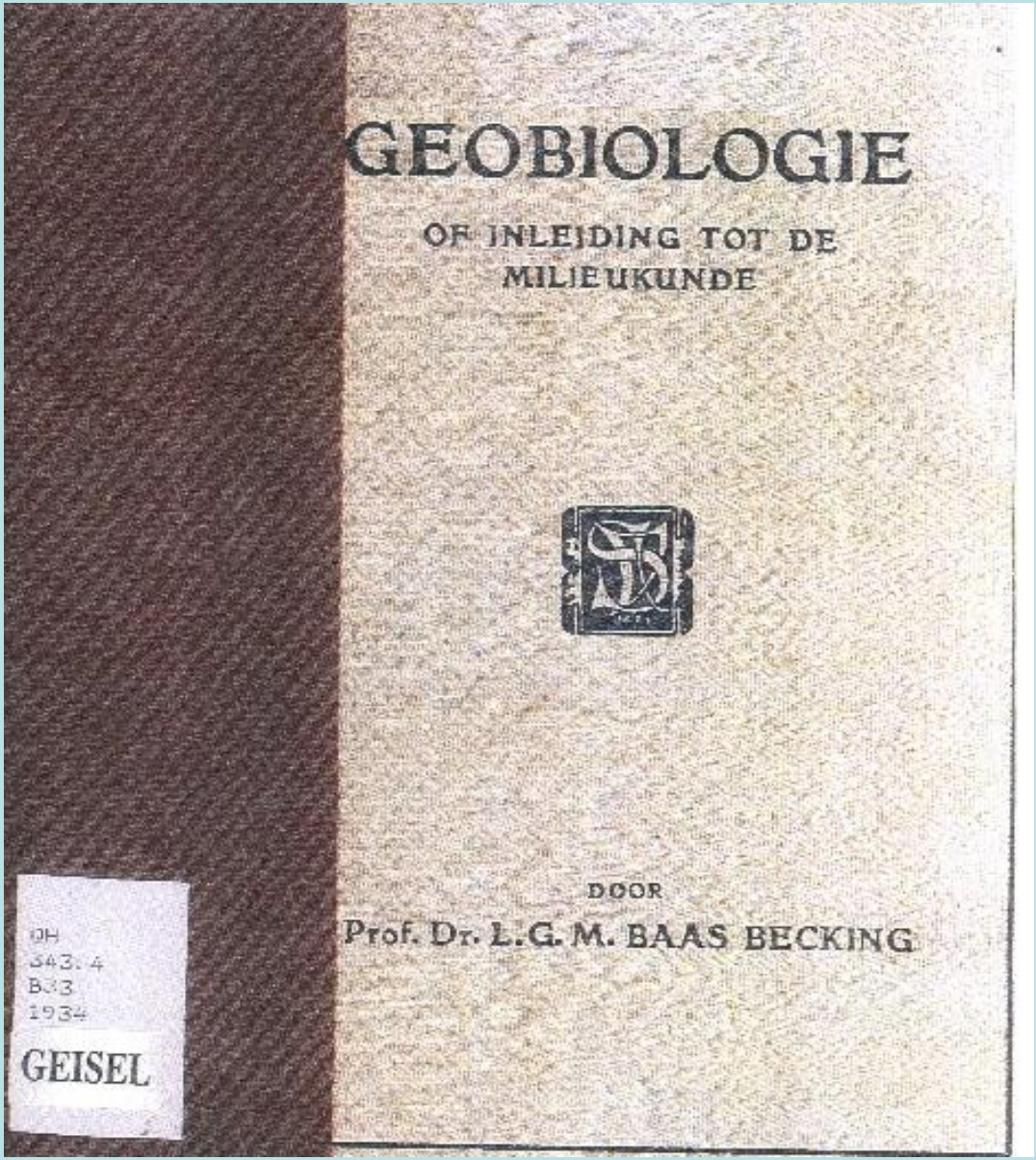
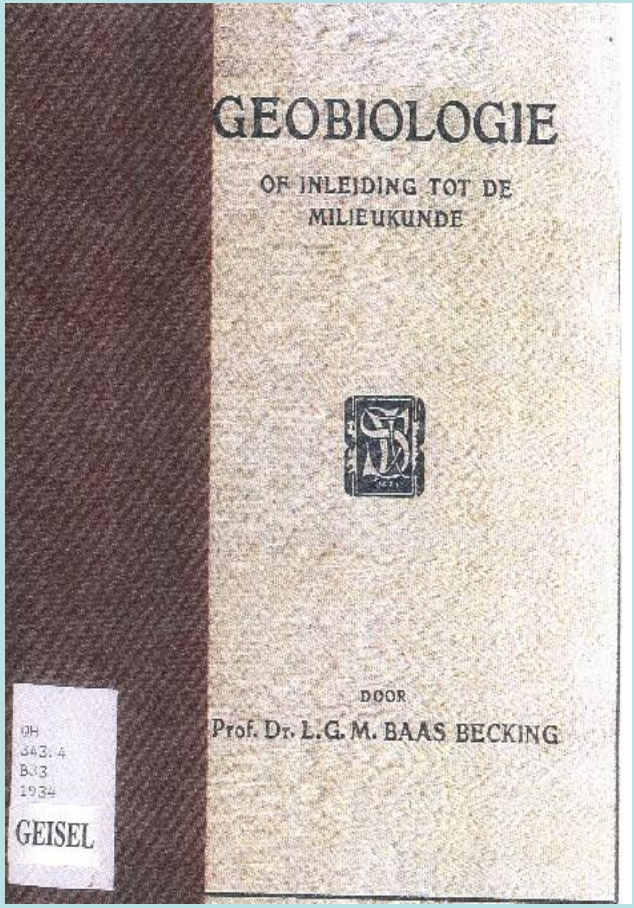

GEOBIOLOGIE
OF INLEIDING TOT DE MILIEUKUNDE
DOOR
Prof. Dr. L. G. M. BAAS BECKING
QH
543.4
B33
1934
GEISEL

Everything is Everywhere, but, the Environment Selects." What ELSE did Baas Becking say about Microbial Ecology in his 1934 Book?

- Donald A. Klein
- Microbiology, Immunology and Pathology
- Colorado State University
- Fort Collins, CO 80523-1682

- 18
- mar15 0918hr.
-

“Geobiology as an introduction to environmental science”



Geobiologie of inleiding tot de milieukunde

Den Haag : W.P. Van Stockum & Zoon, 1934.

18 copies available in libraries around the world, Three copies in N. America.

L. G. M. Baas-Becking 1934

“alles is overal; maar ‘het milieu selecteert’ ”

- “everything is everywhere, but
  the environment selects”

Rutger de Wit and Thierry Bouvier

- Environmental Microbiology (2006) **8** (4), 755–758 doi:10.1111/j.1462-2920.2006.01017.x

http://onlinelibrary.wiley.com/doi/10.1111/j.1462-2920.2006.01017.x/pdf

L. G. M. Baas-Becking 1934

“alles is overal; maar ‘het milieu selecteert’ ”

- “everything is everywhere, but
  the environment selects”
  (Selects for what? To allow functioning)

Rutger de Wit and Thierry Bouvier

- Environmental Microbiology (2006) **8** (4), 755–758 doi:10.1111/j.1462-2920.2006.01017.x

http://onlinelibrary.wiley.com/doi/10.1111/j.1462-2920.2006.01017.x/pdf

L. G. M. Baas Becking – a brief history

Anton Quispel, 1995, Int. Mb. 1: 69-72

- **(Abreviation as "BB," 1895-1963)**
- **Educated at Utrecht,**
- **1923 to Stanford.**

  Jacque Loeb Marine Lab – salt lake studies.

  Two laws - everything is everywhere (but)

  - the environment selects (for function - DAK)

1930 – back to Leiden – botany dept. appt.

