sites of the shad are discussed, as also the environment. A considerable amount of new information is here contained, and we may mention particularly the contribution to the fascinating science (or art) of reading age and life history from the structure of fish scales, by N. Borodin. It seems that for almost every species of fish this presents a separate problem. In the shad scale, so-called "annuli" are difficult to find, but distinct transverse grooves, running across the annuli, two for each year, are readily made out. Dr. Borodin's results are corroborated in a study of otoliths by R. L. Barney.—J. T. NICHOLS.

A MONOGRAPH, "The Termites of Kartabo, Bartica District, British Guiana" has been lately issued by the department of tropical research of the New York Zoological Society. Dr. Alfred E. Emerson, associate professor of zoology at the University of Pittsburgh and for several years associated with the University Zoological Station at Kartabo, British Guiana, is the author. Seventy-eight species, fifty-one of them discovered by Dr. Emerson, are classified in the volume.—LORENZ G. WALTERS.

IN 1902 the Coast and Geodetic Survey published "Principal Facts of the Earth's Magnetism," by L. A. Bauer, then inspector of magnetic work. This covered the early history of the development of knowledge in regard to the earth's magnetism and gave an appraisal of the knowledge of the subject at the time the publication was issued. A new publication "The Earth's Magnetism," by D. L. Hazard, assistant chief of the division of terrestrial magnetism and seismology, U. S. Coast and Geodetic Survey, replaces the earlier one and it covers not only the early history, but also that of the important period since 1902, during which so much advancement has been made in our knowledge of the subject. It is a fact that this period of intensive world-wide study has made very great progress. At the same time it must be recognized that the final solution of the problems is still very far in the future. The outstanding feature of the first quarter of the twentieth century was the extension by the Department of Terrestrial Magnetism of the Carnegie Institution of Washington of magnetic surveys of all parts of the earth not covered by national governments, and to the high seas. Also the precise work done by many governments, especially that of the United States through the Coast and Geodetic Survey. It appears that in every branch of scientific investigation which must be expected to continue for a long period, appraisal from time to time of the progress that has been made is almost as essential as the actual carrying on of the work.—R. L. FARIS.

SPECIAL ARTICLES

X-RAY DIFFRACTION PATTERNS FROM PLANT MATERIALS

DURING the past three or four years the writer has been making many X-ray diffraction patterns of the materials of plants which are normally thought of as solid substances, such as starch grains, cell-walls, both lignified and non-lignified, and those of hemicelluloses. These materials are very probably built up by additions of layer upon layer at the interface between the substance and the living protoplasm, and for that reason they would be expected to have a certain regularity in their structure. The fact that diffraction patterns are obtained from them is evidence that there is undoubtedly a degree of regularity in the structure, which could only be surmised heretofore. Diffraction lines have been obtained from many plant materials, among which are bast fibers of ramie and hemp; hairs of cotton; tracheids of spruce; starch grains of potato, corn, wheat, cassava and arrow-root; and the sclerenchyma cells from the seeds of *Phytelephas* and of another palm, *Erythea*.

The method used was that devised by Hull[1] for obtaining diffraction lines from powdered crystal materials. It was modified somewhat in order to be more usable with fibers and cells of other kinds. The principles involved include not only those pertaining to the powder method, but on account of the modifications also those which apply to large single crystals.[2]

Although the work is by no means completed, there are several points of a general nature which stand out from the mass of details as items of interest in the study of protoplasmic activities.

In the table only a few of the diffraction lines obtained are given, and they include only the wider interplanar spacings for a few representative substances. More complete studies are given elsewhere,[3] or will appear in the literature at an early date. Since the earlier publications on starch,[3] refinement in the apparatus and a better technique have resulted in the resolution of several lines and in their more accurate measurement. The figures in the table, therefore, will not check exactly with those in the paper to which reference was made. A revision of the earlier work is, of course, necessary, but so far

[1] Hull, A. W., *Phys. Review*, X, 661–696, 1917; and XVII, 571, 1921.

[2] Bragg and Bragg, "X-Rays and Crystal Structure," London, 1924.

