and discoveries have spread like an infection until to-day they cover the earth.

Darwin, the master of the organic world, sleeps near Newton, the master of the inorganic, in the great Abbey, among the most famous of his race. Pasteur rests alone in the chapel of his laboratory. The world claimed Darwin's body to place among its great ones. Science kept Pasteur's for its own. Both dwell forever among the immortals. The last half of the nineteenth century may well be called their age—the Age of Darwin and Pasteur.

EDWARD EMERSON BARNARD

THE death of E. E. Barnard on February 6, 1923, brought to a close a life and a career which were at once among the most notable and the most inspiring recorded in the annals of American science. The loss will be felt almost as keenly in every country where science is cultivated and loved. Here and there in every generation there breaks through the magma of our common clay a man whose mind is lighted and whose will is energized by a ray of genius. Such a man was he. The manner in which Nature chooses her sparking points and brings together the unusual elements of personality which make a marked man is only beginning to be recognized.

The outward circumstances of Mr. Barnard's life are so well known to most readers of SCIENCE that recitation of them is barely necessary. Even to himself as he struggled and won there must have come often the thrill of romance. To others, unacquainted with the details of his heroic struggle, he personifies in his life the freedom, the opportunity, the vigor and love of action inherent in our great democracy. Sketches and books will be written about him. No better investment in personality could be made than to render the facts and circumstances of his life and work easily accessible to the boys and girls of our country, whom he loved so well and believed in so fervently.

Mr. Barnard was born in Nashville, Tennessee, December 16, 1857, and died in his home near the Yerkes Observatory in the evening of February 6, 1923. His father died before he was born and his mother in 1884. One brother survives him. His early education was given him by his mother. His work as a boy helper in the photographic studio of the brothers Calvert in Nashville and the loan of Dr. Thomas Dick's book, "The Practical Astronomer," combined to stir his imagination and direct his attention toward the subject which was to become his lifelong and sole passion, astronomy. The acquisition of a five-inch telescope in 1877 led him on in his study of the celestial objects, notably Jupiter. In this year the annual meeting of the American Association for the Advancement of Science was held in Nashville and he became a member. On January 27, 1881, he married Miss Rhoda Calvert, the gentle sister of his employers, whose life became devoted most completely to solicitous care for her husband and whose death came less than two years before his own.

On the morning of May 12, 1881, he found a faint comet in the field with Alpha Pegasi and after observing it again the next morning he telegraphed the discovery to Mr. Lewis Swift, of Rochester, N. Y., a veteran comet-seeker. In spite of diligent search by both of these men, and by others, no further trace of it was ever found. Either just before or after this experience Mr. Barnard began his systematic search for comets and on September 17 he was rewarded by finding the comet which is known as Comet VI 1881. Before he left Nashville to join the newly organized staff of the Lick Observatory on Mount Hamilton in California he had discovered nine new comets. He later found seven more, bringing his total up to sixteen. One of these he found by photography on October 12, 1892, the first ever found in this manner.

His early discoveries and his earnestness and zeal attracted the attention of the chancellor and the instructors of the recently established Vanderbilt University at Nashville. In 1883 he was offered a fellowship at Vanderbilt and was given such sympathetic assistance that by tutoring and studying day and night he was able to graduate in 1887. During this time he was in charge of the university's six-inch telescope. In 1889 he received the A.M. degree of the University of the Pacific, in 1893 the degree of Sc.D. from his alma mater and in 1909 the degree of LL.D. from Queen's University, Kingston.

At the Lick Observatory his association with Sherburne Wesley Burnham cemented a friendship which lasted for life. Mr. Burn-

ham, his senior by nineteen years, was already at that time a famous observer whose kindly interest was reciprocated by the greatest admiration on the part of the younger man. When the Yerkes Observatory of the University of Chicago was organized in the middle nineties, both became professors of practical astronomy on its staff and remained so, Mr. Burnham until he retired in 1914 at the age of seventy-five and Mr. Barnard until his death.

While at the Lick Observatory he continued his visual work on comets and the planets and developed the methods of photographing comets and the star clouds and nebulosities of the Milky Way. Then, on September 9, 1892, he glimpsed the diminutive inner moon of Jupiter, with the thirty-six inch refractor, confirmed his observation on the following nights and in a few weeks he had convinced an incredulous world of astronomers that Jupiter has a fifth satellite which is unique in its location and behavior as well as most difficult to see on account of its close proximity to its brilliant master.

Almost immediately, recognition for this remarkable discovery was given him, when, before the year was out, the French Academy of Sciences voted him the Lalande Medal, following up its growing admiration of his feat by giving him the Arago Medal in 1893. In 1897, formal recognition of this discovery and of his other work came from the Royal Astronomical Society of London in the shape of its gold medal. Later, in 1900, the French Academy again honored him with the Janssen Gold Medal. Then, in 1906, the Astronomical Society of France presented him its Janssen Medal and in 1917 the Bruce Gold Medal of the Astronomical Society of the Pacific was awarded him for his long and notable activity. Only the year before, he had added to his list of discoveries the faint star in Ophiuchus, which has the largest known proper motion, 10.3 seconds of arc a year, and a parallax exceeding half a second of arc. He was a member of the National Academy, the American Philosophical Society and the American Academy of Arts and Letters. Since 1914 he was a trustee of the Benjamin Apthorp Gould Fund and an associate editor of the *Astronomical Journal.*

