**Cellular Energy**

**Essential questions**

**How is energy connected to life?**

Enzyme sub-questions:

* How do reactions occur in organisms?
* What things can affect the activity of an enzyme?

Photosynthesis sub-questions:

* What allows autotrophs in ecosystems make their own food?
* Why do leaves change color?
* How do autotrophs make food?

Respiration sub-questions

* How do organisms in ecosystems survive without oxygen?
* Why is food considered as fuel for organisms in ecosystems?
* How does Rs and Ps contribute to the carbon cycle?

**Instructional goals**

Develop a cause and effect model for specificity of enzymes - enzymes are proteins that speed up chemical reactions (catalysts) by lowering the activation energy, are re-usable and specific, and are affected by such factors as pH and temperature

Analyze overall reactions including reactants and products for photosynthesis and cellular respiration and factors which affect their rates (amounts of reactants, temperature, pH, light,

etc.).

* Determine why oxygen is a product of photosynthesis and CO2 is a product of cellular respiration.
* Describe how the sun’s energy is captured and used to construct sugar molecules that can be used as a form of energy or serve as building blocks of organic molecule.
* Compare these processes with regard to efficiency of ATP formation, the types of organisms using these processes, and the organelles involved. (Anaerobic respiration should include lactic acid and alcoholic fermentation.)

Investigate and analyze the cell as a living system including:

* Energy use and release in biochemical reactions

Summarize the structure and function of organelles in eukaryotic cells

* Mitochondria
* Chloroplasts

Determine why some cells have both mitochondria and chloroplasts while other cells have only mitochondria or neither mitochondria or chloroplast.

**Indiana Standards**

B.1.2 Understand that the shape of a molecule determines its role in the many different types of cellular processes (e.g., metabolism, homeostasis, growth and development, and heredity) and understand that the majority of these processes involve proteins that act as enzymes.

B.2.3 Explain that most cells contain mitochondria (the key sites of cellular respiration), where stored chemical energy is converted into useable energy for the cell. Explain that some cells, including many plant cells, contain chloroplasts (the key sites of photosynthesis) where the energy of light is captured for use in chemical work.

B.3.1 Describe how some organisms capture the sun’s energy through the process of photosynthesis by converting carbon dioxide and water into high-energy compounds and releasing oxygen.

B.3.2 Describe how most organisms can combine and recombine the elements contained in sugar molecules into a variety of biologically essential compounds by utilizing the energy from cellular respiration.

B.3.3 Recognize and describe that metabolism consists of all of the biochemical reactions that occur inside cells, which include the production, modification, transport, and exchange of materials that are required for the maintenance of life.

B.3.4 Describe how matter cycles through an ecosystem by way of food chains and food webs and how organisms convert that matter into a variety of organic molecules to be used in part in their own cellular structures.

B.5.4 Explain how the unique shape and activity of each protein is determined by the sequence of its amino acids.

**Misconceptions**

Enzymes are special molecules and not made of protein.

Enzymes get “used up” during reactions.

Enzymes are only involved in digestion.

Respiration is synonymous with breathing.

Animals breathe in oxygen and breathe out carbon dioxide, while plants breathe in carbon dioxide and breathe out oxygen

Food is anything useful taken into the body including: water, minerals, carbon dioxide (plants), and sunlight

Plants obtain their energy directly from the sun.

Plants have multiple sources of food (heterotrophic as well as autotrophic).

Plants feed by absorbing food through their roots.

Plants use the heat from the sun as a source of energy for photosynthesis.

Sunlight is composed of molecules.

Sunlight is “consumed” in photosynthesis.

Plants absorb water through their leaves.

Plants produce oxygen for our benefit.

Cellular respiration is characteristic of animal cells but not plant cells. Plant cells photosynthesize instead.

The oxygen we breathe comes from the carbon dioxide plants take in.

**Vocabulary** Highlighted Words = Essential Vocabulary

Reactant Product Activation Energy Catalyst Enzyme Substrate

Active Site Competitive Inhibitor Noncompetitive Inhibitor Autotroph

Heterotroph ATP ADP Photosynthesis Pigment Chlorophyll Xanthophyll

Carotene Thylakoid Grana Photosystem Stroma NADP+

NADPH Light Reaction Calvin Cycle (Dark Reaction) ATP Synthase

Glucose Calorie Glycolysis Anaerobic Aerobic Respiration NAD+

NADH Fermentation Lactic Acid Alcoholic Fermentation Krebs Cycle

Electron Transport Chain ~36ATP

**Sequence** Timing ~15 days

*This sequence does not include any time for quizzes and review,*

Optional first experiment: Carbon Cycle in Plants

(20+ days needed to obtain results so plants must be started at least 10 days prior to the beginning of this unit.)

Measuring the mass of a Fastplant seed, then measure the final dry soil mass before and after significant growth of the plant.

Outcome: The mass of the plant increases significantly, while the mass of the soil decreases only very slightly. This should help students to understand the uptake of CO2 and carbon fixation.

Whiteboard: Where did the extra mass come from?

1. Enzyme demo: cheesemaking (1/2 day) (optional)

Model – WB and discuss:

○ “How do reactions occur in living organisms?”

○ “What did you observe taking place?”

○ “How is energy connected to life?”

○ “What change(s) took place in the scenario?”

