BACTERIOLOGICAL NOMENCLATURE
AND TAXONOMY

IN MEMORIAM ALBERT JAN KLUYVER

Dr. Albert Jan Kluyster, Professor of General and Applied Microbiology at the "Technische Hogeschool" of Delft, Holland, died at his home in the night of May 13th-14th, 1956.

Professor Kluyster was born in Breda, Holland, on June 3rd, 1888. During 1910-1916 he served as the assistant of G. van Itersen Jr. at the Botany Department of Delft Institute of Technology. Kluyster was awarded the Doctor's degree at the same Institute in 1914. His Doctor's thesis, entitled "Biochemische suikerbepalingen" is a fundamental contribution to our knowledge of the specific action by microorganisms on carbohydrates and of the quantitative analysis of sugar and sugar mixtures by means of yeasts. In 1921 Kluyster was appointed as the successor of M. W. Beijerinck to the Chair of General and Applied Microbiology at Delft Institute of Technology, and on January 18th, 1922, he gave his inaugural address, entitled "Microbiologie en Industrie." The illustrious period of Beijerinck was now followed by the brilliant era of Kluyster, characterized by restless scientific work with co-operation of a great number of pupils from Holland and abroad under the stimulating leadership of a charming and noble personality.

As an excellent academic teacher Kluyster was beloved all over the world. As a scientific educator he was enthusiastic not only for the research worker and the advanced class, but also for the elementary student. He was ever available for consultation and advice. His gently ironic criticism, as well as his benevolent appreciation of successes and helpful discussion of failures, induced in many students the feeling of being meant for a scientific career. As a matter of fact more than thirty Doctor's theses were prepared under the learned guidance of Kluyster.

Exhaustive studies of the early and current literature combined with the continuous and intimate contact with the experimental work done by his numerous co-workers and pupils in the laboratory made Kluyster a brilliant reviewer of the existing knowledge of the biochemical activities of cells and tissues. Of course he was struck by the surprisingly large diversity in the nutritional requirements of microorganisms as well as by the apparently diverse ways in which various microbial types provide for their indispensable energy requirements. This, however, did not hold him back from looking for principles underlying the bewildering picture of the apparently

infinite complexity of the very different forms of life. Accordingly, he presented the concepts of the "Unity in biochemistry" and the "Comparative biochemistry and physiology" in a great number of excellent lectures and reviews, e.g. "Eenheid en verscheidenheid in de stofwisseling der microben" (1924), "De eenheid in het chemisme van de fermentatieve suikerdissimilatieprocessen der microben" (1924; with H.J.L. Donker), "De katalytische overdracht van waterstof als kern van het chemisme der dissimilatieprocessen" (1925; with H.J.L. Donker), "Die Einheit in der Biochemie (1926; with H.J.L. Donker), "Atmung, Gärung und Synthese in ihrer gegenseitigen Abhängigkeit" (1930), "The Chemical Activities of Micro-organisms" (1931; lectures before the University of London in 1930), "Mikrobenstoffwechsel und allgemeine Biologie" (1933), "Tre Aartiers Fremskridt i Mikrobiologi" (1946; lecture before "Danmarks Naturvidenskabelige Samfund" and "Biologisk Selskab" in 1946 when he was awarded the "Emil Christian Hansen Medal"), "Eenige belangwekkende uitkomsten verkregen bij de toepassing van isotopen in het stofwisselingsonderzoek" (1947; lecture before the "Nederlandsche Vereeniging voor Biochemie" in 1946), "The Changing Appraisal of the Microbe" (1953; Leeuwenhoek Lecture before the Royal Society in 1952), and "The Microbe's Contribution to Biology" (1956; with C.B. van Niel; John M. Prather Lectures at Harvard University in 1954). In these and other lectures and publications Kluver repeatedly drew attention to the fact that the whole of microbial metabolism can be reduced to chains of elementary reactions belonging to a rather small number of types, e.g. transhydrogenation, transphosphorylation, transamination, transsulfuration, transacetylation and transmethylation, in which hydrogen or special groups are split off from one molecule and transferred to a second one. He also very early realized the significance of the phosphorylated energy-rich organic compounds in their capacity to act as material links between the energy-yielding dissimilatory processes (catabolism) and the energy-requiring assimilatory processes (anabolism). Further, Kluver very soon after the discovery of carbon dioxide reduction by methane bacteria (C. B. van Niel; H. A. Barker) and carbon dioxide assimilation by heterotrophic cells (K. T. Wieringa, H. G. Wood and C. H. Werkman) perceived the far-reaching consequences of this discovery for the classical idea of a rational carbon cycle in nature, in which the photoautotrophic green plants and a few chemoautotrophic bacteria assimilate carbon dioxide and convert it into complex organic compounds.

