

NOTE.

A SIMPLE ROOT AUXANOMETER.—None of the standard methods for measuring the rate of growth of roots is convenient for use with large practical classes in that they involve either the use of a horizontal microscope or other expensive apparatus, or else the magnification of the movement is not sufficient to allow the rate of growth to be determined in the course of a few minutes.

A simple method has been used in this laboratory and has proved entirely satisfactory for class purposes. It is sufficiently simple and straightforward for use by elementary students, while, with certain modifications, it can be made to yield results of such accuracy as to warrant its employment for more serious purposes.

In its simplest form the apparatus required consists of a gas jar, *A*, fitted with a cork, *B*. Through a hole in the cork a glass rod, *C*, runs freely. A long pin passes through the cork and impales a seedling, *D*, with a straight root.

The method of procedure is as follows. The glass rod having been inserted through the hole in the cork, as shown in the sketch, a convenient quantity of water is poured into the jar and the height of the seedling adjusted by means of the pin until the root tip just touches the surface of the water. Upon lifting up the glass rod a short way, the level of the water in the jar falls and leaves the root tip above the surface. The rod is then slowly lowered until the root tip just touches the water surface, and the position of the rod in relation to the top of the cork through which it passes (or to a wire pointer) is recorded by making a mark upon it. The apparatus is left for 5 or 10 minutes and a fresh reading taken: this will be found to differ from the previous one by 2 or 3 cm. or more of the glass rod in the case of an actively growing root.

The exact moment at which the root tip touches the water surface is very evident, owing to the sudden rise of the water round the root by surface tension—it is much more evident than the moment of contact of a metal pointer with a surface of mercury which does not ‘wet’ it. If the glass rod is lowered slowly and carefully, readings of its position should vary less than a millimetre.

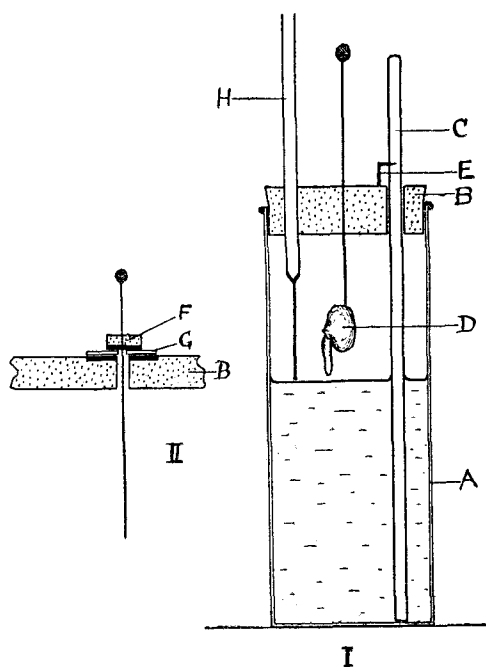
The magnification involved can be determined by measuring the inside area of the cross-section of the jar (*S*) and the area of the cross-section of the glass rod (*s*): the actual elongation of the root will be the distance apart of the marks on the glass rod $\times \frac{s}{S}$. For example, with a glass rod 5 mm. in diameter and a jar 5 cm. in diameter, the magnification will be 100 times, and every millimetre the glass rod is lowered will cause the water level to rise 0.01 mm. in the jar. It is a convenience to employ a rod graduated in millimetres: the absolute amount of growth of the root, if required, is then obtained by dividing the reading on the glass rod by the magnification coefficient.

The sensitiveness of the apparatus can be varied within wide limits by varying the diameters of the jar and rod—the magnification increasing as the square of the radius of the jar and inversely as the square of the radius of the rod.

Care should be taken that the root tip is kept away from the sides of the jar and from the near neighbourhood of the glass rod, as the water surface will be considerably curved there. It is also desirable to have a cylinder of cardboard or black paper to slip over the jar to shield the root from the light.

The inaccuracy due to water adhering to the glass rod when it is raised was found to be negligible.

The following elaborations are suggested where greater accuracy is required or when prolonged observations are contemplated.



(1) The difficulty of accurately measuring the cross-section of the jar at the level of the water surface makes it impossible to obtain really precise absolute readings by the method of calculation suggested above. The following method of calibration is suggested:

An additional small hole is bored through the cork, through which is inserted a long pin (see Fig. II). A small disc of cork, *r*, too large to pass through the hole, slides on the pin, so that the distance of the pin-point from the water surface can be adjusted. The position of the glass rod which just causes contact of the water surface with the pin-point is determined. A thin washer, *g*, of known thickness is then inserted under the supporting cork disc on the pin, and a fresh determination made. From these data the actual rise in water level caused by immersion of a given length of the rod can be calculated.

It would no doubt be advantageous for the under surface of the cork disc and the upper surface of the cork on which it rests to be faced with some harder and more accurately plane surface than cork. A microscope cover-glass with a hole drilled through the centre should serve. Another drilled cover-glass forms a convenient washer.

(2) If the experiment is continued for more than a few hours, the water surface may be measurably lowered as a result of evaporation—the water vapour condensing on the inside of the jar. Error from this cause can be eliminated in the following way. A piece of glass tubing is drawn out to a fine capillary, sealed at the end, and inserted through the cork (H, Fig. I). The height of this is adjusted until the lower end is about the same level above the water surface as the tip of the root. Whenever the position of the glass rod which causes contact of the water surface with the root is determined, that which causes contact with the end of H is also noted. Thus, the position of the root tip is measured at successive intervals in relation, not to the water level, but to the end of H, which is a fixed point. Alteration of the water level during the experiment is thus of no importance:

(3) For prolonged experiments it will be found advisable to have a slow stream of air bubbling through the water in the jar. This provides aeration for the root and also ensures that the atmosphere around the root is kept constantly moist.

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July, 1929.