in all of these stages, and consequently express the action of imbibition and osmosis.

The distinct action of imbibition and the later joint action of hydration by osmosis and by imbibition may be most readily recognized, in organs in which the region of growth is generalized as in the ovate flattened joints of *Opuntia* or in such globular fruits as the tomato. The measurement of the growth of one of these joints may be begun when it has a lateral area no larger than the thumbnail, and during this stage the increase is rapid and shows a minimum disturbance from changes in external conditions, as shown by the illustrations. Growth continues throughout the entire mass until an advanced stage of development is reached, when it first slackens in the basal portion. By this time large vacuoles have been formed in the thin-walled cells, and water loss from the surfaces of the organ has reached such a rate that great daily variation in the volume results and actual shrinkage may ensue. A similar history may be predicated for such structures as the large berry-like fruit of the tomato, it being noted that the material in both illustrations takes on solid matter and water at such rate that not much alteration in their proportions occurs during development.

The enlargement of the trunk of a tree results from the multiplication and growth of cambium and other cells on the outside of the trunk directly inside and covered by the bark. The trunk of the tree is in effect a cylinder of moist but dead woody tissue surrounded by a living sheath which becomes very active at some time in the year and which as a result forms an additional layer or sheet of wood on the trunk which in cross section gives the appearance which has caused it to be designated as an annual ring of growth.

The actual course of growth or formation of these annual cylinders or, more strictly speaking, cones, has not until recently been measured. In 1918 I was successful in making a working model of a dendrograph which might be attached to the trunk of a tree in such manner that its changes in volume due to whatever causes were traced on a ruled sheet of paper carried by a revolving drum. The essential part of this apparatus is a yoke of metal, which has two bearing screws resting on the trunk and carrying a third contact point on the end of the pen lever. It was not possible to make a practicable instrument until a yoke could be constructed which showed but little variation as a result of changes in temperature. Three alloys with a very low temperature coefficient, bario C., manganin and invar have been used and dendrographs are now in operation on the trunks of two species of pine, and oak, an ash, a sycamore and a beech tree, and as these instruments were placed in position before growth began in 1919, there is every prospect that seasonal records will be obtained from which the principal features of growth may be seen. Weekly records show that these trees do not behave alike and that many conditions are to be considered in interpreting the records.

It is evident for example that but little is known concerning the properties of bark as a water-proofing or protecting coat for the tree. The loose bark of the ash and pine trees seems to allow such a great water loss from the surface during the mid-day period as to cause actual shrinkage which does not occur in trees such as the beech and live-oak, which have a perfect living green outer bark or skin. The facts disclosed by these records can not fail to be of interest in a discussion of any phase of the complicated problem of the ascent of sap.

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JOSEPH BARRELL

AMERICAN geology has lost one of its foremost leaders, one who promised to stand as high as the highest. Professor Barrell's other colleagues will undoubtedly agree with Professor T. C. Chamberlin when he says: "We had come to look upon him as one of the most promising leaders in the deeper problems of earth science. We feel that his early departure is a very sad loss to our profession not only, but to the whole group of sciences that center in the earth and its constitution."

Only a few days before his death there came to him the news of the highest honor that can be given to an American scientist, election to the National Academy of Sciences. His election, furthermore, was by a unanimous vote of the academicians present at the April meeting in Washington, and such a vote is rare in the academy.

Joseph Barrell, the son of a farmer, was born at New Providence, N. J., December 15, 1869, and died of pneumonia and spinal meningitis in New Haven on May 4, 1919. He leaves a wife and four sons. Standing 5 feet 10.5 inches in height, of the blue-eyed Nordic type, with a full head of wavy light-brown hair, he was spare and slender in build, but characterized by great muscular strength in comparison to body weight. He was of the eighth American generation from the Puritan George Barrell, who migrated from Suffolk, England, and settled at Boston in 1637. This first American Barrell began as a cooper, but most of his descendants have been sea-going people and shipping merchants. The most widely known and wealthiest was Joseph Barrell of Boston, after whom the subject of our sketch, his great-grandson, was named. This Joseph Barrell is said to have "early espoused and firmly maintained the cause of his country," and for a time represented the town of Boston in the State Legislature. It was in his splendid home that General George Washington was entertained during his visit to Boston.

Professor Barrell received the first part of his collegiate education at Lehigh University, taking in due course its B.S., E.M. and M.S. degrees, and in 1916 this institution gave him its doctorate of science. From 1893 to 1897 he was instructor in mining and metallurgy at his alma mater, and then was given leave of absence to go to Yale for graduate studies in geology, taking his Ph.D. degree in 1900. Returning to Lehigh, he was made assistant professor of geology, and for three years taught not only geology but zoology as well. In 1903 he was called to Yale as assistant professor of geology and in 1908 promoted to the chair in structural geology. In the geological department at Yale he was a unifying force and a tower of strength. During the summer months from 1893 onward, Barrell spent nearly all the time in the field, working at first as an engineer in the coal mines of Pennsylvania, then in the mines of Butte, Montana, devoting one summer to the geology of southern Europe, and later studying widely the geology of the Appalachians and of the New England States.

