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 752 of the text, figure 23.1 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 (see pages 766 and 767 for the individual steps to follow). 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 pages 766 and 767 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. Write which carbon atoms (use the numbering scheme in the original glucose) are still attached.

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

Each partner should take charge of one pyruvate molecule. On page 771, 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 789). Do not label these carbons. Perform the sequence of reactions in the citric acid cycle (reactions 1 through 8 on page 790). 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. 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 go 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.