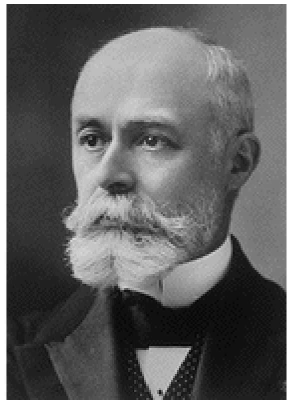
Table of Contents



Antoine Henri Becquerel
1852 - 1908

French physicist who was an expert on fluorescence. He discovered the rays emitted from the uranium salts in pitchblende, called Becquerel rays, which led to the isolation of radium and to the beginning of modern nuclear physics. He shared the 1903 Nobel Prize for Physics with Pierre and Marie Curie for the discovery of radioactivity.[1]

Early Life

Antoine Henri Becquerel was born in Paris, France on December 15, 1852.[3] He was born into a family of scientists and scholars. His grandfather, Antoine Cesar Bequerel, invented an electrolytic method for extracting metals from their ores. His father, Alexander Edmond Becquerel, a Professor of Applied Physics, was known for his research on solar radiation and on phosphorescence.[2, 3] Becquerel not only inherited their interest in science, but he also inherited the minerals and compounds studied by his father, which gave him a ready source of fluorescent materials in which to pursue his own investigations into the mysterious ways of Wilhelm Roentgen's newly discovered phenomenon, X-rays.[2]

Henri received his formal, scientific education at Ecole Polytechnique in 1872 and attended the Ecole des Ponts at Chaussees from 1874-77 for his engineering training. After school and many years working as an engineer for the Department of Bridges and Highways, he became an assistant teacher in 1976 at the Ecole Polytechnique. In 1895, he became the Chair of Physics. During this time, he was also working as an assistant naturalist to his father at the Museum of Natural History. Upon his father's death, he also assumed the physics professorship at the museum.

Henri Becquerel was married to Mlle. Janin, the daughter of a civil engineer. In 1878 they had a son, Jean Becquerel, who as a physicist, would become the fourth generation of scientists in the Becquerel family.[4]

Discovery of Becquerel Rays[1]

Electricity, magnetism, optical phenomena, and energy were the major areas of physical investigation during the 19th century.[4] Most of Henri's early research was concerned with (1) the rotation of plane-polarized light by magnetic fields, (2) examining the spectra of different phosphorescent crystals under infrared stimulation, and (3) absorption of light by crystals.[3] One of the most significant areas of Henri's studies were the extension of his father's work on the relation between the absorption of light and emission of phosphorescence in some uranium compounds. By 1896, Henri was a well respected physicist, but his previous work had become overshadowed by the discovery of the phenomenon of natural radioactivity by Wilhelm Röntgen.[3]

Following a discussion with Henri Poincare, Henri Bequerel decided to investigate whether a relationship existed between X-rays and naturally occurring phosphorescence.[2, 3] Becquerel learned that the X-rays issued from a glass vacuum tube became fluorescent when struck by a beam of cathode rays. He undertook several studies to investigate whether there was some fundamental connection between this invisible radiation and visible light such that all luminescent materials, however stimulated, would also yield X-rays. To test this hypothesis, he placed phosphorescent crystals (a supply of uranium salts inherited from his father)[3] upon a photographic plate that had been wrapped in opaque paper so that only a penetrating radiation could reach the emulsion. Then he exposed his experimental arrangement to sunlight for several hours, thereby exciting the crystals in the customary manner. Upon development, the photographic plate revealed silhouettes of the mineral samples, and, in subsequent experiments, the image of a coin or metal cutout interposed between the crystal and paper wrapping. Becquerel reported this discovery to the Académie des Sciences at its session on February 24, 1896, noting that certain salts of uranium were particularly active in this manner.[4]

Thus, Becquerel confirmed his view that something very similar to an X-ray was emitted by his luminescent salts at the same time it threw off visible radiation.[4] Initially, he believed that the sun's energy was being absorbed by the uranium, which then re-emitted the energy in the form of X-rays. Becquerel had intended to further his investigations on the 26th and 27th of February, but overcast weather caught his experiment to be delayed. The following week Becquerel developed the photographic plates expecting to find only faint images.[2] He was shocked to learn that his uranium salts continued to eject penetrating radiation, even when they had not been made to phosphoresce by the ultraviolet rays found in sunlight. To account for this novelty he postulated a long-lived form of invisible phosphorescence; when he shortly traced the activity to uranium metal, he interpreted it as a unique case of metallic phosphorescence.

Later, Becquerel showed that the rays emitted by uranium, which were for a long time called Becquerel rays, caused gases to ionize and that they differed from X-rays in that the could be deflected by electric or magnetic fields, implying that Becquerel rays must consist of charged particles, which he called beta particles.[2, 4] From the charge to mass value obtained in his deflection experiments, he showed that the beta particle was the same as Joseph John Thomson's recently identified electron.[4]

Another discovery was the circumstance that the allegedly active substance in uranium, uranium X, lost its radiating ability in time, while the uranium, though inactive when freshly prepared, eventually regained its lost radioactivity. When Ernest Rutherford and

Frederick Soddy found similar decay and regeneration in thorium X and thorium, they were led to the transformation theory of radioactivity, which explained the phenomenon as a subatomic chemical change in which one element spontaneously transmutes into another.[4]

Becquerel's last major achievement concerned the physiological effect of the radiation. Others may have noticed this before him, but his report in 1901 of the burn caused when he carried an active sample of the Curies' radium in his vest pocket inspired investigation by physicians, leading ultimately to the medical use of radioactive materials.

Honors

Henri Becquerel was an elected member of the Academie des Sciences de France in 1889 and succeeded Berthelot as Life Secretary of that body. He was also a member of the Accademia dei Lincei and of the Royal Academy of Berlin, as well as other foreign societies. In 1900 he was made an Officer of the Legion of Honour.[4] And finally for his discovery of spontaneous radioactivity, Becquerel shared half of the 1903 Nobel Prize for Physics with Pierre and Marie Curie.

Publications

Becquerel published his findings in many papers, principally in the Annales de Physique et de Chimie and the Comtes Rendus de l'Academie des Sciences.[4] During 1896 Becquerel published seven papers on radioactivity, only two in 1897, and none in 1898. This was an index of both his and the scientific world's interest in the subject, for the period saw studies of numerous radiations (*e.g.,* cathode rays, X rays, Becquerel rays, "discharge rays," canal rays, radio waves, the visible spectrum, rays from glowworms, fireflies, and other luminescent materials), and Becquerel rays were not deemed especially significant at the time. The far more popular X-rays could take sharper shadow photographs and faster. It required the extension in 1898 of radioactivity to another known element, thorium (by Gerhard Carl Schmidt and independently by Marie Curie), and the discovery of new radioactive materials, polonium and radium (by Pierre and Marie Curie and their colleague, Gustave Bémont), to awaken the world and Becquerel to the significance of his discovery.[3]

Antoine Henri Becquerel dies at Le Croisic on August 25, 1908.[3] Today, the standard International System (SI) measure of radioactivity is the becquerel (Bq), which is equal to one disintegration per second or 2.7×10^{-11} curies (Ci). (Note: The curie (Ci) is the non-SI unit of radioactivity commonly used in the United States. A curie is defined as the quantity of any radioactive nuclide undergoing 37.00×10^{9} disintegrations per second.)

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Herman Blumgart
1891 – 1982

An American doctor who pioneered the use of a diluted radon solution as a tracer to study blood circulation.

Age of Nuclear Medicine

In 1927, Berman Blumgart and his colleagues discovered that they could measure circulation and cardiac functions by observing how fast diluted Radon flowed from one side of the body to the other. They were the first to measure physiological functions of the body by using radioactive isotopes. This discovery was the beginning of the "age of nuclear medicine." These studies by Dr. Blumgart and others showed that radioactive material could be used as a tracer.[1]

Dr. Blumgart began working with Boston's Beth Israel Deaconess Medical Center in 1928 as the Chief of a clinical department of medical research. He also had responsibility for teaching medical students.[2]

Honors

Herman Blumgart was the first physician named to the Honor Roll of Nuclear Pioneers by the Society of Nuclear Medicine in 1969.[2]

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 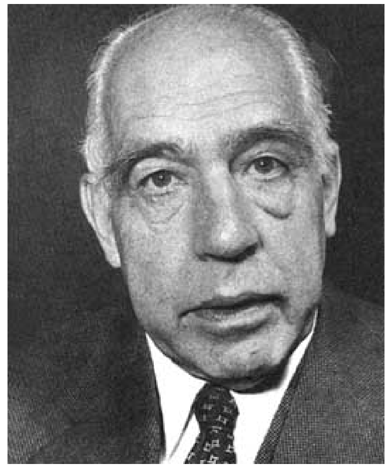

Niels Henrik David Bohr
1885 – 1962

Danish physicist who extended the theory of the atomic structure by using an atomic model and quantum theory to explain the spectrum of hydrogen.[1] He received the 1922 Nobel Prize for Physics for his theory of atomic structure.

Early Life

Niels Henrik David Bohr was born in Copenhagen on October 7, 1885.[2] Niels Bohr's father, Christian Bohr, was a physiology professor at the University of Copenhagen. His mother, Ellen Adler, was the daughter of Jewish politician David Adler. Niels was the second of Christian and Ellen's three children. Niels' older sibling was a sister named Jenny, born in 1883. His younger brother Harold, went on to become a famous mathematician.[3]

In October 1891 Niels entered the Grammelholms school. He attended this school, as did his brother Harald, for his complete secondary education taking his Studenterexamen in 1903. Niels Bohr's formal education was received at the University of Copenhagen, where he studied physics as his main subject, but also pursued minors in mathematics, astronomy, and chemistry. He earned a Master's degree from University of Copenhagen in 1909 and his doctorate in May 1911 for a thesis titled *Studies on the electron theory of metals*.[3, 4] That same year he went to Cambridge, England, to study nuclear physics under the British physicist Sir Joseph John Thomson, but he soon moved to Manchester to work with Ernest Rutherford.[2]

Contributions to Nuclear Science

Bohr went to England in September 1911 to study with Sir J.J. Thomson at Cambridge. He had intended to spend his entire study period in Cambridge, but he did not get on well with Thomson so, after a meeting with Ernest Rutherford in Cambridge in December 1911, Bohr moved to the Victoria University, Manchester (now the University of

Manchester). In Manchester Bohr worked with Rutherford's group on the structure of the atom. Rutherford became Bohr's role model both for his personal and scientific qualities. Using quantum ideas due to Planck and Einstein, Bohr conjectured that an atom could exist only in a discrete set of stable energy states. On July 24, 1912 Bohr left Rutherford's group in Manchester and returned to Copenhagen, just in time to marry his fiancé, Margrethe Norland, on August 1, 1912. It took another year for Bohr to finish the development of his new theory of the atom.[3] Bohr's theory of atomic structure, for which he received the 1922 Nobel Prize in Physics, was published in papers between 1913 and 1915. His work drew on Rutherford's nuclear model of the atom, in which the atom is seen as a compact nucleus surrounded by a swarm of much lighter electrons. Bohr's atomic model made use of quantum theory and the Planck constant. The model proposes the explanation that an atom emits electromagnetic radiation only when an electron in the atom jumps from one quantum level to another. This model contributed enormously to future developments of theoretical atomic physics.[2]

In 1913-1914 Bohr held a Lectureship in Physics at Copenhagen University and in 1914-1916 a similar appointment at the Victoria University in Manchester. He was appointed Professor of Theoretical Physics at Copenhagen University in 1916.[4] The next year Bohr was elected to the Danish Academy of Sciences and he began to plan for an Institute of Theoretical Physics in Copenhagen. This was created for him and, from its opening in 1921, he became its director, a position he held for the rest of his life.[3]

At the Institute for Theoretical Physics, Bohr developed a theory relating quantum numbers to large systems that follow classical laws, and made other major contributions to theoretical physics. His work helped lead to the concept that electrons exist in shells and that the electrons in the outermost shell determine an atom's chemical properties. In 1939, recognizing the significance of the fission experiments of the German scientists Otto Hahn and Fritz Strassmann, Bohr convinced physicists at a scientific conference in the U.S. of the importance of those experiments. He later demonstrated that uranium-235 is the particular isotope of uranium that undergoes nuclear fission.[2]

In 1937, Bohr, his wife, and their son Hans, made a world tour. They traveled to the United States, Japan, China, and the USSR.[4] Bohr then returned to Denmark, where he was forced to remain after the German occupation of the country in 1940.[2] Bohr, although he had been christened in the Christian Church, had Jewish origins on his mother's side and so, when the Nazis occupied Denmark in 1940, his life became exceeding difficult. Eventually, however, he was persuaded to escape to Sweden, under peril of his life and that of his family. He had to escape in 1943 by being taken to Sweden by fishing boat. From there he was flown to England where he began to work on the project to make a nuclear fission bomb. After a few months he went with the British research team to Los Alamos in the United States where they continued work on the project, until the first bomb's detonation in 1945.[4] Throughout his time in the United States, Bohr opposed complete secrecy of the project and feared the consequences of this ominous new development. He desired international control.

In 1945 Bohr returned to the University of Copenhagen, where he immediately began working to develop peaceful uses for atomic energy. In particular, he advocated a development towards full openness between nations. His views are especially set forth in his *Open Letter to the United Nations*, June 9, 1950. He organized the first Atoms for Peace Conference in Geneva, held in 1955, and two years later he received the first Atoms for Peace Award.[4]

Until the end, Bohr's mind remained alert as ever; during the last few years of his life he had shown keen interest in the new developments of molecular biology. The latest formulation of his thoughts on the problem of Life appeared in his final (unfinished) article, published after his death: "Licht und Leben-noch einmal", *Naturwiss*., 50 (1963) 72: (in English: "Light and Life revisited", *ICSU Rev*., 5 (1963) 194).[4] Bohr died from a heart attack in Copenhagen on November 18, 1962.[2]

Publications

Professor Bohr wrote numerous scientific and political articles (some 115 publications) throughout his career. A few of the publications that are available in English are listed below.

- Atomic Physics and Human Knowledge, edited by John Wiley and Sons, New York, 1958
- Essays 1958-1962 on *Atomic Physics and Human Knowledge*, edited by John Wiley and Sons, London, 1963
- *The Theory of Spectra and Atomic Constitution*, University Press, Cambridge, 1922/2nd. ed., 1924
- *Atomic Theory and the Description of Nature*, University Press, Cambridge, 1934/reprint 1961
- *The Unity of Knowledge*, Doubleday & Co., New York, 1955.

Honors

Niels Bohr was President of the Royal Danish Academy of Sciences, of the Danish Cancer Committee, and Chairman of the Danish Atomic Energy Commission. He was a Foreign Member of the Royal Society (London), the Royal Institution, and Academies in Amsterdam, Berlin, Bologna, Boston, Göttingen, Helsingfors, Budapest, München, Oslo, Paris, Rome, Stockholm, Uppsala, Vienna, Washington, Harlem, Moscow, Trondhjem, Halle, Dublin, Liege, and Cracow. He was Doctor, *honoris causa*, of the following universities, colleges, and institutes: *(1923-1939)* - Cambridge, Liverpool, Manchester, Oxford, Copenhagen, Edinburgh, Kiel, Providence, California, Oslo, Birmingham, London; *(1945-1962)* - Sorbonne (Paris), Princeton, Mc. Gill (Montreal), Glasgow, Aberdeen, Athens, Lund, New York, Basel, Aarhus, Macalester (St. Paul), Minnesota, Roosevek (Chicago, Ill.), Zagreb, Technion (Haifa), Bombay, Calcutta, Warsaw, Brussels, Harvard, Cambridge (Mass.), and Rockefeller (New York).[4]

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James Chadwick
1891 - 1974

British physicist that discovered the neutron in 1932 and subsequently received the 1935 Nobel Prize in Physics.

Early Life

James Chadwick was born in October 21, 1891, in Cheshire, England to John Joseph Chadwick and Anne Mary Knowles. He attended Manchester High School prior to attending Manchester University in 1908. Chadwick had planned to study mathematics at the University, but while enrolling for classes he accidentally got in the line for physics majors. Being too shy to admit his mistake, he stayed in line and enrolled in physics coursework.[4] He graduated from the Honors School of Physics in 1911. He received his M.Sc. degree in 1913 after working two years on various radioactivity problems under Professor Ernest Rutherford at the Physical Laboratory.[3]

After completion of his master's degree, Chadwick moved to Germany to work with Hans Geiger at the Physikalisch Technische Reichsanstalt at Charlottenburg. This is where he was the first to show that beta particles possess a range of energies up to some maximum value.[2] When World War I broke out, Chadwick became trapped in Germany. As a result, he was imprisoned in the Zivilgefangenenlager, Ruhleben, essentially, a horse stall at a racetrack that served as an internment camp. After the war, he was released and returned to England to again work with Professor Rutherford, who had moved to the Cavendish Laboratory at Cambridge.[2, 4]

Discovery of the Neutron

Intrigued by Rutherford's speculation about a subatomic particle with no charge, Chadwick began a series of experiments to demonstrate the existence of such a particle. Initially, none of the experiments succeeded. Then, in 1930, Walther Bothe and Herbert Becker described an unusual type of gamma ray produced by bombarding the metal beryllium with alpha particles.[1, 4] Chadwick recognized that the properties of this radiation were more consistent with what would be expected from Rutherford's neutral particle. When Frédéric and Irène Joliot-Curie subsequently claimed that Bothe and Becker's "gamma rays" could eject high energy protons from paraffin, Chadwick knew these were not gamma rays.[1, 4]

In 1932, Chadwick made a fundamental discovery in the domain of nuclear science: he proved the existence of *neutrons* - elementary particles devoid of any electrical charge. In contrast with the helium nuclei (alpha rays) which are charged, and therefore repelled by the considerable electrical forces present in the nuclei of heavy atoms, this new tool in atomic disintegration need not overcome any electric barrier and is capable of penetrating and splitting the nuclei of even the heaviest elements. Chadwick in this way prepared the way towards the fission of uranium 235 and towards the creation of the atomic bomb. For this epoch-making discovery he was awarded the Hughes Medal of the Royal Society in 1932, and subsequently the Nobel Prize for Physics in 1935. [2]

He remained at Cambridge until 1935 when he was elected to the Lyon Jones Chair of Physics in the University of Liverpool. From 1943 to 1946 he worked in the United States as Head of the British Mission attached to the Manhattan Project for the development of the atomic bomb. During this time he was knighted Sir James Chadwick. He returned to England and, in 1948, retired from active physics and his position at Liverpool on his election as Master of Gonville and Caius College, Cambridge. He retired from this Mastership in 1959. From 1957 to 1962 he was a part-time member of the United Kingdom Atomic Energy Authority.[2] Sir James Chadwick died in 1974.

Honors

- Elected Fellow of Gonville and Caius College (1921-1935)
- Became Assistant Director of Research in the Cavendish Laboratory (1923)
- Elected a Fellow of the Royal Society (1927)
- Awarded the Hughes Medal of the Royal Society (1932)
- Won the Nobel Prize for Physics (1935)
- Sir James was knighted in 1945
- Received the Copley Medal (1950)
- Received the Franklin Medal of the Franklin Institute, Philadelphia (1951).
- Honorary Fellow of the Institute of Physics
- Received honorary doctorate degrees from the following universities: Reading, Dublin, Leeds, Oxford, Birmingham, Montreal (McGill), Liverpool, and Edinburgh
- Member of several foreign academies: Académie Royale de Belgique; Kongelige Danske Videnskabernes Selskab, Koninklijke Nederlandse Akademie van Wetenschappen; Sächsische Akademie der Wissenschaften, Leipzig; Pontificia Academia Scientiarum and the Franklin Institute;
- Honorary Member of the American Philosophical Society and the American Physical Society

Publications

Chadwick had many papers published on the topic of radioactivity and connected problems and, with Lord Rutherford and C. D. Ellis, he co-authored the book *Radiations from Radioactive Substances* (1930).

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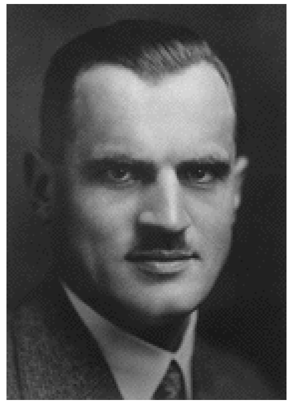

Arthur Holly Compton
1892 – 1962

An American physicist that was awarded the 1927 Nobel Prize in Physics for his experimental proof that electromagnetic radiation could exhibit the characteristics of particles, as well as waves.

Early Life[1]

Arthur Holly Compton was born at Wooster, Ohio, on September 10th, 1892, the son of Elias Compton, Professor of Philosophy and Dean of the College of Wooster. He was educated at the College, graduating Bachelor of Science in 1913, and he spent three years in postgraduate study at Princeton University receiving his M.A. degree in 1914 and his Ph.D. in 1916. After spending a year as instructor of physics at the University of Minnesota, he took a position as a research engineer with the Westinghouse Lamp Company at Pittsburgh until 1919 when he studied at Cambridge University as a National Research Council Fellow.

Contribution to Nuclear Science

In his early days at Princeton, Compton developed a theory of the intensity of X-ray reflection from crystals as a means of studying the arrangement of electrons and atoms.[1] In 1919, shortly after the completion of his doctorate at Princeton, Compton spent a year in Cambridge working under Ernest Rutherford investigating the properties of scattered gamma rays. In the early, 1920's, Compton was appointed Wayman Crow Professor of Physics, and Head of the Department of Physics at the Washington University, St. Louis. While at this post he continued the line of research begun with Rutherford, only this time he was using X-rays instead of gamma rays.[3] This led, in 1922, to his discovery of the increase of wavelength (i.e., lowered energy) of X-rays due to scattering of the incident radiation by free electrons in graphite.[1] Compton hypothesized that the X-ray must be behaving like a particle undergoing a collision such that some of the energy of the incident X-ray is transferred to the electrons in the graphite. This effect, now known as the *Compton Effect*, provided experimental proof that electromagnetic radiation could exhibit the characteristics of particles, as well as waves.[3] This theory was then substantiated by C. T. R. Wilson who, in his cloud chamber, demonstrated the presence of the tracks of the recoil electrons. Another proof of the reality of this phenomenon was supplied by the coincidence method (developed by Compton and A.W. Simon, and independently in Germany by W. Bothe and H. Geiger), by which it could be established that individual scattered X-ray photons and recoil electrons appear at the same instant, contradicting the views then being developed by some investigators in an attempt to reconcile quantum views with the continuous waves of electromagnetic theory. For this discovery, Compton was awarded the Nobel Prize in Physics for 1927 (sharing this with C. T. R. Wilson who received the Prize for his discovery of the cloud chamber method).[1]

In addition, Compton discovered (with C. F. Hagenow) the phenomenon of total reflection of X-rays and their complete polarization, which led to a more accurate determination of the number of electrons in an atom. He was also the first (with R. L. Doan) who obtained X-ray spectra from ruled gratings, which offers a direct method of measuring the wavelength of X-rays. By comparing these spectra with those obtained when using a crystal, the absolute value of the grating space of the crystal can be determined. The Avogadro number found by combining above value with the measured crystal density, led to a new value for the electronic charge. This outcome necessitated the revision of the Millikan oil-drop value from 4.774 to 4.803 X 10^{-10} e.s.u. (revealing that systematic errors had been made in the measurement of the viscosity of air, a quantity entering into the oil-drop method).[1]

Other Scientific Contributions

In his early days at Princeton, Compton devised an elegant method for demonstrating the Earth's rotation, but he was distracted by his studies in field of X-rays for several years before returning to this previous early work. During 1930-1940, Compton led a world-wide study of the geographic variations of the intensity of cosmic rays, thereby fully confirming the observations made in 1927 by J. Clay from Amsterdam of the influence of latitude on cosmic ray intensity.[1] He could, however, show that the intensity was correlated with the earth's magnetic field rather than geographic latitude.[3] This provided conclusive proof that cosmic rays must consist of charged particles and gave rise to extensive studies of the interaction of the Earth's magnetic field with the incoming isotropic stream of primary charged particles.[1]

In 1923 Compton moved from Washington University in St. Louis to the University of Chicago as Professor of Physics.[1] At the outbreak of World War II, Compton's reputation was such that he was appointed Chairman of the National Academy of Sciences Committee to Evaluate Use of Atomic Energy in War.[4] He also was asked to direct the Metallurgical Laboratory at the University of Chicago, as known as "The Met Lab," that helped guide the nation's scientific efforts devoted to the development of the atomic bomb. His investigations, carried out in cooperation with E. Fermi, L. Szilard, E. P. Wigner and others, led to the establishment of the first controlled uranium fission reactors, and, ultimately, to the large plutonium-producing reactors in Hanford, Washington, which produced the plutonium for the Nagasaki bomb, in August 1945.[1] Compton returned to St. Louis as Chancellor in 1945 and from 1954 until his retirement in 1961 he was Distinguished Service Professor of Natural Philosophy at the Washington University.[1, 2]

Publications

Compton has numerous papers on scientific record and he is the author of *Secondary Radiations Produced by X-rays* (1922), *X-Rays and Electrons* (1926, second edition 1928), *X-Rays in Theory and Experiment* (with S. K. Allison, 1935, this being the revised edition of *X-rays and Electrons*), *The Freedom of Man* (1935, third edition 1939), *On Going to College* (with others, 1940), *Human Meaning of Science* (1940), and *Atomic Quest* (1956).[1, 5]

Honors

Dr. Compton was awarded numerous honorary degrees and other distinctions including the Rumford Gold Medal (American Academy of Arts and Sciences), 1927; Gold Medal of Radiological Society of North America, 1928; Hughes Medal (Royal Society) and Franklin Medal (Franklin Institute), 1940.

He served as President of the American Physical Society (1934), of the American Association of Scientific Workers (1939-1940), and of the American Association for the Advancement of Science (1942).

In 1916, Arthur Compton married Betty Charity McCloskey. The eldest of their two sons, Arthur Allen, is in the American Foreign Service and the youngest, John Joseph, is Professor of Philosophy at the Vanderbilt University (Nashville, Tennessee). His brother Wilson is a former President of the Washington State University, and his brother Karl Taylor was formerly President of the Massachusetts Institute of Technology. He died on March 15th, 1962, in Berkeley, California.

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William David Coolidge
1873 – 1975

American physical chemist who invented the process for the carbon-free tungsten light bulb filament and later the Coolidge X-ray tube, which revolutionized the field of medical radiology.