1940 - to Java with his family

1940 – brief visit back to Leiden and 5 years in WWII

1948 - to New Caledonia

later to Australia – with P. A. Trudinger

Baas Becking Geobiological Laboratory,

Baas Becking the scientist.

Fig. 1. Professor Lourens Gerhard Marinus Baas Becking in 1935 on board the R.V. '*Max Weber*' close to Texel. Photography by H.C.J. Oomen, reproduced from 'Vakblad voor Biologen' (1983), 13, 230–232 with the permission of the NIBI (Netherlands Institute for Biology).

The layout of the book

- 263 oages total - intro and 10 chapters:
  - **general aspects of environments.**
  - **environmental factors.**

    (light, temp, chemicals)
  - **nutrient cycles.**
  - **oligotrophic and eutrophic waters.**
  - **radiation.**
  - **marine and saline environments.**
  - **Summary.**

BB and Goethe's perspective.

- Chap. 2,- the environment, intro. puote:
- **"Ein kleiner Ring begrenzt unser Leben."**
- "Small is the ring enclosing our life"

  (from "Grenzen der Menschheit")

  the importance of the microenvironment
-

Examples of importance of measurements in the microenvironment:

(1) Hydrogen concentration in An. Digestion

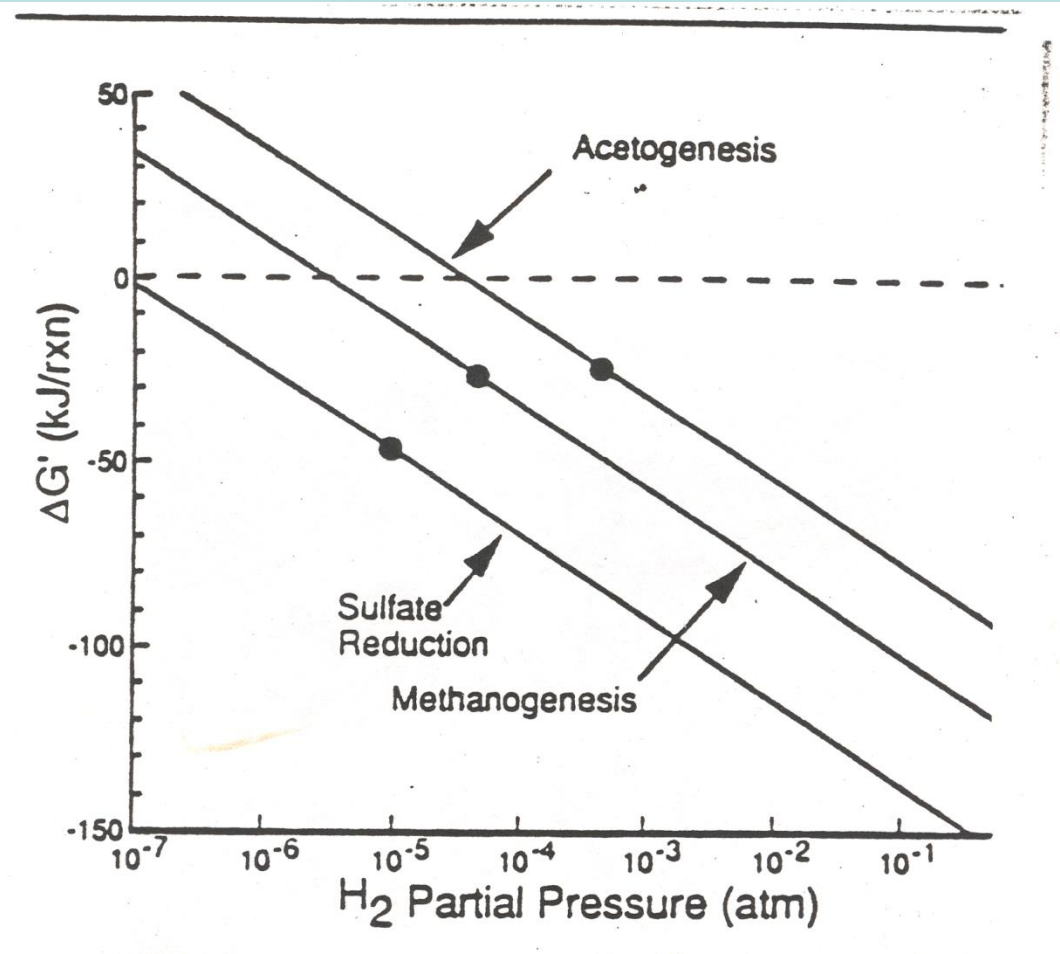
Bulk measurements, H_2 in anaerobic dig.

.

Thermodynamically, won't work!!!

"H_2 transfer occurs within microenvironments of flocs. H_2 conc. is higher than in the bulk fluid"

Effects of H_2 partial pressure on acetogenesis, methanogenesis and sulfate reduction.



H_2 measurement in env critical!

- References:

Hoehler, T. M. et al., 1998, Geochim. et Cosmochim. Acta. 62 (10): 1745-1756.

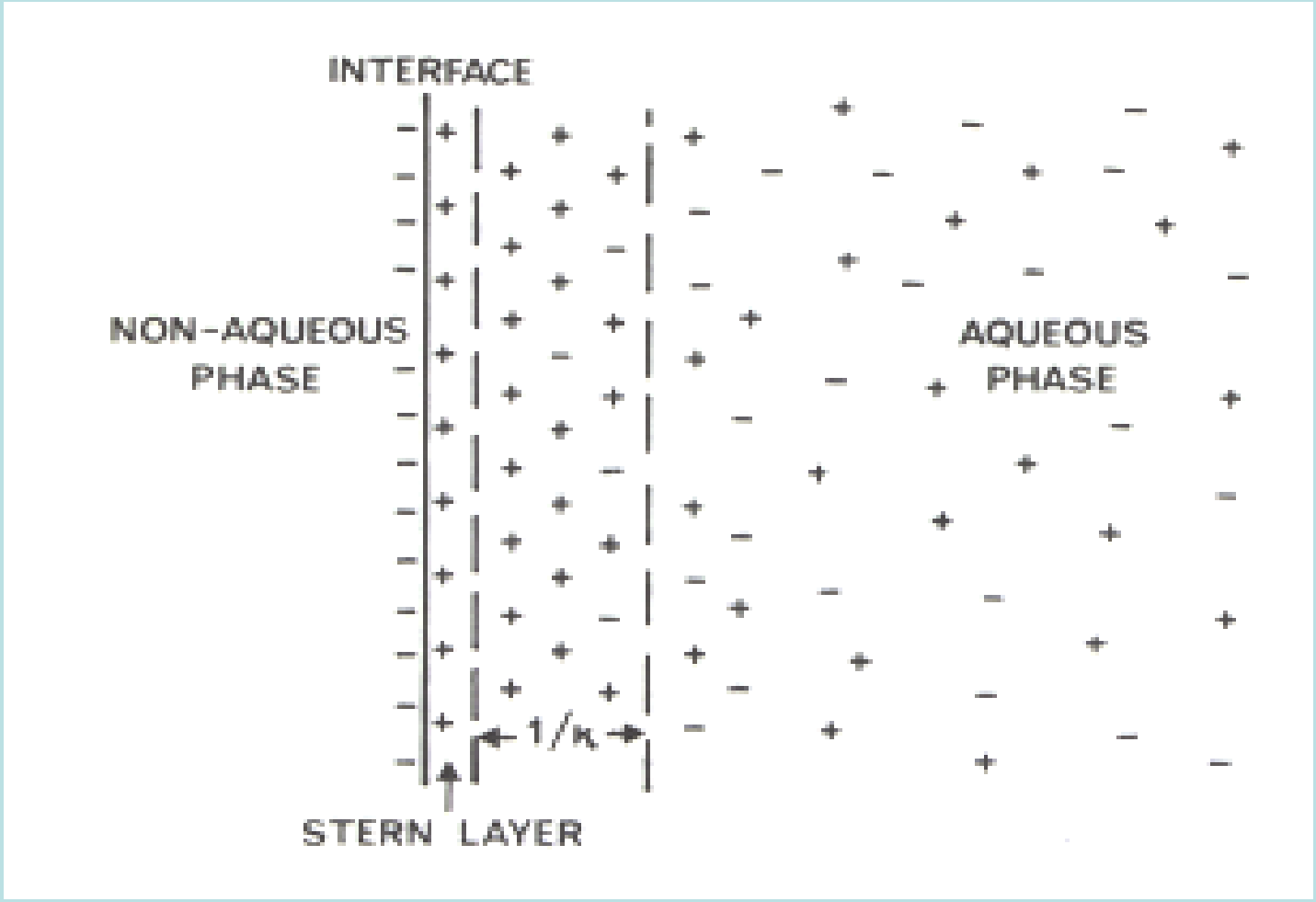
Boone, D. R., R. L. Johnson and Y. liu. 1989. Microbial ecology of interspecies hydrogen-and format- transfer in methanogenic systems. Pp 451-3 in: Recent Advances in Microbial Ecology, T. Hattori et al., (Eds). Japan Sci Soc. Press.

