VIII

In bringing to a close this brief and inadequate review of the major trends of biology I want to say a few words about a purely practical movement which is rapidly gaining force and seems likely shortly to have a pronounced effect upon the development of the whole subject, including its theoretical aspects, and particularly its teaching. I refer to the rapidly growing recognition of the fact that all of the activities of all living things, including man, are properly a part of biology in a greater or less degree. The practical importance of this lies in its corollary that the biologist may and probably does have something important to contribute towards the solution of the most various sorts of human problems, agricultural, medical, social, economic, and so on. During the last quarter of a century it has been increasingly forced upon the attention of university teachers of biology that students of sociology, of philosophy, of medicine, of economics, and of many other subjects, who had no intention to become professional biologists, not only wanted to, but needed to know something about biology. At first covertly resisted, this need is now frankly being recognized and in some degrees met by the reorganization of courses, and departures of varying degree from the traditional method of teaching this subject. This is, I think, entirely healthy and desirable. There is going along with this broadening of the viewpoint of biological teaching a welcome broadening of the opportunities for a useful and profitable career in biology. There are already many kinds of applied biology attracting young men and women. And quite beyond the range of these somewhat narrow specialties, we are witnessing such phenomena as the employment of research workers in general biology by a great corporation manufacturing electrical appliances, to mention but a single instance.

To one who embarked upon a biological career twenty-five years ago, solely because he was seduced by the charm of the subject, and who in yielding renounced, against the advice of family and friends, the supposedly certain and considerable rewards which would come if he continued, as he had tentatively started, on a career in which he might finally become a teacher of Greek, the opportunities for the biologist of the present day seem somehow humorously magnificent.

If in what I have said I have succeeded in any degree in indicating the intellectual justification of Dr. John A. Lichty's splendid gift to Mount Union College for the endowment of its flourishing department of biology, my principal object will have been achieved. Under the able leadership of Professor M. J. Scott we may confidently expect the work of the department to go forward in close touch with each new and promising field of endeavor which biology presents. I can not allow myself to close without expressing, as a biologist, my deep admiration and profound respect for the breadth of vision and deep philosophical insight which is implied in the endowment by a worker of the field of medicine of a chair of general biology. The Milton J. Lichty Chair of Biology is another enduring demonstration of the fact that the most enchanting of all the sciences has really come into its own.

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EARTH-CURRENT OBSERVATIONS[1]

THE Department of Terrestrial Magnetism of the Carnegie Institution of Washington is planning to install earth-current lines for systematic observations at its magnetic observatories. During this year such lines are being installed at the Watheroo Magnetic Observatory, about 120 miles north of Perth, Western Australia, and some time later similar installations will be made at the Huancayo Magnetic Observatory, about 125 miles east of Lima, Peru; both of these magnetic observatories are conducted under the auspices of the Department of Terrestrial Magnetism. Various initial investigations concerning best methods of earth-current

[1] Presented before the Philosophical Society of Washington, February 25, 1922. The full paper is published in the March-June, 1922, issue of *Terrestrial Magnetism and Atmospheric Electricity*, pp. 1-30.

measurements are at present in progress at the Department's laboratory in Washington.

In order to take advantage of the previous experience gained in earth-current work, and to ascertain the direction in which further study is desirable, the writer undertook a discussion of the available data, especially of the 11-year series, 1910-1920, obtained at the Observatorio del Ebro, Tortosa, Spain. For the first time comparisons could be made between the phenomena of terrestrial magnetism, earth currents, and atmospheric electricity, as dependent upon extensive observations at the *same* station. Accordingly, it has been possible not only to confirm and extend certain results previously reached by others, but also to draw important new conclusions.

It is hoped that the present investigation, which had to be confined to a discussion of the observational data on magnetically-calm, or on electrically-calm days, may be supplemented later by a discussion of earth-current data on disturbed days.

The chief conclusions may be stated as follows:

(*a*) The resultant horizontal earth-currents, as observed at the Ebro Observatory, flow, on the average for the year, in the direction from about 29° west of North to 29° east of South, or, approximately, in the direction from the Magnetic North Pole towards south-southeast. The average value, for the magnetically-calm days during 1914-1918, of the potential gradient of the component of the current flowing from true North to South was 0.20 volt per kilometer, and that of the component towards geographic East was 0.11 volt per kilometer, or about one half of the north-south component. The resultant horizontal potential-gradient was 0.23 volt per kilometer, which during electric or magnetic storms may reach a value 0.8 to 1.0 volt per kilometer.

(*b*) The annual variations of the earth-current potential-gradients and of the components of the Earth's magnetism, as observed at the Ebro Observatory, may be related to one another as cause and effect only to a very minor extent; both sets of variations may have to be referred, more or less, to common causes. The range of the annual variation of the north-south electric component is about 2.5 times that of the west-east component.

