UbD: AP Biology Cellular Metabolism

Stage 1 – Desired Results

Established Goals (e.g., standards)

Organisms are linked by lines of descent from common ancestry. (EU 1B)

Growth, reproduction and maintenance of the organization of living systems require free energy and matter. (EU 2A)

Interactions within biological systems lead to complex properties. (EU 4A)

Competition and cooperation are important aspects of biological Systems. (EU 4B)

Transfer

Students will independently use their learning to…

- ➔ communicate scientific phenomena
- ➔ solve scientific problems using representations and models
- ➔ engage in scientific questioning to extend thinking to other disciplines
- ➔ perform data analysis and evaluation of evidence.

Meaning

Understandings

Students will understand that….

The process of evolution drives the diversity and unity of life.

Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.

Biological systems interact, and these systems and their interactions possess complex properties that influence their structure and function.

Essential Questions

- ➔ What evidence drives the diversity and unity of life?
- ➔ How do biological systems grow, reproduce, and maintain homeostasis?
- ➔ How do biological systems and their interactions influence structure and function?

Acquisition

Knowledge

Students will know…

Interactions between molecules affect their structure and function. (EK 4B1)

- ➔ The shape of enzymes, active sites and interaction with specific molecules are essential for basic functioning of the enzyme.

Cooperative interactions within organisms promote efficiency in the use of energy and matter. (EK 4B2)

The structure and function of subcellular components, and their interactions, provide essential cellular processes. (EK 4A2)

- ➔ Mitochondria specialize in energy capture and transformation.

Skills

Students will be able to…

- ➔ analyze data to identify possible patterns and relationships between a biotic or abiotic factor and a biological system
- ➔ use representations and models to analyze situations qualitatively to describe how interactions of subcellular structures, which possess specialized functions, provide essential functions. (LO 4.6)
- ➔ analyze data to identify how molecular interactions affect structure and function (LO 4.17)
- ➔ use representations and models to analyze how cooperative interactions within organisms promote efficiency in the use of energy and matter. (LO 4.18)
- ➔ explain how internal membranes and organelles contribute to cell functions.
- ➔ make a prediction about the interactions of subcellular organelles. (LO 4.4)

	Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. (EK 1B1) ➔ Structural and functional evidence supports the relatedness of all domains. ➔ Structural evidence supports the relatedness of all eukaryotes. (membrane bound organelles-mitochondria) All living systems require constant input of free energy. (EK 2A1) ➔ Living systems do not violate the second law of thermodynamics, which states that entropy increases over time. ➔ Energy-related pathways in biological systems are sequential and may be entered at multiple points in the pathway. (Krebs, Glycolysis, Calvin Cycle, Fermentation) Organisms capture and store free energy for use in biological processes. (EK 2A2) ➔ Heterotrophs capture free energy present in carbon compounds produced by other organisms. ➔ Different energy-capturing processes use different types of electron acceptors. (O2 in cellular respiration) ➔ Cellular respiration in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that harvest free energy from simple carbohydrates ➔ The electron transport chain captures free energy from electrons in a series of coupled reactions that establish an electrochemical gradient across membranes	➔ construct explanations based on scientific evidence as to how interactions of subcellular structures provide essential functions. (LO 4.5) ➔ describe specific examples of conserved core biological processes and features shared by all domains or within one domain of life, and how these shared, conserved core processes and features support the concept of common ancestry for all organisms. (LO 1.15) ➔ justify the scientific claim that organisms share many conserved core processes and features that evolved and are widely distributed among organisms today. (LO 1.16) ➔ explain how biological systems use free energy based on empirical data that all organisms require constant energy input to maintain organization, to grow and to reproduce. (LO 2.1) ➔ justify a scientific claim that free energy is required for living systems to maintain organization, to grow or to reproduce, but that multiple strategies exist in different living systems. (LO 2.2) ➔ use representations to pose scientific questions about what mechanisms and structural features allow organisms to capture, store and use free energy. (LO 2.4) ➔ construct explanations of the mechanisms and structural features of cells that allow organisms to capture, store or use free energy. (LO 2.5)

Stage 2 – Evidence

CODE (M or T)	**Evaluative Criteria** (for rubric)	
		Performance Task(s) *Students will demonstrate meaning-making and transfer by…*