Exampole 2. Charged surfaces and microbial functioning – inert, living, with varied physical characteristics.

- Surfaces have major effects on concentration/repulsion of substances from the surface

- The surface then becomes an environment with different characteristics that the bulk phase.

Interfaces and biological processes: K. C. Marshall – most interfaces in nature have a net negative charge



Nitrification and negatively charged surfaces. McLaren and Skujins

- McLaren, A. D. and J. Skujins. 1963

Nitrification by *Nitrobacter agilis* on surfaces and in soil in respect to hydrogen ion concentration.

Can. J. Microbiol. 9: 729-731

The pH for half maximum nitrification rate is about 0.5 units higher with soil than in liquid suspension culture.

pH optimum for nitrification without and without charged clays (soils) present in solution

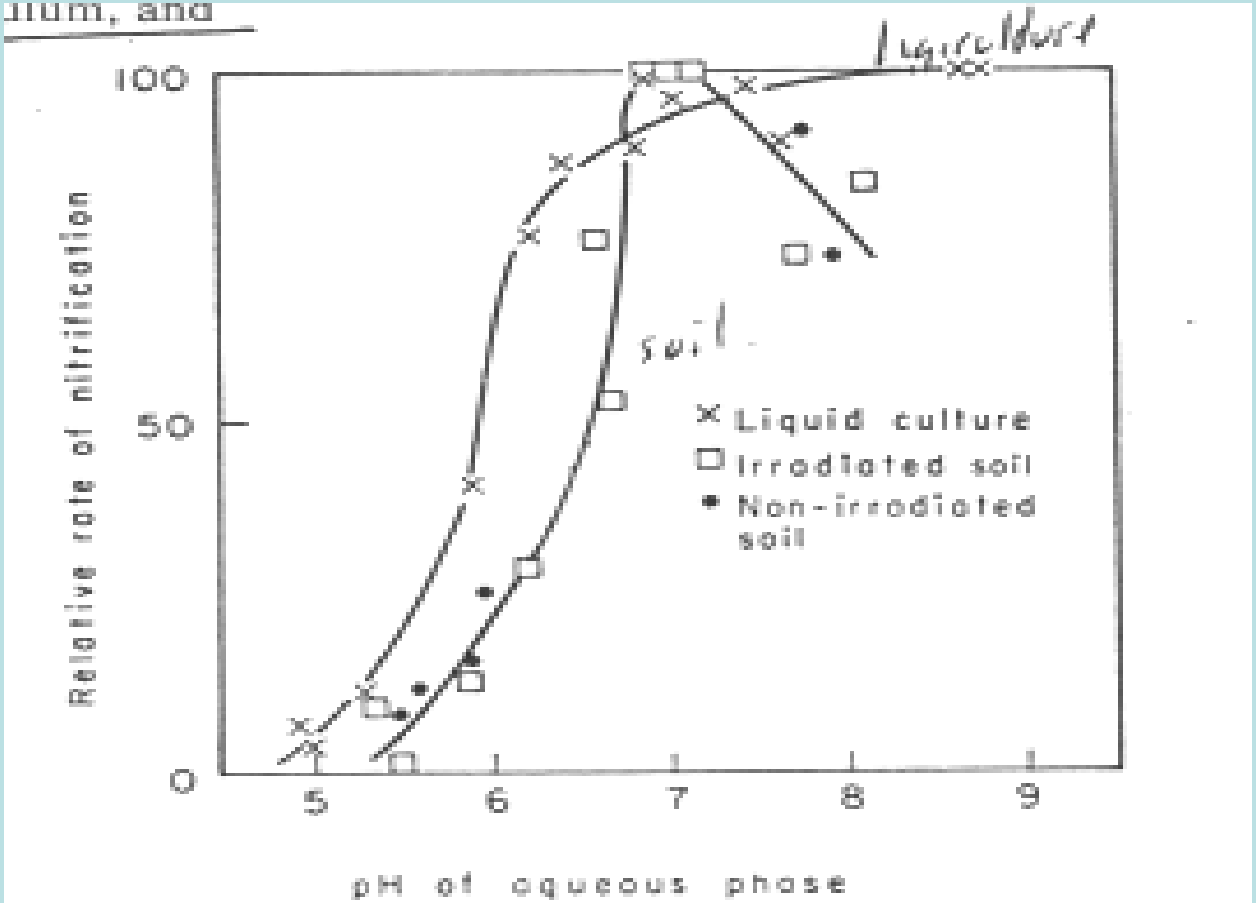


FIG. 1. A comparison of nitrification in soils and in aqueous media.

(2) BB's "Kantian" questions: What is there, by which means, for what purpose?

- Introduction (p. 2)

Wat? What?

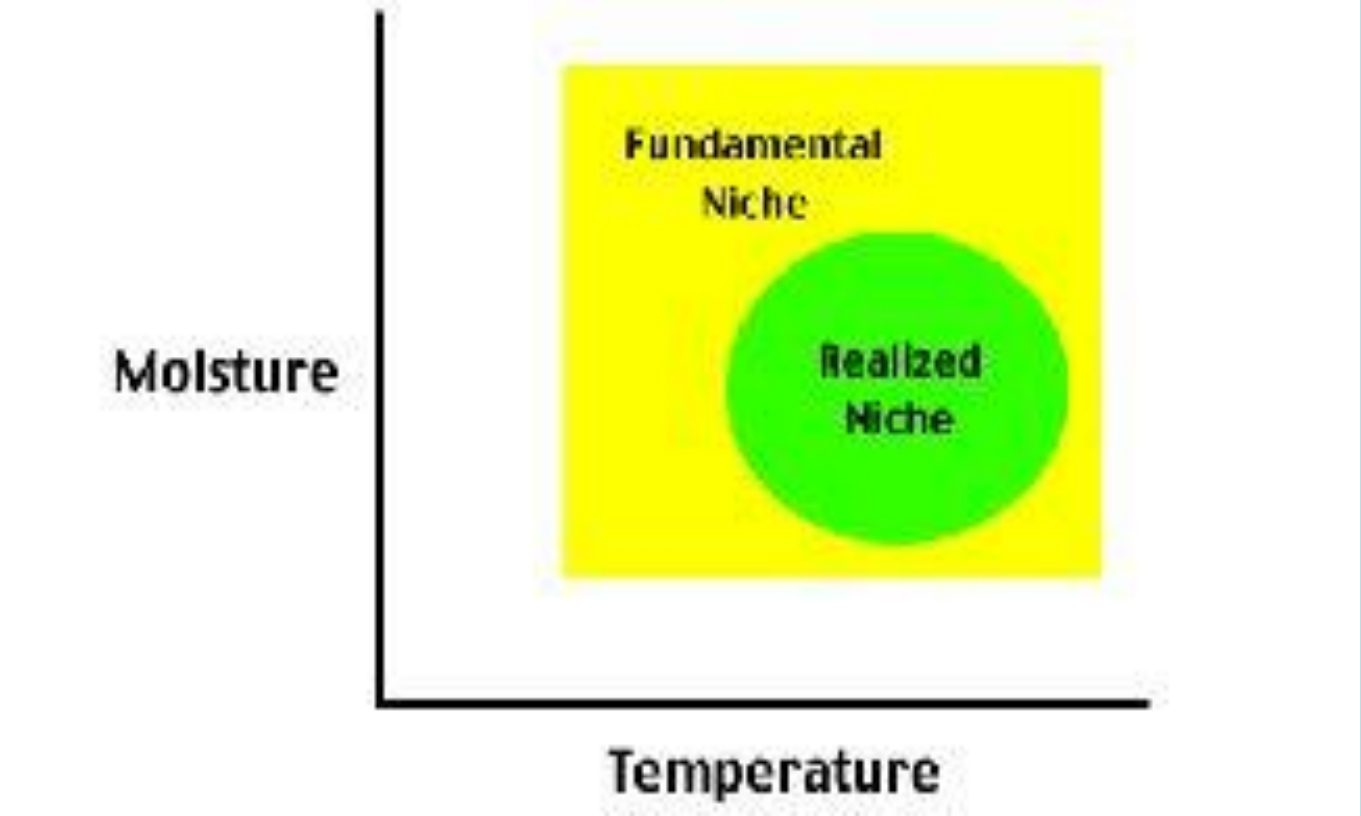
Waardoor? Whereby? By which?

