APPARATUS FOR THE STUDY OF PHOTOSYNTHESIS AND RESPIRATION

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(WITH ONE FIGURE)

Two recent papers have dealt with methods of studying photosynthesis. The first of these[1] discussed photosynthesis in land plants, while the second[2] dealt with aquatics. It seemed to the writer that these methods might be combined, and some experiments were made for this purpose. The outcome was a simple method for the study of photosynthesis in land plants.

The apparatus consists of a large tube (a lamp chimney will serve) closed at the bottom by a stopper through which passes a tube (*A*, fig. 1) of Pyrex glass. Through the stopper at the upper end passes the neck of an atomizer bulb (*B*) with an opening at *C* for the intake of air.[3] To the neck of the bulb is attached a tube of Pyrex glass which extends to within an inch of the bottom of the tube *A*.

Plants[4] are placed in the chamber with their stems dipping in water contained in a small beaker. By means of the tubes *D* and *E* any desired amount of CO_2 may be run into the chamber. When this is finished the bulb is repeatedly squeezed so as to force the gases in the chamber to bubble through the liquid contained in the tube *A*. This liquid consists of distilled water, to which has been added[5] an indicator which is sensitive to CO_2. As the gas bubbles through the liquid[6] the color of the indicator changes.

[1] OSTERHOUT, W. J. V., Amer. Jour. Bot. 5:105. 1918.

[2] OSTERHOUT, W. J. V., and HAAS, A. R. C., Science N.S. 47:420. 1918.

[3] This form of bulb can easily be obtained in the drug trade.

[4] *Tradescantia* may be recommended for this purpose, especially kinds without stripes on the leaves.

[5] The choice of indicator depends on the amount of CO_2 introduced into the chamber; for most purposes phenolsulphonephthalein will prove useful. At the start of the experiment the PH value should be such that a slight change in CO_2 will alter the color of the indicator.

[6] The bulb does not permit the entrance of air from the outside; it merely causes a circulation of the gas within the chamber.

The bubbling must be continued until the color becomes constant. When this is achieved we know that equilibrium has been established between the CO_2 in the liquid and that in the chamber.

In order to determine when the color of the indicator has become constant it is compared with a series of buffer solutions having the same concentration of indicator and contained in Pyrex tubes of the same size, as described in a previous article.

The plant is now exposed to sunlight.[7] After exposure the gas is again bubbled through the liquid. If the plant has taken CO_2 from the air it will be evidenced by the change in the color of the indicator, which will show a greater degree of alkalinity than before. From the amount of change in alkalinity the change in tension of CO_2 can be calculated; or the indicator may be calibrated.[8]

For qualitative results the calculation or calibration is not necessary. In the opinion of the writer, leaves of land plants are not suited to quantitative investigations on photosynthesis, since on exposure to sunlight their temperature (and consequently the rate of photosynthesis) fluctuates greatly (as much as 10° C. in half an hour). This difficulty may be obviated by using suitable aquatics.

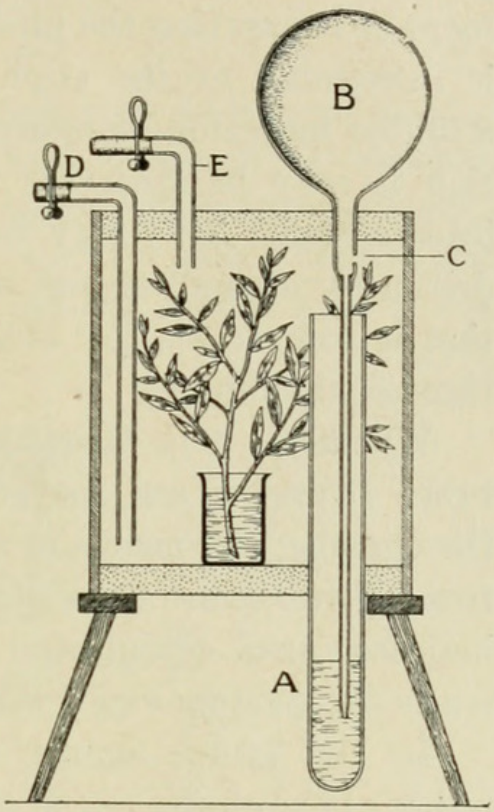

FIG. 1.—Apparatus for measurement of photosynthesis and respiration: plants are placed in the chamber; by means of bulb *B* gas in chamber is bubbled through indicator contained in tube *A;* intake of bulb is at *C* so that no air enters from outside; valve (not shown in figure) prevents air from passing out through *C;* changes in color of indicator show changes in tension of CO_2.

For class demonstration it is not necessary to have a tube projecting through the lower stopper. The apparatus may be

[7] The rise of temperature which occurs in sunlight tends to force gas out through the joints, which should therefore be made tight or sealed with water.

[8] For methods see HENDERSON, L. J., and COHN, E. J., Proc. Nat. Acad. Sci. 2:618. 1916; MCCLENDON, J. F., GAULT, C. C., and MULHOLLAND, S., Publ. no. 251, Carnegie Inst. 1917. p. 21.

simplified by using an ordinary bottle and placing in it a small vial containing indicator, into which dips the tube which is attached to the bulb. It is always advisable to have a control in the light without a plant and a control in the dark containing a plant similar to the one used in the experiment. For the measurement of respiration the procedure is the same, except that no CO_2 is introduced at the start and that phenolsulphonephthalein or a similar indicator is employed. For quantitative work on respiration it may be desirable to have the bubbling go on without interruption. This may be accomplished by an excentric wheel driven by a small motor, and so arranged that at every revolution it compresses the bulb sufficiently to send a few bubbles through the liquid.[9]

Whenever it is desirable to remove the accumulated CO_2 the tubes *D* and *E* are opened and a current of air is run through the chamber (by means of an attached aspirator or syringe). The tubes *D* and *E* are then closed and the gas is bubbled through the indicator until equilibrium is established. The apparatus is then ready for starting a new experiment.

In the same manner air charged with volatile substances (ether, chloroform, etc.) may be introduced in order to study their effect upon photosynthesis and respiration (substances having a pronounced acid or alkaline reaction or a strong buffer effect are unsuitable for this purpose).

Summary

The photosynthesis and respiration of land plants may be studied by placing them in a chamber in which the gas can be made to bubble through an indicator. The changes in the color of the indicator indicate the changes in the tension of CO_2.

The method is so simple and convenient that it is adapted to classroom demonstration as well as to investigation.

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[9] See OSTERHOUT, W. J. V., Jour. Gen. Physiol. 1: 17. 1918.