T		Creating a media outlet(magazine, newspaper, video blog) of their choice to communicate how athletes (or any other highly active individuals) use free energy and molecular building blocks (such as carbohydrates, proteins, or lipids) to perform at high levels, while maintaining homeostasis. --- Other Evidence (e.g., formative)
M		Enzyme Analogy Exit Tickets Check for Understanding Rotation Station Products (Pre-Lab Planning, Creation/Calculation, Investigation) Enzyme Study Questions Quiz Analyze Graph Activity-Cellular Respiration Quizzes + Tests

Stage 3 – Learning Plan

CODE (A, M, T)	Pre-Assessment *How will you check students' prior knowledge, skill levels, and potential misconceptions?* 1-2 classes before 'Cellular Metabolism Unit' will begin, students will complete a 3-2-1 Exit Card where they will list 3 things they know about enzymes, 2 questions they have about enzymes, and 1 request referring to the unit of study. They will repeat this for cellular respiration.	
	Learning Activities (Designed for Block Schedule 1.5 hr class) **DAY 1:**	Progress Monitoring (e.g., formative data)
T	Hook: Scientific American Article: *After a person's pulse and breathing stop, how much later does all cellular metabolism stop?*	
A	Class Discussion to identify possible patterns and relationships between a biotic or abiotic factor and a biological system.	
T	Create various graphs based on predictions that each set of data would generate when looking at enzymatic activity vs variable (temperature, pH, increased concentration of substrate, increased concentration of enzyme).	Walk around and check student graphs.
A M	Discussion of Enzyme-Substrate Fit Students will pair up and come up with an analogy of the enzyme-substrate model to share. (ie Lock and Key). Students will need to justify their answers.	Listen to analogies for correct association

	Introduce Performance Task with handouts.	between enzyme-substrates.
M	<u>Exit Ticket:</u> What I thought I knew...Now I Know...	Read exit tickets.
	DAY 2: Rotation Stations for Enzymes (25 minutes @ each)-	
T, A	1. <u>Creation & Calculation Station</u>: ● Draw free energy profile (Exothermic vs Endothermic), label all parts, include on each profile with an enzyme and without an enzyme. ● Using Page 128 of the textbook (*Campbell Biology in Focus - AP Edition, 1e Urry/Cain/Wasserman/Minorsky/Jackson/Reece*), students will graph and calculate rates. ● Students can check the Energy Profile, Graph, and Calculations with the Answer Key once they have completed the station.	Students check their work at end of station.
T, M	<u>2. Investigation Station (from AP Biology Lab 13)</u>- ● Students choose one of the 2 scenarios listed below to investigate. They will have access to technology (ie. ipad cart) to find evidence to support their claim. ● *1st Scenario:* ○ *Ask the students to assume the role of a farmer growing soybeans. What would be the best soil conditions for maximum productivity? Can you find examples that would support or reject the concept that survival is a matter of a best-fit scenario for the organism and its abiotic and biotic pressures as related to enzymes? Can you suggest which abiotic factors need to be examined?* ● *2nd Scenario:* ○ *Ask students to consider evolutionary questions such as: Have plants evolved different characteristics to cope with specific abiotic conditions, such as salt marsh (salinity issues), high mountain pastures, deserts, acidified environments (acid rain), and estuaries? Are there different optimums for the same abiotic factors within different plants? Have plants evolved over time because of the influence or selectivity due to the abiotic factors associated with their environments?* ● Students will turn in their investigation.	Grade investigation writing.

