

THE WESTERN PENNSYLVANIA HISTORICAL MAGAZINE

VOLUME 60

OCTOBER 1977

NUMBER 4

WESTERN PENNSYLVANIA'S CONTRIBUTIONS TO THE AGE OF SCIENCE

MAX A. LAUFFER

Introduction

WHEN I was invited to present a paper on the history of science in Western Pennsylvania, I was so highly flattered that I accepted without giving adequate thought to the implications. I am not a historian. I think I can appreciate the problem of the historian — the need to abstract the essential from the vast accumulation of recorded human experience, but I know nothing of the peculiar techniques and accepted criteria of the professionals. Something within me warns that my lack of competence would be most dramatically exposed if I were to attempt to evaluate the more recent past. Thus, I made the decision to terminate my history at approximately 1950.

The word science, as I use it, means organized, systematized, or abstracted knowledge about man, about the biosphere which constitutes his environment, and about the physical universe in general. In the English-speaking world, the understanding of the word without modifier is restricted to the equivalent of the German, *Naturwissenschaft*, natural science, as contrasted to the more general term, *Wissenschaft*, denoting all kinds of organized knowledge.

Science is different from but, nevertheless, closely related to technology, industrial, medical, and agricultural. Some argue whether technology advances because of scientific discovery or if basic scien-

Dr. Lauffer, Andrew Mellon Professor of Biophysics at the University of Pittsburgh, is a native of Middletown, Pennsylvania. He received a Ph.D. from the University of Minnesota, and his research interests have concentrated on biophysics, biochemistry, and medicine. This article is derived from Dr. Lauffer's May 4, 1977, public lecture at the Society.—Editor

tific progress is an outgrowth of technological advancement. Such disputation is a waste of time. The truth is that, historically, the two have interacted in a complex way; sometimes technology came first and at other times science. The production and use of bronze and later of iron long antedated any substantial science of metallurgy. Agricultural technologists developed specialized breeds of domestic animals and varieties of plants long before the principles of genetics were understood. Drugs were used effectively in medical practice long before pharmacology was a mature science. Vaccination against smallpox, a virus disease, was practiced successfully a century before there was any science of virology, and one could mention many other examples of the same sort. But there are also numerous instances in which scientific discoveries initiated great technological advancement. X rays were discovered in the laboratory by a physicist merely trying to satisfy his curiosity. The industrial and medical uses of X rays grew out of this basic scientific discovery. Similarly, the discovery of nuclear fission was a purely scientific breakthrough, the result of experiments stimulated in large measure by the theory of relativity. Military and industrial applications of atomic energy and the vast technology we know today followed. Penicillin was discovered almost by accident by an alert scientist actually working on something else. Medical technology and the use of penicillin and similar antibiotics for the treatment of disease came later. DDT was first produced in the laboratory; its use and misuse in the control of disease-transmitting insects and of agricultural pests followed scientific discovery. The modern plastics industry grew out of basic scientific studies in polymer chemistry, but some of the earliest basic findings originated in an industrial laboratory obviously stimulated by technological concerns. The point to all this is that science and technology have developed together with variable lag times; sometimes one was first, sometimes the other; neither can be considered the handmaiden of the other.

Early Industrial Technology

It is necessary, therefore, to outline technological developments in Western Pennsylvania to set the stage for the discussion of science. Overwhelmingly we think of industrial technology in this area. Pittsburgh and the surrounding region is one of the major industrial centers of the world. Pittsburgh is today a leader in the manufacture of glass. One of the first industries established in Pittsburgh was the glassworks founded by James O'Hara and Isaac Craig in 1797. This

glassworks was similar to many others scattered here and there during colonial times and in the early years of the Republic, with one important exception: coal was used as the fuel.¹ Coal in Western Pennsylvania was mentioned by Colonel James Burd in 1759 and on Coal Hill (Mount Washington) in Pittsburgh by the Reverend Charles Beatty in 1760.² As we all know, coal and other fossil fuels so abundant in Western Pennsylvania were the keys to the remarkable industrial development of our area.³

We are also aware of the dominant position of Pittsburgh and Western Pennsylvania in the iron and steel industry. As settlers moved into the west, they established small furnaces for the production of iron. There were thirteen in Fayette County, several in Centre County, and one in Pittsburgh near the end of the eighteenth century.⁴ Small quantities of iron ore, outcrops of limestone, and forests for the production of charcoal were widespread. How then did the iron and steel industry get concentrated close to Pittsburgh? The secret is coke, made from bituminous coal just as charcoal is made from wood. Even though there had been a long prior history of coking in Europe, the first coke in the United States was made in 1817 near Connellsville.⁵ Coke ovens were used beginning in 1841, and by 1859, coke was used as the blast-furnace fuel for the reduction of iron ore. From that point on, it was natural for the iron and steel industry to be concentrated near the supply of good coking coal. When coke is made from coal, there are by-products, especially coal gas, a good fuel, ammonia, and coal tar. These were wasted as atmospheric pollutants in old-style beehive ovens, but in more modern technology they are recovered. Coal tar is useful in its own right for roofing and paving, but is also the source of important chemicals, including benzene, naphthalene, anthracene, phenol, and many others.⁶ Coking technology has thus become the source for a vast chemical technology.

1 Lowell Innes, *Pittsburgh Glass 1797-1891: A History and Guide for Collectors* (Boston, 1976), 10; Dorothy Daniel, "The First Glasshouse West of the Alleghenies," *Western Pennsylvania Historical Magazine* 32 (Sept.-Dec. 1949): 97.

2 C. M. Bomberger, *Twelfth Colony Plus: The Formative Years of Pennsylvania and a Biography of James Buchanan* (Jeannette, Pennsylvania, 1934), 108.

3 Frederick Moore Binder, *Coal Age Empire: Pennsylvania Coal and Its Utilization to 1860* (Harrisburg, 1974), 1-4.

4 Arthur Cecil Bining, *Pennsylvania Iron Manufacture in the Eighteenth Century* (Harrisburg, 1938), 61, 64.

5 Bomberger, *Twelfth Colony Plus*, 112.

6 Edmond O. Rhodes, "The History of Coal Tar and Light Oil," in Arnold J. Hoiberg, ed., *Bituminous Materials: Asphalts, Tars and Pitches*, 3 vols. (New York, 1964-1966), 3: 1-31.

