BOTANY

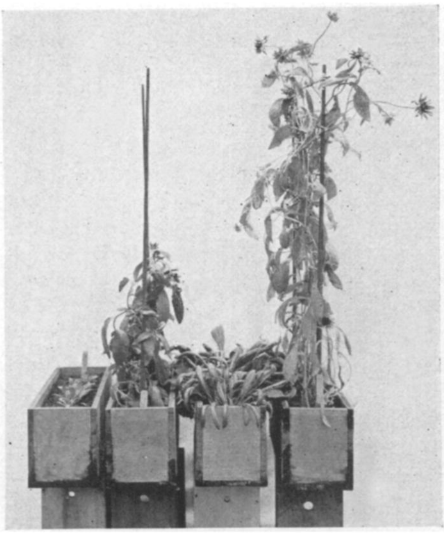
Plants and the Spectrum

"A Classic of Science"

Yellow Light Is Most Favorable to Plant Growth As Shown by Sachs, Whose Centenary Occurs This Year

LECTURES ON THE PHYSIOLOGY OF PLANTS, by Julius von Sachs, translated by H. Marshall Ward. Oxford, Clarendon Press, M DCCC LXXXVII (1887).

ALL THE RELATIONS between the organs of assimilation and light here mentioned, as well as the independence of growth with regard to the latter, must be carefully observed, if the important fact that the decomposition of carbon dioxide and assimilation in the chlorophyll are a function of light is to be properly understood. It follows from what has been said, that not light of any haphazard intensity will do what is necessary. Unfortunately we lack photometric methods to enable us to distinguish those intensities of light which come into consideration in assimilation with the same precision, and generally intelligible exactness, as is possible with the thermometer with respect to temperature. The most exact photometric methods, and especially the method proposed by Bunsen, for instance, only gives us information as to the intensity of the strongly refractive rays of light, the so-called chemical rays; but these, as I shall show subsequently, only come incidentally into consideration. We must therefore adopt entirely different methods with respect to statements concerning the intensity of light necessary for assimilation, and which will not be here given in detail. Only so much is obvious, that, for the decision of certain questions, use may be made of the law that with double the distance of a surface from a luminous point, the intensity of illumination of the latter sinks to one-quarter; at three times the distance to one-ninth, etc.; and that the intensity of illumination of a leaf-surface at the same time depends upon the sine of the angle of incidence. It would cost us too much time, and would moreover lead to no satisfactory result in the end, to enter more in detail into these matters. It must therefore suffice, that assimilation by means of the decomposition of carbon dioxide, in most plants, and especially in the case of meadow and cultivated plants, trees, and garden-plants of the most various kinds, only takes place with normal vigour and productiveness when the ordinary strong daylight of summer is at the disposal of the plants. The much feebler light in greenhouses, or even in ordinary dwelling-rooms, suffices, it is true, with most plants to bring about a less productive assimilation in the green leaves; but the sickliness of the plant shows how feeble is the nutrition under such circumstances. It is also to be observed that a pot plant standing close to a window, under the best of circumstances only receives the light radiating from half the sky, and only meets with the direct rays of the sun occasionally. If the plant stands somewhat further removed from the window, it is only necessary to imagine straight lines running from the plant or a leaf to the edges of the window, and thence direct to the sky, to find the extent of that part of the latter the rays of which fall directly on the leaves: it is then perceived that a plant removed but a few metres from the window, only receives a very small proportion of light from the sky, and as a rule meets with no direct sunlight at all. Accordingly, the nutrition of plants in the middle of a room is extremely poor, and sooner or later they inevitably perish. On the other hand, however, it is also to be observed that while there are many plants which only flourish well in places which receive the full light from the sky, and the direct rays of the sun, others exist which prefer the shade of woods, or even the feeble illumination in the interior of deep caverns. Here belong, for example, besides some species of *Pyrola,* many Mosses, and especially Liverworts; those Algae which grow exclusively in the depths of large seas, and are thus feebly illuminated, also show that they find the conditions of their existence in less intense light. Just as for each manifestation of life in plants there is an upper limit of temperature, which cannot be passed over without injury, so also there is certainly an upper limit of intensity of the light, at which the chlorophyll-grain can no longer accomplish assimilation. Of course this limit of the intensity of light cannot be exactly given, in the absence of suitable photometric methods; and when Pringsheim makes circumstantial statements concerning the behaviour of cells containing chlorophyll in the focus of a lens, or in the sun's image, as he terms it, these purely pathological processes have about as much physiological value as if, for any reason whatever, a so-called sun's image were allowed to act on the retina of the eye through a burning-glass. Much better are the statements of several observers who, employing direct light, allowed the evolution of oxygen of one and the same plant to take place under various degrees of shading, and so established that a maximum effect at a light-optimum exists for this function also. In the absence of photometric measurements of general value however, I pass over these statements also.



