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**Unit 3 Review Packet: Cellular Metabolism**

**Topic #1: Cell Respiration (Aerobic and Anaerobic)**

1. What evidence do scientists have to indicate that glycolysis is an ancient process?

 Happens in the cytosol – No membrane bound organelles needed.

2. Describe the amount and type of ATP production during glycolysis. (Note: The type of ATP production refers to substrate-level phosphorylation vs. oxidative phosphorylation.)

Technically two ATP molecules are used during glycolysis and four are created, so there is a net output of two ATP molecules. This is substrate-level phosphorylation because the ATP is produced from the breaking of the glucose.

3. After the Krebs cycle, how is most of the energy from the original glucose molecule stored?

Energy is store in the electron carriers

1. How are high-energy electrons from NADH and FADH2 used during the electron transport chain?

Electrons are transported down the electron transport chain proteins and their energy is used to pump H+ against their concentration gradient into the inner membrane space.

1. How is oxygen gas (O2) used during the electron transport chain?

Oxygen is the final electron acceptor in the ETC

1. What is the purpose of the folds (aka cristae) in the inner mitochondrial membrane?

Increases the surface area which allows for more ETC complexes

1. Define “proton motive force.” How is this used during the electron transport chain?

H+ builds up in the intermembrane space and wants to flow back down its concentration gradient across the inner membrane into the matrix. This gradient that has been created is called the H+ or proton gradient. We call the “desire” of H+ to move back down its gradient the “proton motive force.” This then causes the H+ to move back down the concentration gradient through ATP synthase to create ATP.

1. How is oxidative phosphorylation / chemiosmosis (the type of ATP production that occurs in the electron transport chain) different from substrate-level phosphorylation? Is there more or less ATP made during oxidative phosphorylation than substrate-level phosphorylation?

The only way that H+ can diffuse across the membrane is through ATP synthase, another membrane protein. As H+ ions flow through ATP synthase, the protein turns, and this turning motion causes ADP and Pi to “squish” together and create ATP. 32-34 ATP molecules can be created during this process (per original glucose molecule).

1. How is aerobic respiration different from anaerobic respiration (aka fermentation)? Which steps of aerobic respiration (i.e. glycolysis, the conversion of pyruvate to acetyl CoA, the Krebs cycle, or the electron transport chain) occur during anaerobic respiration?

Without oxygen to accept electrons in the electron transport chain, most of cellular respiration stops, but fermentation provides a mechanism by which some cells can continue to oxidize (break down) organic molecules like glucose and generate ATP. Glycolysis occurs in both types of respiration.

1. Why does NAD+ need to be regenerated from NADH for glycolysis to continue? How is this accomplished in lactic acid fermentation vs. alcoholic fermentation?

Under aerobic conditions (i.e. oxygen is present), NADH transfers its electrons to the electron transfer chain, recycling NAD+. Under anaerobic conditions (i.e. oxygen is NOT present, pyruvate then accepts electrons from NADH, oxidizing it back to NAD+. The NAD+ is then available to oxidize more glucose

An experiment to measure the rate of respiration in crickets and mice at 10°C and 25°C was performed using a

respirometer, an apparatus that measures changes in gas volume. Respiration was measured in mL of O2

consumed per gram of organism over several five-minute trials and the following data were obtained.

1. How will carbon dioxide produced by the crickets and mice affect the measurements of average respiration (mL O2 / g / min)?

If no measure is taken to get rid of the carbon dioxide (such as include KOH to precipitate it) then it will greatly affect the measurements because the carbon dioxide production will negate the intake of oxygen

**Topic #2: The Light Reactions and Calvin Cycle of Photosynthesis**

1. What pigments are found in the thylakoid membranes? What is their role in the light reactions of photosynthesis?

Chlorophyll along with the accessory pigments. The pigments absorbs the sun’s energy and use that to energize the electrons that go down the electron transport chain.

1. What colors of light are most ABSORBED by chlorophyll a? What color of light is most REFLECTED by chlorophyll a?

Chlorophyll best absorbs red and blue lights and most reflect the green color – that is why chlorophyll appears green.

1. What happens to water during the light reactions of photosynthesis?

Water is split using the sun’s energy into Oxygen (waste product), Hydrogen ions (proton gradient) and electrons (used in the electron transport chain to create proton gradient)

1. What is the goal of cyclic electron flow?

The goal of cyclic electron flow is to be able to create more ATP without creating NADPH, this is because the Calvin Cycle requires more ATP than it does NADPH.

1. What role do the electron transport chains in the thylakoid membrane play in the creation of a proton motive force? How is the proton motive force used?

The electron transport chain uses the energy from the moving electrons to pump the H+ into the lumen. This creates a proton gradient thus creating the proton motive force. This force is then used to allow H+ to flow though ATP synthase back into the stroma. This movement allows ADP+P to come together to form ATP with the help of the ATP synthase enzyme.

1. What is the main goal of the Calvin cycle?

The main goal of the Calvin Cycle is to combine Carbon Dioxide with other carbon molecules using the energy of ATP and NADPH. This carbon fixation leads to the formation of PGAL/G3P and when two of those molecules are combined they form glucose.

1. Describe the relationship between the light reactions and the Calvin cycle.

The light reactions produce the ATP and NADPH that are needed to power the Calvin Cycle.

**Topic #3: Exceptions to Normal Photosynthesis (C4 and CAM)**

1. What occurs during photorespiration? Why is this an issue for plants?

Rubisco can bind to both Oxygen and Carbon dioxide, thus the oxygen serves as a competitive inhibitor and makes the process less efficient. This process (when oxygen binds) is called photorespiration)

1. Compare how C4 and CAM plants minimize photorespiration differently.

C4 plants have the beginning step of the Calvin cycle (the one that uses Rubisco) take place in the bundle sheath cells instead of the mesophyll cells. This allows the Rubisco enzyme to only be exposed to Carbon Dioxide and not to oxygen gas, which decreases photorespiration. CAM plants take in Carbon Dioixde during the night and transform it into Malic Acid and store this molecule in their vacuole. During the daytime they close their stomata to reduce water loss and take the Malic acid that is stored out of the vacuoles and transform it back into carbon dioxide to be used to photosynthesize during the day.

**Topic #4: Comparing Photosynthesis with Celluar Respiration**

1. Why are photosynthesis and cellular respiration often thought of as a cycle? Write out the full, balanced chemical equation for each process and compare them.

The products of photosynthesis are the reactants of cellular respiration and the products of cellular respiration are the reactants of photosynthesis.

\*This is only true for AEROBIC cellular respiration.
\*The other difference is the type of energy – light energy is a reactant for photosynthesis, but energy in the form of ATP is the product of Cellular Respiration

1. Compare / contrast the electron transport chain in the mitochondrion vs. chloroplast in terms of the electron carriers used to “drop off” electrons, the direction of H+ pumping, the creation of an electrochemical gradient, the synthesis of ATP, the final electron acceptor, etc. How are they similar? How are they different?

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|  | **Mitochondria (final step)** | **Chloroplast (first step)** |
| **Electrons Carriers used** | NADH and FADH2 donate electrons to the ETC | NADPH is created during the ETC and then used for the Calvin Cycle |
| **Direction of H+** | Moves from Matrix into the inner membrane space | Moves from the stroma into the thylakoid membrane |
| **Gradient Creation** | Gradient created in the inner membrane space by the energy from the electrons | Gradient created in the lumen by the energy from the electrons |
| **Synthesis of ATP** | Through ATP synthase | Through ATP synthase |
| **Final Electron Acceptor** | Oxygen to form water | NADP+ to form NADPH |