Petroleum technology has revolutionized our way of life during the last century. Machinery of all kinds can be lubricated; a source of fuel is available for land, water, and air transportation; energy and a source of chemicals are supplied to industry. The petroleum industry began in Western Pennsylvania when Colonel Drake struck oil in a sixty-nine-foot well near Titusville on August 27, 1859. Western Pennsylvania in general and Pittsburgh in particular is a major center of the petroleum industry to this day.

Pittsburgh is also the center of the aluminum industry in our hemisphere. This time technology was not attracted by a coal bank but instead by a Mellon bank. In 1886, Charles Martin Hall discovered at Oberlin College that the common mineral, alumina or aluminum oxide, would dissolve in melted cryolite, a mineral composed of sodium, aluminum, and fluorine. This solution would then deposit metallic aluminum when an electric current was passed through it. This basic discovery in electrochemistry was the foundation of America's vast modern aluminum industry. After several unsuccessful attempts to obtain stable financial backing, Charles Hall won the confidence of the Mellon brothers and the financial resources needed to develop his invention on an industrial scale. His first factory was on Smallman Street in Pittsburgh, which began commercial production of aluminum in the summer of 1888.⁷ From this small beginning grew a vast industrial empire with headquarters in Pittsburgh.

George Westinghouse came to Pittsburgh in 1868 and began manufacturing railroad equipment. Later, he became interested in the transmission of electric power. A direct-current system had been installed in New York City in 1882, based on principles devised by Thomas Edison, but the trouble with a low-voltage direct-current system was that power could be transmitted for very short distances only, a mile, more or less. Westinghouse was convinced that the answer to long-distance power distribution was alternating current, transmitted at very high voltages, reduced to safe voltages close to the consumer.⁸ Such a system required the perfection of the transformer and the development of an alternating-current generator. The physical principle on which the transformer could be developed, electromagnetic induction, had been discovered by Michael Faraday in London in 1831 and independently a short time later by Joseph Henry in Princeton. In 1883, Gaulard and Gibbs obtained British patents for an in-

7 "News Report on Award of the Perkins Medal to Charles M. Hall," *Journal of Industrial and Engineering Chemistry* 3 (1911): 143.

8 Donald C. Burnham to the author, Apr. 12, 1977.

duction coil system based on this principle. Westinghouse purchased these patents and then, with the help of William Stanley, developed a practical transformer for changing alternating current back and forth between high voltage for transmission and low voltage for use. Stanley also developed an alternating-current constant-voltage generator. In 1886, the company bearing the name of Westinghouse began business, and that same year the first alternating-current generator was installed in Greensburg, Pennsylvania. Two years later, Westinghouse obtained the Tesla patents underlying polyphase alternating-current machinery, and in 1890, a successful alternating-current transmission line went into operation between Willamette Falls and Portland, Oregon — a distance of fourteen miles. The great electric power industry, with the Pittsburgh area as one of the principal centers in the United States, developed rapidly from this beginning.

Science and Technology

The interaction between science and technology was clearly apparent in Europe in the nineteenth century, but this was not true in America. Industrial technology expanded with little dependence upon recent scientific discoveries and with little feedback to scientific investigation. This was true of the technology in Western Pennsylvania with but few exceptions, notably the electric power and the aluminum industries. Robert Kennedy Duncan perceived this lag, publicized it clearly and convincingly,⁹ and then set about to rectify the situation by establishing a laboratory at the University of Kansas where scientific investigations directed toward the solution of industrial problems were carried out. This he believed would be advantageous to scientists and industrialists alike. Duncan's work attracted the attention of Andrew W. Mellon and Richard B. Mellon, who invited him to come to Pittsburgh to establish a Department of Industrial Research at the University of Pittsburgh in 1911. Within two years, this initial effort evolved into the Mellon Institute of Industrial Research and the School of Special Industries of the university. The institute continued as a part of the University of Pittsburgh until 1927, when it was independently incorporated. Forty years later the Mellon Institute merged with Carnegie Institute of Technology to become Carnegie-Mellon University.

During its history, the Mellon Institute had two closely inter-

⁹ E. O. Rhodes, "The American Way in Industrial Research," *Journal of Industrial and Engineering Chemistry* 31 (1939): 549-56.

related goals. One was the pursuit of fundamental or basic scientific research. The other was the application of scientific knowledge and procedures to the solution of the problems bearing on man's health, welfare, and comfort. Scientific application was supported through contracts with industrial sponsors. Pioneering industrial research carried out at the Mellon Institute, particularly under the long leadership of Edward R. Weidlein, resulted in the creation of many new industries; the Visking Corporation, the Plaskon Company, Dow-Corning Corporation, and Union Carbide Chemicals Company are examples. The Gulf Research and Development Company at Harmarville, with its extensive research program, grew out of a fellowship at the Mellon Institute.¹⁰ All the while, the institute conducted basic research in the fields of synthetic organic chemistry, in part aimed at disease control, and X-ray crystallography. The Mellon Institute has made a great contribution toward establishing close interaction between science and technology in America.

Technology, as well as the applied science closely associated with it, is both local and worldwide. It is local in the sense that the economy of the immediate region is profoundly affected, but worldwide in the sense that the products and services developed can be internationally distributed. Pure science, in contrast, belongs to the whole of humanity. Like art and literature, it is a major achievement of the human mind. Its consequences, including both its benefits and its liabilities, are felt by all of mankind. In one sense, therefore, it is an inappropriate exercise to speak of pure science in our region; pure science originating in Western Pennsylvania is neither more nor less important to us than pure science originating anywhere else. Furthermore, as one will observe as we go along, scientists are an extremely mobile group — here today and gone tomorrow. However, it does appeal to our sense of pride to know that people who lived or worked in our region have made important contributions to pure science; after all, we are not living in an intellectual desert.

