Chapter 9 and 10 Reading Guide
Tokos AP Biology 2012

Chapter 9: Cellular Respiration and Fermentation

9.1 Catabolic pathways

- There is a nuanced distinction made here between *organismal* respiration and *cellular* respiration. The term "respiration" technically means exchange of gases. At the organismal level, you breathe in oxygen and breathe out carbon dioxide. The oxygen that you breathe in is distributed by the bloodstream to every living cell in your body where it crosses over the cell membrane travels through the cytoplasm and crosses over the mitochodrial membranes to be used in the process of *cellular* respiration. Inside the mitochondria, carbon dioxide is generated as a byproduct of the breakdown of glucose. Carbon dioxide crosses out of the mitochondrial membranes and out of the cell membrane where it reaches blood circulation to be returned to the lungs for exhale. The exchange of gases at the organismal level is the aggregate of all of the cellular respiration occurring in individual cells. Cool.
- You must know the meaning of the terms **oxidation** and **reduction**. In the context of the summary equation for cellular respiration, you must know that carbon in glucose is oxidized to form carbon dioxide and elemental oxygen is reduced to form water. **Helpful hint:** in organic reactions, the movement of hydrogen atoms from one compound to another is usually an indication that electrons are being transferred. Removal of hydrogens from a compound is associated with oxidation. Addition of hydrogens to form a new compound is associated with reduction.
- Make sure you are comfortable with the meaning of the term "electronegativity." Atoms that have high electronegativity are "grabby." They hog up electrons. They don't share. In biological molecules, the most electronegative atoms you will encounter are oxygen (the grabbiest) and nitrogen (not as grabby, but pretty grabby).
- I like Fig 9.6 as a way to review the chapter. Come back to this figure after you read each section and talk your way through the diagram. You should be able to describe the chemical changes represented by each white arrow.
- You must be able to distinguish between oxidative phosphorylation and substrate-level phosphorylation. Be able to identify examples of each.

9.2 Glycolysis

- Everything in Fig 9.8 is a must know
- Notice that these processes occur in the cytosol
- Start tracking carbon atoms. Glucose is a 6-carbon molecule. Glycolysis splits glucose into two, 3-carbon molecules.
- It is not critical to know the number of ATP used and yielded, but if you can manage it, this is nice to know (could mean a 5 on the AP exam). It is also not critical to memorize the number of NADH yielded, but again, if you're gunning for a five...
- Fig 9.9 is mostly there for your entertainment. You do not have to memorize structures.

You do not have to memorize enzyme names or the names of the intermediate compounds leading up to pyruvate.

- I do recommend that you remember the name of one enzyme in this pathway: phosphofructokinase. More on this later...

9.3 Citric Acid Cycle

- Everything in Fig 9.10 and 9.11 is a must know
- It is assumed that you are intimately acquainted with the fact that the mitochondrion is bounded by two membranes.
- Notice that Acetyl CoA crosses both membranes of the mitochondrion. The CTA occurs in the matrix.
- It is not critical to know the number of ATP used and yielded, but if you can manage it, this is nice to know (could mean a 5 on the AP exam). It is also not critical to memorize the number of NADH and $FADH_2$ yielded, but again, iif you're gunning for a five...
- Fig 9.12 shows how the carbon skeleton changes. Continue tracking carbon atoms. Pyruvate is a 3 carbon molecule, acetyl CoA is a 2 carbon molecule. (3-1 =2) Oxaloacetate is a 4 carbon molecule. Citrate is a 6 carbon molecule. (4+2=6) It's good to know the names of these intermediates. If you have to refer to them by the number of carbons instead of their chemical names, that's okay.

9.4 Oxidative Phosphorylation

- This is the punchline. This is the million bucks. The pictures tell the whole story.
- Notice the relationships between Fig 9.13 and 9.15. Ubiquinone and cytochrome c are nice to know by name since they have the distinction of being mobile in the inner membrane. You must know the name of ATP synthase.
- The flow of H+ ions across the inner membrane is known as **chemiosmosis**. Be aware that the use of the term osmosis here is NOT in reference to water.
- There are two significant energy coupling events going on here
  - As NADH and FADH2 are oxidized, electrons enter into the **electron transport chain.** Through successive reduction of proteins embedded in the inner membrane, electrons move to lower energy states; the free energy released powers the active transport of H+ out of the matrix and into the inter membrane space
  - As H+ flows back into the matrix by facilitated transport through **ATP synthase** free energy is released; the energy powers the addition of P to ADP, regenerating the cell's supply of ATP
  - The **ETC** and **chemiosmosis** together make up **oxidative phosphorylation**
- This whole process is driven by the electronegative "grab" of oxygen for electrons. Molecular oxygen receives the electrons and combines with H+ to form H2Ot
- Fig 9.14 is a little over the top. But it's an impressive explanation of the energy transformations between the potential energy stored in the H+ ion gradient and the synthesis of ATP.

