SPECIAL ARTICLES

NEW MEASUREMENTS OF PLANETARY RADIATION

IN view of the fact that the popular press has not yet reached such a stage of reliability that one can turn to it for accurate information on scientific subjects this seems an appropriate time and place to record some of the results of our recent measurements on the radiation emitted by the major planets.

Continuing our measurements of 1922, by means of suitable transmission screens the planetary radiation, which consists of wave lengths of 8 to 14 μ, has been successfully separated into spectral components. In this manner it is possible to determine the shape of the spectral energy curve of that part of the planetary radiation which is transmitted by our atmosphere and thus form an estimate of the temperature of the planetary surface.

In the case of Mars, these radiometric measurements show that the equatorial zones are much warmer than the polar regions which emit practically no planetary radiation; the morning side of the planet is at a lower temperature than the afternoon side which has been exposed to the sun's rays for a longer time; the dark regions are at a higher temperature than the light ones, and a gradual rise in temperature of the surface of the southern hemisphere, where summer is now advancing, was recorded.

Tests were applied showing that there is an excess of incoming low-temperature radiation from the planet over the outgoing radiation from the radiometer receiver, which could not occur if the temperature of the effective radiating surface of Mars were at a lower temperature (15° C.) than the receiver.

A direct comparison was made of the spectral components (λ 8–12.5 μ and λ 12.5–5 μ) of the planetary radiation from Mars with similar measurements on the moon, which is commonly supposed to have a temperature of 50 to 100° C. or even higher. This with two other methods of comparison indicate that the temperature of Mars, under a noonday sun, is up to 20° C. or even higher.

In the case of Venus not only does the illuminated crescent show the presence of considerable planetary radiation, but the unilluminated part of the disk also emits a large amount of infra red rays. The planetary radiation (per unit surface) from the unilluminated part of the disk amounts to about 10 per cent. of the total radiation from the brightly illuminated crescent. This radiation is highly selective, the spectral component of wave lengths λ 8–12.5 μ being over 60 per cent. of the total planetary radiation measured.

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THE EXPERIMENTAL REVERSAL OF POLARITY IN PLANARIA

THE establishment of polarity is a universal and fundamental phenomenon among organisms, and since it must precede all further differentiation it is important to understand just what is the basis of polarity itself. Although polarity shows itself as a matter of visible structure, it is probably fundamentally a dynamic phenomenon, the visible polarity being the expression of the physiological activities of the individual; this expression should therefore be capable of reversal if the controlling activities are reversed. Polarity is most susceptible of analysis through regeneration experiments on simple, axiate forms such as Tubularia or Planaria, which have consequently been much used in its study. Both of these forms are definitely polarized along an axis, and this polarity ordinarily reappears in the regeneration of an isolated piece of the body.

Both Morgan[1] and Loeb[2] considered polarity as dependent upon definite organ-forming substances, Morgan postulating a gradation of hydranth-forming substance in the stem of a tubularian and Loeb a condition in the protoplasm "of the nature of a current (*e.g.*, of liquid) by which certain substances were carried through the stem." Mathews[3] reported differences of electrical potential between the anterior and posterior cut surfaces of a stem of hydroid and believed these differences to be due to unequal degrees of protoplasmic activity at different regions.

Child's gradient theory[4] regards polarity as an expression of a gradient along the polar axis. This gradient is susceptible of measurement as a gradation in rate of metabolism, in differences of electrical potential at different points along the axis, or in other ways. Miss Hyman[5] has shown that the anterior end of an isolated piece of a planarian, which is undergoing metabolism more rapidly than is the rest of the piece, is electronegative, galvanometrically, to the posterior end, where the rate is lower. There is a certain stimulation of metabolic activity as a result of cutting, and this, according to Miss Hyman, causes chemi-

[1] Morgan, T. H., 1905, "Polarity considered as a phenomenon of gradation of materials." *Jour. Expt. Zool.*, Vol. 2, p. 495.

[2] Loeb, J., 1906, "The Dynamics of Living Matter." Columbia University Press.

[3] Mathews, A. P., 1903, "Electrical polarity in the hydroids." *Am. Jour. Physiol.*, Vol. 8, p. 294.

[4] Child, C. M., 1915, "Individuality in Organisms." University of Chicago Press.

