Do the Carbon Cycle:
Simulating Photosynthesis and Cellular Respiration
4th Grade

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Benchmarks & Objective:

ES-2: Identify how water exists in the air in different forms (e.g., in clouds, fog, rain, snow and hail).

LS-2: Relate plant structures to their specific functions (e.g., growth, survival and reproduction).

The students will be simulating photosynthesis and cellular respiration using cutouts of molecules, magnets, and paperclips.

Materials:

- The attached 5 pages of "molecules." (One set per student group)
- A small strip of magnetic tape long enough to get 5 small sections (Two strips per group)
    - The goal is to have these strips be attracted to each other; test your strips to see if an arbitrary section is easily held against another arbitrary section.
    - Improvise on this material. Magnetic business cards are one expensive option. Peeling off the adhesive magnet from junk mail refrigerator magnets is another option.
- Paperclips (a box should suffice)
    - The paperclips serve as "energy" from the sun to hold carbon atoms to water molecules to form glucose. It is probably easiest just to bundle all of the molecules together and use one paperclip to hold them. Thus, one paperclip will be needed per PLANT group PER ROUND of "play."

Target Concept:

- The students should understand how photosynthesis and cellular respiration are part of a cycle of energy transport where the sun serves as the energy source and "animals" serve as the sink. This cycle not only keeps itself going (provided the sun is around) but distributes energy so that work can get done on the planet.

Initial Introduction:

Review photosynthesis. Query the students for the term, and then query them for what it means. Specifically, what do plants need (sunlight energy, water, and carbon dioxide) and what do they produce (food as sugar and oxygen). Say that the sugar plants produce is glucose ($C_6H_{12}O_6$) and ask the students to figure out how many carbons are in the molecule based on its formula (six). Ask them if $H_{12}O_6$ looks similar to water (H_2O) and have them figure out how

many water molecules it would take to produce it (six). Knowing that it would take six water molecules and six carbons to produce one sugar molecule, you should be able to write an unbalanced photosynthesis chemical equation on the board and have the students balance the equation based on maintaining the same number of atoms on each side.

Now tell the students that they are going to play the roles of plants and animals in putting these molecules together. Start the activity.

Procedure:

Pass out the five pages to each of the student groups. Try to form an EVEN number of groups. If this is not possible, then have a teacher act as a group. This will help complete the cycle of Plant->Animal->Plant->Animal so that every group has another group for passing inputs and outputs around. There are multiple pages so that each student has something to do. Have the students cut out each of the molecules. If students still need things to do, have them wait until the next step.

Pass out the magnetic tapes (any adhesive magnet that is attracted to another adhesive magnet will work). Have the students cut each tape (there should be two per group) into five small sections.

Have the students stick a piece of magnetic tape to the back of each carbon (C) atom and each oxygen (O_2) molecule. Explain that carbon and oxygen naturally like to stick together in nature, and so the magnets represent their natural ability to be held together.

The **complexity of the next parts can vary** with your classroom abilities. While it might be a good idea to have them figure out which atoms and molecules go together to form what, it may be more effective to simply TELL them this. This way they'll interpret what you say as "rules" of the "game" and may have an easier time retaining the data.

To start, **have each group** magnetically stick each of their carbons to each of their oxygen molecules to make six carbon dioxide molecules. Make sure the students aren't using the ADHESIVE backing to do this. They should be using the magnets so that the carbons and oxygens are held together and yet are easily separated. **The animal groups** have just constructed their waste. **The plant groups** have just constructed their inputs. Now the animal groups have to wait for the plant groups to provide them food before the cycle can continue. Additionally, the plant groups have to wait for the sun to provide them energy in order to turn their inputs into food outputs (note: it may be a good idea to explain that the actual molecules don't really LOOK like what the students are constructing; however, this may be unnecessary information overload).

Now **have the teachers** act as sunlight. Give each plant group a paperclip. This paperclip represents the energy from the sun. Explain how energy involves the capacity to do work. It takes energy to hold things together, so somehow the paperclip is a bundle of energy capable of holding things together too. Once the plants have their energy paperclips, they will have enough energy to strip the carbons from the carbon dioxides and paperclip all six of them to all six water

molecules. This forms one glucose molecule and six oxygen molecules. The glucose is sugar, which is food.

