OBITUARY NOTICES.

WILDER DWIGHT BANCROFT.

1867—1953.

In 1632, twelve years after the *Mayflower* sailed from Southampton and during the period of the " Great Migration," John Bancroft, accompanied by his wife and two young sons, left his English home in Norfolk to take a farm near Lynn, in the colony of Massachusetts. Although he died soon after, his son Thomas became the progenitor of a long line of stalwart churchmen and farmers; and, during more than a hundred and thirty years, five generations of Bancrofts developed a tradition and pattern of life which, as it has been said, " combined civic duties, rock-ribbed Calvinism and farming in equal proportions."

This seemingly settled and unchanging pattern and way of life, however, was shattered when, in November 1755, a son, Aaron, was born to Samuel Bancroft, farmer and deacon of the church in Reading, Massachusetts, and his wife Lydia Parker. Looked upon, even as a boy, as the " family rebel," Aaron liked neither the occupation nor the Calvinistic creed of his father, and, breaking with long-established tradition, he became a prominent Unitarian minister, a leader of the schismatics and a soldier of the Revolution. He also wrote a " Life of George Washington," which enjoyed considerable popularity; and it was his constant prayer that he might be granted a " teachable temper."

The character and cultural mutation introduced by Aaron into the Bancroft line was continued and confirmed in his son George: scholar, politician and diplomat; Secretary of the Navy under President Polk and founder of the U.S. Naval Academy at Annapolis; U.S. Minister in London and in Berlin; author of " History of the American Revolution " and of " History of the Formation of the Constitution of the United States of America." By his first wife, Sarah H. Dwight, he had two sons and a daughter; and the elder son, John Chandler, named after his grandmother, Lucretia Chandler, wife of Aaron Bancroft, became the father of Wilder. It is, I believe, in the mental qualities, outlook on life, personality, and character of his grandfather and great-grandfather, that we can find the key to the personality and character of the subject of this notice.

Wilder Dwight Bancroft was born on October 1st, 1867, at Middletown, Rhode Island, a small town and residential suburb of Newport, R.I. He was the elder of two children whom his father had by his first wife, Louisa Denny, daughter of a mill-owner, who died when Wilder was only four years old. Bancroft's father had studied law and was associated for a time with a firm of stockbrokers in Boston, but he later devoted himself to painting and studied art in France. His love of art, however, did not pass to his son. As a boy, Bancroft attended Roxbury Latin School and Milton Academy, where he showed outstanding ability, but little is known of his special interests or aptitudes during that period of his life. It was not, apparently, until he became an undergraduate at Harvard University in 1884 that any particular interest in science began to develop.

At that time, the senior professor of chemistry at Harvard was Josiah P. Cooke, whose books, " The New Chemistry " and " First Principles of Chemical Philosophy," may entitle him to be regarded as a pioneer of the older physical chemistry, and whose deductive method of approach to the study of chemistry cannot but have exercised an important influence on Bancroft's mind. There is little known about Bancroft's interests in science while at Harvard, but he showed prowess on the football field and was a member of the Harvard football team.

On graduating A.B. in 1888, Bancroft was appointed an Assistant in the Chemistry Department. In the following year he proceeded to Europe where he worked more especially under Wilhelm Ostwald in Leipzig (1890—2), and under van't Hoff in Amsterdam (1892—3). He also spent some time at Strasbourg (1889—90) and in Berlin. In 1892 he presented a thesis entitled " Oxydationsketten " and after the usual oral examination was awarded the degree of Ph.D. by the University of Leipzig. In Amsterdam he continued his electrochemical studies and carried out experiments of an exploratory character on the chemical potential of metals.

On returning to America in 1893, Bancroft took up his former post as Assistant at Harvard and in the following year was promoted to the rank of Instructor. In 1895 Professor Cooke died and Bancroft left Harvard to join the staff at Cornell University as Assistant Professor of Physical Chemistry. In 1903 he became Professor and, in 1919, World War Memorial Professor of Physical Chemistry. Thereafter the whole of his life was spent at Cornell. In

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1937 he retired from his Chair, and for a year was visiting Tallman Professor at Bowdoin College, Brunswick, Maine.

For more than forty years Bancroft was a member of the staff of Cornell. They were very strenuous years, but years which were full of work in which he could find satisfaction and happiness; and as time passed he became one of Cornell's best known and most outstanding professors. As a teacher he sought to impress on his students something of his own high character and enthusiasm for scientific truth. He lectured interestingly and clearly, using the original memoirs as the basis of discussion. His aim was not so much to impart a knowledge of a large number of facts as to impress on his students the importance of thinking things out for themselves; and he assessed the merits and standing of a student not by the range or number of facts which he was able to commit to memory, but by his willingness and ability to think and to draw his own conclusions from the facts discovered by himself or by others. To make people think may, perhaps, be regarded as a major aim of Bancroft's many writings, and the success with which he achieved this aim may be reckoned as among the most important of his contributions to the advancement of physical chemistry in America.

To younger chemists in whom he detected merit, Bancroft gave much help and encouragement, and there are not a few who have since attained to positions of eminence in chemistry, who look back with gratitude to the stimulus, encouragement, and help which they received from him.