[5] Hyman, L. H., 1918, "Suggestions regarding the causes of bioelectric phenomena." SCIENCE, N. S., Vol. 48, p. 518.

cal changes which are directly responsible for the electropotential differences.

Child's experiments on planaria show that in a piece cut from that portion of the animal just posterior to the pharynx, the original polarity usually gains a new expression in regeneration, a new head appearing at the anterior end; the anterior end dominates the rest of the piece and the natural response of a dominant, undifferentiated region in a piece of planarian is the formation of a head. Polarity, however, may be altered, as is witnessed by all cases of heteromorphosis. Lund[6] has reported cases of partial reversal of polarity in *Bursaria* and has completely reversed the polarity of *Obelia commisuralis* by means of the electric current. This reversal was apparently due to direct action of the current on the electrochemical polarity of the organism, but if electrochemical polarity is the result of metabolic differences it should be possible to control the expression of polarity by any external influence which would properly affect metabolism. It is this sort of a regulation of polarity which I have studied, under the direction of Dr. J. Frank Daniel, and wish here to report.

Short, transverse pieces were cut just posterior to the pharynx, from normal, averaged sized individuals of *Planaria maculata,* collected in the Golden Gate Park in San Francisco, and allowed to regenerate. The percentage of cases in which the original polarity reappeared in regeneration was very large. Occasionally, however, there was developed a heteromorphic individual, with a head at either end. Such individuals developed only from extremely short pieces, and in all cases the head which appeared at the originally anterior end of the piece was slightly larger and better developed than the posterior head, which frequently showed some abnormality of the eyes or other feature. In such a case, although there has been obviously some disturbance of the simple, axiate polarity of the normal worm, there is not a real reversal of the polarity of the individual as a whole, for the originally anterior region is still able to exert a certain degree of dominance over the whole individual. It is, however, a partial reversal, for the tail has become the head. It should therefore be possible to secure an individual of completely reversed polarity by separating this posterior portion, which has to a certain extent attained an individuality of its own, from the anterior, partially dominant individual. Complete reversal of polarity was actually accomplished in this way, for when the two heads were separated, each of the resulting pieces became an apparently normal worm, a tail developing at each cut surface. The posteriorly directed heads were in some cases watched for more than two weeks after isolation and always retained the reversed polarity, developing into worms apparently quite normal and with a pharynx normally placed, but which were, in the matter of polarity, the exact opposites of the individuals from which the pieces were originally obtained.

A piece isolated from the body of a planarian must of necessity undergo a considerable rearrangement in all its life processes; it is only because these processes are extremely simple and generalized that the piece can at all survive such isolation. Since the metabolic gradient extends the length of the organism any isolated piece will possess a part of the gradient, so that the anterior end of the piece will be undergoing metabolism more rapidly than is the posterior end. But the establishment of polar relations in the new individual is also partially dependent upon the stimulation of the act of section. The anterior cut surface has been set free from all more anterior levels and is thus stimulated to a greater extent than is the posterior cut surface, which is still under the dominance of the regions above it in the gradient. Given an ordinary, isolated piece, Child explains that head frequency or capacity to form a head at the anterior end of the piece may be expressed by the ratio rate x/rate y, where rate x is the metabolic rate of the cells at the anterior surface and rate y that of the piece as a whole. If rate x is high enough to dominate the piece as a whole, a head will form, but if rate y is high relative to rate x, an imperfect head or none at all will form. In a very short piece, such as those which give rise to the heteromorphic individuals, the initial gradient can not be very pronounced, and on the cells at the posterior cut surface, which may be called the z cells, the stimulation of section may consequently be almost as great as on the x cells, making the z region also independent of the piece as a whole. In that case, head frequency for a posteriorly directed head may be expressed by the ratio rate z/rate y. The heteromorphic individuals may be considered as possessing two oppositely directed gradients which meet at their lowest points, and when these gradients are separated, each piece should regenerate with relation to its own gradient, uninfluenced by the gradient of the other; such indeed was seen to be the case. The two worms thus produced from a single piece taken from the "parent" worm appear to be identical in form, activity, etc., but when their origin is considered, it will be recognized that one is the direct opposite of the other.

