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BOOK REVIEW

Geschichte der Mikrobiologie. Hans Gunter Schlegel, Deutsche Akademic der Naturforcher Leopoldina, e.v. 1999, Halle, Deutschland

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Professor Hans Gunter Schlegel is a world authority in the field of microbiology. The main subject of his research is chemo- and photolithotrophic bacteria (particularly hydrogen-oxidizing, sulfur, and iron bacteria).

Professor Schlegel is a brilliant lecturer and excellent teacher. Eight editions of his book on general microbiology have been published, two of which were translated into Russian and are extensively used by students.

"Geschichte der Mikrobiologie" (The History of Microbiology) is a rather voluminous (280 pages) treatise, which consists of a preface and 22 chapters that provide a good account of the main stages of development of the science of microbiology (from the 16th century to the middle of the 20th century). The book provides detailed footnotes with references to books in which the reader can obtain further information. A separate section is devoted to the biographies of prominent scholars. Biographic information on other scientists is also given in footnotes.

All of the material is well illustrated. Of the 93 illustrations, 67 are photographs and portraits of eminent microbiologists whose contributions to various areas of microbiology have been most noticeable. The figures and drawings provide an idea of how the technique of microbiology developed. The reader can find a drawing of Leeuwenhoek's microscope and the first of Leeuwenhoek's drawings of bacteria, which he sent to the Royal Society of London. Some drawings (such as those depicting Hoffman's and Pasteur's flasks) refer to the discussion of the origins of life. Other tools, without which great microbiological discoveries would have been impossible, are also shown.

Each chapter provides a historical account of the development of a particular branch of microbiology. Pertinent information is presented in a clear and concise form, which makes the book readable and allows the reader to easily follow the main events in the history of microbiology.

The origins of microbiology date back the sixteenth century. This is explained by the fact that empirical knowledge that had accumulated in the ancient Greece and Roman Empire did not progress for nearly a millennium. The medieval Inquisition cruelly suppressed any progressive ideas that could shaken the established dogmas. Jan Baptista van Helmont (1577–1644) was the first to turn away from scholastic speculations, such as how many angels a needle tip can accommodate, toward experimental investigations.

Early microbiological investigations were primarily aimed at elucidating the causes of infectious diseases. It should be emphasized that Schlegel started his historical search not from the well-known discoveries of Leeuwenhoek, but from the works of Girolamo Fracastoro, who lived about a century and a half before Leeuwenhoek.

Girolamo Fracastoro (1478–1553) was born in Verona (Italy) and received his education in Padua, where he studied literature, mathematics, astronomy, philosophy, and medicine, and began his career as an general physician.

Based on the results of indirect observations, Fracastoro foretold the existence of the causal agents of diseases, which he named "seminaria." He used this term in the sense in which we now use the term "microorganisms." Paradoxically, the foundation of the today's theory of infectious diseases was laid by a man who had never seen microorganisms.

In the following chapters, Schlegel discusses the organisms discovered by Leeuwenhoek, which he called "animalcules" (ganz kleinen Tierchen). Surprisingly, the influence of the fundamental discoveries of Leeuwenhoek on medicine had been limited for centuries.

One chapter of the book is devoted to the history of microscopic technique, from the first primitive Leeuwenhoek's microscope to the complex optical microscopes of Zeiss, and then to the first electron microscope of Marton and Ruska. Unfortunately, the author of the book does not mention the striking discoveries that were made as the electron microscopic technique continued to develop.

Much discussion in the book is centered on the origin of life. Schlegel emphasizes that the search for the experimental bases for the theory of spontaneous generation, according to which living organisms originate from inorganic matter, has stimulated bacteriological

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investigations in the 17th–19th centuries. As he notes, it took a good amount of time to admit that the life of any living organism originates not from nonliving but from a living things: omne vivum ex vivo (every living thing comes from the living thing). So much emotion has been spent, so many lances have been broken, so many passionate discussions, and ingenious experiments have been carried out for this point of view to be accepted!

