agricultural arts of a high degree of excellence. They developed a calendar more accurate than ours, and they devised a highly original system of mathematics. But amazingly enough, though they carried on this most successful agricultural society, they were quite incapable of inventing the plough.

We may well question why the Romans, who were such capable administrators, military experts, road and bridge builders, should have been unable to produce a power-industry civilization. We may go further and say that the basic concept was actually in existence, but that it simply could not be expanded and applied; for, in 130 B.C., Hero of Alexandria described in his "Pneumatica" at least two methods of harnessing power to steam.

We have been inclined to obscure this puzzle as to why scientific and industrial development came so late by considering that these earlier periods were somehow representative of the youth of our species—and, as everyone knows, the boy really does become smarter when he grows up. This might be a simple way out if we still believed that we originated in 4004 B.C. But now that we know that the first traces of man go back for at least half a million years, we have to think of the Romans almost as contemporaries. This concept of cultural indoctrination as affecting scientific behavior as well as all other forms of behavior has, of course, immediate signi ance. We shall want to know to what extent curre indoctrinations—political, nationalistic, religious—li it our ability to conceptualize our world and, the by, hinder the progress of our control of our univer through science.

I have tried to show th ugh what vistas we have the scene of the extremely teresting and provocative things which are happening to our conception of science. It is the inmost germinal place of our future.

I reiterate my belief that psychiatrists, with their unique position between the medical and social sciences, have a special responsibility to act as leaders and guides in entering and opening up this new territory. We have the responsibility not only to create the new tools and the new concepts but we also have a most serious duty to assist in finding means to destroy the old and the obstructionist. It is one of the graver lessons of our times that the new, the more liberal, the more effective, does not immediately succeed without our active assistance in driving out the old, the harmful, and the entrenched.

Obituary

Burton Edward Livingston
1875-1948

Burton Edward Livingston began his career as a botanist at a very early age in the fields and woods, along the ponds and streams in the vicinity of his home in Grand Rapids, Michigan. Early experiences with trees, flowers, and the general flora of his native region undoubtedly exerted a strong determinative influence upon his life. His parents and older brothers and sisters were unusually interested in plants, their habitats and behaviors. This home environment must have been a powerful stimulus to his development.

In addition to contacts with the flora of central Michigan, he had an opportunity to become familiar with all kinds of tools and machinery, for his father was a contractor in the street-paving and sewer-construction business in Grand Rapids.

A third factor which helped to shape his background development was the home library, which was quite out of the ordinary at that time. Burton acquired the habit of reading rather widely and became omnivorous in his literary tastes. He also had the privilege of playing with simple microscopes and of becoming familiar with their use before he ever attended school. All of these factors had a definite bearing upon the course of his life and helped to create that interest in the plant sciences which made him later on a great leader in the fields of plant physiology and forest ecology.

Grand Rapids was the scene of his grade and high school training. In the high school he had the good fortune to learn the fundamentals of many sciences, as well as a number of languages which would be useful to him as a leader of research in his chosen field. He began making an herbarium in high school and afterwards continued to collect plants as a scientific project. Having gone far beyond the requirements for school work, he acquired a wide acquaintance and knowledge of the plant kingdom and, upon entering the University of Michigan, was rewarded by being given 10 hours of advanced credit in botany for his herbarium activity.

When he was old enough to engage in gainful employment, he obtained a job at the Pitcher and Manda United States Nurseries at Short Hills, New Jersey. The year he spent at Short Hills gave him the oppor-

tunity to learn every operation that a great nursery requires. This was an invaluable experience for a young man turned toward scientific problems. He left the nursery in the early summer of 1894 and spent the remainder of that summer botanizing and adding largely to the herbarium, which had by this time become a very considerable collection.

In the autumn of 1894 he entered the University of Michigan, where he had the good fortune to work with such outstanding botanists as V. M. Spalding and F. C. Newcombe. It was the latter who turned Livingston decisively into the field of plant physiology. After a year of study, he became Newcombe's laboratory assistant. In a sense, that was the beginning of his career as a plant physiologist interested in plant habitats and distribution and in the impact of soils and climates upon plant behavior. He took naturally to the problems of plant physiology as modified by environmental complexes of temperature, light, humidity, and wind flow, which were recognized as dynamic systems. Soil conditions and plant growth also challenged his interest. Altogether, these were fields of unlimited ramifications and possibilities.