Bancroft was interested in teaching, in making known to others what he had learned himself. He was obsessed with the importance of chemistry and he strove to make its importance more widely known and appreciated. " It should be the aim of all chemists," he wrote in the Jubilee volume of the *Journal of the American Chemical Society,* " to have chemistry take its place as the fundamental science," and he also urged physical chemists " to develop the borderlands between physical chemistry and the other sciences, such as, biology, geology, physics, medicine, engineering, psychology, etc." Nor was it on his students and fellow-scientists alone that he wished to press the importance of chemistry. Its importance must be recognised by the community as a whole, and he suggested that universities should teach chemistry as a cultural study—as part of a general education. He urged, also, the institution of courses of public popular lectures on chemistry for those not to be chemists—" chemistry of or pertaining to all the people "—pandemic chemistry, he called it. Bancroft drew up a syllabus of such a course, a course not to teach a man chemistry but to teach him about chemistry, but he recognised, as all teachers have recognised, that the success of such a course depends more on the teacher than on the syllabus.

Bancroft was himself endowed with the gift of popular exposition, as shown by his lecture on " Blue Eyes and Blue Feathers " with which he gave pleasure to many audiences. Blue eyes, like the blue of the sky or of skimmed milk, are due to the Tyndall effect in turbid media; but the blue eyes of infants may change to hazel or brown through the development of a pigment in the front of the iris. Green eyes, due to a combination of structural blue with a yellow pigment, are " not common in human beings, except as a symbol of jealousy." The green colour on the back of the green tree-frog has a similar origin. " If we scrape the pigment layer off the back of an unfortunate frog, he turns blue." Blue and iridescent colours of feathers are due not to pigments but to physical structure. The lecture was a good example of Bancroft's happy lecture style; and the way in which apparently unrelated phenomena were brought together was characteristic of Bancroft's highly perceptive mind.

In 1895, physical chemistry—the newer physical chemistry of which Arrhenius, van't Hoff, and Ostwald were the pioneers—was only in its infancy in America, and Bancroft, with boundless energy and full of missionary zeal, sought, on joining the staff at Cornell, to develop this branch of science. In his view, physical chemistry was not merely a branch of chemistry but covered the whole of chemistry, and he aimed at presenting the science as a complete and systematic whole.

While in Amsterdam, Bancroft had no doubt become acquainted with the work of Bakhuis Roozeboom and had become impressed with the importance of the phase rule as a basis of classification of heterogeneous systems and as a guide in their investigation. Although it owed its discovery to the great Yale mathematician, Willard Gibbs, there was, in America, almost no knowledge of the great generalisation or recognition of its practical importance. There was, moreover, no exposition in English by means of which the student could become acquainted with it. Bancroft, therefore, set himself the task of making good this deficiency and published his first book, " The Phase Rule," in 1897. In this work, at the cost of what must have been much labour, he collected together in a systematic manner the existing items of knowledge scattered throughout the literature, and was, as Bakhuis Roozeboom wrote, " exceedingly successful in making clear the coherence of the phenomena and in presenting an inspiring picture of the imposing science of heterogeneous equilibria." Unfortunately he was not quite successful, as he himself admitted, in producing a book which a student could read with profit and without difficulty. Nevertheless, it was a remarkable work to be written by one who was under thirty years of age and still on the very threshold of his teaching career. Along with the many papers written by Bancroft and the experimental work carried out by his pupils under his inspiration and guidance, " The Phase Rule " constituted a very important pioneering advance into a domain which, later, was vigorously and fruitfully cultivated in America. As Bancroft pointed out, the renowned Geophysical Laboratory at Washington is a wonderful example of what can be done with the phase rule as an instrument of research.

It is, perhaps, worthy of note that Bancroft, in this book, introduced into phase rule terminology the words non-variant, monovariant, divariant, etc., suggested to him by his colleague, Joseph E. Trevor.

In his desire to further the study of physical chemistry in America, Bancroft no doubt recognised, as Ostwald in Germany had recognised, that if this new branch of science was to grow and develop, it must have a special organ through which it could express itself, and so, in 1896, he founded *The Journal of Physical Chemistry* as " an organ for the publication of research in all branches of experimental and theoretical physical chemistry." Until 1932, Bancroft was editor of the *Journal* (associated during the first thirteen years with J. E. Trevor), contributed many articles to its pages, and wrote also for it many book reviews and abstracts of scientific papers published elsewhere. Not only did Bancroft found the *Journal of Physical Chemistry* and thereby, it may be, rendered his greatest service to chemistry, but he also financed it out of his private resources. In 1924, when the financial burden became too great for him, he handed the Journal over the the American Chemical Society, the Chemical Society, and the Faraday Society, under whose auspices it was published until 1932. In 1947 its title was altered to *Journal of Physical and Colloid Chemistry.* It would be impossible with any accuracy to assess, as it would be difficult to exaggerate, the value and importance of this journal in promoting the development of physical chemistry in America by uniting the workers in this new domain of knowledge, by giving them their own organ of publication and thereby making effective advance possible.

From 1913 until his death, Bancroft was also Associate Editor of the *Journal of the Franklin Institute*, an institute founded, in 1826, in the State of Pennsylvania, to " diffuse information on every subject connected with the useful arts." To this journal Bancroft contributed, in 1925, an article on the Development of Colloid Chemistry.

The numerous papers on emulsions, colloids, adsorption, etc., which from just before the First World War appeared in the *Journal of Physical Chemistry* under the name of Bancroft and of his pupils, were evidence that a new interest, one which became, perhaps, his strongest and most enduring interest, had developed in Bancroft's mind.

