Molecular Model Kits for Photosynthesis and Cellular Respiration

Purpose of kit:

This kit will help students understand the transitions of matter and energy during photosynthesis and cellular respiration. They can build the reactants and products of each reaction to see that matter is conserved during this conversion, and that one form of energy is transformed to other forms of energy.

This lesson has significant impact on student understanding if it comes after a lab experience where they see that carbon dioxide either increases (in the case of cellular respiration) or decreases (in the case of photosynthesis) in a closed system with a living organism (See Monitoring Gas Exchange kit). They are left wondering where the carbon dioxide came from or went. These models help students investigate what is happening at the atomic-molecular scale during these reactions, giving them a deeper understanding of conservation of matter and energy in living systems.

Contents:

- 4-5 student sets, each of which contains a complete set of atoms, bonds, and twist ties for one reaction:
  - 6 carbon atoms (black)
  - 12 hydrogen atoms (white)
  - 18 oxygen atoms (blue)
  - 36 bonds (white tubes)
- At least 12 yellow high-energy bond twist ties
- Additional atoms, bonds, and twist ties to replace lost parts
- Student instructions
- Copy of student worksheet
- Key to student worksheet

Preparation:

1. You will need the document camera
2. Ensure that kits have a complete reaction (check contents above)
3. Create large placemats for the students to work on. Divide the paper in half: one side labeled reactants, one side labeled products (this is not critical, but does help prevent students from losing the pieces)
4. Think about how you will divide up your students into groups. This activity works best when groups of 4 students can use the molecules. For larger classes, you might want to have half the students work on the models one day while the other half of the class works on something different. The next day, students can switch.

Lesson:

1. Introduce the models to the students: black represents carbon atoms, white represents hydrogen atoms, and blue represents oxygen atoms. The white tubes are bonds, and can connect the atoms.
2. Show that in order to build a molecule, all bonds must be filled. For example, carbon atoms have 4 prongs, and all prongs must be attached using a bond to another atom. Hydrogen makes 1 bond, oxygen makes 2, nitrogen (not in kit) makes 3 bonds, and carbon makes 4 bonds. An easy way to remember this is to tell students “HONC! 1234”
3. Point out that the tubes bend and can be used to make double bonds. For example, to make an oxygen molecule, O2, you will have two oxygen atoms joined by two bonds.
4. Introduce the yellow twist ties that represent chemical energy. These can be attached to bonds that represent “high energy” bonds. These are the bonds that, when broken and join to form new molecules,

release energy that can be transformed into other forms of energy (motion, heat). They can also represent light energy when they are not attached to any chemical. High energy bonds exist between C-C and C-H only. So, a molecule of O2 will not have these high energy bonds, but a molecule like glucose, which has many C-C and C-H bonds will have many twist ties attached.

5. Once students are familiar with what the models represent, hand out the instruction sheets and display the student worksheet on a document camera.
6. Circulate the room to see that students are building the appropriate models and attaching the twist ties correctly.
7. You can post the answer key on the wall somewhere for student to check their own work
8. When students have finished the activity, make sure they return all pieces to the bag. They should count each of the materials to ensure the kits are complete.
9. Student assessment:
    a. Photosynthesis:
        i. During photosynthesis, what happens to the carbon atoms in carbon dioxide? *(answer: the carbon atoms become incorporated into glucose)*
        ii. A student tells you that during photosynthesis, light energy is turned into glucose. Explain to this student why he is wrong, and what actually happens to light energy during this process. (*Answer: During photosynthesis, light energy is converted into chemical energy that is stored in the C-C and C-H bonds of glucose)*
    b. Cellular respiration:
        i. During cellular respiration, what happens to the carbon atoms in glucose? *(Answer: the carbon atoms in glucose become part of the carbon dioxide molecules that are produced during cellular respiration)*
        ii. A student tells you that you turn your food into energy. Explain to this student why he is wrong, and where the energy actually comes from. *(Answer: When you use you food for energy, the glucose molecules are converted into carbon dioxide and water. The energy you get from your food actually came from the high-energy bonds in the glucose molecule, not from the matter in the food)*

<u>Back pocket questions:</u>

If students are stuck:

- Let's look at the instructions together. What atoms do you need to build these molecules?
- Can you show me where there are high energy bonds?

If students are doing well:

- Can you explain to me what you are doing?
- Do you agree with what s/he is doing with the molecules?