Early Life

William David Coolidge was born in Hudson, Massachusetts, on October 23, 1873.[1, 2] His father, Albert Edward, was a shoemaker by occupation, but he supplemented his income by running a farm of seven acres. His mother, Martha Alice, was a dressmaker in her spare time. William attended a grade school about a mile from town, where one teacher presided over the six grades that attended the one-room schoolhouse. After grade school, he attended Hudson High School, where he graduated valedictorian of his class of thirteen students. Due to the financial situation of his family, he had always assumed that he would not attend college, however, a friend who had been impressed with his mechanical and electrical aptitude suggested that he apply for a state scholarship.[2] In 1891 he enrolled in a nine-year-old electrical engineering program at the Massachusetts Institute of Technology (MIT) in Cambridge.[1]

When Coolidge entered college, there was a growing interest in science and engineering, and the opportunities for engineers in industry were numerous. Thus, Coolidge enrolled in the Electrical Engineering program. Coolidge spent the summer between his junior and senior year working at the East Pittsburgh plant of Westinghouse Electric. After this experience, he realized that engineering practice was not exactly how he wished to spend his career. After completing his undergraduate degree in 1896, he took a position as an assistant in physics to focus on his science studies and research orientation of his laboratory work. A year later, a fellowship permitted him to go on to the famed University of Leipzig to earn a Ph.D. in physics in 1899.[1, 2]

In Coolidge's second year at Leipzig, he became lecture assistant to Professor Paul Drude. One day during the winter term, the celebrated Professor Wilhelm C. Roentgen visited Leipzig and the Physikalishes Institute. Coolidge had a chance to talk with

Roentgen and was much impressed by the experience. William didn't know it at the time, but his later research would serve to provide the major embodiment for the practical usefulness of Roentgen's X-ray discovery. In July 1899 Coolidge received high marks in all of his examinations and was awarded the doctorate summa cum laude (a Ph.D. in physics with excellence).[2]

His application for an MIT teaching position coincided with an opening in the Physics Department, so Coolidge was back in Boston for the fall term in 1899. The following year he became a research assistant to Professor Arthur A. Noyes of the Chemistry Department, where, to his surprise, he remained for five years working on research into the electrical conductivity of aqueous solutions at high temperatures. He became reacquainted with Dr. Willis R. Whitney, who was then commuting to Schenectady during the formative years of the new General Electric (GE) Research Laboratory there. To Coolidge's complete surprise, Whitney offered him a job. He visited GE and accepted the offer in 1905.[2]

Coolidge's first assignment was to investigate why tantalum lamp filaments quickly broke when operated on alternating current. This work led him to develop a metal filament to replace the carbon filament developed by Thomas Edison. In 1904, several European inventors began to develop filaments made of metal tungsten. Coolidge began investigating how he might improve tungsten lamps by making a bendable or "ductile" wire. In 1909, Coolidge succeeded in preparing a ductile tungsten wire by doping tungsten oxide before reduction. The resulting metal powder was pressed, sintered and forged to thin rods. Very thin wire was then drawn from these rods. Lamps made with ductile tungsten filaments appeared on the market in 1911, and they have dominated the lighting industry ever since. Tungsten lamps are still made essentially the same way Coolidge made them 70 years ago.[1, 2]

Contribution to Nuclear Science

General Electric also manufactured X-ray tubes and Coolidge recognized that his tungsten filament together with additional modifications could significantly improve the performance of the tube.[3] Coolidge had been fascinated by William Roentgen's discovery of X-rays in 1895 and had experimented with them on his own. Thus, it was a natural step from the ductile-tungsten work to experimenting with tungsten as a target material.[1]

A theoretical assist from the brilliant Irving Langmuir, gave Coolidge an important lead, and the tube was introduced to the world at a radiologist's dinner in 1913.[1] Coolidge's improved X-ray tube, shown to the right, employed a heated tungsten filament as its source of electrons (i.e., the cathode). Since residual gas molecules in the tube were no longer necessary as the electron source, the Coolidge (or hot cathode) tube could be completely evacuated which permitted higher operating voltages. These

higher voltages produced higher energy X-rays which were more effective in the treatment of deep-seated tumors. In addition, the intensity of the X-rays didn't show the tremendous fluctuations characteristic of earlier tubes and the operator had much greater control over the quality (i.e., energy) of the X-rays.[3] Coolidge's second major invention, the X-ray tube, is also essentially the same today as it was then.[1]

In 1917 it became evident that the involvement in World War I by the U.S. was unavoidable. During the war Coolidge developed a sealed rubber binaural listening tube that allowed Navy ships carrying depth bombs to accurately locate and destroy submarines. Additionally, the Coolidge tube was adapted to a field X-ray unit for use in World War I, and it became a major medical tool in field hospitals, where many practitioners became acquainted with it for the first time.[2, 4]

In 1932, William Coolidge succeeded Willis Whitney as the director of research at General Electric. In 1940, he became vice-president of the company.[4] At the beginning of World War II, Coolidge was appointed to a small committee established to evaluate the military importance of research on uranium. This committee's report led to the establishment of the Manhattan District for nuclear weapons development.[3, 4] He retired after the war, but continued consulting for General Electric until about 1965.[4]

Honors

Coolidge was awarded the AIEE Edison Medal in 1926, "for the origination of ductile tungsten and the fundamental improvement of the X-ray tube." In an example of the integrity for which Coolidge is still remembered, he shortly after declined the award on the basis that his ductile tungsten patent was invalid. The AIEE committee got Coolidge to accept the 1927 AIEE Edison Medal, by awarding it "For his contributions to the incandescent electric lighting and the X-rays art."[1, 2]

In 1975, with 83 patents to his credit, William David Coolidge was elected to the National Inventor's Hall of Fame, the only person to receive this honor in his lifetime.[3]

William Coolidge married Ethel Woodward, the daughter of the president of a local bank, on December 30, 1908. A daughter, Elizabeth, and a son, Lawrence, were born to this marriage. Early in 1915 Ethel became seriously ill and died at the hospital in February of that year. Dorothy Elizabeth MacHaffie, a graduate nurse from Ellis Hospital, was engaged by William to help his mother with the two children at home. Dorothy was a charming person and, about a year later, she and William Coolidge were married.[2]

Coolidge was unusual because he was both a major technical contributor and a successful research leader during a trying time in GE's history -the Depression of the 1930s. Few people have been able to combine these roles as successfully as Coolidge.[1] William Coolidge was blessed with remarkable health throughout his very active lifetime, and he retained a keen mind into his late nineties. He died on February 4, 1975, in Schenectady, New York, at the age of one-hundred-and-one.[2]

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 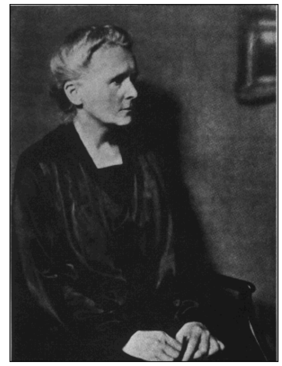

Marie Curie
1867 – 1934

Marie Curie is the most famous woman of physics. She and her husband, Pierre, discovered the elements radium and polonium. She received the 1903 Nobel Prize for Physics jointly with her husband "their joint researches on the radiation phenomena discovered by Professor Henri Becquerel." In 1911 she received a second Nobel Prize, this time in Chemistry, for her work on radium and radium compounds.

Early Life

Manya Sklodowska was born November 7, 1867 in Warsaw, Poland. She was the youngest of Wladislaw and Bronislava Boguska Sklodowska.[1] Manya was a brilliant student who graduated her secondary education with top honors in 1883. Because women were not allowed to attend universities in Russian-dominated Poland, she earned her living by becoming a private tutor. She made huge financial sacrifices so that her sister, Bronia, could travel to Paris to study medicine. In 1891 her sister repaid her by allowing Manja to come live with her in Paris, so that she could study physics.[1, 3] When she arrived in Paris, Manya changed her name to Marie and enrolled in the Sorbonne.[2]

When classes began in November 1891, Marie was enrolled as a student of physics. By 1894 she was desperately looking for a laboratory where she could work on her research project, the measurement of the magnetic properties of various steel alloys, and it was suggested that she see Pierre Curie at the School of Physics and Chemistry of the University of Paris. The next summer Marie and Pierre were married. By mid-1897 Marie had obtained two university degrees and a fellowship for graduate studies, had written a monograph on the magnetization of tempered steel, and had given birth to her first daughter, Irene.[1, 3]

Contributions to Nuclear Science

Wilhelm Roentgen had discovered X-rays in 1895, and in 1896 Antoine Henri Becquerel had discovered that the element uranium gives off similar invisible radiations.[2] In 1897

Marie had decided to pursue a doctorate degree in physics and chose to study the mysterious radiations of uranium. On July 18, 1898, Marie and Pierre presented the first of two papers announcing the discovery of a new radioactive element. The first newly discovered element was named polonium after Marie's native country. On December 26, a second paper was presented to announce the discovery of radium. Between 1898 and 1902 Pierre and Marie processed several tons of pitchblend ore in order to isolate minute amounts of radium. The Curie's published a total of 32 papers during these four years, including one that described how tumor-forming cells were destroyed faster than healthy tissue when exposed to radium.[1] In 1903, three French scientists, A.H. Becquerel and Marie and Pierre Curie were awarded the Nobel Prize in Physics for their joint work in the study of uranium "radioactivity," the term coined by Marie to describe the mysterious emanations Becquerel had discovered. In December 1904 the Curie's second daughter Eve, was born.

The first academic year of Pierre Curie in his new professorship at the University of Paris was not yet over when, on the rainy mid-afternoon of April 19, 1906, he was run down by a heavy carriage and killed instantly. Two weeks later the widow was asked to take over her late husband's post. In 1908 she began to give as titular professor at the Sorbonne the first, and then the only, course on radioactivity in the world. In the same year she edited the collected works of her late husband, and in 1910 she isolated pure radium metal and determined its atomic weight as well as published her massive *Traite de radioactivite*. In 1903, Marie Curie had been the first female recipient of a Nobel Prize.[2] In 1911 she became the first person to receive the Nobel Prize twice.[1] The 1911 Nobel Prize was in the field of chemistry and had been awarded for her work with radium and radium compounds.

During World War I Marie and her eldest daughter, Irene, devoted much of their time to creating mobile x-ray machines to assist in the location of shrapnel and bullets. In addition to her mobile facilities, Marie helped provide equipment for hospitals and to train 150 female x-ray technicians. When the war was over, Marie went back to the Radium Institute, which had been founded specifically for her research in 1914. Her daughter, Irene, became her assistant in 1918 and later, she and her husband, Frederic, another of Marie's assistants at the radium Institute, discovered artificial radioactivity, for which they jointly received the 1935 Nobel Prize in Chemistry.[1, 3]

Publications

Marie published numerous scientific papers throughout her career, including 32 scientific papers Marie published, either jointly or separately, between 1898 and 1902. She also edited the collective papers of Pierre Curie after his death and published a few massive books or her own. A small list of her most famous publications is provided below:

- Traite de radioactivite (1910)
- La Radiologie et la guerre (1921)
- Radioactivite (1934)

Honors[1]

In 1902, Pierre had unsuccessfully presented himself for membership to the French Academy of Sciences. In November 1903 the Royal Society in London gave the Curies one of its highest awards, the Davy Medal; and a month later the announcement from Stockholm that three French scientists, A. H. Becquerel and the Curies, were the joint recipients of the 1903 Nobel Prize in Physics.[1] In 1904, the French Academy of Sciences elected Pierre to its membership, but elected to maintain its all male status and refused membership to Marie. The Academy continued to exclude women for another 40 years, thus, Marie's daughter, Irene, was also later denied membership to the Academy.

In 1911 Marie became the first person to be awarded a second Nobel Prize, this time in the field of Chemistry. In the same year, Marie was elected as a permanent member of the Solvay Conferences in physics and offered the directorship of the Warsaw Institute of Radioactivity.

Marie Curie died of pernicious anemia in Haute Savoie on July 4, 1934 – she was 66 years old.[2]

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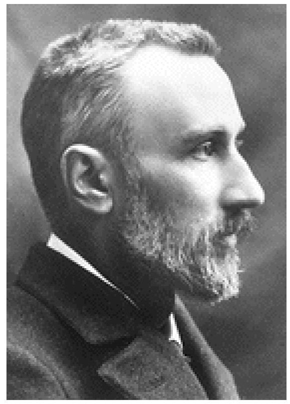

Pierre Curie
1859 - 1906

French scientist, a pioneer in the study of crystallography, magnetism, piezoelectricity and radioactivity. Received the 1903 Nobel Prize for Physics jointly with his wife, Marie, "in recognition of the extraordinary services they have rendered by their joint researches on the radiation phenomena discovered by Professor Henri Becquerel."[3]

Early Life

Pierre Curie was born in Paris, where his father was a general medical practitioner, on May 15, 1859. He received his early education at home since his father believed that his son's intellect and personality would be best nurtured through private tutoring. By the time Pierre was 14 years old he demonstrated a gift for mathematics.[2] At 16 he entered the Faculty of Sciences at the Sorbonne. He gained his Licenciateship in Physics in 1878 and continued as a demonstrator in the physics laboratory until 1882 when he was placed in charge of all practical work in the Physics and Industrial Chemistry Schools. In 1895 he obtained his Doctor of Science degree and was appointed Professor of Physics. He was promoted to Professor in the Faculty of Sciences in 1900, and in 1904 he became Titular Professor.[1]

Contributions to Nuclear Science

Pierre's first important scientific achievement occurred as a collaboration with his older brother, Jacques.[1] T he Curie brothers had found that when pressure is applied to certain crystals, they generate electrical voltage. Reciprocally, when placed in an electric field these same crystals become compressed. This effect was named the piezoelectric effect, from the Greek word meaning "to press." Recognizing the connection between the two phenomena helped Pierre to develop pioneering ideas about the fundamental role of symmetry in the laws of physics. The brothers meanwhile put their discovery to immediate practical use by devising the piezoelectric quartz electrometer, which can measure faint electric currents. In the century following its discovery by the Curie brothers, the piezoelectric effect was put to use in such familiar everyday devices as microphones, quartz watches, and electronic components.[2]

After a while, Pierre turned his attention towards the field of magnetism. He discovered a basic relationship between magnetic properties and temperature. Today the temperature at which the change in magnetic properties occurs is referred to as the Curie point.[1, 2]

In the spring of 1894, Pierre met Marie Sklodowska. She urged him to write up his research on magnetism as a doctoral thesis. He was awarded his doctorate a few months before he and Marie were married in 1895.[2] When Marie's own thesis research led her to believe that she was on the verge of discovering a new element, Pierre joined her in the search.[2] They announced the discovery of radium and polonium by fractionation of pitchblende in 1898.[1] Their work, including Marie's celebrated doctoral work, made use of a sensitive piezoelectric electrometer constructed by Pierre and his brother Jacques. They were the first to use the term 'radioactivity'.[3] After their discovery of polonium and radium, the Curies decided on a division of labor: he concentrated on investigating the properties of radium, while she did chemical experiments with a view to preparing pure compounds.[2]

So it was Pierre (with a student) who noticed that a speck of radium spontaneously and perpetually emits heat--discovering what is now called nuclear energy. He was also, with collaborators, the first to report the decay of radioactive materials and the skin burns that radioactive substances can inflict.[2] He also investigated the radiation emissions of radioactive substances, and through the use of magnetic fields was able to show that some of the emissions were positively charged, some were negative and some were neutral. These correspond to alpha, beta and gamma radiation.[3] Pierre and Marie were awarded half of the Nobel Prize for Physics in 1903 on account of their study into the spontaneous radiation discovered by Henri Becquerel, who was awarded the other half of the Prize.[1, 2, 3]

Publications

Pierre Curie's work is recorded in numerous publications in the Comptes Rendus de l'Académie des Sciences, the Journal de Physique and the Annales de Physique et Chimie.[1]

Honors

Curie was awarded the Davy Medal of the Royal Society of London in 1903 (jointly with his wife) and in 1905 he was elected to the Academy of Sciences.[1] The curie is a unit of radioactivity (3.7×10^{10} decays per second) originally named in honor of Pierre Curie by the Radiology Congress in 1910, after Pierre's death. Both Pierre and Marie were enshrined in the crypt of the Pantheon in Paris in April 1995. [3]

His wife was formerly Marie Sklodowska, daughter of a secondary-school teacher at Warsaw, Poland. One daughter, Irene, married Frederic Joliot and they were joint recipients of the Nobel Prize for Chemistry in 1935. The younger daughter, Eve, married the American diplomat H. R. Labouisse. They have both taken lively interest in social problems, and as Director of the United Nations' Children's Fund he received on its behalf the Nobel Peace Prize in Oslo in 1965. Eve is the author of a famous biography of her mother, Madame Curie.[1]

Pierre died as a result of a carriage accident in a rain storm while crossing the rue Dauphine in Paris during April 19, 1906 after having his head crushed under the carriage wheel, thereby avoiding probable death by radiation poisoning, which later killed his wife.2, 3

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John Dalton
1766 – 1844

British chemist and physicist who developed the atomic theory of matter and hence is known as one of the fathers of modern physical science.

Early Life

John Dalton was born September 6, 1766 at Eaglesfield, near Cockermouth in the Lake District of Cumberland, Great Britian.[1, 5] His father, Joseph Dalton, was a weaver in poor circumstances, who, with his wife (Deborah Greenup), belonged to the Society of Friends; they had three children; Jonathan, John and Mary.[7]

John received his early education from his father and from John Fletcher, teacher of the Quaker school at Pardshow Hall in Eaglesfield.[3, 7] John Fletcher, the master, was a superior man who did not use the rod to hammer in learning. He provided John with a superb background and lifelong quest for knowledge.[3] Upon the retirement of Fletcher in 1778, when John Dalton was only 12 years old, he took charge of the Quaker school in Cumberland and two years later taught with his brother at a school in Kendal, where he was to remain for 12 years.[1] This youthful venture was not successful, the amount he received in fees being only about five shillings a week, and after two years he took to farm work. In 1781 he left his native village to become assistant to his cousin George Bewley, who kept a school at Kendal. There he passed the next twelve years, becoming in 1785, through the retirement of his cousin, joint manager of the school with his elder brother Jonathan. About 1790 he seems to have thought of taking up law or medicine, but his projects met with no encouragement from his relatives and he remained at Kendal till, in the spring of 1793, he moved to Manchester as a tutor at New College where he spent the rest of his life. It was here that John would rise above his country schoolteacher background to do his greatest work.[3]

In the early days of his teaching, Dalton's way of life was influenced by a wealthy Quaker, Elihu Robinson, a capable meteorologist and instrument maker, who interested him in the problems of mathematics and meteorology.[1, 5] During his life, Dalton was fascinated by the earth's atmosphere.[5] His first scientific work, which he began in 1787 and continued until the end of his life, was to keep a diary - which was ultimately to contain 200,000 entries - of meteorological observations recording the changeable climate of the lake district in which he lived.[1, 2] He then became interested in preparing collections of botanical and insect species. Stimulated by a spectacular aurora borealis display in 1788, he began observations about aurora phenomena - luminous, sometimes colored displays in the sky caused by electrical disturbances in the atmosphere.

Along with his other researches he also became interested in color blindness, a condition that John Dalton and his brother, Jonathan, shared. In 1794 he was elected a member of the Manchester Literary and Philosophical Society, and a few weeks after election he communicated his first paper on *Extraordinary facts relating to the vision of colors*, in which he gave the earliest account of the optical peculiarity known as Daltonism or color-blindness. In his essay, Dalton had postulated that deficiency in color perception was caused by discoloration of the liquid medium of the eyeball and summed up its characteristics as observed in himself and others.[1, 5, 7] Although Dalton's theory lost credence in his own lifetime, the meticulous, systematic nature of his research was so broadly recognized that Daltonism became a common term for color blindness.

These are only some of the subjects on which he wrote essays that he read before the Philosophical Society: others included such topics as the barometer, thermometer, hygrometer, rainfall, the formation of clouds, evaporation and distribution and character of atmospheric moisture, including the concept of the dew point.[1]

Contributions to Nuclear Science

An indefatigable investigator or researcher, Dalton had an unusual talent for formulating a theory from a variety of data. Although he taught chemistry for six years at New College, he had no experience in chemical research. His early studies on gases led to development of the law of partial pressures (known as Dalton's law; *q.v.*), which states that the total pressure of a mixture of gases equals the sum of the pressures of the gases in the mixture, each gas acting independently.[1] In 1803, while attempting to explain his law of partial pressures, John Dalton started to formulate his most important contribution to science the atomic theory. He was studying nitrogen oxides for Dr. Priestley's test for percentage of nitrogen in the air. Among the reactions he studied were those of nitric oxide with oxygen. He discovered that the reaction can take place in two different proportions in exact ratios, namely:

$$2NO + O \text{ ---> } N_2O_3$$
$$NO + O \text{ ---> } NO_2$$

John stated that oxygen combines with nitrogen sometimes 1 to 1.7 and at other times 1 to 3.4 by weight. On August 4, 1803, he stated the law of multiple proportions: the weights of elements always combine with each other in small whole number ratios. John published his first list of atomic weights and symbols that year, which gave chemistry a language of its own. [3]

These experiments also resulted in his theory according to which gas expands as it rises in temperature. On the strength of the data gained in these studies he devised other experiments that proved the solubility of gases in water and the rate of diffusion of gases. His analysis of the atmosphere showed it to be constant in com-position to 15,000 feet. Dalton discovered butylene and determined the composition of ether, finding its correct formula.

Finally, he developed his masterpiece of synthesis - the atomic theory.[1] He proposed the *Atomic Theory* in 1803 which stated that (1) all matter was composed of small indivisible particles termed atoms, (2) atoms of a given element possess unique characteristics and weight, and (3) three types of atoms exist: simple (elements), compound (simple molecules), and complex (complex molecules).[4, 6] Dalton's theory was presented in *New System of Chemical Philosophy* (1808-1827). This work identified chemical elements as a specific type of atom, therefore rejecting Newton's theory of chemical affinities.[4]

Publications

Altogether Dalton contributed 116 memoirs to the Manchester Literary and Philosophical Society, of which from 1817 till his death he was the president. Of these the earlier are the most important works, a few of which are listed below.[7]

- *Meteorological Observations and Essays* (1793)[1]
- *Extraordinary Facts Relating to the Vision of Colors* (1794)[1]
- *Elements of English Grammar* (1801)[6]
- *A New System of Chemical Philosophy Part I* (1808)[2] and *Part II* (1810)[3]

In another paper, read in 1814, Dalton explains the principles of volumetric analysis, in which he was one of the earliest workers. In 1840 a paper on the phosphates and arsenates, which was clearly unworthy of him, was refused by the Royal Society, and he was so incensed that he published it himself. He took the same course soon afterwards with four other papers, two of which *On the quantity of acids, bases and salts in different varieties of salts* and *On a new and easy method of analysing sugar*, contain his discovery, regarded by him as second in importance only to the atomic theory, that certain anhydrous salts when dissolved in water cause no increase in its volume, his inference being that the salt enters into the pores of the water.[7]

Honors

Before he had propounded the atomic theory he had already attained a considerable scientific reputation. In 1804 he was chosen to give a course of lectures on natural philosophy at the Royal Institution in London, where he delivered another course in 1809-1810. In 1810 he was asked by Sir Humphrey Davy to offer himself as a candidate for the fellowship of the Royal Society, but declined, possibly for pecuniary reasons; but in 1822 he was proposed without his knowledge, and on election paid the usual fee.[2] Six years previously he had been made a corresponding member of the French Academy of Sciences, and in 1830 he was elected as one of its eight foreign associates in place of Davy.[7]

John Dalton died on 27 July 1844 of a stroke, after noting the weather conditions for the day in his journal. Dalton had requested that his eyes be examined after his death, in an attempt to discover the cause of his color-blindness; he had hypothesized that his aqueous humor might be colored blue. Postmortem examination showed that the humors of the eye were perfectly normal.[7] It was his final experiment and proved that the condition called Daltonism is not caused by the eye itself, but some deficient sensory power.[3] However, an eye was preserved at the Royal Institution, and a 1990s study on DNA extracted from the eye showed that he had lacked the pigment that gives sensitivity to green; the classic condition known as a *deuteranope*.[7]

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 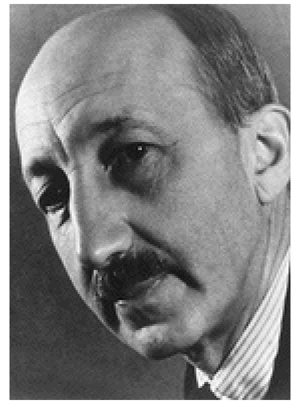

George Charles de Hevesy
1885 – 1966

Hungarian chemist whose development of isotopic tracer techniques greatly advanced the understanding of the chemical nature of life processes. He earned the 1943 Nobel Prize in Chemistry for this work. He also co-discovered the element hafnium.[2]

Early Life

George de Hevesy was born in Budapest, Austria-Hungary [now in Hungary] on August 1, 1885, the son of Louis de Hevesy, Court Counsellor and Eugénie, née Baroness Schosberger. After matriculating at the Gymnasium of the Piarist Order in 1903 he studied at Budapest University and Berlin Technical University (Technische Hochschule). He gained his doctor's degree at the University of Freiburg in Breisgau in 1908. He worked for two years as an assistant at the Institute of Physical Chemistry, Technical University of Switzerland before having a short spell with Professor Fritz Haber when he was able to witness much of the fundamental work of Haber and Rossignol on ammonia synthesis.[3]

Contributions to nuclear Science

He traveled to Manchester, England in 1910 to study radium-D (Pb-210) under Professor Ernest Rutherford. Ironically, it was his inability to accomplish a task assigned by Ernest Rutherford in 1911 that led to his greatest discovery: radiotracers. Hevesy had just joined the research group at the University of Manchester headed up by Rutherford who was investigating the radioactive properties of radium-D (Pb-210). Much to Rutherford's annoyance, the lead with which the radium-D was associated interfered with his analyses. Not realizing that radium-D was a radioactive form of lead, Rutherford erroneously thought it could be chemically isolated.[1] Out of his failure to complete that impossible task, de Hevesy conceived the radiotracer technique by which radioisotopes could be used to investigate the behavior of stable atoms.[2]

He interrupted early in 1913 his studies to carry out jointly with Frederic Paneth the first radioactive-tracer experiment at the Vienna Institute of Radium Research.[3] Radioactive-tracer technique is considered by some to be a technique second to none in its analytical power. De Hevesy not only performed the first radiotracer studies on plants and animals, using both natural and artificial radionuclides, he also performed the first tracer studies employing stable nuclides by using deuterated water to measure the turnover of hydrogen in the body. In addition to these studies, which earned him the 1943 Nobel Prize in Chemistry, de Hevesy developed the technique of neutron activation analysis, perhaps the most powerful non-destructive technique for the elemental analysis of solid samples.[1]

During his stay in Vienna he obtained the Venia Legendi in the University of Budapest. In 1915 he was drafted into the Austrian-Hungarian Army. After the end of the war he was teaching for 6 months in the University of Budapest and left the spring of 1919 for Copenhagen to discuss his future activities at Niels Bohr's Institute which was to be erected. In 1920 he was invited to Copenhagen.[3]

In Copenhagen, de Hevesy's researches were initially concerned with isotopic separations and in 1923, together with Coster, (and pursuing a suggestion by Niels Bohr) he discovered the element hafnium in the ores of zirconium.[3] Despite the importance of the radiotracer technique and neutron activation analysis, de Hevesy took the greatest pride in his discovery of the element hafnium. In part, this was because of the magnitude of the effort involved and in part because of the important role hafnium played in the organization of the periodic table.[1]

In 1926, de Hevesy returned to Freiburg as Professor of Physical Chemistry, where he began to calculate the relative abundance of the chemical elements and was involved in the first clinical use of isotopes.[2] In 1930 he was appointed Baker Lecturer at Cornell University, Ithaca. Four years later he took up again his activities at Niels Bohr's Institute which he terminated in 1952.[3] In 1934, after the preparation of a radioactive isotope of phosphorus, he began to study various plant and animal physiological processes by tracing the course of "labeled" radioactive phosphorus through the body. These experiments revealed the dynamic state of the body constituents.[2] He also demonstrated the formation of new artificially radioactive isotopes and subsequently introduced a method of activation analysis based on neutron bombardment of the element to be investigated.[3]

Fleeing from the Nazis in 1943, de Hevesy became an Associate of the Institute of Research in Organic Chemistry, Stockholm.[2] His work in Sweden continued on the same lines and he studied, amongst other things, the effect of X-rays on the formation of nucleic acid in tumors and in normal organs, and iron transport in healthy and cancerous organisms; this work was supported by the Swedish State Research Council and the Wallenberg Foundation.[3]

In 1949 he was elected Franqui Professor in the University of Ghent. In his retirement, he remained an active scientific associate of the University of Stockholm.

Publications

Professor de Hevesy was the author of several important books on radiochemistry (including the two-volume *Adventures in Radioisotope Research* (1962), and his many scientific papers are valuable and accurate records of devoted work.[2]

Honors[3]

He was awarded the Cannizaro Prize (Academy of Sciences, Rome) in 1929, he was the Copley Medallist (Royal Society, London) in 1949, Faraday Medallist in 1950, Baily Medallist in 1951 and Silvanus Thompson Medallist in 1955. In 1959 he received the Ford Foundation's Atoms for Peace Award Medal, in 1961 the Niels Bohr Medal and the Rosenberger Medal of the University of Chicago. Honorary degrees conferred upon Professor de Hevesy included Doctor of Philosophy, Uppsala, Freiburg, and Copenhagen; Doctor of Science, Ghent, Liège, London, and Capetown; and Doctor of Medicine, São Paulo, Rio de Janeiro, Turin, and Freiburg. He was a Fellow of the Royal Society (London), the Swedish Academy of Sciences, Gothenburg Academy, and eleven other scientific academies. He was Honorary Fellow of the Chemical Society (London), the Royal Institution (London), the British Institute of Radiology, the Finnish Chemical Society, the German Bunsen Society, the German Physiological Society, the Chemical Society of Japan, and the American Society of Nuclear Medicine. In addition, he held honorary memberships of many more learned societies.

Professor de Hevesy married Pia Riis in 1924. They had one son and three daughters. George de Hevesy died July 5, 1966, in Freiburg im Breisgau, West Germany.