For some time interest in the colloid state had been growing in America, as in Europe, and although books on colloid chemistry existed, they had been written, in Bancroft's opinion, in too purely descriptive a manner and presented the subject empirically. By 1920, he considered that theory had developed sufficiently to allow the data to be presented deductively, and this he sought to do in his " Applied Colloid Chemistry," which first appeared in 1921 and of which two further editions were published, in 1926 and 1932.

This book, in its enthusiastic presentation of the subject, its critical sifting of reputed facts and explanations which the author regarded as doubtful or conflicting, its stimulating suggestiveness of how information gained in one field of investigation may be applied in many other fields, is entirely characteristic of Bancroft and deals clearly and comprehensively with a wide range of facts and observations. It is a book which is not only interesting and easy to read, but is sometimes almost entertaining, as when Bancroft writes : " There is one experiment which I always like to try, because it proves something whichever way it goes. A solution of iodine in water is shaken with bone-black, filtered, and tested with starch paste. If the colourless solution does not turn starch blue, the experiment shows how completely charcoal extracts iodine from aqueous solution. If the starch turns blue, the experiment shows that the solution, though apparently colourless, still contains iodine which can be detected by means of the sensitive starch test." One can almost see the engaging twinkle in his eyes as he carries out this experiment in front of his class.

The title of the book shows that Bancroft was interested not only in the general theory of colloid matter, but also in the importance of colloids and colloid theory in industry. To quote the author's own words : " At first sight colloid chemistry may not seem to be an important branch of chemistry, either theoretically or technically; but this opinion changes when we consider that a knowledge of colloid chemistry is essential to anybody who really wishes to understand about: cement, bricks, pottery, porcelain, glass. enamels; oils, greases, soap, candles; glue, starch, and adhesives; paints, varnishes, lacquers; rubber, celluloid, and other plastics; leather, paper, textiles; filaments, casts, pencils, and crayons; inks; roads, foundry cores, coke, asphalt; graphites, patines; zinc, phosphorus, sodium, and aluminum; contact sulphuric acid, hardened oils, etc.; beer, ale, and wine; cream, butter, cheese, and casein products; cooking, washing, dyeing, printing; ore flotation, water purification, sewage disposal; smoke prevention; photography; wireless telegraphy; illuminants; comets; pharmacology, physiology, and medicine. In other words, colloid chemistry is the chemistry of everyday life. It now looks as though insanity were primarily a problem in colloid chemistry."

A committee on the chemistry of colloids, of which Bancroft was a member, was set up in 1921 by the National Research Council. A National Symposium on Colloid Chemistry was held at Madison, Wis., in 1923, and thereafter became an annual event. At the 8th Annual Colloid Symposium the chemistry of anæsthesia, a problem in which Bancroft was directly interested and to the study of which he made valuable contributions, was discussed; and a Testimonial Dinner was arranged in his honour. In 1941, the 18th Annual Symposium, held at Cornell University, which was one of the first American Universities to institute courses in colloid chemistry, was designated " The Wilder D. Bancroft Symposium," " in recognition of his position as a pioneer among the teachers and investigators of colloid chemical phenomena in America and of his contributions to colloid science."

Although Bancroft was the author of only two books, writing, with him, may almost be said to have been an inherited characteristic, and he wielded the pen with ease and dexterity. He was an omnivorous reader and a voluminous writer, living constantly under the urge not only to seek out truth but to proclaim to others the truth when found. He had a wonderfully retentive memory and was a great encyclopaedist. In the many papers which he published in the *Journal of Physical Chemistry* and elsewhere, and in the numerous lectures and addresses which he delivered, Bancroft sought to bring together the facts already known, to sift them carefully and critically, to point out what he regarded as errors or defects in the interpretation of experimental data, to indicate what, in his opinion, were the fundamental problems to be investigated, and to put forward generalisations for testing by experiment. Ideas, suggestions of problems for investigation, sprang in almost bewildering profusion out of an extensive knowledge and exuberant imagination; and not a few of these problems were thereafter investigated by Bancroft's pupils in his laboratory at Cornell and under his stimulus and direction. It is, I believe, in his numerous writings and in the stimulus and encouragement which he gave to workers in widely different fields to take the data and conceptions from one branch of study and to consider their application to another, that we find Bancroft's chief contribution to the advance of scientific thought and knowledge.

Tall and strongly built, robust both physically and mentally and with a fair and fresh complexion, Bancroft looked out on a world which was to him so full of interest, through blue eyes from which a smile was never far distant. Throughout most of his life he retained as a spectator an enthusiastic interest in athletics, especially baseball and football, in which, in his younger days, he had gained no little distinction. Independent, as always, of the opinions of others, Bancroft was also inclined to be unconventional in dress. Van't Hoff tells how, during a visit which he paid to Bancroft in 1901, he was surprised to see his host dressed in knickerbockers and shoes, and how he reminded him somewhat of an *impressario*. He recounts, also, a somewhat hair-raising excursion to Taughannock Waterfall which he and his wife made in a horse carriage with Bancroft as driver. By some mistake they had got on to a road long disused and they had to descend and push or pull the carriage over the roughest parts, or even to lift it over a water conduit. However, they all arrived back again without serious mishap, and van't Hoff committed his feeling of relief to his diary in the words, " How fortunate we were to have such a safe driver as Wilder."

