mentalists that bio-mechanical adaptation can be induced by sudden changes in the genes. Whatever may be true of sudden bio-chemical adaptations a presumption from this overwhelming bio-mechanical evidence is that *both bio-chemical and bio-physical evolution is also along continuously adaptive and creative lines.*

William Bateson, founder of the genetic school, finally declared that genetics could not explain the origin of a single species. Modern paleontological research, on the other hand, reveals with absolute clearness and fullness not only how species originate bio-mechanically, but the inner interpretation of divergence in every grade of animal organization from the minute ascending mutations up to the higher points in the development of genera, families and orders.

The modes of these transmutations of form which from the same original materials produce the horse, the rhinoceros, the titanothere and the elephant are now absolutely clear, but the internal causes of these marvelous bio-mechanical transmutations of the germ plasm are far more mysterious and incomprehensible than they were in the time of Charles Darwin.

# OBITUARY

## ALBERT A. MICHELSON

AT one o'clock on Saturday afternoon, May 9, 1931, death came very quietly in his home in Pasadena to the most illustrious of the American physicists of our generation, at the age of seventy-eight years and five months. Six weeks earlier he had taken to his bed, after having made with his associates, Messrs. Pease and Pearson, enough observations to assure himself that his last experiment on the speed of light as measured in an evacuated pipe a mile long and three feet in diameter buried in the earth on the Irvine ranch near Santa Ana, California, was going to yield results as satisfactory as he had anticipated. This experiment had been planned for the sake of obtaining a check by a method entirely free from atmospheric effects of all kinds upon the accuracy of his next preceding determination made over a twenty-one mile stretch between California mountain peaks. He did not expect by these new experiments to exceed the accuracy previously obtained, but rather to add something to the *reliability* of the previous determination.

More than a month before his death, Mr. Michelson had known that he would never get up again, for a creeping paralysis was coming over him of which he himself was altogether conscious. His mind was quite clear until two days before the end, when a lesion occurred which brought on unconsciousness within an hour, an unconsciousness from which he never again awoke.

As one of the men who has had the most enduring and most intimate association with Mr. Michelson and his work, I esteem it a privilege to now make a few additions to my former appreciation of him and his achievement.

Under the caption, "Michelson's Economic Value," now published as Chapter VII in a volume by Scribner's entitled "Science and the New Civilization," I have attempted to appraise in broad lines the significance for our times of measurements of the highest skill and accuracy of the sort which Michelson has done and for which his name stands the world over, and I should like to refer to that appraisal and merely supplement it here by adding some details both of a scientific and of a personal sort.

Practically all Mr. Michelson's work in physics centered about determinations for increasing the precision of measurement. He has been called an extremely skilful and intelligent instrument designer, but while he was that he was much more than that, for his attention was always on the problem to be solved, not primarily on the instrument for solving it, and he was always seeking for problems incapable of solution save by improvements in the accuracy of measurement. Ten different times in the fifty-one years of his activity, extending from 1880, when at the age of twenty-eight he became the best known American physicist by virtue of his new speed-of-light measurement, up to 1931, when he died, still trying to prove the certainty of his determination and precision of that most fundamental constant, he made major outstanding advances, which I list as follows:

(1) Measurements of the speed of light, 1880–1931.

(2) Development of the Michelson interferometer, 1882, *et seq.*

(3) Ether-drift experiments, 1887–1928.

(4) The first analysis of the fine structure of spectral lines, 1894–1900.

(5) Development of the Michelson-Stratton harmonic analyzer, 1897.

(6) Development of the principle of the Echelon spectrograph, 1898.

(7) Perfection and increase in resolution of the line grating, 1902–1917.

(8) First accurate measurement of the rigidity of the earth, 1916.

(9) Development of the U. S. naval range finder, 1918.

(10) Direct interferometer measurement of the diameter of stars, 1921.