Waartoe? What for? Whereto?
Whereunto?

(3) The potential and actual niches of microbes: their conditional occurrence.

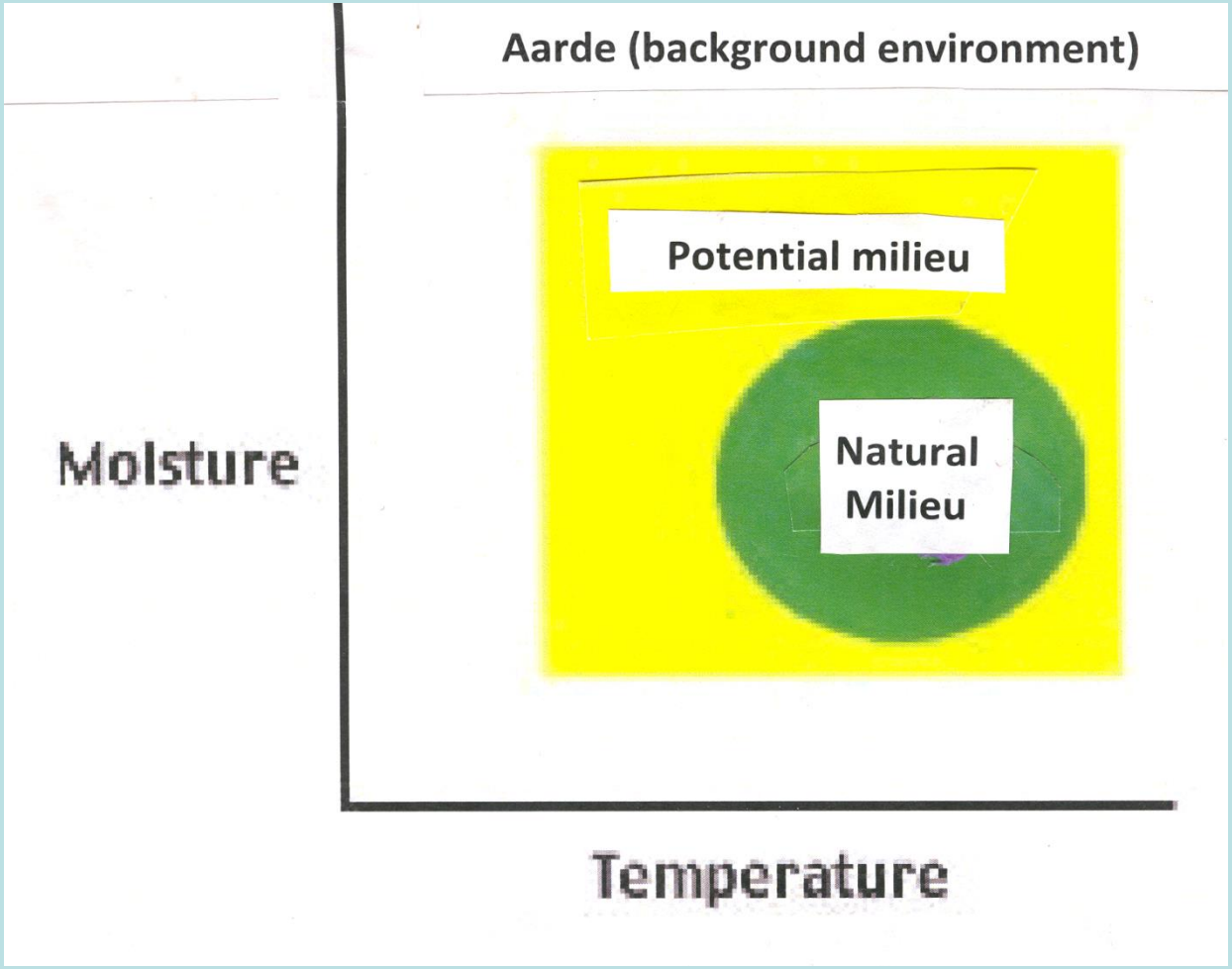
- **G. E. Hutchinson**, 1958
- Fundamental Niche
- Realized Niche
- **Baas Becking**, 1934 p. 11
- Aarde (“earth” or background conditions)
- Potential milieu
- Natural milieu
- (natural always smaller than potential milieu)

Hutchinson - Potential and realized niche



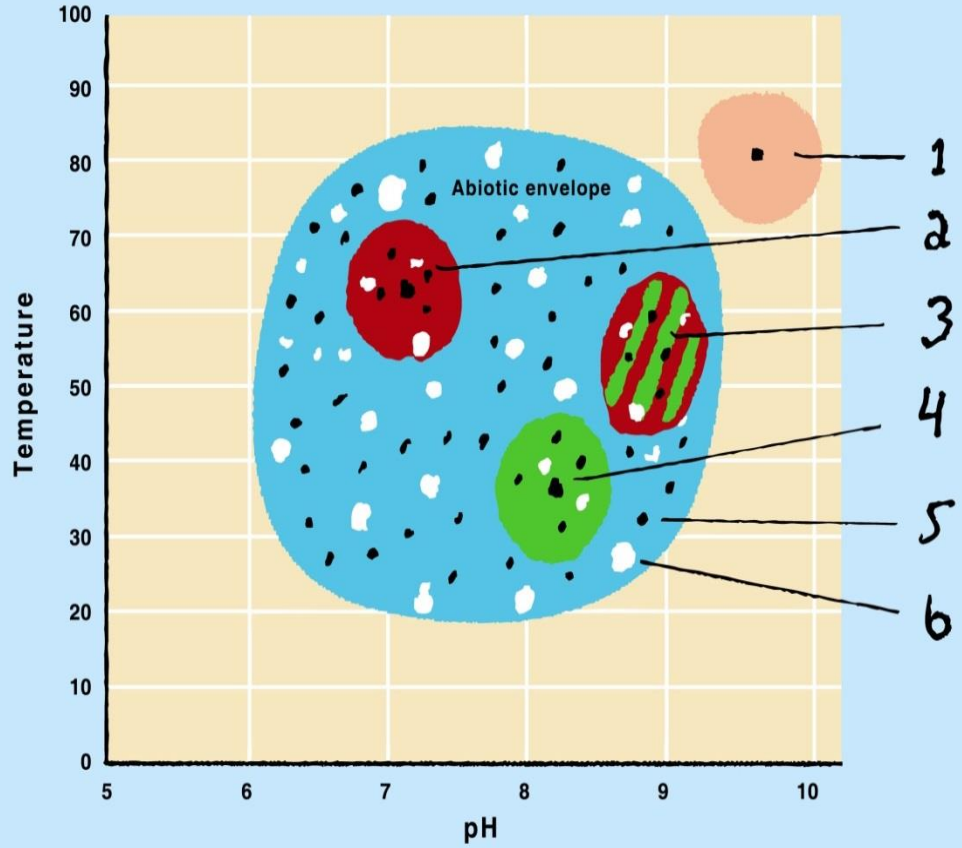
LecPopEcol3b.science.kennesaw.edu326

Baas Becking 1934 Aarde, potential and natural milieu relationships



What if the Aarde coes not contain the potential mileau for a particular microbe?