During the Ann Arbor period there was a visit to New York, where he met N. L. Britton and John K. Small, both of whom proved to be very stimulating. In 1898, having completed the undergraduate work at Michigan, he was awarded the B.S. degree and began teaching at the Freeport, Illinois, high school. In the midst of his first year of teaching, he applied for fellowships at a number of universities. Among several that were offered to him, he chose to accept a fellowship and assistantship in the Department of Botany of the young, but already famous, University of Chicago. He entered Chicago in the summer of 1899 and became the first of a distinguished group of men who assisted Charles Reid Barnes in the plant physiology laboratory there.

Although Livingston completed his work for the Ph.D. degree in 1901, he remained as laboratory assistant and associate in botany until 1905. His book, *The rôle of diffusion and osmotic pressure in plants*, published by the University of Chicago Press in 1903, is still an important summary of the field up to that time. It was during this period at Chicago that the writer was first privileged to know him as a tall, friendly, earnest young man who was adept in all of the techniques used in the study of plant physiology.

Beginning in 1905, Dr. Livingston held various positions which must be thought of as preparatory for his real life work. For a part of the year he was in charge of fertility investigations in the Bureau of Soils, U. S. Department of Agriculture, Washington, D. C. In 1906, the Carnegie Institution of Washington, which was just getting well started, offered him a position as staff member of the Department of Botanical Research, which he accepted. He went to Tucson, Arizona, and found conditions around the Desert Laboratory a great challenge to his interests. Here he first developed and used the porous porcelain atmometers in studying the evaporativity of the plant environment and the drying influence of sunlight. Then followed a year at eastern institutions and at the Missouri Botanic Garden, where he studied particularly the transpiration of greenhouse-grown cacti. In 1908 he traveled in Europe, spending time mainly with von Goebel at Munich, but visiting Pfeffer's institute at Leipzig for several weeks, Klebs at Heidelberg, and Hall at the Rothamsted Agricultural Experiment Station in England. He returned from Europe late in 1908 and attended the Baltimore meeting of the AAAS. At this time he first saw D. S. Johnson's Botanic Garden at Homewood, which was just becoming the home of Johns Hopkins University. He returned to the Desert Laboratory, but in 1909 he was invited to accept the chair of plant physiology at Johns Hopkins and promptly accepted the offer.

In estimating the personal influences most important to him during these years leading up to the Hopkins appointment, Dr. Livingston always acknowledged his special indebtedness to Newcombe, Barnes, Cowles, and Jacques Loeb.

In 1913 Dr. Livingston was made director of the Laboratory of Plant Physiology at Johns Hopkins, a position which he held with great distinction until 1940. In 1932, forest ecology was added to his field. As soon as the Johns Hopkins Laboratory of Plant Physiology was opened, it became a sort of mecca for plant physiologists, not only from the United States but also from far-distant lands. About 140 graduate students were enrolled in advanced work in the laboratory during the period 1909–40; of these, there were 28 Ph.D. candidates who successfully met the requirements and obtained degrees.

Livingston's contributions to the advancement of science were many and varied. He and his students published nearly 300 papers during the tenure at Johns Hopkins. These papers were especially valuable because they presented full discussions and masterly integrations of the old and new knowledge which illuminated the whole field covered. Such problems as temperature, light intensity, 3-salt nutrient solutions, the continuous renewal of culture solutions, foliar transpiring power, the daily march of transpiration, the seasonal march of soil moisture conditions, the water-supplying power of soils in relation to the wilting and withering of plants, the carbon dioxide-supplying power of the air, and the oxygen-supplying power of soils and its relation to seed germination are representative examples of topics pursued in the

wide-ranging quest for new understanding which went on continuously in the Laboratory.