Once the plants have made oxygen and food, have pass to the nearest animal. Have the animals pass their waste carbon dioxide and water to other plants. **Have the animals tables** take the paperclips off of the incoming glucose and keep them. However, explain that once the carbons are free of the water, they are going to rush toward the oxygens and stick to them. So if the paperclips are removed, the oxygen has to change to carbon dioxide. This creates six waste carbon dioxide molecules and six waste water molecules. The animals can do whatever they want with the paperclip. It was delivered by the sun to the plants, where it was turned into a form that could be given to the animals. Now the animals are free to use it.

Next, have everyone wait on sunlight. It might be a good idea to pretend that it is NIGHTTIME to show how plants might have to wait a while for sunlight. After enough waiting, pass another paperclip to all of the plant tables and repeat the process.

Run this process for a number of iterations until the students all know what they're doing. They should see how the energy gets deposited in the plants by the sun, and the plants feed the animals while also getting fed by the animals. The energy ends up getting shifted to the animals, which can use that energy for lots of things (note: respiration also goes on within plants, so really "animals" includes activities going on within the plant as well; you may elaborate on this if you wish).

It may be helpful to take a packet of molecules and, with the class, move around each of the plant and animal stations watching the carbons move back and forth between the water molecules and the oxygen molecules, depositing a new paperclip at each animal each time. After one or two iterations (with the students calling out what goes where and when), many more students will start participating and will have the carbon cycle in their heads.

The students also may be able to balance the photosynthesis and cellular respiration equations. Ask the students what would happen if there were fewer carbons or water. There clearly is too much water on the planet to be tied up in this process full-time, and so that water hangs around in the ocean and in water vapor.

Make sure the students see that oxygen, water, sunlight, and carbon are all critical to the process in just the right quantities.

Target Observations:

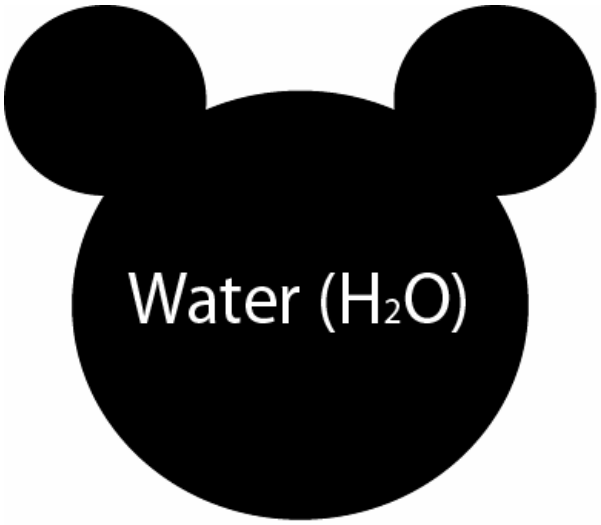
- All energy comes from the sun.
- That energy is stored in sugar and transported to animals, who use it for a variety of things.
- By taking sugar apart, the animals provide what other plants need to continue the process.
- This cycle shows how plants and animals depend on each other, and both depend upon the sun.
- This cycle shows how water, oxygen, and carbon play a role in energy transport.

Final Target Concept:

- Energy comes from the sun.
- Photosynthesis and cellular respiration are simply ways of moving carbon around in an effort to transport energy from the sun to various life forms on the earth.
- Plants need sunlight, oxygen, and water to survive, and animals need plants to make food and oxygen for them.