Among those who took part in this discussion was Francesco Redi, with his well-known biological dictum omne vivum ex ovo (every living thing comes from the egg), which is often erroneously attributed to Harvey, and which later transformed later into omne vivum ex vivo. Redi's opponents were John Turberville Needhan, Georges-Louis Leclerc de Buffon, and others. His attitude was experimentally confirmed first by Lazzaro Spallanzani and later by Schulze, T. Schwann, Schroeder, Coon, and Koch. Conclusive experimental evidence was obtained by Louis Pasteur, for which he was awarded the Paris Academy of Sciences prize. Since that time, the problem of generatio spontanea (spontaneous generation) has no longer been discussed, and the statement "omne vivum ex vivo" was concluded to be valid for microorganisms as well.

In subsequent chapters, the author considers the problem of alcoholic fermentation. There was a controversy between mechanists (Liebig, Berzelius, Weller, and others) and vitalists (Pasteur, Schwann, de Latour, and others) in regards to this problem. Unlike vitalists, who believed that alcohol fermentation was due to the activity of special microorganisms, Liebig, who headed the mechanists, erroneously thought that fermentation is a purely chemical process that occurs without the involvement of living organisms.

Liebig's article "On the Unravelled Puzzle of Wine Fermentation," a large portion of which is cited by Schlegel, belongs to the remarkable documents in the history of microbiology. Although the article is witty and sharp-tongued, and perhaps amused the scientific community, it indicates how tactless, supercilious, and haughty the opponents of a new point of view can be.

In the chapter devoted to bacteria as a new and specific group of organisms, Schlegel mentions the names Otto Fridrich Muller (the 18th century scholar who was the first to attract attention to the diversity of microorganisms), Ferdinand Coon (one of the first taxonomists of bacteria), and Robert Koch, whose contribution to bacteriology is especially great. Koch developed methods for obtaining bacteria in pure cultures, he discovered a number of the causative agents of infectious diseases, and he postulated three principles for discerning the causative agents of infectious diseases, which are known as Koch's triad. These methods are used today in bacteriology with only minor modifications, and, as Schlegel notes, their development can be considered as one of the greatest achievements of humankind.

The French microbiologist L. Pasteur discovered the phenomenon of immunity, and is the author of some fundamental achievements in this field of science. Other prominent immunologists were P. Ehrlich, who devised the principles of standardization of bacterial toxins and serum antibodies, and I.I. Metchnikoff, who considered immunity to be a defense response of an organism to the invasion of another foreign organism, and who devised the theory of phagocytes. Both the theory of antibodies and the theory of phagocytes turned out to be two sides of the united theory of immunity, which won a Nobel prize. Schlegel also provides an account of the collections of pure cultures of microorganisms, which became available with the development of the pure-culture methods. The Kral collection in Prague, which was established in 1890, is the world's first known culture collection.

A large part of the book is devoted to the problem of fermentation. The author notes that the investigations of Schwann and Pasteur on fermentation had great resonance in the scientific world and work was continued by M. Traube, V. Kune, and F. Hoppe-Seyler. Traube was the first to suggest that fermentation is accomplished by catalytic agents (enzymes), although the term *enzyme* was introduced by Kune and, in spite of being greatly criticized by Hoppe-Seyler, soon became the generally accepted term.

Studies of fermentation processes led to the development of so-called biotechnology (technical and industrial microbiology), which uses microorganisms as the producers of many valuable substances. Schlegel presents a number of interesting facts about how biotechnological processes can be used in industry and even in the household.

Other chapters are devoted to the study of metabolic pathways and their regulation. By the early 1930s, bacteria were already extensively used as models for investigating fundamental biochemical processes. Characterizing this situation, A. Kluyver exclaimed: "From the elephant to butyric acid bacterium, it is all the same!" (1926).

The recognition of the identity of fundamental biochemical The research involved processes in all living organisms beneficially influenced the investigation of molecular biological problems, such as the mechanism of DNA replication, DNA transcription, RNA translation, and membrane functioning. Microorganisms proved to be very suitable objects for genetic analysis due to their abundance and short lives. It took some time, however to appreciate these advantages of microorganisms.

The reader can also trace how the mutations in microorganisms were discovered. Schlegel notes that M. Beijerinck was the first to reveal bacterial mutations. The method of replication, which was proposed by I. Lederberg to study bacterial mutations, was soon widely used and stimulated numerous investigations into metabolic pathways and their regulation.

