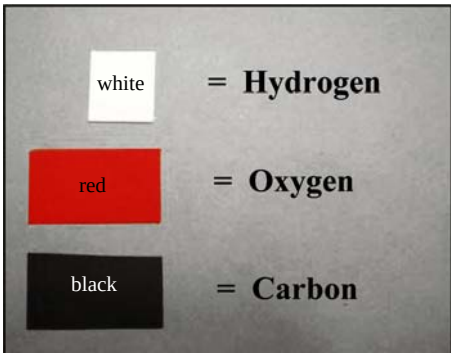
Instructions for Modeling Photosynthesis with Paper Atoms

Designed by Kathleen M. Vandiver (Copyright MIT 2009)

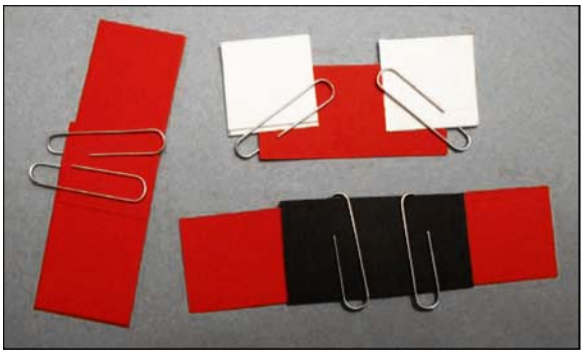
Materials to prepare in advance

Paper atoms cut from colored paper should be prepared prior to the photosynthesis lesson. Store the paper atom sets in an envelope. Each group of 2-4 students will need the following materials.

- Oxygen = 36 rectangles. Red paper = 2.5 cm X 5.0 cm (about one sheet of paper)
- Carbon = 12 rectangles. Black paper = 2.5 cm X 5.0 cm (about half a sheet of paper)
- Hydrogen = 24 rectangles. White paper = 2.5 cm X 2.5 cm (about quarter of a sheet)
- Paper clips = 50 clips (size about 3 cm in length) to be used to hold atoms together.
- Large paper = (11X17 inches) for the photosynthesis equation. Alternatively 2 paper sheets placed side by side may be used. Sheets can be folded and kept inside the envelope.
- One envelope (4 ¼ X 9 ½ inches) for storage. Rubber band to bind the envelope, optional.



Key for the atoms is shown above.

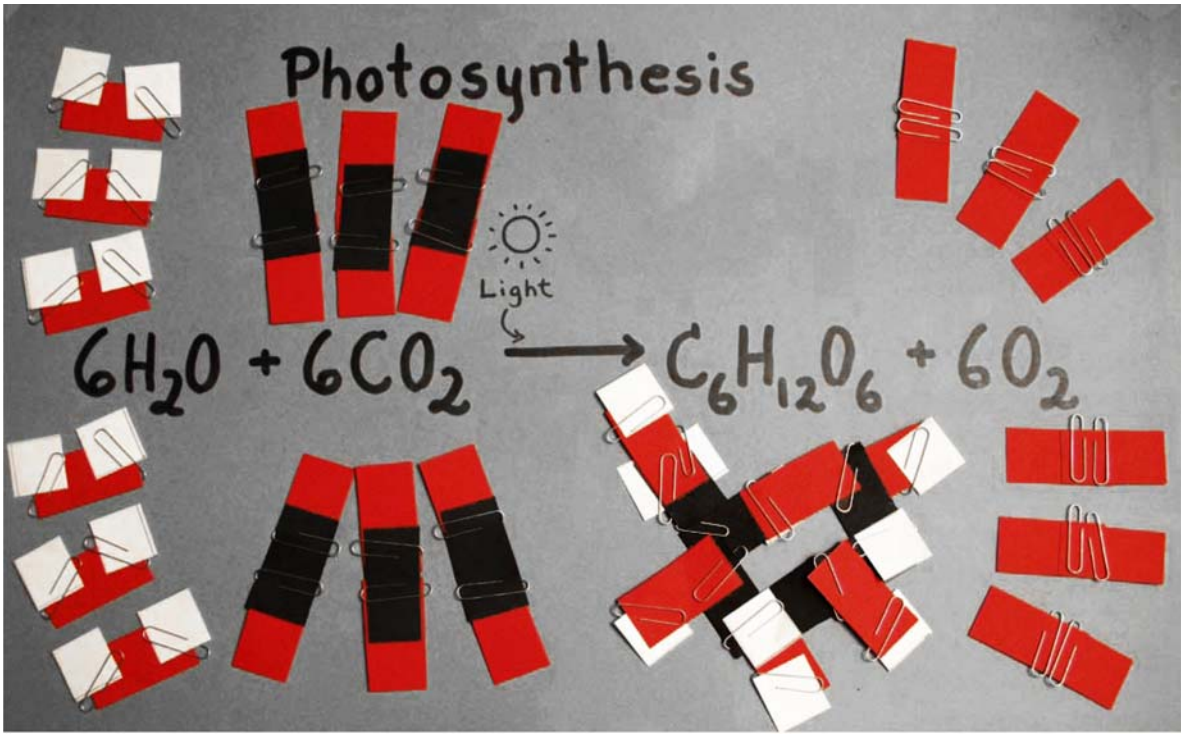


Structures for H_2O, CO_2, and O_2 are shown here.