Like his great friend Burnham a tireless worker, he was most unlike him in the distribution of his efforts. Mr. Burnham concentrated on two allied lines of work, orbital motions and proper motions of stars. Mr. Barnard's published observations encompass every type of object in the sky. While thoroughly philosophic in his method and in his attitude of mind his interest was in discovery and description rather than in theory. His published articles and notes number more than eight hundred and forty. Here, to mention a few, are announcements of comets; positions, photographs and drawings of these fascinating objects, which never ceased to thrill him, and of surface details of the planets; measures of sizes and positions of primaries and satellites; exhaustive light curves of novæ and of variable stars, for one of which, at least, he gave the period to such a degree of accuracy that he was wont to say it could be used as a fundamental clock, in somewhat the same manner that Mr. Michelson's wave-length of the red line of cadmium can be used as the standard of measurement of length; long lists of auroræ with dates and descriptions; discussions of meteoric trails and methods of defining them precisely; discussions of the technique of photography and the performance of lenses; measures of difficult and important double stars like Sirius and Procyon; the parallax of Krüger 60 from micrometric measures; a long series of micrometric measures of position of Eros in 1900-1901; magnificent photographs of terrestrial cloud forms which have found their way into treatises on the atmosphere of the earth; a masterful biographical appreciation of his friend Burnham; photographs and description of the solar corona obtained in the three total eclipses which he observed, in California, 1889, North Carolina, 1900, and Wyoming, 1918;[1] observations of the Zodiacal Light, the Gegenschein, which he discovered independently in 1883, and the luminous night haze. Volume XI of the Publications of the Lick Observatory is made up of his photographs of the Milky Way and of comets taken at Lick and his notes and descriptions of them.

[1] All his preparations and the longest journey he ever made to observe a total eclipse of the sun were in vain when bad weather obscured the sun at the critical time in the Sumatra eclipse of 1901.

Up to within less than a week of his death, while in bed, he worked with his invaluable assistant, Miss Mary Ross Calvert, upon the text of his "Atlas of the Milky Way" from negatives taken at the Yerkes Observatory and, for some of the more southerly fields, at Mount Wilson during a stay of some months at that observatory in 1905. This atlas, which he had hoped to finish during the present year, will be published by the Carnegie Institution of Washington. His close study of these magnificent photographs led him to distinguish sharply between what he held were vacant spaces in the galaxy and those due to opaque masses of matter lying on the near side of the star clouds. His great series of triangulations with the micrometer on many of the globular clusters were continued for a quarter of a century and will be published in due time. When he began them he expected to find internal motions within a few years, but, as he measured, his universe grew larger and even with the great Yerkes telescope he was able to find the slightest traces of motion only for a very few stars. His one hobby was his orchard, where he fought valiantly and scientifically the pests which would rob him of his fruit. His eye was keenly open to terrestrial nature about him and he never wearied in telling the beauty of the swelling bud, the marvelous structure of the oak ball, the mysterious career of the *Cicada septendicem* or the adaptation of form to mode of life of the lowly chigger.

Observing with a large telescope was to him as a sacrament and with his highly varied program of observation he would persist under atmospheric conditions which compelled other observers to desist. When he lectured, as he did often and well, he was not at ease until he became so completely engulfed in the flow of his presentation that his self-consciousness left him.

More than most men, he was beloved by his fellows for his unselfish charm. We, who have lived with him for many years, miss his light footfall in the corridor, his friendly smile and his charitable counsel.

Astronomy, which gave him his greatest pleasure in life, was herself immeasurably enriched by his restless activity for nearly half a century.

OLIVER J. LEE

SCIENTIFIC EVENTS

THE HABER PROCESS[1]

THE lecture delivered by Professor F. Haber on the award of the Nobel Prize at Stockholm on June 1, 1920, is printed in *Die Naturwissenschaften* for December 8. Professor Haber dealt first with the work done on the synthesis of ammonia before his first research in 1905. Practically nothing of importance had come to light, and the very small yields at ordinary pressures did not hold out much promise of technical application.

The early experiments of Haber, like most of those which have served as the foundations of great industrial undertakings, were made with a purely scientific object, and with no technical applications in view. The results obtained, however, soon made it clear that the basis of an important technical process could be found in ammonia synthesis, and further work was undertaken with this end in sight.

In 1908 the Badische Gesellschaft placed at Haber's disposal all the means requisite for the further progress of the research on the synthesis of nitric oxide in the electric arc which he had begun in 1907, but his proposal to undertake research on the synthesis of ammonia was received with open doubts as to the potential value of the method. The nitric oxide syntheses, in cooled arcs under reduced pressure, and in flames and explosions, were not found suitable for technical application, and attention was then turned to the stone which the builders had rejected. The judgment of the technical chemists of the Badische Gesellschaft had been at fault, since ammonia synthesis was ultimately a very real solution of the problem of the economic utilization of atmospheric nitrogen.

Ramsay and Young in 1884 had found that with nitrogen and hydrogen in presence of iron at 800° C. no ammonia was produced. This was found to be incorrect, and traces of ammonia were detected. Other catalysts were tried, and from the results it was evident that an equilibrium state was attained, from which it was possible to calculate the yields at other temperatures and pressures. No further progress was made, however, since it was judged by the technical experts to be impos-

[1] From *Nature*.