Chemistry 236, Spring 2008 Name(s):

Exercise 10: Biochemical pathways

The process of **respiration** (the controlled combustion of glucose in order to gain useful energy for other metabolic processes) is a fairly complex sequence of individual chemical reaction, *all* mediated by enzymes. On page 1150 of the text, figure 25.4 shows a schematic diagram of the various pathways. In this exercise, you will trace the origin and fate of individual atoms as they make their way through this process.

Needed: Molecular model kit; six colors of lab tape

The process: With a partner, construct a glucose molecule. Use the following scheme to label the six carbon atoms in glucose: **carbon 1 = red; carbon 2 = orange; carbon 3 = yellow; carbon 4 = green; carbon 5 = blue and carbon 6 = violet**.

Use **orange** atoms to represent phosphate groups; it is not necessary to have every single oxygen in the phosphate group represented.

Go through the sequence of steps outlined on page 1150 to reduce the glucose to two pyruvate molecules. **Do not worry about ATP, ADP or NAD^+ because what you are doing is tracing the fate of the carbon atoms in the original glucose.**

1. Clearly, at the end of these steps, all six carbon atoms from the original glucose are still present; however, they have been separated into two pyruvates. Note that step 4, the reverse of an aldol addition, is critical in determining where the carbon atoms end up; you may wish to use the more in-depth diagram shown in figure 23.12 on page 1093. Using the numbering scheme in the original glucose, write the carbon numbers in each pyruvate molecule that are still attached.

Each partner should take charge of one pyruvate molecule. On page 1153, the next step of respiration (the transformation to acetyl CoA) occurs. Perform this on each of your molecules; use a **green** atom to represent the S—CoA group.

2. Which carbons (use the numbering scheme in the original glucose) were "lost" as carbon dioxide?

At this point the acetyl CoA enters the citric acid cycle. Each partner should now construct a molecule of **oxaloacetate** (see page 1156). Do not label these carbons. Perform the sequence of reactions in the **citric acid cycle** (reactions 1 through 8 on page 1156). **Do not worry about the electron carriers NAD^+ and FAD; what you are doing is tracing the fate of the carbon atoms in the original glucose.**

3. Does the oxaloacetate you ended up regenerating as a result of the last reaction (reaction 8) contain *any* of the original carbon atoms? If so, identify which ones by number.

To summarize, explain what molecule each of the carbon atoms ended up in, and at what point (give a reaction name like "the citrate to isocitrate reaction") that happened.

4. Carbon 1 (red):

5. Carbon 2 (orange):

6. Carbon 3 (yellow):

7. Carbon 4 (green):

8. Carbon 5 (blue):

9. Carbon 6 (violet):

10. Will the remaining carbons from the original glucose molecule be removed in the next citric acid cycle? If not, at what point will those carbons finally be oxidized to carbon dioxide?

11. Finally, how can we be so sure of this pathway? (That is a rhetorical question and needs no answer). As you may have noticed, there does not seem to be much ambiguity in what atoms goes where at what step during this whole complex process. Obviously, if we were able to label each carbon atom with a piece of tape, then tracking them would be easy. Clearly, we cannot use a piece of tape on real atoms. Suggest a **method** or **technique** that might allow the tracking of real carbon atoms through the set of reactions you just performed. Be specific as to which atom(s) are affected. Of course, your method should also include a way to **detect** the labelled atoms!