Bancroft found relaxation mainly in playing golf, and he was one of the organisers of the Country Club at Ithaca. He greatly enjoyed taking part in national and international congresses and conferences where he could discuss scientific problems with fellow workers. On such occasions, his genial and enthusiastic manner and his witty talk ensured for him a cordial welcome.

Bancroft was ambidextrous and, when lecturing, he liked sometimes to astonish and impress his audience by a demonstration of his ambidexterity. Standing at the middle of the blackboard he would begin to write a line with his left hand and then, transferring the chalk but without altering his position, would complete the line with his right hand.

Bancroft's eminence in science and his sound judgment in administrative matters were recognised both nationally and internationally. In 1905, and again in 1919, he was elected President of the American Electrochemical Society, in the foundation of which, in 1902, he had played an important part and of which he had been one of the first vice-presidents; and in 1910 he had the high honour bestowed upon him of being called to the Presidency of the American Chemical Society. He was also elected a member of the National Academy of Sciences. Other honours came to him both from within and without the United States. The Chemical Society elected him to Honorary Fellowship in 1920, and a similar honour was conferred upon him by the Polish Chemical Society and by the Société Chimique de France. Lafayette College conferred on him the honorary degree of Doctor of Science (1919), and the University of Southern California conferred the degree of Doctor of Laws (1930). On the occasion of the meeting of the International Congress in 1923, the honorary degree of Doctor of Science was conferred upon him by the University of Cambridge. On this occasion, the Public Orator presented him to the Vice-Chancellor with the words : Sequitur Wilder D. Bancroft et studiis et affinitate nobis conjunctus, qui alter Ulixes multorum providus, novam Ithacam novis artibus illuminavit.

During World War I, Bancroft was a member of the Advisory Committee, Chemical Warfare Service, and from 1918—19 had the rank of Lieutenant-Colonel. He was, very appropriately, in charge of the editorial section of the Chemical Warfare Service and had to deal with all reports coming in from various sections with reference to the preparation and properties of war gases. On the basis of these reports and of information collected from all available sources, monographs relating to each poison gas, to canister ingredients, etc., were compiled and made available to all interested in these matters.

For the year 1919—20, Bancroft was Chairman of the Division of Chemistry, National Research Council, and in that capacity wrote a Report in which he outlined a number of borderland problems which interested him and which he thought worth investigating. They included a wide range of subjects, from the bread-making quality of flour to tapping trees for turpentine and rubber; from chemotherapy to structural colours; from plasticity of clay to adsorption of gases; a range of topics which sufficiently indicates the catholicity of Bancroft's interests.

From 1922 to 1923, Bancroft was Vice-President of the International Union of Chemistry; from 1922 to 1925 a member of the Board of Visitors, Bureau of Standards; and in 1928 a member of the Advisory Board, Cancer Research Fund.

On June 19th, 1895, Bancroft married Kate Bott, of Albany, N.Y., whose father had emigrated from Germany to the United States about the middle of the nineteenth century, and whom he had first met during his period of study in Berlin in 1893. She died in February, 1942.

In 1937, when Bancroft retired from the active work of his Chair, he was still in the enjoyment of good health and could look forward to spending the evening of a very busy life in the unhurried, happy, and peaceful pursuit of his scientific interests. But this was not to be. In 1938, after returning from Bowdoin College, he was run over by a motor car on the Cornell Campus and received very severe injuries. For several months he lay in hospital and, although, thereafter, he was able to move about quietly with the help of a walking-stick and to pay occasional visits to the Chemistry Department, he never fully recovered his health. A year or two before he died he fell out of bed during another period in hospital and was then confined to his home.

During his many years of partial or complete invalidism Bancroft, undaunted by the cruel rub of fortune, remained cheerful and retained his interest in science and athletics; and smiling into the frowning face of Fate, he fulfilled his allotted span of life. Peacefully, on the morning of February 7th, 1953, he fell on sleep.

Bancroft is survived by two sons and three daughters, of whom the eldest is married to M. L. Nichols, Professor of Chemistry, Cornell University.

With his alert and wide-ranging mind, with his independence of outlook and fearlessness in expressing his views, which were in no way inferior to those of his New England forebears, Bancroft was an outstanding personality and exercised a great influence on the development of physical chemistry in America. It may be that in his editorial chair Bancroft was apt to regard himself not only as the professor but also as the autocrat of physical chemistry; it may also be that with his unusually wide knowledge and confidence—not unjustified—in his own judgment, he was inclined to be intolerant of the views of others when they differed from his own and to express his criticisms not only freely but, occasionally, with an unnecessary acerbity of language, and so was apt to make personal enemies of those who, through association in work and community of interests, should have been his friends. If, in the interests of scientific truth, he provoked controversy; if sometimes he even seemed, almost wilfully, to revert to the character of his grandfather, " the aggressive partisan who appeared to court unpopularity," yet in the social relations of everyday life how considerate and lovable he could be, how gracious and charming his manner, how interesting and entertaining his conversation. He died leaving a wealth of achievement as his monument and a treasured memory that will not quickly fade.

Bancroft's scientific interests were very varied and evidence of his encyclopaedic mind is given in the numerous papers and articles which he wrote on electrochemistry, oxidation–reduction cells, and overvoltage; phase rule; osmotic pressure and dilution law; contact catalysis; corrosion; colloids and emulsions; hydrogenation; charcoal; theory of photography and the photographic plate; photochemistry; structural colours; proteins; colouring of glass by metal oxides; etc. To discuss here his scientific contributions in detail, would be impossible; and one must restrict oneself to indicating only some of the more important aspects of his scientific work.

