tremely able man and that his book contains a great deal of valuable information. The mere fact that it has been through seven German editions is proof in itself that people read it. There is a fine sound to the subdivisions of the book: the universal properties of matter; atom and molecule; the transformation of matter; the transformation of energy. What could be better than this? When a man sandwiches a chapter on colloidal solutions in between one on radioactivity and one on the absolute size of the molecules, one is almost tempted to forgive him for talking about the enormous molecular weights of substances in the colloidal state. In a great many chapters what Nernst has to say is very well worth while and of course it is not fair to read the parts on colloid chemistry, photochemistry, and flame spectra in the light of what one now knows. It is possibly the war, though I think not; but the whole tone of Nernst's book grates on one, perhaps more when it is presented in English than when one reads it in German. The contrast between this book and van't Hoff's Lectures is very striking.

The translation is very much better done than has been the case in most of the previous English editions. Either the translator or the proofreader has been very careless, however, in regard to proper names, many of which are misspelled.

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## SPECIAL ARTICLES

### THE MEASUREMENT OF LIGHT IN SOME OF ITS MORE IMPORTANT PHYSIOLOGICAL ASPECTS

The principal relations of light to organisms include the following phases of its action:

1. Photosynthesis, in which specialized protoplastic masses containing chlorophyll elaborate carbohydrates from carbon dioxide and water. The well-known absorption bands of chlorophyll in the red and in the blue are taken to indicate the portions of the spectrum concerned in this action.

2. Influence of illumination on transpiration and water content. It is probable that the red end of the spectrum chiefly furnishes the wave-lengths which cause changes in temperature, and variations in water loss.

3. Influence of illumination on the respiration and other metabolic processes in protoplasm as induced by the photolysis of substances important to the life of the organism.

4. Coagulatory, neutralizing or disintegrating action of light or toxic effect of products, especially of the shorter wave-lengths, on living matter as exemplified by the fatal effects of blue-violet rays on minute organisms.

5. Tropistic reactions, in which the position of the axes or of the entire body is changed in response to direction or intensity of the rays and with respect to special wave-lengths. Various parts of the spectrum may be active in different organisms.

6. The indirect action of light on rate, course and amount of growth, together with morphogenic reactions. Such effects have not yet been analyzed to an extent which might furnish data for a rational discussion of the direct effects of light on growth. Indirect effects are recognizable.

7. Action of light on environic conditions exemplified in the ionization of the air by the shorter wave-lengths as described by Spoehr.

Experimentation upon any of these subjects requires sources of light under good control, screens for transmitting special regions of the spectrum and methods of measurement of the relative intensity of the illumination falling on the organism.

Sunlight may serve in some work when the requisite screens are available, but incandescent filaments, mercury and amalgam vapor arcs enclosed in glass or in quartz may be used as sources of light down to wave-lengths of .28 $\mu$.

Layers of liquid, pigments in gelatine and other perishable screens have served admirably in some demonstration and research work, but when long-continued exposures to intensities approaching those of normal sunlight are desired a durable screen is necessary. A series of formulæ for a number of glasses which would transmit various parts of the spectrum has been developed in the laboratory of a prominent firm of glass-makers. These may now be obtained in stamped plates $6\frac{1}{2} \times 6\frac{1}{2}$ inches.

A brief characterization of a few of these is given below:

*Red:* High transmission in red removes all light below .61 $\mu$.

*Blue:* Transmits only blue below .52 $\mu$ and may be made deeper to transmit only below .50 $\mu$.

*Yellow:* High transmission in red and infra-red and through green to .48 $\mu$ giving about 75 per cent. of incident white light. All ultra-violet absorbed.

*Uviol:* Transparent to visible spectrum, transmitting ultra-violet to .31 $\mu$ in sheets $\frac{1}{4}$ inch thick, to 30 $\mu$ through $\frac{1}{8}$ inch thick.

*Heat-Absorbing:* Absorbs most of infra-red and 97 per cent. of heat of Nernst lamp—gives a pyrheliometer reading about half that of good window glass. Transmits 65 per cent. of incident white light.

Formulæ of twenty other glasses are available by the use of which the regions of the spectrum noted above may be modified or different separations made. Desirable effects may also be obtained by combination of two screens. Thus for instance light passing through a yellow of the type described above and the heat absorbing glass loses all the spectrum except the yellow and a small part of the red.

The only thoroughly reliable measurements of solar radiation available to the biologist are those made with the Ångström and Abbot type of pyrheliometer which recorded the total normal insolation in heat units. However, in the blue-violet region of the spectrum, which is of especial interest to the biologist, this type of instrument is not sufficiently sensitive. It is therefore proposed to use the *photo-electric cell* as developed by Elster and Geitel. This instrument has the great advantages of extreme sensitiveness in the blue-violet region and ease of manipulation; it records immediate and directly proportional values, and can be used for extensive ranges of intensities.

