The Delft School in America: The Contributions of C. B. van Niel (1897-1985)

Prepared by Jeff Karr, 2016
This slide show illustrating some highlights of the career of Cornelis B. van Niel contains images of materials held in the Center for the History of Microbiology / ASM Archives (CHOMA), located in the Albin O. Kuhn Library, University of Maryland Baltimore County. Visit www.asm.org/CHOMA.
“C. B. van Niel, possibly the foremost microbiologist of [the 20th] century, brought to America in 1929 a new philosophy of general microbiology. He brought the ingenious techniques of Beijerinck and Winogradsky. He brought the comparative biochemistry of Kluyver. He brought the thinking of the Delft School, an inquisitiveness about the vast world of microbes. Along with his own notable research in photosynthesis, he wove these into stimulating concepts which he modestly ascribed to the Delft School, although they were largely the product of his own thinking.”

Robert Hungate, Holger Jannasch and Ralph Wolfe, 1985
Van Niel’s years of study at what is now the Delft University of Technology bridged the careers of M. W. Beijerinck and A. J. Kluyver, and he took lifelong heed of the former’s summary of his own approach to the study of microbes:

“This approach can be concisely stated as the study of microbial ecology, i.e., of the relation between environmental conditions and the special forms of life corresponding to them. It is my conviction that, in our present state of understanding, this is the most necessary and fruitful direction to guide us in organizing our knowledge of that part of nature which deals with the lowest limits of the organic world, and which constantly keeps before our mind the profound problem of the origin of life itself.”
Though his interest was strongly piqued by the purple sulfur bacteria, van Niel was persuaded by Kluyver to write his thesis on bacteriological aspects of the production of propionic acid. His work was published, and the Ph. D. conferred, in 1928.
The Propionic Acid Bacteria
Plate 1

PLATE I.
PLATE CULTURES OF PROPIONIC ACID BACTERIA.

FIG. 1.
Plate cultures from the same suspension of a mixed colony of propionic acid and colon bacteria.
FIG. 2.
Many separate colonies of propionic acid bacteria.
FIG. 3.
Separate colonies.
FIG. 4.
Mycobacterium-like development in heavily inoculated strokes.
Propionib. Petterssonii.

COLONY TYPES OF PROPIONIC ACID BACTERIA.
2nd Series: Propionib. rubrum (19), P. technicum (22), P. Petterssonii (20), P. rubrum (23), P. Jensenii (24).
In 1929, at the behest of L. G. M. Baas-Becking of Stanford University (who was also interested in the sulfur bacteria), van Niel accepted a position at the Hopkins Marine Station in Pacific Grove, California.
“Soon after my arrival, Dr. Walter K. Fisher, Director of the Hopkins Marine Station, inquired about the research program I intended to develop. When I had answered his question in rather general terms, he asked whether I had any plans to emphasize marine microbiology. I explained that my interests covered a broad spectrum, comprising morphology, taxonomy, ecology, physiology, and biochemistry of bacteria, fungi, algae, and protozoa. And, because the fundamental problems pertained to fresh-water and soil organisms as much as to marine forms, it seemed to me unwise to restrict my attention to the latter, whose only distinguishing feature was their occurrence in salt water. “

C. B. van Niel, 1967
“[van Niel] is best known for the discovery of bacterial photosynthesis which couples the oxidation of organic or inorganic compounds to the reduction of carbon dioxide without formation of oxygen. This discovery revolutionized thinking about the chemical nature of the photosynthetic process and led van Niel to develop the concept that the essential feature of all photosynthesis is the photolytic conversion of water to powerful reducing and oxidizing moieties, the former serving for the reduction of carbon dioxide and the latter serving for the production of oxygen in green plants or for the oxidation of various compounds in bacterial photosynthesis. This postulate had an important influence on the development of research in this field.”

H. A. Barker, 1982
Van Niel first presented these findings at a meeting of the Western Society of Naturalists in 1929. Additional studies continued to build upon his linking of bacterial photosyntheses to larger biological processes. This work led to his receiving the National Medal of Science in 1964.