Summary & Discussion:

The students should have a finer understanding of how photosynthesis and cellular respiration work. The students should understand how the sun, carbon, oxygen, and water have a place in the transport of energy.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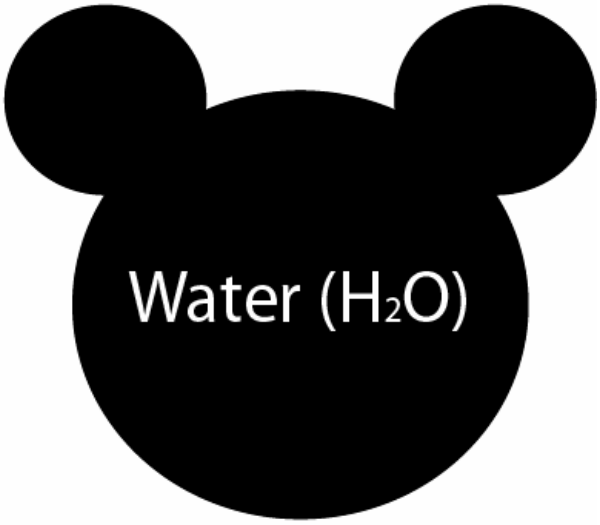
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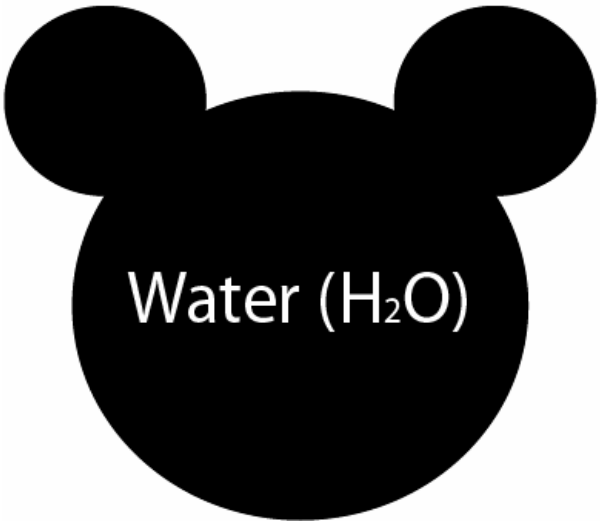
