new ideas by leaders of industry. The war destroyed much of the crippling conservatism which had hitherto hampered development. The outcome is to be seen in more scientific organization and production in factory and workshop. Probably no movement has been of greater value to industry than the setting up of research associations in 1918, 1919 and 1920 under the government's scheme for industrial research and the consequent growth of cooperation and team work in dealing with problems common to the methods and processes of the various trades. The report shows that many of these problems are incapable of solution by one branch of science alone, and consequently it is essential that there should be increasing cooperation between chemists and physicists, biologists and engineers. An interesting instance of cooperation with medical research is seen in the financial help given to the Medical Research Council, accompanied by expert assistance from the Engineering Research Board, to enable the council to investigate problems of machine design in relation to the comfort and efficiency of the operator. Employers are only now beginning to understand how greatly industrial contentment, efficiency and output can be increased by comfort in manipulation and adequate light and ventilation in the factory.

There is need also to educate public opinion in regard to the value of research in the domain of national health, and the work of the Fuel Research Board in this direction should receive more general recognition. The Gas Regulation Act of 1920, which was based on the work of the board, has already led to substantial savings. The physical and chemical survey of the national coal resources, the research in carbonization and in by-products, the possible modification of the blast furnace are all likely to have important bearing on the prevention of waste and the diminution of the smoke evil. Public opinion, however, must press for proper fuel control in industrial works; "without it," says the report, "the advantages of better fuel which research may provide would be largely nugatory."—*Educational Supplement of the London Times.*

SCIENTIFIC BOOKS

The Physiology of Photosynthesis. By SIR JAGADIS CHUNDER BOSE. Longmans, Green and Co., New York, 1924; VII—287 pp., with 60 illustrations.

THE work under review comprises twenty-eight short chapters on about as many separate problems of the phenomenon of photosynthesis. The author confines himself largely to a description of apparatus and experiments of his own design and the results he has obtained therewith. The experiments were carried out with the water plant, *Hydrilla verticilla,* and the evolution of oxygen from the plant during illumination was taken as a measure of the rate of photosynthesis. As has been known for a long time, the gas which is emitted from an illuminated plant is not composed of pure oxygen but contains varying amounts of nitrogen and carbon dioxide. In order to avoid this source of error in the determination of photosynthetic activity by the volume of oxygen emitted, the author, in one of the methods described, removes the nitrogen from the water and the plant by placing these under a vacuum at the beginning of the experiment. It is stated that under these conditions pure oxygen is evolved in the light. Another familiar error in the bubble-counting method is due to the variation in the volume of the bubbles. This error the author has endeavored to remove by the use of a device which collects a definite volume of gas; a slight increase in the pressure of the gas causes its release, which is recorded on a revolving drum. By means of this apparatus, which was also elaborated into an automatic recorder of photosynthesis, a variety of factors which influence the rate of photosynthesis were studied.

In the results obtained on the relation between light intensity and photosynthetic activity no new contributions are made. Thus it is concluded (p. 48) that "Taking all factors into account, we find that *the activity of photosynthesis is proportional to the quantity of incident light.*" It is most unfortunate that absolutely no regard should have been taken of the mass of valuable information which has accumulated during the past twenty-five years on this and many other phases of the photosynthesis problem. In the arrangement of the experiments and in the interpretation of the results obtained the facts which led to the formulation of the theory of limiting factors are entirely disregarded, nor is there any consideration of the conclusions of other recent workers in the field, such as Harder and Lubimenko. The result of this general neglect in endeavoring to coordinate the observations recorded with the body of existing knowledge in photosynthesis is a most unsatisfactory one. Many of the phases of the photosynthesis problems are touched upon; none of them have been subjected to a thorough investigation. There are many interesting observations recorded, but their bearing is not certain because either they are purely unconnected or incomplete.

Interesting are the results of traces of iodine, formaldehyde and nitric acid on the photosynthetic activity. It was found that minute traces of these substances accelerate the activity enormously. Less fortunate are the author's conceptions of the "period of photosynthetic induction" and "photic stress"; the phenomena observed have been fully discussed some years ago by Kniep and others. Chapters XIII and XIV describe an ingenious self-recording radiograph and a portable photometer which make use of the selenium cell as the light sensitive element.