Conceptual view: abiotic envelope and DNA sources in natural microbial assemblages



Abiotic limited

Biotic limited

Dormant, Seed bank

In situ active, Mb community

Virions, viricells, temp. virus

Extracellular DNA (eDNA)

MICROBIAL GROWTH/FUNCTIONING is CONDITIONAL!–

- - proper abiotic environment
- - all nutrients present to form
- microbial cells
  - Macroelements, (C, N, P, S, Fe, Mg, etc.)
  - Microelements/trace elements
    Mn, Zn, Co Mo, Ni, Cu

- - must meet energetic needs:
- Energy source
- Electron source
- Carbon source

- - must meet possible symbiotic requirements

- - must be able to get rid of electrons after release of energy

Do microbes “drive” biological processes?

- This statement often in the biogeochemical literature

- The reality: Microbes only function when conditions are suitable! They don’t “drive” anything - better terms:

  - facilitate.
  - mediate
  - carry out,
  - respond

Viewing the niche/milieu as a dynamic interaction evolving over time

- The expression of the inner capabilities of an organism is only possible in a suitable/favorable external environment.
- (Also discussed by Woese 2009 MMBR 73: 14-21)
-

- “Aber die Erscheinung der Organismen wird von Aussen,
- nicht von Innen hergeleitet und die Innenwelt ist in der Aussenwelt eingefasst”. (p. 9)

Woese, 2009, MMBR 73: 14-2, p. 15

- “He (Beijerinck) realized that the organism cannot be understood apart from the ecology, the community structure in which it is found”

- “He (Beijerinck) understood that the organism does not define the organismal community- if anything, the reverse” .

BB concept: microbes foundational to all life,

- **In Dutch**: In deze voordrachten zullen wij ons beperke n tot de z.g "lagere organismen" en slechts nu en dan een hoogere plant of een hooger dier vermelden.
-
- **In English**: In these lectures we shall emphasize the so-called "lower organisms" and only now and then discuss a higher plant or a higher animal.

Microbes and fundamental concepts – p. 12

- These considerations have been limited to the so-called lower organisms, as they make it possible to bring the great and eternal to light. They bring some very general rules regarding their environment. These rules should serve us well in the future.

(4)) The concept of geobiology, a word coined by BB.

- **microbes and the geological earth co-evolved - geobiologie. (p. 9)**
- **The word "biogeochemistry" earlier**

Vladimir Vernadsky (1926)

the combination of geochemical and living processes -

BB and the Gaia hypothesis

- Wikipedia: The hypothesis was formulated by the chemist James Lovelock[1] and co-developed by the microbiologist ynn Margulis in the 1970s

- Reality: BB discussed the word GAIA in a paper presented in 1931. No mention of Gaia in the 1934 book.

- Anton Quispel, BB inaugural address, Leiden
- 1931, z" The hypothesis was formulated by the chemist James Lovelock[1] and co-developed by the microbiologist Lynn Margulis in the 1970sGaia or Life and Earth."

(5) The biocoenosis and its significance. Chap. 11, summary, p. 245

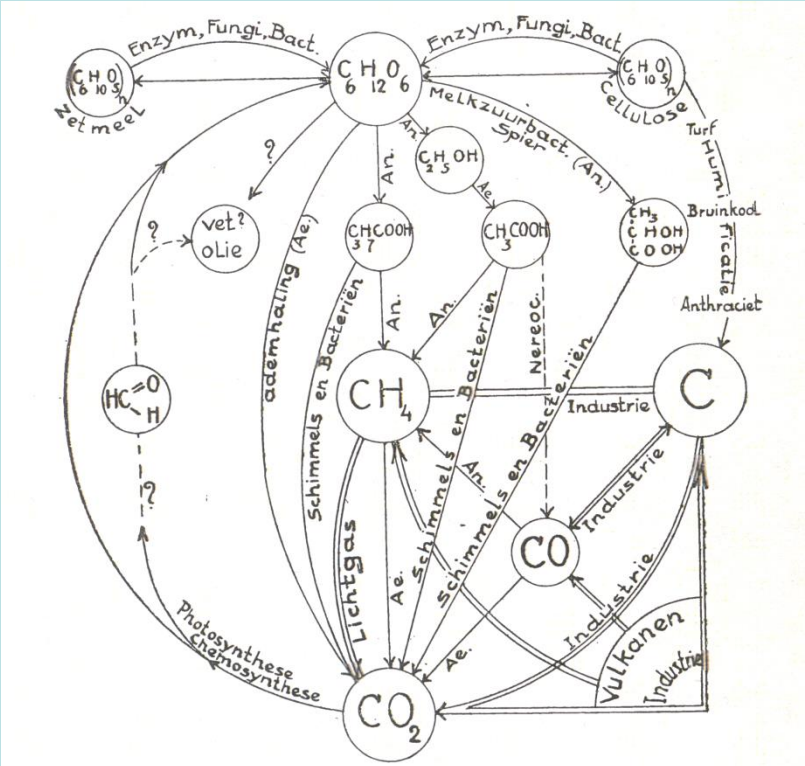
- The word “biocoenose” describes living communities.
- The potential milieu controls the biocoenosis/community that can develop.

- This community has the characteristics of microbes that “belong together.”

(6) Inorganic and organic cycles - abiotic vs. biotic processes. P. 108.

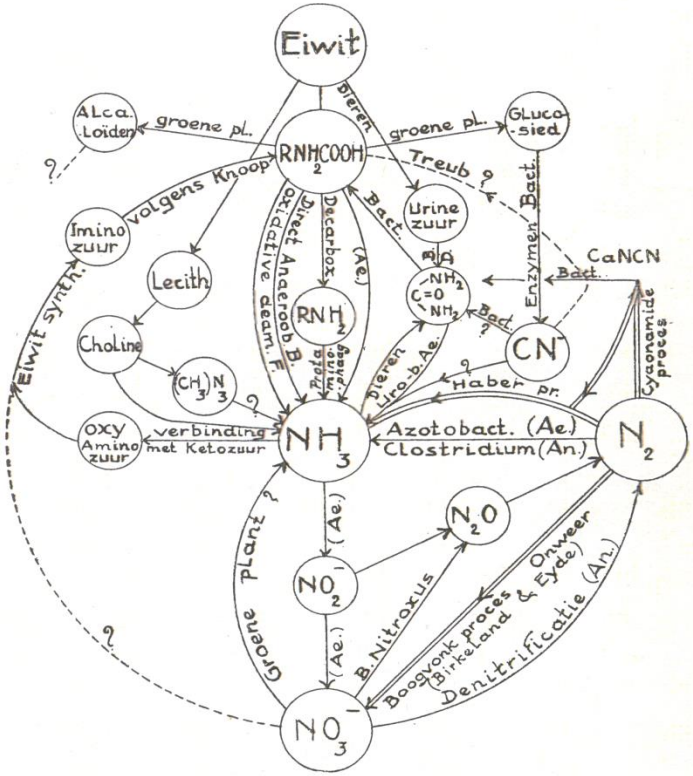
- everything flows, nothing remains, in spite of appearances that things are static (Goethe)
- The energetic moment will occur at some time that allows processes to proceed.
- Abiotic processes confront the time when they interact with biological processes.
- The living cycles interact with the chemical, mediated by energetic factors.