2. Jello Pineapple lab (2 1/2 days)

Postlab questions:

● What is the adaptive advantage of protease to pineapple?

● How does heat impact the function of the protease in pineapple?

● What other fruits do you think have this protease? How could you tell?

● What could proteases be used for?

● Exit Card: The recipe for pineapple jello calls for boiling the pineapple first or using pasteurized canned pineapple. Why is that?

Optional video on use of proteases:

<http://www.youtube.com/watch?v=y0xPd6nyQ-Q>

3. Enzyme Kinetics Lab (1 day)-Penny, Nickel, Dime Activity.

Postlab questions:

○ “What did you observe taking place?”

○ “How is energy connected to life?”

○ “What change(s) took place in the scenario?”

Formative assessment on enzymes (quiz, worksheet....) TO BE DEVELOPED

4. Model – “What allows autotrophs in ecosystems to make their own food?” – WB and discuss (1 day)

Goal: Elicit prior knowledge from students about photosynthesis (but do not use the word photosynthesis).

Show Images of starch tests with Iodine fumes in different leaves (Von Sach’s Experiment)...

<http://classes.midlandstech.edu/carterp/courses/bio101/labquiz3/starch1.JPG>

And<http://www.bbc.co.uk/learningzone/clips/images/previews/s_scie/s_scie_ec_14187_16x9.jpg>

And Potato Starch Iodine

<http://www.bbc.co.uk/scotland/learning/bitesize/standard/chemistry/images/potato_to_black.gif>

Whiteboard Prompt:

What do you think is happening in those leaves to produce the dark color? (Use words and pictures)

Postlab Questions:

Why did the leaves exposed to light turn dark when exposed to iodine?

Why didn’t the leaves covered in foil turn dark when exposed to iodine?

Explain how the data observed connects to energy production.

5. Spinach disk photosynthesis lab (1 day)

Revisit: What allows autotrophs in ecosystems to make their own food?”

Prelab Questions:

What else do plants produce besides starch/glucose? - They should know oxygen.

Where does the oxygen come from? How can we measure it?

Postlab questions:

Why did spinach float?

What if you used disks from a dead leaf, what would happen?

How does that compare to boiled pineapple and its enzyme activity?

How do you know plants make oxygen?

What does the green color do for the plant?

6. Pigment Discussion and Lab (2 days-Optional)

Model – “How do leaves collect sunlight to make their energy/glucose/starch?” – WB and discuss (1 day)

Pre-Questions:

Are all leaves green? How do you know?

Why do leaves change color?

Plant pigment chromatography lab

Pre-Questions:

Predict what color spinach/kale/collard greens/poinsettia would turn in the fall? How could you figure this out?

Formative assessment on photosynthesis (quiz, worksheet....) TO BE DEVELOPED

7. Cheese puff on fire energy demo. Burn a cheese puff using tongs. (1 day)

Alternative cheese puff videoclip: <http://www.youtube.com/watch?v=Jy-QV05WIXo>

Model – WB and discuss:

○ “We’re not on fire, so where’s the energy in our body come from?”

○ “What did you observe taking place?”

○ “How is energy connected to life?”

○ “What change(s) took place in the cheesepuff?”

○ “How do autotrophs use the energy (food) they make during photosynthesis?”

8. Setup Cellular respiration lab (wait two days for results, Friday works best).

Model - “Why is food considered as fuel for organisms in ecosystems?” - WB and discuss (1 day)

9. Continue to model “Why is food considered as fuel for organisms in ecosystems?” (1 day)

Formative assessment on cellular respiration

(Exit ticket, worksheet, clicker questions)

10. Model - “How do organisms in ecosystems survive/obtain energy without oxygen?” - WB and discuss (0.5 day)

○ “What organisms can live without oxygen?”

○ “When do humans try to/have to survive without oxygen?”

○ “What is the adaptive advantage of being able to survive with little or no oxygen?”

Demonstration: Use an organism (yeast), react it with sugar, observe what happens, and complete a splint test to show that oxygen is not being released. The next question to ask students would be... “What gas is being released?” → Splint test shows it is not oxygen. Therefore, what do you think is being given off?

11. Yeast fermentation lab (1.5 day)

Pre-Questions:

Show them potential materials yeast, sugar, fruits, ice, hot plates, thermometers, gas beakers.

Measure: Bubbles released per minute from yeast

Post-Lab:

What do you expect the bubbles per minute will be tomorrow with the same reaction tubes?

12. Model - How does Respiration and Photosynthesis contribute to the carbon cycle (use words and pictures)? – WB and discuss (1 day)

Questions:

Where does the carbon come from? Where does the carbon go?

What role does carbohydrate play?

What role does sugar play?

What role does CO2 play?

Showing a cross section of a leaf, ask the question, “What is the functional importance of these little holes (stoma)?” “What is the adaptive advantage of these holes?”

Formative assessment on cellular respiration (quiz, worksheet....) TO BE DEVELOPED

Review activity for the energy unit (jeopardy, clicker questions, game...) TO BE DEVELOPED

Summative evaluation of the energy unit. TO BE DEVELOPED

**Instructional Notes:**

*This sequence does not include any time for quizzes and review, Also, you are strongly encouraged to incorporate one of the Vernier labs listed at the end of this module.*

*Energy Transfer:*

**1. Activity Title**

Apparatus

Pre-activity discussion

Instructions

Post-activity discussion

Potential