T, A	3. PreLab Planning Station: ● Students will receive a copy of AP Biology Lab 13: Enzyme Activity to plan and determine what manipulated variable they would like to introduce. ● Students will keep their planning sheet and lab, but will write their groups members names on a notecard provided, along with what manipulated variable they will be introducing and materials they will need. This notecard will be handed to the teacher.	Approve manipulated variable.
	DAY 3:	
T, M	AP Biology Lab 13: Enzymatic Activity How do abiotic or biotic factors influence the rates of enzymatic reactions? As each group finishes, have students fill in their lab results for each manipulated variable on the whiteboard. If time allows, discussion of results with entire class.	Constant monitoring and random questioning from group to group about the experiment.
	DAY 4:	
A	Enzyme Study Questions Quiz (assigned questions at end of previous Free Energy Unit)	Grade Quiz
M	Using results from the lab, have students justify an argument for the role of enzymes in maintaining homeostasis at the cellular level.	Listen to justifications provided by students.
A	Discussion to elaborate on how enzyme activity can regulate metabolism by not only environmental conditions, but allosteric and feedback regulation, and enzyme inhibitors (competitive vs. noncompetitive)	
M	Exit Ticket: Foldable to organize ideas with the various types of conditions that can influence enzymatic reaction (abiotic and biotic).	Review exit tickets.
	DAY 5:	
T, M	Show Picture: How does the grass power the work for this rabbit? Students should be prepared to think, pair, and share. Students need to justify their answers.	Listen to justifications.
A	Guided Reading- Take a Deep Breath: Cellular Respiration Students will make connections to the relationship between cell transport, enzymes, molecular building blocks, and ATP to cellular respiration. Questions are provided to guide their reading.	Grade guided reading.

A	Discuss the importance of enzymes in cellular respiration; emphasize that it is a series of coordinated enzyme-catalyzed reactions.	
M	Students will then receive a word that relates to cellular respiration. They will create their own definition for that word (no technology!). Students will then get into groups with others that have the same word and come up with a common definition. Following that students will form groups where everyone has a different word. They will share their common definitions of their word and will work through and decide how all the words relate to each other and how they relate to cellular respiration. (Suggested words: catabolic pathway, metabolic pathway, aerobic respiration, anaerobic respiration, fermentation).	Walk around the room and listen in on groups conversatio; correct misconceptions.
A	As a class discuss what catabolic pathways are and how catabolic reactions are linked to cells doing work. This will segway into oxidation/reduction reactions.	
A	Have students list what they know about oxidation/reduction on the board. Once everyone has had a chance to write down what they know discuss the concepts of oxidation, reduction, oxidizing agent, and reducing agent drawing upon what they already know. Use a simple problem to introduce the concept such as $Na + Cl \rightarrow Na^{+} + Cl^{-}$	
T, M	Using more sample problems and in small groups have students practice identifying which parts are oxidized, reduced, the oxidizing agent, and the reducing agent.	Review sample problems.
M	Exit Ticket: Students will need to identify which parts have been oxidized and reduced for the cellular respiration equation.	Read exit tickets.
	DAY 6:	
M	Have the Cellular Respiration equation written on the board. Students need to identify which parts have been oxidized and reduced and justify their answers. They will write, pair, and share.	Students will share their answers and misconception can be corrected.
A	Discuss the importance of NAD+ as related to oxidation and energy.	
A, M	Students will then be grouped based on exit ticket from previous class and receive the steps that outline glycolysis. As a groups they will first identify where in the cell is this process	Monitor group work.

	occurring. They will then highlight in yellow anywhere an enzyme appears, circle ATP in red, and box NADH in orange. They will then put a "+" or "-" sign next to the ATP they've circled based on if it's been produced (+) or used (-). As a group they will decide how much ATP is used, how much ATP is made, and what is the net gain or loss of ATP. They will then determine if glucose is being oxidized or reduced and to what.	
A, M	As a whole group discuss what the students discovered. Draw on prior knowledge of substrate-enzyme relationship. Define substrate level phosphorylation. Have students discuss at what points during glycolysis is substrate level phosphorylation occurring-and label it on their diagram. Lead this discussion into what is needed for pyruvate to enter into the mitochondria from the cytosol.	Use discussion as means to determine level of understanding.
M	Check for understanding: What molecules are being oxidized? How does oxidation relate to energy? For every 1 glucose molecule, how many pyruvate are being produced?	Check for understanding.
T	Ask students to think about what if oxygen is not present?	
T, M	Anaerobic Cell Respiration & Evolution Activity Students will look at alternate pathways for producing ATP by harvesting the chemical energy of food.	
	DAY 7:	
T	Entrance Ticket: Conclusion from Anaerobic Cell Respiration & Evolution Activity	Grade Activity
A	Bell Activity: All students will receive a diagram of the mitochondria. They are to label the parts of the mitochondria, identify where glycolysis, pyruvate oxidation, kreb's cycle, and oxidative phosphorylation/electron transport/chemiosmosis occur.	
A	Discuss the importance of mitochondria to cellular respiration. Explain how internal membranes and organelles contribute to cell functions.	
A, M	Students will receive a overview of the intermediate step and Kreb's Cycle. In small groups they will again identify where in the cell this process is occurring. They will circle ATP in red (label substrate level phosphorylation), box NADH and $FADH_2$ in orange, and highlight production of CO_2 in green. They will then put a "+" or "-" sign next to the ATP they've circled based on if it's been produced (+) or used (-). As a group they will decide	Monitor group work. Correct misconceptions.