Carbon p. 114



Figuur 25.
Kringloop van de Koolstof.

Nitrogen p. 118



Figuur 26.
Kringloop van de Stikstof.

Abiotic vs. biotic cycles p. 124

- Vernadsky noted that inoorganic cycles are particularly reversible.
- Biological cycles are different from these.

Living beings can have pools that do not readily turn over and which accumulate in nature. He termed these “Slakken” pr “snails/slugs” in living organism cycles.

Table of “slugs” in biotic cycling p. 125

- Organic - Petroleum, asphalt, turf, coal, guano, amber
- Inorganic - Phosphate, vivianite, coral

- Organism remains. –

- Bacterial changing of environments.
- Stimulation of sedimentation

(6) The constant and continuing movement of microbes around the earth.

- Page 18. If the rule holds t hat everything is everywhere actuallly is valid, we should be able to see homogenous distribution.

Atmospheric processes need to be examined more closely. For small cells is a cosmopolitan distribution possibility already (a) given.

Led to “biogeography” see PNAS 2013 Sul et al.

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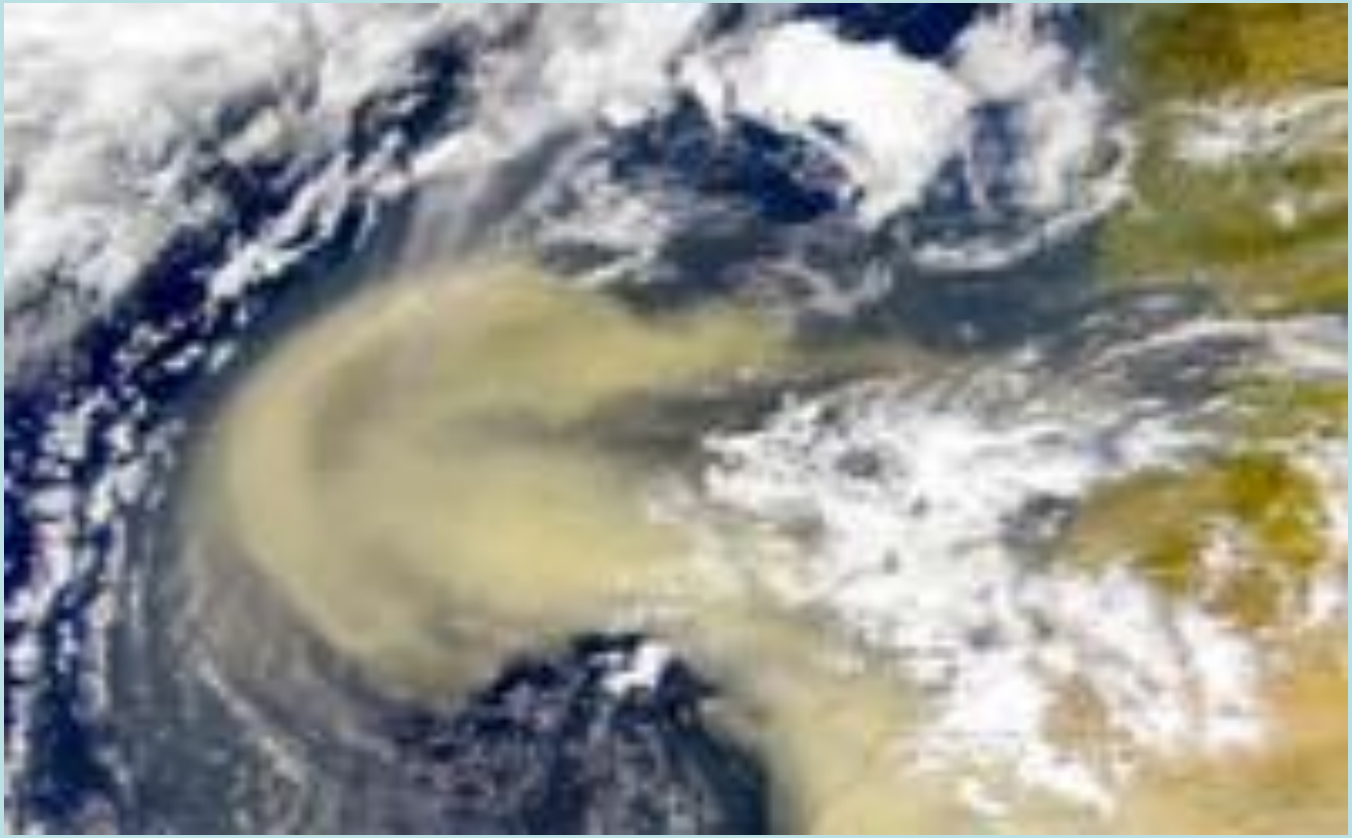
NASA and NOAA satellites have recorded Saharan dust crossing the Atlantic Ocean



Niwot Ridge and soil in snow

2006 snow profile illustrating dust events, Niwot Ridge, CO

CU Boulder, Hydrologic Sciences.
2010 talk
Impact of Dust Events on Snow Surface Characteristics and Meltwater Flow Paths at Niwot Ridge, Colorado
Petrzelka, Jennifer et al.

(8) Most microbes in nature are present in a latent state.

- The first rule can briefly formularted, namely that everything is everywhere, This microbial life is in a latent form (p. 13)