A survey of the large number of oxidation-reduction reactions known to be accomplished by micro-organisms led Kluyver and Donker (9) to their theory of the “unity in biochemistry” based upon Wieland’s ideas and on Boekeken’s dislocation theory of catalytic action. This theory may be briefly formulated as follows:

Each special organism can bring about a specific activation of certain hydrogen atoms in the substratum. When the activation has reached a certain point, this activated hydrogen can be transferred to an acceptor, which, in its turn, is also activated.

The value of this theory as a working hypothesis has been shown by many important contributions in the field of microbial metabolism. It allows, here, a tentative explanation of the metabolism of the purple sulphur bacteria. For if we consider carbon dioxide assimilation (or reduction) in the light of this concept, it follows that, during the well-known photosynthetic reactions of the green plants, the hydrogen of the water molecule is sufficiently activated to be transferred to the carbon dioxide. And it is equally conceivable that other organisms can bring about the activation of hydrogen atoms to the same degree only when they act upon certain other hydrogen compounds.

In this connection attention may be directed to the oxidation of the dextrose molecule by various micro-organisms, all with oxygen as the hydrogen-acceptor. Alisberg (1) has shown that B. Savastanoi converts this sugar into gluconic acid only. But Kluyver and de Leeuw (10) have proved that Acetobacter suboxydans oxidizes both dextrose and gluconic acid into oxygluconic acid. We may say, therefore, that B. Savastanoi can accomplish the first step but cannot go farther and activate the hydrogen of the gluconic acid sufficiently to cause its transfer to the acceptor. Acetobacter suboxydans, on the other hand, can accomplish this but is unable to activate the oxygluconic-hydrogen sufficiently, although a great many microbes are known which are capable of oxidizing the dextrose or the oxygluconic acid still further.

For the process of photosynthetic carbon dioxide assimilation (or reduction) we may then say that the reaction

\[ \text{CO}_2 + 2 \text{H}_2\text{A} = \text{CH}_2\text{O} + \text{H}_2\text{O} + 2 \text{A} \]

requires various and special compounds of hydrogen for various and special organisms. From which it follows that the photosynthetic activity of the chlorophyll-bearing organisms, in which H₂A represents H₂O, rep-

<table>
<thead>
<tr>
<th>H₂S Oxidized</th>
<th>H₂SO₄ Produced</th>
<th>CO₂ Reduced</th>
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<tbody>
<tr>
<td>Calculated</td>
<td>Found</td>
<td>Calculated</td>
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<tr>
<td>Exp. 1, Analyzed after 14 days...</td>
<td>12.7</td>
<td>36.7</td>
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<tr>
<td>Exp. 2, Analyzed after 24 days...</td>
<td>24.8</td>
<td>71.5</td>
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<tr>
<td>Exp. 3, Analyzed after 25 days...</td>
<td>24.8</td>
<td>71.5</td>
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<tr>
<td>Exp. 4, Analyzed after 47 days...</td>
<td>24.8</td>
<td>71.5</td>
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</tbody>
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Contributions to Marine Biology: Lectures and Symposia
Given at the Hopkins Marine Station, December 20-21, 1929, at the Midwinter Meeting of the Western Society of Naturalists
In 1954 van Niel and Kluyver were invited to give the prestigious Prather Lectures at Harvard. From the publisher’s summary:

“[The lecturers] emphasize some aspects of microbiological research which, in their opinion, have contributed significant principles to an interpretation of the behavior of living organisms generally, and which indicate that the microbes may play a crucial role in the eventual formulation of fundamental biological concepts. The various examples also serve to establish the notion of the essential unity in the mode of operation of all living creatures.”
Contents

1. Microbial metabolism and the energetic basis of life, 1
   A. J. KLUYVER

2. Microbial metabolism; further evidence for life's unity, 31
   A. J. KLUYVER

3. Phototrophic bacteria; key to the understanding of green-plant photosynthesis, 73
   C. B. VAN NIEL

4. Life's flexibility; microbial adaption, 93
   A. J. KLUYVER

5. Trial and error in living organisms; microbial mutations, 130
   C. B. VAN NIEL

6. Evolution as viewed by the microbiologist, 155
   C. B. VAN NIEL

References, 177
The Summer Course in General Microbiology
1930-1962
“I attended the Hopkins Marine Station in the spring quarter of 1930 and, on the recommendation of Lewis Thayer, enrolled in van Niel’s course as the only student. The first lecture, on yeasts, was delivered formally and I took notes. Subsequently we sat side by side at a table as he explained microbiology, making notes and drawings on a paper tablet and giving me the notes at the termination of each session. I was enthralled.”

