THE Horace H. Rackham Fund of the University of Michigan has made an annual gift of $10,000 to a new clinic for the study of rheumatism. Dean A. C. Furstenberg, of the Medical School, has appointed a committee to take charge of the work and has placed Dr. Richard H. Freyberg at its head. Other members are: Dr. Cyrus C. Sturgis, director of the department of internal medicine; Dr. Harley A. Haynes, director of the University Hospital, and Dr. Carl E. Badgley, of the department of surgery.

DISCUSSION

LIFE; A PHOTOCHEMICAL STEADY STATE

THE assumption that living systems obey the second law of thermodynamics is made, at least tacitly, by most biologists, but is occasionally questioned by physicists and chemists. There is a great amount of experimental evidence to support the assumption, and none that definitely opposes it. Thus all opposition is based on theoretical argument, and a brief reconsideration from such a standpoint seems justified.

Actually, the system to be studied is somewhat different from those ordinarily postulated for thermodynamic treatment. From an energetic point of view it is not correct to consider living organisms inclusively, as an isolated system limited to the surface of the earth; they should be treated as a coupled system including both the sun and the earth. The free energy used for virtually all life processes is derived from sunlight through the photosynthetic activity of plants, the free energy so obtained being spent by both plants and animals. The accumulation and expenditure of free energy appear to be virtually equal, so that the total process may be considered roughly as a photochemical steady state. The chemosynthetic organisms may be excluded from the picture as comprising only a very small part of the total energy exchange; they do not disobey the second law of thermodynamics.[1]

The difference in temperature between sun and earth makes it possible to convert the energy of sunlight into chemical energy. The sun may be assumed to be a black-body at 6000° K, the maximum radiation from which is emitted at the wave-length 4800 Å, according to Wien's displacement law: $T \times \lambda_{max} = 0.2884$ cm. deg., where T is the absolute temperature and λ_{max} the wave-length of maximum emission. The earth may be assumed to be a black-body at 288° K, whose maximum emission is at 100,000 Å. The quantum of energy is inversely proportional to the wave-length ($e \times hc/\lambda$, where e is the quantum, h is Planck's constant, c is the velocity of light and λ the wave-length), so that the energy of the quantum for 4800 Å is twenty times that for 100,000 Å, the values being, respectively, 3.9×10^{-12} and 2.0×10^{-13} ergs. Since the temperature of the earth is virtually constant, it must radiate the same quantity of energy which it receives from the sun, but the quanta radiated must be smaller and more numerous than those received. For the latter reason the energy radiated by the earth must be considered to be more random in character than that received from the sun, which allows for the capture of free energy by the plant in the course of degradation of energy from larger to smaller quanta. Considered more specifically, a great part of the quanta in sunlight are of magnitude sufficient to produce changes in the electron orbits of those molecules which absorb them, and thus to produce photochemical reactions, whereas the reradiated quanta are not of sufficient magnitude to bring about such changes. Since the quantum is directly absorbed by the molecule, photochemical reactions, unlike thermal reactions, may go with an increase of free energy. Opportunity for the efficient capture of the energy of sunlight is thus provided, and plants have developed appropriate mechanisms which accomplish this.

It seems, then, that the complexity of the living world, which has been the basis of most arguments against the application of the second law of thermodynamics to living organisms, is only made possible by processes for which the degradation of energy is obligatory; and that the energy exchange of the total system is not contrary to the second law of thermodynamics.

If life is considered as a photochemical steady state, it seems to offer no exception to the second law of thermodynamics, unless many photochemical reactions *in vitro* also constitute such exceptions. The problem of the maintenance of such a steady state offers less difficulties to a thermodynamic approach than the problem of the development of complex living systems through evolution from less complex systems. However, as the writer has pointed out elsewhere,[2,3] the latter problem may also be approached from such a standpoint.

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COAL IN GLACIO-FLUVIAL DEPOSITS IN OHIO

DURING an investigation of molding sands in the vicinity of New Philadelphia, Ohio, for the Mus-

[1] Baas-Becking and Parks, *Physiol. Rev.*, 7: 66, 1927.

[2] Blum, *American Naturalist*, 69: 354, 1935.