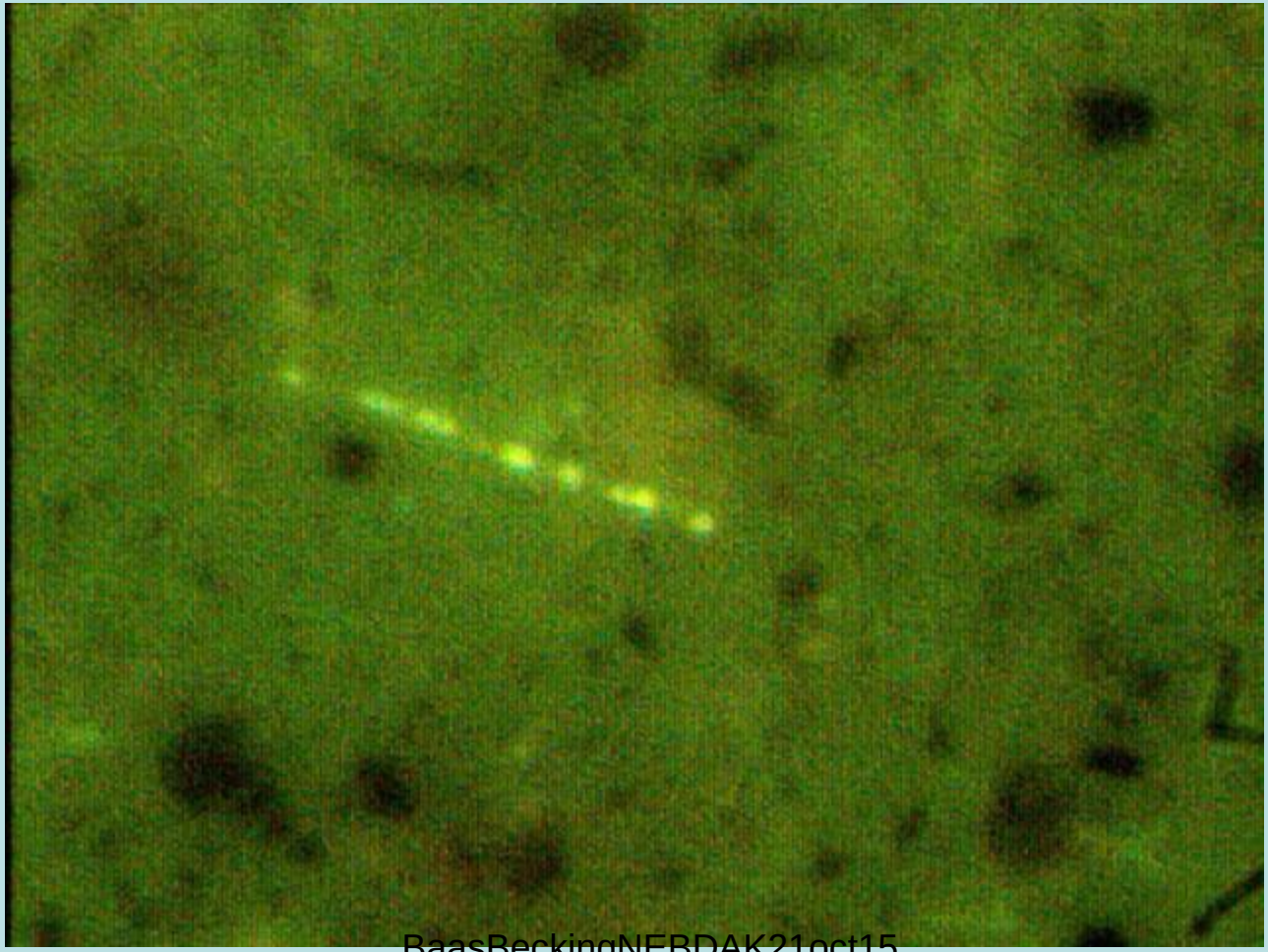
- How to “wake up” these organisms? P15.

Beijerinck’s sharp answer: provide a proper/selected milieu

Recent example: constant flux of thermophiles into the cold Arctic seabed

- Hubert et al., 2009, Science 325:1541-44, 18 Sept., 2009
- “Microorganisms have been repeatedly discovered in environments that do not support their metabolic activity”

A fungal hypha – FDA stained



Observation of a soil particle (ped) with active hyphae

Prove the’re active, to say the’re active

- Kim Lewis, Northeastern Univ. 23 Mar 11;
- Talk: Persisters and uncultured bacteria

“Dormancy is the default mode of existence in uncultured bacteria that make up 99% of all microbial species”

http://www.biology.neu.edu/pdf/010PersReviewARM.pdf

Review on persister cells

Developing a philosophy for studies of microbes and their environmental interactions: assume Baas Becking is looking over your shoulder ----

- Be sure organisms are active in situ
- If working with cell components, be sure these are derived from in situ active organisms

- Sources to have in place:
- For Beijerinck: Stockhausen F. Oekologie, Anhäufungen nach Beijerinck : Beiträge zur natürlichen Reinzucht der Mikroorganismen: Berlin : Institut für Gärungsgewerbe, 1907

- Baas Becking LGM Geobiologie of inleiding tot de milieukunde: W.P. Van Stockum & Zoon, 1934.

- Sources to have in place:
- For Winogradsky:

. Winogradsky S. Microbiologie du Sol. Paris: Masson et Cie, 1949.

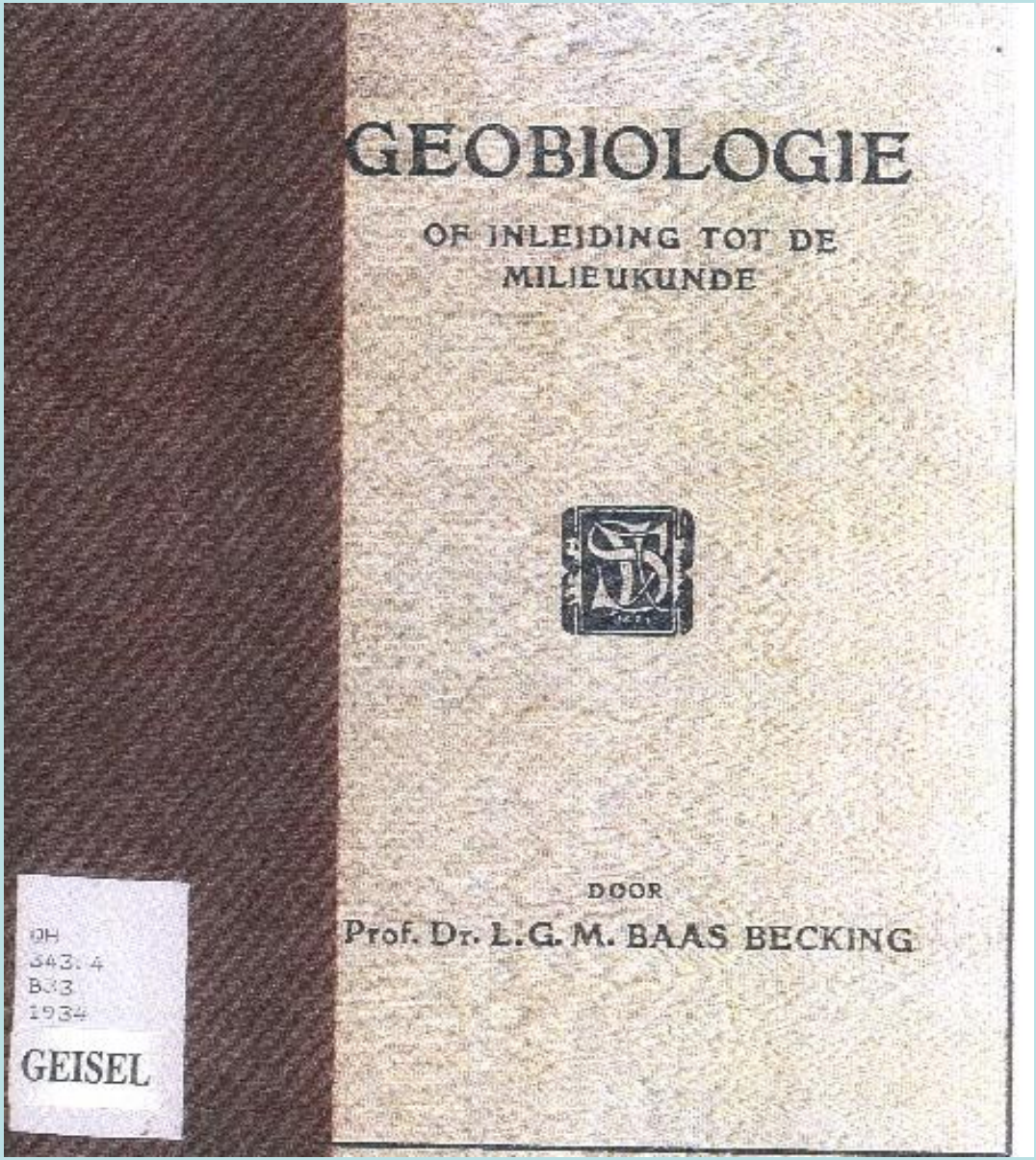
Winogradsky S. Principes de la microbiologie oecologique Antonie van Leeuwenhoek. 1947;12:5-16.

A “what if” of biology

- How would the studies of microbial ecology and biogeochemistry be different today if the 1934 Baas Becking book had been widely available 80 years ago?

How would ecology be different?

- Fundamental concepts of ecology are best understood using microbes.
- - most microbes in nature aren’t doing anything – they are in a latent state
- The niche/milieu, allowing activity, is dynamic and evolving. Microbial communities thus also are dynamic and evolving.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543.4
B33
1934
GEISEL

Thank you!