Of these ten, four—namely, the second, third, fourth and tenth—have to do primarily with the interferometer or its application to various sensitive measurements. It was in measurements relating to the interference of light and speed of light that he was by far the greatest expert that the world has yet seen. He spent his scientific life largely in these two fields. He was not an omnivorous reader of the literature of physics, and did not try to follow closely the developments of the theoretical fields of electronics and quantum theory. He was essentially a classical physicist, but any one who ever heard him conduct a Ph.D. examination in physics, and any one who ever attended his lectures or heard him speak knows that his grasp of classical physics was penetrating and precise. His lectures and his papers were masterpieces of elegance and conciseness. He used few words, but they were just the ones he wanted. Indeed, the precision of his mind was its dominating characteristic, which showed even in his sports. I have played tennis with him all my life, and his calling of balls, for example, was never generous either to himself or to his opponent. It was simply exact and just. Closely allied to this characteristic was his altogether extraordinary honesty. Pretense of any kind was utterly foreign to his make-up. Indeed, he was one of those very rare persons who would not even tolerate fooling himself with respect to his own motives, as so many of us do. If his conduct was ever ungenerous he knew it and frankly admitted it, whether he thought it wise to change it or not. Before I became intimately associated with him I had heard that he was considered by his pupils to be somewhat unapproachable, occasionally arbitrary, and at times dictatorial, if not unreasonable, but in the twenty-five years in which we worked together I could not have been treated with greater courtesy and consideration, even in the few cases in which we differed in judgment. His dignity and courtesy of bearing were altogether striking characteristics, and as the years passed he grew to be a man of great mellowness, kindness and affability.

Like many a scientist, Mr. Michelson was also an artist, with a keen feeling for form and color, as well as for music. He painted well, played the violin well, and did well at tennis, chess and billiards.

American science and the American nation have lost in his death one of their finest and greatest figures.

ROBERT A. MILLIKAN

MAY 11, 1931

## VERANUS ALVA MOORE—PIERRE AUGUSTINE FISH

BOTH these men were natives of New York State—Dr. Moore, of the western border in the Lake Ontario basin, and Dr. Fish of the eastern portion in the Hudson River Valley. Both received their early education in the schools and academies of the state, and both were graduates of Cornell University.

Both were called as heads of departments in the original faculty of the New York State Veterinary College at Cornell, and finally both became deans of the college, Dr. Moore succeeding Dr. James Law in 1908, and Dr. Fish succeeding Dr. Moore in 1929. Their friendship, mutual help and confidence in each other continued without a break till the end of life. Both, as if of one spirit, served their country in the World War.

Veranus Alva Moore was born at Houndsfield, Jefferson County, New York, April 13, 1859, and died at Ithaca, New York, on February 11, 1931. His parents were Alva and Antoinette Eastman Moore.

The Moore family, as was common in pioneer days, had mainly the wealth of strong hands and independent character. The father died when the boy was but thirteen years old, thus compelling him to assume the duties of a man very early in life. Young Moore had the manly qualities, and went out to work on a farm to support himself and to help the mother and children. In this farm labor he had the misfortune to step on a nail, which penetrated his foot and set up an infection in the bones which caused him much suffering for the next ten years.

This accident compelled him to come in contact with physicians to obtain relief, and he finally became a patient in Bellevue Hospital, New York. There he saw hospital management and ate the hospital food of the time. He also saw and was operated upon by the famous surgeons of the period, and saw all too often the infections which followed operations. Knowledge of the rôle played by bacteria in infections was known and appreciated by very few, and the pioneer work of Lister in applying to surgery the knowledge of micro-organisms which Pasteur had made known was then not deemed worthy of serious consideration in the minds of most of the medical men.

This contact with physicians and hospitals was destined to have a great influence on Moore's life and to determine later its trend. Meanwhile he made great progress in fundamental education, taught district school, and made a success of it in spite of the crutches he had to use. Never satisfied with present attainments, he passed from the district schools to Mexico Academy, in Oswego County. There he came under the stimulating influence of one of the fine principals (James Gifford) found everywhere as heads in the academies (really junior colleges) of those days. He graduated from the academy in the spring of 1883, and in the fall of that year entered Cornell University, and graduated with his class in 1887.