figures merely indicates the approximate magnitude of required lens.

It is preferable to use the microscope at the proper tube length for the greatest definition, and this can be done if a rubber ring cut from a piece of rubber hose is placed around the draw tube to prevent telescoping from the weight of the camera. Many modern microscopes have the draw tube fixed at the proper length, so no additional friction is needed.

The use of the vest pocket kodak with the autographic feature allows permanent labeling of the negatives, which can not be done with the box camera. The magnification obtained will depend on the lens on the camera and the distance from the lens to the film. It can be obtained easily by photographing a stage micrometer. When it is desirable to reduce the cost of the negative film an insert can be made to reduce the opening in the back of the camera, cut from the thin aluminum of an ordinary cookie tin, and less expensive moving picture film used. The distance that the film is to be turned ahead between pictures can be noted by extending the opening on the back of the camera to the edge of the film and counting the perforations of the film through a red window as the film is wound. The disadvantage of this method is that the camera must be loaded and unloaded in the dark room or in a changing bag. In the previous work[2] I used an insert with an opening of 1 x 1½″, which is twice the size of the cinema frame and thereby reduced the cost of the negatives to about one cent per exposure.

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A NEW TECHNIQUE FOR OBTAINING OOSPORES OF THE HOP DOWNY MILDEW BY INOCULATING COTYLEDONS

FIELD observations in the Fraser Valley, British Columbia, in 1930, showed that young hop seedlings were badly infected with the hop downy mildew, *Pseudoperonospora Humuli* (Miy. and Tak.) Wilson. Cotyledons and primary leaves were covered with conidiophores bearing conidia.

Following this observation hop seed were gathered from plants of the clusters variety and sown in flats in the laboratory in 1931. As the cotyledons and young primary leaves appeared, they were inoculated by placing on them minute portions of infected leaves obtained from diseased "basal spikes." The seedlings had been previously moistened. The seedlings were afterwards covered with vials so as to maintain maximum humidity. They were grown in the basement of the laboratory, where the temperature remained fairly constant at 58° to 65° F. The seedlings were moistened with water each day.

After a period of six days, the time varying with different seedlings, it was noticed that the cotyledons showed signs of "damping off." Microscopic examination of the cotyledons showed that no conidiophores had developed, but on teasing out the tissue, it was found that oogonia and oospores were present in abundance. Approximately eighty oospores were found in each cotyledon, giving an average of 160 oospores per seedling. The oospore dimensions corresponded with those reported by other workers, ranging between 23 and 37 μ. Further work revealed that when maximum humidity was not maintained, conidiophores bearing conidia were produced, as well as oospores.

At present it is possible to collect abundant oospore material by inoculating hop seedling cotyledons in the manner described and gathering the latter when they show signs of damping off. By this method it will also be possible to obtain conidia for experimental purposes in the greenhouse during the winter period.

The writer considers that this technique of inoculating cotyledons may be applicable to other members of the Phycomycetes, which means a great saving of time for the worker who wishes to examine oospore material within the host.

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SPECIAL ARTICLES

ON THE VARIATION OF THE OXYGEN CONTENT OF CULTURAL SOLUTIONS

EARLIER observations led to the conclusion that there may be a translocation of oxygen from the shoot to the root of plants when the shoot is in sunlight and the root is in soil.[1] The present note records observations, to be published in detail elsewhere, that a similar movement of oxygen may take place when the roots of plants are in cultural solutions, particularly in distilled water.

The plants referred to are willow, cotton, corn and sunflower. These were grown in a standard culture solution and were transferred to distilled water for

[1] W. A. Cannon, "Studies on Roots," Carnegie Institution of Washington. Year Book No. 25, p. 317, 1925–26.

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the tests only but were kept ordinarily in the culture solution. One willow cutting, or three of the plants, were placed in each glass jar, darkened always and of one-quart size. The cultures were subjected to two- or three-hour periods, alternately, of sunlight and of dense shade, and were covered with bell glasses over which a spray of water was constantly played. By this means the temperature both of the solutions and of the bell glasses was kept fairly low and constant, and, also, the atmosphere of the bell glasses was maintained highly humid. Fresh distilled water was used in each period.

