HALL OF FAME
Meet the Nobel Laureates (9th)

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Meet the Nobel Laureates in Physiology or Medicine (In chronological order)

1921

No Nobel Prize was awarded this year. The prize money was allocated to the Special Fund of this prize section.

1922

The Nobel Prize in Physiology or Medicine 1922 was divided equally between **Archibald Vivian Hill** and **Otto Fritz Meyerhof**.

Archibald Vivian Hillwas awarded the Nobel Prize *"for his discovery relating to the production of heat in the muscle"*.

Background
Born: 26 September 1886, Bristol, United Kingdom

Died:3 June 1977, Cambridge, United Kingdom

Affiliation at the time of the award: London University, London, United Kingdom

Prize motivation: "for his discovery relating to the production of heat in the muscle"

Field: metabolism, muscle physiology
Archibald V. Hill received his Nobel Prize one year later, in 1923.

Biography

Archibald Vivian Hill was born in Bristol on September 26,1886. His early education was at Blundell's School, Tiverton, whence he obtained scholarships to Trinity College, Cambridge. Here he studied mathematics and took the Mathematical Tripos, being Third Wrangler (1907). After graduating, he was urged to take up physiology by his teacher, Dr. (later Sir) Walter Morley Fletcher.

Hill started his research work in 1909. It was due to J.N. Langley, Head of the Department of Physiology at that time that Hill took up the study on the nature of muscular contraction. Langley drew his attention to the important (later to become classic) work carried out by Fletcher and **Hopkins** on the problem of lactic acid in muscle, particularly in relation to the effect of oxygen upon its removal in recovery. During his initial studies Hill made use of the Blix' apparatus, obtaining his first knowledge of the subject from papers of this Swedish physiologist. This led him to study the dependence of heat production on the length of muscle fibre (a relation later developed by Starling in his investigation of the mechanism of the heart beat).

After having obtained a Fellowship at Trinity in 1910, Hill spent the winter of 1910 – 1911 in Germany, working among others with Bürker (who taught him much about the technique of myothermic observations) and Paschen (who introduced the galvanometer to him, which he since used for his investigations). From 1911-1914, until the outbreak of World War I, he continued his work on the physiology of muscular contraction at Cambridge. During this for him important period, however, he also took up other studies: on the nervous impulse (with Keith Lucas), on haemoglobin (with Barcroft), and on calorimetry of animals (partly with T. B. Wood), having also as colleagues Gaskell, Anderson, W. B. Hardy, Mines, **Adrian**, Hartridge, and others.

In 1914 he tended to drift away from physiology and was actually appointed University Lecturer in Physical Chemistry at Cambridge. During the war he served for the entire period as captain and brevet-major, and as Director of the Anti-Aircraft Experimental Section, Munitions Inventions Department.

In 1919 he took up again his study of the physiology of muscle, and came into close contact with **Meyerhof** of Kiel who, approaching the problem from a different angle, has arrived at results closely analogous to his study. They have cooperated continuously ever since, by personal contact and through correspondence. In 1919 Hill's friend W. Hartree, mathematician and engineer, joined in the myothermic investigations – a cooperation which had rewarding results.

In 1920 Hill was appointed Brackenburg Professor of Physiology at Manchester University; there he continued the work on muscular activity and began to apply the results obtained on isolated muscles to the case of muscular exercise in man. From 1923 to 1925 he became Jodrell Professor of Physiology at University College, London, succeeding E.H. Starling. In 1926 he was appointed the Royal Society's Foulerton Research Professor and was in charge of the Biophysics Laboratory at University College until 1952. After retiring he returned to the Physiology Department, where he continues with his experiments to the present.

His work on muscle function, especially the observation and measurement of thermal changes associated with muscle function, was later extended to similar studies on the mechanism of the passage of nerve impulses. Very sensitive techniques had to be developed and he was eventually able to measure temperature changes of the order of 0.003°C over periods of only hundredths of a second. He was the discoverer of the phenomenon that heat was produced as a result of the passage of nerve impulses. His researches gave rise to an enthusiastic following in the field of biophysics, a subject whose growth owes much to him.

Dr. Hill is the author of many scientific papers, lectures, and books. Perhaps his best-known books are *Muscular Activity* (1926), *Muscular Movement in Man* (1927); also *Living Machinery* (1927), *The Ethical Dilemma of Science and Other Writings* (1960), and *Traits and Trials in Physiotogy* (1965).