The first investigations which Bancroft undertook after graduating at Harvard were electrochemical. In Ostwald's laboratory in Leipzig he carried out a large number of determinations of the electromotive force of cells in which unattackable electrodes were placed, one in a solution of a reducing agent and the other in a solution of an oxidising agent, the two solutions being connected by a salt bridge. This investigation had been suggested by Ostwald who recognised the importance of such cells in enabling one to calculate the chemical affinity of oxidation and reduction processes; and Bancroft was the first to carry out a large series of such determinations. The work gave evidence of Bancroft's experimental skill, but the value of the results was diminished because it was not realised or recognised that, as Le Blanc first pointed out, the electrode potentials are well-defined only when the solution contains both oxidant and reductant, and vary with the ratio of the concentrations or activities of these in the solution.

Pioneer determinations of the potential of irreversible electrodes were also carried out by Bancroft and his pupils at Cornell University, and this work was extended to the investigation of a number of cells with the object of finding a convenient standard cell with an e.m.f. of about 0·5 v.

The more practical applications of electrochemistry to the deposition of metals also claimed Bancroft's interest, and he showed that the crystal size of the deposited metal is decreased when there are present at the cathode surface substances which are adsorbed by the deposited metal. Thus, by the addition of suitable organic substances of high molecular weight to the cathode solution, smoother and finer-grained deposits could be obtained.

A process for the electrodeposition of chromium on steel, from a solution of chromic acid to which a small amount of chromium sulphate had been added, was worked out by Bancroft and his pupils. Further investigation of the process was, however, abandoned as the primary object of the investigation, the obtaining of a chrome steel, was not attained.

Overvoltage, the occurrence of which is of importance in the electrolytic reduction of both inorganic and organic compounds, was considered by Bancroft to be due to the formation of monoatomic hydrogen followed by the combination of the atoms to form molecules. If the reaction $2H \longrightarrow H_2$ is slow, hydrogen atoms will accumulate and give rise to a greater counter-electromotive force. Different metals may have specific catalytic effects on the rate of this reaction and so give different overvoltages. In practice, one must also take into account the possibility of selective adsorption on the metal of the substance to be reduced. Thus, phenol is hydrogenated at a platinum electrode but practically not at all at a lead cathode, although here the overvoltage is higher.

Another field of study in which Bancroft showed an early interest was that of heterogeneous equilibria, the Cornell Laboratory being the first one in America in which serious work on the practical applications of the phase rule were carried out.

In the Preface to his " Phase Rule." Bancroft classified the facts and phenomena of physical chemistry into the divisions: Qualitative Equilibrium, Quantitative Equilibrium, Electrochemistry, Mathematical Theory. " My idea ", he wrote, " is that all qualitative experimental data should be presented as particular applications of the Phase Rule and the Theorem of Le Chatelier, while the guiding principles for the classification of quantitative phenomena should be the Mass Law and the Theorem of van't Hoff." The view thus expressed explains no doubt why, when Bancroft first began his studies of heterogeneous equilibria with the investigation of ternary mixtures, he approached the subject not from the standpoint of the phase rule but from that of the law of mass action.

The simplest case investigated was that of three liquid components two of which, A and B, are only partially miscible, while the third, S, is miscible in all proportions with A and B separately. Bancroft then considered the amounts of A and B, namely, x and y which will dissolve simultaneously in a fixed amount of S, and derived the expressions $x^{n_1}y$ = constant and $x^{n_2}y$ = constant, for the two sets of saturated solution. Other expressions were derived for other systems, and these were found to be in harmony with experimental determinations carried out by Bancroft and by his pupils.

Although these early studies of ternary mixtures no longer possess much interest, they no doubt served to direct attention to other ternary liquid systems discussed later in a general manner by Bancroft and investigated experimentally by others according to the principles of the phase rule.

It is worthy of mention that it is to Bancroft that we owe the term " solute," a term which he suggested in his first paper on ternary mixtures presented to the American Academy of Arts and Sciences on May 9th, 1894. While one could be grateful to Bancroft for this useful and generally adopted term, one could not accept his contention that " there is a fundamental difference between the solute and the solvent." One really has some difficulty in understanding how such a view came to be held, for it is not consistent with the definition of a solution, accepted by Bancroft, as a homogeneous mixture the composition of which can undergo continuous variation within limits. This definition neither creates nor recognises any distinction between solvent and solute.

Through drawing a distinction between solvent and solute, Bancroft was led to draw a distinction between fusion curves and solubility curves and so to separate phenomena which are in every respect similar. One must not, however, overemphasise early mistaken views which a growing knowledge and familiarity with the phenomena would soon correct.

To Bancroft we also owe the term " consolute liquids " for liquids which are miscible in all proportions.

At a time when the systematic study of heterogeneous equilibria was still in its early years, Bancroft and his pupils made many valuable contributions to the advancement of knowledge in this domain, a general discussion and exposition of the principles of the phase rule marching hand in hand with the experimental investigation of a wide variety of systems. It is possible to deal here only with some of the most important aspects of Bancroft's work in this field.