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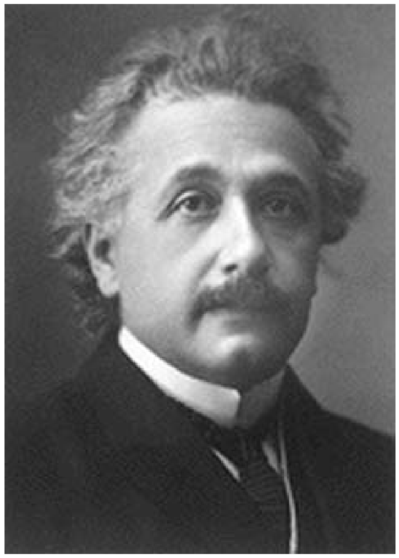 

Albert Einstein
1879 – 1955

German-born physicist known primarily for his general theory of relativity, summarized by the well known equation $E=mc^2$.

Early Life

Albert Einstein was born March 14, 1879 in Ulm, Germany. His father, Hermann Einstein, owned a small electrochemical factory in Munich.[1] Einstein began attending school in Munich in 1886. Two years later he entered the Luitpold Gymnasium. In 1895, after his father's business failed, the Einstein family moved to Milan, Italy. Albert Einstein remained in Germany to continue his studies.[1, 3] That same year Einstein failed the entrance examination that would have allowed him to study for a diploma in electrical engineering at the Eidgenössische Technische Hochschule (ETH) in Zurich. Thus, Einstein attended a secondary school at Aarau planning to use this route to enter and obtain a degree from the ETH. Einstein finally gained admittance to the ETH in 1896. That same year he renounced his German citizenship and several years later he became a Swiss citizen.[3]

Einstein graduated from the ETH in 1900 hoping to become a teacher of mathematics and physics. Although several of his fellow students were able to obtain appointed assistantships at the ETH in Zurich, Einstein was unable to secure such a position. By mid-1901 he had managed to secure a temporary job teaching mathematics at the Technical High School in Winterthur. Another temporary teaching position in Schaffhausen followed.[3] In 1903, Einstein married his university sweetheart, Mileva Maric.[1]

Contribution to Nuclear Science

Between 1902 and 1909, Einstein worked as an examiner at the Swiss Patent Office in Bern.[2] While employed at the patent office, Einstein continued his own studies in theoretical physics. The significant amount of free time he enjoyed at work enabled him to complete a large number of publications, including the article "A New Determination of Molecular Dimensions," which earned him a doctorate from the University of Zurich in 1905.[1, 3] He published four other papers in the Annelen der Physik during the same year, including his revolutionary theory that light exists as both waves and particles and the initial version of his famous theory of relativity.[3]

After 1905 Einstein continued working in the areas described above. In 1908 Einstein became a lecturer at the University of Bern. The following year he became professor of physics at the University of Zurich, having resigned his lectureship at Bern and his job in the patent office in Bern. He was appointed a full professor at the Karl-Ferdinand University in Prague in 1911. That same year, Einstein was able to make preliminary predictions about how a ray of light from a distant star, passing near the Sun, would appear to be bent slightly, in the direction of the Sun. This would be highly significant as it would lead to the first experimental evidence in 1919 in favor of Einstein's theory. About 1912, Einstein began a new phase of his gravitational research, with the help of his mathematician friend Marcel Grossmann, by expressing his work in terms of the tensor calculus of Tullio Levi-Civita and Gregorio Ricci-Curbastro. Einstein called his new work the general theory of relativity. He moved from Prague to Zurich in 1912 to take up a chair at the Eidgenössische Technische Hochschule in Zurich.[3]

Einstein returned to Germany in 1914 with his wife and two sons, Hans Albert and Eduard, but did not reapply for German citizenship.[1] What he accepted was an impressive offer. It was a research position in the Prussian Academy of Sciences together with a chair (but no teaching duties) at the University of Berlin. He was also offered the directorship of the Kaiser Wilhelm Institute of Physics in Berlin.[3]

It was not until 1915 that Einstein completed the definitive version of his general theory of relativity. In November 1919, the Royal Society of London announced that their experiments conducted during the solar eclipse confirmed the predictions of Einstein.[1]

Unhappy with life in Berlin, his wife Mileva returned to Switzerland with their sons near the beginning of World War I; their separation led to a divorce in 1919. Einstein married his second cousin, Elsa Lowenthal, later that year.[1]

In the years following WWI, he received a great deal of criticism within Germany for his theories, as well as his active support of pacifism (including the League of Nations), liberalism, and Zionism. He traveled a great deal to deliver lectures on relativity, touring Europe, Asia, the Middle East, and South America.[3]

In 1933, just after Adolf Hitler became chancellor of Germany, Einstein emigrated to America, where he was offered a full-time position at the newly-founded Institute for

Advanced Study in Princeton, New Jersey.[3] Early on, Einstein recognized the serious threat to world security posed by Hitler and Nazism. After Elsa's death in 1936, Einstein lived alone in Princeton, throwing himself even more completely into political activism.[1] Despite his history of pacifism, he publicly urged European nations to ready themselves for defense. In 1939, Einstein wrote a famous letter to President Franklin D. Roosevelt warning of the possibility of Germany's building an atomic bomb and urging nuclear research.[2] Though he played no direct part in the development of the atomic bomb and was publicly horrified by its use in Japan in 1945 and its implications for the future of war, his name and research were inextricably linked to the dawning of the age of atomic power.[3] He joined other scientists in a push to prevent future use of atomic weapons, proposing the establishment of a system of world government that would provide "the binding authority necessary for world security."[1]

By 1949 Einstein was unwell. A spell in hospital helped him recover, but he drew up his will leaving his scientific papers to the Hebrew University in Jerusalem. He died on April 18, 1955, at the age of 76. He was cremated and his ashes were scattered at undisclosed place.[3]

Publications

The year 1905 was an epoch-making one in the history of physics, because Einstein contributed three papers to Annalen der Physik (Annals of Physics), each of which ultimately became the basis of a new branch of physics.[2]

In one of the papers, Einstein suggested that light could be thought of as a stream of tiny particles. In 1900, the German physicist Max K. E. L. Planck had proposed that the radiation of light occurred in packets of energy, called quanta.[2] The energy of these quanta was directly proportional to the frequency of the radiation. This contradicted classical electromagnetic theory, which assumed that electromagnetic energy consisted of waves that could contain any small amount of energy.[3] Einstein extended this idea by arguing that light itself consisted of quanta, which were later called photons. Scientists before Einstein had discovered that a bright beam of light striking a metal caused the metal to release electrons, which could form an electric current. They called this phenomenon the photoelectric effect. But scientists could not explain the phenomenon as long as they assumed that light traveled only in waves. Using his theory of quanta, Einstein explained the photoelectric effect. He showed that when quanta of light energy strike atoms in a metal, the quanta forced the atoms in the metal to release electrons. Einstein received the 1921 Nobel Prize in physics for this paper on quanta.[2]

In a second paper, titled "The Electrodynamics of Moving Bodies," Einstein presented the special theory of relativity, the theory for which he is most widely known. In this paper, he showed how the theory demonstrated the relativity of time.[2] He based his new theory on a reinterpretation of the classical principle of relativity, namely that the laws of physics had to have the same form in any frame of reference. As a second fundamental hypothesis, Einstein assumed that the speed of light remained constant in all frames of reference, as required by Maxwell's theory.[3]

The third major paper of 1905 concerned Brownian motion, an irregular motion of microscopic particles suspended in a liquid or gas. It confirmed the atomic theory of matter.[2]

Honors

Albert Einstein received the 1921 Nobel Prize in Physics, not for his theory of relativity for which he is popularly know, but instead for his 1905 work on the photoelectric effect. Among further honors were the Copley Medal of the Royal Society in 1925 and the Gold Metal of the Royal Astronomical Society in 1926.[3]

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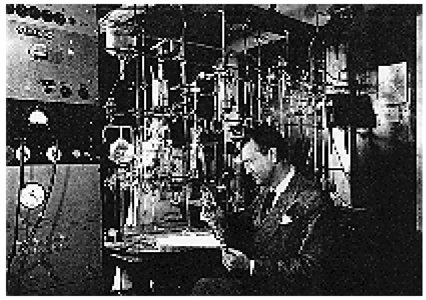

(Provided by the MIT Museum)

Robley D. Evans
1907 – 1995

American physicist considered one of the founders of Nuclear Medicine. He developed the first standard for the "maximum permissible body burden" of radium and pioneered the use of radioiodine by physicians to assess human thyroid conditions.

Early Life

Robley Evans was born on May 18, 1907 in University Place, NE. At the California Institute of Technology, he received the BS degree in physics in 1928, the MS in 1929 and the PhD in 1932.[3] He started at Massachusetts Institute of Technology in 1934 as an Assistant Professor and later in 1945 became a full Professor of Physics.[2]

Contribution to Nuclear Medicine

While Evans' was a graduate student at Caltech, the Los Angeles County Health Officer, Frank Crandall, was investigating the hazards that radium-containing patent medicines posed to the public health. Since these products were being manufactured in the Los Angeles area and therefore any possible effects were Crandall's concern. Crandall contacted Evans' supervisor, Robert Millikan, and this proved to be a pivotal moment in the young Evans' life because he spent most of his career researching the physiological effects of radiological substances.[1]

After graduation he worked at Massachusetts Institute of Technology and was able to continue his research into radium poisoning. The scintillation cameras currently found in hospitals are the results from the first whole body counter to measure radium uptake using radium dial painters. This first generation counter was used to conduct the first measurement of a radionuclide in the human body. He didn't just use his expertise for measuring radium in the body. He sought to determine what effects radium had on the human body; this included the body's metabolism, the hazards, and how to minimize any harmful side effects.[1, 2] This research led Professor Evans in 1941 to establish one ten-millionth of a gram (01. μCi) of radium as the "maximum permissible body burden"-the greatest quantity of a radioactive substance that the human body can tolerate without a likelihood of damage, allowing a large margin for safety.[3]

Perhaps the greatest contribution Robley Evans made to the medical field was the use of radioiodine to assess human thyroid conditions without invasive surgery. This method was used from the 1930's to the 1980's and was counted as one of the medical community's greatest tools for monitoring the health of patients. [1, 2]

Professor Evans's accomplishments in medical physics included development of a technique to preserve human whole blood, research primarily undertaken for the benefit of wounded servicemen in World War II. By using as many as two radioactive forms of iron and one of iodine-a so-called "triple tracer" experiment-doctors could determine how well transfused blood cells remained in a recipient's blood stream. A chemical was found to preserve the blood for up to three weeks, the time it required to reach distant battlefields and subsequently was used in blood banks for several decades.[3]

Dr. Robley D. Evans died of respiratory failure on December 31, 1995 in Paradise Valley, AZ, where he lived in retirement. He was 88.[3] For all of his efforts and research he is considered one of the founders of Nuclear Medicine.

Publications

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Honors

Among his many honors, Professor Evans was the recipient of the Theobald Smith Medal and Award in the Medical Sciences from the American Association for the Advancement of Science, the Presidential Certificate of Merit, the Hull Award and Gold Medal from the American Medical Association, The Silvanus Thompson Medal from the British Institute of Radiology, the Distinguished Achievement Award from the Health Physics Society and the William D. Coolidge Award from the American Association of Physicists in Medicine. In 1990, Dr. Robley D. Evans won the Enrico Fermi Award and a pioneer in studying the effects of radium on the human body.[3]

He was a member of many societies and professional organizations, and served as president of both the Radiation Research Society and the Health Physics Society. Among his memberships were the American Academy of Arts and Sciences (Life Fellow), the American Association for the Advancement of Science (Fellow), the American Association of Physicists in Medicine, the American Association of Physics Teachers, the American Industrial Hygiene Association, the American Nuclear Society, the American Roentgen Ray Society and the Royal Scientific and Literary Society of Sweden.[3]

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Gioacchino Failla
1891 - 1961

Gioacchino Failla was a pioneer in the fields of biophysics and radiobiology. His contributions to nuclear science include the construction of the first U.S. radon generator and helping to found the International Commission on Radiation Units and Measurements (ICRU) and the Radiation Research Society.

Contributions to Nuclear Medicine

Gioacchino Failla began his career at New York's Memorial Hospital in 1915. Within a few years of joining the hospital staff, he had established the first research program devoted to improving the medical applications of radiation. One of the initial products of this research was the construction of a radon generator, the first in the United States. In 1921, Failla was the first to suggest that radiation doses be expressed as the amount of radiation energy absorbed and made the first dose estimates in radium therapy in terms of microcalories per cc of tissue. In the following year, Failla constructed the first human phantom in the U.S. so that he could determine the effects of filtration and distance on X-ray fields in the body. In 1925, Failla published protocols and described equipment permitting radiotherapists to deliver the desired radiation doses to their patients accurately.

Later in his career, Failla and colleague Edith Quimby left Memorial Hospital for Columbia University. While at Columbia University, Gino made important contributions to the understanding of radiation mutagenesis and the induction of cancer by radiation.[1, 2] During the course of his research, Failla built a counting system to specifically to aid in quantify beta sources. It consists of a 5.5" diameter spherical chamber, the collecting electrode of which is connected to the fiber of a Lindemann-Ryerson electrometer. When viewed through the horizontally mounted microscope (projecting towards the right in the photograph), the fiber is seen superimposed on a scale. To perform a measurement, the chamber is lowered down onto the sample, and the time it takes the fiber to move a specific number of divisions across the scale is recorded and then related to the sample activity via a calibration. The National Bureau of Standards (NBS) used this design in developing the instrument for calibration of the NBS secondary beta standards.[3]

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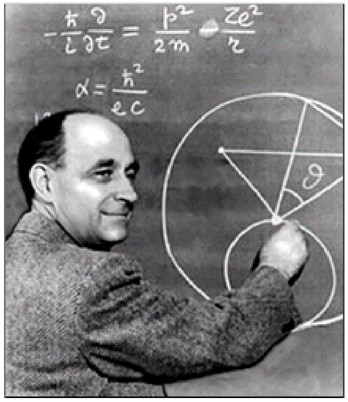  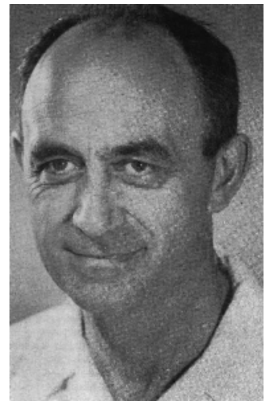

Enrico Fermi
1901 – 1954

Italian-born physicist that developed a statistical method for explaining the behavior of atomic particles and the theory of beta decay which introduced the nuclear "weak force." He received the 1938 Nobel Prize in Physics for the artificial production of radionuclides using neutrons. In1942 he and Leo Szilard created the first controlled nuclear fission chain reaction.

Early Life

Enrico Fermi was born in Rome on September 29, 1901, the son of Alberto Fermi, a Chief Inspector of the Ministry of Communications, and Ida de Gattis, a schoolteacher.[1, 3, 4] In 1918, he won a fellowship of the Scuola Normale Superiore of Pisa. He spent four years at the University of Pisa, gaining his doctor's degree in physics in 1922, with Professor Puccianti.[1]

Soon after graduation he was awarded a scholarship from the Italian Government and spent some months with Professor Max Born in Göttingen. With a Rockefeller Fellowship, in 1924, he moved to Leyden to work with P. Ehrenfest, and later that same year he returned to Italy to occupy for two years (1924-1926) the post of Lecturer in Mathematical Physics and Mechanics at the University of Florence.[1] While at the University of Florence, he developed a new form of statistical mechanics, today known as Fermi-Dirac statistical mechanics, to explain the behavior of subatomic particles.[3, 5] Fermi also developed the theory of beta decay, which introduced the "weak nuclear force" and the concept of the neutrino.[1, 2, 5]

In 1926, Fermi became a professor of theoretical physics at the University of Rome. From 1934 on he studied the production of artificial radioactivity by bombarding elements with neutrons.[2] It was during this research that he and his colleagues unwittingly split the nuclei of uranium. Fermi believed that a new element was being created rather than the splitting of the uranium nuclei. He was awarded the 1938 Nobel Prize in Physics for his creation of reactivity using neutrons.[3] This same experiment also led Fermi to discover that "slowing" neutrons by passing them through a moderator material increased their effectiveness for producing the desired reaction. This knowledge later allowed for the release of nuclear energy in a reactor.

Development of a Nuclear Reactor

Fearing for the safety of his Jewish wife because of Mussolini's anti-Semitic legislation, Fermi went directly from the Nobel Prize presentation in Stockholm to Columbia University in New York City.[3] Upon the discovery of fission, by Otto Hahn and Fritz Strassmann early in 1939, he immediately saw the possibility of emission of secondary neutrons and of a chain reaction.[1] In 1940, Fermi's team confirmed that the absorption of a neutron by the uranium nucleus can cause the nucleus to split into two nearly equal parts.[4] In 1942, Fermi moved to the University of Chicago to join the Manhattan Project, the American led effort to build the first atomic bomb.

On December 2, 1942, the first controlled nuclear fission chain reaction occurred on the squash courts under the west stands of Stagg Field of the University of Chicago.[2, 3, 5] The pile ran for twenty-eight minutes and produced 200 watts of power, paving the way for the 1945 invention of the plutonium-based atomic bomb.[3]

In 1944, Fermi became and American citizen and moved to Los Alamos, New Mexico continue his work on the bomb. Despite his immeasurable contribution to the atomic bomb, Fermi opposed the development of the more powerful hydrogen bomb, calling it a "weapon which in its practical effect is almost one of genocide."[1] After the war, in 1946, Fermi became a professor of physics and the director of the new Institute of Nuclear Studies at the University of Chicago.[2] There he turned his attention to high-energy physics and led numerous investigations into the pion-nucleon interaction.[1]

Publications[1]

Professor Fermi was the author of numerous papers both in theoretical and experimental physics. His most important contributions were:

"Sulla quantizzazione del gas perfetto monoatomico", Rend. Accad. Naz. Lincei, 1935 (also in Z. Phys., 1936), concerning the foundations of the statistics of the electronic gas and of the gases made of particles that obey the Pauli Principle.

Several papers published in Rend. Accad. Naz. Lincei, 1927-28, deal with the statistical model of the atom (Thomas-Fermi atom model) and give a semiquantitative method for the calculation of atomic properties. A resumé of this work was published by Fermi in the volume: Quantentheorie und Chemie, edited by H. Falkenhagen, Leipzig, 1928.

"Uber die magnetischen Momente der AtomKerne", Z. Phys., 1930, is a quantitative theory of the hyperfine structures of spectrum lines. The magnetic moments of some nuclei are deduced there from.

"Tentativo di una teoria dei raggi ß", Ricerca Scientifica, 1933 (also Z. Phys., 1934) proposes a theory of the emission of ß-rays, based on the hypothesis, first proposed by Pauli, of the existence of the neutrino.

The Nobel Prize for Physics was awarded to Fermi for his work on the artificial radioactivity produced by neutrons, and for nuclear reactions brought about by slow neutrons. The first paper on this subject "Radioattività indotta dal bombardamento di neutroni" was published by him in Ricerca Scientifica, 1934. All the work is collected in the following papers by himself and various collaborators: "Artificial radioactivity produced by neutron bombardment", Proc. Roy. Soc., 1934 and 1935; "On the absorption and diffusion of slow neutrons", Phys. Rev., 1936. The theoretical problems connected with the neutron are discussed by Fermi in the paper "Sul moto dei neutroni lenti", Ricerca Scientfica, 1936.

Honors[1]

Fermi was member of several academies and learned societies in Italy and abroad (he was early in his career, in 1929, chosen among the first 30 members of the Royal Academy of Italy). He was the first recipient of a special award of $50,000 - which now bears his name - for work on the atom.[1] The Enrico Fermi Award honoring his memory is given annually to the individual who has contributed most to the development, use, or control of atomic energy.[2]

Enrico Fermi married Laura Capon in 1928. They had one son Giulio and one daughter Nella. Fermi died of stomach cancer on November 28, 1954, in Chicago.[3]

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Otto Robert Frisch
1904 – 1979

Austrian-born, British nuclear physicist who, with his aunt, Lise Meitner, first described and named the uranium fission process and later helped developed the atomic bomb.

Early Life

Otto Robert Frisch was born in Vienna, Austria on October 1, 1904. His father was a printer and his mother was a gifted musician. He received his doctorate from the University of Vienna in 1926 and then spent a year working in a private laboratory. In 1927, Frisch began work at the Physikalisch-Technische Reichsanstalt, the German government's national physics laboratory, in Berlin. Three years later he moved to Hamburg to assist Otto Stern in his studies of molecular beams. During this time he developed a device called the "beam chopper" because it could selectively separate atoms based on passing them through a rotating slotted disk. [1]

After fleeing Nazi Germany in 1933, Frisch worked first under Patrick Blackett at Birkbeck College in London and then for Neils Bohr at the Institute for Theoretical Physics in Copenhagen, Denmark.[3] Frisch developed a device for rapidly moving a sample from a radioactive source to the vicinity of a cloud chamber, and used it to discover two new radioactive isotopes while in London. He discovered an additional two isotopes while in Denmark.[1]

Contributions to Nuclear Science

Frisch became involved in explaining the idea of nuclear fission in 1938, while visiting his aunt, Lise Meitner, over the Christmas holidays. Meitner, who was also living in exile during the war years, had received a letter from her collaborator, Otto Hahn, that stated that a collision between uranium and neutrons could produce barium. Frisch and Meitner realized that the impact of a neutron must have distorted the uranium nucleus in such a way that it became elongated and eventually split into two roughly equal pieces. Frisch suggested the term 'fission' to describe this splitting process.[1]

In 1939 Frisch and his aunt Lise Meitner wrote a letter to Nature magazine explaining the theory of uranium fission.[3] In this paper they discuss the fact that the mass of the two fission fragments is slightly less than the mass of the uranium nucleus, and, according to Einstein's famous equation, this mass difference was equal to the energy acquired y the fragments.[1] They calculated that the released energy was surprisingly large at about 200 MeV and argued that splitting a few pounds of uranium could thus create the explosive and destructive power of thousands of pounds of dynamite.[3]

By 1939 it was clear that the German forces were going to overtake Denmark. Mark Oliphant was able to make arrangements for Frisch to go to the University of Birmingham in England, remaining focused on nuclear fission. Neils Bohr had already observed that fission in uranium was due almost exclusively to the rare isotope, uranium-235.[1] In 1940, Otto Frisch and Rudolf Peierls conceived one of the most significant documents of the twentieth century. Originally named the "Memorandum on the properties of the radioactive "super-bomb"," they argued that if the rare isotope uranium 235 (0.7% naturally occurring) could be extracted from naturally occurring uranium 238, the amount needed for an atomic bomb could be measured in kilograms rather than the early estimates of tons.[3]

The MAUD committee worked out the basic principles of both the fission bomb design and uranium enrichment by gaseous diffusion. The work completed by this top-secret committee alerted the United States to the feasibility of an atomic bomb. In July 1941, the MAUD committee published "On the Use of Uranium for a Bomb," which reaffirmed that the weapon suggested by Frisch and Peierls would definitely work. This report helped crystallize the American bomb effort because it outlined specific plans for producing a bomb. Interestingly, most of the experimental and theoretical scientific calculations and assessments that formed the basis for the MAUD Report were the work of Otto Frisch and Rudolf Peierls. However, since they were both Germans living in England, they were "officially classified as "enemy aliens", and could not, by law, be part of a wartime committee.[3]

Frisch moved to Liverpool in August 1940 and began work with James Chadwick. e continued to work on the nuclear cross-sections relevant to a uranium chain reaction, and developed a device to measure the isotopic composition of uranium based on its alpha-ray spectrum. In late 1943 it was decided that Britain's research into atomic energy should be combined with America's atomic weapons project, and Britain's leading scientists should relocate to the United States. Frisch could not enter America as a German, so he was hastily naturalized as a British citizen.[1]

On arrival in the United States, Frisch was assigned to the group working at Los Alamos. There were so many Robert's at Los Alamos that Frisch used his middle name, Otto, while in America. Among many other well-respected positions Frisch held, he was the head of the Critical Assembly Group for the Manhattan project from 1943-1946.[3]

After World War II, Frisch returned to England to work for the Atomic Energy Research Establishment at Harwell.[2] He was appointed head of the Nuclear Physics Division, and used his influence to create an informal atmosphere, while leaving most of the administration to his deputy, Robert Cockburn.[3] In 1947 Frisch was offered the Jacksonian Professorship of Natural Philosophy at Cambridge, and elected to a Fellowship in Trinity College.[1] He held that position until his retirement in 1979.[2]

Publications

While at Harwell, Frisch began to write books aimed at popularizing science. His book, *Meet the Atoms*, was a guide to modern physics aimed at interested members of the public.[1]

In 1951 Frisch married Ursula Blau, a Viennese artist. They had a daughter and a son. In 1979 an accidental fall put Frisch in hospital. A short time later, on 22nd September, he died, a week short of his seventy-fifth birthday.[1]

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Hans Geiger
1882 – 1945

German physicist that developed a devise to measure beta-ray activity, the devise is still known as the Geiger counter.

Early Life

Johannes (Hans) Wilhelm Geiger, was born in Neustadt-an-der-Haardt, German, on September 30, 1882.[3, 4] He studied physics in Munich and Erlangen. He received his doctorate from the University of Erlangen in 1906, before moving to Manchester, England to study under Ernest Rutherford from 1906 to 1912.[1, 2, 3]

Contributions to Nuclear Science

Over the next couple of years Geiger studied the mathematical relationship between the amount of alpha scattering and atomic weight.[2] In 1911, Rutherford and Geiger devised the first version of the Geiger counter to count the number of alpha particles and other ionizing radiation. With the aid of other radiation detectors, he used his counter in early experiments that led to the identification of the alpha particles as the nucleus of the helium atom. They also demonstrated that alpha-particles had two units of charge. It was also observed that occasionally alpha-particles are deflected through large angles when thy strike a thin leaf of gold or silver. This scattering experiment was essential in leading to Rutherford's nuclear theory of the atom, made in 1912, that in any atom, the nucleus occupies a very small volume at the centre.[3]

Many theories of radioactivity were also found and demonstrated by Geiger. In 1910, with Rutherford, they showed that two alpha-particles are emitted in the radioactive decay of uranium and in 1912, with J. M. Nuttal, they proved that this is caused by two uranium isotopes. The Geiger-Nuttall rule of 1911, states that the relationship is linear between the logarithm of the range of alpha-particles and the radioactive time constant, which is involved in the rate of decay of emitting nucleus.[3]

Geiger returned to Germany in 1914. During World War I, he served as an artillery officer in German Army. With Walther Bothe, Geiger devised the technique of coincidence counting and used it in 1924 to clarify the detail of the Compton Effect. In the next year, at the University of Kiel, where he was offered a professional appointment, he and graduate student, Walther Müller, improved the sensitivity, performance, and durability of the particle counter which Geiger made before.[1, 3] Named the Geiger-Müller counter, the improved device detects not only alpha particles but other types of ionizing radiation such as beta particles (electrons) and ionizing electromagnetic photon.[3]

In later years Geiger concentrated on researching cosmic radiation.[2] Geiger also participated in Germany's abortive attempt to develop an atomic bomb during World War II.[3] He died in Berlin on September 24, 1945.[3, 4]

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Maria Goeppert-Mayer
1906 - 1972

Polish-American chemical physicist that developed the “magic numbers” theory of nuclear shell structure. In 1963, Maria Goeppert-Mayer and Hans Jensen (who independently developed a similar “magic numbers” theory) were jointly awarded the Nobel Prize in Physics for their work.1, 2

Early Life

Maria Goeppert Mayer was born on June 28, 1906, in Kattowitz, Upper Silesia, Poland.[1] She was the only child of Friedrich Goeppert and Maria nee Wolff.[1, 4] In 1910 her father obtained a pediatric professor position at the University of Göttingen, so she moved with her parents to Germany. She attended private and public schools in Göttingen. Georgia Augusta University, better known simply as " Göttingen," was at the height of its prestige, especially in the fields of mathematics and physics during the period when she was growing up. She was surrounded by the great names of mathematics and physics. David Hilbert was an immediate neighbor and friend of the family. Max Born came to Goettingen in 1921 and James Franck followed soon after; both were close friends of the Goeppert family. Richard Courant, Hermann Weyl, Gustav Herglotz, and Edmund Landau were professors of mathematics.[4]

Maria Goeppert was attracted to mathematics very early and planned to prepare for the University, but there was no public institution in Göttingen serving to prepare girls for this purpose. Therefore, in 1921 she left the public elementary school to enter the Frauenstudium, a small private school run by suffragettes to prepare those few girls who wanted to seek admission to the University for the required examination. The school closed its doors before the full three-year program was completed, but she decided to take the University entrance examination promptly in spite of her truncated formal preparation.[4]

In the spring of 1924, after completion of the arbitur examination in Hannover, she enrolled at the University at Göttingen, with the intention of becoming a mathematician.[1] But the young and exciting field of quantum mechanics caught her interest and she decided to study physics instead. Except for one term which she spent in Cambridge, England, where her greatest profit was to learn English, her entire university career took place in Göttingen. In 1930, she earned her doctorate in theoretical physics with a thesis devoted to the theoretical treatment of double photon processes.[4] There were three Nobel Prize winners on her doctoral committee, Max Born, James Franck, and Adolf Windaus.[2]

After receiving her degree, she married and moved to Baltimore, Maryland, where her husband, Joseph Edward Mayer, took up an appointment in the Chemistry Department of Johns Hopkins University. Opportunities for her to obtain a normal professional appointment at that time, which was at the height of the Depression, were extremely limited. Nepotism rules were particularly stringent then and prevented her from being considered for a regular appointment at Hopkins; nevertheless, members of the Physics Department were able to arrange for a very modest assistantship, which gave her access to the University facilities, provided her with a place to work in the Physics Building, and encouraged her to participate in the scientific activities of the University.

