Eoanthropus skull was probably a washout river channel specimen from some old sand or gravel bank and the problem is whether it came from a Pliocene gravel bank with the primitive elephant and mastodon, or from a Pleistocene gravel bank with a primitive hippopotamus.

In either case *Eoanthropus,* the dawn-man of Sussex, now appears to be of greater geologic age than *Pithecanthropus,* the Trinil ape-man. Thus in the course of the last eighteen years *Eoanthropus* and *Pithecanthropus* have changed places in the geologic time scale.

HENRY FAIRFIELD OSBORN
AMERICAN MUSEUM OF NATURAL HISTORY

GROUP THEORY AND APPLIED MATHEMATICS

PROFESSOR H. WEYL, of Zurich, Switzerland, recently published a book under the title, "Gruppentheorie und Quantenmechanik," Leipzig, 1928, which he regards as half mathematics and half physics, and hence it belongs to the borderland of two large domains of science. Group theory is not a complete stranger in this borderland. Its usefulness in crystallography, for instance, is well known. The fact that it appears to be useful in such a new field of mathematical physics as quantum mechanics may perhaps be regarded as a sign that the mathematical public is becoming more conversant with the fundamental notions involved in group theory and hence writers no longer hesitate to express themselves in the language of this subject in case they are familiar with it.

Professor Simon Newcomb once said[1] that "the mathematics of the twenty-first century may be very different from our own; perhaps the schoolboy will begin algebra with the theory of substitution groups, as he might now but for inherited habits." We seem to be as yet very far from such a fundamental change in our courses in elementary mathematics, and the change is not likely to come until applied mathematicians make much more use of this theory. Two fundamental aspects of mathematics are idealization and actualization. As regards group theory the former concerns itself with a study of the structure and the abstract properties of groups, while the latter makes groups useful in the intellectual penetration of our actual surroundings in the physical world. The development of these two aspects of the subject seems to call for very different types of mind, and the latter naturally gives rise to the more extensive developments. It is in this field that group theory seems to be as yet in its infancy and hence one welcomes the more heartily such works as those of Professor Weyl.

In connecting group theory and quantum mechanics Professor Weyl directs attention to the fact that the former subject is in reality very old and may have been at the base of the early developments of ornaments, especially by the ancient Egyptians. He thus partly supports the view that the earliest developments in mathematics may have been inspired by a sense of beauty and harmony as exhibited in symmetrical geometric figures, and that when Euclid wrote his "Elements" the fundamental concept of group was so fully ingrained in the minds of the people that Euclid did not regard it as necessary to mention it explicitly. The emphasis which it began to receive during the nineteenth century is so marked that the late Felix Klein regarded it as the most characteristic feature of the mathematical developments during this century. Its essence is a study of a few fundamental laws of mathematical operations, and it has created for itself a marvelously rich but isolated mathematical universe which has proved to be very attractive to a number of pure mathematicians, who are accustomed to ignore their actual physical surroundings in their intellectual activities and to study ideal situations.

While the applied mathematician is not accustomed to such isolation and hence can not be expected to enter with as much enthusiasm as the pure mathematician upon the study of the particular laws involved in group theory, yet he seems to realize more and more that the actualization of such a rich store of abstract mathematical knowledge is likely to extend his insight into our actual physical surroundings. Hence it seems reasonable to expect that in line with the work noted above more and more frequent use of group theory will be made in the future by applied mathematicians, but that some of the most optimistic statements relating to this use will not be realized in view of the fact that those who are continually reminded of laws which are not considered in group theory will be more forcibly impressed by its limitations than the idealists.

G. A. MILLER
UNIVERSITY OF ILLINOIS

[1] *Bulletin of the American Mathematical Society,* 3: 107. 1893.

THE MOVEMENT OF SAP IN PLANTS

VERY great interest has been roused in Europe and America by the striking researches and discoveries of Sir J. C. Bose on the unity of physiological mechanism in the plant and in the animal. After the conclusion of his lecture at the University of Vienna, Sir J. C. Bose was kind enough to lend me his instruments for the repetition of his more important experiments in the institute of plant physiology of the university. As this is the first time that his experiments have been successfully repeated in a European laboratory, the following results which I obtained, will, no doubt, prove of interest.

