A TILTING BLACKBOARD FOR GEOLOGIC INSTRUCTION

PERSONS accustomed to geologic profiles and structure sections can readily imagine them tilted this way or that on the blackboard or on paper. In other words, they can readily imagine the horizontal of the drawing to be something other than the horizontal of the blackboard or the paper. Beginning students find this difficult, and some help is desirable in introducing the general concept of tilting to classes in geology.

In my classroom is a light, auxiliary blackboard about 18 inches high and 48 inches long. The writing surface is of special blackboard paint on very dense, thin wallboard made of wood fiber compacted under unusually great pressure. A frame of fir, of $\frac{7}{8}$ by $2\frac{1}{2}$ inch cross-section, gives adequate stiffness to the whole. Rubber-covered nails, driven into the back of the fir frame, protect the permanent, main blackboard. Both ends of a slack cord are attached to screw-eyes in the upper edge of the frame. The cord is passed over two hooks in the upper molding of the permanent blackboard. By sliding the cord over the hooks the auxiliary blackboard may be hung horizontally or may be tilted either way.

The simplest and yet the most valuable use to which I have put it is in explaining unconformities. The auxiliary blackboard is placed so its long axis is horizontal, and half a dozen horizontal lines are drawn on it to represent the deposition of some horizontal strata. Then the board is tilted and erasure above a new horizontal line represents erosion to a new horizontal surface that bevels the tilted strata. Addition of a new set of horizontal strata gives an angular unconformity. Overlaps, both transgressive and regressive, may be illustrated readily. A cross-section of a lake may be tilted, bringing wave-made features above the water on one side of the lake and submerging them on the other side.

The auxiliary blackboard is also convenient on quiz days. The first question or two may be written on the blackboard in the office beforehand. As soon as the paper is distributed and the blackboard hung up the students can get to work. There is no delay while the instructor writes the questions.

It happened that our university carpenter shop had suitable scrap material, so the cost to my department was nil. I judge that new material would cost a dollar or at the most two dollars.

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SPECIAL ARTICLES

EVAPORATION, TRANSPIRATION AND OXYGEN CONSUMPTION BY ROOTS[1]

EARLIER experiments by one of us showed that, other factors being equal, the rate of oxygen absorption by roots might be less when the shoot is in light than when it is in shade or darkness.[2] The experiments here summarized support the earlier conclusion and suggest certain possible causes for exceptions.

In the present experiments the most important conditions were the following, namely, the plants were in distilled water during the tests, but were kept otherwise in a normal culture solution, and the shoots were either in dense shade, or darkness, or were directly exposed to sunlight. The temperature of the solution was fairly constant. The evaporating power of the air was determined with white and black atmometers. The oxygen determinations were made with the Thompson-Miller apparatus and by the Winkler method. The plants used were cuttings of willow (*Salix laevigata* Bebb, from Stanford University, and *S. exigua* Nuttall, from San Diego). The experiments were carried out in the summer at Stanford University. The leading results can be briefly presented, as follows:

When the shoots were kept in dense shade, or darkness, for one hour, as from 8 to 9, or from 9 to 10 A. M., and immediately thereafter placed in direct sunlight for one hour, the consumption of oxygen by the root was usually less during the period of light.

The evaporating power of the air was always greater during the light period, but it varied from day to day. Especially the ratio of black to white atmometer readings (B/W) were found to range from 1.5 to 1.9, which was in part the result of haziness, from whatever cause, often obtaining in early morning. Although further work must be done to surely establish the relation, it was apparent from the experiments that a high ratio would be expected to be coincident with low oxygen consumption of the roots, other factors being equal, and that the converse would be expected with a low ratio. This, it will be seen, is merely a means of defining in a certain way the light-oxygen-consumption relation of the root.

Quite as important a factor is that of the temperature of the culture. When the temperature was low, as about 16° C., the oxygen consumption was also low, whatever the light conditions may have been. But the converse did not appear to follow necessarily.

[1] The investigation was carried out in part with the aid of a grant from the National Research Council.

[2] SCIENCE, n. s., 75: 1934, 108, 1932. *Plant Physiology*, 4: 673, 1932.