While working at John Hopkins, Karl F. Herzfeld, who taught all of the theoretical physics graduate courses, took interest in her work. Herzfeld was an expert in classical theory, especially kinetic theory and thermodynamics, and he had a particular interest in what has come to be known as chemical physics. This was also Joseph Mayer's primary field of interest, and under his and Herzfeld's guidance and influence Maria Mayer became actively involved in this field, thereby deepening and broadening her knowledge of physics.[1, 2, 4]

In 1939, Joseph Mayer took a chemistry associate professor appointment at the University of Columbia. In 1941, Maria was offered her first real position, a half-time job teaching science at Sarah Lawrence College. Maria taught one year at Sarah Lawrence College, but in 1942, when Enrico Fermi moved to Chicago, she began work on the separation of uranium isotopes at the Substitute Alloy Materials (SAM) Project under the direction of Harold Uray.[1] She worked half-time at the S.A.M. Laboratory and taught Fermi’s courses at Columbia as an unpaid professor, and continued, on an occasional basis, to teach part time at Sarah Lawrence throughout the war.[2, 4]

In February of 1946, the Mayers moved to Chicago where Joe had been appointed Professor in both the Chemistry Department and the newly formed Institute for Nuclear Studies of The University of Chicago.[4] Maria again took a voluntary, unpaid professorship under Enrico Fermi at the Institute for Nuclear Studies.[2, 3] In, after the war, in July 1946, the Atomic Energy Commission established the Argonne National Laboratory as the replacement for the Metallurgical Laboratory. She was offered and was pleased to accept a regular appointment as Senior Physicist (half time) in the Theoretical Physics Division of the newly formed laboratory. The main interest at Argonne was nuclear physics, a field in which she had had little experience, and so she gladly accepted the opportunity to learn what she could about the subject. She continued to hold this part-time appointment throughout her years in Chicago, while maintaining her voluntary appointment at the University. The Argonne appointment was the source of financial support for her work during this very productive period of her life, a period in which she made her major contribution to the field of nuclear physics, the nuclear shell model, which earned her the Nobel Prize.[4]

Contribution to Nuclear Science

The part-time position at Argonne allowed Maria to maintain close ties with the Institute for Nuclear Studies. Among the many subjects being discussed at the Institute was the question of the origin of the chemical elements. Edward Teller convinced Maria to work with him on a cosmological model of the origin of the elements. In pursuit of data required to test any such model, she became involved in analyzing the abundance of the elements and noticed that there were certain regularities associating the highly abundant elements with specific numbers of neutrons or protons in their nuclei. Further research indicated that these “magic numbers” (a term apparently coined by Eugene Wigner) were somehow related to the notion of stable "shells" in nuclei similar to the stable electron shells associated with atomic structure.[4]

The work concerning the “magic numbers” had begun in 1948, but it took a year to find the explanation for their existence and several more years to work out most of the consequences.[3] While she was preparing the spin-orbit coupling model for publication, she learned of a paper by other physicists presenting a different attempt at an explanation and, as a courtesy, she asked the Editor of the Physical Review to hold her brief Letter to the Editor in order that it appear in the same issue as that paper. As a result of this delay, her work appeared one issue following publication of an almost identical interpretation of the magic numbers by Otto Haxel, Johannes Hans Daniel Jensen, and Hans E. Suess. Jensen, working completely independently in Heidelberg, had almost simultaneously realized the importance of spin-orbit coupling for explaining the shell structure, and the result had been this joint paper.[4]

In 1950, Maria traveled to Germany and met Jensen. This trip began a friendship and collaboration that ultimately resulted in the publication of *Elementary Theory of Nuclear Shell Structure* in 1955.[2] In 1963, Maria Goeppert-Mayer was awarded the Nobel Prize jointly with Hans Jensen for their work on the shell model of nuclear structure, i.e. their discoveries concerning the organization of neutrons and protons within atomic nuclei. When she received the Nobel Prize in Physics, Maria Goeppert Mayer was the second woman in history to win that prize—the first being Marie Curie, who had received it sixty years earlier—and she was the third woman in history to receive the Nobel Prize in a science category.[4]

In 1960 Maria accepted a regular appointment as Professor of Physics at the University of California at San Diego. Her appointment as a full professor in her own right at a major university was very gratifying to her. However, shortly after arriving in San Diego, she had a stroke, and her years there were marked by continuing problems with her health. After a protracted illness, she died in San Diego on February 20, 1972.[1, 2, 4]

Publications

During the early years in Baltimore, she spent the summers of 1931, 1932, and 1933 back in Goettingen, where she worked with her former teacher, Max Born. In the first of those summers she completed with him their article in the Handbuch der Physik, "Dynamische Gittertheorie der Kristalle." In 1935 she published her important paper on double beta-decay, representing a direct application of techniques she had used for her thesis, but in an entirely different context.[4]

In 1940, Maria and husband, Joseph, co-authored the book *Statistical Mecahnics*.[2, 4] In 1955, she and Hans Jensen published *Elementary Theory of Nuclear Shell Structure*, which ultimately led to their joint receipt of the 1963 Nobel Prize in Physics.

Honors

In addition to being elected to the National Academy of Sciences in 1956 and receiving the Nobel Prize in 1963, Maria Goeppert Mayer's honors included being elected a Corresponding Member of the Akademieder Wissenschaften in Heidelberg and receiving honorary degrees of Doctor of Science from Russell Sage College, Mount Holyoke College, and Smith College.[4]

Maria and Joseph Mayer had two children, both born in Baltimore, Maria Ann Wentzel, now in Ann Arbor, and a son, Peter Conrad, a graduate student of economics in Berkeley.

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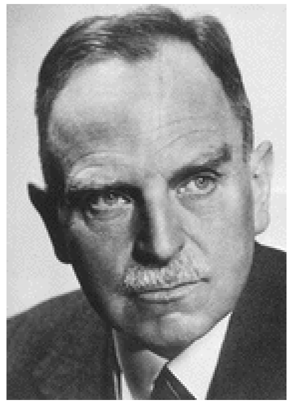

Otto Hahn
1879 - 1968

German radiochemists Otto Hahn and Fritz Strassmann are credited with the discovery of nuclear fission. Mr. Hahn was awarded the Nobel Prize for Chemistry in 1944 and shared the Enrico Fermi Award in 1966 with Fritz Strassmann and Lise Meitner.

Early Life[1]

Otto Hahn was born on March 8, 1879, at Frankfurt-on-Main, Germany. He attended the secondary high school there until he matriculated. His parents wanted him to become an architect; however, he eventually decided to study chemistry at the University of Marburg. From 1897 until his doctoral thesis examination in 1901, Hahn studied chemistry at Marburg and Munich under the tutelage of Professor Theodor Zincke. After a year of military service, he returned to the university as chemistry lecture assistant, hoping to find a post in industry later on.

In 1904 he went to London, primarily to learn English, and worked at University College with Sir William Ramsay, who was interested in radioactivity. While working on a crude radium preparation that Ramsay had given to him to purify, Hahn showed that a new radioactive substance, which he called radiothorium, was present. Inspired by this early success and encouraged by Ramsay, who thought highly of him, Otto Hahn decided to continue with research on radioactivity rather than go into industry.

With Ramsay's support he obtained a post at the University of Berlin. Prior to beginning his appointment at the University of Berlin, Mr. Hahn decided to spend several months at the Physical Institute of McGill University, Montreal (Canada), with Ernest Rutherford to gain further experience with radioactivity. Here he discovered radioactinium and conducted investigations with Rutherford on alpha-rays of radiothorium and radioactinium.

On his return to Europe in 1906 Hahn moved to Berlin, to the Chemical Institute (Emil Fischer) of the University. There he qualified as a university lecturer in the spring of 1907. Later that year he discovered mesothorium.

At the end of 1907, Dr. Lise Meitner came to Berlin from Vienna, beginning a collaboration that spanned more than thirty years. Their joint work involved: investigations on beta rays, their absorbability, magnetic spectra, etc.; and the use of the radioactive recoil, discovered shortly before by Hahn, to obtain new radioactive transformation products. In 1911, they moved to the new Kaiser Wilhelm Institute for Physical Chemistry at Berlin-Dahlen. Hahn was to eventually serve as director of the institute from 1928 until the end of World War II.

Feeling that his future was more secure once at the Institute, Hahn married Edith Junghans, the daughter of the chairman of Stettin City Council, in 1913. They had one son, Hanno, born in 1922.

Between 1914 and 1918 Hahn's work was interrupted by his service in the First World War. He was posted to a regiment, and then in 1915 he became a chemical-warfare specialist, serving on all the European fronts.

Prelude to Fission

After the war, Hahn and Meitner were among the first to isolate protactinium-231, an isotope of the recently discovered radioactive element protactinium. Because nearly all the natural radioactive elements had then been discovered, he devoted the next 12 years to studies on the application of radioactive methods to chemical problems.

This led to Hahn's discovery of uranium Z, the first case of a nuclear isomerism of radioactive kinds of atoms. Using radioactive methods he investigated the absorption and precipitation of the smallest quantities of substances, and normal and abnormal formation of crystals. Hahn also elaborated the strontium method to determine the age of geological periods. Professors Meitner and Hahn worked together on the discovery of an artificially active uranium isotope, later revealed by American scientists to be the basic substance of the elements neptunium and plutonium.

In 1934 Hahn became keenly interested in the work of the Italian physicist Enrico Fermi, who found that when the heaviest natural element, uranium, is bombarded by neutrons, several radioactive products are formed. Fermi supposed these products to be artificial elements similar to uranium. Hahn and Meitner, assisted by a young Fritz Strassmann, obtained results that at first seemed in accord with Fermi's interpretation but that became increasingly difficult to understand. Meitner fled from Germany in July 1938 to escape the persecution of Jews by the Nazis, but Hahn and Strassmann continued the work.[2]

Fission

The story of Hahn's discovery began in 1938 with a report by Irène Joliot-Curie that bombarding uranium with neutrons had resulted in the production of a radionuclide of thorium, which they later speculated was a transuranium element similar to lanthanum. The astounded Hahn told Irène's husband, Frédéric, that such a thing was nonsense and that he would perform an experiment to prove as much. In the process of duplicating her work, Hahn and co-worker Fritz Strassmann discovered that, among other things, three isotopes of barium had been produced. This was incredible because the mass of barium is about half that of uranium. No known reaction could explain such a huge change in mass. When they published their results (Jan. 6, 1939, *Naturwissenschaften*) Hahn and Strassmann noted that such a thing was "in opposition to all the phenomena observed up to the present in nuclear physics." Hahn, conscious of the fact that as a chemist he was treading in the domain of physics, did not offer an explanation. Instead, he left it up to Lise Meitner, his longtime collaborator, to whom he had sent a letter (December 19, 1938) describing his findings and asking "Perhaps you can suggest some fantastic explanation." Meitner, in cooperation with her nephew Otto Frisch, formulated a plausible explanation of the process, to which they gave the name nuclear fission.[3]

Scientists before the outbreak of World War II realized the tremendous implications of this discovery, and a group was formed in Germany to study possible military developments. Much to Hahn's relief, he was allowed to continue with his own research, including investigation of the separation of elements and studies to learn about the kinds of atoms that are produced through fission.

In autumn 1943, Hahn wrote a paper to the Swedish Academy of Sciences on his latest work in nuclear chemistry. In that paper Hahn referred to the possibility of splitting uranium by means of a chain reaction. In this process such enormous quantities of energy would be produced in a short instant that the effect would exceed any explosion phenomenon so far known. Hahn, however, doubted whether it was possible to surmount the technical difficulties involved. It was often suggested based on several statement made by Hahn that he wished that this conquest of atomic energy had been made at a much later date.[4]

Honors

Despite the contributions of Fritz Strassmann and Lise Meitner, it was Otto Hahn who was awarded the 1944 Nobel Prize in chemistry for the discovery of fission. Unfortunately, Hahn was not at the awards ceremony to receive his prize. As the Chairman of the Nobel Committee for Chemistry reported "Professor Hahn . . . has informed us that he is regrettably unable to attend this ceremony." The reason he was unable to attend the ceremony was that he was being questioned by British government officials who were seeking information about the failed German effort to develop an atomic bomb.

However, it was only after the war in Europe, when Hahn and other German nuclear scientists were taken to England, that he learned that he had been awarded the Nobel Prize for 1944. The announcement of the explosion of the atomic bomb at Hiroshima in 1945 was said to have profoundly affected Hahn.

On his return to Germany he was elected president of the former Kaiser Wilhelm Society (renamed the Max Planck Society for the Advancement of Science) on April 1, 1946, and was named Honorary President of the same Society in May 1960. Hahn became a respected public figure, a spokesman for science, and a friend of Theodor Heuss, the first president of the Federal Republic of Germany. He campaigned against further development and testing of nuclear weapons. In 1966 he, Meitner, and Strassmann shared the prestigious Enrico Fermi Award. This period of his life was saddened, however, by the loss of his son, Hanno, and his daughter-in-law, who were killed in an automobile accident in 1960. His wife never recovered from the shock. Hahn died on July 28, 1968, after a fall; his wife survived him by only two weeks.

In the course of his career, Hahn was granted membership of the Academies of Berlin, Göttingen, Munich, Halle, Stockholm, Vienna, Boston, Madrid, Helsinki, Lisbon, Mainz, Rome (Vatican), Allahabad, Copenhagen, and the Indian Academy of Sciences. It was proposed in 1970 that the newly synthesized element number 105 be named Hahnium in his honor, but another naming system was adopted for transuranium elements beyond 104.

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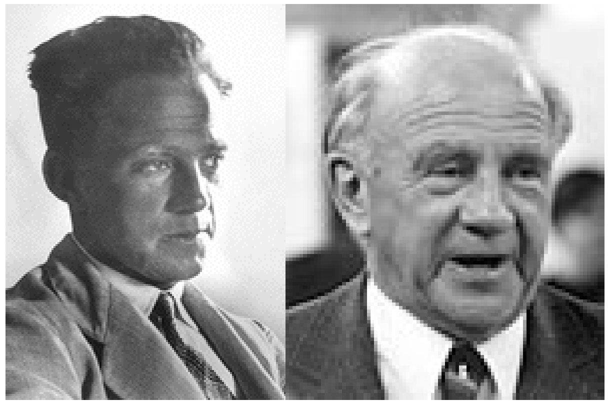

Werner K. Heisenberg
1901 – 1976

German physicist awarded the 1932 Nobel Prize in Physics for his establishment of the field of quantum mechanics.

Early Life

Werner Karl Heisenberg was born on December 5, 1901 in Würzburg, Germany. He was the son of Dr. August Heisenburg and Annie Wecklein.[1] Shortly before his fifth birthday, Werner enrolled in primary school at Würzburg, where he spent three years studying before his father was appointed professor at the University of Munich. He attended the Elisabethenschule from September 1910 before entering the Maximilians Gymnasium the following year. In 1920 Heisenburg took the arbiter examination and was one of two pupils from the Maximilians Gymnasium to complete for a scholarship from the Maximilianeum Foundation. Heisenburg one the last of eleven scholarships available that year.[2]

During the summer of 1920 Heisenberg was, as he had been for some time, intending to study pure mathematics at university. He had read Weyl and also Bachmann's text which gave a complete survey of number theory and this was to be his intended research topic for his doctorate. He approached Ferdinand von Lindemann to see if he would be his research supervisor. Had the interview with Lindemann been a success then Heisenberg might today be known as an outstanding number theorist. Following this Heisenberg had an interview with Arnold Sommerfeld who happily accepted him as a student.[2]

In 1920, Wolfgang Pauli and Werner Heisenburg began their graduate work theoretical physics. Pauli convinced Heisenburg to study atomic structure since he felt much work was needed in order to reconcile the differences between the current theory and experimental findings. In June 1922 he attended lectures by Neils Bohr in Gottingen. During one of Bohr’s lectures Heisenberg publicly questioned the mathematics of the Nobel Prize winner, earning Bohr's attention.[3] While Heisenburg’s advisor was in the United States, he presented preliminary results of a problem on a fluid stream turbulence at a conference in Innsbruck. The final results of this research ultimately became his doctoral dissertation which was defended in 1923.[2]

From September 1924 until May 1925 he worked, with the support of a Rockefeller grant, with Niels Bohr at the University of Copenhagen, returning for the summer of 1925 to Göttingen. Heisenberg invented matrix mechanics, the first version of quantum mechanics, in 1925. He did not invent these concepts as a matrix algebra, however, rather he focused attention on a set of quantised probability amplitudes. These amplitudes formed a non-commutative algebra. It was Max Born and Pascual Jordan in Göttingen who recognized this non-commutative algebra to be a matrix algebra. Matrix mechanics was further developed in a three author paper by Heisenberg, Born and Jordan published in 1926.[1]

Heisenberg is perhaps best known for his uncertainty principle, discovered in 1927. The principle states that determining the position and momentum of an atomic particle necessarily contains errors the product since the method of measuring the property alters the property. He went further to state that the error associated with the measurement cannot be less than the quantum constant h. Heisenberg published *The Physical Principles of Quantum Theory* in 1928.[1, 2, 3]

In May 1926 Heisenberg was appointed Lecturer in Theoretical Physics in Copenhagen where he worked with Niels Bohr. In 1927 Heisenberg was appointed to a chair at the University of Leipzig. He was only 26.[1] He was to hold this post until, in 1941, he was made director of the Kaiser Wilhelm Institute for Physics in Berlin.

During the Second World War, a deeply patriotic Heisenberg headed the unsuccessful German nuclear weapons project Uranverein. He worked with Otto Hahn, one of the discoverers of nuclear fission, on the development of a nuclear reactor but failed to develop an effective program for nuclear weapons.[2] After the war he was arrested by Alsos, a secret mission that followed the advancing Allied forces in Europe, to determine the progress of Germany's atomic bomb project. He was interned at Godmanchester, Huntingdonshire, England, with other leading German scientists. However he returned to Germany in 1946 to reorganize the Institute of Physics in Göttingen. The institute was renamed the Max Planck Institute for Physics and Astrophysics in 1948 and he was appointed its director. In the winter of 1955-1956 he gave the Gifford Lectures "On physics and philosophy" at the University of St Andrews. These lectures were subsequently published as a book. When the Max Planck Institute moved to Munich in 1958 Heisenberg continued as its director. He held this post until he resigned in 1970.[1]

Publications

Heisenburg wrote numerous scientific papers, including a paper with Max Born on the helium atom, a joint paper with Max Born and Pascual Jordan on matrix mechanics, and his famous uncertainty principle. He was also interested in the philosophy of physics and wrote *Physics and Philosophy* (1962) and *Physics and Beyond* (1971).[2]

Honors[2]

Heisenberg received many honors for his remarkable contributions in addition to the Nobel Prize for Physics. Heisenberg received an honorary doctorate of the University of Bruxelles, of the Technological University Karlsruhe, and of the University of Budapest in 1964. He was also a recipient of the Order of Merit of Bavaria, and the Grand Cross for Federal Services with Star (Germany).[1] He was a Fellow of the Royal Society of London and a Knight of the Order of Merit (Peace Class). He was a member of the Academies of Sciences of Göttingen, Bavaria, Saxony, Prussia, Sweden, Rumania, Norway, Spain, The Netherlands, Rome (Pontificial), the German Akademie der Naturforscher Leopoldina (Halle), the Accademia dei Lincei (Rome), and the American Academy of Sciences.[1, 2] During 1949-1951 he was President of the Deutsche Forschungsrat (German Research Council) and in 1953 he became President of the Alexander von Humboldt Foundation.[1] Among the various prizes and metals he received was the Copernicus prize.[2]

Werner Heisenburg married Elisabeth Schumacher on April 29, 1937. Elizabeth was only 22 when they met, Heisenberg was 35. They were married a mere three months after they met.[2] Werner and Elisabeth had seven children, three sons and four daughters. Werner Heisenburg died in Munich in 1976.

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Victor Francis Hess
1883 – 1964

Victor Francis Hess, has in the course of more than fifty years, made basic contributions to an understanding of radiation and its effects on the human body. Victor F. Hess is best known for his discovery of cosmic rays in 1911. For his discovery of cosmic radiation Hess was named co-recipient of the Nobel Prize in Physics in 1936. He shared the prize with Professor Carl D. Anderson of the California Institute of Technology,

Early Life [1]

Victor Francis Hess was born to Vinzens and Sarafine (Grossbauer) Hess on June 24, 1883 at Waldstein Castle near Deutsch Feistritz, Styria, Austria, where his father was chief forester on the estate of Prince Oettingen-Wallerstein. He attended the Gymnasium in the nearby city of Graz from 1893 to 1901 and the University of Graz from 1901 to 1905. In June 1906 Hess obtained the Ph.D. degree in physics summa cum laude.

Hess was a demonstrator at the mineralogical institute of the University of Vienna in 1907 and 1908. In 1910 he began lecturing as a Privatdozent at the university, and in the same year he was appointed assistant at the new Institute for Radium Research of the Austrian Academy of Sciences, a post he held until 1920. From 1908 to 1920 Hess was also a lecturer in medical physics at the Vienna Veterinary Academy.

Contributions [1]

A pioneer in the study of radiation, Professor Franz Exner of the University of Vienna, and Professor von Schweidler of Physical Institute in Vienna, got Hess interested in investigating radioactivity and atmospheric electricity.

In 1911 Hess began the work that twenty-five years later made him a Nobel Prize winner. For some time scientists had been puzzled by the fact that the air in electroscopes-instruments for detecting electrical charges became electrically charged (ionized) no matter how well the containers were insulated. It was thought that radioactivity from ground minerals was responsible, but if such were the case the effect should have diminished greatly at a height of about 300 meters. In 1910 Theodore Wulf measured ionization at the bottom and top of Eiffel Tower, which is some 300 meters height, and found that considerably more ionization existed at the top than could be expected if it were caused by ground radiation. His results were not given unqualified acceptance, however. Nor were the experiments of the scientists who in 1909, 1910 and 1911 made balloon ascents to record ionization, for their instruments developed defects.

Reading about these earlier experiments, Hess speculated as to whether the source of ionization could be located in the sky rather than the ground. Before making balloon ascents himself, he determined the height at which ground radiation would stop producing ionization (about 500 meters) and designed instruments that would not be damaged by temperatures and pressure changes. He then made ten ascents (five at night) - two in 1911, seven in 1912, and one in 1913 - and found that ionization soon ceased to fall off with height and began to increase rapidly, so that at a height of several miles it was many times greater than at the earth's surface. He concluded, therefore, that "a radiation of very high penetrating power enters our atmosphere from above."

After making an ascent during an almost total eclipse of the sun on April 12, 1912 Hess further concluded that, since ionization did not decrease during the eclipse, the sun could not itself be the main source of the radiation. Hess's theory about rays from space did not receive general acceptance at the time he proposed it, but increased research after World War I supported it. First named for Hess, the newly discovered radiation was dubbed "cosmic" by Robert A. Millikan in 1925.

In 1919-20 Hess served as an assistant professor at the University of Vienna, and in 1920 he became an associate professor of experimental physics at the University of Graz. In February 1921 he took a leave of absence to make his first trip to the United States, where he became chief physicist and director of a research laboratory, built under his supervision, of the United States Radium Corporation in New Jersey. During his two years in the United States, Hess lectured at several American universities and served as a consultant to the United States Bureau of Mines.

Hess returned to the University of Graz in 1923 and was made a full professor in 1925 and dean of the faculty in 1929. He stayed at Graz until 1931, when he accepted a position as professor of experimental physics and head of the institute for radiation research at the University of Innsbruck. In 1931 with the support of the Rockefeller Institute, the Austrian Academy of Sciences, and the Emergency Society for German Sciences (a university association for the support of science after World War I), Hess founded a station for the observation of cosmic radiation on Hafelekar mountain near Innsbruck at a height of 2,300 meters (about 7,000 feet).

For his discovery of cosmic radiation Hess was named co-recipient of the Nobel Prize in Physics in 1936; he shared the prize with Professor Carl D. Anderson of the California Institute of Technology, who had discovered the positron. Commenting on the award to Hess, a 'Scientific Monthly' writer noted: "After a decision had been made that the first significant work in the field of cosmic rays was to be honored by a Nobel Prize, there was certainly no living person who could for a moment be considered for the award except Dr. Hess."

In 1938 his family escaped to Switzerland from Austria on the warning from a sympathetic Gestapo officer that they would be taken to concentration camp if they stayed in Austria. Offered a full professorship at Fordham University in New York, Hess immigrated with his wife to the United States, where a son of Mrs. Hess already lived. He became an American citizen in 1944. In 1946, less than a year after the atomic bomb was dropped on Hiroshima, he and Paul Luger of Seattle University conducted the first tests for radioactive fallout in the United States. Many of these were made from the eighty-seventh floor of the Empire State Building. The following year Hess went from the heights to the depths of Manhattan, measuring the radioactivity of granite in the 190th Street subway station at the base of Fort Tyron which was covered by 160 feet of rock.

In a 1947 issue of the American 'Journal of Roentgenology and Radium Therapy', Hess and William T. McNiff reported that they had worked out "an integrating gamma-ray method" by which they could detect minute amounts of radium in the human body. This new procedure made it possible to detect radium poisoning before it reached a critical stage. In 1948 Hess visited Europe and was a guest professor at the University of Innsbruck.

Two years later, at the request of Mayor William O'Dwyer of New York City, Hess joined five other scientists in investigating the possibility of producing rain artificially in New York State, which at that time was suffering a severe drought. Another project with which he became involved in 1950 was a United States Air Force study to determine the effects of atomic bomb tests in terms of radioactive fallout. Completed in 1955, the study reported a distinction between artificial and natural radiation and found that since the tests there had been a trace of artificial radiation in the atmosphere.

Hess retired from his Fordham professorship after twenty years of service in 1958 and became a professor emeritus, but he continues to do research in his laboratory at the school. His was one of four laboratories in the United States that conducted tests on measurement of radioactivity in the breath of people who worked with radium, and he has also sought to establish a more accurate scale of the toleration limits of radioactivity of the human body. Hess has found that there are individual differences in the amount of radiation a person can tolerate without serious injury. Research in this area is difficult, he has said, for the effects of radioactivity are cumulative and may sometimes take as long as fifty years to make themselves fully felt. For this reason he strongly opposes nuclear weapon testing. "We know too little about radioactivity at this time", he notes "to state definitely that testing underground or above the atmosphere will have no effect on the human body." Hess has avowed that he intends to dedicate the rest of his working life to further study of the effects of radiation on human beings.

A contributor to many scientific journals and compilations in Europe and the United States, Hess has also written several books, some of which have been translated from the original German. His books include 'Luftelektrizitaet' (Atmospheric Electricity) (Braunschweig, 1928), written with H. Benndorf; 'The Electrical Conductiviy of the Atmosphere' (Akademie, 1934); and 'Die Weltstrahlung und ihre biologische Wirkung' (Fuessli, 1940), written with Jakob Eugster and published in a revised edition as 'Cosmic Radiation and its Biological Effects' by the Fordham University Press in 1949.