An entire chapter of the book is about the history of discovery of bacteriophages and plasmids. It seems that this reads as a criminal story in which the criminal has remained unknown for a long time. The discovery of plasmids as extrachromosomal hereditary elements is described in relation to the bacterial resistance to antibiotics. After the structure of DNA, its replication mechanisms, and the relevant properties of plasmids had been understood, the only remaining experiment was to insert foreign DNA into a plasmid to obtain a hybrid plasmid carrying new genetic information. Such experiments were first carried out by H. Boyer and S. Coen in 1972.

Another chapter is devoted to the fundamental investigations of S.N. Winogradsky, who discovered, as his Strasburg colleagues said, a new mode of life (modus vivendi). This concept formulated by Winogradsky based on his discoveries is one of the pillars of science. To illustrate how these discoveries were made, Schlegel presents short descriptions of Winogradsky's works with detailed descriptions of his experiments on sulfur, iron, and nitrifying bacteria, and his conclusions. Highly appreciative of Winogradsky's contributions to the investigation of nitrifications and nitrogen-fixing bacteria, Schlegel underlines that they were due to the scholar's great power of observation, foresight penetration into the subject, and responsibility for the conclusions made.

Some chapters provide an account of the discovery of phototrophic purple and green bacteria, which are able to utilize light as a source of energy. In the 19th century (the time of discovery of these bacteria) phototrophy was yet unknown as a type of animal nutrition.

The pioneering works on the mechanism of nitrogen fixation by bacteria were performed by O. Meyerhof, M. Voronin, H. Hellriegel, M. Beijerinck, and S.N. Winogradsky.

Attention is also paid to the conceptual evolution of the structure and functions of bacterial cells, which was closely associated with the development of microscopic technique.

Schlegel also considers the problem of symbiosis in nature. Investigations of the symbiotic interrelations between organisms, classical examples of which are lichens and mycorrhizas, were started by Anton de Bary and A. Frank. De Bary was the first to introduce the notion of symbiosis. Further studies involved the investigation of symbiotic relations between various insects, bacteria, yeasts, and fungi. The pioneering studies along this line were performed by Neapolitan researchers. Of great importance for agriculture is the symbiosis between legumes and nitrogen-fixing bacteria, which was discovered by H. Hellriegel and H. Wilfahrt in 1886.

The symbiotic relationships of bacteria in the rumen of grazing animals were investigated by F. Hoppe-Seyler, H. Tappeiner, and V. L. Omeliansky. The historical survey of the problem of symbiosis in nature led Schlegel to the conclusion that the theory of symbiogenesis is well-substantiated.

The problems of systematics and classification of bacteria, which are touched upon to varying extent, to some extent or another, in different chapters, are ferther considered in a separate chapter, with emphasis on the different schemes of bacterial classification.

One chapter is devoted to mycology, with particular attention to the works of de Bary, who greatly contributed to this area of biology by studying the complex life cycles of rust fungi and the causative agents of the disastrous potato disease in Ireland, which led to widespread famine and mass migration of people to the United States.

Schlegel also reports on the fundamental works of Brefeldt, who studied mold fungi, and of Frank, who was the first to discover mycorrhiza (1885). Some attention is given to the use of fungi in genetic experiments.

The coverage of the ecological aspects of microbiology is much less comprehensive because the author restricts his discussion to the 1950s, when microbial ecology was in an early stage of development. The author remarks that the outstanding ecologist H. Odum did not give a single example of microbial ecology in his fundamental ecological treatise published in 1953.

As a whole, the book by Professor Schlegel is a brilliant example of the honest and careful analysis of events that took place in the microbiology scene over the course of its development. The book briefly describes the main lines of microbiological research and the fundamental achievements and discoveries that have contributed to the establishment of this science. As part of world culture, the history of microbiology is a good example of how biological knowledge was utilized at different times and how its infiunce was manifested at those times. The publication of this book on the history of microbiology is a noticeable cultural event.

The reader of the book understands that present-day scientific advances in microbiology originate from groundwork that was laid by researchers over the last 300 years.

The numerous quotations and epigraphs from books written by outstanding people, the witty remarks, and intriguing details concerning particular discoveries, make the book very readable.

This is indeed a worthy book for students and teachers who will surely find much interesting information regarding fundamental microbiological discoveries and discoverers. Regretfully, in surveying the history of microbiology, Schlegel restricts himself to investigatons prior to the 1950s, leaving the exciting discoveries of subsequent years untouched.

T.G. Mirchink