A comparison of the results to be obtained by the use of the two methods is afforded by the data given below. Direct sunlight at the Desert Laboratory is taken as 100, and the figures in both cases are percentages of this total. The values from the pyrheliometer were calculated in calories per sq. cm. per minute, and those of the sodium photo-electric cell are from readings of the high sensitvity galvanometer.

| Illumination | Proportion of Direct Sunlight (Sunlight = 1.39 Calories per Sq. Cm. per Minute) | |
|---|---|---|
| | Smithsonian Pyrheliometer Values | Sodium Cell Values |
| Direct sunlight at ..... | 100% | 100% |
| Transmission— | | |
| Uviol glass ......... | 90.2% | 86.6% |
| Yellow glass ........ | 53.6% | 5.1% |
| Red glass .......... | 42.4% | 0.62% |
| Heat-absorbing glass. | 25.4% | 63.2% |
| Blue glass .......... | 10.5% | 49.0% |

These results show a total value of normal sunlight through *uviol* glass transmitting the entire spectrum not being widely different by the use of the two instruments, although the pyrheliometer values are derived from the longer wave-lengths and those of the sodium cell from the shorter ones.

It may be assumed that half of the total energy registered by the pyrheliometer is strictly within the red, which causes but little action in the sodium cell.

The pyrheliometer shows a total of nearly 54 per cent. of the energy of sunlight passing through the yellow screen which transmits from red to and including the blue-violet.

Perhaps the most interesting results are those which are obtained by measurement of light passed through the so-called heat-absorbing screen, which has been found to transmit the visible spectrum except the longer red and infra-red.

The pyrheliometer reading of such a glass is but 25 per cent. of clear sunlight, while the sodium cell records 63.2 per cent. of the total. A notable difference between the recording action of the two instruments in the blue is also evident. It is self-evident that the universal method of calibration of sunlight intensities by the pyrheliometer does not give results which are adequate or correct in all of the various aspects of the physiological effects of light.

Measurement of light from artificial sources has been done chiefly by photometric methods, but it is to be pointed out that the results obtained in this manner are scarcely more adequate than those of the pyrheliometer.

The sodium cell connected with a suitable portable galvanometer offers many advantages for the measurement of light intensities in natural habitats, and a comparison should be made between it and the various photometers and illuminometers which are now being recommended to the forestry student and the ecologist. It seems highly probable that more exact measurements in the blue-violet region so important in photolysis and phototropism will yield information by which some of the current discordant results may be harmonized. In any case the action of the photoelectric cell in light is more nearly parallel to that of the organism than that of any other light measuring instruments hitherto available.

We are indebted to Professor Jacob Kunz, of the University of Illinois, who has very kindly constructed some cells to meet our particular needs and whose advice has been most helpful in the application of this instrument to physiological uses.

D. T. MacDougal,
H. A. Spoehr

Desert Laboratory,
Tucson, Arizona,
March 30, 1917

## SOCIETIES AND ACADEMIES

### THE BIOLOGICAL SOCIETY OF WASHINGTON

The 569th regular meeting of the society was held in the Assembly Hall of the Cosmos Club, Saturday, April 7, 1917, called to order at 8 P.M. by President Hay with 45 persons in attendance.

Under the heading brief notes and exhibition of specimens Dr. R. W. Shufeldt exhibited lantern slides of living California quail, calling attention to their rapidly diminishing numbers. Dr. L. O. Howard called attention to the cocoon of a *Cecropia* moth containing moon-stones that had lately come to his notice. He expressed the opinion that they had been placed there by a thieving crow or bluejay. Mr. A. Wetmore stated in this connection that he had seen bluejays insert small acorns and kernels of corn into large cocoons.

The regular program consisted of two communications:

*A Note on the Hibernation of the Mud-turtle:* Alexander Wetmore and Francis Harper.

The authors reported finding a specimen of *Kinosternon pennsylvanicum* shortly after it had left its underground winter-quarters. The hole from which it had emerged was beneath a dense growth of green-briar in an old field and about fifty yards from the nearest marsh. The burrow was 9½ inches deep, and was open save at the lower end, where the animal had apparently lain encased in a mass of mud. The actions and conditions of the turtle after being placed in water were described in detail, and an account of a post-mortem examination of the viscera was given. Messrs. W. P. Hay, M. W. Lyon, Jr., and Wm. Palmer took part in the discussion.

*Botanizing in the Hawaiian Islands:* A. S. Hitchcock.

The speaker visited the Hawaiian Islands during five months of 1917. He said the trade winds deposit their moisture upon the eastern and northern mountains of all the islands, furnishing the conditions for rain forests in these regions. The lee side of the islands is dry even to aridity. An interesting feature of the wet areas at or near the summit of the ridges are the open bogs. These bogs are devoid of trees and large shrubs, but contain a variety of low shrubs and herbaceous plants. Many species form tussocks, or hemispherical masses raised above the level of the bog. The most conspicuous of the tussocks is made by a sedge (*Oreobolus furcatus* Mann.). Three peculiar species of *Panicum* are tussock-formers (*Panicum monticola* Hillebr., *P. imbricatum* Hillebr. and *P. isachnoides* Munro). Owing to the extreme isolation of the islands the flora is peculiar and interesting. The family Lobeliaceæ is represented by about 100 species, belonging to about 6 genera. Many species are arboreous, forming trunks ten to twenty feet, or in a few cases as much as forty feet high. The crown of foliage gives the aspect of a palm. The grasses, disregarding the introduced species, are not numerous, but several are peculiar. The genus *Eragrostis* is represented by numerous species. A rare species of *Poa* (*Poa siphonoglossa* Hack.) produces leafless rushlike stems, as much as fifteen feet long. His talk was illustrated by maps, botanical specimens and numerous lantern-slide views of various features of the islands.

M. W. Lyon, Jr.,
*Recording Secretary*