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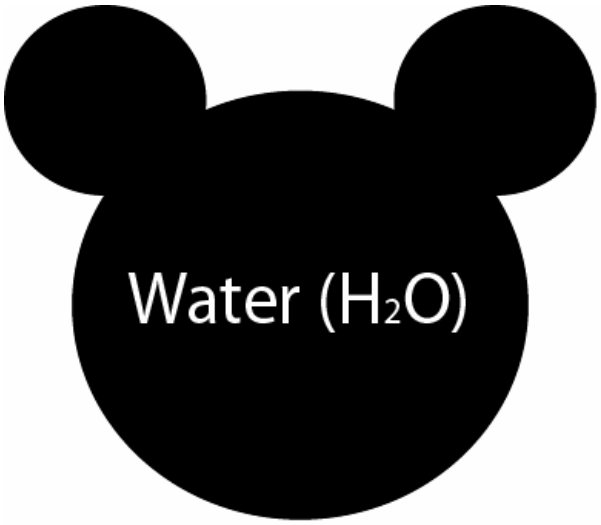
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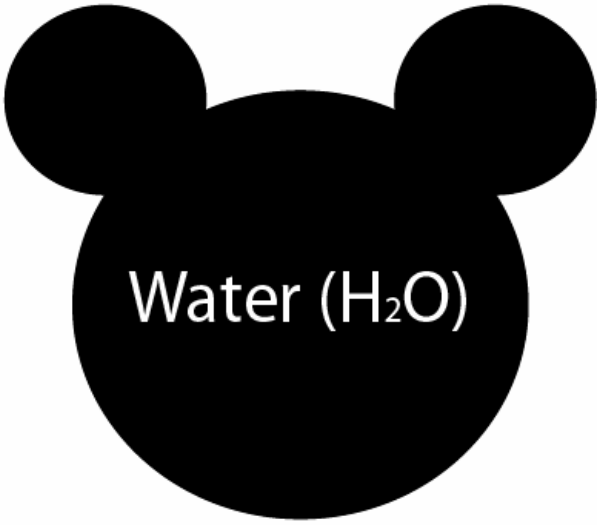
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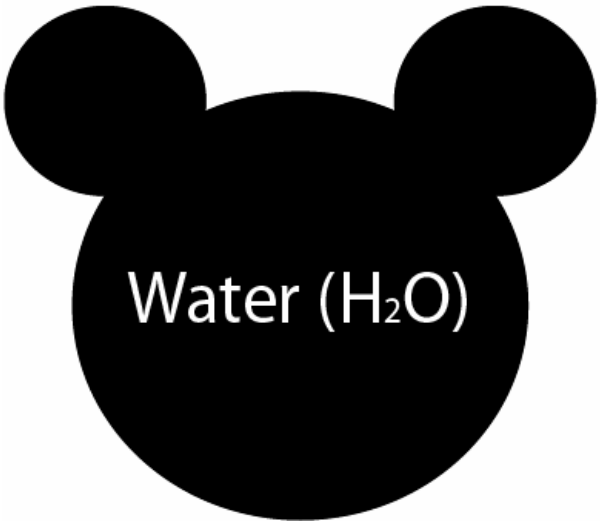
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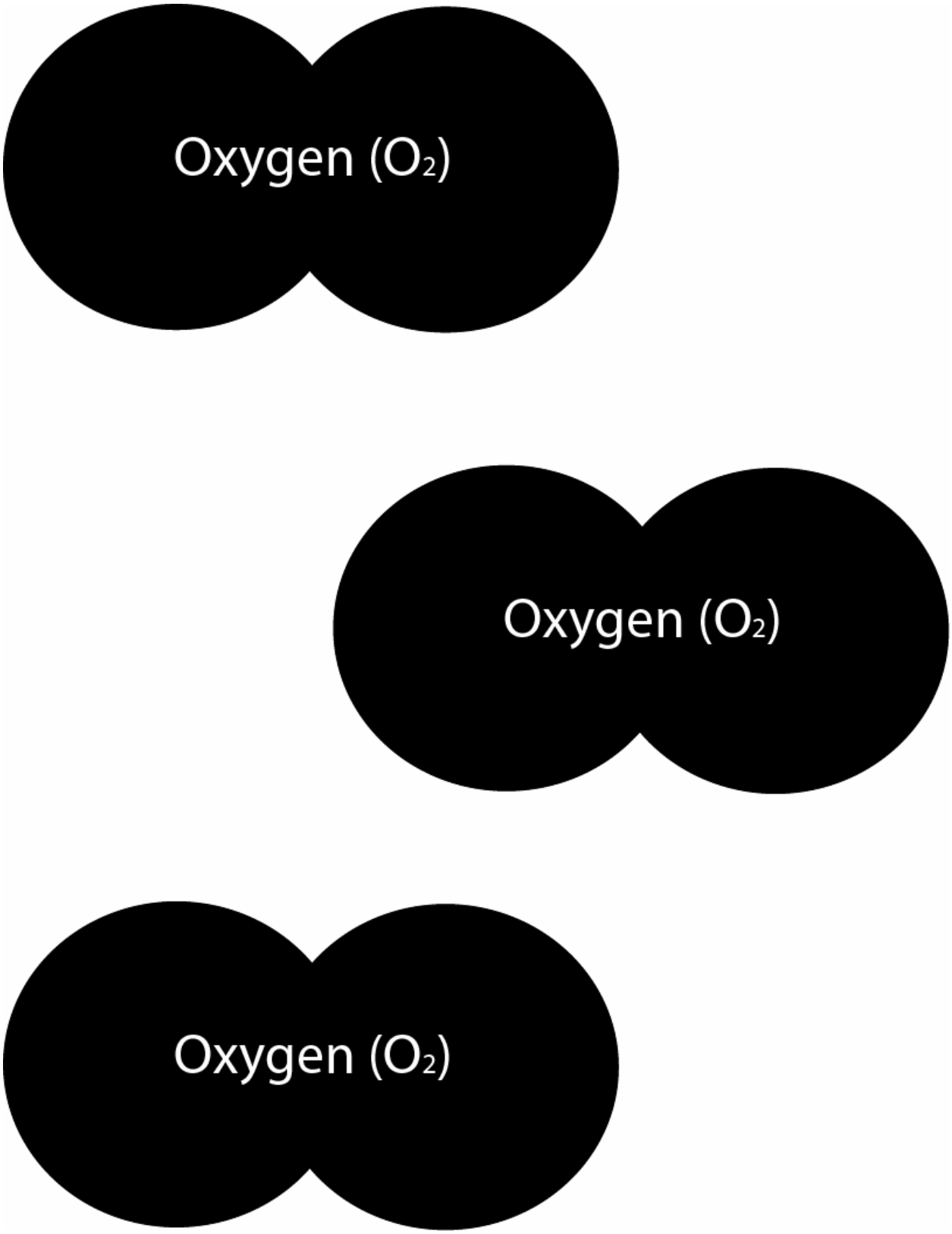