U. S. Dept. of Agriculture

GREEN LIGHT, STOP!

The two plants on the left grew under blue-green light for different lengths of time. The two at the right spent the same amounts of time under yellow-green light.

We have much more information as to the various effects of the individual constituents of sunlight, than with respect to the cardinal points of the intensity of the light concerned in assimilation. As is well known, the light of the sun, like that of most incandescent bodies, is a mixture of very different luminous rays, which are distinguished by their refrangibility, *i. e.,* by the amount of divergence which they undergo on entering another medium, as well as by their chemical effects; and obviously the question must force itself upon the investigator whether, and in what manner these different rays of light, of which daylight is made up, influence assimilation in the chlorophyll. For the preliminary guidance of those not quite familiar with the physical knowledge appertaining here, the following remarks may be made. If the sun's rays are allowed to fall through a narrow slit in the shutter of a room, they proceed through space in the form of a straight band, which can easily be seen as luminous striae in the dusty air: if these luminous striae or bundles of rays are allowed to pass through a triangular glass prism, the edges of which we suppose vertical, two results follow. First, the ray of light is diverted from its straight path—it falls on quite another spot on the hind wall of the chamber than was the case in the absence of the prism; and secondly, instead of the one bright stripe which the solar rays originally formed on the hind wall, there now appears a horizontal coloured band, the so-called solar spectrum, in which the colours of the rainbow, red, orange, yellow, green, blue, and violet, follow one another in such a way that the red portion is least, and the violet most strongly diverted from the rectilinear path of the beam of light. In this spectrum, by proper management, a number of black lines appear, running perpendicularly in the horizontal band of colours; these are the so-called Fraunhofer's lines, which, as Kirchoff and Bunsen have shown, are produced by the absorption of certain rays of light by the incandescent vapours of certain metals in the solar atmosphere. From these fixed lines in the solar spectrum, the most evident of which are distinguished by the letters *A, B, C.—H,* it is possible to determine exactly the place where definite effects occur. The refrangibility and colour of the different parts of the spectrum are a consequence, as the science of optics teaches, of the different wave-lengths in the vibrations of the luminous æther, of which the light consists.

If now the solar rays, passing through the slit, are allowed to traverse a glass vessel with parallel walls containing a dark blue solution of ammoniacal oxide of copper, the whole of the red and yellow, and part of the green bands in the spectrum disappear; the blue solution has absorbed, kept back, or destroyed these constituents of the sun-light. If a vessel with a concentrated solution of bi-chromate of potash, which appears to our eyes of a deep orange colour, is placed at the same spot, just those parts of the spectrum are cancelled which previously passed through the blue solution—*i. e.,* we now see in the spectrum the red-orange, yellow, and a part of the green, while the blue and violet have disappeared. We have thus in these two fluids excellent means for cutting out the one or the other half of the solar light; and we can therefore, with the aid of these two solutions, experimentally answer the question, what effect does the red-yellow or the blue-violet half of the spectrum respectively exert in the decomposition of carbon dioxide? After the preliminary and less instructive researches of Daubeny (1836), I made in 1864 a detailed investigation with regard to this question. In a glass cylinder filled with water containing carbon dioxide a water-plant was placed; at the cut surface of the stem of this the oxygen evolved under the influence of light escaped regularly in the form of bubbles. This cylinder was placed in a second, wider cylinder, and the space between both filled with one or other of the solutions previously mentioned, or with pure water. After careful consideration and preparation, I employed as a measure of the decomposition of carbon dioxide in the plant, the number of bubbles which escaped from the cut surface of the stem in one minute. It was now possible to conduct the investigations in such a manner that the plant could be observed alternately for one minute respectively in white complete light, in red-yellow, or in blue-violet light, one immediately after the other, and the gas-bubbles counted. It turned out that in the blue-violet light only very little carbon dioxide was decomposed, while (having regard to accessory circumstances) the effect in red-yellow light was nearly as strong as in the full light which passed through pure water. This result, as well as the observations previously made by Daubeny, Draper (1844), Cloez and Gratiolet (1851), contradicted the prevailing view of the physicists and chemists, that it is the blue-violet part of the spectrum which almost alone brings about photo-chemical effects. The decomposition of carbon dioxide in the plant evidently depends upon a photo-chemical effect; and yet we here see that that portion of the spectrum which is distinguished by physicists as the one chemically effective, is relatively inactive, while the other half of the spectrum is here the effective one. I directly confirmed this apparent contradiction again, by placing in the upper part of the glass cylinder containing the plant a small apparatus which enabled me, while observing the separation of oxygen, simultaneously to observe the effect of the coloured light on photographic paper. When the light passed through the blue-violet solution, the *(Please turn page)*