He was elected a Fellow of the Royal Society in 1918, serving as Secretary for the period 1935-1945, and Foreign Secretary in 1946. He was awarded the Society's Copley Medal in 1948. He holds honorary degrees of many universities, British and foreign. He was decorated with the Order of the British Empire in 1918 and became a Companion of Honour in 1948. He also holds the Medal of Freedom with Silver Palm (USA., 1947) and is a Chevalier of the Legion of Honour (1950). He has also been prominent in public life, being a Member of Parliament during the period 1940 – 1945, when he represented Cambridge University in the House of Commons as an Independent Conservative. He was a member of the University Grants Committee for 1937 – 1944 and served on the Science Committee of the British Council, 1946-1956. He was appointed a Trustee of the British Museum in 1947.

During World War II, he served on many commissions concerned with defence and scientific policy. He was a member of the War Cabinet Scientific Advisory Committee (1940-1946). He was Chairman of the Research Defence Society (1940 – 1951) and Chairman of the Executive Committee of the National Physical Laboratory (1940 – 1945).

He is also a member of the Society for the Protection of Science and Learning, and was President in 1952 of the British Society for the Advancement of Science.

Dr Hill married Margaret Neville Keynes in 1913. They have two sons and two daughters.

Otto Fritz Meyerhof was awarded the Nobel Prize *"for his discovery of the fixed relationship between the consumption of oxygen and the metabolism of lactic acid in the muscle"*.

Background

Born:12 April 1884, Hanover, Germany

Died:6 October 1951, Philadelphia, PA, USA

Affiliation at the time of the award: Kiel University, Kiel, Germany

Prize motivation:"for his discovery of the fixed relationship between the consumption of oxygen and the metabolism of lactic acid in the muscle"

Field: metabolism, muscle physiology
Otto Meyerhof received his Nobel Prize one year later, in 1923.

Biography

Otto Fritz Meyerhof was born on April 12, 1884, in Hannover. He was the son of Felix Meyerhof, a merchant of that city and his wife Bettina May. Soon after his birth his family moved to Berlin, where he went to the Wilhelms Gymnasium (classical secondary school). Leaving school at the age of 14, he was attacked, at the age of 16, by kidney trouble and had to spend a long time in bed. During this period of enforced inactivity he was much influenced by his mother's constant companionship. He read much, wrote poetry, and went through a period of much artistic and mental development. After he had matriculated, he studied medicine at Freiburg, Berlin, Strasbourg, and Heidelberg.

In 1909 he graduated in medicine with a thesis on a psychiatric subject and devoted himself for a time to psychology and philosophy, publishing a book entitled *Beiträgezur psychologischen Theorie der Geistesstörungen* (Contributions to the psychological theory of mental disturbances) and an essay on Goethes*Methoden der Naturforschung*(Goethe's methods of scientific research). Under the influence of **Otto Warburg**, however, who was then at Heidelberg, he became more and more interested in cell physiology. After working for a short time on physical chemistry with Bredig at Heidelberg, Meyerhof spent some time in the laboratory of the Heidelberg Clinic and at the Zoological Station at Naples. In 1912 he went to Kiel, where he qualified in 1913, under Professor Bethe, as a university lecturer in physiology; and lectures which he delivered at Kiel, in England and the United States were published as*The Chemical Dynamics of Living Matter*. In 1915, when Professor Höber assumed the Directorship of the Institute of Physiology, Meyerhof was appointed Assistant. In 1918 he became Assistant Professor. In 1923 he was offered a Professorship of Biochemistry in the United States, but Germany was unwilling to lose him and in 1924 he was asked by the Kaiser Wilhelm Gesellschaft to join the group working at Berlin-Dahlem, which included C. Neuberg, **F. Haber**, M. Polyani, and H. Freundlich.

In 1929 he was asked to take charge of the newly founded Kaiser Wilhelm Institute for Medical Research at Heidelberg. In 1938 conditions became too difficult for him and he decided to leave Germany. From 1938 to 1940 he was Director of Research at the Institut de Biologiephysico-chimique at Paris, where he was helped financially by the Josiah Macy, Jr. Foundation.

In June, 1940, however, when the Nazis invaded France, he had to flee from Paris. Driving with his family to Toulouse, he was befriended by the Medical Faculty there, but escape became essential and a tragic flight followed. Eventually, with the help of the Unitarian Service Committee, he reached Spain and ultimately, in October 1940, the United States, where the post of Research Professor of Physiological Chemistry had been created for him by the University of Pennsylvania and the Rockefeller Foundation.

Meyerhof's own account of his earlier work states that he was occupied chicfly with oxidation mechanisms in cells and with extending methods of gas analysis through the calorimetric measurement of heat production. In this manner he studied the metabolism of sea-urchin eggs, blood corpuscles, and various bacteria and especially the respiratory processes of nitrifying bacteria.

