Lesson Title: The Plant/Animal Balance: Photosynthesis and Respiration.

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Grade Level: Middle School

Type of Lesson: Life or Earth Science

Objectives: The students will understand the balance between photosynthesis and respiration. Through this experiment they should be able to see that (1) plants perform photosynthesis at a higher rate than they perform respiration so that carbon dioxide is drawn down in a plant only system (and oxygen is driven up), (2) with the addition of animals (crickets) this draw-down of carbon dioxide is halted and the system reaches an equilibrium with the plant providing oxygen for the crickets and the crickets providing carbon dioxide to the plant, and (3) the day/night cycle is evident in the data as photosynthesis only takes place during the day.

Background: The students should have spent time reviewing photosynthesis and cellular respiration before this activity is planned. This activity is not designed to introduce photosynthesis and respiration but to put these processes within a global perspective. The Earth functions as a closed system. All materials needed for the maintenance of life cycle within the Earth system. Plants provide all oxygen that animals need to carry our respiration. In fact, before plants developed on Earth 2.5 billion years ago there was very little free oxygen in the atmosphere. It took another 500 million years for oxygen levels to get high enough for respiration to evolve. Since then plants and animals have been involved in a cycle where plants provide oxygen for respiration and animals provide carbon dioxide for photosynthesis. Without plants animals could not exist and without animal plants could not reach their current size and population.

References:
http://www.vernier.com/experiments/awv/12c/photosynthesis_and_respiration_co2_and_o2/

Lesson Vocabulary: Photosynthesis, Respiration, Carbon Dioxide, Oxygen, Cycle

Materials:
2 X CO_2 Sensors: http://www.vernier.com/products/sensors/co2-bta/
2 X O_2 Sensors: http://www.vernier.com/products/sensors/o2-bta/
2 X 2000 mL chambers: http://www.vernier.com/products/accessories/bc-2000/
2 X LabQuest Mini: http://www.vernier.com/products/interfaces/lq-mini/

2 X laptops with Vernier's free software: http://www.vernier.com/products/software/
-bamboo plants and water containers
-crickets
-netting and a rubber band to keep crickets out of the plant water
-a piece of carrot for cricket food

Preparation: At this point the students should know about photosynthesis and respiration and what the inputs and outputs of each process are. Take the two chambers. Place the same number of bamboo plants into each chamber. Place plants into a small container of water inside the chamber and drape mesh netting around each set of plants and fasten with a rubber band. This mesh is to prevent the crickets from jumping into the water and drowning. A small piece of carrot should be added to each chamber. Next, add about 12 crickets to only ONE of the chambers. Seal both chambers and insert the CO_2 and O_2 probes into ports on top of the chamber. Plug the sensors into the LabQuest Mini collectors and plug the collectors into the computers. Choose your collection interval and start collecting data. Place these chambers somewhere in the sunlight where the students can see them easily.

Safety Information: None.

Engagement: Draw the students' attention to the chambers. Explain that one chamber contains just plants and the other chamber contains plants and animals. Also explain that you have inserted carbon dioxide and oxygen sensors into the chambers to monitor these gases during the entire length of the experiment (at least one week but two would be better). Ask the students to make predictions about the organisms in the chambers. Will the plants die? Will the animals die? Will both survive? Make sure they mention carbon dioxide and oxygen in their justifications. Leave the experiment running and face the computer screens towards the classroom so the students can check on the progress during the experiment.

Exploration: After one or two weeks download the data from the computers. Either have the students plot the data with graphing software or sub-sample the data set (5 samples per day?) and have the students plot the data by hand. In groups have the students look at the trends in the data. How do the O_2 and CO_2 levels behave differently in the chamber with only plants vs. the chamber with plants and animals? What is O_2 doing when CO_2 is going down? What is O_2 doing when CO_2 is going up? What are O_2 and CO_2 doing during the day? Do they do something different during the night? What are the levels of O2 and CO2 in the chamber vs. the O_2 and CO_2 levels in the room? What are some sources of error in this experiment?

Explanation: Bring the class together and have a group discussion regarding their results. Ask the students if the outcome (nothing died) makes sense given the CO_2 and O_2 levels in the chamber. Ask how the system must have functioned (cycles) and relate this back to the Earth. Talk about other cycles on the Earth as well (carbon, nitrogen, water, etc.). Explain what happens when cycles become unbalanced (sky-rocketing CO_2, eutrophication and dead zones in the Gulf of Mexico, etc.).

Elaboration/Extension: With a smaller class you can let students design their own experiments using the chambers and sensors. What happens if you use 100 crickets? What happens if you put a lamp on the chambers?

Evaluation: Check the plots the students have made to make sure they plotted correctly. Give the plots back to the students during a science assessment and ask them to write a paragraph explaining the trends in the data (O_2 vs. CO_2 levels).

Wrap-up: Show the students a plot showing the recent rise in CO_2 levels. Relate this increase to an imbalance in material cycles. Ask the students where this CO_2 is coming from. Ask them if there are downsides to this CO_2 increase. Ask them if there are some benefits to this CO_2 increase.