Hess holds honorary degrees from the University of Vienna, Loyola University in Chicago and in New Orleans, Fordham University, and the University of Innsbruck. In 1958 the University of Graz held a celebration in honor of the fiftieth anniversary of Hess's completion of his graduate work, and Fordham University awarded him its Insignis and Bene Merenti medals. Hess also received the Lieben Prize of the Austrian Academy of Sciences in 1919, the Ernst Abbe Prize of the Carl Zeiss Foundation in 1932, and the Austrian government's Honorary Insignia for Art and Science in 1959. He is a fellow of the American Physical Society and the American Geophysical Union; one of the handful of American members of the Pontifical Academy of Science in Rome; and a member of the Swiss Physical Society, the Physical Society of London, and the American Meteorological Society. He is a Republican and a Roman Catholic.

Publications [1,2]

Hess's work which gained him the Nobel Prize, was carried out during the years 1911-1913, and published in the Proceedings of the Viennese Academy of Sciences. In addition he has published some sixty papers and several books, of which the most important were:

1. "Die Wärmeproduktion des Radiums" (The heat production of radium), 1912;
2. "Konvektionserscheinungen in ionisierten Gasen-Ionenwind" (Convection phenomena in ionized gas-ionwinds), 1919-1920;
3. "The measurement of gamma rays", 1916 (with R.W. Lawson);
4. "The counting of alpha particles emitted from radium", 1918
5. *Elektrische Leitfähigkeit der Atmosphäre und ihre Ursachen* (book), 1926 (in English: *The Electrical Conductivity of the Atmosphere and Its Causes*, 1928); *Ionenbilanz der Atmosphäre* (The ionization balance of the atmosphere - book), 1933;
6. *Luftelektrizität* (Electricity of the air - book, with H. Benndorf), 1928;
7. "Lebensdauer der Ionen in der Atmosphäre" (Average life of the ions in the atmosphere), 1927-1928;
8. 'The Electrical Conductiviy of the Atmosphere' (Akademie, 1934)
9. "Schwankungen der Intensität in den kosmischen Strahlen" (Intensity fluctuations in cosmic rays), 1929-1936.
10. 'Die Weltstrahlung und ihre biologische Wirkung' (Fuessli, 1940), written with Jakob Eugster and published in a revised edition as 'Cosmic Radiation and its Biological Effects' by the Fordham University Press in 1949.

Honors [1]

Honorary degrees from the University of Vienna, Loyola University in Chicago and in New Orleans, Fordham University, and the University of Innsbruck

1919 The Lieben Prize of the Austrian Academy of Sciences .
1932 Ernst Abbe Prize of the Carl Zeiss Foundation
1936 Nobel Prize in Physics
1958 Insignis of Fordham University and Bene Merenti medals.
1959 Austrian government's Honorary Insignia for Art and Science.

Jobs/Positions [1]

1907 – 1908	Demonstrator at the mineralogical institute of the University of Vienna
1908 – 1920	Lecturer in medical physics at the Vienna Veterinary Academy Assistant at the Institute for Radium Research of the Austrian Academy of Sciences
1919 – 1920	Assistant professor at the University of Vienna
1920 – 1921	Associate professor of experimental physics at the University of Graz
1921 – 1923	Chief physicist and director of a research laboratory, at United States Radium Corporation in New Jersey
1923 – 1925	Associate professor at the University of Graz
1926 – 1929	Professor at the University of Graz
1929 – 1931	Dean of the faculty at the University of Graz
1931 – 1938	Professor of experimental physics and head of the institute for radiation research at the University of Innsbruck
1938 – 1958	Professor at Fordham University in New York

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Jean Frederic Joliet-Curie
1900 - 1958

French chemist, who with his wife, Irene, discovered artificial radioactivity. They were jointly awarded the 1935 Nobel Prize in Chemistry for their discovery.

Early Life

Jean Frédéric Joliot was born to Henri Joliot and Emilie Roederer on March 19, 1900 in Paris, France.[3] He graduated from the Escole de Physique et Chimie in Paris.[2] He studied at the Sorbonne, where in 1925 he became assistant to Marie Curie, and in 1926 married her daughter Irène, with whom he shared the 1935 Nobel Prize for Chemistry.[1] Joliot received his Doctor of Science degree in 1930 for his research in the electrochemistry of radioactive elements, and became a lecturer in the Paris Faculty of Science in 1935.[2, 3]

Contributions to Nuclear Science

Frédéric and Irène carried out significant collaborative research concerning the structure of the atom. In particular they worked on the projection of nuclei, which was an essential step in the discovery of the neutron (Chadwick, 1932) and the positron (Anderson, 1932). However, their greatest discovery occurred in 1934, when they learned that radioactivity could be created artificially. In the laboratory, they had been conducting experiments where they bombarded boron, aluminum, and magnesium with alpha particles. As a result of this bombardment process, they produced the isotope 13 of nitrogen, the isotope 30 of phosphorus and, simultaneously, the isotopes 27 of silicon and 28 of aluminum. These elements, which are not found naturally, decompose spontaneously, with a more or less long half-life, by emission of positive or negative electrons. It was for this very important discovery that Frédéric and Irène received in 1935 the Nobel Prize for Chemistry.[3]

In 1937 he was nominated Professor at the Collège de France.[2, 3] He left the Radium Institute and had built for his new laboratory of nuclear chemistry the first cyclotron in Western Europe. After the discovery of the fission of the uranium nucleus, he produced a physical proof of the phenomenon; and then with Hans Halban and Lev Kowarski, joined by Francis Perrin, he worked on chain reactions and the requirements for the successful construction of an atomic pile using uranium and heavy water. He earned five patents between 1939 and 1940 in relation to his atomic pile work.[2] On the advance of the German forces, Frédéric managed to get the documents and materials relating to this work transported to England.[2, 3]

Joliot, who had always taken an interest in social questions, joined the Socialist Party, the S.F.I.O. (1934), then the League for the Rights of Man (1936). During the French occupation in World War II he took an active part in the Resistance; he was President of the National Front and formed the French Communist Party.[3]

After having been Director of the Centre National de la Recherche Scientifique, he became the first High Commissioner for Atomic Energy. As commissioner he directed the construction of the first French atomic pile in 1948. The changing political climate in France and his ties to the Communist party resulted in removal from the Atomic Energy Commission in 1950.[2] A year later Irène was also dropped from the commission because of her political affiliations. In 1947, Irene became a professor and the director of the radium laboratory at the Sorbonne. [4] While still retaining the control of his laboratories, Frédéric Joliot-Curie took a considerable part in politics and was elected President of the World Peace Council. On the death of Irene Joliot-Curie, in 1956, he became, while still retaining his professorship at the Collège de France, holder of the Chair of Nuclear Physics which she had held at the Sorbonne.[3]

Honors

Frédéric Joliot held numerous memberships and had been awarded several honors in addition to the 1935 Nobel Prize for Chemistry for his collaborative "synthesis of new radioactive elements."1, 2 Frédéric Joliot was a member of the French Academy of Sciences and of the Academy of Medicine. He was also a member of numerous foreign scientific academies and societies, and holder of an honorary doctor's degree of several universities. He was a Commander of the Legion of Honor.3 As President of the Communist-sponsored World Peace Council, he was awarded the 1951 Stalin Peace Prize.1

Joliot devoted the last two years of his life to the inauguration and development of a large centre for nuclear physics at Orsay. He died in Paris in 1958.3

Jean Frederic and Irene Joliot-Curie had one daughter, Helene, and one son, Pierre.[3]

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Irène Joliet-Curie
1897 – 1956

French physicist, who with her husband, Frederic, discovered artificial radioactivity. They were jointly awarded the 1935 Nobel Prize in Chemistry for their discovery.

Early Life

Irène Curie, the eldest daughter of the famous Marie and Pierre Curie, was born on September 12, 1897 in Paris, France. Early on it was clear that Irene had an exceptional talent in mathematics. Irène's earliest education was provided in a special "cooperative" school attended by several other children of prestigious French scholars. In these early years of "home schooling" she was taught by her mother, Marie Curie, Paul Langevin, and Jean Perrin. In 1914, she graduated with the equivalent of a high school degree from the College Sévigné and headed to the University of Paris. However, her studies were soon interrupted when she left the Sorbonne to assist her mother as a radiographer with the mobile military X-ray facilities during World War I. [1]

In 1918, Irène returned to the Sorbonne and joined the staff of the Curie Institute as her mother's assistant. She also began her doctoral dissertation work studying the alpha rays of polonium. She successfully defended her thesis in March 1925. Frédéric Joliet had visited the Curie Institute in December 1924 at the urging of his mentor, Paul Langevin. 1 The following year he joined the institute as one of Marie Curie's assistants. Irène was assigned the task of teaching Frédéric the techniques of working with radiation in the laboratory.2 They got along superbly and a year later, Irène and Frédéric were married, forming one of the greatest scientific partnerships of all time.

Contributions to Nuclear Science

Irène, the physicist, and Frédéric, the chemist, were heavily involved in the rapidly emerging field of atomic physics. Early in their careers they managed to just miss the discovery of the neutron (they misidentified it as a gamma ray) and the positron.2 However, in 1934, their luck changed dramatically when they used alpha particles to bombard boron.4 In their experiment they had expected to see neutrons and positrons emitted from the boron sample during the bombardment. However, they were astonished to discover that the positrons were still emitted from the sample after the alpha bombardment had stopped. Careful chemical analysis of the sample showed that the sample now contained a positron-emitting isotope of nitrogen.2 Thus, they had demonstrated the artificial creation of radioactive nitrogen. They quickly repeated the process with aluminum and magnesium foils and found that they could artificially create radioactive phosphorus and silicon as well.1

The discovery of artificially created radioactive elements fundamentally changed the understanding of the relationships between the elements and ultimately lead to the understanding of the fission of heavy elements to produce lighter ones and the fusion of light elements to produce heavier ones. Additionally, once difficult to purify and therefore rare samples of radioactive isotopes quickly became available for medicine, research, and eventually weapons. Within a year of their astonishing discovery, the Joliet-Curie research team was awarded the 1935 Nobel Prize in Chemistry "for their synthesis of new radioactive elements."1

In later years, Irène and Frédéric focused their research efforts towards the identification of the products of nuclear fission. In 1936, Curie was appointed Undersecretary of State for Scientific Research. She became the Director of the Radium Institute in 1946, a position which she held until 1950.4 During World War II, Irène and Frédéric helped hamper German efforts to develop an atomic bomb by ensuring that the entire stock of heavy water from the Norsk Hydro Plant was secured and shipped to Britain before France and Norway came under German control.2 From 1946 to 1951, Irène served as a member of the French Atomic Energy Commission with her husband. During this time, they both assisted in establishing France's first atomic pile. She was excused of her services in 1951 because of her association with the French Communist party, which her husband founded.3

Honors

After World War I, Irene was awarded a Military Medal for the time she spent with her mother as a radiographer in mobile military medical facilities during World War I.1

Irène Joliet-Curie was the director of the Curie Laboratory, a member of the Commissariat of Atomic Energy, and a professor at the Sorbonne. Although she won many awards for her contributions to science, including the 1935 Nobel Prize for Chemistry, she was never admitted to the French Academy of Science due to policy of maintaining an all male membership.1

Irène and Frédéric Joliet-Curie were married in a civil ceremony on October 29, 1926. Their daughter, physicist Helene, was born on September 17, 1927. Their biochemist son, Pierre, was born March 12, 1932.1 Irene Joliet-Curie died from radiation induced leukemia on March 17, 1956.[1, 3]

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Martin Heinrich Klaproth
1743 – 1817

German chemist who discovered uranium (1789), zirconium (1789), and cerium (1803). He described them as distinct elements, though he did not obtain them in the pure metallic state.[1]

Early Life

Martin Heinrich Klaproth was born December 1, 1743 in Wernigerode, Saxony. When he was 16 he became apprenticed to an apothecary, a profession he maintained for a large portion of his life.[4] On January 1st, 1817 he passed away in Berlin, Germany.[2]

Contributions to Nuclear Science

In 1771, Martin Klaproth was a pharmacy manager and then four years later when he was still a pharmacy student he established his Berlin laboratory.[2] Later in his career he discerned the difference between baryta (barium oxide) and strontia (strontium oxide).[3] In 1789, he found the elements zirconium in zircon and uranium in pitchblende. At the Berlin School of Artillery he lectured in Chemistry starting in 1792. Later, Klaproth verified the existence of and named titanium. Next, in 1797 he isolated chromium separately from French chemist Louis Vauquelin. The next year he extracted and named tellurium, but gave credit for the discovery to Franz Muller. In 1803, he verified the existence of cerium which was discovered by a Swedish chemist Jons Berzelius and also found cerium oxide in the process.[3] The University of Berlin was founded in 1810 and Klaproth became the institutions first professor of chemistry.

Publications

His papers, over 200 in number, were collected by himself in Beitrage zur chemischen Kenutniss der Mineralkorper (5 vols., 1795 1810) and Chemische Abhandlungen gemischten Inhalts (1815). He also published a Chemisches JVOrterbuch (1807-1810), and edited a revised edition of F. A. C. Grens Hand buch der Chemie (1 806).[4]

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Paul Langévin
1872 – 1946

French physicist and chemist noted for his work on the electron theory of magnetism and for his research on sound devices for submarine detection, which is the basis of modern echolocation techniques. [1]

Early Life

Paul Langévin was born in Paris on 23 January 1872. Langévin was educated in Paris and also studied in the UK at the Cavendish Laboratories, Cambridge.[5] He attended the Ecole Lavoisier and the Ecole de Physique et de Chimie Industrielles, where he was supervised by Pierre Curie during his laboratory classes. In 1891 he entered the Sorbonne, but his studies were interrupted for a year in 1893 by his military service. In 1894, Langévin entered the Ecole Normale Superieure, where he studied under Jean Perrin. Langévin joined the Collage de France in 1902, and was made Professor of Physics there in 1904, a post he held until 1909 when he was offered a similar position at the Sorbonne.[2]

Contributions to Nuclear Science[2]

Paul Langévin was a contemporary to Marie Curie, Albert Einstein and Hendrik Lorentz, he was noted for his work on the molecular structure of gases, analysis of secondary emission of X-rays from metals exposed to radiation, and for his theory of magnetism. Langévin postulated that the magnetic properties of a substance are determined by the valence electrons, a suggestion which influenced Niels Bohr in the construction of his classic model describing the structure of the atom. He was able to extend his description of magnetism in terms of electron theory to account for diamagnetism. He showed how a magnetic field would affect the motion of electrons in the molecules to produce a moment that is opposed to the field. This enabled predictions to be made concerning the temperature-independence of this phenomenon and furthermore to allow estimates to be made of the size of electron orbits.

He published his work on the atomic theory of paramagnetism in 1905. In the same year Albert Einstein correctly identified Brownian motion (such motion, visible only under a microscope, is the incessant, random movement of micrometre-sized particles immersed in a liquid) as due to imbalances in the forces on a particle resulting from molecular impacts from the liquid. Shortly thereafter, Langévin formulated a theory in which the minute fluctuations in the position of the particle were due explicitly to a random force. Langévin's approach proved to have great utility in describing molecular fluctuations in other systems, including nonequilibrium thermodynamics.

In 1906, Paul Langévin’s former professor, Pierre Curie, was accidentally killed while crossing a busy street. The sudden loss of Pierre left Marie Curie a widow with two small children and without her lifelong research companion. In the summer of 1910, Marie Curie began a love affair with fellow physicist Paul Langévin. . It was well known that Paul's marriage to Jeanne Langévin was at times a volatile one. Shortly after they married, Jeanne threatened him with divorce. Langévin had been a former student of Pierre's, and he admired him tremendously. He would later develop the basic concept of sonar from Pierre's earlier work with crystals. Marie and Paul also taught science at the same private girls' school outside Paris. Marie was a woman who needed male companionship, and Paul Langévin filled this empty void in her life. Marie wrote to Paul, suggesting that he separate from his wife. Jeanne, Paul’s wife, already suspicious and jealous of Marie, intercepted this letter and others from Marie. Eventually, portions of the letters were published, and angry mobs gathered around Marie's house and the lab. Thus, it was not completely surprising when the news broke about their affair. Although the public ridicule surrounding the affair nearly destroyed Marie Curie’s career, today, their "youthful indiscretion" is all but forgotten by the general public.[4]

In the later years, Langévin became increasingly involved with the study of Einstein's work on space and time. He was a firm supporter of the theory of the equivalence of energy and mass. Einstein later wrote that Langévin had all the tools for the development of the special theory of relativity at his disposal before Einstein proposed it himself and that if he had not proposed the theory, Langévin would have done so.

Langévin was responsible for some of the most important work on piezoelectricity and on piezoceramics for which he was generally remembered. He was the inventor of the underwater Sonar for submarine detection during World War I, where his theories and researches were extensively utilized by the French and the Americans. In 1916 he was able to obtain echoes from the bottom and from a sheet of metal at a distance of 200 meters. In 1917 Langévin started to use the piezoelectric effect, rather than the electrostatic projector and carbon-button microphone used in 1916. He also started the use of vacuum tube amplifiers in underwater sounding equipment, this is thought to be the first use of electronics in this manner. With this new technology echoes were received from a submarine for the first time, in 1918, as deep as 1500 meters. After

World War I his echo sounding devices were employed in many French ocean-liners, starting with the *Ile de France* in 1928.

In 1940, after the start of World War II and the German occupation of France, Langévin became director of the Ecole Municipale de Physique et de Chimie Industrielles, where he had been teaching since 1902, but he was soon arrested by the Nazis for his antifascist views.[3, 5] He was first imprisoned in Fresnes, and later placed under house arrest in Troyes. The execution of his son-in-law and the deportation of his daughter to Auschwitz (which she survived) forced Langévin to escape to Switzerland in 1944.[5] He returned to Paris later that year and was restored to the Directorship of his old school, but died soon after, in Paris on 19 December 1946.[2]

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Ernest Orlando Lawrence
1901 – 1958

American physicist who won the 1939 Nobel Prize for Physics for his invention of the cyclotron, a devise that accelerates atomic particles.[1]

Early Life

Ernest Orlando Lawrence was born on August 8, 1901, at Canton, South Dakota.[1, 4, 5] His parents, Carl Gustavus and Gunda (née Jacobson) Lawrence, were the children of Norwegian immigrants, his father being a Superintendent of Schools. His early education was at Canton High School, then St. Olaf College. In 1919 he went to the University of South Dakota, receiving his B.A. in Chemistry in 1922. The following year he received his M.A. from the University of Minnesota. He spent a year at Chicago University doing physics and was awarded his Ph.D. from Yale University in 1925. He continued at Yale for a further three years, the first two as a National Research Fellow and the third as Assistant Professor of Physics. In 1928 he was appointed Associate Professor of Physics at the University of California, Berkeley, and two years later he became Professor, being the youngest professor at Berkeley.[4, 5] He was called the "Atom Smasher," the man who "held the key" to atomic energy. "He wanted to do 'big physics,' the kind of work that could only be done on a large scale with a lot of people involved," said Herbert York, the first director of the Lawrence Livermore Laboratory, as quoted on the lab's official Web site.[5] In 1936 he became Director of the University's Radiation Laboratory as well, remaining in these posts until his death.[4]

Contributions to Nuclear Science

During World War II he made vital contributions to the development of the atomic bomb, holding several official appointments in the project. He produced most of the uranium used in the Hiroshima atomic bomb. After the war he played a part in the attempt to obtain international agreement on the suspension of atomic-bomb testing, being a member of the U.S. delegation at the 1958 Geneva Conference on this subject.[4]

Lawrence was primarily interested in nuclear physics. His early work was on ionization phenomena and the measurement of ionization potentials of metal vapors.[4] The invention that brought Lawrence to international fame started out as a sketch on a scrap of paper. While sitting in the library one evening, Lawrence glanced over a journal article by Rolf Wideröe and was intrigued by one of the diagrams. The article had described an accelerator that employed a pair of linearly arranged cylinders and an alternating electric field. Lawrence's inspiration was to reconfigure the cylinders into D-shaped chambers and to position the chambers between the poles of a magnet. The idea was to produce very high energy particles required for atomic disintegration by means of a succession of very small "pushes" over a spiral path.[3] Lawrence told his colleagues that he had found a method for obtaining particles of very high energy without the use of any high voltage.[5]

The first model of Lawrence's cyclotron was made out of wire and sealing wax and probably cost $25 in all. And it worked: When Lawrence applied 2,000 volts of electricity to his makeshift cyclotron, he got 80,000-volt projectiles spinning around.[4]

The photo to the left depicts a four-inch copper-encased cyclotron, one of Ernest Lawrence's earliest models.[2] In 1931, and later the same year, with a 25 cm cyclotron, 1 million electron volts were generated. Cyclotrons got successively larger, with new and different capacities. A 69 cm cyclotron could accelerate ions containing both protons and neutrons.[5] Lawrence had discovered a way to "smash" atoms, and in doing so he unwittingly paved the way for the U.S. nuclear weapons program that was to follow a decade later.[4] The swiftly moving particles were used to bombard atoms of various elements, disintegrating the atoms to form, in some cases, completely new elements. Hundreds of radioactive isotopes of the known elements were also discovered.

With this, researchers produced artificial radioisotopes like technetium and carbon-14 used in medicine and tracer research. In 1939, a 152 cm device was being used for medical purposes, and Lawrence won the Nobel Prize in Physics. Work was begun on a 467 cm machine in 1940, but World War II interrupted its development. Lawrence's team turned its attention to the production of the uranium-235.[2] His group produced most of the uranium used in the Hiroshima atomic bomb.[1] In 1941 the instrument was used to generate artificially the cosmic particles called mesons, and later the studies were extended to antiparticles.[4]

He was also the inventor of a method for obtaining time intervals as small as three billionths of a second, to study the discharge phenomena of an electric spark. In addition he devised a very precise method for measuring the *e/m* ratio of the electron, one of the fundamental constants of Nature.[4]

Publications

Lawrence was a most prolific writer. During 1924-1940 his name appeared on 56 papers (an average of $3^{1}/_{2}$ papers a year), showing his exceptional breadth of interest. Most of his work was published in *The Physical Review* and the *Proceedings of the National Academy of Sciences*.[4]

Honors

Among his many awards may be mentioned the Elliott Cresson Medal of the Franklin Institute, the Comstock Prize of the National Academy of Sciences, the Hughes Medal of the Royal Society, the Duddell Medal of the Royal Physical Society, the Faraday Medal, and the Enrico Fermi Award. He was decorated with the Medal for Merit and was an Officer of the Legion of Honour. He held honorary doctorates of thirteen American and one British University (Glasgow). He was a member or fellow of many American and foreign learned societies.[4]

Lawrence married Mary Kimberly Blumer, daughter of the Emeritus Dean at Yale Medical School, in May 1932. They had six children.[4]

President Eisenhower sent Lawrence to Geneva, Switzerland, in July 1958 to negotiate the suspension of nuclear weapons testing with the Soviet Union. Lawrence became ill while in Geneva and was forced to return to Berkeley. He died on August 27, 1958, at Palo Alto, California.[5]

In 1961, element 103 was discovered and named "lawrencium" in his honor.[1, 2] Just 23 days after his death, the Regents of the University of California voted to rename the Lawrence Livermore and Lawrence Berkeley Laboratories after him.[5]

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Lise Meitner
1878 – 1968

Austrian-Swedish physicist who discovered protactinium with Otto Hahn in 1917 and later devised the theoretical explanation of nuclear fission with her nephew, Otto Frisch.

Early Life

Lise Meitner, the third child of a successful and prosperous Jewish lawyer, was born in Vienna, Austria on November 7, 1878.[1, 4] Lise's parents placed great importance on education and paid for her to be privately tutored. In 1901 she entered the University of Vienna to study mathematics and physics. She completed her doctorate in physics in 1906. Her thesis had been written on the conduction of heat in inhomogeneous solids. Her first job after graduation was at the institute of Ludwig Boltzmann. Despite her good relationship with her former professor, she realized that a woman had limited career opportunities in Vienna. Despite her parents objections to her traveling alone, they financially supported her move to Berlin to embark on a professional career.[1]

Contributions to Nuclear Science

At the University of Berlin, Meitner began her studies in the new and exciting field of radioactivity and began a long professional collaboration with the gifted organic chemist, Otto Hahn.[1] In 1913 she and Hahn moved to the newly formed Kaiser Wilhelm Institute, and began to study the emission of beta radiation from radioactive elements.[2] Their research was slightly interrupted when Lise Meitner volunteered to work as a radiologist in an Austrian field hospital, similar to the work Marie Curie was doing in France. Even though she was away, she and Hahn managed to meet regularly. In 1917 they announced the discovery of the element protactinium, the parent element of actinium. A year later she was appointed head of the Physics department at the Wilhelm Kaiser Institute.

Throughout the next decade Meitner and Hahn worked on projects in their respective departments, although, they continued to collaborate frequently. During this time Meitner worked to determine the relationship between beta and gamma radiation.

Contrary to current scientific opinion, in 1925, Meitner demonstrated that the electron lines were emitted before and not after the beta transformation.[1]

In 1934, Hahn and Meitner's collaboration became more direct. Following the discovery of the neutron in 1932 by Chadwick, Meitner was enthusiastic about the new developments in nuclear physics. Enrico Fermi had recently published experiments that showed that bombarding a heavy element with neutrons created a heavier isotope of the element. Meitner, Hahn, and a new collaborator, Fritz Strassman set to work replicating and expanding on Fermi's original experiments.[1] However, in 1938, when the German army entered Austria, it was no longer possible for Meitner (a Jew by descent, but not practice) to remain in Berlin. She fled to Manne Siegbahn's institute in Stockholm, Sweden in July 1934, aided by Niels Bohr.[4] In her absence, Hahn and Strassman continued their experiments and demonstrated that barium was produced when uranium was bombarded with neutrons.[3]

In October 1938, Hahn wrote Meitner a letter explaining the inexplicable discovery of barium after the completion of his uranium bombardment experiment. Meitner's nephew, Otto Frisch, whom Meitner was visiting for the holidays, immediately realized that the uranium atom had split in two rather than merely having chipped a small particle off the larger atom.[1] Meitner realized that if one of the two fragments was Barium, the other must be Krypton, and that there should also be an accompanying release of several neutrons and a large amount of energy. Meitner and Frisch were the first to explain what had happened and to calculate the expected energy release (200 MeV) using Einstein's famous equation for mass-energy equivalence: $E = mc^2$.

At the end of the holiday visit, Frisch returned to Copenhagen where he and Neils Bohr experimentally demonstrated Frisch and Meitner's theoretical description of atomic fission. On January 6, 1939 Frisch and Meitner's paper explaining the newly-titled process of fission appeared in Nature, a German scientific magazine. Meitner was then invited to join the Manhattan Project in the United States, but declined to play a part in building a destructive weapon. She did come to the United States, however, to spend a year teaching at the Catholic University in Washington, D.C.[1]

Honors

Over her brilliant career, Lise Meitner published over 135 scientific papers. In 1992, honor of her career, element 109 was named Meitnerium.[1]

In 1945, the Royal Swedish Academy of Sciences awarded the Nobel Prize in Chemistry to Otto Hahn for the discovery of nuclear fission. Due to the separation of the former collaborators, Meitner received no recognition from the Nobel committee in relation to this award. To make matters worse, Hahn publicly downplayed Meitner's contributions to his research. Meitner never fully recovered from this denial, despite Niels Bohr's efforts to set the record straight. In 1966 the Nobel "mistake" was partly rectified when Hahn, Meitner, and Strassman were jointly awarded the U.S. sponsored Enrico Fermi Prize.[4]

Lise Meitner died peacefully in Cambridge, England on October 27, 1968, a few days shy of what would have been her 90th birthday.

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Robert Andrews Millikan
1868 – 1953

American physicist who determined the charge on an electron using charged oil drop experiments in 1909. In 1916, Millikan experimentally verified Einstein's predictions on the photoelectric effect, measuring the value of Planck's constant (*h*) in the process.