Think back to the summary equation for cellular respiration:
glucose + oxygen → carbon dioxide + water + ENERGY
Can you account for each of these in the pathways of cellular respiration?

Take a detour now to page 181. Remember phosphofructokinase? This enzyme is worth remembering due to its regulatory role described in Fig. 9.20 Read this page carefully

9.5 Fermentation and anaerobic respiration

- Know the difference between **facultative** and **obligate anaerobes**
- Compare and contrast **alcohol** and **lactic acid fermentation**
- Note the relationship of fermentation to glycolysis both in terms of the chemistry and the location in the cell
- Fermentation yields very little ATP in comparison to oxidative phosphorylation, but it's better than none (that would mean death).

9.6 Connections to other pathways

The only part of this section that you need to know in detail is the regulatory role of phosphofructokinase. General familiarity with Fig 9.19 is recommended.

Chapter 10: Photosynthesis

Take advantage of the opportunity to review some vocab that you encountered previously in the context of ecology: autotroph and heterotroph

Before you dive into photosynthesis (PSN), page ahead to p. 750 and read the section on "Tissue Organization of Leaves." Familiarize yourself with the mesophyll (these are the cells that carry out PSN) and the stomata.

10.1 Photosynthesis converts light energy to the chemical energy of food

- Use fig. 10.4 to get acquainted with the chloroplast. Notice that this organelle has THREE membrane. The green pigment, chlorophyll is only associated with the innermost membrane, the thylakoid.
- Be able to distinguish between all of the parts of the chloroplast that are labeled
- Read "tracking atoms," but don't dwell on this
- Use fig 10.6 to help you review. After you read section 10.2, come back to this diagram and practice talking about the light reactions. Come back again after you read 10.3 and practice talking about the Calvin cycle. Can you put the two parts together?

10.2 The light reactions

- Be able to explain why plants are green in terms of the absorptive properties of chlorophyll a and b.
- Distinguish between the function of chlorophylls and carotenoids
- In order to produce sugar, the chloroplast needs reducing power (NADPH) and energy (ATP). It is the job of the light reactions to produce both
- For fig 10.14 be able to:
  Identify which membrane is home to the light reactions. [Hint: rhymes with android]
  Describe the role of H2O
  Distinguish the reaction center chlorophyll from other chlorophylls
  Describe the process of photophosphorylation
  Distinguish between the output of the electron transport that follows PSII (ATP) and the output of the electron transport that follows PSI (NADPH)
  Be aware that although this is described as "linear" electron flow, in reality, both photosystems are operating simultaneously
- Cylic electron flow shuttles an electron from PSI back to the first ETC in order to supplement ATP production
- If you are very secure in your understanding of RSP, fig 10.17 is a big help. If you are not secure with RSP yet, save this diagram for later
- Chemiosmosis is the energy coupling step for both oxidative phosphorylation in RSP and photophosphorylation in RSP. The same enzyme, ATP synthase, catalyzes the reaction in both cases
- Try to overlay fig. 10.14 with fig. 10.18

10.3 The Calvin Cycle

- Make sure you can identify which compartment of the chloroplast is home to the Calvin Cycle. [Hint: rhymes with *aroma*]
- Keep track of the following carbon-containing compounds: CO2, RuBP, and G3P
- Notice that the cycle represents a triplet of molecules: 3 CO2's go in and join up with 3 RuBP's (a 5 carbon compound), yielding six 3-carbon intermediates. One of these goes on to become G3P (the precursor to glucose), the other 5 become rearranged to regenerate the 3 RuBP's so that the cycle may go around again
- This is a reductive, energy-consuming process, so both NADPH and ATP are consumed

10.4 Alternative mechanisms

- You are not responsible for the material on C4 and CAM plants
- But don't overlook the very last page "The Importance of Photosynthesis"