He also studied the effects of narcotics and methylene blue on oxidation processes, and the respiration of killed cells. The physicochemical analogy between oxygen respiration and alcoholic fermentation caused him to study both these processes in the same subject, namely, yeast extract. By this work he discovered a co-enzyme of respiration, which could be found in all the cells and tissues up till then investigated. At the same time he also found a co-enzyme of alcoholic fermentation. He also discovered the capacity of the SH-group to transfer oxygen; after **Hopkins** had isolated from cells the SH bodies concerned, Meyerhof showed that the unsaturated fatty acids in the cell are oxidized with the help of the sulphydryl group. After studying closer the respiration of muscle, Meyerhof investigated the energy changes in muscle.

Of Meyerhof's many achievements, perhaps the most important is his proof that, in isolated but otherwise intact frog muscle, the lactic acid formed is reconverted to carbohydrate in the presence of oxygen, and his preparation of a KC1 extract of muscle which could carry out all the steps of glycolysis with added glycogen and hexose-diphosphate in the presence of hexokinase derived from yeast. In this system glucose was also glycolysed and this was the foundation of the Embden-Meyerhof theory of glycolysis. For his discovery of the fixed relationship between the consumption of oxygen and the metabolism of lactic acid in the muscle, Meyerhof was awarded, together with the English physiologist **A.V. Hill**, the Nobel Prize for Physiology or Medicine for 1922.

The discovery of Otto Meyerhof and his students that some phosphorylated compounds are rich in energy led to a revolution, not only of our concepts of muscular contraction, but of the entire significance of cellular metabolism. A continuously increasing number of enzymatic reactions are becoming known in which the energy of adenosine triphosphate, the compound isolated by his associate Lohmann, provides the energy for endergonic synthesis reactions. The importance of this discovery for the understanding of cellular mechanisms is generally recognized and can hardly be overestimated.

In 1925 Meyerhof succeeded in extracting the glycolytic enzyme system from muscle, retracing a pathway which **Buchner** and **Harden** and Young had explored in yeast. This proved to be a decisive step for the analysis of glycolysis. Meyerhof and his associates were able to reconstruct *in vitro* the main steps of the complicated chain of reactions leading from glycogen to lactic acid. They verified some, and extended other, parts of the scheme proposed by Gustav Embden in 1932, shortly before his death.

Among other honours and distinctions, Meyerhof was a Foreign Member of the Harvey Society and of the Royal Society of London, and a Member of the National Academy of Sciences of the U.S.A.

As a man Meyerhof was a fine experimenter and a master of physiological chemistry. By temperament he was most interested in theory and interpretation and he had a remarkable gift of integrating a variety of phenomena. He spent much time daily at his desk and in stimulating discussions with his pupils and collaborators. His chief scientific work was accomplished while he was at Heidelberg, but he also produced much while he was in America; and in America also he showed that he had never relinquished his active interest in philosophy by presenting to the Goethe Biennial Celebration of the Rudolf Virchow Society in New York a profound and critical evaluation of Goethe's scientific ideas. Throughout his life he retained a great love of art, literature, and poetry. His interest in painting was much stimulated by his wife Hedwig Schallenberg, herself a painter, whom he married in 1914. There were three children of this marriage.

In 1944 he suffered a heart attack; in 1951 another one which ended his life.

1923

The Nobel Prize in Physiology or Medicine 1923 was awarded jointly to **Frederick Grant Banting** and **John James Rickard Macleod** *"for the discovery of insulin"*.

Frederick Grant Bantingwas awarded the Nobel Prize *"for the discovery of insulin"*.

Background

Born:14 November 1891, Alliston, Canada

Died:21 February 1941, Newfoundland, Canada

Affiliation at the time of the award: University of Toronto, Toronto, Canada

Prize motivation:"for the discovery of insulin"

Field: endocrinology, metabolism

Biography

Frederick Grant Banting was born on November 14, 1891, at Alliston, Ont., Canada. He was the youngest of five children of William Thompson Banting and Margaret Grant. Educated at the Public and High Schools at Alliston, he later went to the University of Toronto to study divinity, but soon transferred to the study of medicine. In 1916 he took his M.B. degree and at once joined the Canadian Army Medical Corps, and served, during the First World War, in France. In 1918 he was wounded at the battle of Cambrai and in 1919 he was awarded the Military Cross for heroism under fire.