Science Teaching Before the Civil War

It is impossible to set a specific date for the beginning of modern science, but the publication in 1686 of the *Principia* by Isaac Newton certainly represented an event which gave enormous impetus to the development of physics, the most mature of the sciences. This event

¹⁰ Agnes Lynch Starrett, *Through One Hundred and Fifty Years: The University of Pittsburgh* (Pittsburgh, 1937), 469-80.

occurred almost simultaneously with the founding of Pennsylvania and only 101 years before the founding of the Pittsburgh Academy, the legal and institutional forerunner of the University of Pittsburgh. As early as 1789, mathematics, and later astronomy and natural philosophy, were advertised as part of the academy's curriculum. Beginning in 1811, a Dr. Aigster gave lectures in chemistry. In 1819, a new charter was granted, transforming the Pittsburgh Academy into the Western University of Pennsylvania. Robert Bruce, who became the first principal of the new university, lectured on astronomy in 1819. His full title was: Principal and Professor of Natural Philosophy, Chemistry, Mathematics, etc. Ten years later, the university engaged Peter Laurig to teach chemistry.

Gilbert Morgan interrupted the principalship of Dr. Bruce for one year. When he was inaugurated president of the university in 1835, he added Dr. Tobias Harper Mitchell as professor of chemistry, mineralogy, and natural history. When Dr. Heman Dyer became principal in the middle 1840s, he appointed Lemuel Stephens professor of chemistry, mathematics, and natural philosophy. Dr. George McLean served as professor of chemistry from 1857 to 1859 and was succeeded by Dr. George F. Barker. Dr. Barker had the distinction of producing light in the course of one of his lectures by passing an electric current through a resisting element.¹¹

The Western University of Pennsylvania and its forerunner, the Pittsburgh Academy, were not the only educational institutions established by the pioneers in the late eighteenth and early nineteenth centuries. Not later than 1780, the Reverend John McMillan opened a Latin school in the kitchen of his home to train young men for the ministry.¹² Later the school moved to Chartiers, and in 1791, according to some authorities, it became part of Canonsburg Academy, which evolved into Jefferson College, chartered in 1802. In 1826, the Reverend Richard Campbell became professor of languages and mathematics at Jefferson, resigning in 1827. The Reverend John H. Kennedy was appointed professor of mathematics and natural philosophy in 1830 and remained in office until he died in 1840. In 1832, Jacob Green, M.D., was appointed professor of chemistry, mineralogy, and natural history. He died in 1851. Other prominent scientists were William Darby, who served as professor of history, geography, and mathematics in 1838-1839, Richard S. McCulloh, who was professor of

¹¹ *Ibid.*, 97, 112-13, 143.

¹² Dwight Raymond Guthrie, *John McMillan: The Apostle of Presbyterianism in the West, 1752-1833* (Pittsburgh, 1952), 80.

mathematics, natural philosophy, and chemistry between 1841 and 1843, and McCulloh's successor, S. R. Williams, who resigned in 1852.¹³

Washington Academy was chartered in 1787, a few months after Pittsburgh Academy, and became Washington College in 1806. That same year saw the appointment of James Reed as professor of mathematics and natural philosophy, and he served until his resignation in 1823. John W. Scott was professor of mathematics from 1824 to 1828. Then there seems to have been a hiatus until 1852, when the Reverend William P. Alrich became professor of mathematics, resigning in 1860. From 1854 until 1865, when Washington College and Jefferson College combined to form the present Washington and Jefferson, William J. Martin, William H. Brewer, Dr. Alex Muckle, and the Reverend William J. Brugh served successive terms as professors of natural science.¹⁴

To the north, Allegheny College in Meadville was founded in 1815 and chartered three years later. Reynell Coates, M.D., became Winthrop Professor of Natural Philosophy and professor of chemistry in 1829, and the Reverend David McKinney became professor of mathematics that same year. Both resigned after one year. Matthew Simpson served as professor of chemistry from 1837 to 1839. About 1864, a Professor Tingley was appointed in physics and chemistry, a combination of duties which persisted for thirty years.¹⁵

The First Major Scientific Discovery

It is apparent from the preceding discussion that during the first half of the nineteenth century there was an awareness of science in Western Pennsylvania as reflected by the fact that it constituted part of the curriculum, even though sporadically, in each of the institutions of higher education operating at that time. The first major scientific discovery in Western Pennsylvania came in the beginning of the second half of the century. Dr. David Alter¹⁶ was a physician who resided in Elderton and later in Freeport. He obtained his medical degree in New York in 1831 and then returned to practice

13 Joseph Smith, *History of Jefferson College* (Pittsburgh, 1857), 116; *Biographical and Historical Catalogue of Washington and Jefferson College* (Philadelphia, 1902), 14-15.

14 *Catalogue of Washington and Jefferson College*, 282-83.

15 Ernest Ashton Smith, *Allegheny — A Century of Education, 1815-1915* (Meadville, 1916), 61-62, 106-7, 192.

16 W. A. Hamor, "David Alter and the Discovery of Spectrochemical Analysis," *Isis* 22 (1935): 507-10.

medicine in Western Pennsylvania. From his boyhood and throughout his life, he had an interest in electricity, and later in life he also studied chemistry and spectroscopy. In 1854, he published a paper in the *American Journal of Science and Arts* with the imposing title, "On Certain Physical Properties of Light, Produced by the Combustion of Different Metals in the Electric Spark, Refracted by the Prism." Anyone who has seen a rainbow knows that droplets of water will spread sunlight into a spectrum with high-wavelength red light on one edge and low-wavelength violet light on the other. From a scientific, though not from an aesthetic, point of view, a prism made of good quality optical glass does an even better job. We are all familiar with the bright colors obtained by sprinkling certain kinds of salt over an open fire. What we see is the light emitted by the atoms in those salts when they are raised to high temperatures. Again, from a scientific viewpoint, an electric arc does an even better job in producing atomic emissions.

What Alter did was to examine with a prism the light coming from electric arcs with different kinds of atoms in the gap. He found that the spectrum was composed of sharp, bright lines of light with the high-wavelength red on one edge and the low-wavelength violet on the opposite edge, and with the other colors in between. Others had seen atomic emission spectra before, but Alter was the first to realize that each kind of material examined exhibited a different characteristic spectrum.¹⁷ Thus, he laid the foundation for atomic emission spectroscopy as a tool of chemical analysis. This work was done five years before the great European physicists Bunsen and Kirchhoff systematized the subject, and as will be seen subsequently, much of the work of developing this discovery into an important tool for chemical analysis took place in our area.