Professor Barrell's first publications, in 1899 to 1900, deal with mining, but since 1901 nearly all his work has been in geology. His bibliography has upward of forty-five titles, totalling more than 1,500 pages. Several articles remain unpublished, at least two of which it is hoped to print during this year. A more detailed account of his life and work will appear in an autumn number of the *American Journal of Science*.

Barrell's most important work has to do with the strength of the earth's crust. The series of papers bearing that title examine into "the mechanics of the earth considered as a body under stress, owing to the variation in density and form which mark its outer shell." He was all the more able to handle this most difficult subject because of his thorough training in engineering at Lehigh. His last work along this line will be published this fall. From the manuscript we learn that "The larger features of the earth's surface are sustained in solid flotation, and at some depth the strains due to the unequal elevations largely disappear, the elevations being compensated by variations of density within the crust. In consequence, the subcrustal shell is subjected to but little else than hydrostatic pressure." Isostatic balance is, however, not everywhere in adjustment, but the adjustments are held to be irregular and imperfect in distribution and mostly concentrated in the outer one hundredth of the earth's radius, with a tendency to progressively disappear with depth. On the other hand, "the outer crust is very strong, capable of supporting individual mountains, limited mountain ranges, and erosion features of corresponding magnitude."

Barrell also did much toward working out the criteria by which the climates, marine deltas and geographies of the geologic past may be discerned in the sediments or stratified rocks that make up the greater portion of the geologic record. This work brings out especially the importance in earth history of the ancient formations laid down upon the lands by the fresh waters and the wind, in contradistinction to those deposited by the seas and oceans.

The length of geologic time was another problem that deeply interested Barrell. In his "Rhythms and the Measurements of Geologic Time," he came to the conclusion that through the rhythmic oscillations of the terrestrial processes which the earth has undergone, its age is many times greater than even geologists in general have imagined—in fact, that it is of the order of about 1,500 million years.

A fourth line of research which occupied Barrell was the origin and genesis of the earth, and here he extended in modified form the Chamberlin-Moulton planetesimal hypothesis, *i. e.*, that the planets and their moons arose out of the sun during a time of induced tidal disruption. Some of his best work was to develop along this line, and an extensive manuscript on "The Genesis of the Earth" is ready for publication.

Since 1913, Barrell has on a number of occasions taken opportunity to point out that the supposed Mesozoic peneplain of southern New England was in reality "stairlike or terraced in its character, facing the sea, and bore the marks of ultimate control by marine denudation. These terraces [more than five in number] are now dismantled by erosion except in regions favored by the presence of broadly developed resistant rock structures. . . . All are regarded as younger than the Miocene." With this view, he adds, we get "a suggestion of the geological rapidity of completion of an erosion cycle in a region near the sea and of a sequence of diastrophic rhythms there recorded." Here too there is considerable manuscript that will be published later on.

Finally, the evolutionary problems connected with paleontology claimed his interest, and he has presented evidence to show that fishes probably arose in the early Paleozoic in the fresh waters of the lands, and thence migrated to the seas. Also that lungs developed out of air-bladders in water-breathing animals caught in recurrent epochs of semiaridity. Such great environmental changes brought about the necessity for change from a water habitat to seasonal dry ones, and hence "the piscine fauna which endured these conditions came through profoundly changed." The primitive sharks of Silurian time, having no air-bladder, "were driven to the seas. The fresh-water fishes which remained were ganoids and dipnoans, fishes with air-bladders efficient for the direct use of air." Finally, from crossopterygian ganoids, under the stimulus of the semiaridity of the Devonian, there emerged the amphibians, able to carry forward their activities as terrestrial animals.

Similarly, he held that man was brought to his present high physical and mental state not merely as the "product of time and life," but that he is "peculiarly a child of the earth and is born of her vicissitudes." The changing climates during the Pliocene and Pleistocene, acting upon the vegetation of these times, caused the prevalent forests of Asia, he thinks, to dwindle away, producing "a rigorous natural selection which transformed an ape, largely arboreal and frugivorous in habits, into a powerful, terrestrial, bipedal primate, largely carnivorous in habit, banding together in the struggle for existence, and by that means achieving success in chase and war. The gradual elimination, first of the food of the forests, lastly of the refuge of the trees, through increasing semiaridity, would have been a compelling cause as mandatory as the semiaridity which compelled the emergence of vertebrates from the waters, transforming fishes into amphibians."

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SCIENTIFIC EVENTS

THE SOLAR ECLIPSE[1]

TELEGRAMS received by the Astronomer Royal report that at the station at Sobral, in Brazil, occupied by Dr. Crommelin and Mr.

[1] From *Nature*.