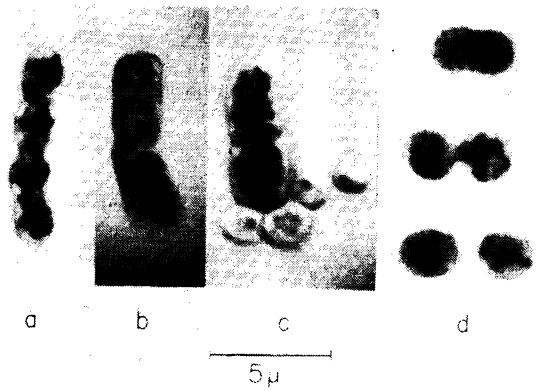

FIG. 3. a–c, Large bodies of *A. agile* M.B. 4.4. In b, the indentation in the side of the cell represents collapse of the cell wall, not incipient cell division. In c, a large body and some smaller cells from the same microcolony. Note the very small cells to the right which have resulted from irregular cell division. In d, normal cells in various stages of cell division. All preparations giemsa stained after treatment with *N*/1 HCl at 58° C for 8 min.

No cell fusions were observed. However, a heterocaryon could be formed by mutation in a multinucleate cell. A satisfactory explanation of the observed phenomena can be made by postulating a mutation which has no effect at low ratios of mutant to normal nuclei, but which interferes with cell division and not with nuclear division when the nuclear ratio exceeds a critical value.

Toxic factors, as the agents responsible for large body formation, were not entirely ruled out by these observations. However, the physical disposition of the cells on the surface of the agar was such that a large body could arise from a cell in direct contact with a normal cell. Because the incidence of large bodies was clonal rather than general, it seems more likely that the expressed effect was genetic rather than environmental.

Since the reported observations were subsidiary to the main purposes of the experiments being undertaken at the time, no further efforts were made to investigate alternative possibilities.

References

1. LÖHNIS, F., and SMITH, N. R. *J. Agr. Research,* **23**, 401 (1923).
2. LEWIS, I. M. *J. Bacteriol.,* **34**, 191 (1937).
3. EISENSTARK, A., WARD, C. B., and KYLE, T. S. *Ibid.,* **60**, 525 (1950).
4. SCHAECHTER, M. *Science,* **116**, 637 (1952).
5. KARLSSON, J. L., and BARKER, H. A. *J. Bacteriol.,* **56**, 671 (1948).
6. ZELLE, M. R. *Ibid.,* **61**, 345 (1951).
7. HANSEN, H. H., and SMITH, R. E. *Phytopathology,* **22**, 953 (1932).

Sergei Nikolaevitch Winogradsky: 1856–1953

Selman A. Waksman

Department of Microbiology, Rutgers University, New Brunswick, New Jersey

SERGEI NIKOLAEVITCH WINOGRADSKY was born September 14, 1856, in the city of Kiev, Russia. His father, N. K. Winogradsky, was a native of Bessarabia, the most southwestern province in Russia. His mother, N. V. Skoropadskaia, came from an old Ukranian Getman family. His father engaged in banking and eventually became director of the first private commercial bank of Kiev. He purchased several estates in the Podol region, in the neighborhood of the town of Gorodok, or Grudok, state of Kamenetz-Podolsk, not far from the city of Proskurov. These estates he combined into one and brought the soil under intensive cultivation, paying special attention to seed selection.

Winogradsky was born and brought up in a large old family house, with an extensive garden, overlooking the river Dnieper. He had two brothers and one sister. His older brother, Alexander Nikolaevitch, received a law education at the University of Kiev, but subsequently became interested in music.

Winogradsky entered the second class of a classical gymnasium at the age of 10 and was graduated from the eighth class, at the age of 16, with a gold medal. To prove his hearty dislike of the bureaucratic atmosphere of the gymnasium, which was characteristic of the Russian middle schools in general, he sold his medal immediately.

In 1873, Winogradsky entered the University of Kiev, where he spent 2 years, at first studying law as his father and elder brother had done, but, tiring of legalistic studies, he soon transferred to the division of natural sciences, in the physico-mathematical faculty. This period at the university left no deep impression upon his development. Although he attended the lectures regularly and passed all his examinations on time, the whole atmosphere of this institution of higher learning offered but little attraction for him.

Science, especially as it was organized at the University of Kiev, failed to satisfy his natural curiosity, and he became interested in music. This led him to the Conservatory of Music at St. Petersburg, where he was admitted to the piano classes of the most brilliant music teacher of that time, Professor Leshetitski, who later became the teacher of Paderewski and of many other famous musicians. Winogradsky developed a deep interest in his work at the conservatory, which left an indelible imprint upon his personality. He soon became convinced, however, that "aesthetic emo-

tions alone, without any activity of the brain, could not satisfy him for very long."