Science from the Civil War to World War I

For the period between the Civil War and World War I, we now turn our attention to scientific developments at the Western University of Pennsylvania, now the University of Pittsburgh, and especially to its Allegheny Observatory. The appearance of Donati's comet in 1859, a very bright object, excited the interest of several Pittsburgh businessmen to organize the Allegheny Telescope Association, which in 1861 mounted a telescope in a new building in the city of Allegheny, later to become part of Pittsburgh. In 1867, the instrument

¹⁷ *Ibid.*

and its building were donated to the Western University of Pennsylvania. In that same year, Samuel Pierpont Langley came to Pittsburgh as professor of astronomy and physics and director of the Allegheny Observatory. With the help of Pittsburgh industrialist William Thaw, Langley improved the equipment of the observatory and built additional apparatus, including a small transit telescope used to observe the position of stars crossing the celestial meridian. From this he could determine time precisely. He then set up a telegraph network to Pittsburgh city hall and to local railroads, an event accredited by some as the beginning of eastern standard time. It permitted the railroads to coordinate their schedules. The money earned from this service helped to finance the Allegheny Observatory and its basic research.¹⁸

Langley's studies in astronomy included detailed investigations of sunspots and later of the intensity of solar radiation. For this latter purpose, he invented an extremely sensitive instrument for measuring radiation intensity — the bolometer. By attaching a spectroscope to the telescope, Langley was able to spread the sun's radiation into a spectrum and measure the intensity, or the amount of heat energy per unit area per unit time, coming from each portion of the solar spectrum. Not only did he study the visible spectrum but he also made measurements on the high wavelengths beyond the visible range, what we now call the infrared region. We are all familiar with the wonderful warmth radiated from glowing coals; we are therefore acquainted with infrared radiation. These accomplishments earned for Langley a position among the foremost scientists of the world.

However, Langley is even better known for his basic studies in aerodynamics. In the 1880s, Langley built his famous whirling table at Allegheny Observatory, where he determined the lifting power of various planes whirled at different speeds and at different angles. Langley left Pittsburgh in 1887, after a tenure of twenty years, to go to the Smithsonian Institution in Washington. He was soon elevated to the top position of secretary, but he continued to direct fundamental studies on aerodynamics at the Allegheny Observatory for several years. At the Smithsonian Institution, Langley built a small flying machine with a steam engine which, in May 1896, made a successful flight of three-quarters of a mile on the Potomac. In October

18 Theodora M. Lauterbach, "The Allegheny Observatory of the University of Pittsburgh," *Pitt* 46 (Spring 1952): 21-29; Starrett, *Through One Hundred and Fifty Years*, 289-92.

1903, Langley supervised a test of a man-carrying flying machine. It failed because of a defective launching apparatus, fortunately without injury to the pilot, and the machine was dubbed "Langley's Folly" by an unsympathetic press. Congress promptly cut off funds for further experimentation. Two months later the Wright brothers succeeded in human flight at Kitty Hawk. Langley died in 1906 in apparent defeat, but only eight years later, Glenn H. Curtiss flew "Langley's Folly" over Lake Keuka in New York State, although it is reported he did so with certain structural modifications and a new engine.¹⁹ Thus, Langley actually did build the first plane capable of manned flight, fickle fame to the contrary notwithstanding.

In 1876, a millworker named John A. Brashear offered Langley a homemade five-inch telescope lens for his inspection and comment. With the encouragement of Professor Langley and the financial help of Pittsburgh philanthropist William Thaw, Brashear became the best-known lens maker of his time. This remarkable man, with only a common-school education, became famous, not only as a lens maker, but as an astronomer, scientist, and educator. He served for a time in 1898 as acting director of the Allegheny Observatory and, in 1901, as acting chancellor of the university. He also played an active role in the development of the School of Engineering at the university.

Langley's successor as director of the Allegheny Observatory, beginning in 1891, was James E. Keeler. Keeler's fame rested substantially upon his demonstration that the rings of Saturn were not solid but composed of vast numbers of small particles in orbit about the planet. He proved this by combining the spectroscope with the telescope. Those of us who are old enough remember the romantic sound of the whistle of a locomotive, high pitched as the train approached, followed by a sudden lowering of the tone as it sped by. This is known in physics as the Doppler effect. The sound waves coming from a moving object have a shortened wavelength and, therefore, a higher pitch as an object approaches and have the opposite effect as it moves away. For exactly the same reason, the wavelength, and therefore the color, of light coming from a rapidly moving object depends upon the speed of the object relative to that of the observer. Keeler showed with his spectroscope that the rings of Saturn move at different speeds than they would if the rings were solid. From this,

¹⁹ J. Gordon Vaeth, *Langley: Man of Science and Flight* (New York, 1966), 35, 42-45, 83-85, 106-8.

he concluded logically that the rings were made up of small particles revolving about the planet at different speeds — a profoundly interesting basic scientific discovery. Keeler left the university in 1898 to become director of Lick Observatory, and he was succeeded briefly by Brashear as acting director; then, F. L. O. Wadsworth became director in 1899, remaining until 1906. Wadsworth's main contribution in Pittsburgh was to plan and supervise the initial stages of the construction of the present Allegheny Observatory, which, however, was not completed until 1912.

Frank Schlesinger became director in 1906 and remained until 1920. He was an expert in parallax when he came to Allegheny and there he instituted a program for measuring the distance of our neighbor stars. The principle involved was that of triangulation used by surveyors. The diameter of the earth's orbit about the sun forms the baseline of the triangle, and the angles pointing to a particular star are determined at six-month intervals. It is relatively easy to determine the distance to the nearest star by this method, but the farther out a star is, the more difficult accurate measurement becomes. Schlesinger became a worldwide authority on this method and the program he instituted at Allegheny Observatory has provided the most extensive and most reliable star-distance information obtained anywhere in the world.

Chemistry also made great strides just after the Civil War. In 1864, a chair was endowed in chemistry, geology, and mineralogy at the university, which was occupied by Professor B. C. Jillson until 1871. In 1872, he was succeeded by John W. Langley, the brother of Samuel P. Langley, who remained until 1875. John Langley was the first to introduce laboratory instruction in chemistry at the school. Francis Clifford Phillips, a chemist trained at the University of Pennsylvania and several German universities, arrived in 1875 to begin a forty-year tenure. At first, he too alone was responsible for chemistry, geology, and mineralogy, but he soon became a full-time chemist and developed chemistry from a one-man operation into an active department. For several years, beginning in 1911, chemistry had the status of a school with Dr. Raymond F. Bacon, director of the Mellon Institute, as dean and Phillips as department head. The university awarded the first doctor of philosophy degrees in chemistry in 1913.²⁰

Phillips collaborated for a time with Samuel P. Langley in a

²⁰ Starrett, *Through One Hundred and Fifty Years*, 149, 165; Alexander Silverman, "Francis Clifford Phillips," *Pitt* 43 (Spring 1951): 7-10; Fred Y. Herron, "Chemistry and the University of Pittsburgh," *ibid.*, 5-7.

study of the stars and nebulae by spectroscopic methods. His major contributions to science, however, dealt with methods of analyzing the constituents of iron and steel and in his studies of the chemistry of natural gas, during which he discovered a cracking process. Cracking processes are widely used in the petroleum industry to this day.