Create the photosynthesis equation with atom models

In photosynthesis, 6 molecules of water and 6 molecules of carbon dioxide combine to form 1 molecule of glucose and 6 molecules of oxygen.

1) To write out the equation in large letters across the page as shown below, place the arrow in the middle first.
2) Next, build the molecules H_2O, CO_2, and O_2. See the photo above for building them correctly with the paper clips. Place each model near its molecular formula on the paper.
3) Instructions for building the glucose molecule ($C_6H_{12}O_6$)can be found on pages 2 and 3.



Instructions for building glucose

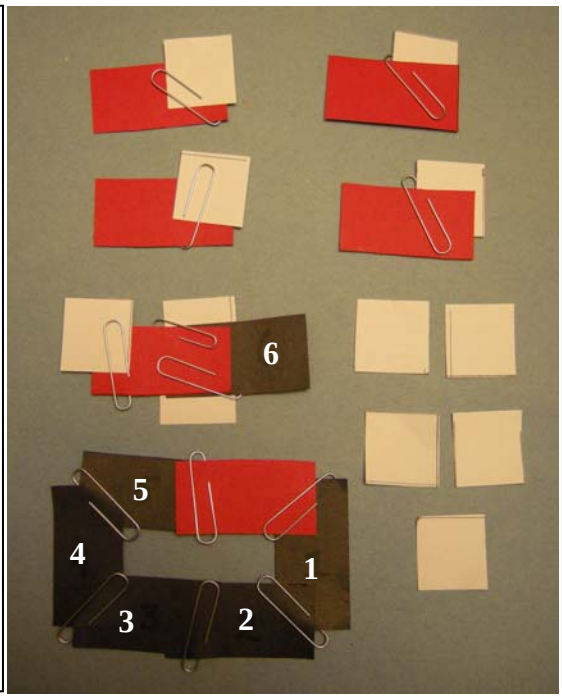
1) Prepare the ring structure and the side chains exactly as shown below. Note positions of paper clips.

OH side chain (H up) ➡

OH side chain (H up) ➡

$CHOH_2$ side chain (Note 3 H positions) ➡

Ring structure: ➡
5 Carbons and Oxygen
(Use only 6 paper clips. Place exactly in these positions.)



⬅ OH side chain (H down)

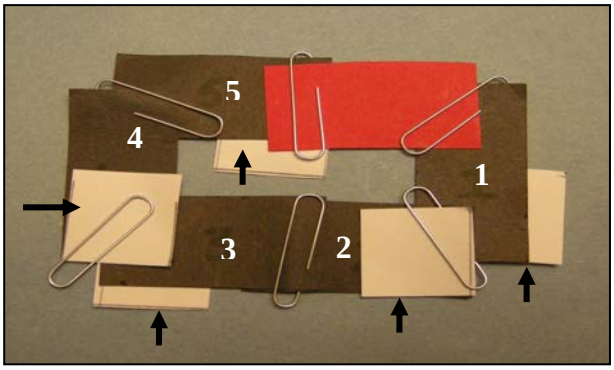
⬅ OH side chain (H down)

} 5 H side chains

(These will be added separately to the ring.)

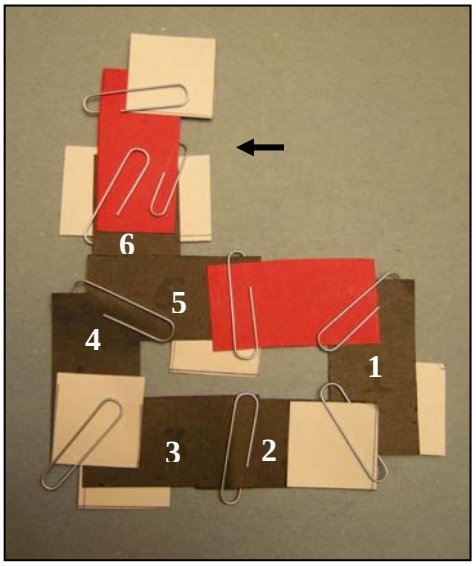
2) Add the 5 hydrogen atoms as shown in the figure on the right. The five hydrogens are marked with arrows.