In 1877, Winogradsky entered the natural science faculty of the University of St. Petersburg, which at that time consisted of a group of some of the most brilliant and enthusiastic scientific minds ever gathered at any one time at a Russian institution. Since he was particularly anxious to receive a thorough preparation in chemistry, he began immediately to study analytical chemistry under the leadership of Professor Menshutkin.

On his graduation from the university in 1881, he was invited by the faculty, on the recommendation of the botanist Famintzin, to remain as a candidate in preparation for a professorship. He accepted and, attracted by the epoch-making discoveries of Pasteur and the mycological investigations of deBary and Woronin, began immediately to study microorganisms and their activities.

In 1879, while still an undergraduate, Winogradsky married Z. A. Tichotzkaia, with whom he led a happy married life, which lasted for exactly six decades. The couple had four daughters, three of whom are still living.

Beginning with his graduate work at the university, the life and scientific activities of Winogradsky can be divided into seven periods:

1. *The first St. Petersburg period (1881–1884)*, when his interest in science matured. Though this may be considered as still a period of intensive training, Winogradsky began and completed his first scientific problem, on microbial variation, which proved to be highly successful. During this period, he worked in the laboratory of plant physiology of the university.

2. *The Strasbourg period (1885–1888)*, in which he carried out his first investigations on the autotrophic bacteria. The problems dealing with the sulfur and iron bacteria were begun and completed at the botanical laboratory of the university under deBary.

3. *The Zürich period (1888–1891)*. The study of the organisms concerned in the process of nitrification was begun and nearly completed at the agricultural faculty of the Polytechnicum and at the hygienic laboratory of the University.

4. *The second St. Petersburg period (1891–1905)*. This began with research activities and ended in administrative work, the latter being largely responsible for his subsequent temporary retirement from both. The most important research problems of this period concerned the fixation of atmospheric nitrogen and the retting of flax. The work was done at the Institute of Experimental Medicine.

5. *The period of transition and rest (1905–1922)*. These 17 years were spent by Winogradsky on his estates in the Ukraine, away from scientific work. As a result of political upheaval following World War I and the revolution, he was eventually forced to leave his native country forever. After a few months spent in Jugoslavia, he finally arrived at the Pasteur Institute in France.

6. *The active Brie-Comte-Robert period (1922–1940)*, which signalized a return to scientific work. The problems considered were largely connected with the broad aspects of soil microbiology. This work was done in the Division of Agricultural Microbiology of the Pasteur Institute.

7. *The period of forced retirement (1940–1953)*. During his retirement from active scientific work, he devoted himself to collecting all his papers and translating many of them. His collective work, under the title *Soil Microbiology; Problems and Methods. Fifty Years of Research*,[1] was published in 1949 by the Pasteur Institute in Paris.

Winogradsky was an accurate observer. Many of his early physiological studies, especially on the sulfur and iron bacteria, were made largely by the use of the microscope. His chemical methods were very simple. They always gave valuable results because they were invariably supplemented by careful and most painstaking observation. He always disliked "standard methods" and usually devised his own simple and direct methods for a particular problem. This happy combination of observation and experimentation resulted in his brilliant contributions to microbiology.

Winogradsky attacked some of the most difficult problems in the field of microbiology, and his name will be forever connected with certain phases of this young but rapidly growing science. His investigations dealt primarily with microorganisms of a highly specific physiology, which sets them apart from other microbes. These organisms were recognized as important agents in the cycle of life in nature—transforming such elements as nitrogen, sulfur, and iron in the soil, in the sea, and in sewage—as well as in a great variety of processes upon which the very life of plants and animals is based. Winogradsky was one of the few true pathfinders in microbiology. Among the various groups of bacteria he studied and with which his name has become primarily associated, none is more important and more specific than the group of autotrophic bacteria, with which he began his epoch-making work in bacteriology and which served as the subject for some of his more recent studies.

As a result of the brilliant investigations of Louis Pasteur, Ferdinand Cohn, and Robert Koch, bacteriology developed rapidly from a mere biological curiosity into a science of great practical importance, with numerous ramifications, stretching into the domains of medicine, agriculture, industry, and certain arts. Winogradsky's name is particularly associated with certain special branches of bacteriology, which he not only discovered but also developed to a high stage of perfection. These include, besides his studies on the autotrophic bacteria, his contributions to knowledge of the nonsymbiotic nitrogen-fixing bacteria, as well as his investigation on the oxidation of sulfur, the bacteriology of cellulose decomposition, and the microbiology of the soil. His work thus has proved to be the basis for a better understanding of the nature and physiology of various highly specialized and important groups of bacteria.

[1] *Microbiologie du Sol; Problèmes et Méthodes. Cinquante ans de Recherches.* Paris, Masson, 1949.