	how many of each of the following are produced for every 1 pyruvate molecule: ATP, CO2, NADH, and FADH2. They will also determine in the formation of $FADH_2$ and NADH what is reduced and what is oxidized.	
M	Group sharing: Each group will take turns filling in a class overview on the overhead.	
T	Check for understanding: What interactions are occurring? How are the interactions occurring influencing the structure and function of the molecules produced?	Check for understanding.
A	Pass out overview of Electron Transport Chain (ETC) and Chemiosmosis. Review what is substrate level phosphorylation. Compare this to oxidative phosphorylation.	
M	In pairs, students will begin to label their diagrams as done before. Identify where in the cell this process is occurring. They will circle ATP in red (label with type of phosphorylation occurring), box NADH and $FADH_2$ in orange [put a "+" or "-" sign based on if it's been produced (+) or used (-)]. They will also determine if $FADH_2$ and NADH are being reduced or oxidized. Students will identify the role of oxygen in the ETC. They will also explain the formation of water from the ETC. Students will complete the above for homework if they do not finish in class.	Monitor group work. Correct misconceptions.
	DAY 8:	
T, M	Students will resume their work in groups of 4. They are to answer the following questions about the ETC: ● Is any ATP generated directly from the ETC? ● How does the mitochondria couple the electron transport and energy release to ATP synthesis?	Monitor group work. Correct misconceptions.
A	Discussion of Chemiosmosis. Draw upon prior knowledge of cell transport and enzymes for discussion. Relate ATP produced to what work can be done at the cellular level.	
	Check for understanding: Play 4 corners (expert, almost there, basic understanding, still wandering). List various topics related to Cellular Respiration to gage where students understanding lies. Prior Knowledge: Are there other sources of energy besides glucose? What are other sources of energy?	Check for understanding.

A	Class Discussion: Alternate Metabolic Pathways + Muscles and ATP (Page 798 of Campbell Biology. Use table of different types of muscles to discuss how energy is used).	
T, M	Think, Pair, Share: ● Compare the structure of a fat with that of a carbohydrate. What features of their structure make fat a much better fuel? ● During intense exercise, can a muscle cell use fat as a concentrated source of chemical energy?	Monitor group work. Correct misconceptions.
A, M	Students will then analyze the following case study and answer the corresponding questions to ensure that they understand the overall process and contribution of cellular respiration. Mystery of the 7th Deaths: A Case Study in Cellular Respiration	Grade case study.
	DAY 9: Lab Design and PreLab for Cellular Respiration Lab 6- ● Students will receive a copy of AP Biology Lab 6 to plan and determine what manipulated variable they could introduce. ● Students will work individually using available technology (ie. ipad cart) to view LabBench Activity: Cellular Respiration and take notes about the procedure. ● Students will then complete the 4 lab quiz questions at the end of the tutorial. Once they have completed the 4 questions, then will check their answers. For each question they are to write down the justification provided for each correct answer to ensure that they understanding those key points. ● As students complete the tutorial + quiz, they will be assigned groups based on exit ticket from prior day. ● The group will then discuss the procedures of the lab and complete the prelab questions provided by the AP	Lab Quiz Approve each experimental setup.
T	Lab manual found on page S73. ● On the notecard provided students will write down what manipulated variable they would like to use and turn into the teacher as an exit ticket.	
T	● As a group they will write the problem, hypothesis, and design (this will be their entrance ticket to class)	
	Finish case study.	
	DAY 10: Collect entrance ticket **AP Biology Lab 6: Cellular Respiration**	Constant monitoring and random questioning from group

	What factors affect the rate of cellular respiration in multicellular organisms? **DAY 11:** Formative Assessment: Multiple Choice + Free Response Essay **Formative Assessment: Performance Task Due**	to group about the experiment. Test Performance Task