The series of experiments of August 12 to 21 on the sunflower will serve to illustrate the leading results obtained by a study of all the plants, except only corn, which will be referred to below.

In these experiments two periods were selected each day for the tests. Of these one ran from 8 to 11 A. M. and the other from 11 A. M. to 2 P. M. Except in one instance the plants were kept in shade during the first of the periods and were exposed directly to sunlight during the second. The temperatures of the bell glasses and solutions were recorded in each test, and, at the same time, the amount of oxygen was determined. The results may be briefly given. In every instance more oxygen was found in the cultures exposed to sunlight than in those kept in shade. The difference was about 10 per cent.

In further account of the experiments it should be stated that the temperature of the bell glasses in the sunlight, and of the solutions as well, was higher than that of the solutions and bell glasses in the shade. As the rate of respiration, at the temperatures used, varies directly with the temperature, it would be expected that where the temperature was low the oxygen content would be high, and *vice versa,* but the opposite was found to be the case. That is to say, the greatest amount of oxygen was in the solutions with the highest temperatures. But these were also in sunlight, or at least the plants growing in them were in direct sunlight. The conclusions, therefore, seem warranted that there is an important relation, even if an indirect one, between evolution of oxygen in photosynthesis and the variation of the oxygen content of the solution as noted above. Thus it appears that oxygen, liberated in the course of carbon dioxide assimilation in chlorophyll bearing organs and in light, moves downward toward and ultimately into the root to fill wholly or in part its requirements for oxygen. Thus the root may apparently secure its oxygen supply from one of two sources: from the plant itself, internal oxygen,[2] and from the immediate environment. Whether this is the case under "natural" conditions, as it has been found to be in the experiments, remains to be seen. However that may be, that oxygen taking its origin in this manner constitutes a large proportion of what the root may ordinarily use seems quite possible, and under conditions similar to those employed in the experiments reported, it is more than probable.

It has already been mentioned that corn was found to be an exception to the effect, although indirect, of sunlight on the oxygen content of solutions similar to those in which the sunflower, cotton and willow were growing. To show this it will suffice to summarize one representative series of tests. In this series in which the temperature varied in the same direction as that in the experiments on sunflower above cited, but in which the variation was not so great, the oxygen concentration of the cultures in sunlight was always less than the concentration in the shade tests. It was found, in short, that the roots of plants exposed to sunlight absorbed about 14 per cent. more oxygen than did those of shaded specimens. This suggests either that the rate of respiration of the roots of the plants which had been in sunlight was high because of the higher temperature, or more rapid than the supply of internal oxygen from the shoot, or perhaps that the latter was wanting. However this may be, it can be pointed out that at temperatures favorable for a rapid rate of root growth corn appears to require an exceptionally good supply of oxygen.[3] Whether, on the other hand, such a form as willow, which does not appear to have a high oxygen requirement for root growth, may depend importantly on the shoot for its oxygen supply is another matter but may well be the case. It either is in solution or is a gas. In whatever state or in whatever way the internal oxygen may move from one part of the plant to another, whether molar or molecular, or both, presents no especial difficulty. In the event that it is tied up with the movements of solutions it yet can make its way from tissue to tissue and from the shoot to the root. Downward movement of solutions in plants are well known. This may even extend to the root where, as in the present study, movement of a solution from the leaves to and well into the roots of sunflowers was demonstrated to take place. It thus appears possible that internal oxygen may take an important part in the aeration of plant tissues, whether they are of the shoot or of the root, although whether this is of general occurrence among land plants must remain for further investigation.

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[2] G. F. Beardsley, and W. A. Cannon, "Note on the Effects of a Mud-flow at Mt. Shasta on the Vegetation," *Ecology,* 11, 1930.

[3] W. A. Cannon, "Physiological Features of Roots," Pub. No. 368, Carnegie Inst. Washington, 1925.