Robert Hungate, 1986
April 2, 1930

Pastor's idea that for every biologic conversion of material, a microorganism was responsible. Data based on fact that sugar fermentation differs, depending on type of organism. Pastor studied alcoholic fermentation of yeast. He found lactic acid bacteria and fermentation of milk; organism for each to be peculiar. Silverman's experiment believed in spontaneous generation. Pastor fought idea. Ludwig thought death of organic compound resulted in microorganisms. Pastor used warm milk flasks to prevent contamination.

By imbibing, Winozorsky, and Pastor later showed any kind of microorganism may be found anywhere. Winozorsky has found them in soil in ditch water. Winogradsky found one more in canning vessels.

As selective methods (Dissociating) the organism is found. Imbibe some medium with inoculum containing all kinds of genus. Those organisms most suitable to the medium will develop. Inoculating, then, the medium will result in survival of these most fitted.

Two selective methods may be employed:
1. Knowing conditions most favorable to a certain organism, giving the conditions will result in finding of that organism.
2. Certain medium may be employed to find what occurs. In order a certain organism can be growing condition, it is essential to be sure the culture is pure. Microscopic examination is a common means of determining purity of culture. Determination of spheroplasts and cultures. Pure culture is grown by obtaining by dissection with single cell. Commercial yeast is considered against cultures. But contamination, with any machinery, would lead to formation of other organisms.

Yeast will develop in some critical, but not under all conditions:
1. Microorganism about 1 gram of yeast.
2. Dissociate yeast into small unit
   a. 25-30°C
   b. 37°C
   c. 25°C
   d. 37°C
   e. 46°C
Hungate prepared an 11-page summary of his work in van Niel's lab in the spring of 1930. He and van Niel remained close over the years, and in 1987 Hungate donated to CHOMA a file of letters (with annotations) he received from van Niel from 1932-1968.
Thanks to a donation by Thomas Brock, CHOMA owns photocopies of van Niel’s notes for each summer course from 1930-1960, as well audio recordings of the final course (1962).

This page contains some of van Niel’s notes for the first (June 22) session of the 1960 course. Detail on following slide.
I. Introduction.

1. What is microbiol? Try to define. The value of rigorous definitions as means to clarity & unambiguous communication; & their deficiency in relation to abstractions...downwards. See Hayakawa, p. 128 ff.

Instead: find context? E.g.: all forms of life start as, i.e., comp. e.g. microbe (Hooke, Schleiden & Schwann, 1839, cell theory). If such unit = entire organism, then microbes (even if it grows very big, like Halicystis?) or if studied as single cell, like Eagle's human (animal) cell lines. In such context, microbes represent life as it simplest form & shows basic features. Clearly recognized by O. Rahn, 1932; in his book on "Bact. Physiol." While practically all the discussion in the book refers to bacteria, the principles developed reach beyond the domain of bacteriology, and apply to biology generally. More than that, I believe that some of the principles of biology can be found and studied only with the simplest forms of life, and that general physiology has much to learn from the physiology of bacteria (p.vi)

To what great extent this has happened since Rahn wrote this book? I hope...become clear during course. I ought to say that, for this very reason...
Ronald Bentley (1922-2011) took the summer course in 1960; the three notebooks he maintained are part of the CHOMA collections. The following two slides contain his notes on the same June 22 session outlined by van Niel in his own notes (previous slides)
June 22, 1960

Microbiology

Definition: What is a micro-organism?

"Language in action" by
- quote a definition in general.

Course is more concerned with concepts than definitions.

Hooke, early 17th cent.
Schleiden & Schwann, 1838 "Cell Theory".
Organisms are built up of elementary units, the latter being called cells.

How does this hold up?
- E.g., slime molds - not composite of cells, but large masses of material, with some differentiation later.

Is an egg to be considered a micro-organism? No - part of a larger unit.
But H. Eagle's refers to tissue culture of animal cells as microbiology.