ENGINEERING

New Orleans Better Able To Pump From Under Water

RAIN that falls in New Orleans must be pumped out.

Because the city is below ocean and river level, New Orleans has always been pumping itself from under rain water. For years her pumping installations have been described in the superlative. And now their capacity has been made even larger.

The increase in size became necessary because during the past five years all previous precipitation records were exceeded, George C. Earl, civil engineer of this city, explains in the current issue of *Civil Engineering.* The present system will in one day remove 14 inches of water covering the entire city. It cost roughly $1,400,000 per inch of capacity and when all necessary canals are completed this figure will be increased to at least $2,000,000 per inch.

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evolution of oxygen in the plant was extremely small, while the photographic paper became deep brown; when, on the other hand, the red-yellow solution was interposed, the plant evolved large quantities of oxygen, while the photographic paper reacted but little and feebly.

It may here simply be remarked that it was an inaccurate generalisation on the part of physics and chemistry to designate the blue-violet portion of the spectrum as the part chemically active, simply because the corresponding rays of light cause silver salts to decompose and a mixture of chlorine and hydrogen to form hydrochloric acid. The action of the red-yellow light on the decomposition of carbon dioxide which we have established contradicts no fact, but only a false generalisation; since it shows that other chemical processes which take place in the chlorophyll are brought about by other rays of light, namely the red-yellow.

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PSYCHIATRY

Most Patients Recover From Quick-Striking Mental Disease

A NEW TYPE of mental disease in which the outbreak is sudden and dramatic but in which the patient has a good chance for recovery was described by Dr. J. Kasanin, clinical director of the Rhode Island State Hospital for Mental Diseases, at the meeting of the American Psychiatric Association in Philadelphia.

The nine patients in whom Dr. Kasanin studied this disease were young people, in the twenties and thirties. They had all been well adjusted in their social lives and at their jobs. They were of average or superior intelligence, keenly interested in life and its opportunities, and ambitious to get the most they could out of it. Their personalities before the mental breakdown were not very different from the general run of people in the community. Some were sociable and others were seclusive. They considered themselves very sensitive and self-critical, unhappy and preoccupied with their own problems, but this was not apparent to anyone else. Some of them had suffered mental or nervous breakdown during their teens but had recovered.

Suddenly, as a result of some definite emotional or mental conflict with their environment, these apparently well-adjusted persons "blew up" in a dramatic disorder, Dr. Kasanin reported. But unlike many mentally ill persons, they did not remain passive, nor seem to accept the mental breakdown in a hopeless way. Instead they went through it as an extremely severe emotional experience, and after a few weeks or months of treatment, they recovered. Dr. Kasanin ascribed their recovery partly to the treatment, partly to their previous good adjustment to life, and partly to the fact that they were not ill long enough for their thought processes to disintegrate.

When he first saw these patients, their ailment had been diagnosed as the form of mental disease called dementia praecox. However, he did not think their symptoms exactly fitted the picture of that ailment, nor did they seem to fit any of the other classifications of mental disease. Consequently he believes that they are suffering from a somewhat different form of mental disorder.

The outlook for these patients is distinctly hopeful, in Dr. Kasanin's opinion. He recommended psychiatric treatment and thorough psychoanalysis in order to prevent recurrence.

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