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CRITICISM

A Review of the Textbook *Microbiologiya. Biologiya prokariotov* (Microbiology. Biology of Prokaryotes) by A.V. Pinevich (St. Petersburg: St. Petersburg University Press, 2007–2009, in three volumes, second edition)

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This textbook by A.V. Pinevich, professor at St. Petersburg State University, is a continuation of his massive work encompassing *all fields* of microbiology. His previous textbooks on various special fields of microbiology published by St. Petersburg University Press include A.V. Pinevich and S.G. Averina's *Oksigennaya fototrofia: Rukovodstvo po evolutsionnoi kletochnoi biologii* (Oxygenic Phototrophy: A Textbook on Evolutionary Cell Biology, 2002, 236 pp., 300 copies) and Pinevich's *Mikrobiologiya zheleza i margantsa* (Microbiology of Iron and Manganese, 2005, 374 pp., number of copies unspecified), followed by three volumes of *Biologiya prokariotov* (Biology of Prokaryotes), with the third volume (on cytogenetics) being published in 2009. All these books offer a profound and up-to-date analysis and are reliable manuals. I do not believe that any of our microbiologists are able to meet such a challenge single-handedly. This work is of truly Herculean proportions.

I drew the reader's attention to the number of copies for a reason: the creation of such a textbook is important for all Russian-speaking scientists of the former Soviet Union if only for the sake of standardization of terminology and mutual understanding. I am not sure whether we should completely change over to scientific English, as occurred in Germany. Adequate English proficiency should doubtlessly become the norm for all university students specializing in biology. However, I believe that a complete changeover to English is problematic, although this possibility cannot be dismissed. The book by Pinevich is a university textbook that encourages the reader to think and ask questions along with the author, rather than memorize instructions. The etymological analysis of terminology is very informative, since the terms acquire meaningful content, rather than remain enigmatic hieroglyphs.

All of the book sections were written and designed for maximum clarity. It is obvious that a scientist specializing in a narrow field will be able to find flaws in the description and understanding of the relevant problem; however, it is unlikely that this specialist will be able to compete with the coverage of the field of microbiology as a whole. The requirement of maximum coverage renders the task almost impossible for any specialist, but necessary for lecturers and professors. Pinevich has written a wonderful book with a univocal approach. First of all, it captivates the reader with the feeling of the trustworthiness of the information and involvement in the process of understanding. One may have different views on the problem, as I did when I was reading the book; however, you cannot say that the author is wrong, and, although there are no references in the textbook, professionals can tell you immediately which data were used by the author. It was not only 30 years of experience of presenting a continually revised course of lectures that contributed to the textbook, but also the answers given by his students during examinations, which suggested a balanced description. It is well known that, during lectures, a student acquires information in an emotional context, this depending on the emotional level of the presentation. However, during an examination, quite different emotions are involved. As H.G. Schlegel told me many years ago, he wrote his textbook as a pocket crib note providing solid and necessary knowledge. The result was epoch-making for the microbiological mode of thinking. It should be noted immediately that only people knowledgeable in microbiology, i.e., postgraduate students and, certainly, lecturers or specialists who are aspiring to gain insight into related fields of microbiology, will be able to read and appreciate Pinevich's textbook.

A textbook represents a cross section of knowledge accumulated at the time it is written. By comparing textbooks, one can clearly observe the attitudes and tendencies in a certain field of science in a given period. During the 20th century, in Russia, microbiology was subsequently represented by the textbook by V.L. Omelyanskii, the biology-oriented *The Microbial World* by Roger Y. Stanier et al., the textbook by H.G. Schlegel, and, finally, the translated edition of *Biology of the Prokaryotes* by J.W. Lengler, G. Drews, and H.G. Schlegel. A textbook contains well-established principles that should be accepted as standard for each graduating student. Unlike textbooks, a manual may contain notions and judgments that a graduating student is not required to know and are usually preceded by the phrase "according to..." A textbook should be complete and cover the entire discipline. The primary virtue of a textbook is strict orderliness of knowledge, since, while many facts gradually become out of date, the order is to be kept in mind. These facts constitute the minimum for which our educational establishment coined the elegant term "residual knowledge." Pinevich's textbook provides a picture of the sum of knowledge accumulated by modern microbiology as perceived by a thoughtful specialist. The data are arranged in an accurate four-level table of contents that acts as an efficient search tool. The textbook reflects his position and views on prokaryotes as objects of bacteriology, as follows from the title *Biology of Prokaryotes*.

