

References

1. Lightner, Jerry P., Advanced biological science in large secondary schools, *The American Biology Teacher*, Vol. 22, No. 4, pp. 226-227.
2. Kelly, Richard D., The development and implementation of a course in advanced animal biology, A case study of twelve talented students. Unpublished doctoral dissertation, Syracuse University, Syracuse, New York, 1965.
3. Thurber, Walter A. and Collette, Alfred T., Teaching science in today's secondary schools (2nd ed. rev.;) Boston: Allyn & Bacon, 1964, 468 pp.

Carbon Dioxide In Photosynthesis and Respiration

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A laboratory exercise designed to show that CO₂ is consumed during photosynthesis and liberated during cellular respiration. It only requires materials that usually are stocked in all high school laboratories.

The plant used in this experiment is the fresh water green plant called elodea. Elodea grows free from any root or rhizoid attachment to substrate. Elodea has many flat leaves which contain hundreds of cells which in turn contain thousands of chloroplasts. In this experiment, elodea is suspended in a water solution, free from any attachments, and displays its capacity for photosynthesis. It is in such a situation that CO₂ consumption and liberation can best be studied. As CO₂ is absorbed by water, carbonic acid is formed; thus CO₂ concentration in water can be measured very exactly in terms of pH levels.

Procedure: To prepare for this experiment, a slightly basic solution at pH 9.0 containing a very sensitive pH indicator should be prepared in advance. This solution will be used later to test for the carbonic acid content of the water in which the elodea is immersed. To make this solution, place 100 ml of distilled water into a 100 ml beaker. Add approximately 2.2 ml of 0.1 molar NaOH solution, drop by drop, until this solution has a pH of 9.0. Then add 0.1 grams of phenolphthalein powder to the water. Place the beaker on a hot plate and boil gently for 20 minutes, or until the solution turns a deep red in color.

If a 0.1 molar NaOH solution is not available, it may be prepared by adding 0.4 grams of sodium hydroxide to 100 ml of

distilled water. Sodium bicarbonate may be substituted for sodium hydroxide by slowly sprinkling baking powder into the water until pH 9.0 is reached.

While waiting for the test solution to slowly boil, take 300 ml of water from the aquarium in which the elodea is growing. Place this water into a 500 ml beaker and bubble CO₂ from your breath into the water with a 10 inch piece of glass tubing. If a tank of CO₂ is available in your laboratory, a length of rubber tubing may be attached to the nozzle of the tank, and in this way CO₂ may be slowly bubbled into the water from the aquarium. Regardless of either method used, CO₂ should be slowly bubbled into the water until the pH of the water is lowered to 6.0. As CO₂ is bubbled in the water, carbonic acid is formed. The formula expressing this chemical reaction is $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3$. It is not recommended that any other method be used to place CO₂ into the water, otherwise other ions, acids, buffers, etc., may be introduced which may offset your final results during the laboratory portion of this experiment. PH paper, or a standard pH meter may be used to check pH levels in the water during the execution of the experiment.

At this point in the experiment 20 grams of fresh green elodea sprigs, approximately 3 inches long, should be removed from the aquarium. Then three 100 ml graduated

cylinders should be filled with the water which was previously prepared with carbonic acid. Two of the graduated cylinders should be filled with 10 grams each of elodea sprigs. The other graduated cylinder will not contain sprigs.

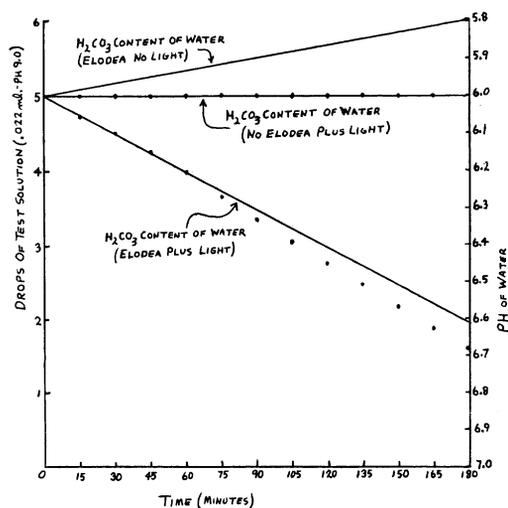
Immediately after completing the above mentioned steps in the experiment, two 40 watt desk lamps should be placed facing each other, one foot apart. Exactly between these lamps should be placed one graduated cylinder filled with 10 grams of elodea sprigs, and the other graduated cylinder without any elodea sprigs. The remaining cylinder containing sprigs should be placed in a dark place.

As light from the lamps shines through the leaves of elodea, CO_2 is removed from the water. The CO_2 is utilized during the dark reaction of photosynthesis which is taking place within the cells of elodea. As CO_2 is taken out of the water, carbonic acid will convert to water and the pH of the surrounding water will be raised, (become less acidic).

As soon as the graduated cylinders are placed between the lamps, a pH reading should be taken of the water in each cylinder and 1 ml of water should be removed from each and placed into two separate test tubes. One ml of water should be removed from the graduated cylinder that was placed in a dark place, and placed in another test tube. Into each of these test tubes, add the appropriate number of drops of previously prepared test solution until each just turn pink. As the drops of test solution are added to each test tube, the carbonic acid in each will be neutralized by the OH ions in the test solution. As the pH of the water in each test tube is raised

to 7.00, the water will become pink. This occurs because phenolphthalein, which is also in the test solution, is a very sensitive pH indicator and turns pink at pH 7.00. When it takes more drops of test solution to turn the 1 ml of water in the test tube pink, there was more carbonic acid in the water originally.

At 15 minute intervals, pH readings should be taken and 1 ml of water from the graduated cylinders should be tested with drops of test solution. A record should be kept of the various pH readings and number of drops it takes to turn the water pink. The test tubes prepared during the first 15 minute interval should be saved to serve as a standard of comparison for the other test tubes in the experiment.



The graph expresses the results of this experiment. The actual number of drops to neutralize the water from each graduated cylinder is corrected to the H_2CO_3 content per 100 ml H_2O . These corrected values were used to construct the graph.

Canadian Science Teacher's Conference

For the first time, Toronto, Ontario will host the North East Regional Conference of the National Science Teachers' Association November 2-4, 1967. It will be held at Toronto's Inn on the Park. The conference will be the biggest of its kind ever held in Canada and will be the first international program held in Eastern Canada. Planning, which has taken nearly two years, will bring together American and Canadian teachers in

all fields of science from kindergarten to university, together with the largest gathering of supervisors ever assembled at a science convention on this continent. For further information write to the Conference Chairman, H. Dene Webber, Althouse College of Education, 1137 Western Road, London, Ontario, Canada, or to the Conference Vice-Chairman, W. E. Patrick Fleck, Thomson Collegiat Institute, 2470 Lawrence Avenue East, Scarborough, Ontario, Canada.