When the war ended in 1919, Banting returned to Canada and was for a short time a medical practitioner at London, Ontario. He studied orthopaedic medicine and was, during the year 1919-1920, Resident Surgeon at the Hospital for Sick Children, Toronto. From 1920 until 1921 he did part-time teaching in orthopaedics at the University of Western Ontario at London, Canada, besides his general practice, and from 1921 until 1922 he was Lecturer in Pharmacology at the University of Toronto. In 1922 he was awarded his MD degree, together with a gold medal.

Earlier, however, Banting had become deeply interested in diabetes. The work of Naunyn, Minkowski, Opie, Schafer, and others had indicated that diabetes was caused by lack of a protein hormone secreted by the islands of Langerhans in the pancreas. To this hormone Schafer had given the name insulin, and it was supposed that insulin controls the metabolism of sugar, so that lack of it results in the accumulation of sugar in the blood and the excretion of the excess of sugar in the urine. Attempts to supply the missing insulin by feeding patients with fresh pancreas, or extracts of it, had failed, presumably because the protein insulin in these had been destroyed by the proteolytic enzyme of the pancreas. The problem, therefore, was how to extract insulin from the pancreas before it had been thus destroyed.

While he was considering this problem, Banting read in a medical journal an article by Moses Baron, which pointed out that, when the pancreatic duct was experimentally closed by ligatures, the cells of the pancreas which secrete trypsin degenerate, but that the islands of Langerhans remain intact. This suggested to Banting the idea that ligation of the pancreatic duct would, by destroying the cells which secrete trypsin, avoid the destruction of the insulin, so that, after sufficient time had been allowed for the degeneration of the trypsin-secreting cells, insulin might be extracted from the intact islands of Langerhans.

Determined to investigate this possibility, Banting discussed it with various people, among whom was **J.J.R. Macleod**, Professor of Physiology at the University of Toronto, and Macleod gave him facilities for experimental work upon it. Dr. Charles Best, then a medical student, was appointed as Banting's assistant, and together, Banting and Best started the work which was to lead to the discovery of insulin.

In 1922 Banting had been appointed Senior Demonstrator in Medicine at the University of Toronto, and in 1923 he was elected to the Banting and Best Chair of Medical Research, which had been endowed by the Legislature of the Province of Ontario. He was also appointed Honorary Consulting Physician to the Toronto General Hospital, the Hospital for Sick Children, and the Toronto Western Hospital. In the Banting and Best Institute, Banting dealt with the problems of silicosis, cancer, the mechanism of drowning and how to counteract it. During the Second World War he became greatly interested in problems connected with flying (such as blackout).

In addition to his medical degree, Banting also obtained, in 1923, the LL.D. degree (Queens) and the D.Sc. degree (Toronto). Prior to the award of the Nobel Prize in Physiology or Medicine for 1923, which he shared with Macleod, he received the Reeve Prize of the University of Toronto (1922). In 1923, the Canadian Parliament granted him a Life Annuity of $7,500. In 1928 Banting gave the Cameron Lecture in Edinburgh. He was appointed member of numerous medical academies and societies in his country and abroad, including the British and American Physiological Societies, and the American Pharmacological Society. He was knighted in 1934.

As a keen painter, Banting once took part of a painting expedition above the Arctic Circle, sponsored by the Government.

Banting married Marion Robertson in 1924; they had one child, William (b. 1928). This marriage ended in a divorce in 1932, and in 1937 Banting married Henrietta Ball.

When the Second World War broke out, he served as a liaison officer between the British and North American medical services and, while thus engaged, he was, in February 1941, killed in an air disaster in Newfoundland.

John James Rickard Macleod was awarded the Nobel Prize *"for the discovery of insulin"*.

Background

Born:6 September 1876, Cluny, Scotland

Died:16 March 1935, Aberdeen, Scotland

Affiliation at the time of the award: University of Toronto, Toronto, Canada

Prize motivation:"for the discovery of insulin"

Field: endocrinology, metabolism

Biography

John James Rickard Macleod was born on September 6, 1876 at Cluny, near Dunkeld, Perthshire, Scotland. He was the son of the Rev. Robert Macleod. When later the family moved to Aberdeen, Macleod went to the Grammar School there and later entered the Marischal College of the University of Aberdeen to study medicine.

In 1898 he took his medical degree with honours and was awarded the Anderson Travelling Fellowship, which enabled him to work for a year at the Institute for Physiology at the University of Leipzig.

In 1899 he was appointed Demonstrator of Physiology at the London Hospital Medical School under Professor Leonard Hill and in 1902 he was appointed Lecturer in Biochemistry at the same College. In that year he was awarded the McKinnon Research Studentship of the Royal Society, which he held until 1903, when he was appointed Professor of Physiology at the Western Reserve University at Cleveland, Ohio, U.S.A.