[3] Blum, *American Naturalist*. In press.

kingum Conservancy District, the writer discovered waterworn fragments of coal scattered throughout sand and silt sediments laid down during the ice-age. These deposits are located near the mouth of Conotton Creek between Dover and Mineral City, Ohio. Here an extensive area parallels the creek and is evidently a flood-plain deposit, below which the stream has cut its channel, forming a terrace. Excavations and boreholes indicate that the deposit is a series of water-laid beds, much of it apparently deposited in slack water. The material is mainly fine quartz sand and clay, the size of the grains and the proportion of sand and clay varying considerably. In these beds fragments and finely ground coal occur in such abundance as to render the sand unfit for foundry purposes. The coal is not scattered uniformly throughout the mass but seems to be more abundant at certain horizons. Some of the fragments are two inches long and appear to be waterworn. In some cases the smaller fragments are thoroughly weathered and break down readily to black powder. Some of the larger fragments are unweathered and angular. Since the deposits are extensive they must contain a large amount of coal. It is probable that the sands and silts are of glacial origin, although it is possible that they may be of post-glacial age. During the retreat of the ice-sheet from Ohio, the streams were doubtless flooded; slack-water conditions occurred and the fine sand and silt was laid down. The coal fragments evidently were eroded from veins No. 5, No. 6 and No. 7, which outcrop on the hillsides in the region.

According to Wilber Stout, state geologist of Ohio, fragments of coal are prominent in the deposits of molding sand and along the railroad east of the No. 2 brick plant of the Burton-Townsend Company at Zanesville, and small pieces of coal occur in the molding sand deposits in South Zanesville, worked by the Ayres Mineral Company. In fact, coal is present in some quantity in all these deposits. While engaged in field work the writer has observed small fragments of coal in glacial sand and gravel deposits in Holmes County, Ohio.

The same process is doubtless taking place to-day in southeastern Ohio, in the Appalachian Plateau and elsewhere, where the coal veins are being eroded and the material deposited by the streams in their channels and on their floodplains. The Susquehanna River in eastern Pennsylvania is an outstanding example. This stream and its tributaries, which drain the anthracite coal fields, have been carrying coal in the geologic past and the process to-day is very pronounced. During every heavy rain the swollen tributaries are black with coal-dust and mud eroded from the slack-coal deposits from the heaps of culm and waste from the mines. The fragments are rolled along the channel or float down stream and are ultimately deposited on the bottom of the Susquehanna, from which dredges remove the coal in large quantities.

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MAGNESIUM SULFATE VALUELESS AS A CONTROL FOR THE BEAN BEETLE

A RECENT article in SCIENCE[1] would indicate "that $MgSO_4$ used as a spray, in the proper concentration, constitutes an effective control for the Mexican bean beetle (*Epilachna varivestis* Muls.)." About ten years ago a report became current that magnesium sulfate, $MgSO_4 \cdot 7H_2O$ (Epsom salt) was satisfactory for the control of the Mexican bean beetle, and large quantities of it were sold in several southern states. Some tests were undertaken to determine the value of this material.

At Athens, Ohio, in 1928, a plot of beans was sprayed with magnesium sulfate in solution at the rate of 1 pound to 10 gallons of water, on August 9, August 17 and August 25. A number of other insecticides were used in the same experiment on plots in the same field. On September 5, to quote from original notes, referring to the plot treated with magnesium sulfate, "Bean foliage injured 20 per cent. to 95 per cent. (estimated), plot average 60 per cent., not distinguishable from the checks at ends of rows. Numerous pupae." In this field the plots treated with calcium arsenate and those treated with magnesium arsenate showed visible foliage injury by the bean beetle estimated at 1 to 2 per cent. In the same field the untreated check plots showed injury ranging from 40 to 70 per cent., with an average of 60 per cent.

Since it was thought that possibly a stronger concentration than that used in the initial test might be effective, another plot was included with a later experiment and the material was used at a concentration of 1 pound to 2½ gallons of water. The field of beans was beginning to show some injury by the Mexican bean beetle. On August 24, 1928, the plot was sprayed and received only one treatment. On September 5, to quote from original notes, referring to the magnesium sulfate plot, "Bean beetle injury to foliage 75 per cent. (estimated), as bad or worse than check aside plot." The untreated checks in this experiment were estimated to be injured by the beetle to the extent of 65 to 70 per cent., respectively, while the plot treated once with magnesium arsenate was injured to the extent of 15 per cent.

Recently this material was tested by R. A. Fulton in the Columbus, Ohio, laboratory of the Bureau of Entomology and Plant Quarantine. When bean foliage was treated with dosages 100 times as great as the

[1] "Magnesium Sulphate, a New Insecticide," SCIENCE, 85: 428, 1937.