[3] Sponsler, O. L., *Amer. Jour. Bot.*, IX, 471, 1922, and *Jour. Gen. Physiol.*, V, 757–776, 1923.

as studied up to the present time it seems doubtful that any great change in the conclusions will be found.

INTERPLANAR SPACINGS

Cellulose Ramie fibers	Hemi-cellulose Phytelephas	Starch grains Potato	Starch grains Corn
6.10 A.U.	5.65 A.U.	6.13 A.U.	5.96 A.U.
5.40	4.99	5.23	5.23
5.15	4.48	4.57	4.99
4.35	3.84	4.05	4.40
3.98	3.56	3.73	3.90
3.40	3.33	....	....
3.20	....	....	....

The significance of the figures given in the table becomes more evident when we recall the chemical composition of the substances and the way in which diffraction lines are produced. For details of the latter we must refer to the literature already cited. In general, however, we may think of the lines as being produced by "reflection" from planes or layers of atoms, and as the result of reflection from hundreds or thousands of those planes very uniformly spaced. The substances are all carbohydrates of the hexose type. The atoms which produce the reflection, therefore, are those of carbon and oxygen. Hydrogen has a negligible reflecting power, and the amount of other elements which might occur is too small to produce diffraction lines.

In the table it will be noticed that the dimensions of the spacings are comparatively uniform for the different substances. The greatest interplanar spacing is about the same in each; that is, in the neighborhood of 6 A.U. All of them are greater than 3 A. U. Since the diameters of oxygen and carbon atoms are about 1.5 A.U. or less, it seems fairly certain that the units which make up the lattice structure of these materials are composed of *groups of atoms*.

It is not, of course, a safe procedure to predict the size of these structural unit groups until the lattice is carefully worked out, but attention should be directed to what seems to be at least a peculiar coincidence. The volume of a $C_6H_{10}O_5$ group of atoms as it occurs, presumably, in the materials[4] is about equal to the volume of an elementary cell whose dimensions are $6 \times 5.5 \times 5$ A.U. Approximately the same values are present in each column of the table. The C_6 group seems to be the structural unit in starch grains[5] and in plant fibers,[6] and from the data so far presented it would not be surprising if that group kept its identity throughout all these materials.

We may feel fairly certain of this much—that in the plant parts with which we have been working units of structure which approach in size that of a C_6 carbohydrate group occur in a very uniform arrangement; that is, they are not laid down in a haphazard manner. On the contrary, each unit is fitted more or less neatly in place so that a definite lattice structure is formed.

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4 *Ibid.*

5 *Ibid.*

6 The data on plant fibers will soon be submitted for publication.

SUCTION FORCE OF SOILS: A NOTE ON THE APPLICATION OF THIS PRINCIPLE IN THE STUDY OF THE SOIL-PLANT SYSTEM[1]

IT was pointed out[2] how the principle of the suction force of a soil may be utilized for the estimation of the soil colloids. The suction force is measured with the aid of a mercury manometer attached to a porous clay candle which is filled with water and inserted in the soil. The capillary and molecular forces exert a pull on the water producing a negative pressure in the clay candle which is registered on the manometer. The greater the amount of colloids in the soil the greater the suction force. The ratio from the same soil multiplied by 100 gives the percentage of colloids in the soil. The figures in the following table will suffice to illustrate the relationship between the amount of colloids present and the suction force. The various types of the same soil series contain various amounts of clay and apparently the suction force follows the clay content.

Clay	Suction force: rise of mercury column on manometer
Percentage	cm.
4.15	16.9
4.68	16.0
7.11	17.9
19.09	29.05
21.82	39.1

The figures on the clay content are taken from the

1 Paper No. 248 of the Journal Series, New Jersey Agricultural Experiment Stations, Department of Soil Chemistry and Bacteriology.

2 Joffe, J. S., and McLean, H. C., 1925, "Colloidal behavior of soils and soil fertility. I. Suction force of soils as an index of the colloid content of soils." To appear soon in *Soil Sci.*, v. 20, 1925.