Early Life

Robert Andrews Millikan was born on March 22, 1868, in Morrison, Illinois. He was the second son of the Reverend Silas Franklin Millikan and Mary Jane Andrews. He attended Maquoketa High School (Iowa) and entered Oberlin College (Ohio) in 1886. In 1893, after obtaining his masters in physics, he was appointed Fellow in Physics at Columbia University. He received his Ph.D. two years later for research on the polarization of light emitted by incandescent surfaces - using for this purpose molten gold and silver at the U.S. Mint.[1, 3]

Contribution to Nuclear Science

As was customary at the time, Millikan spent a year in Germany at the Universities of Berlin and Göttingen. While in Germany he got a message from A. A. Michelson, offering him a teaching assistantship at the newly established Ryerson Laboratory at the University of Chicago. Millikan made his first mark as a teacher and textbook writer. There was a time in 1906 when he had considered devoting himself solely to education, but he decided to give research one last try in an attempt to "publish results of outstanding importance."[2]

As a scientist, Millikan made numerous momentous discoveries, chiefly in the fields of electricity, optics, and molecular physics. His earliest major success was the accurate determination of the charge carried by an electron, using the elegant "falling-drop method."[1] The Millikan oil-drop experiment was far superior to previous determinations of the charge of an electron. Where other workers had attempted to measure the quantity by observing the effect of an electric field on a cloud of water droplets, Millikan used single drops, first of water and then, when he found these evaporating, of oil. The experiment had broader significance than a simple refinement of a number. Millikan emphasized that the very nature of his data refuted conclusively the minority of scientists who still held that electrons (and perhaps atoms too) were not necessarily fundamental, discrete particles. And he provided a value for the electronic charge which, when inserted in Niels Bohr's theoretical formula for the hydrogen spectrum, accurately gave the Rydberg constant—the first and most convincing proof of Bohr's quantum theory of the atom. Shortly after his publication of the oil drop experiment in 1910, Millikan was rewarded with a full professorship.[2]

Next, he experimentally verified Einstein's all-important photoelectric equation, and made the first direct photoelectric determination of Planck's constant, *h* (1912-1915). In addition his studies of the Brownian movements in gases put an end to all opposition to the atomic and kinetic theories of matter.[1] Millikan was awarded the 1923 Nobel Prize in Physics for his measurement of the charge on an electron and for his work on the photoelectric effect.[4]

Early in 1917 Millikan went to Washington to be executive officer of the National Research Council of the National Academy of Sciences, charged with war research on the detection of submarines and other essential problems. This work threw him into contact with the astrophysicist George Ellery Hale, one of America's chief organizers of science. After the war Hale bombarded Millikan with requests to join him at the new and still obscure California Institute of Technology.[2] In 1921, he was appointed Director of the Norman Bridge Laboratory of Physics at the California Institute of Technology, Pasadena; he was also made Chairman of the Executive Council of that institute. In 1946 he retired from this post.[1]

During 1920-1923, Millikan occupied himself with work concerning the hot-spark spectroscopy of the elements (which explored the region of the spectrum between the ultraviolet and X-radiation), thereby extending the ultraviolet spectrum downwards far beyond the then known limit. The discovery of his law of motion of a particle falling towards the earth after entering the earth's atmosphere, together with his other investigations on electrical phenomena, ultimately led him to his significant studies of cosmic radiation (particularly with ionization chambers).[1]

Publications[1, 4]

During his early years at Chicago he spent much time preparing textbooks and simplifying the teaching of physics. Throughout his life Millikan remained a prolific author, making numerous contributions to scientific journals. He was author or co-author of the following books:

- *A College Course in Physics,* with S.W. Stratton (1898)
- *Mechanics, Molecular Physics, and Heat* (1902)
- *The Theory of Optics,* with C.R. Mann translated from the German (1903)
- *A First Course in Physics,* with H.G. Gale (1906)
- *A Laboratory Course in Physics for Secondary Schools*, with H.G. Gale (1907)
- *Electricity, Sound, and Light,* with J. Mills (1908)

- *Practical Physics* - revision of *A First Course*(1920)
- *The Electron* (1917; rev. eds. 1924, 1935)
- *Science and Life*(1924)
- *Evolution in Science and Religion* (1927)
- *Science and the New Civilization* (1930)
- *Time, Matter, and Values* (1932)
- *Electrons (+ and –), Protons, Photons, Neutrons, Mesotrons, and Cosmic Rays* (1947; another rev. ed. of The Electron, previously mentioned)
- *Autobiography*(1950)

Honors[1, 3]

Professor Millikan has been President of the American Physical Society, Vice-President of the American Association for the Advancement of Science, and was the American member of the Committee on Intellectual Cooperation of the League of Nations, and the American representative at the International Congress of Physics, known as the Solvay Congress, at Brussels in 1921. He held honorary doctor's degrees of some twenty-five universities, and was a member or honorary member of many learned institutions in his country and abroad. He has been the recipient of the Comstock Prize of the National Academy of Sciences, of the Edison Medal of the American Institute of Electrical Engineers, of the Hughes Medal of the Royal Society of Great Britain, and of the Nobel Prize for Physics 1923. He was also made Commander of the Legion of Honour, and received the Chinese Order of Jade.

Professor Millikan married Greta Erwin Blanchard in 1902; they had three sons: Clark Blanchard, Glenn Allen, and Max Franklin. Robert Millikan died on December 19, 1953, in San Marino, California.[1]

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Henry G. J. Moseley
1887 - 1915

British chemist who developed the application of X-ray spectra to study atomic structure; his discoveries resulted in a more accurate positioning of elements in the Periodic Table by closer determination of atomic numbers.[1]

Early Life

Henry Gwyn Jeffreys Moseley was born in Weymouth, England on November 23, 1887. In 1906 he entered Trinity College of the University of Oxford, and on graduation from that institution went to Manchester University to work with Ernest Rutherford. For his first year at Manchester, he had a full teaching load, but after a year he was relieved of his teaching duties and began full-time research.[2]

Contributions to Nuclear Science

Henry Moseley's fame was achieved in only two years of research ending in 1914, when he enlisted in the British army at the start of World War I. His work during those two brief years, however, produced results that contributed significantly to our understanding of the structure of the atom.

Shortly after Wilhelm Roentgen discovered X-rays in 1895, Charles Barkla, working at the University of London, found that the wavelength of X-rays depends on the element used as the positively-charged target inside an X-ray tube. In 1911, Rutherford showed that the nucleus of an atom is a densely-packed, positively-charged particle. This led the Dutch scientists, van dan Broek, to suggest that the charge on the nucleus should be an integral multiple of the charge on the hydrogen nucleus. To test this theory, Rutherford asked Moseley, who was one of his students, to see if he could find any relationship between the charge on a nucleus and the wavelengths of the X-rays produced by the elements.[3]

Moseley began his work by constructing twelve X-ray tubes, each having a different element as a target. Later he tested thirty more elements. The X-rays produced by

Moseley's samples were diffracted by a crystal and focuses on photographic plates in an operation similar to that taking place in an optical spectrograph. Moseley found that the spectrum of each element was composed of two major lines. When he placed his exposed plates next to one another and compared them, he found that the lines on the plates formed a series of regular steps. Each line was displaced from the position of the preceding one by about the same interval.

In interpreting the results, Moseley stated, "We have here a proof that there is in the atom a fundamental quantity, Z, which increases by regular steps as we pass from one element to the next. This quantity, Z, can only be the charge on the central positive nucleus, of the existence of which we already have definite proof." He went on to say that Z is the same number as the number of the place occupied by the element on the periodic chart of elements. When he discovered gaps between the regularly spaced steps of his results, he predicted that these spaces at 43 and 61 now known to be radioactive, non-naturally-occurring, technetium and promethium, respectively) belonged to undiscovered elements.[2] It soon became evident that the arrangement of the periodic system according to Moseley's atomic numbers was more satisfactory than Dmitri Mendeleev's original arrangement according to molar masses. Within a few years it was discovered that the atomic number corresponded to the number of protons in the nucleus of an element.

Moseley never knew how important his work had been. In 1914 he resigned at Manchester to return to Oxford to pursue his research, but when World War I broke out, he enlisted in the Royal Engineers.[2] He was killed in a battle at Gallipoli in Turkey on June 15, 1915.

Publications

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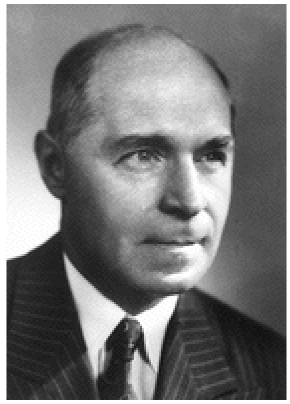

Hermann Joseph Muller
1890 – 1967

American geneticist who discovered that X-rays can produce mutations. Known as the father of radiation genetics. Awarded the 1946 Nobel Prize in Physiology or Medicine for his pioneering work in radiation genetics.

Early Life[1]

Hermann Joseph Muller was born on December 21, 1890 in New York City. Hermann's father had maintained the family business of art metal works, but passed away in 1900, when Herman was still a boy. Herman's mother, Frances Lyons Muller, was also a native New Yorker. From an early age, both of his parents instilled an interest in living things and a love of nature, which he maintained throughout his life.

Hermann was brought up in Harlem, attending public schools there and later attending Morris High School in the Bronx. He and two friends (Lester Thompson and Edgar Altenburg) started a high school science club (possibly one of the first). He was able to attend Columbia University on the Cooper-Hewitt scholarship, which was automatically granted to him based on his exceptional entrance exam scores.

Before the end of his first year at Columbia University, Hermann had become fascinated by the subject of biology. In the summer of 1908, his interests became focused on the field of genetics, primarily due to his reading of R.H. Lock's book on the subject. He was also greatly influenced in his early years by the courses he took under E.B. Wilson and books by experimental biology and physiology writers such as Jacques Loeb.

Father of Radiation Genetics

Hermann Muller began graduate studies on a scholarship in 1910. His second year of graduate school was funded through a teaching fellowship at Cornell Medical College and a side job teaching English to foreigners. Finally, however, he obtained a teaching assistantship in zoology at Columbia (1912-1915).[1]

It was in 1912 that Hermann Muller began his career with Thomas H. Morgan studying mutations in fruit flies (Drosophila). His first experimental work investigated the how the theory of cross-over was supported by inter-relationships of many linked genes. This ultimately became the topic of his doctoral thesis, although, he was simultaneously analyzing variable, multi-factor, characters using marker genes. This work eventually led to his theory of balanced lethals and extended the validity of both chromosomal inheritance and of gene stability.[1]

After the completion of his degree at Columbia University, Hermann Muller moved to Rice Institute in Houston, Texas to teach biology and begin his studies on mutation. After three years, he returned to Columbia University as an instructor. In 1920, he again returned to Texas, this time as an Associate Professor at the University of Texas in Austin, gaining a full professorship in 1925. During this time, he was teaching genetics and evolution and still doing research on mutations.

Muller grew impatient with the mutation rate in Drosophila and was the first to increase the mutation rate using heat. Still not satisfied, he irradiated the flies with 50 kilovolt X-rays that resulted in an even greater incidence of mutations. In doing so, he was the first to demonstrate radiation-induced genetic alterations! Moreover, he did so in a quantitative manner that determined the mutation frequency. Nevertheless, it took nearly two decades for this work to be recognized with the Nobel Prize. The delay was in large part due to his left-wing politics, his controversial views on eugenics, and his often unpopular opinions about the hazards of radiation.[2]

In 1931, the severe criticism and pressure to which these views exposed Muller caused him to leave the United States.[2] In 1932, he was awarded a Guggenheim Fellowship and worked at Oscar Vogt's institute in Berlin, in Timoféeff's department of genetics for about a year. Then at the request of N.I. Vavilov, he then spent 3 1/2 years as Senior Geneticist at the Institute of Genetics of the Academy of Sciences of the U.S.S.R., first in Leningrad and later in Moscow.[1] Eventually, Stalin's reign of terror and disagreements with Trofim Lysenko led Muller to leave for Scotland, where he and S.P. Ray-Chaudhuri studied mutation frequency and dose rate dependence at the Institute of Animal Genetics at the University of Edinburgh. About this time, he began warning about needless exposures to radiation and their associated risks of cancer and heritable genetic effects. 1By the late 1940s, the nuclear weapons testing program had begun and Muller was back in the United States as in interim professor at Amherst College and a vocal critic of the Atomic Energy Commission's views on the hazards of worldwide fallout. As a result, the AEC did not choose Muller as an official US delegate at the 1955 United Nations International Conference on the Peaceful Uses of Atomic Energy. Nonetheless, Muller attended and after virtually every presenter referenced his work, he was given an extended standing ovation![2]

Finally, in 1945, he accepted a professorship in the Zoology Department at Indiana University, Bloomington, Indiana. Here he again devoted his time chiefly to work on radiation-induced mutations, using them on the one hand for purposes of genetic analysis and on the other hand in the study of how radiation produces its biological effects. He retired from Indiana University in 1964 and took a one year appointment to the Institute for Advanced Learning in the Medical Sciences in Duarte, California. He died in 1967.[1]

Publications

Muller contributed over 300 articles on biological subjects to the scientific publications of learned societies. His principle books are *The Mechanism of Mendelian Heredity* with T. H. Morgan and others, 1915 & 1922, *Out of the Night - A Biologist's View of the Future,* 1935, 1936, & 1938, and *Genetics, Medicine and Man* with C. C. Little and L. H. Snyder, 1947.[1]

Honors[1]

- 1946 Nobel Prize in Medicine and Physiology
- President of the 8th International Congress of Genetics (1948)
- President of the American Humanist Association (1956-1958)
- He received Doctor of Science degrees from Edinburgh (1940), Columbia (1949) and Chicago (1959) universities
- Honorary Doctor of Medicine from Jefferson Medical College (1963)
- Annual Award of the American Association for Advancement of Science (1927)
- Kimber Genetics Award (1955)
- Darwin-Wallace Commemoration Medal (1958)
- He was Pilgrim Trust Lecturer (Royal Society) and Messenger Lecturer (Cornell University) in 1945
- Designated Humanist of the Year by the American Humanist Association in 1963
- He also received honorary memberships and fellowships of many learned societies in the United States, England, Scotland, Sweden, Denmark, India, Japan, and Italy.

Herman Muller was married twice. He and his first wife, Jessie M. Jacobs, married in 1923, they had one son, David Eugene Muller. In 1939 he married Dorothea Kantorowics and had a daughter, Helen Juliette Muller.[1]

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Ida Tacke Noddack
1896 – 1979

German chemist, who is credited, along with her husband, Walter, and Otto Burg with the discovery of the element rhenium in 1925. In September 1934 Ida Noddack suggested that elements in the middle of the periodic table were being formed as uranium broke up on the introduction of a neutron into its nucleus. However, nobody had taken her suggestion seriously at the time as it was contrary to all conventional thinking, and she did not even try to verify her theory.

Early Life

Ida Eva Tacke was born in 1896 in the village of Lackhausen, Germany. She studied chemistry at Technische Hochschule in Berlin. She received her diploma in 1919, and her doctorate in 1921.[2]

Contribution to Nuclear Science

In her first assignment of her professional career she, with her future husband Walter Noddack; and along with Otto Berg (the X-ray technician), discovered rhenium. The discovery of rhenium was incredible; it was one of the last naturally occurring elements to be discovered. Mendelev developed the periodic table in 1869. He left gaps in his Table for future scientists to discover the missing elements; he also predicted the properties of these elements based on their position in the Periodic Table. Because element 75 (Rhenium) and 43 (Technetium) were the last two members of Group VII, their properties could not be predicted. Ida and Walter Noddack researched the possible properties of those elements, which eventually led to the discovery of Rhenium. Ida Tacke, Walter Noddack, and Otto Berg discovered rhenium in June 1925. It was isolated in milligrams by Ida Noddack-Tacke in 1926.[2]

Ida Noddack-Tacke was also the first person to mention the possibility of uranium fission.[2] In a 1934 paper she observed that the radioactivity that Enrico Fermi observed following the bombardment of uranium with neutrons might be caused by the disintegration of uranium into several heavy fragments.[3] Because of the fact that she was a woman scientist her idea was scoffed at by Otto Hahn. It wasn't till five years later that the chemical analyses performed by Otto Hahn with Fritz Strassman and Lise Meitner proved that Ida Noddack's theory was correct. Otto Hann did not cite her paper on uranium fission. Emilio Segrè, Fermi's co-worker in Rome later wrote " The possibility of fission, however, escaped us although it was called specifically to our attention by Ida Noddack. … The reason for our blindness is not clear."[3]

In 1960 Walter Noddack died, and in 1968 Ida retired. She lived in Bad Neuenahr near Bonn on the Rhine until 1978 when she passed away.[2]

Honors[1]

First prize department of chemistry and metallurgy, Technical University, Berlin 1919
First woman to give a major address to the Society of German Chemists 1925
Justus Leibig Medal, German Chemical Society 1931, for the discovery of rhenium
Scheele Medal, Swedish Chemical Society 1934
Honorary Doctorate, University of Hamburg 1966
High Service Cross of the German Federal Republic 1966
Honorary Member, Spanish Society of Physics and Chemistry
Honorary Member, International Society of Nutrition Research

Publications[3]

Ida Tacke Noddack was a distinguished chemist with many publications in scientific journals, chemical journals in particular. In the paper which reported the discovery of rhenium, the authors also reported evidence for another missing element, the element 43 which they named masurium. This was, and is still, a disputed discovery because all known isotopes of this element are highly radioactive with half-lives much shorter than the age of the earth. In 1937, C. Perrier and E. Segrè found and identified this element in an irradiated foil in the Berkeley cyclotron and named it technetium. In a now famous paper ,"*Über das Element 93" Zeitschrift für Angewandte Chemie* 47: 653 (1934), she suggested that the radioactivity which Fermi observed resulting from neutron bombardment of uranium, which he proposed might be evidence for production of the transuranic element 93, might instead be caused by disintegration of the uranium nucleus into several heavy fragments - a process now known as fission. It is conjectured that what is considered as Noddack's premature report of the discovery of element 43 is responsible for the neglect of her prescient 1934 paper that correctly draws attention to the fact that uranium fission may be responsible for the neutron induced radioactivity Fermi observed in uranium. She also has been criticized for not following up her own suggestion and performing chemical analyses of the reaction products of neutron irradiated uranium herself.

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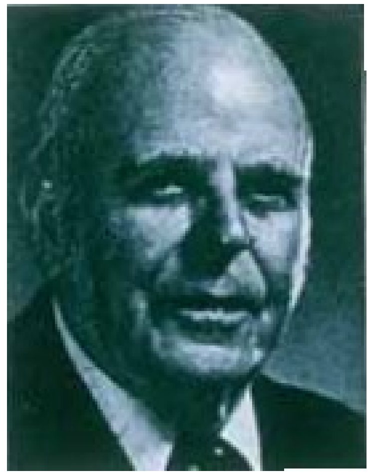

Herbert M. Parker
1910 – 1984

Herbert Parker is credited along with James. R. Paterson with developing the Manchester System for radium therapy in 1932.[1] Additionally, he played an important role in organizing the radiological safety programs in the United States during and after World War II.[2]

Early Life

Herbert M. Parker was born in Accrington, England, on April 13, 1910. He received an M.S. in physics from the University of Manchester in 1931 and began his career as a medical physicist at the Christie Hospital and Holt Radium Institute in Manchester. While there, he shared in the development of the Paterson-Parker method, also known as the Manchester System, of determining the size of the radiation dose to cancerous tissue from radium therapy. This method was a major development in radiotherapy, which is still used more than half a century after it was first published.[2] The Manchester System for therapy was the most comprehensive and widely used system in the field of radiology. It allowed physicians to arrange radium needles or tubes in ways that would maximize the radiation dose to a tumor while minimizing the dose to healthy tissue.[1]

Contribution to Radiation Protection

Mr. Parker left England in 1938 and worked at the Swedish Hospital in Seattle, Washington where he conducted Supervoltage Therapy research at the Tumor Institute.[1] He became associated with Simeon T. Cantril, a radiologist at the institute who, together with Parker, was to play a prominent role in the wartime atomic energy program.[3] At the beginning of WWII, Parker joined the University of Chicago in the "Metallurgical Laboratory," the assembly site for the nucleus of the Manhattan Project. His group was one of the first radiation protection specialists to use the title "health physicist."

In 1943 Mr. Parker left Chicago to establish the health physics program at Oak Ridge National Laboratory.[1] This program was the first radiological safety program for a major U.S. atomic energy research and production facility, which was no small undertaking considering that researchers' experience with radioactive substances was extremely limited prior to World War II. Only slightly more than one kilogram of radium hack been extracted from the earth's crust, but the processing and use of that small amount of radium, mainly in luminescent compounds, had already caused the deaths of more than one hundred people. Accidental injuries and deaths had been caused by overexposure to the X-rays used in medical practice. With this limited base of experience, Parker and his small group of associates faced the prospect that the material to be processed by the Manhattan Project would be the radioactive equivalent of hundreds of tons of radium! Fortunately, information from earlier misadventures with radium and X-rays provided a starting point for dealing with the new problems that had to be faced. The use of this meager information to design procedures that safeguarded atomic energy workers and the public from the effects of ionizing radiation was one of the truly remarkable and unheralded technological achievements of the Manhattan Project. New instrumentation had to be developed, people trained, and procedures instituted that would protect human lives and also permit the expeditious achievement of the program's goals.[2]

In 1944, he returned Washington State where he began the Health Physics program at the Hanford Engineer Works.[1] In addition to organizing a model radiological protection program at Hanford, Parker also initiated research to develop new instrumentation and to obtain information on the dispersion of radiological materials in the environment. Herbert Parker actively supported early studies of the environmental and biomedical aspects of radioactive particles containing fission products and plutonium. He was also among the first scientists to undertake quantitative assessments of the effects of reactor accidents, presenting a landmark paper on the subject at the first United Nations Conference on the Peaceful Uses of Atomic Energy in 1955. In 1947, when the operation of Hanford was transferred from Du Pont to General Electric, Parker became manager of operational and research activities in radiological sciences.[2] He directed this program until 1956 when he became the overall manager at the Hanford Labs.[1] He held this position until 1965, when responsibility for the operation of the labs was transferred from General Electric to Battelle Memorial Institute and the facility was renamed the Pacific Northwest Laboratory.[2]

Herbert Parker was a leader in introducing the radiation protection units and quantities used to describe the absorption of energy in tissue. Parker is known for helping to develop the roentgen equivalent physical (rep), (also known as roentgen equivalent parker or roentgen equivalent biological, reb, units), which are predecessors to the rad and rem. He also established the first maximum permissible concentration for a radionuclide in air: 3.1×10^{-11} $\mu Ci/cm^3$ for Plutonium-239.[1]

Honors

Herbert Parker was widely respected by his peers with whom he joined in the work of a number of professional groups. He was elected to the National Academy of Engineering in 1978. He was a member of the National Council on Radiation Protection and Measurements, and he served as chairman of its Scientific Committee on Basic Radiation Protection Criteria. He was also a member of the American Nuclear Society, where he served on the board of directors. He was a fellow of the American Physical Society and of the British Institute of Physics, and he served on numerous scientific and technical committees, freely contributing his ideas and knowledge. Parker was certified as a health physicist by the American Board of Health Physics and as a radiological physicist by the American Board of Radiology. He received the Distinguished Achievement Award of the Health Physics Society and the Janeway Medal of the American Radium Society.[2]

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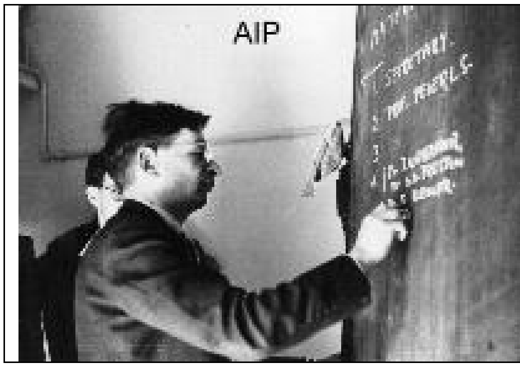

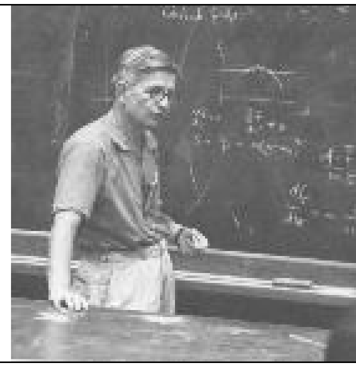


Rudolph Ernest Peierls
1907 – 1995

German born, British physicist who contributed to the early theory of neutron-proton system and later helped to develop the atomic bomb.[1]

Early Life

Rudolph Peierls, the son of a Jewish businessman, was born in Berlin, Germany, on June 5, 1907.[2] He studied nuclear physics under respected physicists Werner Heisenberg and Wolfgang Pauli in Berlin, Munich, Zurich, and Leipzig. In 1929, he conceived the theory of positive carriers to explain the thermal and electrical conductivity behaviors of semiconductors.[2, 3] He arrived in England in 1933 on Rockefeller Fellowship to Cambridge. With the Nazi purge of Jews in German Universities, he chose to stay in England. Peierls moved to England and found a job teaching physics at Birmingham University.[3] In 1939, he began research in the field of atomic physics with James Chadwick and Otto Frisch.[1] He was naturalized as a British Citizen in 1940.[4]

Contribution to Nuclear Science

In the late thirties, Rudolf Peierls had begun to make significant contributions to the possible explosive effects of nuclear fission. French scientist Francis Perrin had recently published his paper describing an approximate formula for calculating the critical mass of uranium. Peierls figured out a way to sharpen Perrin's formula. Then Peierls and Otto Frisch collaborated on critical mass and nuclear cross section calculations.[4] In 1940, Otto Frisch and Rudolf Peierls conceived one of the most significant documents of the twentieth century. Originally named the "Memorandum on the properties of the radioactive "super-bomb"," they argued that if the rare isotope uranium 235 (0.7% naturally occurring) could be extracted from naturally occurring uranium 238, the amount needed for an atomic bomb could be measured in kilograms rather than the early estimates of tons.[3]

The MAUD committee worked out the basic principles of both the fission bomb design and uranium enrichment by gaseous diffusion. The work completed by this top-secret committee alerted the United States to the feasibility of an atomic bomb. In July 1941, the MAUD committee published “On the Use of Uranium for a Bomb,” which reaffirmed that the weapon suggested by Frisch and Peierls would definitely work. This report helped crystallize the American bomb effort because it outlined specific plans for producing a bomb. Interestingly, most of the experimental and theoretical scientific calculations and assessments that formed the basis for the MAUD Report were the work of Otto Frisch and Rudolf Peierls. However, since they were both Germans living in England, they were “officially classified as “enemy aliens”, and could not, by law, be part of a wartime committee.[3]

In 1943 Peierls joined the Manhattan Project in the United States.[2] A year later he went to work in Los Alamos.[4] Over the next two years he worked with Robert Oppenheimer, Edward Teller, Otto Frisch, Felix Bloch, Enrico Fermi, David Bohm, James Chadwick, James Franck, Emilio Segre, Eugene Wigner, Leo Szilard and Klaus Fuchs in developing the atom bombs that were ultimately dropped on Hiroshima and Nagasaki.[2]

After the war Peierls returned to England. He was professor of physics at Birmingham University until 1963 and moved to Oxford University until his retirement in 1974.[2] Rudolph Peierls died in Oxford on September 19, 1995.[2, 4]

Publications

Rudolf Peierls wrote several books including The Laws of Nature (1955), Surprises in Theoretical Physics (1979) and an autobiography, Bird of Passage (1985).[2]

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Edith Hinkley Quimby
1891 – 1982

Edith Hinckley Quimby was a physicist who helped develop radioactive techniques for the diagnosis and treatment of cancer and helped to establish tolerance levels for exposure of the human body to radiation.[1]

Early Life

Born in Illinois, Edith Hinkley Quimby attended Whitman College in Walla Walla, WA on a full scholarship, which resulted in her obtaining bachelors degrees in the fields of mathematics and physics in 1912. She taught for two years as a science teacher before entering the University of California at Berkeley, where she obtained her master's degree in physics in 1916.[3]

After marrying and moving to New York City in 1919, Edith secured a job at the New York City Memorial Hospital as an assistant physicist. She began her career at the Memorial Hospital, where Gioacchino Failla had established the first research laboratory devoted to the medical uses of radiation. At that time, she was the only woman in America engaged in medical physics research. Failla needed an assistant and, as Quimby remembers it, "This job turned up. I took it."[2]

Contributions to Nuclear Medicine

In the early 1900's, the field of radiological physics did not exist, although the use of x-rays and radium for the treatment of diseases was being practiced at a number of hospitals. Quimby's job was to establish the most effective and safest method of using these new radioactive isotopes to fight diseases like cancer.

