cession, South Carolina in 1824, Massachusetts in 1830, Tennessee in 1831, Maryland in 1833, Connecticut, New Jersey and Virginia in 1835, Georgia, Maine, New York and Pennsylvania in 1836, Delaware, Indiana, Michigan and Ohio in 1837, Rhode Island in 1838, New Hampshire, Iowa, Illinois and Wisconsin in 1839, and Vermont in 1844. Three botanical gardens were opened in the first decade of the last century. The major line of activity was, however, very largely the formation of local scientific societies, academies, institutes and museums. These were the natural outgrowth of local enterprise and ambition and were obviously the most practical type in a period when travel was both expensive and time-consuming.

While there are these marked developments of state and local enterprises, there is at the same time a noticeable absence of federal activities, aside from exploring expeditions which usually utilized the federal army or navy personnel and guidance; and of national societies. Two notable exceptions to this are the American Philosophical Society (1769) and the American Academy of Arts and Sciences (1780).

In the period from 1769 to 1844, and mainly after 1800, no less than 65 societies, lyceums, institutes, and the like, with state, county, city, or institutional designations in their names, were formed. Many of these were short-lived, a few now continue to function abreast of the times, and a number of others seem to have acquired the status of ancient and honorable desuetude. The close of this period saw the dawn of national solidarity in scientific matters with the formation of the Association of American Geologists and Naturalists (1840), out of which grew the American Association for the Advancement of Science and the National Institution for the Promotion of Science (1840), the predecessor of the Smithsonian Institution.

Scientific journals and publishing enterprises also multiplied in this period. Fourteen such serials, not professedly attached to institutions, were established between 1800 and 1844. Of these all but one, *The American Journal of Science,* have vanished, often after a brief career. They lacked the environing conditions and institutional continuity to enable them to survive in the struggle for pabulum and patronage.

The bibliographer and librarian will find in this volume a valuable record of the fugitive publications of the early expeditions, the state surveys and the ephemeral societies and lyceums which sprang up throughout the Republic in its early days from Portland to Little Rock. The investigator will find here accurate citations of all papers on subjects in natural history in practically all of the serials issued by the scientific agencies in the United States published prior to 1845. The historian of this scientific age will find here, in so far as names and titles can express it, an epitome of the pioneer days of American science.