Another remarkable member of the faculty of the Western University of Pennsylvania was Reginald A. Fessenden, who came to Pittsburgh from Purdue in 1893 to occupy the newly created chair of electrical engineering. Fessenden was already a distinguished scientist at the time, so to make the situation financially attractive, George Westinghouse provided him with a generous consultantship. Fessenden was a student of the work of Maxwell and Hertz on long-wavelength electromagnetic radiation — radio waves as we know them today. He had also studied Marconi's development of these basic discoveries into wireless telegraphy, but he was not satisfied with the Marconi system, which permitted the transmission of telegraph signals only. During his seven-year tenure at Pittsburgh, his experiments led to the development of a device called a "liquid barretter," a more sophisticated device than Marconi used for modulating radio waves. This ultimately permitted, on Christmas Eve in 1906, transmission by radio of the human voice and of a violin solo.²¹

William Jacob Holland²² served as pastor of the Bellefield Presbyterian Church between 1874 and 1891. He was a man of many cultural interests, among them entomology, a field in which he became widely known. In 1891, he became chancellor of the Western University of Pennsylvania, resigning in 1901. Even before his resignation in 1898, he became the director of Carnegie Museum, a post he held until 1932. While Chancellor Holland was pursuing his entomological interests, E. A. Patterson, a teacher in several school districts in Western Pennsylvania, was busy assembling more than 12,000 botanical specimens, which he eventually donated to the Carnegie Museum.²³ Early in Holland's administration at the museum, in 1904, Dr. O. E. Jennings began his career in the section of botany. In his half century of active botanizing, Jennings added 75,000 specimens to the museum collection. Jennings also served the University of Pittsburgh, becoming head of the Department of Biological Sciences, a position he held until after World War II, when he

21 H. E. Dyche, "Fessenden," *ibid.* 7 (Spring 1941): 41-42.

22 Starrett, *Through One Hundred and Fifty Years*, 188-89.

23 "Wild Flowers of Western Pennsylvania and the Upper Ohio Basin," *Pitt* 38 (Autumn 1949): 3-5.

became director of the Carnegie Museum.²⁴ He collaborated for many years with the noted artist, Dr. Andrey Avinoff, to produce in 1949 the magnificent two-volume set, *Wild Flowers of Western Pennsylvania and the Upper Ohio Basin*.²⁵

Science Between the Wars

The industrial dislocations experienced in America during World War I resulted in a great upswing in emphasis on chemistry and other sciences in American universities. The Western University of Pennsylvania, which had changed its name to the University of Pittsburgh in 1908, was part of this movement. A few years after the retirement of Professor Phillips, Dr. Alexander Silverman, a noted expert on the chemistry and technology of glass, became head of the Department of Chemistry at the university²⁶ and assembled an unusually able faculty. One of the first outstanding chemists was Alexander Lowy, an authority in organic chemistry and electrochemistry. Charles Glen King obtained the master's degree in 1920 and the Ph.D. in 1923 under Professor Lowy's direction. King remained on the faculty of the university until he resigned in 1942 to become director of the Nutrition Foundation and professor of biochemistry at Columbia University. King was famous for his work on the isolation, structure determination, and synthesis of vitamin C, as well as for outstanding studies on the molecular structure and physical properties of fats and of enzymes.²⁷ Beyond that, as we will see later, King made an enormous administrative contribution by setting the stage for the growth of all the natural sciences at the end of World War II. Other members of the chemistry faculty at that time active in research included Gebhard Stegeman and A. L. Robinson, both physical chemists concerned with problems of reaction rates and the properties of solutions.²⁸ Before 1942, King also attracted a notable group of biochemists: Max Schultze worked on vitamin C and copper in nutrition; Carl V. Smythe studied energy-yielding biochemical reactions; Bernard Daubert analyzed the structure of fats; Herbert E. Longenecker researched the synthesis and breakdown of fats in the human body and later became the dean of the Division of

²⁴ *Ibid.*

²⁵ (Pittsburgh, 1949).

²⁶ Herron, "Chemistry and the University," 5-7.

²⁷ Charles Glen King, "Earlier Days at Pitt; And An Important Contribution by the Buhl Foundation," *Pitt* 43 (Spring 1951): 28-29.

²⁸ Herbert E. Longenecker, "Chemistry in Research in the Natural Sciences," *ibid.*, 30-32.

Research in the Natural Sciences and also dean of the graduate school; Richard H. McCoy worked on nutrition and later served the university with distinction as associate dean of the Division of the Natural Sciences and later of the faculty of the College of Arts and Sciences.²⁹

Among the outstanding research scientists graduated from the Department of Chemistry in this period was Robert B. Corey (B.S., 1919), who later had a distinguished career as an X-ray crystallographer at the California Institute of Technology and who collaborated with Linus Pauling in determining the way in which protein molecules are folded into secondary structures.³⁰ Henry Sorg Frank (B.S., M.S., 1922) became, in spite of a long teaching career in China, an internationally recognized authority on the structure of water and returned to Pittsburgh after 1950 to become chairman of the Department of Chemistry. Tobias Henry Dunkelberger (Ph.D., 1937) served as head of the Department of Chemistry at Duquesne University and then returned to the university to be professor of chemistry and later associate dean of Arts and Sciences. William Edward Wallace (Ph.D., 1941) remained at Pittsburgh to become internationally known in the field of magnetic and low-temperature physical chemistry and in the thermochemistry of alloy formation. He has just completed a long and distinguished term as chairman of the Department of Chemistry. Raymond Scott Craig (Ph.D., 1944), currently professor of chemistry at Pitt, has also earned fame in the field of low-temperature physical chemistry.

