sessions, and members, other than past-presidents, officers and committee chairmen, are requested not to attend the business meetings. Hotel reservations should be made direct with the Hotel Statler, Buffalo, N. Y.

THE Minnesota Chapter of the American-Soviet Medical Society held a symposium on February 15 on the "Development of the Blood Bank." Professor Maurice B. Visscher, of the department of physiology of the University of Minnesota, presided and introduced the discussion with a review of the work on the utilization of cadaver blood in the U.S.S.R. and the organization of the first blood bank in the United States. Dr. E. B. Flink discussed the problems of transfusion reactions. Speakers included Dr. D. State, Dr. S. A. Corson, Dr. D. A. Needham, Captain J. Mehlman and Lieutenant Commander J. W. Edwards. The proceedings will be published in the next issue of the *Bulletin* of the Minnesota Medical Foundation.

IT is planned to erect at the cost of $1,500,000 a new building for the Medical and Dental Schools of Loyola University, Chicago. Science laboratories, lecture halls, student commons and faculty lounges will be arranged so that they may be used both by the medical and dental schools. It is hoped that the plan will encourage cooperation between the professors of medicine and dentistry.

DISCUSSION

ANAEROBIC RESPIRATION OR FERMENTATION

SEIFRIZ[1] has argued in SCIENCE for the use of the term "respiration" for all forms of energy liberation in living cells and for the retention of the term "anaerobic respiration" for energy liberation in the absence of oxygen. Our attention should be directed to the concepts involved with full recognition that terms are but useful symbols. However, confusion concerning terms may lead to confusion in ideas.

Several patterns of biological energy liberation may be recognized:

(1) Oxidation of organic compounds with the simultaneous reduction of molecular oxygen to water. The oxidation may be complete, with all the carbon converted to CO_2, or it may be incomplete with the formation of organic acids as end products. This type of oxidation is known to most cellular physiologists as respiration or cellular respiration.

(2) Oxidation of inorganic compounds and the reduction of oxygen to water, such as the oxidation of ammonia to nitrites, nitrites to nitrates, etc., in chemosynthetic bacteria. No suitable term for this "inorganic respiration" has been proposed.

(3) Degradation of an organic molecule into two or more simpler molecules by an oxidation and reduction occurring within the original molecules or its products. This is illustrated by the conversion of glycogen or glucose into lactic acid (glycolysis) or into alcohol and CO_2 (alcoholic fermentation), etc. This type of mechanism does not require molecular oxygen, and may or may not be suppressed by molecular oxygen. It is known as fermentation, intramolecular respiration or anaerobic respiration.

(4) Oxidation of organic compounds with the simultaneous reduction of carbon dioxide, nitrates or nitrites, or sulfates. This type of reaction has been particularly studied by Barker.[2] It is included by some under the name of fermentation, but probably needs a distinct term.

There are several features common to all these types of metabolism, and two or more types may occur in the same cell, even simultaneously. We may use the term respiration in a generic sense to include all metabolic processes liberating energy (occurring with a free energy decrease) and have specific names for the different types of respiration, such as aerobic respiration for types 1 and 2, and anaerobic respiration for types 3 and 4, or we may use respiration for metabolism involving oxygen consumption and use fermentation for metabolism of type 3 and perhaps 4.

The writer objects to anaerobic respiration, because it implies a type of metabolism that only occurs in the absence of molecular oxygen. However, it is well recognized that in some tumors, contracting muscles, certain yeasts and some varieties of seeds, the pathway of carbohydrate degradation is fermentative, resulting in the accumulation of lactic acid, ethyl alcohol or other products, even when the tissues are exposed to oxygen. The terms aerobic and anaerobic glycolysis are widely used and aerobic and anaerobic fermentation are in frequent use. If we follow Seifriz we will be forced to discuss anaerobic respiration occurring aerobically!

A second objection to the use of anaerobic respiration is that it has led to a confusion of ideas particularly when the plant physiologist measures metabolism only by the carbon dioxide liberated, for in some cases the rate of carbon dioxide production is the same under aerobic and anaerobic conditions. Such an

[1] William Seifriz, SCIENCE, 101: 88–89, 1945.