The question of the influence of CO_2-concentration on the rate of photosynthesis has received much attention during the past ten years. It is of particular importance on account of its bearing on Blackman's theory of limiting factors. That the curve of photosynthetic activity with varying concentration of CO_2 and constant light intensity exhibits no sharp turn but is rather approximately a logarithmic one was indicated by the results of Boysen-Jensen (1917), Willstaetter (1918), Warburg (1919), Harder (1921). Bose also concludes: "My results show that the top of the photosynthetic curve rounds off gradually after the turning-point, and is never abruptly horizontal . . ." Only one light intensity was used; had similar experiments been carried out with a variety of light intensities they would have constituted a valuable test of Harder's conception of limiting factors. An attempt is also made to determine the oxygen-carbohydrate factor, a ratio between the weight of oxygen emitted and that of carbohydrate elaborated during photosynthesis. On the basis of the chemical equation commonly assumed to represent the photosynthetic reaction: $6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$ this ratio would be $\frac{C_6H_{12}O_6}{6O_2} = \frac{180}{192} = 0.9375$. The author measured the gas emitted and determined the increase in weight during a definite period of photosynthetic activity. He comes to the conclusion that the oxygen-carbohydrate factor is 0.8906 or 5 per cent. less than the theoretical value. This is called the normal value. In specimens which previously had been exposed to strong light the factor was 0.91, in those exposed to semi-darkness 0.87. The explanation for these discrepancies is sought in the possibility that other carbohydrates besides those having a molecular weight of 180 are elaborated. Apparently the fact, clearly established by Kniep, was lost sight of: that the gas evolved in photosynthesis is not pure oxygen, the composition varying with the rate of gas evolution. Analyses of the gas were not made nor were precautions taken to avoid admixture of other gases. The low value of the $\frac{\text{carbohydrate}}{\text{oxygen}}$ ratio is in all probability due to the fact that the gas collected was not pure oxygen. Furthermore, under conditions of high light intensity (more active photosynthesis) the proportion of oxygen in the emitted gas is high, which accounts for the relatively high value of the carbohydrate-oxygen factor found; while under low light intensity the proportion of oxygen is low, which would result in a correspondingly low factor by the methods employed.

It is undoubtedly true that physiology is more than applied physics and chemistry; yet in endeavoring to ascribe to every effect a discernible cause in a quantitative as well as qualitative sense, it is doubtful whether physiology can find, for the present, more valuable methods and conceptions than are offered by physics and chemistry. This is especially true in the subject of photosynthesis, for which the exact sciences have made available most valuable information during the past few years, and it is only through the application and elaboration of these conceptions that we can hope for a true physiology of photosynthesis.

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LABORATORY APPARATUS AND METHODS

INSTANTANEOUS PHOTOMICROGRAPHY OF THE SKIN CAPILLARIES IN THE LIVING HUMAN BODY

LOMBARD,[1] in 1911, showed that certain capillaries in the human body could be rendered visible under the microscope by adequate illumination. Dr. Mueller and his pupils have extended the usefulness of this method in clinical medicine. Professor Krogh,[2] of the University of Copenhagen, and his colleagues have made very elaborate studies on the anatomy and physiology of capillary circulation. For several years past, Drs. G. E. Brown[3] and H. Z. Giffin[4] and others, of the Medical Research Laboratories of the Mayo Clinic, have been making extensive quantitative clinical studies of the capillaries, as to sizes and blood circulation, both in normal and disease conditions.

In the microscopic study of the physiology of capillaries, the general method of procedure has been to observe visually by the aid of the microscope the changes taking place and the reactions to various experimental procedures. However, no documentary evidence of these observations by means of photographic records has been, in general, possible and, so far as we know, no such documentary evidence exists in the various studies on the capillaries of the living human body. Krogh[5] and others have suc-

[1] Lombard, *American Journal of Physiology*, Vol. xxix, 335, 1911–12.

[2] Krogh, "The Anatomy and Physiology of the Capillaries," New Haven, 1922.

[3] Brown, *American Annals of Clinical Medicine*, Vol. 1, 69, 1922.

[4] Brown and Giffin, *American Journal of Medical Sciences*, Vol. 166, 489, 1923.

[5] Krogh and Rehberg, *American Journal of Physiology*, Vol. lxviii, 153, 1924.