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SPECIAL ARTICLES

EFFECT OF SHORT ALTERNATING PERIODS OF LIGHT AND DARKNESS ON PLANT GROWTH

IN earlier papers dating from 1920, it has been shown that the relative length of the day and night may profoundly affect the course of development of plants. With many species flowering and fruiting may be hastened or retarded by appropriate regulation of the daily period of illumination. In some plants flowering is favored by relatively short days, while in others reproductive activity is induced by long days. Thus it was found that plants normally flowering during the fall or winter may be readily caused to flower in midsummer by excluding the early morning or late afternoon light for a few hours each day. When, however, these plants were darkened for a like number of hours during the middle of the day the vegetative period was not materially shortened. In this respect the plants behaved about the same as if they had remained in the light throughout the day. It appears that with the same total number of hours of daily illumination two shorter periods of light do not produce the same effect as a single uninterrupted light period. The view has been previously expressed that the length of day effect is not due simply to the total quantity of light energy received by the plant and additional evidence in support of this view is seen in the results of recent experiments having to do with the response of plants to variations in the distribution of a given number of hours of illumination through the 24-hour period. Considerable work will be required to complete these studies but it seems desirable to report briefly at this time some of the results thus far obtained. It has been previously shown that in June plantings of the Biloxi variety of soybeans the normal vegetative period at Washington is 80 to 90 days while exposure to a daylight period of 8 to 12 hours may induce flowering in 20 to 25 days. Similar plantings were darkened daily from 10 a. m. to noon and from 2 to 4 p. m. As compared with the full length of day of summer this treatment not only failed to hasten flowering but actually delayed it by two weeks. On the other hand, when these and other plants of similar behavior were exposed to the full daylight period, but on alternate days only, the vegetative period was materially shortened, although not to the extent effected by a short daily illumination period. Experiments were next undertaken with uniform, relatively short alternating periods of light and darkness, using for the purpose small light-proof compartments, with 1,000-watt Mazda lamps as the light source. Excess radiant heat energy from the lamps was prevented from reaching the plants by interposing a 2-inch screen of rapidly flowing clear water. Light intensities of 2,000–4,000 foot candles at normal temperatures were thus provided. Special timing devices were used for automatically turning the lights on and off at the proper intervals. As a standard of comparison for the shorter intervals, 12 hours of illumination alternating with 12 hours of darkening was used and in some instances continuous illumination also was employed. In addition to Biloxi soybeans, the Mandarin which readily flowers in the long days of June (at Washington) and the Peking variety, normally flowering under a somewhat shorter day, were included in the tests. With a 6-hour alternation of light and darkness the vegetative period of Mandarin was increased from 22 days (12-hour controls) to 34 days and the height was increased from 25 inches to 45 inches. Neither the Peking nor the Biloxi showed flower buds at the end of 51 days although their respective heights were 42 and 40 inches. The 12-hour controls flowered in 23 and 43 days, respectively, and their heights were 29 and 51 inches. In Rudbeckia bicolor, a plant in which flowering is favored by very long days, the vegetative period was reduced from 45 days to 37 days by the 6-hour alternation and the number of blossoms was considerably increased although the average size of the blossoms was reduced. In these tests the mean daily temperature ranged from 69° to 72°, with extreme daily ranges seldom departing from the mean by more than 5 degrees and without important differences between the two compartments. With a 4-hour alternation of light and darkness Mandarin and Peking soybeans gave similar results. Experiments were then made with alternating light and darkness intervals of 1 hour, 1 minute, and 15 seconds, respectively. In several tests running from 36 to 53 days the Mandarin flowered after considerable delay under the 1-hour alternation, as measured by the vegetative period under the 12-hour interval, but failed to flower under the two shorter intervals. Biloxi soybeans failed to flower under any of the short alternations. In contrast with the effect on soybeans, reproductive activity was materially hastened in Rudbeckia bicolor by the short alternations of light and darkness. Moreover, the vegetative period was about the same as under continuous illumination. In one test the vegetative period under the short alternations and under continuous light ranged from 31 to 37 days, as compared with 56 days under the 12-hour alternation. The average height of the plants was 40 inches under continuous illumination and 20 inches under each of the light-darkness alternations. Summing up, it is apparent that with the plants in which flowering is favored by short days as well as with those in which the opposite is true, the general effect of the relatively short alternations of light and darkness on reproductive activity is much the same as that produced by long days or continuous illumination. There is no suggestion of a short-day effect. However, the short light-darkness alternations may bring about more or less serious nutritional disturbances and growth relations are markedly affected. A striking feature of these tests with soybeans and Rudbeckia and with *Cosmos sulphureus* has been the chlorotic, weak, spindling type of growth produced by the short light-darkness alternations, which is especially marked under the 1-minute interval. These effects seem to increase with decrease in the duration of the alternation until a climax is reached with the 1-minute interval. Curiously enough, the type of growth is much improved again with the 15-second interval. Evidently, assimilation and other functions may be much disturbed under relatively short alternations of light and darkness. In this connection it is of interest to note that Warburg (Biochem. Zeitschr., v. 100, 1919, p. 230–270), working with Chlorella under very short illumination intervals, did not obtain the normal average rate of assimilation found for continuous illumination till the alternations were reduced to a length of about .004 second. Under the 1-minute interval in our tests with soybeans leaf development was poor, the leaves being reduced in size, chlorotic and showing large splotches of dead tissue. The stems were slender and weak. Cosmos showed much the same characteristics in leaf and stem. Larger plants of Rudbeckia showed somewhat less leaf injury but small seedlings were unable to survive at all under the 1-minute interval. Taking 100 to represent the average dry weight of the aboveground parts of Rudbeckia under the 1-minute interval, in a typical case, the corresponding values for the 15-seconds, 1-hour and 12-hour intervals were 150, 175, and 250, respectively. Similarly, with 100 as the dry weight of tops produced by Biloxi soybeans at the end of 21 days under the 1-minute interval, the corresponding values for the other intervals were 190, 280, 280, respectively, and 310 for continuous illumination. Similar, though somewhat larger, differences under the different exposures were obtained with Cosmos. Interesting contrasts in relative growth of root and top were shown by the soybeans and cosmos under the different light exposures. In the soybeans root development was very poor under the 1-minute and 15-seconds exposures, the ratio of root to top being 1:7. On the other hand, the dry weight of roots produced by cosmos under these intervals greatly exceeded that of the tops, the proportion being 1:.3–.4. Under the other exposures the ratio of root to tops remained nearly constant and was about the same for both plants, namely, 1: 3.0–4.0. The combined dry weight of root and tops of cosmos was the same for all alternations of light and darkness and slightly less than half of that produced under continuous illumination. With the soybeans this relation did not hold, the combined dry weight produced under continuous illumination being only slightly greater than that under the 12-hour and 1-hour alternations while the combined weight under the 1-minute alternations was relatively quite small. The effect on the growth and nutrition of the plant, at least in some particulars, suggests that commonly produced by weak light, although the leaf injury possibly could be considered as indicating excess illumination. There seems to be no feature resembling the typical short-day effect except possibly that on root growth in cosmos. These tests are being further elaborated and it will be of interest to study the effects of various other alternations with both equal and unequal durations of the light and darkness intervals.