Although no standard techniques were available at the time, radium was widely used to treat cancer. Radium-containing needles were applied to tumors in a makeshift fashion, with no certainty that the tumors received the required exposures. She measured the amount of radiation emitted by x-rays and radium and was the first to establish the levels of radiation that the human body could tolerate. She measured the generation and penetration of various forms of radiation to make exact dosages of radiotherapy possible. Her work provided the first practical guidelines to physicians using radiation therapy.[1]

Quimby was the first to determine the distribution of the radiation doses in tissue from various arrangements of radium needles. The techniques she described in 1932 for choosing the most effective grouping of radium needles were widely adopted in the United States and served as the forerunner of Parker and Paterson's Manchester system.[2]

During the same period, Edith quantified the different doses from beta and gamma radiation required to produce the same biological effect such as skin erythema (i.e., reddening of the skin). In doing so, she pioneered the concept of the relative biological effectiveness of radiation (RBE), i.e absorbed dosages of radiation. This important concept is still employed by radiobiologists and served as the basis for the quality factor used to convert an absorbed dose measured in rad (or gray) to a dose equivalent in rem (or sievert).1 Although radiologists had previously used X-ray film to estimate radiation exposures, Quimby was the first (ca. 1923) to institute a full scale "film badge" program. The process consisted of cutting X-ray film into strips, covering them with black paper and distributing them among the laboratory personnel.[2]

In the 1940s, Quimby and Failla moved to Columbia University and began working with the newly available artificial radioisotopes being produced by accelerators and reactors. Edith conducted research in the use of artificially produced radioactive sodium in medical research, including the protection of those handling radioactive substances from the harmful effects. The early clinical trials with radioactive sodium and iodine to diagnose and treat various medical disorders established her as one of the pioneers of nuclear medicine.[1, 2]

Edith developed and taught techniques for disposal of radioactive wastes occurring in hospitals, and procedures for cleaning up accidental radioactive spills. She studied the application of radioactive isotopes in the treatment of thyroid disease, and for circulation studies and diagnoses of brain tumors." Quimby finished her career at Columbia University by teaching a new generation about radiation physics and the clinical use of radioisotopes.[1]

Publications

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Honors[4]

Fellow, American Physical Society
Fellow, American College of Radiology
Janeway Medal, American Radium Society 1940
Honorary Sc.D., Whitman College 1940
Gold Medal, Radiological Society of North America 1941
Achievement Medal, International Women's Exposition of Arts and Industries 1947
Lord and Taylor American Design Award 1949
Honorary Sc.D., Rutgers University 1957
Medal of the American Cancer Society 1957
Gold Medal, Inter-American College of Radiology 1958
Gold Medal, American College of Radiology 1963

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Dixie Lee Ray
1914 – 1994

The first woman on the Atomic Energy Commission (AEC), as chairman (1973-1975) she championed nuclear power plant construction.[1]

Early Life[3]

Dixie Lee Ray was born Margaret Ray in Tacoma, Washington. She was the second of five girls in a working-class family. Family and friends nicknamed her "Dick" as a child -- short for "little Dickens." She later changed her name to Dixie Lee, purportedly after the Southern region of the United States and after the Confederate Civil War General Robert E. Lee. At age 12, she established a record as the youngest girl to climb Mount Rainier.

After graduating from Tacoma's Stadium High School, she won a scholarship to Mills College, where she graduated with honors in 1937. She worked as a teacher, lab assistant, and janitor to boot-strap her way to a doctorate in zoology at Stanford University. In 1945, she joined the Zoology Department at the University of Washington in Seattle. She served on the faculty for almost three decades, specializing in marine biology.

Contribution to Nuclear Science

Dixie Ray started her career as an associate marine biology professor at the University of Washington (1947-1972).[1] In 1963, Dr. Ray accepted the position of director of the Seattle's Pacific Science Center, which was in desperate need of strong leadership and funding. The architecturally stunning facility had opened the previous year as a cornerstone of the Century 21 Exposition (World's Fair). Dr. Ray held the directorship for nine years and is widely credited with the survival of the facility.[3]

After nine years at the Pacific Science Center, Dixie resigned in 1972 to accept the appointment of President Richard M. Nixon to the Atomic Energy Commission (AEC), which she later chaired. One of her assignments was to find a solution for the crisis of a national fuel shortage. She devised strategies to eliminate defects in nuclear power plants and orchestrated a plan to speed construction of new plants.[3] The first woman on the Atomic Energy Commission, as chairman (1973-5) she championed nuclear power plant construction.[1, 2]

She was also a presidential appointee to other governmental offices, serving as Assistant Secretary of State with responsibilities for the Bureau of Oceans and the Office of International and Scientific Affairs. During all of her service, she was outspoken in her support of a scientific basis for energy and environmental decisions. She strongly supported the view that technology should be used for the benefit of people but it should be used with care.[2]

Following the phase-out of the Atomic Energy Commission, President Gerald R. Ford appointed Dr. Ray to become the first Assistant Secretary of State for the Bureau of Oceans, International Environment and Scientific Affairs. After a brief six months, she resigned and permanently burnt her bridges.[2, 3] Having served under two Republican presidents, Ray returned home to run for governor of Washington state on the Democratic ticket. Dixie Lee Ray served as governor of the state of Washington from 1977 to 1981, the first woman to hold the office. During her time as governor, she refused to close the nuclear waste dump at Hanford, WA.

When she left the governorship, Ray closed the door on political life and returned to her farm on Fox Island. Continuing to speak out against the allegedly overzealous environmentalists, she and Lou Guzzo co-authored two books on the subject, *Trashing the Planet* (1990) and *Environmental Overkill* (1993).

In January 1994, the 79-year-old Dixie Lee Ray died at her home of a bronchial condition.

Honors

Dixie Lee Ray was the recipient of numerous awards including 21 honorary doctoral degrees and, in 1973, the Peace Medal of the United Nations.

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Wilhelm Conrad Roentgen
1845 – 1923

German physicist that discovered X-rays in 1895 and was awarded the first Nobel Prize in Physics in 1901 for that discovery.

Early Life

Wilhelm Conrad Roentgen was born on March 27, 1845 in Lennep, which is located in the Lower Rhine Province of Germany. His father was a cloth manufacturer and merchant while his mother, Charlotte Constanze Frowein, was from an old Lennep family that had settled in Amsterdam.[2]

At the age of three his family relocated to Apeldoorn, The Netherlands. Once there he began boarding school at the Institute of Martinus Herman van Doorn. While a student there he was known for his love of the outdoors, but did not make apparent what he later would be capable of.[2]

In 1862 he started attending the Utrecht Technical School located in Holland. Unfortunately he was wrongly expelled for a prank that another student was responsible for.[1] He then entered the University of Utrecht to study physics in 1865. Not having the credentials required to be a regular student at Utrecht led to him to take a special entrance examination to gain admittance to the Polytechnic at Zurich which is comparable to an American university.[2] After being accepted he began his studies in Mechanical Engineering. At the Polytechnic his two greatest influences were Kundt and Clausius. He met Kundt while he worked in Kundt laboratory and he attended Clausius' lectures at the Ploytechnic. These two individuals guided him in his academic endeavors. He received his Ph.D. from the University of Zurich in 1869.[2]

He married Anna Bertha Ludwigin 1872 in Apeldoorn, The Netherlands. He met her at her father's café; she was the niece of the poet Otto Ludwig. Although they had no children, they adopted Josephine Bertha Ludwig, daughter of Anna's brother in 1972.[2]

Professional Academia

After working for almost four years as Kundts' assistant he became qualified as a Lecturer at Strasbourg University in 1874. The next year in 1875 he became a Professor in the Academy of Agriculture at Hohenheim in Wurtemberg, Germany.[2] The next year, 1876, the Strasbourgh University offered him the position of Professor of Physics which he accepted and remained there for three years. After Strasbourgh University he was named the new Chair of Physics at the University of Giessen. In 1888 he changed universities and was the Chair of Physics at the University of Wurzburg, but in 1990 the Bavarian Government, by special request, asked him to be the Chair at the University of Munich and he remained the chair there for the rest of his life.[2]

Contributions to Nuclear Science

Throughout Roentgen's career he studied many areas that caught his attention. His first published material covered the specific heats of gases, which was published in 1870.[2] Next, was a paper on the thermal conductivity of crystals. After words he tackled variations in the functions of the temperature and the compressibility of water and other fluids; the modification of the planes of polarized light by electromagnetic influences; and influence of pressure on the refractive indices of various fluids.[2]

His greatest achievement though was the unintentional discovery of X-rays. On November 8, 1895 he was running an experiment where he was studying the effects of electrical current through a low pressure gas in a Hittorf-Crookes tube.[1] During his experiment he noticed that even thought the tube was inside a thick black carton to exclude any light that a barium platinocyanide paper plate became fluorescent in a dark room.[2] This phenomena occurred even if the paper plate was two meters away. Since the cathode rays, which are now called beams of electrons, could not travel through air that distance he knew something else was being emitted from the tube.[3] Since the rays were new and unknown he dubbed them "X-rays" for simplicity. He performed more experiments using a photographic plate and realized that objects with different thicknesses and densities left varying images on the photographic plate. He even placed his wife's hand on the plate and was able to discern the differences between the bones in her hand, skin, and a ring she wore. This was because the parts of the hand that were less dense let more X-ray pass through and were more of a transparent nature on the photographic plate. When he was asked what thoughts ran through his head on that historical night he said "I didn't think, I investigated".[1]

When his discovery was made public he became famous for his efforts, but this went against his nature. He was a quite man and did not seek the fame that was all but force onto him. He was awarded many prizes, honorary doctorates, and memberships in the scholarly societies of the time. His fame at that time was such that he even had streets named after him.[2] Unfortunately there were some detractors that claimed he stole his discovery from some very respected scientists of the time that were did similar work with cathode rays. The difference was that he noticed an effect from the experiment that the others in the field did not and that was what separated their efforts from his.[1] What can be called an insight to his character is that he decline almost all of the honors and prizes bestowed upon him and this included and title that would have admitted him into the German nobility.[1] He even refused to take out patents on his discovery so that the rest of the world could reap the benefits from his work. He did accept an honorary degree of Doctor of Medicine given to him by the University of Wurzburg and the Nobel Prize in Physics and he donated his prize money from this to his university.[1] Even though he was famous he remained the modest and compassionate man he always was. He spent summer vacations at his summer cottage near the Bavarian Alps with his wife and friends and held onto his love of the outdoors to the extent that he was known for getting into some serious situations while mountaineering.[2]

Wilhem Conrad Roentgen passed away on February 10, 1923 due to carcinoma of the intestine.[2] Unfortunately due to his generosity combined with the inflation Germany suffered after World War I he was almost bankrupt when he died.[1]

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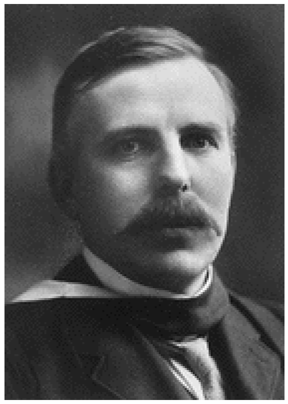
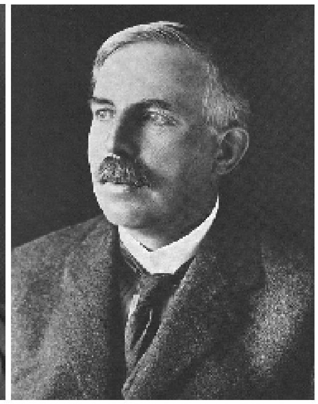

Ernest Rutherford
1871 - 1937

Ernest Rutherford is considered the father of nuclear physics. He is primarily know for three major scientific contributions, although, many of his lesser contributions would have brought fame to almost any other scientist. Rutherford (1) explained radioactivity as the spontaneous disintegration of atoms, (2) determined the planetary structure of the atoms, and (3) was the first to successfully converted one element to another.

Early Life[1, 2]

Ernest Rutherford was born on August 30, 1871, at Spring Grove in Nelson, New Zealand, the fourth child and second son in a family of seven sons and five daughters. His father James Rutherford, a Scottish wheelwright, immigrated to New Zealand with Ernest's grandfather in 1842. His mother, Martha Thompson, was an English schoolteacher, who, with her widowed mother, also went to live in New Zealand in 1855.

Ernest received his early education in Government schools. In 1897, on his second attempt, Ernest won a scholarship to the Nelson Collegiate School. In 1889 he was awarded one of ten available scholarships to University of New Zealand, Wellington. He graduated M.A. in 1893 with a double First Class Honors in Mathematics and Physical Science. That same year, 1894, he was awarded an 1851 Exhibition Science Scholarship, enabling him to go to Trinity College, Cambridge, as a research student at the Cavendish Laboratory under J.J. Thomson to study the electrical conduction of gases.

In 1898 Rutherford discovered that two quite separate types of emissions came from radioactive atoms and he named them alpha and beta rays. Beta rays were soon shown to be high speed electrons. That same year Rutherford in 1898 accepted a professorship at McGill University in Montreal, Canada.

Contributions to Nuclear Science

At McGill Rutherford promptly discovered radon, a chemically unreactive but radioactive gas. In this he was assisted by his first research student, Harriet Brookes. Rutherford, with the later help of a young chemist, Frederick Soddy, unraveled the mysteries of radioactivity, showing that some heavy atoms spontaneously decay into slightly lighter atoms. This was the work which first brought him to world attention. In 1908 he was awarded the Nobel Prize in Chemistry for his investigations into the disintegration of the elements and the chemistry of radioactive substances.

On realizing that lead was the final decay product of uranium, Rutherford proposed that a measure of their relative proportions and the rate of decay of uranium atoms would allow minerals to be dated and, subsequently, this technique placed a lower limit on the age of the formation of the Earth. Radioactive dating of geological samples underpins modern geology.

Rutherford transferred to Manchester University in 1907. Shortly after the move, he showed that the alpha particle was a helium atom stripped of its electrons. He and an assistant, Hans Geiger, developed the electrical method of tirelessly detecting single particles emitted by radioactive atoms, the Rutherford-Geiger detector. With this he could determine important physical constants such as Avogadro's number, the number of atoms or molecules in one gramme-mole of material.

While at McGill Rutherford had also noted that a narrow beam of alpha particles became fuzzy on passing through a thin sheet of mica. Rutherford set Ernest Marsden the task of investigating whether any alpha particles were reflected from metals. Marsden found that some alpha rays were scattered directly backwards, even from a thin film of gold. In 1911, Rutherford deduced from these results that almost all of the mass of an atom, an object so small that it would take over five million of them side-by-side to cross a full stop on this page, is concentrated in a nucleus a thousand times smaller than the atom itself.

Rutherford was knighted in the 1914 New Years Honors list and visited Australia and New Zealand for a scientific meeting and for a family reunion. War was declared just before he reached Australia. After a three month visit to New Zealand Rutherford returned to Britain where he worked on acoustic methods of detecting submarines for the British Admiralty's Board of Invention and Research. Rutherford's only patent is from his development of a directional hydrophone and that was assigned to the Admiralty. When the Americans finally entered the war in 1917 Sir Ernest Rutherford led the delegation to transfer submarine detection knowledge to them.

Near the end of the war Rutherford returned to the pursuit of non-war science. In 1919 Rutherford became the Director of Cambridge University's Cavendish Laboratory, where he had previously done his graduate work under J.J. Thomson. While bombarding nitrogen with alpha rays, he observed outgoing protons of energy larger than that of the incoming alpha particles. From this observation he correctly deduced that the bombardment had converted nitrogen atoms into oxygen atoms. He thus became the world's first successful alchemist.

Publications

Rutherford published several books: *Radioactivity* (1904); *Radioactive Transformations* (1906), being his Silliman Lectures at Yale University; *Radiation from Radioactive Substances*, with James Chadwick and C.D. Ellis (1919, 1930) - a thoroughly documented book which serves as a chronological list of his many papers to learned societies, etc.; *The Electrical Structure of Matter* (1926); *The Artificial Transmutation of the Elements* (1933); *The Newer Alchemy* (1937).[1]

Honors

Rutherford was knighted in 1914; he was appointed to the Order of Merit in 1925, and in 1931 he was created First Baron Rutherford of Nelson, New Zealand, and Cambridge. He was elected Fellow of the Royal Society in 1903 and was its President from 1925 to 1930. Amongst his many honors, he was awarded the Rumford Medal (1905) and the Copley Medal (1922) of the Royal Society, the Bressa Prize (1910) of the Turin Academy of Science, the Albert Medal (1928) of the Royal Society of Arts, the Faraday Medal (1930) of the Institution of Electrical Engineers, the D.Sc. degree of the University of New Zealand, and honorary doctorates from the Universities of Pennsylvania, Wisconsin, McGill, Birmingham, Edinburgh, Melbourne, Yale, Glasgow, Giessen, Copenhagen, Cambridge, Dublin, Durham, Oxford, Liverpool, Toronto, Bristol, Cape Town, London and Leeds.[1]

Rutherford married Mary Newton, only daughter of Arthur and Mary de Renzy Newton, in 1900. Their only child, Eileen, married the physicist R.H. Fowler. Ernest Rutherford died in Cambridge on October 19, 1937, the result of delays in operating on his partially strangulated umbilical hernia.[2] His ashes were buried in the nave of Westminster Abbey, just west of Sir Isaac Newton's tomb and by that of Lord Kelvin.[1]

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Glenn Theodore Seaborg
1912 – 1999

American chemist who discovered ten new elements (numbered 93 – 102) as well as several new radioisotopes. He shared the 1951 Nobel Prize in Chemistry, with Edwin McMillan, for their discoveries of the transuranic elements and determination of their chemistry.

Early Life

Glen Theodore Seaborg was born April 19, 1912 in Ishpeming, Michigan. At the age of 10 his family moved to California.[1, 3] In 1929 he graduated valedictorian of David Starr Jordan High School in Los Angeles. He received a B.A. in chemistry from the University of California, Los Angeles in 1934 and completed his Ph.D. from the University of California, Berkley in 1937.[1, 5]

Contributions to Nuclear Science

Seaborg's early interest was in discovering radioactive isotopes, many of which are used in medical therapy as well as in basic scientific research.[5] After completion of his doctorate he worked as a laboratory assistant to Gilbert N. Lewis. In 1939, Seaborg became an instructor of chemistry at the University of California, Berkley. He was subsequently promoted to Assistant Professor in 1941 and full Professor in 1945.[1] In 1939 he turned his attention to the transuranic elements (those with nuclei heavier than that of uranium); working with the cyclotron and his colleagues at the University of California, Berkeley.

In February 1941, Seaborg, Edwin McMillan, Joseph Kennedy, and Arthur Wahl, using the 60-inch cyclotron built by Ernest Lawrence, bombarded a sample of uranium with deuterons and transmutated it into plutonium.[2] This was the first of ten elements to be co-discovered by Seaborg and his colleagues.

In 1942, Seaborg took a leave of absence from the lab in Berkley to head the plutonium work for the Manhattan Project at the University of Chicago Metallurgical Laboratory.[1] During most of World War II he worked to develop techniques for the large-scale production of plutonium. The plutonium he produced at the University of Chicago went into the two bombs dropped on Japan in 1945.[5] At the end of the war (1946) he returned to Berkley to continue his research on the transuranic elements as the director of nuclear chemical research at the Lawrence Radiation Laboratory. That same year he was also appointed to the Atomic Energy Commission's General Advisory Committee. [1]

In 1944, Seaborg formulated the "actinide concept" of heavy element electronic structure.[1] In this theory, Seaborg predicted that the actinides -- including the first eleven transuranium elements -- would form a transition series analogous to the rare earth series of lanthanide elements. Called one of the most significant changes in the periodic table since Mendeleev's 19th century design, the actinide concept showed how the transuranium elements fit into the periodic table, thus, demonstrating their relation to the other elements.[1, 2] Seaborg and his colleagues used this concept as a stepping stone to the creation of a succession of transuranium elements, including americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, and seaborgium.[2, 4]

In1951, Seaborg and Edwin McMillan were awarded the Nobel Prize in Chemistry for their discovery of the transuranic series of elements and their determination of the chemistry of these new elements. He was appointed Chancellor of the University of California Berkley in 1958 and served in that capacity until he was appointed to the Atomic Energy Commission in 1961. Between 1959 and 1961 he was also a member of the President's Science Advisory Committee.[1] In the early eighties he was a member of President Regan's National Commission on Excellence in Education.[2, 6]

Publications

Glenn Seaborg is the author of approximately 500 scientific papers, including a number of comprehensive reviews and compilations in scientific publications. [1] He is also the author and co-author of several books on chemistry and the elements, including an autobiography published in September 1998 entitled: " A Chemist in the White House: From the Manhattan Project to the End of the Cold War."[2]

Honors[1]

- Glenn Seaborg was awarded numerous honors throughout his lifetime.
- U.S. Junior Chamber of Commerce named him as one of America's 10 outstanding young men (1947)
- American Chemical Society's Award in Pure Chemistry (1947)
- John Ericsson Gold Medal by the American Society of Swedish Engineers (1948)
- Nichols Medal of the New York Section of the American Chemical Society (1948)
- John Scott Award and Medal of the City of Philadelphia (1953)
- Perkin Medal of the American Section of the Society of Chemical Industry (1957)

- Atomic Energy Commission's Enrico Fermi Award for his outstanding work in the field of nuclear chemistry and for his leadership in scientific and educational affairs (1959)
- Swedish American of the Year by Vasa Order of America, Stockholm (1962)
- Franklin Medal of the Franklin Institute, Philadelphia (1963)
- National Metal of Science (1991)

Dr. Seaborg is an Honorary Fellow of the Chemical Society of London and of the Royal Society of Edinburgh. He is a Fellow of the American Institute of Chemists, the New York Academy of Sciences, the California Academy of Sciences, the American Physical Society and the American Association for the Advancement of Science. He served as president of both the American Association for the Advancement of Science and the American Chemical Society.[2] He is a Member of the National Academy of Sciences, the American Academy of Arts and Sciences, the Royal Society of Arts of England, and the Royal Swedish Academy of Engineering Sciences.

Honorary degrees awarded to Dr. Seaborg include Doctor of Science degrees from the University of Denver, 1951; Gustavus Adolphus College, 1954; Northwestern University, 1954; University of Notre Dame, 1961; Ohio State University, 1961; Florida State University, 1961; University of Maryland, 1961; Temple University, 1962; Tulane University, 1962; Drexel Institute of Technology, 1962; Georgetown University, 1962; University of the State of New York, 1962; Mundelein College, 1963; and Trinity College, 1963; the degree of Doctor of Laws from the University of Michigan, 1958; and University of Massachusetts, 1963; the degree of Doctor of Humane Letters from Northern Michigan College, 1962; the degree of Doctor of Public Service from George Washington University, 1962; and the degree of Doctor of Public Administration from the University of Puget Sound, 1963.

In August 1997, the element 106 was named Seaborgium, in honor of Seaborg's life-long achievements in radiochemistry. It marked the first time that an element had been named for a living person.[4] Glenn T. Seaborg is also in the Guinness Book of World Records for having the longest entry in "Who's Who in America."[2, 6]

Dr. Seaborg married Helen L. Griggs, then secretary to the late Dr. Ernest O. Lawrence on June 6, 1942. They had six children: Peter (b. 1946), Lynne (b. 1947), David (b. 1949), Stephen (b. 1951), John Eric (b. 1954), and Dianne (b. 1959). On August 24, 1998 Glenn Seaborg suffered a stroke while in Boston for the national meeting of the American Chemical Society. He died after a significant convalescence at his home in Lafayette, California on February 25, 1999.[2]

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Frederick Soddy
1877 – 1956

English radiochemist who received the 1921 Nobel Prize for Chemistry for discovering the existence of different form of the same element with identical chemical properties, but different atomic weights.[2] He is also credited with the joint discovery of the element protactinium in 1917.[1]

Early Life

Frederick Soddy, the son of Benjamin Soddy, a London merchant, was born at Eastbourne, Sussex, England, on September 2, 1877. He was educated at Eastbourne College and the University College of Wales, Aberystwyth.[3]

In 1895 he obtained a scholarship at Merton College, Oxford, from which University he graduated in 1898 with first class honors in chemistry. After two years of research at Oxford he went to Canada and from 1900 to 1902 was Demonstrator in the Chemistry Department of McGill University, Montreal.[1, 3] Here he worked with Professor Sir Ernest Rutherford on the disintegration of radioactive elements.[1] Together they published a series of papers on radioactivity and concluded that it was a phenomenon involving atomic disintegration with the formation of new kinds of matter. He and Rutherford realized that the anomalous behavior of radioactive elements was due to the fact that they decayed into other elements. This decay also produced alpha, beta, and gamma radiation.[4] They also investigated the gaseous emanation of radium.[3]

Contributions to Nuclear Science

Leaving Canada, Soddy then worked with Sir William Ramsay at University College, London where he continued the study of radium emanation. In 1903, Soddy and Ramsay were able to demonstrate, by spectroscopic means, that the element helium was produced in the radioactive decay of a sample of radium bromide.[3, 4]

From 1904 to 1914 Soddy was lecturer in physical chemistry and radioactivity in the University of Glasgow. Here he did much practical chemical work on radioactive materials, including showing that uranium decays to radium.[3, 4] During this period he evolved the so-called "Displacement Law", namely that an atom moves lower in atomic number by two places on alpha emission, higher by one place on beta emission.[3, 4] This was a fundamental step toward understanding the relationships among families of radioactive elements.[4]

His peak was reached in 1913 with his formulation of the concept of isotopes, which stated that certain elements exist in two or more forms which have different atomic weights but which are indistinguishable chemically (for which he received the Nobel Prize for Chemistry in 1921).[2, 3] These, upon a suggestion by Margaret Todd, he called isotopes. In *Science and Life* (1920) he pointed out their value in determining geologic age.[1]

After his period at Glasgow he did no further work in radioactivity and allowed the later developments to pass him by. His interest was diverted to economic, social and political theories which gained no general acceptance, and to unusual mathematical and mechanical problems.[3]

In 1914 he was appointed Professor of Chemistry at the University of Aberdeen. Here, his plans for research were hampered by World War I, although he is credited, along with others, with the discovery of the element protactinium in 1917.[1] In 1919 he became Dr. Lees Professor of Chemistry at Oxford University, a post he held until 1937 when he retired, on the death of his wife.[3]

Publications[3]

His books include *Radioactivity* (1904), *The Interpretation of Radium* (1909), *The Chemistry of the Radioactive Elements* (1912-1914), *Matter and Energy* (1912), *Science and Life* (1920), *The Interpretation of the Atom* (1932), *The Story of Atomic Energy* (1949), and *Atomic Transmutation* (1953).

Honors[3]

Soddy was elected a Fellow of the Royal Society in 1910 and Oxford awarded him an honorary degree. In 1921 he was awarded the Nobel Prize in Chemistry for his discovery/concept of isotopes. He was awarded the Albert Medal in 1951.

In 1908, Frederick Soddy married Winifred Beilby. He died on September 22, 1956 at Brighton, England.[3]

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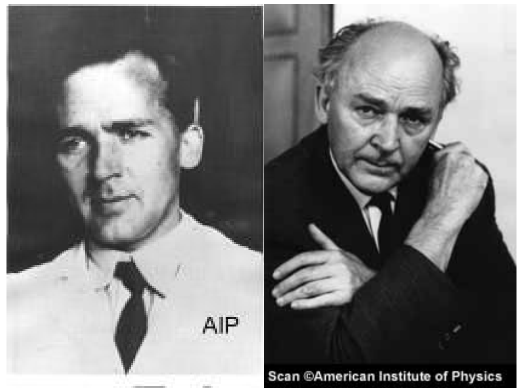

Fritz Strassman

1902 – 1980

German analytical chemist who co-discovered the process of nuclear fission in ^{235}U.