How has bulk-extracted DNA been described?

- - cells
  - microbial community
  - rare biosphere
  - dormant cells
  - the microbial seed bank.
  - as a measure of diversity

Community: definition

- an interacting population of various kinds of individuals (or species) in a common location” (8). In a microbial context, this has been defined as the in situ active cells

- NOTE: eDNA should not be on outer surfaces or in sample matrix. Cells are active in situ.

“Ecological Diversity,” by E. C. Pielow (l975, John Wiley and Sons).

- A defensible approach: development of a definition for microbes parallel to that for plants and animals (Pielou, 1975 :

- “Any assemblage of plants and animals living together in one place and to a greater or lesser degree, interacting with one another – in a word, an ecological community ----

“Ecological Diversity,” by E. C. Pielow (l975, John Wiley and Sons).

- Replace “plants and animals” with “microbes” -----

- “Any assemblage of microbes living together in one place and to a greater or lesser degree, interacting with one another – in a word, an ecological community ----

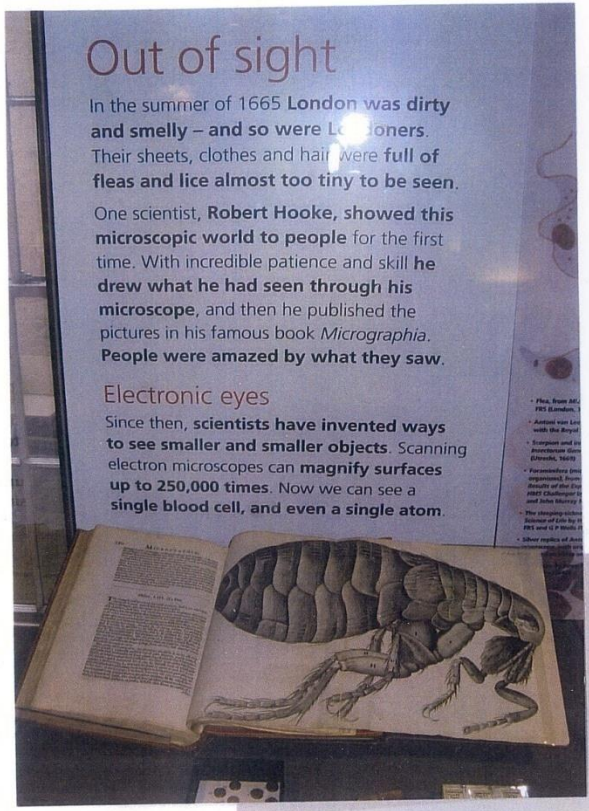
Microbial diversity thoughts:

- The late Howard Gest (IU)) discussed "the meaning of diversity:"

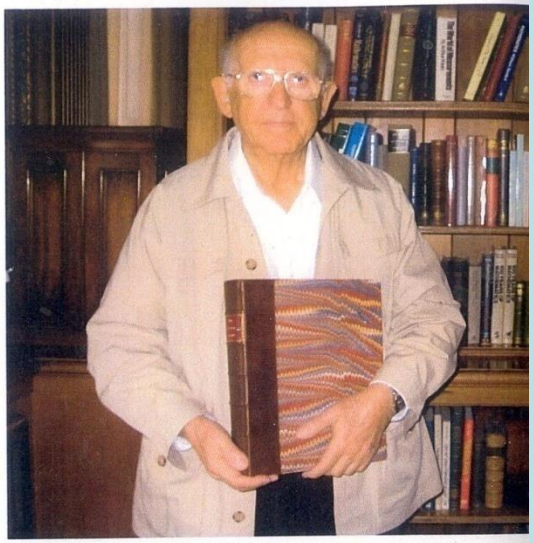
- "unfortunately, the word diversity can have several meanings, and the one in mind is frequently not specified."

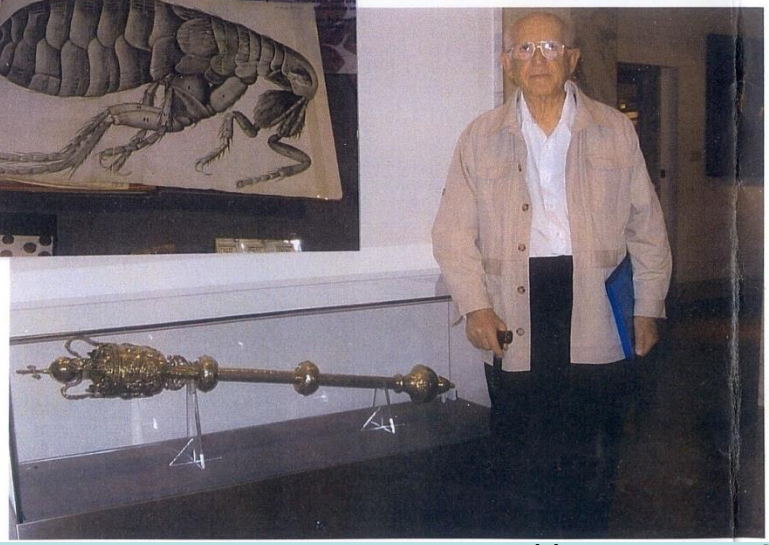
Howard Gest http://hdl.handle.net/2022/3275

Facts and myths about authentic bacteria/lessons from pioneers of microbiology

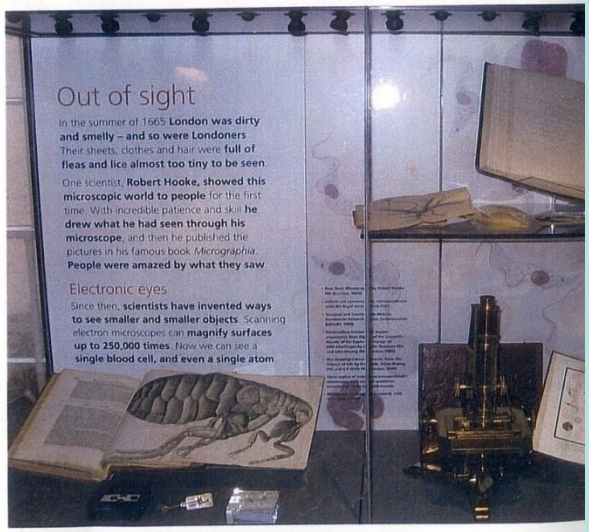


recently discovered
Howard Gest holding the Hooke Folio at the Royal Society, London.
Also displays of Hooke's *Micrographia* and early microscopes.
October 2008





Royal Mace, given to Roy. Soc. by Charles II (1660)



Defining Microbial diversity using molecular approaches:

- **Definition 1.**
- Molecular sequence diversity.
- All recovered sequences with bulk extraction of NMA:

- **Definition 2**. Cellular molecular diversity. Molecular sequences, are derived from microbes.(Pools 1-4). No need to prove active in situ.

Microbial diversity using molecular appraoches

- **Definition 3**. Acellular molecular diversity viroids, virocells and/or the cryptic viral genome.

- **Definition 4**. In situ active microbe molecular diversity. This involves molecular information/sequences derived solely from in situ active microbes, the microbial community.

Assessing growth in nature:

- “The assessment of microbial growth, growth rates and population turnover dynamics in natural systems is one of the most difficult tasks to approach as a microbial ecologist.”

- Thomas D. Brock, l971. Microbial growth rates in nature. Bact. Reviews. 35:39 l97l.

Natural microbial assemblages

- 1. inactive microbes, abiotic-limited
- 2. inactive microbes, abiotic permissive but biotic-limited
- 3. dormant microbes , abiotic permissive, biotic-limited, but can become active
- 4. in situ active microbes, the microbial community
- 5. virions, viricells, temperate cell DNA
- 6. extracellular DNA (eDNA)