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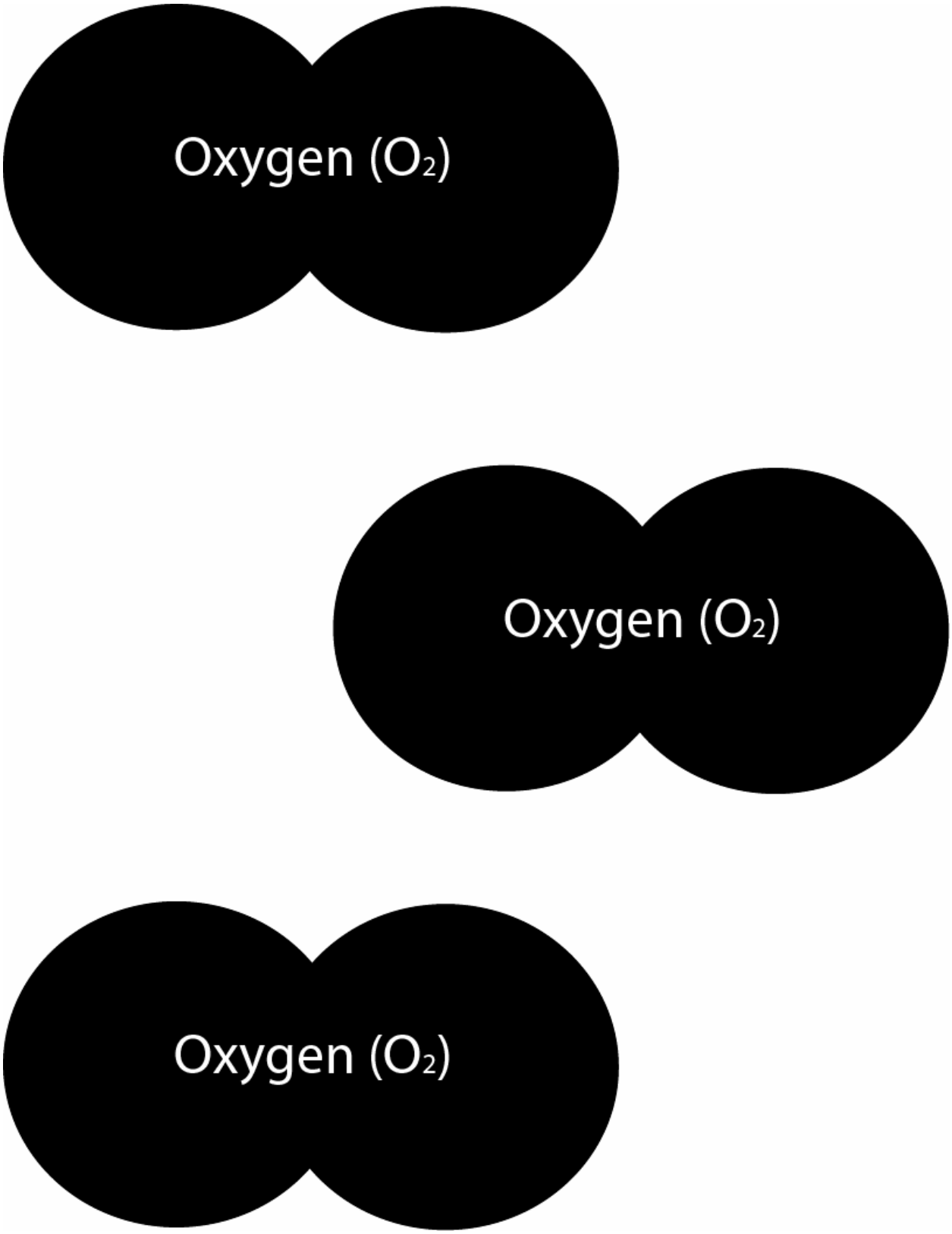
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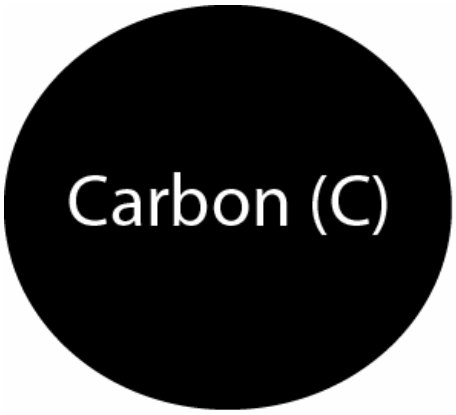
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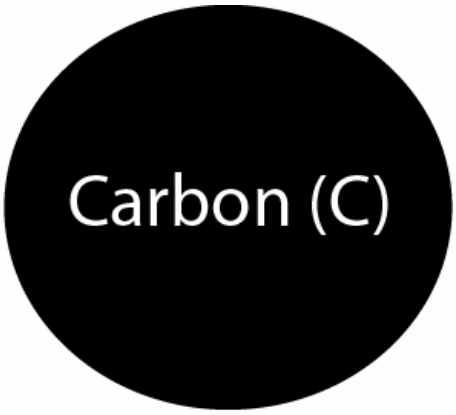
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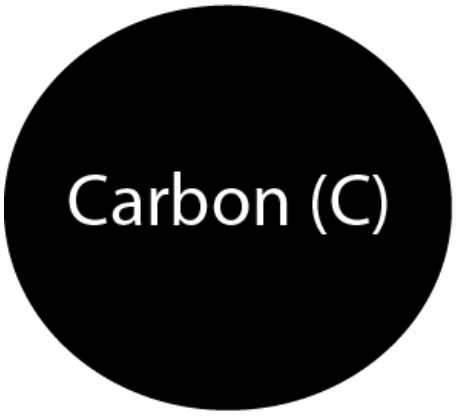