The reestablishment of polarity thus seems to depend on a balance between the very strong factor of a previously established polarity and various external influences, which are able materially to affect this

[6] Lund, E. J., 1917, "Reversibility of morphogenetic processes in Bursaria." *Jour. Expt. Zool.,* Vol. 24, p. 1. 1921. "Experimental control of polarity by the electric current." *Jour. Expt. Zool.,* Vol. 33.

polarity only when that factor is weakened by some such condition as unusual shortness of the piece.

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THE EFFECT OF DRYING UPON THE ACIDITY OF SOIL SAMPLES[1]

BURGESS[2] has recently reported a study of the effect of air and oven drying upon the H-ion concentration of soils, using samples of Miami silt loam from a series of plots at the Rhode Island Agricultural Experiment Station. He found that drying had little or no effect upon acid soils, but increased the H-ion concentration of alkaline soils.

In an investigation of the H-ion concentration of Minnesota soils that has been in progress for some time at this laboratory, numerous samples of soil from different parts of the state and from soil types of different genesis have been tested. Early in the investigation we tried to determine the proper conditions of moistness and freshness of the samples and have now satisfied ourselves that the determinations should be made with soil freshly taken from the field from which little or no moisture has been allowed to escape. Only then are the results a reliable indication of the conditions actually existing in the field.

In order to determine the effect of drying upon the H-ion concentration, we made determinations upon about 200 samples of soils in both the moist and the air-dry condition. With part of these oven-dried samples also were used. All the determinations were made by the gas chain electrometric method.

Comparing samples from five of our experimental fields, the soils of which are naturally acid, we find that samples from one field show marked changes upon being allowed to become air dry; those from two fields change somewhat less, but still appreciably, and those from the remaining two change only slightly. Generally the H-ion concentration increased, but in a few instances it decreased. With the samples from plots where sufficient lime or marl had been added to make the soil alkaline, some showed no change in H-ion concentration, some an increase and others a decrease upon air-drying.

A group of 92 glacial soils, partly acid and partly alkaline, were found after air-drying to be decidedly more acid than before, the alkaline soils, however, showing the more marked change. A group of loessial soils, on the whole more acid than the glacial soils, showed less change.

Oven-drying was found to increase the H-ion concentration more than air-drying. Samples moistened after air-drying became more acid than the original moist samples and usually more acid than the air-dried samples. Moist samples kept in air-tight glass containers generally become more acid on standing; out of 20 samples tested, 13 became more acid, five showed little change and two became less acid.

H-ION CONCENTRATIONS OF FRESH AND DRIED SOILS SHOWING VARIABLE EFFECT OF DRYING AND REMOISTENING

Sample No.	Formation	Fresh pH	Air-Dried pH	Oven-Dried pH	Remoistened pH
1	Glacial Outwash	5.53	5.79	.....	.....
2	" "	6.32	5.33	5.21	.....
3	" "	7.20	6.54	6.04	.....
4	" "	7.34	7.66	.....	.....
5	Till Plain	5.44	5.19	.....	5.28
6	"	5.60	5.46	.....	5.04
7	"	5.78	5.74	.....	.....
8	"	6.20	5.90	5.55	5.50
9	"	6.49	5.11	.....	.....
10	"	7.19	6.54	.....	6.15
11	"	8.00	7.39	7.79	.....
12	Loessial	5.87	5.80	5.31	.....
13	"	6.32	5.90	5.19	5.02
14	"	6.63	6.12	5.34	.....
15	"	7.51	7.13	.....	.....

Air-dried samples, when tested by the qualitative potassium thiocyanate method, gave a more acid reaction than moist ones freshly taken from the field. The full data are now being prepared for publication, but the accompanying few given in the table will serve to illustrate the magnitude of the changes we have found.

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THE BENEFICIAL EFFECT TO WHEAT GROWTH DUE TO DEPLETION OF AVAILABLE PHOSPHORUS IN THE CULTURE MEDIA

THE exceptionally good growth wheat seedlings, grown four weeks in complete nutrient solutions, make when transferred to aqueous culture media that contain all essential nutritive salt elements except phosphorus, presents a problem of great importance from the standpoint both of theory relating to fertilizer practice and of that pertaining to the physiology of the wheat plant. In experiments designed to test the effects of the absence of the commonly assumed essential elements in the culture media at various stages of growth on the development of wheat, it

[1] Published with the approval of the director as Paper No. 373 of the Journal Series of the Minnesota Agricultural Experiment Station.

[2] SCIENCE, 1922, N. S., 55, 647–648.