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IRON ORGANISMS

DURING the last two years we have endeavored to investigate iron organisms of the Gallionella group (Toxothrix, Spirophyllum, etc.).

In the course of the work it became clear that a medium consisting of tap water (pH = 7.6) and iron filings was beneficial to their growth.

The air carries, as spores or cysts, many iron organisms. This was demonstrated by sucking outside air through sterile culture flasks. Within five days cultures appeared, among which the curious Toxothrix, described by Molisch[1] from Japan, was conspicuous.

The natural occurrence of iron organisms around Stanford University seems to be related to aeration of deep waters, either through cracks in a reservoir dam or from deep wells and springs. In the former case aeration of the hydrotroilite black mud, containing large amounts of $(FeS)_x\ (H_2O)_y$ causes a formation of H_2S, while the oxidation of ferrous iron goes parallel with a noticeable acidification of the aerated water (pH changes from 7.6 – 6.8).

[1] Molisch, H., Rep. Imp. Tohoku. Univ. Japan Series I. 2, 1925.

The reactions involved are either

$$4FeCO_3 + 6H_2O + O_2 = 4Fe(OH)_3 + 4CO_2$$
$$4Fe(HCO_3)_2 + 2H_2O + O_2 = 4Fe(OH)_3 + 8CO_2$$

As soon as the pH drops below 7 the black suspended hydrated pyritite will begin to decompose.

It was at first thought that this fairly acid medium constituted the normal environment for the organisms. This view seemed to derive support from the observation that Fe^{+++} becomes soluble at pH <5 while Fe^{++} becomes soluble around pH <6.2. This fact was checked with various organic and inorganic salts with fairly consistent results. The availability of Fe^{++} for the alleged autotrophonts would be of course greater at a lower pH.

However, cultures were very successful up to pH = 9.2 with an optimum activity around pH = 8.6. Here less than one part of Fe^{++} in 5×10^6 water was present, as checked by colorimetric determination. Therefore, if the organism is able to use iron in its metabolism, it has to lower the pH locally so as to make it soluble.

A series of experiments was carried out in which the increase in weight of infected and sterile iron media (c.p. iron filings, Cu-free, in tapwater) was established. It appeared that no acceleration of the oxidation in the infected media could be observed in an eighteen-day run, although cultures developed normally. Our microscopic findings check Cholodny's work.[2] We observed, however, that the terminal organism may swarm, sometimes over a rather large area. It will settle down and begin to form a new stalk, which may be independent or become attached to the old stalk when the excreted mass increases. The terminal organisms are very small ($.8 \times .5\,\mu$). Directly below the terminal cell the stalk is non-incrustated. Incrustation starts in patches, hardly ever gradual.

Both Molisch and Cholodny deny the presence of a core in the sheath and claim that the entire Gallionella is soluble in "dilute" acids. Unfortunately, the H^+ concentration of their solutions is not mentioned in their papers.

It was soon found that by using various acids of a pH close to 5 (acetic, lactic, citric, butyric, tartaric) the sheath will dissolve, leaving a thin glistening core. We believe that Cholodny's comparison of the Gallionella group with certain flagellates (Anthophysa, Phalansterium, Spongomonas, Rhipidodendron) is a significant one.

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[2] Cholodny, N., Die Eisenbakterien. Jena. Gustav Fischer, 1925.