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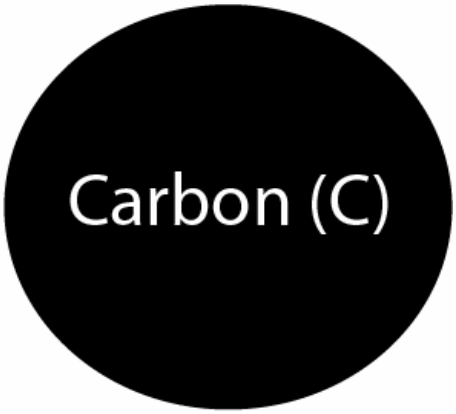
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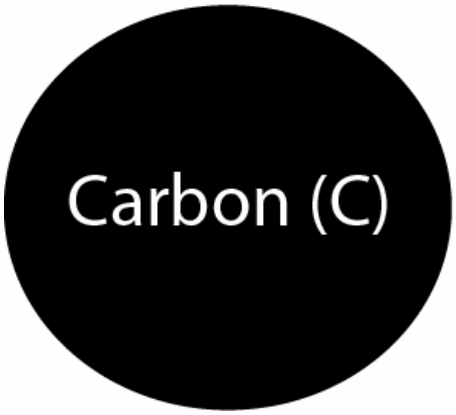
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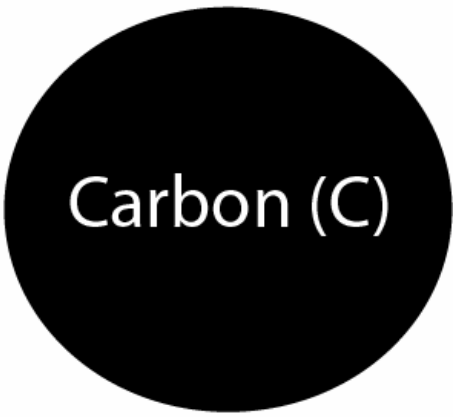
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