In the period between the two World Wars, the physics department expanded greatly at the university, developing a strong reputation for teaching under such pedagogical giants as Oswald Blackwood, W. N. St. Peter, and F. L. Bishop. Archie G. Worthing was widely known for his research on black-body radiation.³¹ Towards the end of the period, Mary Warga established a spectroscopy laboratory at the university which made a major contribution by training industrial scientists in the use of spectroscopy as a substitute for the older methods of chemical analysis. S. S. Sidhu developed an X-ray crystallography laboratory, specializing on the structure of metals.

²⁹ Charles Glen King, "A Center for Scientific Research and for the Training of Future Scientists," *Pitt* 9 (Autumn 1941): 4-6.

³⁰ Alexander Silverman, "Research History of the Department of Chemistry in the University of Pittsburgh" (booklet, University of Pittsburgh Department of Chemistry, 1945).

³¹ Herbert E. Longenecker, "Research in the Natural Sciences," *Pitt* 27 (Winter 1947): 12.

Beginning in 1937 and continuing through the war years, Edward U. Condon was associate director of research at Westinghouse and served as adjunct professor of physics at Pittsburgh. Condon was famous for his work on atomic and molecular spectra, quantum mechanics, and nuclear physics.³² Outstanding graduates of the physics department in that period included Vladimir K. Zworykin (Ph.D., 1926), later to become an expert in electronics, television, electron optics and electron microscopy, director of research, and later vice-president of the RCA Laboratories. Another distinguished graduate was David Halliday (Ph.D., 1942), who later measured the beta and gamma spectra of radioactive atoms and became professor of physics, department head, dean, and coauthor of a phenomenally successful textbook of physics.

At the Allegheny Observatory studies on stellar distances by the method of parallax, begun before World War I, continued during the period between the wars — indeed up to the present time — under the leadership of a succession of directors, Herbert D. Curtis, Frank Craig Jordon, and Nicholas Wagman.³³ Other research has dealt with the orbits of double stars, or binaries. Dr. Wagman discovered a number of so-called astronomic binaries, which are double-star systems where only one star is visible, the companion being too faint to be seen or photographed. Dr. Kevin Burns made great contributions to both astronomy and physics through his studies in spectroscopy. His comparison of wavelengths in solar radiation with wavelengths associated with the same atoms in the laboratory provided an important test of the theory of relativity, and his pure laboratory research on atomic spectra accumulated massive data on wavelengths to serve as standards for spectroscopic analysis.

In biology, Professor Jennings's eminent career spanned this entire period. Professor Peter Gray, noted author and editor, initiated his studies on embryology during the interwar period,³⁴ and, during the war years, carried out a large program on tropical testing. He later served with distinction for many years as head of the Department of Biological Sciences.

The medical school of the university was served during these years by an outstanding anatomist, Dr. Davenport Hooker. For more than thirty years Dr. Maude Menten was on the faculty in the De-

³² Edward U. Condon, "A World Center of Science — Pittsburgh's Opportunity," *Pitt* 2 (Jan. 1940): 24-25.

³³ Lauterbach, "Allegheny Observatory," 21-29.

³⁴ King, "A Center for Scientific Research," 5-6.

partment of Pathology.³⁵ She remained almost unnoticed in the Pittsburgh community, in spite of the fact that, prior to coming here in 1916, she had coauthored the Michaelis-Menten theory of enzyme action,³⁶ well known to this day in every biochemistry laboratory in the world. The most successful scientist graduated from the university's medical school in that era was Philip Hench (M.D., 1920), who ultimately shared the Nobel Prize for his work at the Mayo Clinic on cortisone.³⁷

The Carnegie Institute of Technology developed into an outstanding center of pure science in this period.³⁸ This institution took the lead in mathematics with Richard Duffin, who worked in a broad area of applied mathematics and whose most important work was on discrete potential theory and networks. John L. Synge, who is now head of the Irish Institute for Advanced Study in Dublin, achieved fame for his accomplishment in the interface between mathematics and physics; much of his work foreshadowed the theoretical and computational techniques of the past fifteen years.

The Carnegie Institute of Technology likewise assumed a role of leadership in physics. Otto Stern, who won the Nobel Prize in physics in 1943, was a professor at the school from 1933 until his retirement in 1944. He was the principal developer of the molecular beam method for studying the properties of atoms, molecules, and ions, especially their velocities when they were not undergoing collisions. He also measured the magnetic moment of the proton. Frederick Seitz, later to become successively president of the National Academy of Sciences and president of Rockefeller University, and one of the top theoretical solid state physicists, was professor and head of physics at Carnegie Tech from 1938 to 1949. Emmanuel Esterman, now in Israel, came to the school in 1933 with Stern and went on to do first-class research on the effect of high energy radiation on the physical and optical properties of ionic solids.

In metallurgy, Carnegie Tech has also attracted some outstanding personalities. Robert F. Mehl has had a long record of accomplishments. Perhaps his most outstanding contribution was his development of a comprehensive science of the rate and mechanism of phase transformations in metals and alloys, which explained many

³⁵ Jacques Cattell, ed., *American Men of Science*, 7th ed. (Lancaster, 1944), 1202.

³⁶ L. Michaelis and Maude L. Menten, "Die Kinetik der Invertinwirkung," *Biochemische Zeitschrift* 49 (1913): 333-69.

³⁷ *Pitt* 42 (Autumn-Winter 1950-1951): 15.

³⁸ J. C. Warner to the author, Apr. 5, 1977.

of the empirical observations of the ancient art of heat-treating of metals. Incidentally, we are all familiar with phase transitions — the melting of ice is a transition of water from a solid phase to a liquid phase. Charles Barrett, who came to Carnegie Tech with Mehl in 1930 and left in 1950, was a highly esteemed X-ray crystallographer.

The Carnegie Institute of Technology also assumed a commanding position in physical chemistry. Preeminent among its physical chemists has been John C. Warner, whose interests ranged from thermodynamics to spectroscopy to rate processes. He is best known for his work in which he was able to provide a rational explanation for the differences between reaction rates in gases and in solutions.³⁹ Warner came to Carnegie Tech in 1926, became head of the chemistry department in 1938, dean of graduate studies in 1945, and president in 1950. Harry Seltz arrived a year before Warner and studied heat capacities of metal oxides at temperatures close to absolute zero. Before his death at age fifty, Seltz was best known for his studies on alloys by measuring the electrical potential of cells using fused salts at a variety of temperatures. Paul Fugassi came to the school about 1938 and is still active in science. Researching the rate of reactions in the gaseous state, he has shown an experimental relationship between the rates of such reactions and the frequency of vibration of the chemical bonds broken in the reaction.