(*c*) The diurnal variation of earth currents as observed at the Ebro Observatory along lines somewhat over one kilometer long is remarkably similar to that observed at Berlin along telegraph lines, 120 and 262 kilometers in length, from 1884-1887. In both cases the diurnal variations for the component of the current along the meridian is considerably more pronounced (2-3 times) than that along the parallel of latitude. The diurnal variation in the north component of the earth's magnetism is not such as to correspond to the direct magnetic effect of the diurnal variation of the west-east component of the earth currents. A similar conclusion had to be reached with regard to the east component of the earth's magnetism and the north-south component of the earth currents. The general conclusion was that the north-south earth-current might be the result of electro-magnetic induction, caused by the fluctuation during the day of the west-east component of the earth's magnetism. *If it be recalled that all analyses of the diurnal variation field of the earth's magnetism have shown that the magnetic diurnal variation is in part to be ascribed to electric currents circulating in the regions overhead and in part to currents circulating within the earth's crust, exact agreements between magnetic variations and earth-current variations are not to be expected. It further remains to point out that until we have some knowledge of the actual course or distribution of the earth currents in the earth's crust and as to how the conductivity of the crust may vary with temperature and other meteorological causes during the day and at the actual place of observation, attempts to find a quantitative relationship between terrestrial-magnetic and earth-electric effects may be futile.*

(*d*) The horizontal vector-diagrams both for the magnetic and earth-electric components vary during the sun-spot cycle in about the same proportion. The earth-current vector-

diagram is symmetrical about a line approximately in the direction of the Magnetic North Pole.

(*e*) The extreme diurnal range of the Ebro earth currents reaches its highest values near the equinoctial months, and lowest near the solstitial months. Earth currents, atmospheric electricity, the Aurora Borealis, and the earth's magnetic disturbances, all show similar annual variations in the ranges of their fluctuations.

(*f*) The potential gradients of earth currents and of atmospheric electricity apparently vary during the sun-spot cycle, the former decreasing in the direction of normal flow of current, and the latter increasing with increased sun-spot activity. The diurnal ranges of the potential gradients of earth currents, as well as of atmospheric electricity, just as is the case for the diurnal variation of terrestrial magnetism, increase with increased sun-spot activity.

(*g*) There is evidence of a similar six-hour wave in atmospheric electricity, earth currents and terrestrial magnetism.

The analyses referred to in (*c*) are chiefly those by Schuster, Fritsche, Chapman, Walker, and Miss van Vleuten, the method of investigation employed by them being that first suggested by Gauss, which is based on the well-known Amperian rules of deflection of a magnetic needle by an electric current. The general result reached by these investigators, as stated in (*c*), has been accepted by every modern magnetician; it post-dates the investigations by Airy and Weinstein quoted by Dr. Sanford in his recent article[2]. In this connection it may be pointed out that the conclusions drawn by Dr. Sanford do not depend upon simultaneous earth-current and magnetic data at the *same* station, as was the case in my investigations.

As stated above, my present conclusions apply only to possible relations between the *diurnal variation* phenomena of earth currents and of the earth's magnetism. It does not appear that definitive conclusions can be safely reached until we have at the *same* station unquestioned coincident magnetic and electric data, and until we can furthermore consider in our comparisons only that portion of the magnetic diurnal variation caused by systems of forces below the earth's surface.

A fresh examination is also being made regarding the relations between earth currents and severe disturbances of the earth's magnetism, such as occur during the so-called magnetic storms. There are some indications which may support the views recently advanced by Satyendra Ray[3], though I am not prepared just now to make a definite statement.

With the view of giving renewed stimulus to systematic earth-current investigations, a special committee, "to consider and report on best methods and instruments," was formed at the Rome meeting of the International Section of Terrestrial Magnetism and Electricity last May. The chairman of the committee is Sir Arthur Schuster, and the secretary, Dr. S. J. Mauchly, of the Department of Terrestrial Magnetism.

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[2] Earth currents and magnetic variations, SCIENCE, October 27, 1922, p. 466.

[3] Ray, S., "Ueber parallele Störungen von parallelen erdmagnetischen und erdelektrischen Elementen," Zs. Physik, Berlin, v. 7, 1921 (201-205).

COLLABORATORS IN THE STANDARDIZATION OF BIOLOGICAL STAINS

FROM time to time reports from the Committee on Standardization of Biological Stains have appeared, dealing with the investigations in progress. Many congratulations have been received by the chairman of the committee on the results accomplished; but as these accomplishments would have been impossible but for the very hearty collaboration of a long list of investigators, credit for the work should be given where it belongs by publishing the following list of committee members and collaborators:

COMMITTEE MEMBERS

F. W. Mallory, Boston City Hospital, Boston, Mass.

F. G. Novy, University of Michigan, Ann Arbor, Michigan.