During his tenure of this post he was occupied by various war duties and acted, for part of the winter session of 1916, as Professor of Physiology at McGill University, Montreal.

In 1918 he was elected Professor of Physiology at the University of Toronto, Canada. Here he was Director of the Physiological Laboratory and Associate Dean of the Faculty of Medicine.

In 1928 he was appointed Regius Professor of Physiology at the University of Aberdeen, a post which he held, together with that of Consultant Physiologist to the Rowett Institute for Animal Nutrition, in spite of failing health, until his early death.

Macleod's name will always be associated with his work on carbohydrate metabolism and especially with his collaboration with **Frederick Banting** and Charles Best in the discovery of insulin. For this work on the discovery of insulin, in 1921, Banting and Macleod were jointly awarded the Nobel Prize for Physiology or Medicine for 1923.

Macleod had, before this discovery, been interested in carbohydrate metabolism and especially in diabetes since 1905 and he had published some 37 papers on carbohydrate metabolism and 12 papers on experimentally produced glycosuria. Previously he had followed the earlier great work of von Mering and Minkowski, which has been published in 1889, and although he believed that the pancreas was the organ involved, he had not been able to prove exactly what part it played. Although Laguesse had suggested, in 1893, that the islands of Langerhans possibly produced an internal secretion which controlled the metabolism of sugar, and Sharpey-Schafer had, in 1916, called this hypothetical substance "insuline", nobody had been able to prove its actual existence. Others had made extracts of the pancreas, some of which had proved to be active in affecting the metabolism of sugar, but none of these products had been found reliable, until Banting and Best, jointly with Macleod, could announce their great discovery in February 1922. The process of manufacturing the pancreatic extract which could be used for the treatment of human patients was patented; the financial proceeds of the patent were given to the British Medical Research Council for the Encouragement of Research, the discoverers receiving no payment at all. Subsequently, the active principle of these earlier pancreatic extracts, insulin, was isolated in pure form by John Jacob Abel in 1926, and eventually it became available as a manufactured product.

Earlier, in 1908, Macleod had done experimental work on the possible part played by the central nervous system in the causation of hyperglycaemia and in 1932 he returned to this subject, basing his work on the experiments done by Claude Bernard on puncture diabetes, and Macleod then concluded, from experiments done on rabbits, that stimulation of gluconeogenesis in the liver occurred by way of the parasympathetic nervous system.

Macleod also did much work in fields other than carbohydrate metabolism. His first paper, published in 1899, when he was working at the London Hospital, had been on the phosphorus content of muscle and he also worked on air sickness, electric shock, purine bases, the chemistry of the tubercle bacillus and the carbamates.

In addition he wrote 11 books and monographs, among which were his *Recent Advances in Physiology* (with Sir Leonard Hill) (1905); *Physiology and Biochemistry of Modern Medicine*, which had reached its 9th edition in 1941;*Diabetes: its Pathological Physiology* (1925); *Carbohydrate Metabolism and Insulin* (1926); and his Vanuxem lectures, published in 1928 as the *Fuel of Life*.

In 1919 Macleod was elected a Fellow of the Royal Society of Canada, in 1923 of the Royal Society, London, in 1930 of the Royal College of Physicians, London, and in 1932 of the Royal Society of Edinburgh. During 1921-1923 he was President of the American Physiological Society, and during 1925-1926 of the Royal Canadian Institute. He held honorary doctorates of the Universities of Toronto, Cambridge, Aberdeen and Pennsylvania, the Western Reserve University and the Jefferson Medical College. He was an honorary fellow of the AccademiaMedica, Rome, and also a corresponding member of the Medical and Surgical Society, Bologna, the Societá Medica Chirurgica, Rome, and the Deutsche Akademie der Naturforscher Leopoldina, Halle, and Foreign Associate Fellow of the College of Physicians, Philadelphia.

Macleod was a very successful teacher and director of research. His lucid lectures were delivered in an attractive manner and his pupils and research associates found him a sympathetic and stimulating worker, who demanded exact work and the humility that was a feature of his character. He would not tolerate careless work. He was much interested in the development of medical education and especially in the introduction of scientific methods of investigation into clinical work.

Outside the laboratory he was keenly interested in golf and gardening and the arts, especially painting. A sensitive, loyal and affectionate man of engaging personality, his serene spirit met with courage and optimism the painful and crippling disabilities which troubled the final years of his busy life.

Macleod was married to Mary McWalter. He died on March 16, 1935.

Source: From ***Nobel Lectures**, Physiology or Medicine 1922-1941*, Elsevier Publishing Company, Amsterdam, 1965

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