Early Life

Fritz Strassman was born in Boppard, Germany, on February 22, 1902. Strassman studied physics at the Technical University at Hannover and received his Ph.D in 1929.[1]

Contribution to Nuclear Science

Strassman helped develop the rubidium-strontium method of dating used in geochronology. He joined Otto Hahn and Lise Meitner at the Kaiser Wilhelm Institute for Chemistry and in 1938 they co-discovered that uranium nuclei split when bombarded with neutrons. During the Second World War Strassman and Otto Hahn continued to work in the field of nuclear physics but they made no attempt to turn their knowledge into a military weapon.[1]

After the war Strassman became professor of inorganic and nuclear chemistry at the University of Mainz. He was also director of the chemistry department at the Max Planck Institute for Chemistry. Fritz Strassman died in Mainz, West Germany, on April 22, 1980.[1]

Honors

Received the 1966 Enrico Fermi Award for the U.S. Department of Energy[2]

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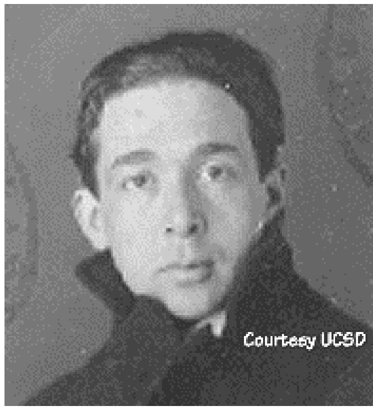

Leo Szilard
1898 – 1964

Hungarian-born physicist known for his contributions to the fields of thermodynamics, biophysics, nuclear physics, and the development of the atomic bomb.[1]

Early Life

Leo Szilard was born on February 11, 1898 in Budapest, Austro-Hungary. In 1916, he began his education as an engineering student at Budapest Technical University, where he studied electrical engineering and physics. In 1917, he joined the Austro-Hungarian Army and fought in World War I. He was honorably discharged in 1918.[2] In 1919, anti-Semitism forced Szilard to leave Austro-Hungary. He decided to continue his education in engineering at the Berlin Institute of Technology. In 1920, Szilard became a physics student at the University of Berlin. He completed his doctorate in physics two years later. While studying at the University of Berlin he made important contacts with Albert Einstein that would last throughout his life.[3]

In 1923 Szilard began carrying out x-ray diffraction experiments at Kaiser-Wilhelm Institute for Chemistry. The following year he became Max von Laue's assistant at the Institute for Theoretical Physics in Berlin. Szilard was appointed a lecturer in physics in 1929. When Adolf Hitler gained power in 1933 Szilard left Nazi Germany and moved to England.[2] While in London, he read an article by Ernest Rutherford, after which he conceived the idea of a nuclear chain reaction. The following year he filed a patent on the nuclear chain reaction. Although his first attempts at a chain reaction using Beryllium and Indium were unsuccessful, he decided to assign his chain reaction patent to the British Admirality in 1936.[3]

Contribution to Nuclear Science

Szilard immigrated to the United States in 1938 to pursue a teaching opportunity at Columbia University. Shortly after his move to New York, Szilard learned of the work of Otto Hahn and Fritz Strassman. Then he read an article by Otto Frisch and Lise

Meitner explaining the theory of uranium fission. At that point he became concerned that Nazi Germany would discover the ability to produce an extremely powerful and destructive weapon using uranium.[2] Szilard contacted Albert Einstein about these developments. On 2nd August, 1939, Leo Szilard, Albert Einstein, and another Jewish scientist, Eugene Wigner, wrote a joint letter to President Franklin D. Roosevelt, about the developments that had been taking place in nuclear physics. They warned Roosevelt that scientists in Germany were working on the possibility of using uranium to produce nuclear weapons and urged the US government to develop the weapon before Germany.[3]

On December 2, 1942, Leo Szilard and Enrico Fermi were successful in creating the first controlled nuclear chain reaction at the University of Chicago. The following year Szilard joined the Manhatten Project and moved to Los Alamos, New Mexico. Over the next two years he worked with Robert Oppenheimer, Edward Teller, Otto Frisch, Felix Bloch, Enrico Fermi, David Bohm, James Chadwick, James Franck, Emilio Segre, Niels Bohr, Eugene Wigner, and Klaus Fuchs in the development of the atomic bomb.[3]

In 1945, after the atomic bomb had been developed, Szilard and James Franck circulated a petition to President Harry S. Truman asking that the bomb not be used against Japan. Although the petition was signed by 68 members of the metallurgical laboratory who developed the bomb, the advice was ignored and the bombs were ultimately dropped on the Japanese cities of Hiroshima and Nagaski.[2, 3]

After the war Szilard involved himself in numerous efforts to control nuclear arms. He publicly opposed the development of the Hydrogen bomb.[3] In 1946, Szilard co-founded the Emergency Committee of Atomic Scientists with Einstein. In 1947 he wrote Letter to Stalin, proposing methods for reducing tensions between the United States and the Soviet Union.[2] He obtained a patent on the nuclear reactor in 1955 and later that year he abandoned the field of nuclear physics for work in the field of biophysics at the Enrico Fermi Institute for Nuclear Studies at the University of Chicago.[1] In 1957, he began participating the Pugwash Conferences, which were established to bring scientists from the East and West together to discuss peace and security. And in 1962 he founded the Council for Abolishing War.[3]

Publications

In 1962 Szilard founded the Council for Abolishing War. He also published a book on the misuse of scientific knowledge entitled The Voice of Dolphins (1961).[3]

Szilard died of a heart attack in his sleep on May 30, 1964 in La Jolla, California.[2, 3]

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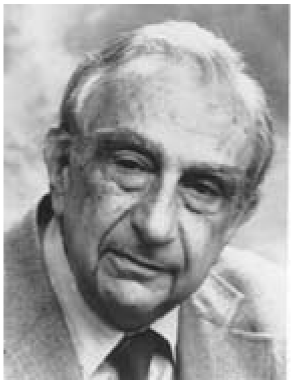  

Edward Teller
1908 - 2003

Hungarian-born physicist known as the "Father of the Hydrogen Bomb." Additionally, his research added to the knowledge of quantum theory, molecular physics, and astrophysics.

Early Life

Edward Teller was born into an affluent, educated Jewish family in Budapest, Hungary on January 15, 1908.[5] In 1926, Edward left Budapest to study chemical engineering in Karlsruhe, Germany, where he became intrigued by physics, particularly the new theory of quantum mechanics. The young chemical engineer transferred to the University of Munich in 1928 to pursue this interest. In Munich, disaster struck. A streetcar accident cost Teller his right foot. Once Teller had recovered from his injury and learned to walk with a prosthesis, he transferred to the University of Leipzig, to study with Werner Heisenberg. Teller received his doctorate in physics in 1930 and took a job as research consultant at the University of Göttingen. His first published paper: "Hydrogen Molecular Ion," was one of the earliest statements of what is still the most widely held view of the molecule.[4]

When Adolf Hitler came to power in Germany, Teller knew immediately that there was no future for him in Germany.[4] In 1934, under the auspices of the Jewish Rescue Committee, Teller served as a lecturer at the University of London. He spent two years as a research associate at the University of Göttingen, followed by a year as a Rockefeller fellow with Niels Bohr in Copenhagen.[2] There he joined the Institute for Theoretical Physics, where the Bohr led a team of young scientists attempting to unlock the secrets of the atom. In this year, Teller also married Augusta Harkanyi, a marriage that weathered years of expatriation and controversy.[4]

At Bohr's institute, Teller met the Russian physicist George Gamow, also a political refugee. After a year, Gamow and Teller went their separate ways. Gamow headed for George Washington University in Washington, DC, while Teller headed for England. He worked briefly at the University of London, but within a year, received an invitation from

Gamow to join him at George Washington University.[4] Teller gratefully accepted the offer and entered the United States in 1935. At George Washington University, Teller and Gamow collaborated on classifications of rules for beta decay and applications of astrophysics to controlled thermonuclear reactions.[1] Both Edward and his wife, Augusta, became naturalized U.S. citizens in 1941.[1, 4]

Contributions to Nuclear Science

The development of nuclear physics had continued at a slower pace in Hitler's Germany, but by 1939, German scientists had discovered nuclear fission. It was theoretically possible to split the atom, releasing energy as heat. It appeared to Teller and the other refugee physicists that the most destructive force ever known to man might fall into the hands of Adolf Hitler.[4] It was this fear that drove Teller and fellow Hungarian physicist, Leo Szilard, to recruit Albert Einstein to convince President Franklin D. Roosevelt of the need to develop American nuclear weapons.[1]

In September 1941, before the atomic bomb had even been built, Italian-born physicist Enrico Fermi got Teller thinking about the possibility of a hydrogen based bomb.[5] In the summer of 1942, after having served as a consultant to the Briggs committee, Teller joined the Manhattan Project.[2] After preliminary work in Chicago with Enrico Fermi, and in Berkeley with J. Robert Oppenheimer, Teller moved to the isolated laboratory at Los Alamos, New Mexico. Here, under Oppenheimer's leadership the first atomic bomb would be built.[4]

Edward Teller made a major contribution to the development of the atomic bomb. From the beginning, some scientists had feared that an uncontrolled nuclear reaction, like that of the proposed bomb, might continue indefinitely, consuming the earth. Teller's calculations reassured the team that the nuclear explosion, while enormously powerful, would only destroy a limited area.[4] However, Teller’s single-minded pursuit of the hydrogen bomb and his autocratic style alienated him from many of the scientists he worked with at Los Alamos.

In 1945, the atom bomb was successfully tested at Alamagordo, New Mexico. The German project was nowhere near completion when Germany surrendered. Within months of the first test, America's bombs had destroyed the Japanese cities of Hiroshima and Nagasaki. Japan surrendered and the war was over.

Once the war was over, Teller tried again, without success, to persuade his superiors at Los Alamos to pursue fusion and create a thermonuclear weapon vastly more powerful than the bombs dropped on Japan. In 1946, Teller became a professor of physics at the University of Chicago.[2] When the Russians detonated their own atomic bomb in August 1949, Edward Teller returned to Los Alamos. A the end of January 1950, President Harry S. Truman ordered the Los Alamos lab to develop a fusion weapon.[4] Teller quickly became frustrated with the lack of progress on the H-bomb. When he and mathematician Stanislaw Ulam finally came up with an H-bomb design that would actually work, he was not chosen to head the project that culminated in the first H-bomb test in 1952 at Enewetak, one of the Marshall Islands in the Pacific Ocean.[5]

Believing strongly in the need to develop the next generation of nuclear weapons Teller lobbied Congress and the armed services vigorously for the establishment of a second laboratory for thermonuclear research. The Atomic Energy Commission responded by establishing the Lawrence Livermore Laboratory in northern California.[1, 4] In 1952 Teller left Los Alamos to become a consultant at the rival weapons lab in California. He served as associate director of the Lawrence Livermore Laboratory from 1954 until 1958. He was director of the lab for two years until 1960 when he took a joint appointment as a professor of physics at the University of California and associate director of the lab. He held this dual post until his retirement in 1975.[2] Teller spent his retirement as a senior research fellow at the Hoover Institute for the Study of War, Revolution, and Peace at Stanford University in Palo Alto, California, where he specialized in international and national policies concerning defense and energy.[4]

Edward Teller died at his home on the Stanford campus on September 9, 2003. He was 95.[2]

Publications

His books include *Memoirs: A Twentieth-Century Journey in Science and Politics* (written with Judith Shoolery, 2001), *Conversations on the Dark Secrets of Physics* (Plenum Press, 1991), *Better a Shield Than a Sword* (Free Press, 1987), *Pursuit of Simplicity* (Pepperdine Press, 1980), and *Energy from Heaven and Earth* (W. H. Freeman, 1979).[2]

Honors[2]

Edward Teller was a member of the Scientific Advisory Board of the U.S. Air Force, a member of the Advisory Board of the Federal Emergency Management Agency, and on the White House Science Council. He received numerous honors, among them the Presidential Medal of Freedom, the Albert Einstein Award, the Enrico Fermi Award, the Harvey Prize from the Technion-Israel Institute, and the National Medal of Science. He was a fellow of the American Physical Society and the American Nuclear Society and was a member of the National Academy of Sciences and the American Academy of Science. From 1956 to 1958 he served as a member of the General Advisory Committee of the U.S. Atomic Energy Commission (AEC) and was chairman of the first Nuclear Reaction Safeguard Committee.

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Joseph John Thompson
1856 – 1940

British physicist credited with the discovery of the electron. Awarded the 1906 Nobel Prize for Physics for his theoretical and experimental investigations into the electron and the conduction of electricity by gases.[1]

Education and early career

Sir Joseph John "J.J."Thomson was born in Cheetham Hill, a suburb of Manchester on December 18, 1856.[2] Thomson was the son of a bookseller in a suburb of Manchester. When he was only 14, he entered Owens College, now the Victoria University of Manchester. He was fortunate in that, in contrast with most colleges at the time, Owens provided some courses in experimental physics. In 1876 he obtained a scholarship at Trinity College, Cambridge, as a minor scholar.[4] He became a Fellow of Trinity College in 1880, where he was Second Wrangler and Second Smith's Prizeman, and remained a member of the College for the rest of his life, becoming Lecturer in 1883, professor of physics in 1884, and Master in 1918.[2]

After taking his B.A. degree in mathematics in 1880, the opportunity of doing experimental research drew him to the Cavendish Laboratory. He also began to develop the theory of electromagnetism. As set forth by James Clerk Maxwell, electricity and magnetism were interrelated; quantitative changes in one produced corresponding changes in the other.[4]

Prompt recognition of Thomson's achievement by the scientific community came in 1884, at age 28, with his election as a fellow of the Royal Society of London and appointment to the chair of physics at the Cavendish Laboratory at Cambridge University, where he succeeded Lord Rayleigh, continuing in that position until 1919.[2, 4] No one was more surprised than Thomson who had been decried as a "mere boy." Nevertheless, this mere boy turned what he described as a "string and sealing wax laboratory" into the world's preeminent center for experimental nuclear physics.[1]

It has been said that Thomson, like Michael Faraday, was greater than his discoveries. However, those discoveries were far from insignificant. Thomson and his student Ernest Rutherford were the first to demonstrate the ionization of air by X-rays. So fundamental is this phenomenon that the phrase "ionizing radiation" remains the most concise way to characterize the wide range of electromagnetic and particulate radiation emitted by atoms.[1]

Thomson entered physics at a critical point in its history. Following the great discoveries of the 19th century in electricity, magnetism, and thermodynamics, many physicists in the 1880s were saying that their science was coming to an end like an exhausted mine. By 1900, however, only elderly conservatives held this view, and by 1914 a new physics was in existence, which raised, indeed, more questions than it could answer. The new physics was wildly exciting to those who, lucky enough to be engaged in it, saw its boundless possibilities. Probably not more than a half dozen great physicists were associated with this change. Although not everyone would have listed the same names, the majority of those qualified to judge would have included Thomson.[4]

Discovery of the electron

Thomson's most important line of work, interrupted only for lectures at Princeton University in 1896, was that which led him, in 1897, to the conclusion that all matter, whatever its source, contains particles of the same kind that are much less massive than the atoms of which they form a part. They are now called electrons, although Thomson originally called them corpuscles. His discovery was the result of an attempt to solve a long-standing controversy regarding the nature of cathode rays, which occur when an electric current is driven through a vessel from which most of the air or other gas has been pumped out. Nearly all German physicists of the time held that these visible rays were produced by occurrence in the ether--a weightless substance then thought to pervade all space--but that they were neither ordinary light nor the recently discovered X-rays. British and French physicists, on the other hand, believed that these rays were electrified particles.[3, 4]

By applying an improved vacuum technique and deflecting "cathode rays" with an electric field, something that had been done previously with a magnetic field, Thomson provided conclusive proof that “cathode rays” were composed of negatively charged particles.[1] Furthermore, they seemed to be composed of the same particles, or corpuscles, regardless of what kind of gas carried the electric discharge or what kinds of metals were used as conductors.[4] Thomson's conclusion that the corpuscles were present in all kinds of matter was strengthened during the next three years, when he found that corpuscles with the same properties could be produced in other ways--e.g., from hot metals.[4]

By the turn of the century most of the scientific world had fully accepted Thomson's far-reaching discovery. In 1903 he had the opportunity to amplify his views on the behavior of subatomic particles in natural phenomena when, in his Silliman Lectures at Yale, he suggested a discontinuous theory of light; his hypothesis foreshadowed Einstein's later theory of photons.[4]

Although it would fail the test of time, Thomson is usually credited with the first "modern" model of the atom, the so-called "plum pudding" model. In it, he pictured a sphere of positive charges mixed together with an equal number of electrons (i.e., negative charges). For his theoretical and experimental investigations into the electron and the conduction of electricity by gases, Thomson was awarded the 1906 Nobel Prize in physics. Ironically, Thomson, who had characterized the material (i.e. particle like) properties of electrons, would live to see his son George P. Thomson receive the Nobel Prize for experimentally confirming the wavelike properties of electrons.

Subsequently, Thomson turned his attention to positively charged ions. His research showed that neon gas was made up of a combination of two different types of ions, each with a different charge, or mass, or both. He did this by using magnetic and electric fields to deflect the stream of positive ions of neon gas onto two different parts of a photographic plate. This demonstration clearly pointed to the possibility that ordinary elements might exist as isotopes (varieties of atoms of the same element, which have the same atomic number but differ in mass).

Thomson considered teaching to be helpful for a researcher, since it required him to reconsider basic ideas that otherwise might have been taken for granted. The group of men he gathered around him between 1895 and 1914 came from all over the world, and after working under him many accepted professorships abroad. Thomson was a highly gifted teacher--seven of his research assistants as well as his son, George, won Nobel Prizes for physics--and he led Great Britain to dominance in the field of subatomic particles in the early decades of the 20th century.[4]

In 1890, he married Rose Elisabeth, daughter of Sir George E. Paget, K.C.B. They had one son, now Sir George Paget Thomson, Emeritus Professor of Physics at London University, who was awarded the Nobel Prize for Physics in 1937, and one daughter. J.J. Thomson died on August 30, 1940.[2] He was accorded the honor of burial in Westminster Abbey.[4]

Publications[2]

Thomson's early interest in atomic structure was reflected in his *Treatise on the Motion of Vortex Rings* which won him the Adams Prize in 1884. His *Application of Dynamics to Physics and Chemistry* appeared in 1886, and in 1892 he had his *Notes on Recent Researches in Electricity and Magnetism* published. This latter work covered results obtained subsequent to the appearance of James Clerk Maxwell's famous "Treatise" and is often referred to as "the third volume of Maxwell". Thomson co-operated with Professor J. H. Poynting in a four-volume textbook of physics, *Properties of Matter* and in 1895 he produced *Elements of the Mathematical Theory of Electricity and Magnetism,* the 5th edition of which appeared in 1921.

In 1896, Thomson visited America to give a course of four lectures, which summarized his current research, at Princeton. These lectures were subsequently published as *Discharge of Electricity through Gases* (1897). On his return from America, he achieved the most brilliant work of his life - an original study of cathode rays culminating in the discovery of the electron, which was announced during the course of his evening lecture to the Royal Institution on Friday, April 30, 1897. His book, *Conduction of Electricity through Gases*, published in 1903 was described by Lord Rayleigh as a review of "Thomson's great days at the Cavendish Laboratory". A later edition, written in collaboration with his son, George, appeared in two volumes (1928 and 1933).

Thomson returned to America in 1904 to deliver six lectures on electricity and matter at Yale University. They contained some important suggestions as to the structure of the atom. He discovered a method for separating different kinds of atoms and molecules by the use of positive rays, an idea developed by Aston, Dempster and others towards the discovery of many isotopes. In addition to those just mentioned, he wrote the books, *The Structure of Light* (1907), *The Corpuscular Theory of Matter* (1907), *Rays of Positive Electricity* (1913), *The Electron in Chemistry* (1923) and his autobiography, *Recollections and Reflections* (1936), among many other publications.

Honors[2]

Thomson, a recipient of the Order of Merit in 1912, was knighted in 1908. He was elected Fellow of the Royal Society in 1884 and was President during 1916-1920; he received the Royal and Hughes Medals in 1894 and 1902, and the Copley Medal in 1914. He was awarded the Hodgkins Medal (Smithsonian Institute, Washington) in 1902; the Franklin Medal and Scott Medal (Philadelphia), 1923; the Mascart Medal (Paris), 1927; the Dalton Medal (Manchester), 1931; and the Faraday Medal (Institute of Civil Engineers) in 1938. He was President of the British Association in 1909 (and of Section A in 1896 and 1931) and he held honorary doctorate degrees from the Universities of Oxford, Dublin, London, Victoria, Columbia, Cambridge, Durham, Birmingham, Göttingen, Leeds, Oslo, Sorbonne, Edinburgh, Reading, Princeton, Glasgow, Johns Hopkins, Aberdeen, Athens, Cracow and Philadelphia.

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Paul Ulrich-Villard
1860 – 1934

French physicist who first observed in 1900 what were later named gamma rays.

Early Life[1]

Paul Villard was born in a small village near Lyon, France in 1860. In 1881 he entered the *École Normale Supérieure* in Paris and graduated with a license to teacher at government schools. He taught for s few years at various lycées in the providence of Lyon, but ultimately determined that he wanted to do research in Paris. He spent the remainder of his professional life at the *École Normale* in *rue d'Ulm*.

Contribution to Nuclear Science

Paul Villard's main interest was the field of physical chemistry. His earliest investigations involved the hydration of various gases under pressure. His creation of completely new hydrates formed the basis for his doctoral thesis.[1] In 1897 Villard gained access to a Crookes tube and started his work on cathode rays and X-rays. Pierre and Marie Curie had reported observations of radium rays converting oxygen to ozone and that the rays caused glass and fluorescent screens to become discolored. These observations sparked Villard's interest in radioactivity, as he had noted similar physical observations associated with X-rays. Thus, Villard set out to compare the reflection and refraction properties of beta rays with cathode rays in order to emphasize that they were indeed the same type of ray.[1]

Villard set up his experiment to measure the refraction of the beta rays using photographic plates. However, when he developed the plates he noticed that nearly every plate revealed a trace non-refracted beam. Next he attempted to diffract the second beam using a magnetic field, but the rays were unaffected. He was even able to show that the second beam of rays was penetrating enough to transverse the protective black paper and even a small layer of aluminum foil.[1]

In April and May 1900, Villard presented several papers concerning his work with "radium rays" to the Académie des Sciences. On May 18 at a meeting of the *Société francaise de physique* Villard demonstrated that radium rays emit rays that are non-deviable (not bent by a magnetic field) and extremely penetrating.[1] He recognized them as being different from X-rays because the gamma rays had a much greater penetrating depth. Unfortunately, his discovery was generally overlooked by his contemporaries who were focused on alpha and beta (particle) ray studies. It was not until 1914, when Ernest Rutherford showed that they were a form of electromagnetic (EM) like light only with a much shorter wavelength than X-rays that Villard's rays became known as gamma rays.[2]

After the publication of his two papers on his 1900 discovery of gamma rays, Villard did no further studies of the phenomenon. In 1908 Villard suggested the idea of using the ionization of air as a measure of the output of an X-ray tube. Twenty years later, the principle laid down by Villard became internationally recognized when the Second International Congress on Radiology recommended the roentgen as the unit of radiation exposure.[1]

Publications[1]

He published his first papers in the *Comptes rendus des Séancesde l'Académie des Sciences* in 1888 together with Robert Hippolyte de Forcrand. His first paper on radium rays, "Sur la réflexion et la réfraction des rayons cathodiques et des rayons déviables du radium," was presented at the April 9, 1900 session of the Paris *Académie des Sciences.*

Honors[1]

The *Académie des Sciences* awarded him its Wilde prize in 1904 and its La Caze prize in 1907. In 1908 he succeeded physicist Eleuthère Mascart as a member of the Academy.

During the last years of his life, Villard was forced to spend extended periods of time outside of Paris because of his deteriorating health. He died in Bayonne on January 13, 1934.[1]

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Rosalyn Sussman Yalow
1921 –

Received the 1977 Nobel Prize in Medicine for the development of radioimmunoassay (RIAs) of peptide hormones.

Early Life[1]

Rosalyn Sussman was born in New York City on July 19, 1921. Her mother, Clara Zipper, came to America from Germany at the age of four. Her father, Simon Sussman, was born on the lower east side of New York City. Although neither of her parents were high school graduates, there was never any doubt that Rosalyn, or her older brother, Alexander, would be college graduates.

In middle school, Rosalyn showed an aptitude for mathematics, in high school she was interested in chemistry, but by the time she was at Hunter College for Women (now the City University of New York) her interests had been diverted to physics. In September 1940, Rosalyn was afforded what seemed like a good opportunity to fund graduate work for a woman in physics. Basically, she was to become the part time secretary to Dr. Rudolf Schoenheimer, a leading biochemist at Columbia University. The position was supposed to provide a backdoor entry into graduate school at Columbia. However, in mid-February she received a teaching assistantship offer from the University of Illinois. In September she moved to Champaign-Urbana, only to discover that she was the only woman on the 400 member College of Engineering faculty.

Rosalyn's first year of graduate school was not easy. From junior high through her undergraduate degree she had never taken classes with men, except for one night class in thermodynamics and two summer courses at NYU. In addition, it was soon apparent that her coursework for a major in physics had been significantly less than that of the other first year graduate students. Thus, her first year in graduate school she took two remedial undergraduate level courses without credit, three graduate level courses, and was a half-time teaching assistant for a freshman physics course.

World War II took its toll on the Physics Department as junior and senior faculty were whisked away to work on secret weapons work and campus began to fill up with young soldiers sent to campus by their respective service for training. Despite the increased workload Rosalyn managed to marry Aaron Yalow, a fellow graduate student, in 1943 and to finish her doctorate in Nuclear Physics in January 1945. After completing her thesis she returned to New York, without her husband, to become an assistant engineer at federal Telecommunications Laboratory, again the only female engineer. Later that year, when her husband finished his degree, he returned to New York and they bought an apartment in Manhatten followed by a house in the Bronx.

Contribution to Nuclear Medicine

Although Rosalyn had a full-time teaching position at Hunter College, she did not feel like her time was well occupied. Through her husband she met Dr. Edith Quimby and volunteered to work in her laboratory to gain research experience in the medical applications of radioisotopes. After meeting with Dr. Gioacchino Failla, she joined the Bronx Veterans Administration Hospital as a part-time consultant in December 1947. In January 1950, she chose to leave teaching and join the VA as a full-time. That spring she met Dr. Solomon A. Berson and soon thereafter they began a close research partnership.[1]

Their first investigations were in the application of radioisotopes in blood volume determination, clinical diagnosis of thyroid diseases and the kinetics of iodine metabolism. These techniques were then extended to study the distribution of globin, which had been suggested for use as a plasma expander and of serum proteins. These methods were applied to smaller peptides, i.e., the hormones. Insulin was the hormone most readily available in a highly purified form. They soon deduced from the retarded rate of disappearance of insulin from the circulation of insulin- treated subjects that all these patients develop antibodies to the animal insulins. In studying the reaction of insulin with antibodies, they had developed a tool with the potential for measuring circulating insulin. It took several more years of work to transform the concept into the reality of its practical application to the measurement of plasma insulin in humans. Thus the era of radioimmunoassay (RIA) can be said to have begun in 1959. RIA is now used to measure hundreds of substances of biologic interest in thousands of laboratories in our country and abroad. Dr. Yalow received the Nobel Prize in Medicine in 1977 "for the development of radioimmunoassays of peptide hormones."[3]

Honors[2]

- National Medal of Science (1988)
- Member, American Academy of Arts and Sciences
- Member, National Academy of Sciences
- Fellow, New York Academy of Sciences
- Member, American College of Nuclear Physicians
- Associate Fellow in Physics, American College of Radiology
- Eli Lilly Award, American Diabetes Association (1961)
- Van Slyke Award, American Association of Clinical Chemists (1968)

- Gairdner Foundation International Award (1971)
- American College of Physicians Award (1971)
- Koch Award, Endocrine Society (1972)
- Cressy Morrison Award in Natural Sciences, New York Academy of Sciences (1975)
- Scientific Achievement Award, American Medical Association (1975)
- Boehringer-Mannheim Award, American Association of Clinical Chemists (1975)
- Modern Medicine's Distinguished Achievement Award (1976)
- Albert Lasker Basic Medical Research Award (1976)
- American Academy of Achievement Golden Plate Award for Salute to Excellence (1977)
- *La Madonnina* International Prize of Milan (1977)
- Alumni Association Achievement Award, University of Illinois (1978)
- Banting Medal, American Diabetes Association (1978)
- Gratum Genus Humanum Gold Medal, World Federation of Nuclear Medicine and Biology (1978)
- Rosalyn S. Yalow Research and Development Award (1978)
- Theobold Smith Award (1982)
- George Charles de Henesy Nuclear Medicine Pioneer Award (1986)
- Inducted into the National Women's Hall of Fame (1993)

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