At high temperatures, as, for instance, at 29° C., the rate of consumption was also high when the shoot was in darkness, but whether relatively rapid or not, the expected drop in rate took place during the first hour in light (following the hour of darkness). The high temperature, therefore, did not swamp the expected reaction during the light period.

As would be expected, the rate of transpiration was found to be greater during the exposure to sunlight than during the dark period. The ratio between the two (TL/TD) was found to be as much as 44:1. It is apparent, therefore, that a rapid rate of transpiration during the light period does not inhibit the fall of oxygen consumption of the root.

From what has been said it will be seen that the rate of oxygen consumption by the root of willow is indirectly affected by the light relations of the shoot, and may be directly affected by the temperature of the solution. There does not appear to be a positive relation between transpiration rate and that of oxygen absorption by the root. There may be a direct relation between the evaporating power of the air, as revealed by the B/W atmometer readings, and the rate of oxygen consumption. Whether, on the other hand, a high evaporation rate, in the willow at least, influences oxygen absorption by the root remains to be shown.

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SPROUTING AND GRAFTING FRACTIONAL PARTS OF AVOCADO EMBRYOS WITH ATTACHED COTYLEDONOUS MATERIAL

(1) Sprouting or Germination

Growth responses following splitting in approximately equal parts of the avocado embryo, *Persea americana, P. drymifolia,* either before or after it has sprouted, and planting these fractions with attached cotyledonous material in a sawdust sprouting medium are of general scientific interest. Usually when the whole seed is planted, one sprout from the embryo takes the lead and dwarfs any secondary multiple sprouts which as a rule do not show above the ground. However, when the embryo was split into two fractions and these planted separately with attached cotyledonous material, in many cases, more than one sprout developed from each of the fractional parts of the embryo. These multiple sprouts were in many cases of equal strength. In some cases as many as eight sprouts were observed. It was desirable in the case of multiple sprouting to prune out all but one in order to secure in a reasonable length of time a plant suitable for budding. One-fourth embryos also sprouted and grew. These were secured by splitting half embryos, with cotyledonous material attached, into two portions. The application of this principle makes it possible to secure two or more plants from each avocado seed. An experiment to determine the relative vigor of plants from whole seeds and fractional embryos with attached cotyledonous material is now in progress.

(2) Fractional Embryo Grafting

The method of avocado propagation here briefly described is of general scientific interest in that it makes use of the principle of grafting a cion into either the sprouted or unsprouted fractional embryo. The seed is split in two, as reported above, and the cion is then wedge grafted into the fractional embryo with attached cotyledon at any of the three desired developmental stages: (*a*) immediately after splitting the unsprouted embryo; (*b*) after halves planted in sawdust just begin root and plumule elongation; (*c*) after the development of the fractional units has progressed still further—the root is 3 inches or more, and the plumule ½ to 1 inch or more, in length. In the last-named case, the plumule is cut back to point of union with the cotyledon. In a fourth method the whole seed is sprouted and then the developing embryo, including the plumule and tap-root which have reached the stage as indicated under (*c*) above, is split in half and each portion or split plumule is cut back to the point of union of the cotyledon and then grafted. The relative effectiveness of the four procedures has not been fully determined. After all the exposed cut surfaces are waxed with paraffin the completed grafts are placed horizontally with grafted embryo fraction on top, in a propagating medium, covered to a moderate depth (1½ to 2 inches) set in partial sunlight to provide solar heat, and watered liberally. When vigorous sprouts appear on the cion and additional roots have developed, the time varying with different experimental conditions, the grafts are transferred either to standard 12 by 6 by 6 inch cypress plant boxes or planted in the nursery row. When planted deeply, cion roots are formed in many cases.

The anatomy of the graft union and the physiology of growth are being studied. The chief difference between this and other methods of propagating the avocado, *Persea americana, P. drymifolia,* consists in grafting a cion into the sprouted or unsprouted fractional embryo at point of union with cotyledon, and not higher up into the developing plumule or stem. In this method the cion actually takes the place of the developing plumule. Possible advantages are bench operation in propagating, securing double the number of plants from the same number of available seeds and the production of satisfactory nursery trees