Organic chemists had made known the existence of isomeric substances which could exist in two different solid forms, each corresponding to a single definite constitution, but which, in the liquid state, could undergo transformation one into the other until a state of homogeneous equilibrium between the two molecular species was established. The behaviour of such substances gave rise to much controversy, and Bancroft was the first to show that many of the observed facts became more intelligible when one studied the heterogeneous solid–liquid equilibria met with in the case of these " dynamic isomerides." To the value of his work in this domain Ernst Cohen paid tribute in the words : " Einen nicht unwesentlichen Dienst bei dieser Zeit- und Streitfrage auf dem Felde der ' geometrischen ' Isomerie haben auch physikalisch-chemische Untersuchungen geleistet, so namentlich . . . das Studium der Gleichgewichtsverhältnisse von Bancroft."

The behaviour met with in the case of dynamic isomerides depends on the rate of transformation of the one isomer into the other in the liquid state. If the transformation is relatively very rapid, so that equilibrium in the liquid state is rapidly attained, the system will behave like a one-component system; but if the isomeric change is comparatively slow, the behaviour will be that of a two-component system; and, in the absence of compound formation between the isomers, a two-branched freezing-point curve will be obtained.

If isomeric transformation takes place with measurable velocity and if the temperature of the liquid equilibrium mixture is allowed to fall, a point on the freezing-point curve of one of the solid isomers will be reached, and that form will separate out, if supercooling is excluded. This is called the " natural " freezing point. The stable solid modification in the neighbourhood of the melting point is that which is in equilibrium with the liquid phase at the natural freezing point.

The two solid modifications of dynamic isomerides may be monotropic or enantiotropic. It was found by Soch, working in Bancroft's laboratory, that in the neighbourhood of the melting point, the yellow form of benzil-2-carboxylic acid, melting at 141·5°, is the stable form, whereas, at room temperature, the white modification, melting between 125° and 130°, is the stable form. Investigation showed that there is a transition point at about 65°. The two isomeric forms are therefore enantiotropic.

The behaviour of a number of different dynamic isomerides was investigated by Bancroft's pupils.

Bancroft also considered the behaviour of two components which can form a compound.

If the compound is stable, not only in the solid, but also in the liquid state, the equilibrium curve for the compound will consist of two branches meeting at a point, the melting point of the compound. If, however, the compound undergoes dissociation in the liquid state, the dissociation products will lower the freezing point of the compound, and the composition of the liquid will vary continuously with the temperature. The equilibrium curve becomes continuous and the crest of the curve is rounded. The greater the degree of dissociation, the flatter will the curve become, and from the extent of the flattening of the curve one can calculate approximately the degree of dissociation of the compound in the liquid state.

The boiling-point curves of binary liquid mixtures were also investigated by Bancroft and his pupils. Among the mixtures which show a minimum in the boiling-point curve it was found that in many cases one or both of the components is associated. The reason why in such cases a minimum is obtained was first explained by Bancroft as due to the fact that the boiling-point curves of such components intersect.

In other directions, in the investigation of the freezing-point equilibria in three-component systems, in the indirect determination of the composition of the solid phase separating from two-component systems, etc., Bancroft and his pupils were pioneers. At a much later period, when Bancroft's interests had extended to biochemical phenomena, use was made of phase-rule principles in the investigation of the behaviour of proteins towards hydrogen chloride and ammonia. It was shown that casein, zein, arachin, fibrin, and gliadin form no chemical compound with ammonia, and that casein, arachin, fibrin, gliadin, and edestin, but not zein, form definite compounds with hydrogen chloride.

To Bancroft's interest in colloids and the colloid state reference has already been made. In his mind, colloid chemistry, which he defined as " the chemistry of life and inheritance and of bubbles, drops, grains, filaments and films," extended over almost the whole field of chemistry and physical chemistry. The width of its applications, as Bancroft understood it, is indicated by the passage previously quoted from his book " Applied Colloid Chemistry."

Of the subjects which at an early stage attracted Bancroft's interest, one may mention the preparation and properties of emulsions.

In order that a permanent emulsion may be produced on shaking together two immiscible liquids, *e.g.*, water and oil, an emulsifying agent, such as soap, must be added. It is, of course, clear that two different emulsions are possible, an emulsion of oil in water and an emulsion of water in oil. According to the adsorption-film theory of emulsions put forward by Bancroft, an emulsifying agent is adsorbed into the surface separating the two liquids and forms there a coherent film. This film, if in contact with two phases, oil and water, will have two surface tensions, and will tend to curve towards the side having the higher surface tension. The dispersed liquid, therefore, is on the side of the film having the higher surface tension. Since soaps of univalent cations (Na^+,K^+) are readily dispersed in water but not in oil, they form a film which is wetted more readily by water than by oil. Consequently, the surface tension is lower on the water side than on the oil side, and the film tends to curve so that it encloses globules of oil in water. Thereby the area of the side of the film of higher surface tension is reduced compared with that of lower surface tension. Soaps of bivalent cations, however, are freely dispersed in oil, but not in water, and the film is wetted more easily by the oil than by the water. Thereby the formation of globules of water in oil is favoured. According to this theory, the preferential wetting of the adsorbed film by water or by oil is an important factor.

The theory put forward by Bancroft was investigated more fully by his pupils, more especially by G. H. Clowes, and the antagonistic action of Na^+ and Ca^{++} on oil–water emulsions established. This antagonistic action of ions has been found to be of great importance not only in the interpretation of many biological phenomena but also in the oil industry.

