notes:**
A procedure for this lesson will be attached to this lesson.