Under microbiology, consider anything that comes in handy. General grip of techniques, general approach.
Anything set for study by microbiological techniques.

Possibility for study under controlled conditions - & results immediately applicable to all other living things. Very simple forms of life - & fundamentals of life generally applicable.

Otto Rahn 1882 in "Physiology of bacteria" - principles reach far beyond the domain of bacteriology. Some fundamentals probably only to be studied with bacteria.

Should not therefore, study of biology start with m.o.? To use build up knowledge on the basis of experience - largely plants & animals.

Levels of understanding.

Not permissible to extrapolate.

Some fundamentals found in m.o. Not all.

Find complexes of different kinds of organization. More organization - more properties. Fundamental properties not encountered at
In recognition of van Niel’s scientific contributions and the landmark influence of the summer course, in 2004 ASM designated van Niel’s laboratory at the Hopkins Marine Station as a Milestones in Microbiology site.

The ASM Milestones in Microbiology program recognizes institutions and the scientists who worked there that have made significant contributions toward advancing the science of microbiology. By placing explanatory plaques at these sites, ASM hopes to increase professional and public recognition of the significance of the science of microbiology.

For more information on this program visit the Milestones home page.
The Milestones celebration also occasioned a reminiscence from Moselio Schaechter, who took the summer course in 1959, as well as a brief historical article from Susan Spath.

van Niel’s Finishing School

The heyday of van Niel’s course in the 1950s and 1960s coincided with the development of molecular biology. Because this was a microbial science, it seemed like a good idea to many—especially those entering from other fields such as physics—to learn something about microbes. A paradox ensued: most of the work in the fledgling science of molecular biology was being done with *Escherichia coli* and its phages, but these were topics that van Niel barely mentioned. So, why was his course so popular that eminent molecular biologists as well as their apprentices flocked to Pacific Grove as inexorably as the swallows coming (far down the coast) to Capistrano? Mind you, the course was meant principally for Stanford undergraduates, with the heavyweights being allowed as auditors only.

Two answers suggest themselves. One is that the master was not just a teacher but also a magician. All who took the course reported that they had come under his spell. To wit, who else could keep an audience at the edge of their seats and with pencils poised for 8 hours or more of lecture in one day? Who else, on other days, would lead the class in a discussion that, hours later, ended with the conclusion that a certain experiment would solve the problem, only to find that the equipment for just THAT experiment was ready at the back of the room? All this was being witnessed by a wise old sea anemone that had been living in a tank in the laboratory for over 20 years. I can attest to the fact that the van Niel spell can last a lifetime.

The second reason derives from the meaning of the Delft School of microbiology to which van Niel had made stellar contributions. The early days of microbiology included not only its better-known medical discoveries, but also exceptional work on the role of microbes on the cycles of matter in nature by Beijerinck, Kuyper, and their students. They came to the realization that, in Kuyper’s words, “Civilization owes much to the microbe.” He could have added: “and so does all of life.” Although the Delft school followed a different development than molecular microbiology, it was held in high esteem. It carried so much authority that taking a course taught by one of its eminent members was considered a sure way to learn about microbes in general. There may well have been some unintended consequences. I wonder how many people who came to Pacific Grove to take a course that might give them a license to work with *E. coli* came away with the big picture of the rest of the microbial world instead. Not a bad bargain.

Moselio Schaechter
San Diego State University
San Diego, Calif.
Van Niel had an abiding interest in bacterial taxonomy. Beginning with his doctoral thesis and in several subsequent works, he stressed that any system of classification should be based on phylogenetic relationships: “A true reconstruction of the course of evolution is the ideal of every taxonomist.”
In summarizing the “Outline of a rational system for bacterial classification on the basis of our present knowledge,” (Part IV of this paper) van Niel and Kluyver conclude:

“…it appears likely that the idea which is largely responsible for the outline, viz. the occurrence of both morphological and katabolic evolution in the bacterial kingdom, will reappear in future classifications, thus perhaps justifying the use of the word prospects in the title of this paper. In the meantime the system in its present imperfect shape may well serve the purpose of stimulating interest and research in this field.”
“By 1946, van Niel no longer believed that a taxonomic system based on phylogenetic considerations was possible in view of the relatively few morphological properties of bacteria, the general absence of developmental processes, and the probability of the occurrence of both convergent and divergent evolution in the development of existing groups….By 1955, van Niel had become skeptical of the possibility of separating bacteria and blue-green algae from other organisms on the basis that they lacked nuclei, plastids, and sexual reproduction.”