In Bancroft's view, surface adsorption was a factor of the greatest importance in many diverse phenomena. In the development of the photographic plate, for example, Bancroft was the first to suggest that adsorption of the developer on the silver bromide grain is the important thing, a view which was later worked out more fully by Sheppard. " If the reducing agent is adsorbed much more strongly by exposed silver bromide than by unexposed silver bromide, the former will develop more rapidly than the latter, and we shall get a negative. If the reducing agent is adsorbed more strongly to unexposed than to exposed silver bromide, we shall get a positive. If there is not much difference in the adsorptions, we shall have exposed and unexposed silver bromide developing at so nearly the same rate that we get a more or less uniform fogging."

Sensitisers, also, of the photographic plate, Bancroft pointed out, must be such that the dye is adsorbed strongly by the silver bromide, does not bleed into the gelatin sufficiently to act as a colour screen, and is a reducing agent powerful enough, when exposed to light, to produce a latent image on silver bromide.

In 1922 the First Report, and in the following year the Second Report, of the National Research Council's Committee on Contact Catalysis were published in America. Both reports were written by Bancroft, the chairman of the committee, and were a very stimulating and valuable contribution to the study of contact catalysis. In these reports, which appeared at a time when contact catalysis was largely an empirical art, Bancroft not only showed the position which had been reached but also pointed out what were the fundamental questions which had to be answered and indicated many problems, minor or major, which called for investigation.

For Bancroft, contact catalysis formed an aspect of colloid chemistry and embraced phenomena in which adsorption and surface action play an important part. Two things of fundamental importance, he suggested, had to be done: (1) to determine in what cases definite intermediate compounds are formed, and what they are; (2) to determine what bonds and contravalencies are opened when adsorption takes place and to show that the opening of these bonds and contravalencies accounts for the formation of the reaction products. Later, Bancroft pointed out that the attempt to determine in which group a particular reaction falls, whether there is formation of definite compounds or of indefinite complexes, had led to the brilliant work at Princeton on catalysis at an interface.

In the activation process, however, adsorption is only one factor. "In organic chemistry we get activation and reaction as a result of the formation of radicals . . . The conclusion to be drawn is that the organic chemistry of the future will deal with the reactions of radicals instead of the reactions of the molecules."

Even if it might be difficult to point to direct experimental contributions by Bancroft to the solution of the problems of contact catalysis, there can be no doubt that through his writings he did much to define and clarify the *science* of catalysis and to encourage others to carry out the necessary experimental investigations.

Towards the end of his academic career Bancroft took up the study of anæsthesia, drug addiction, and insanity from the standpoint of colloid chemistry. It can be accepted that for the normal, healthy functioning of the animal organism, a certain balance must be maintained between the degree of dispersion or the hydration and dehydration of the body colloids. Starting with Claude Bernard's theory that the reversible coagulation of the colloids of the sensory nerves produces or accompanies anæsthesia, Bancroft and his co-workers concluded from their experimental investigations that narcotics coagulate reversibly the cell colloids and, conversely, that a reversible coagulation of the cell colloids, however, produced, will cause narcosis. At low concentrations, narcotics may have a stimulating effect by decreasing the stability of the colloids. Similarly, the action of drugs, such as morphine, is due to a coagulation, reversible or irreversible of the nerve colloids. Administration of peptising agents, such as sodium thiocyanate, will facilitate return to normality.

A relation between the state of flocculation or deflocculation of the brain colloids and mental disorders was also believed to have been established, different forms of mental disorder depending on whether the coagulation of the colloids was too great or too little.

The conclusions reached by Bancroft and his fellow-workers led to much controversy and were not entirely confirmed by other research workers. It seems very clear that, although the state of aggregation or dispersion of brain colloids no doubt has a bearing on the physiology of narcosis and insanity, factors of importance other than those considered by Bancroft enter in and affect the colloid state.

On many other problems in colloid chemistry and other sections of physical chemistry, Bancroft shed a powerful light which was both exploratory and clarifying, and the inspiration of his enthusiasm and critical exposition still lives.

For particulars about Bancroft I am indebted more especially to his son-in-law, Professor M. L. Nichols, of Cornell University.

ALEX. FINDLAY.

JOSEPH MICHAEL CONNOLLY.

1913—1952.

JOSEPH MICHAEL CONNOLLY was born in Loughborough, Leicestershire, on June 3rd, 1913. He was educated at the Loughborough Grammar School (1924—1930) and proceeded to the Loughborough College, where he studied in the Department of Pure and Applied Science, taking the Honours Diploma of that institution and the external honours B.Sc. in chemistry of London University in 1933, both with 2nd Class Honours. During the period 1933—1936 Connolly acted as research assistant to the writer and took his Ph.D. of London externally in 1936. His publications with the writer included several papers in the *Journal* on the chemistry of thiocarbonyl tetrachloride (*J.*, 1934, 822; 1935, 679; 1937, 827).

In 1934 he was appointed as demonstrator in the Department of Pure and Applied Science at Loughborough, and became a full lecturer in 1934, and senior lecturer in 1951. During the latter part of the last decade, however, he became seriously ill with disseminated sclerosis and, although the condition never affected his normally cheerful disposition, both he and his friends knew that the only termination could be a fatal one, and he succumbed to the malady on June 28th, 1952.

Quiet and reserved in nature, Connolly was an excellent chemist, a painstaking teacher and lecturer, and an invaluable member of the department; in private life he was a man of the highest integrity, a pleasant companion, and of that serene disposition which contributed so greatly to his enjoyment of family life. He is survived by his wife and daughter, and will be held in affectionate remembrance by his colleagues and pupils.