The Mellon Institute flourished during this period under the able leadership of Edward R. Weidlein. While the institute's major contributions were in industrial research — by definition beyond the scope of detailed consideration here — important basic scientific contributions were made in its laboratory of pure science under the direction of Dr. Leonard H. Cretcher. Cretcher himself was noted for his work on antimalaria and antipneumonia agents.⁴⁰ His close associate, Robert S. Tipson,⁴¹ made many basic contributions in this field and in the chemistry of sugars. Dr. Jerald J. Cox, famous for his studies on the relationship of fluorides to dental caries, was on the Mellon Institute staff for more than ten years before becoming professor of Dental Research in the School of Dentistry at the University of Pittsburgh.⁴²

One achievement in applied science deserves special comment

39 J. C. Warner, "Activation Energies in Solution Reactions," *Annals of the New York Academy of Sciences* 39 (1940): 345-54.

40 Robert Stuart Tipson, "Mellon Institute's Wartime Antimalarial Research Recorded," *Pitt* 29 (Summer 1947): 39.

41 Cattell, ed., *American Men of Science*, 1791.

42 *Pitt* 34 (Autumn 1948): 22.

because of its close relationship to medicine.⁴³ The Curies discovered radium in 1896, and the utility of this radioactive material in the treatment of cancer soon became apparent. Radium is an extremely rare element, and the concentration and eventual purification and crystallization of radium salts from radium-bearing ores is a formidable task. In the period 1913 to 1920, it is estimated that more than half of the world's supply of purified radium salts came from Pittsburgh. Two University of Pittsburgh chemistry graduates, Glenn Donald Kammer and Henry Titus Koenig, teamed up with Dr. Charles H. Viol from Chicago to carry out this task. Professor Holbrook Botset, former head of the Department of Petroleum Engineering at the university, joined them in 1922.⁴⁴ An ore called carnotite from Colorado was processed, or concentrated, at Canonsburg. The chemists, working in the Flannery Building in Oakland, then took over and purified and crystallized the radium salts, which they packaged in a form suitable for medical application and sold to medical centers throughout the world. The hazards associated with handling radioactive materials had to be learned the hard way; all three of the original chemists died from radiation overexposure.

Strategy at Pitt in the Half Decade Following World War II

Major wars always disrupt basic scientific research. This point is probably not understood by the general public. Many, sometimes most, scientists are taken away from their normal activities in order to devote themselves to the solution of immediate technical problems. Wartime pressures, however, do reveal very clearly at each stage the inadequacy of our basic scientific understanding. This was certainly true in World War II. The result was a great stimulation of concern for and support of basic research at the end of the war. Largely as a result of the creation of the National Science Foundation and of the extramural research program of the National Institutes of Health, there has been an enormous nationwide expansion of basic scientific research in the physical and biological sciences. Pittsburgh has benefited to a conspicuous degree. Today at Carnegie-Mellon University and at the University of Pittsburgh there are great numbers of highly skilled basic researchers in physics, chemistry, and in the biological and medical sciences.

43 Alexander Silverman, "Radium in the University of Pittsburgh," *Pitt* 22 (Autumn 1945): 9-10.

44 Cattell, ed., *American Men of Science*, 181.

In my judgment, the progress at the University of Pittsburgh has been outstanding. The university's strategy in capitalizing on a nationwide opportunity to acquire research funds seems to me to have been unique. Since I came to Pittsburgh early enough to have been involved in the initial stages of the postwar development and to know firsthand something about that strategy, I want to conclude by elaborating on it.⁴⁵ The other research centers in Pittsburgh probably also had interesting strategies, but I am not acquainted with them and therefore cannot discuss them.

The key to what happened at the university involves major Pittsburgh foundations and goes back to the work of Charles Glen King, already described. King's enormously successful research on vitamin C attracted both international and local attention. To further his own research, he obtained a grant from the Buhl Foundation several years before the beginning of World War II. King was a man of vision who saw the need to stimulate the research of others, and he persuaded the Buhl Foundation of the validity of his aspirations. The result was that by the time King left the university, the Buhl Foundation Project was supporting not only the extensive program in biochemistry already described, but additional work in physical chemistry, Dr. Gray's embryological research in the biological sciences department, the X-ray diffraction and spectroscopy laboratories in the physics department, and the work of Robert A. Patton on experimental psychopathology.⁴⁶ Patton later became head of the psychology department and developed a strong program in experimental psychology.

Herbert E. Longenecker succeeded King as director of the Buhl Foundation Project and later reorganized it into the Division of Research in the Natural Sciences, of which he became dean in 1944. At every stage in the division's development, the Buhl Foundation's generosity increased. The Division of Research in the Natural Sciences was, in my opinion, unique among American universities. The University of Pittsburgh, with the exception of Allegheny Observatory, was primarily a teaching institution prior to the Litchfield era. The excellent research accomplished in the early years was done by a few outstanding individuals, essentially on an overtime basis with minimal financial support. The Division of Research in the Natural

45 King, "A Center for Scientific Research," 4-6; Longenecker, "Research in the Natural Sciences," 12-17.

46 King, "Earlier Days at Pitt," 28-29; King, "A Center for Scientific Research," 6.

Sciences bought research time for key scientists by replacing part or all of their salaries from the regular university budget, thereby reducing teaching loads in proportion. The initial faculty of the Division of Research in the Natural Sciences was composed of the individuals who had been enjoying support from the Buhl Foundation Research Project, its predecessor.

The first new appointment made by Dean Longenecker in May 1944 was Klaus Hofmann,⁴⁷ a brilliant organic chemist who came initially into the Department of Chemistry to carry out work on the synthesis of biologically important molecules. After 1950, Hofmann transferred to the medical school to become head of the Department of Biochemistry. There he assembled a strong group of active investigators and provided enormous impetus to the development of the medical school into a first-rate scientific institution. Hofmann also continued his own research, a high point of which was the synthesis in the laboratory of an anterior pituitary hormone, a very complicated protein structure.