While reviewing Pinevich's book as a significant event in Russian microbiology, I would like to give a quick overview of the most general views of the author. It is absolutely impossible—and pointless—to recapitulate a book covering "all of microbiology" or itemize its omissions. Needless to say, some sections of the textbook are written with less enthusiasm and thoroughness than the others; however, it is technically impossible to write a textbook on "modern microbiology"; even a brief review in a journal cannot be cutting-edge knowledge.

Volume I describes the cytology of prokaryotes and their biodiversity. Here, two clauses of the author appear interesting. They are expressed in two words, "chimera" and "monad." A monad is defined as an atom of life, a prokaryotic cell; a chimera is defined as a combination of monads. As a matter of fact, I do not unquestionably believe in the supremacy of phylogeny to which the author orthodoxically adheres. Phylogeny is a way to reach the final state in which an object can exist "here and now." This means that functional compliance with the accommodating system gains the lead. I have a different concept of life than the author gives on p. 61: "organic life is a potentially unrestricted expansion of polynucleotide templates, the replication of which occurs in cells, or polyvariant membrane compartments capable of self-reproduction." The polynucleotide templates of viruses do not convince me to consider them independent life forms. Moreover, from a genetic point of view, lysogenized bacterial cells are chimeras. The concept that the author presents on p. 63 is more congenial to my own ideas: "the cell (monad) is the elementary unit of life." Below this, the author gives an explanation of four cellular components, i.e., the membrane, ribosome, cytoplasm, and genome. Self-reproduction as the basic mode of existence of living matter as an elementary unit of life, death as a state alien to nonliving matter, and metabolism as a means of maintaining the metastable state of life remain to be mentioned. All eukaryotic chimeras are integral organisms in terms of functionality and exist in nature as independent units. The problem lies with the level of integration of the system constituents. From whence their parts originate is a secondary issue.

The chapter on the diversity of prokaryotes is wonderfully written. It begins with the table, showing the differences between *Bacteria, Archaea*, and *Eucarya*; however, one should read the textbook from cover to cover to fully appreciate it. The author's comment on "paradoxicality as a law of the phylogenetic system of prokaryotes" (p. 84), which does not conform to the phenotypic (i.e. functional) system, is quite typical. By "paradox" he means the difference between the binary oppositions "prokaryotes–eukaryotes" and the triple division "bacteria–archaea–eukaryotes." Does not this paradoxicality cast doubt on the universality of the modern rRNA classification? The existence of "eukaryology" as a high-quality protistology is quite justified, although the understanding of this area among the microbiological community is absolutely inadequate. Protists and fungi inhabit the same life space as bacteria and exist in the micrometer range of "microorganisms." Classifications exist only in our mind, not in nature. There is no "natural" classification; all of them are creations of the mind, rather than nature, and should be consistent with the target goal. The existence of an organism is determined by its actual functional properties implemented in the ecosystem, rather than by its phantom taxonomic traits. Therefore, among the many possible classification schemata, the one consistent with the target goal should be adopted. Molecular techniques that make it possible to carry out direct in situ studies, as microscopic methods did in their time, have expanded the field of microbiology. The rules of nomenclature denoted by the Code of Nomenclature of Bacteria are to be stated with judicial accuracy even if one needs to memorize the obtuse modern game rules, as in taxonomy, since they are an object of pedantry. At present, the taxonomy of culturable bacteria is reduced to one practical rule: a pure culture deposited in two international culture collections deserves to be given a binary name, the rank of which is determined by quantitative molecular indices requiring no mental effort. Molecular taxonomy is presented in the table (p. 84), showing the 16S rRNA homology levels: the similarity levels between the tree domains and domain phyla are 10 and 10–15%, respectively; the classes of one phylum exhibit different intervals in different phyla; and the similarity levels between orders, families, genera, species, and strains are 82–88, 88–93, 93–95, 95–98, and 98–100%, respectively. All subjectivity is eliminated. This recommendation of the International Committee on the Systematics of Bacteria is based on the classification of one gene, which was arbitrarily accepted as the sole criterion; such classification therefore does not convey any meaning. In practice, rapid multiplication of names occurs according to the scheme colony –> 16S rRNA –> two international collections –> publication in IJSEM. At the moment I am writing this review, 10 000 names exist. The complete genomes of 1000 microorganisms have been obtained. During the period required for the publication of this review, these numbers will certainly have increased. Molecular characterization of the genome will result in a situation in which the requirement for pure cultures in a top-ranked international culture collection specified by the Code will become an archaism. However, the practical use of microorganisms will be awkward without cultures obtained by the methods applied in the 19th and 20th centuries.