G. M. DYSON.

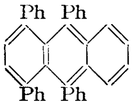
JOSEF LEON HASKELBERG.

1902—1953.

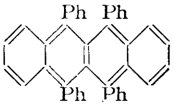
ON January 17th, 1953, death brought to a premature end the scientific career of Dr. Josef Leon Haskelberg, member of the Daniel Sieff Research Institute at Rehovoth, Israel.

Born on December 28th, 1902, in Warsaw, and educated there, Haskelberg enrolled at the University of Liège in Belgium. Very early in his studies, however, he joined the group of people who were inspired by the idea of a Hebrew University in Jerusalem; he drew the logical conclusion from this idea and emigrated in 1924 to Palestine, where he became one of the first students in the Department of Chemistry at that University and, indeed, one of the pioneers of chemistry in the country. As at that time the Hebrew University did not confer academic degrees, he went in 1928 to Paris to complete his studies at the Sorbonne and receive his degree of D.Sc. In 1933, he returned to Palestine to become (in 1934) one of the Seniors in the Department of Organic Chemistry and Biochemistry at the newly created Daniel Sieff Research Institute.

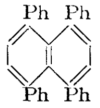
Haskelberg was an organic chemist in the classical sense of the word. His main interest was in the synthesis of new compounds of possible theoretical and practical interest; he enjoyed the art of synthesis and the preparation of well-defined, beautifully crystallised compounds. In accordance with the general line of work at the Sieff Institute, he specialised in the field of polycyclic aromatic and of potentially chemotherapeutic substances. Amongst the former, the highly phenylated derivatives of the fundamental aromatic hydrocarbons attracted his interest, because of the influence such substitution was bound to exert on their fine structure. Thus, he succeeded in preparing the dark-yellow 1 : 4 : 9 : 10-tetraphenylanthracene (I) which resembled the red rubrene (II) in its autoxidation, its spectrum—which is devoid of all fine structure—and even in its isomerisation under the catalytic influence of acids. Haskelberg's last—unpublished—investigation in this field was directed towards the lower homologue of (I) and (II), 1 : 4 : 5 : 8-tetraphenylnaphthalene (III); the essential step in its synthesis was the diene condensation between the tetraphenylated benz*iso*furan (IV) and maleic anhydride. The hydrocarbon (III), a yellow compound, turned out to be the first photo-oxidisable naphthalene derivative and thus a true homologue of (I) and (II). The obvious deformation of the naphthalene system, caused by the two pairs of phenyl rings, recalls the recent observations by Kloetzel, Dayton, and Herzog (*J. Amer. Chem. Soc.*, 1950, **72**, 273), Abadir, Cook, and Gibson (*J.*, **1953**, 8), and Donaldson and Robertson (*J.*, **1953**, 17) on poly*methylated* naphthalenes.



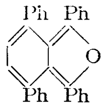
(I)



(II)



(III)



(IV)

In the chemotherapeutic field, Haskelberg's work was devoted to the preparation of lipophilic derivatives of parent substances, known or likely to exhibit therapeutic activity; it was hoped that these derivatives might be active against the acid-fast bacteria, because of the affinity between the fatty envelope of these bacteria and the lipophilic substituents, and against bacteria which had invaded the lymphatic system of the body. Haskelberg found that introduction of long-chain alkyl or acyl groups, of steroid radicals, and also of highly halogenated side-chains, conferred on many drugs affinity to lipoids; indeed, some of the substances he prepared proved active against tubercle bacilli. These studies were interrupted by the Second World War and were not continued later, as the problems of tuberculosis therapy had in the meantime found other solutions. However, occupation with the synthesis of chemotherapeutic substances enabled Haskelberg during the Second World War to organise, and help in, the production of the complicated drugs which were then in short supply in Palestine, *e.g.*, atebrine and plasmoquine. He thus rendered the country and the Allied armies in the Middle East an invaluable service.

Haskelberg had a strong leaning towards agriculture, and agricultural chemicals became one of his favourite subjects. He studied the synthesis of analogues of DDT and of 2 : 4-D and developed a new method for the preparation of the latter and of similar compounds. In particular, he devoted a great deal of effort to the chemistry of castor oil and the substances derived from it, such as undecenoic acid and heptaldehyde. From the former, he obtained, *e.g.*, by the OXO reaction the 12-oxododecanoic acid which could be converted by reductive amination into 12-aminododecanoic acid. Analogously, he studied the oxidative degradation of undecenoic acid to 10-oxodecanoic and 10-aminodecanoic acid; these amino-acids were expected to afford, on polycondensation, polyamides of the same type as 11-aminoundecanoic acid (Genas, U.S.P. 2,462,855; B.P. 591,027; cf. *Chem. Abs.*, 1948, **42**, 592). Also the chemistry of other unsaturated and, therefore, reactive natural fatty acids was studied in similar directions; it is hoped that the results will be published in the not too distant future.

Haskelberg was passionately fond of nature; he devoted his spare time—as much as the laboratory left him—to gardening, and applied his keen sense of observation to the phenomena of plant life not less than to those of organic chemistry. He was a good colleague, a friend always willing to help, a model citizen interested in every problem of the community, and a patriot of his country; during its War of Independence he served in the Scientific Unit of the Israeli Defence Army. His death is a grievous loss not only to his wife and two daughters, but also to his colleagues, his many friends, and the chemists of Israel.

ERNST D. BERGMANN.