- Each hydrogen atom attaches to a different carbon.
- Do not use more paper clips. Use the original 6 paper clips in the ring.
- Look carefully. Some hydrogen atoms are added on top of the carbon and some below the carbon.



3) Add the $CHOH_2$ side chain as shown in the figure to the right. It is marked with an arrow.

- Do not use more paper clips. Use the original 6 paper clips in the ring.
- Add this side chain to back of carbon 5 as shown.
- This side chain contains the 6th carbon.



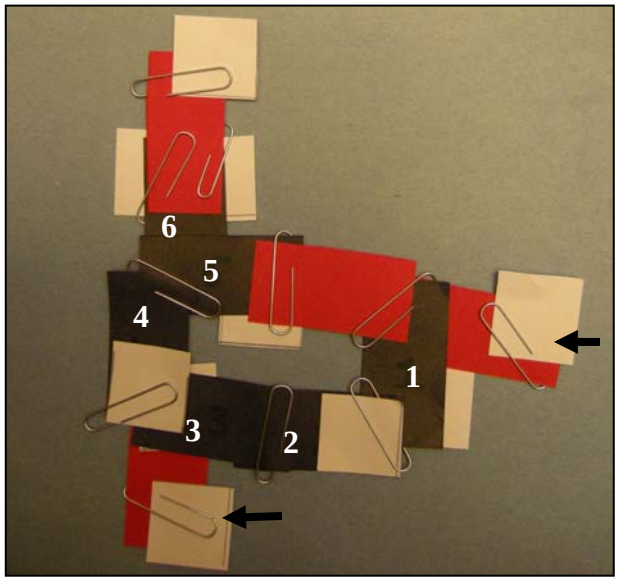
Does this side chain look like a "head and neck"? We will add "arms" to carbons 1 and 4 and "legs" to carbons 3 and 2.

Every carbon in the ring (1, 2, 3, 4) needs to receive one OH side chain next.

Instructions for building glucose (continued)

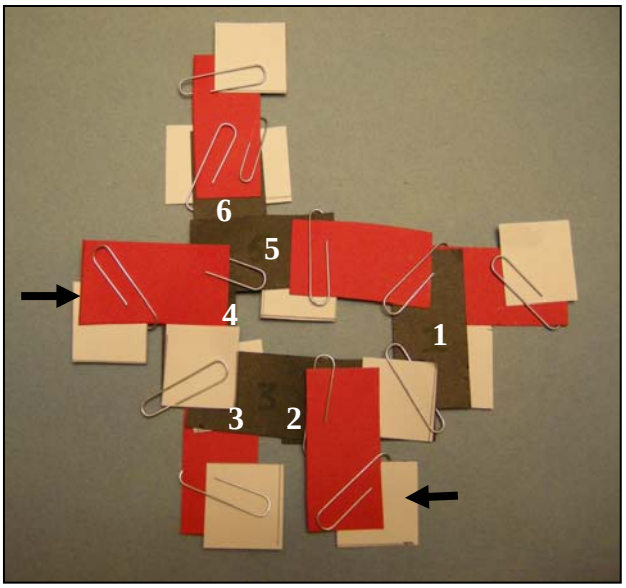
4) Add 2 of the OH side chains (H up) as shown in the figure on the right. The arrows indicate the new side chains.

- Do not use more paper clips.
- Place the OH groups under carbon 1 and carbon 3.



5) Add the last 2 OH side chains (H down) as shown in the figure on the right. The arrows indicate the new side chains.

- Again do not use more paper clips.
- Place the OH groups above carbon 2 and carbon 4.



This completes your glucose molecule!

A glucose molecule has a ring with many side chains. (We did not represent all the bonds with paper clips but the overall shape is there.) Glucose is a sugar molecule used by the plant for quick energy. It is also used to make other structures. Glucose is used as a building block to produce many larger and more complicated molecules such as cellulose and starch in plants.

Further Instructions with the photosynthesis equation: Do PHOTOSYNTHESIS like a plant does!

After you have created all the molecules in the equation, do what a plant does!
Use only the H_2O and CO_2 molecules and create a glucose molecule with the same atoms.

- **Step 1** Remove the glucose molecule and the O_2 from the right side of the equation paper. Put these atoms away in your envelope.
- **Step 2** Take apart the 6 H_2O and 6 CO_2 molecules on the left side of the equation to reuse the atoms like a plant would.
- **Step 3** Build the glucose from the 6 H_2O and 6 CO_2. What atoms are left-over? Does this happen in nature, as well?