H. A. Barker and Robert Hungate, 1990
In 1962, van Niel and Roger Stanier addressed the “abiding intellectual scandal” of bacteriology by attempting (finally, they hoped) to define the concept of a bacterium. The prokaryote/eukaryote distinction they offered became the ruling paradigm of the science for several decades.
Van Niel served as President of the Society of American Bacteriologists (now ASM) in 1954. His presidential address was subsequently published in *Bacteriological Reviews*.
Upon Kluyver’s death in 1956

“I learned that a group of Kluyver’s admirers, mostly former students residing in the Netherlands, were planning a book in memory of the Master. It was deemed desirable that it be published in English, but many of the articles selected and solicited for inclusion had been or were being written in the Dutch language, and I offered to prepare the English translations. I had also accepted an invitation to write an evaluation of Kluyver’s contributions to microbiology and biochemistry for the book. All together, I spent more than two years on this undertaking. It was a labor of love and a partial redemption of the great debt of gratitude for the incalculable role Kluyver had played in guiding my education and development in much more than just a scientific sense.”

C. B. van Niel, 1967
ALBERT JAN KLUYVER

HIS LIFE AND WORK

BIOGRAPHICAL MEMORANDA
SELECTED PAPERS
BIBLIOGRAPHY AND ADDENDA

1959
NORTH-HOLLAND PUBLISHING COMPANY, AMSTERDAM
INTERSCIENCE PUBLISHERS INC., NEW YORK
In 1996 Lesley Robertson compiled a ‘family tree’ of the Delft School: “We have defined Members of the Delft School as those who had done their doctorate, postdoc or a research fellowship with another member.” In addition, “all of the people, as far as we can tell, who attended the Summer School taught by Cees van Niel have been included”
M. W. Beijerinck Professor of Microbiology, Delft

[1] N. L. Söhnge Professor of Microbiology, Wageningen, the Netherlands
[2] A. Grijs
[3] C. Coolhaas Professor of Tropical Plant Breeding, Agricultural University of Wageningen, the Netherlands

[1] G. van Iterson Jr Professor of Technical Botany, Delft
[2] A. J. Kluiver Professor of Microbiology, Delft University of Technology
[8] A. P. Struyk Gist brocades, the Netherlands
[9] C. B. van Niel Stanford University, USA

[4] R. S. Wolfe Professor of Microbiology, University of Illinois, USA
[5] M. J. Gilchrist Director of Microbiology, Veterans Admin. Medical Centre, Cincinnati, USA
[6] E. Canale-Parola Professor of Microbiology, University of Massachusetts, USA
[7] J. A. Breznak Professor of Microbiology, Michigan State University, USA
[8] J. E. Schultz Cytel Corp., San Diego, USA
[9] C. J. Potrikus Reese Pfizer Central Research, USA
[10] D. A. Odelson Upjohn Co, Kalamazoo, Michigan, USA
[14] M. J. Renner Michigan State University, USA
[16] T. M. Petey Chergen Corp., Maryland, USA
[17] S. Wagener Office of Radiation, Chemical and Biological Safety, Michigan State University, USA
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[10] R. B. Hespell National Centre of Agricultural Utilization Research, Peoria, USA
[12] J. Leadle Chris Hansen Labs, Milwaukee, USA
[13] J. Patterson Purdue University
[14] M. Cotta National Center for Agricultural Utilization Research, U.S. Department of Agriculture, USA
[16] J. Argyle University of Washington, USA

The section shown here is the beginning of the van Niel branch of the family; it goes on for 18 pages.
In 1977, ASM Past-President Helen Whiteley and President Harlyn Halvorson visited van Niel on the occasion of his 80th birthday. The photo described in the first paragraph of his note of thanks is reproduced in the following slide.

The third paragraph offers an interesting observation on his nickname, Kees.
Some Resources