The second appointment, in September 1944, was the author, who came from the Rockefeller Institute for Medical Research to the physics department for the purpose of establishing a laboratory in biophysics as an integral component of a basic virus research program. Soon thereafter, a sizable research grant was obtained from the National Foundation for Infantile Paralysis to initiate fundamental studies on the nature of viruses. In 1945, the university announced the establishment of a virus research program under the supervision of a committee composed of Dean Longenecker, Dean McElroy of the School of Medicine, and myself as chairman.⁴⁸ The plan included the development of the biophysics laboratory for research on viruses, the creation of a laboratory for the study of plant viruses, and establishment of a laboratory in the medical school for the study of animal and human viruses. This committee, through the initiative of the chairman, brought into the program Dr. W. C. Price,⁴⁹ a distinguished plant pathologist, and Dr. Jonas Salk,⁵⁰ subsequently of polio vaccine fame. Price developed a program, housed at the Phipps Conservatory, in plant virus research, made possible to a great extent

⁴⁷ *Pitt* 20 (Winter 1944-1945): 9.

⁴⁸ Max A. Lauffer, "The Smallest Pathogens," *Pitt* 22 (Autumn 1945): 6-7.

⁴⁹ *Ibid.*, 6.

⁵⁰ Lauffer to Salk, June 20, July 16, 1947; Salk to Lauffer, June 27, July 21, 1947, author's files, University of Pittsburgh.

by a generous grant from the Sarah Mellon Scaife Foundation.⁵¹ Price remained in Pittsburgh until 1954. Salk's academic appointment was in the medical school, and his direct affiliation with the coordinated virus research program was of short duration because of his rapidly expanding involvement in the development of the polio vaccine.⁵² Another consequence of the original virus research program was the development of the biophysical laboratory in 1949, with major help from the Sarah Mellon Scaife Foundation, into one of the first departments of biophysics in the United States.⁵³ The work of the biophysics department was greatly expanded a few years later by major grants from both the Buhl Foundation and the Sarah Mellon Scaife Foundation. The program developed in this department has since been incorporated, along with biochemistry, microbiology, and biology, into a large Department of the Life Sciences.

The next major appointment in the Division of Research in the Natural Sciences was Dr. Robert F. Griggs in 1947.⁵⁴ Griggs was the discoverer in 1916 of the Valley of Ten Thousand Smokes in Alaska. He had just retired as chairman of the Division of Biology and Agriculture of the National Research Council when Longenecker brought him to the University of Pittsburgh with an academic appointment in the Department of Biological Sciences. A major fruit of Griggs's relatively short stay at the University of Pittsburgh was the development in 1949 of the Pymatuning Field Laboratory of the university near Linesville, Pennsylvania, a focal point of research in ecology and limnology. During that same year, 1947, Longenecker made a most unconventional move for an academic administrator by providing Dr. Robert McConnell, then a junior member of the physics faculty and a proven expert in the field of electronics, with an opportunity to set up an exacting research program in parapsychology. This is a potentially highly important but currently controversial field involving such phenomena as extrasensory perception and psychokinesis. McConnell transferred to the biophysics department a few years later and continues at the university to this day, supported by the A. W. Mellon Educational and Charitable Trust.

Paralleling the developments in the Division of Research in the

51 Jane Ambrose, "Plant Virus Laboratory," *Pitt* 38 (Autumn 1949): 20-21.

52 *Ibid.* 35 (Winter 1948-1949): 46.

53 *Ibid.* 39 (Winter 1949-1950): 4.

54 *Ibid.* 30 (Autumn 1947): 15.

Natural Sciences was the construction of a cyclotron and the expansion of associated laboratory facilities. The building of the cyclotron was projected as early as 1941, funded by a grant from Mrs. Allen M. Scaife, but plans were delayed by the war. In 1944, Dr. Alexander J. Allen, a man with vast experience in radiation research, especially in designing cyclotrons, returned to the university as Westinghouse Professor of Engineering and director of the Radiation Laboratory. With additional support from the Sarah Mellon Scaife Foundation, construction of the cyclotron began early in 1945. Operations started two years later. Many Pittsburgh industries contributed materials and equipment. A few years later, a grant from the Scaife Foundation made it possible to build a nuclear research laboratory adjacent to the cyclotron. The Sarah Mellon Scaife Radiation Laboratory became the major research arm of the Department of Physics. Allen and the head of the physics department, David Halliday, cooperated closely to assemble a distinguished group of physicists at the university.⁵⁵

Two developments in the health area also occurred in the half decade following World War II. In 1948, the Addison H. Gibson Foundation made a substantial grant to the School of Medicine for the establishment of the Addison H. Gibson Laboratory, with Dr. Campbell Moses as its director.⁵⁶ Moses became a well-known authority in the field of cardiovascular diseases. In 1948, Dr. Thomas Parran, surgeon general of the United States Public Health Service during most of the Roosevelt administration and a man responsible for the reorganization of the National Institutes of Health into essentially their present form, came to the University of Pittsburgh to be the first dean of the newly established Graduate School of Public Health, previously endowed by the A. W. Mellon Educational and Charitable Trust.⁵⁷ Parran patiently supervised the construction of the original building for that school and assembled a distinguished faculty, including many scientists engaged in basic research.

Thus, prior to 1950, thanks to major support from Pittsburgh foundations, key investigators were well established with ongoing research programs in the basic biological sciences, in organic, biological, and physical chemistry, in nuclear physics and biophysics, in ex-

⁵⁵ A. J. Allen, "The University of Pittsburgh Cyclotron," *ibid.* 28 (Spring 1947): 14-15; "Nuclear Research Laboratory," *ibid.* 36 (Spring 1949): 13.

⁵⁶ *Ibid.* 32 (Spring 1948): 35.

⁵⁷ Agnes Lynch Starrett, "The University of Pittsburgh's New Graduate School of Public Health," *ibid.* 34 (Autumn 1948): 24-25.

perimental psychology, and in virology and other aspects of biomedical science. The timing was perfect to take maximum advantage of the enormous expansion in federal support of basic science. The fruits of all these activities of the half decade following World War II have been enormous. To attempt to describe the accomplishments here would be impossible. I am too close, too much involved personally, to be trusted to make wholly objective evaluations. This task I leave to a future amateur historian.