At the same time, Dr. Livingston contributed to the advancement of plant physiology and ecology by the invention or improvement of many excellent instruments for measuring the effects or intensities of dynamic environmental factors. The porous porcelain atmometers, cylinders, spheres, and plates, in both black and white, with standardized techniques, made possible more accurate measurements of the evaporativity of environments. Batteries of black and white spheres went all over the world to help ecologists and physiologists to evaluate the effects of atmospheric humidity and sunlight upon the water relations of plants. Auto-irrigators provided means of control for soil moisture conditions in pot culture experiments; soil points of porous porcelain were invented to measure the water-supplying power of soils. These soil points were extremely accurate in their readings when they were used at some definite hygrometric water content.

In addition to these various porous instruments, he made and sold to laboratories many supplies that could not be obtained elsewhere. These included leaf clips used in transpiration experiments, hygrometric paper, permanent color standards, tripartite color standards, and standard evaporating surfaces with which leaves could be compared. A reconditioning service was maintained to clean, rewaterproof, and restandardize apparatus for laboratories not equipped to perform these necessary operations for themselves. These instruments and services were widely used, and thus the influence of the Johns Hopkins Laboratory was extended to many lands.

In addition to the book published in 1903 and his numerous scientific contributions in journals, he published with Forrest Shreve a book on *The distribution of vegetation in the United States as related to climatic conditions* (1921). In 1918 he edited an English translation of Palladin's *Plant physiology,* which appeared in three editions by 1926.

Dr. Livingston was a skillful editor, and he contributed to various journals in an editorial capacity. Notable among these were *The American Scholar, Physiological Researches, Botanical Abstracts,* and *Plant Physiology.* He exerted much influence on the editorial policies of the latter journal, upon whose editorial committee he served for many years. He deserves a great deal of credit for the general excellence of appearance and contents of the early volumes of *Plant Physiology.*

It would be difficult to overstate the value of his services to the American Society of Plant Physiologists in the first few years of its existence. Although he was not a prime mover in its organization, he was very sympathetic toward its ideals, and it was through his interest and advice that the new society was affiliated with the AAAS in October 1924, before the Society was 6 months old and before it had held an annual meeting. Affiliation gave the plant physiologists representation on the Association's Council. Many were the times that Livingston's advice and encouragement steered the new Society away from the reefs. So important were his contributions that when the Charles Reid Barnes honorary life memberships were established at Kansas City in 1925, Dr. Livingston was chosen to be the first recipient of this honor at Philadelphia in 1926.

In 1927, when the Society celebrated the Stephen Hales anniversaries at Nashville by founding the Stephen Hales award, Dr. Livingston made the largest single contribution to the fund for the Hales endowment, and it was made in a manner to encourage generous giving by others.

In 1934 he was elected president of the American Society of Plant Physiologists. During that year the constitution was revised, and many changes were made in the procedures, all in the direction of more liberal and democratic management of the Society's affairs. His long-continued interest and his vital contributions to plant physiology through the Johns Hopkins Laboratory finally led to his selection as recipient of the Stephen Hales award in 1946. He was too ill by December 1947 to deliver his address in response to this award at the annual meeting of the Society.

Although he belonged to many organizations, his first love and loyalty was the American Association for the Advancement of Science. He became its permanent secretary in 1920 and served for three successive terms, until 1931. During his secretaryship the Association grew rapidly. It was the writer's privilege to be associated with him in the office of the Association in Washington and also in the Johns Hopkins Laboratory, for a few months in the autumn of 1923. It was always a marvel to me how one man could carry two such man-sized obligations without apparent physical impairment. Dr. Livingston seldom admitted that he was tired, yet he always carried a burden too heavy for one man's shoulders. He served the Association for three years as general secretary (1931–34); and throughout the whole period of his connection with the Association, he was a member of its Executive Committee, helping to shape its policies during a long period of phenomenal growth. Few men have served the Association so long and so well.

Dr. Livingston's death on February 8, 1948, leaves his many students, colleagues, and friends, who were legion, with a deep sense of personal loss.

CHARLES A. SHULL
42 Oakwood Street, Asheville, North Carolina