(1) *The infinitesimal contraction recorder:* This apparatus, a marvel of ingenuity, records the cellular contraction in the interior of the plant under external stimulation. The principle of the instrument is extremely simple; the extreme delicacy of the apparatus bears testimony to the extraordinary skill of the Indian mechanicians trained at the Bose Institute. The stem or other organs of the plants are placed between a fixed and movable primary lever. The diametric contraction of the plant under stimulation is indicated by the movement of this primary lever, which is further magnified by optical means, the total magnification produced being a million times. The indication of the instrument is not affected by mechanical disturbances.

(2) *Sensitiveness of ordinary plants:* An extremely feeble electric shock was sent through me and the plant, both being places in the same electric circuit. It was a startling revelation that the plant should visibly respond by a contraction to a shock which was below the threshold of my perception. With stronger shock the cellular contraction was more intense; under excessively strong shocks the contractile spasm became very violent; after a short time the tissue ceased to respond, being effectively killed by the electric discharge. It is quite easy to show that the cortical cells in every section of the stem and of the leaf-joint are fully sensitive, proving a continuity of contractile cortex throughout the length of the plant. A wave of peristaltic contraction may thus sweep onward from the point of stimulation.

(3) *The movement of sap:* The following striking experiment affords conclusive proof that the movement of sap is essentially not a physical but a physiological process. A cut piece of stem of Antirrhinum with a pair of opposite leaves is suitably held at the cut end by a piece of sponge. Under excessive drought the leaves fall down, become crumpled up and appear to be wilted. A few drops of cardiac stimulant—dilute solution of camphor—applied on the sponge bring about a most striking transformation. The drooping leaves are quickly revived; they rear themselves up with great rapidity, and become fully erect in the course of two to three minutes.

(4) *Active cellular pulsation in propulsion of sap:* The pumping of sap by the propulsive layer is clearly demonstrated by the optical sphygmograph. The flow of sap along the stem is observed to consist of a series of pulsations. The pulsatory activity is greatly increased by drugs which enhance cardiac activity in the animal; it is enfeebled or arrested by depressing agents. Extracts from certain Indian plants are seen to have a potent influence in the propulsive activity of the plant and cardiac activity of the animal. This aspect of the investigation has roused considerable interest in the Medical Faculty of Vienna.

(5) *Movement of sap in sealed stems:* It has been thought that the movement of sap is essentially due to push from below by root-pressure and suction from above by transpiring leaves. The fact that there is an inherent activity in the stem itself, independent of those in terminal organs, is clearly demonstrated by experiments on an isolated stem covered with impermeable varnish. The sap can now be made to flow either upwards or downwards, according to differential stimulation. The law of directive movement of sap is that it moves from the stimulated to unstimulated or depressed regions. The cellular mechanism is highly sensitive, being automatically adjusted for subserving the well-being of the plant. A local depression or stimulation starts the alert machinery into action, making the sap rush towards the depressed or away from the overstimulated region. It is in this way that chemical substances stored in one region are conveyed to distant parts. By this hydraulic mechanism the plant as a whole becomes an organized unity.

H. MOLISCH

VIENNA, AUSTRIA

STOMATA WHICH SHOW FUNCTIONAL MOVEMENT FOR A CENTURY

THE establishment of the fact that medullary cells of the tree cactus of Arizona live for more than a century and have a capacity for enlargement during the greater part of this period at the Desert Laboratory early in 1926 has been followed by the discovery of long-lived cells in the cortex of both Carnegiea and Ferocactus, in the medullary rays of the California redwood (Sequoia) and of both medullary and wood-cells in Parkinsonia. The living elements in question are in such relations to other tissues as to be well protected from sudden or intense action of environmental agencies and do not appear to be the seat of rapid metabolic activity.

While collaborating in the preparation of one of the brief papers concerning this subject it appeared that the stomatal cells of the tree cactus (Carnegiea) also sustained a long period of functional activity, as mentioned by MacDougal and Brown.[1] This matter was held for continued observation. On a trunk of this massive cactus 10 meters in height the green epidermis persists to within a meter of its base, where it is displaced by bark or corky tissue. This is taken to mean that all the epidermis except

[1] D. T. MacDougal and J. G. Brown, "Living Cells Two and a Half Centuries Old, SCIENCE, lxvii, 447–448, 1928.