[2] H. Albert Barker, *Ann. Rev. Biochem.*, 10: 555–586, 1941.

experimental result led in a manuscript submitted to the *American Journal of Botany* to the following statement, "The respiration was identical under aerobic and anaerobic conditions." In the experimental situation the anaerobic metabolism was almost certainly alcoholic fermentation, and if we examine the two equations we can see the errors in this statement:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O \quad \Delta F = -704 \text{ kg. cal.}$$

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 \quad \Delta F = -54 \text{ kg. cal.}$$

Since the rate of carbon dioxide production was equal in each case, 3 times as much glucose disappeared under anaerobic conditions, alcohol accumulated, and the rate of energy liberation was but 23 per cent. the aerobic rate. A common term, respiration, led the unwary into calling a difference in energy liberation of over 400 per cent. an identity!

There appears to be objection to the use of fermentation in reference to higher organisms because it has been used uncritically for the metabolism, regardless of its nature, occurring in certain micro-organisms. However, the term has a more precise meaning, as a type of metabolism without reference to the organism in which it occurs. That the later term is justified may be seen from historical considerations. Fermentation initially meant the effervescence of a gas, either in brewing or in a chemical reaction. Pasteur[3] recognized fermentation as a type of energy liberation occurring in certain micro-organisms, but he also recognized that ordinary oxygen consumption could occur in such organisms. Later he[4] broadened the term, fermentation, to include a type of metabolism regardless of the organism in which it was found. On page 267 (*loc. cit.*) he says, "We can even conceive that the fermentative character may belong to every organized form, to every animal and vegetable cell, on the sole condition that the chemico-vital acts of assimilation and excretion must be capable of taking place in that cell for a brief period . . . without the necessity . . . of atmospheric oxygen." On page 273 *et seq.* Pasteur says, "Our theory mentions that all cells become fermentative when their vital action is protracted in the absence of air, which are precisely the conditions that hold in the experiments on fruits immersed in carbon acid gas. The vital energy is not immediately suspended in their cells, . . . consequently, fermentation must result." There is thus excellent justification in the writings of Pasteur for fermentation as applied to higher plants and animals.

Respiration is a very old term in the medical literature, and it meant the inspiration and expiration of air. During the mid-nineteenth century the term was broadened to include the utilization of oxygen in cellular oxidations. This aspect has been well reviewed by Scheer.[5] Pfeffer[6] recognized that anaerobic metabolism occurred in higher plants, and he designated it by intramolecular respiration, though he clearly uses the term as equivalent with fermentation. The writer has been unable to locate the first use of anaerobic respiration, but the term has become widely adopted in our text-books of plant physiology. However, the author does not believe our texts are authorities to be blindly followed when their usage is less precise than that of many research workers in a particular field.

The writer believes we would do well to retain respiration for metabolism of type 1, above, and retain fermentation for type 3. If this is objectionable to some, intramolecular respiration is preferable to anaerobic respiration. Seifriz implies that those who disagree with him (and are unnamed) are not plant physiologists but physiological chemists. I do not see the relevance of Seifriz's classification of scientists to the subject under discussion. Further, Seifriz claims his views are those of plant physiologists, medical physiologists (are they to be denied the use of their term glycolysis?) and bacteriologists. At least one plant physiologist raises his voice in dissent.

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3 Louis Pasteur, *Ann. de Chimie et de Physique*, 3rd S. 58: 323, 1860.

4 Louis Pasteur, "Studies on Fermentation, The Diseases of Beer." Eng. ed. London, 1879.

5 B. F. Scheer, *Ann. Sci.*, 4: 295, 1939.

6 W. Pfeffer, *Landw. Jahr.*, I: 805, 1878.

"PHOTOPERIODISM" VERSUS "PHOTOPERIODICITY"[1]

BIOLOGISTS who have had occasion to refer to the literature on the influence of the length of the daylight period on living organisms have doubtless noticed that botanists refer to this phenomenon as "photoperiodism," while most zoologists use the term "photoperiodicity." Assuming that such synonymy is useless and confusing and that there is still a possibility of eliminating it in a field as new as this, it may be well to consider the origin, use and aptness of the two terms in an effort to reach some conclusion as to which of the two terms is preferable.

The term "photoperiodism" was not used by Garner and Allard[2] in their 1920 paper in which they announced the discovery of the influence of the length of the daylight period on the growth and reproduction of plants, but was used in a brief paper[3] which appeared in SCIENCE in 1922. In both this paper and the paper entitled "Further Studies in Photo-

1 Contribution No. 87 from the Science Divisions of the University of Houston.

2 W. W. Garner and H. A. Allard, *Jour. Agr. Res.*, 18: 553–606, 1920.

3 W. W. Garner and H. A. Allard, SCIENCE, 55: 582–583, 1922.