The description of cytology of prokaryotic cells is unique among all course books and has been performed at a very high level. It was not without reason that the famous morphologists A.D. Khazarova and Yu.V. Gamaley were the reviewers of this volume. Microbiologists are often taught to think like chemists (homogeneously), while, in the case of organisms, heterogeneous structures are involved; in the case of prokaryotic cells, they are at an ultramicroscopic or, as they say now, nanostructure level. However, the morphological approach used to study prokaryotic cells is not supplemented by the morphology of microcolonies in situ and, especially, by description of the microbial mode of existence in nature in the form of biofilms. The extent of physical adaptation to ambient conditions within a range from tens to hundreds of micrometers (as in biofilms, the most common form of bacterial existence in the physical space of the environment) was neglected. Bacteria excrete slime to create their own colloidal environment, both individual for cells and shared for communities. Until very recently, the geobiophysics of microbiota existence escaped consideration.

Volume II describes the energy metabolism of bacterial cells and, to a greater extent, includes educational material. The description is based on the biochemistry of the protonophore energy-producing system, rather than on the microbial diversity, and names of enzymes dominate over microbial names. Is this concept correct? Microbiology is an organism-level science, and microbial species constitute its primary material. A transition to the intracellular level signifies another level of systemic understanding of the world. Detalization results in loss of the system concept, as well as of the answer to the question "why is it needed?" This question is of a functional nature and suggests the priority of a goal, the goal being the existence of an object under given conditions. When referring to the types of metabolism, Pinevich does not employ the concept of "primary producers" and skips to autotrophy, by which he understands both CO_2 assimilation and the metabolism of C_L compounds (primarily by methanotrophs), thus treating autotrophy as formation of carbon–carbon bonds and substituting autotrophy with "monocarbotrophy" (p. 30). I believe that change in the priority understanding of the terms in the "photosynthesis–chemosynthesis" opposition for primary producers, which has been attempted by other authors as well, is hardly a useful approach. The range of vision limited by the outer membrane is inherent to the dominant field of biology, which tries to convince itself and others of its inherent (intrinsic) worth. This results in a paradoxical feeling that deep insight into a problem results in the loss of its perception in its initial general form. My doubts are based on the priority of functional properties in my own world concept, which are significant for large systems (such as the ecosystem for a bacterial species) and for the entire biosphere, over a single mechanism and, all the more so, over the origin of this mechanism. The question "why is it needed?" precedes the question "how it is achieved?" A goal-oriented description, even if we consider expediency as a superficial feature, results in gaining insight in the system structure, as well as in the organized acquisition of knowledge. Elimination of inexpediency is a result of natural selection.

The third volume deals mainly with cytogenetics. It is written very thoroughly. It can be easily foreseen that complete genomes will be required for description of novel organisms within the next five years. Analysis of the properties of an organism will become a the task for a computer to search for gene sequences. The microbiology of the 21st century is becoming a very different science with a sequencing factory and a design bureau specializing in sequence analysis. Instead of determining the precise genealogy of an organism, combinatorial matrices of functional genes will be provided. Lateral transfer, which microbiologists previously disregarded, is becoming a standard when determining gene sequences. Phylogeny should be reconstructed for each gene and each protein encoded by this gene. In this case, methods of transfer of information and bacterial viruses are becoming essential for microbiology as a specific area of genetic interactions that explains (partially) the observed pattern of microbial biodiversity.

The final section of Volume III deals with synecology. This section was included in the volume concerned with genetics by didactic necessity. Microbial communities are not genetic constructs. They are assembled from diverse material. Their existence depends on ambient conditions requiring quite different scientific knowledge, which, to a great extent, belongs to geography and, specifically, to landscape science. For its existence, microbiota needs a microlandscape moving upward in the hierarchy to higher levels of physical geography. Although we can learn something from metagenomics, the majority of characteristics of the environment belong to the Earth sciences. This field includes such synthetic branches of science as hydrobiology and soil biology in a general sense, these requiring a comprehensive approach for understanding them.

This textbook by Pinevich is a significant event in Russian microbiology. We should thank the author for this work, which sums up the results of 30 years of teaching.

What changes in teaching (in particular, teaching microbiology) are likely to occur in the 21st century? First of all, these changes will be due to the availability of the Internet and electronic means for information processing. It has become incomparably easier to access reference material. The mass and rate of data flow exceed those of data assimilation. Psudeoscientific tabloid journalism poses a certain threat. Therefore, contrary to past notions, systematization of knowledge and the ability to search using descriptive terms are turning out to be especially important. These skills should remain in the memory of each scientist. One can pay much more attention to the understanding of a problem based on fundamental laws and a systematic approach that requires comprehensive knowledge. At the same time, detailed elaboration of each field goes beyond the capacity for memorization. Therefore, the course should be concise, all the more so because the biology of prokaryotes now represents literally the central problem of biology.

The series of books by Pinevich is necessary and useful for biologists.

G.A. Zavarzin