BACTERIOLOGICAL NOMENCLATURE AND TAXONOMY

They thus lift the carbon from the inorganic level to the organic one, while the heterotrophic cells of living animals and most microorganisms mineralize these compounds in their dissimilation processes, thus returning the carbon to the carbon dioxide state. Kluyver has also considered two further aspects of the discovery of heterotrophic carbon dioxide assimilation, namely, on one hand, its importance for our insight into the actively metabolizing cells as systems in which simultaneously a vast number of reversible equilibrium reactions are going on, and on the other hand its significance for the interpretation of dissimilation processes in which the products formed consist of molecules larger than those serving as a substrate. In a lecture given in Helsinki in 1939, published as an article entitled "Die Kohlensäure im Stoffwechsel der Lebewesen" (1939), Kluyver expressed himself on the significance of carbon dioxide as a requisite for all living cells in the following sentence: "Während Plinius sie bald nach dem Anfange unserer Zeitrechnung als 'spiritus letalis' deutete, liegt, angesichts der ans Licht getretenen Unentbehrlichkeit dieses Gases für alles was lebt, vielmehr Grund vor, ihr den Namen zu schenken von 'spiritus vitalis'." The fertilizing influence exerted by this brilliant lecture on the biochemical approach to the problem of heterotrophic carbon dioxide assimilation has been generally acknowledged. In a review published in 1941 under the title "Spiritus Vitalis" (*Chronica Botanica*, 6:337-342) Foster, Carson and Ruben confirm this by the following statement: "To the eminent Dutch microbiologist, A. J. Kluyver, goes the credit for being the first to present an integrated picture of our existing knowledge of the participation of CO₂ in metabolism, especially from the standpoint of comparative biochemistry."

Professor Kluyver has declared: "...since Pasteur's startling discoveries of the important role played by microbes in human affairs, microbiology as a science has always suffered from its eminently practical implications. By far the majority of the microbiological studies were undertaken to answer questions either directly or indirectly connected with the well-being of mankind" (p. 2 in "The Microbe's Contribution to Biology", Harvard University Press, 1956). Nevertheless, he did not forget that he was the second tenant of a Chair of General and Applied Microbiology, founded for the industrial microbiologist Beijerinck at an Institute of Technology. Kluyver was fully aware of the practical aspects of microbiology and we would do injustice to him if we did not take notice

of his fundamental contributions to this field. Among these are to be found reviews, e.g. "Microbiologie en Industrie" (1922; inaugural address) and "Microbial Metabolism and its Industrial Implications" (1952) as well as original works in cooperation with numerous pupils, e.g. on acetic acid bacteria (with F.J.G. de Leeuw and F. Visser't Hooft), lactic acid bacteria (with H.J.L. Donker, C. B. van Niel and H. G. Derx), yeasts (with H.J.L. Donker, F. Visser't Hooft, A. P. Struyk, J. C. Hoogerheide, M. Th. J. Custers and J. P. van der Walt), and molds forming gluconic, citric and kojic acid (with L. H. C. Perquin). Further, Kluyver and his collaborators have made outstanding contributions to our knowledge of the propionic acid fermentation (C. B. van Niel), methane fermentation (C. B. van Niel, H. A. Barker and Ch. G. T. P. Schnellen), butyric acid and acetone-isopropyl alcohol-butyl alcohol fermentation (H. J. L. Donker and J. B. van der Lek), the Coli type of fermentation (E. L. Molt and M. A. Scheffer), bacterial sulfate reduction (J. K. Baars and R. L. Starkey) and nitrate reduction (W. Verhoeven), nitrifying bacteria (T. Y. Kingma Boltjes), sulfur bacteria (C.B. van Niel, F.M. Muller and P.A. Roelofsen), and luminous bacteria (K. L. van Schouwenburg), the cellulose-decomposing bacteria in the rumen of cattle (A. K. Sijpesteijn), the "Tibi-Konsortium" (H.D. Mayer), microbial amylases (F.A.M.J. van Waesberghe), the oxidation-reduction potentials in cultures of bacteria and yeasts (B. Elema, J. W. van Dalen and J. C. Hoogerheide) and the Pasteur-Meyerhof effect (J. C. Hoogerheide and M. Th. J. Custers), etc., etc. Through these and other works, done by the "Delft School" under the encouraging and stimulating leadership of Kluyver, a great many occupants of professorial chairs in Holland and abroad and holders of other academic as well as eminent governmental and industrial positions obtained a solid training in biochemical and microbiological techniques and simultaneously a thorough insight into the marked diversity in the chemical manifestations of life and the general principles underlying the highly different ways in which living cells provide for their energy and nutritional requirements.

Although Kluyver's tastes and training were mainly those of a biochemist and physiologist he paid due attention to the problems of taxonomy and nomenclature of microorganisms, particularly of bacteria and yeasts (partly with C.B. van Niel). He was a member and chairman of the International Committee on Bacteriological Nomenclature of the International Association of Microbiologists and a member of its Judicial Commission.

BACTERIOLOGICAL NOMENCLATURE
AND TAXONOMY

Kluyver also emphasized the adequacy of biochemical and physiological microbiology to devise fruitful approaches to the mechanisms of the transition of nonliving organic matter to living organisms as well as to those of heredity and evolution.

In the course of the thirty-five years, during which Kluyver directed the work at "Laboratorium voor Microbiologie te Delft", he received numerous distinctions. Thus honorary degrees were conferred upon him by Iowa State College, Louvain University, Rutgers University and Swiss Federal Institute of Technology. He was elected to membership in the Netherlands's Koninklijke Akademie van Wetenschappen. The Finnish and Royal Flemish Academies of Sciences made him a Foreign Member. He became a Foreign Associate of the National Academy of Sciences (Washington, D. C.) and an Honorary Foreign Member of the American Academy of Arts and Sciences. Further, he was elected a Foreign Member of the Royal Society and an Honorary Member of the British Society for General Microbiology, of New York Academy of Sciences and of the Society of American Bacteriologists. In Denmark he received the "Emil Christian Hansen Medal" and in England the "Copley Medal" of the Royal Society.

Numerous pupils, scattered all over the world, will ever remember Kluyver not only as a critical and stimulating scientist of strong responsibility and receptivity and with enormous experience and capacity for work, but also as a noble and charming personality of great benevolence giving moral support and evoking enthusiasm, intellectual admiration, deep affection and veneration. He was something of a Confucian gentleman without flaw and without reproach.

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