

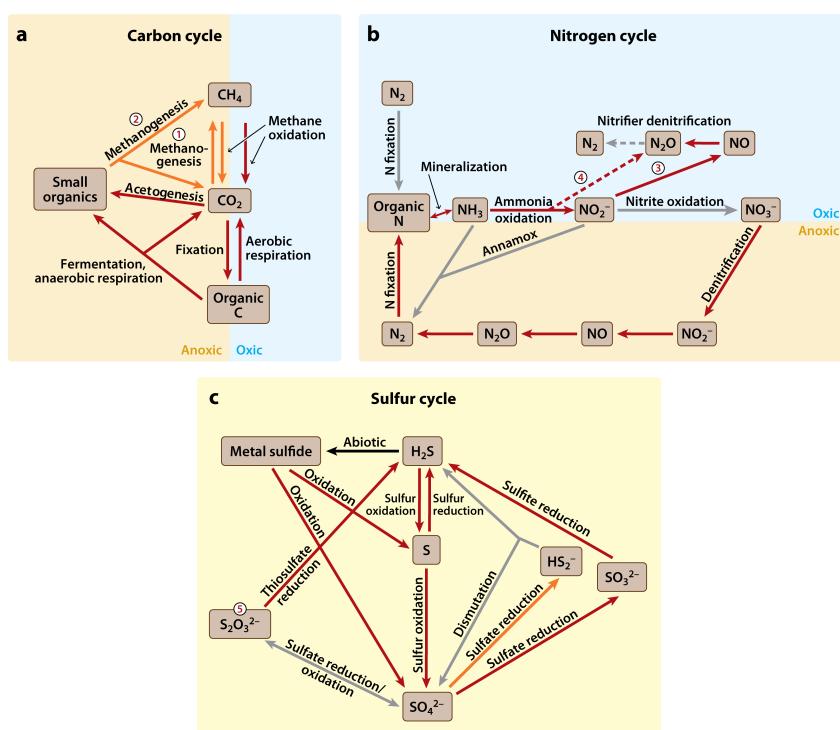
Lecture : The Role of Microbes in the N cycle

Topics

- Microbes in the N cycle
- Identification of Archaea in the N cycle
- Discovery and role of Annamox Bacteria

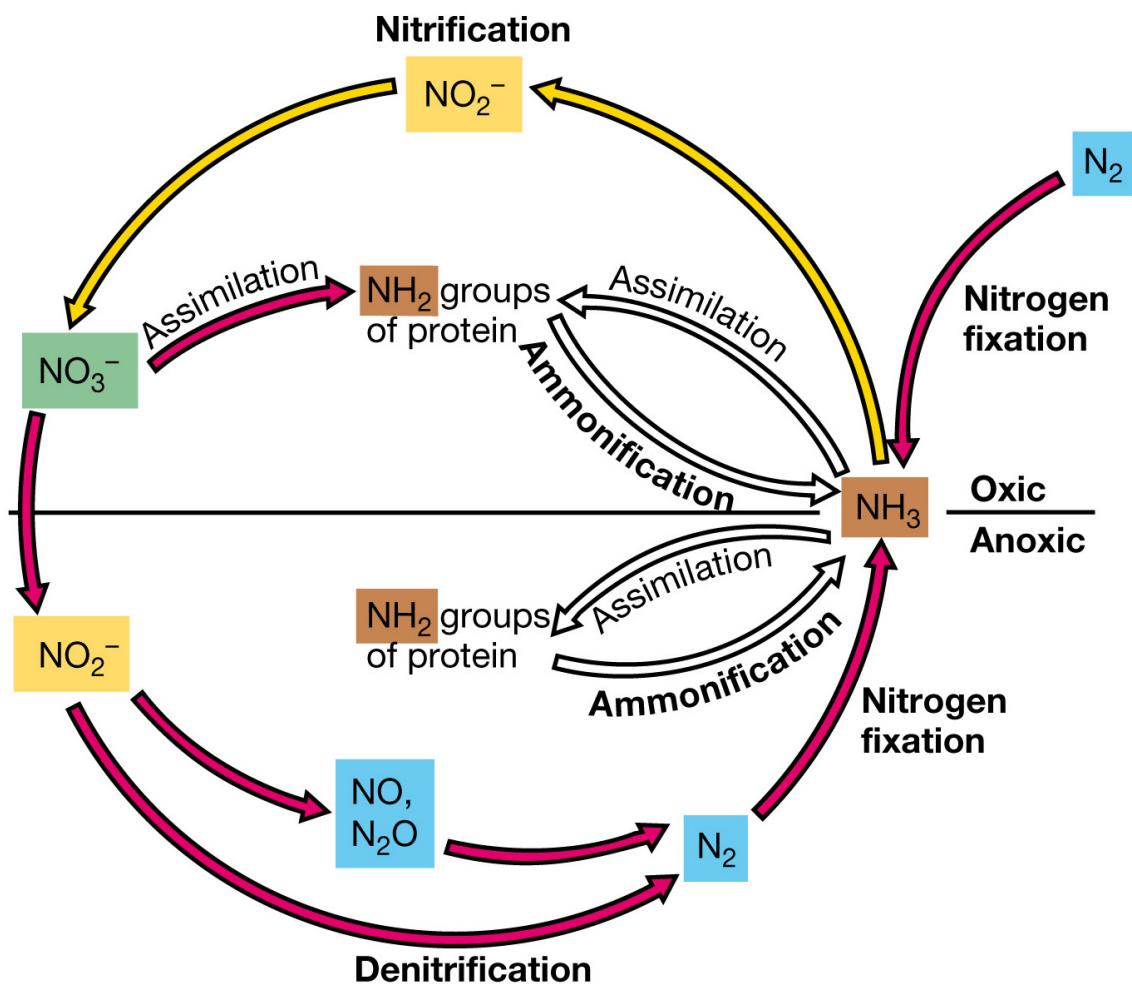
Learning Outcomes

- Identify and explain the key steps in the nitrogen cycle
- Explain how new methods have changed the way that we think about microbes and nutrient cycles

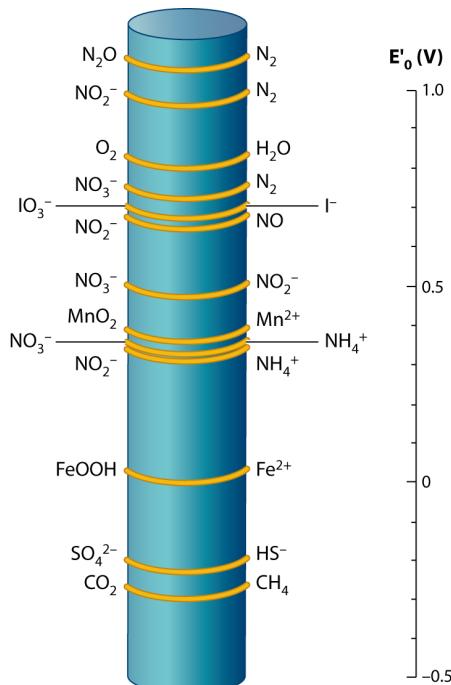


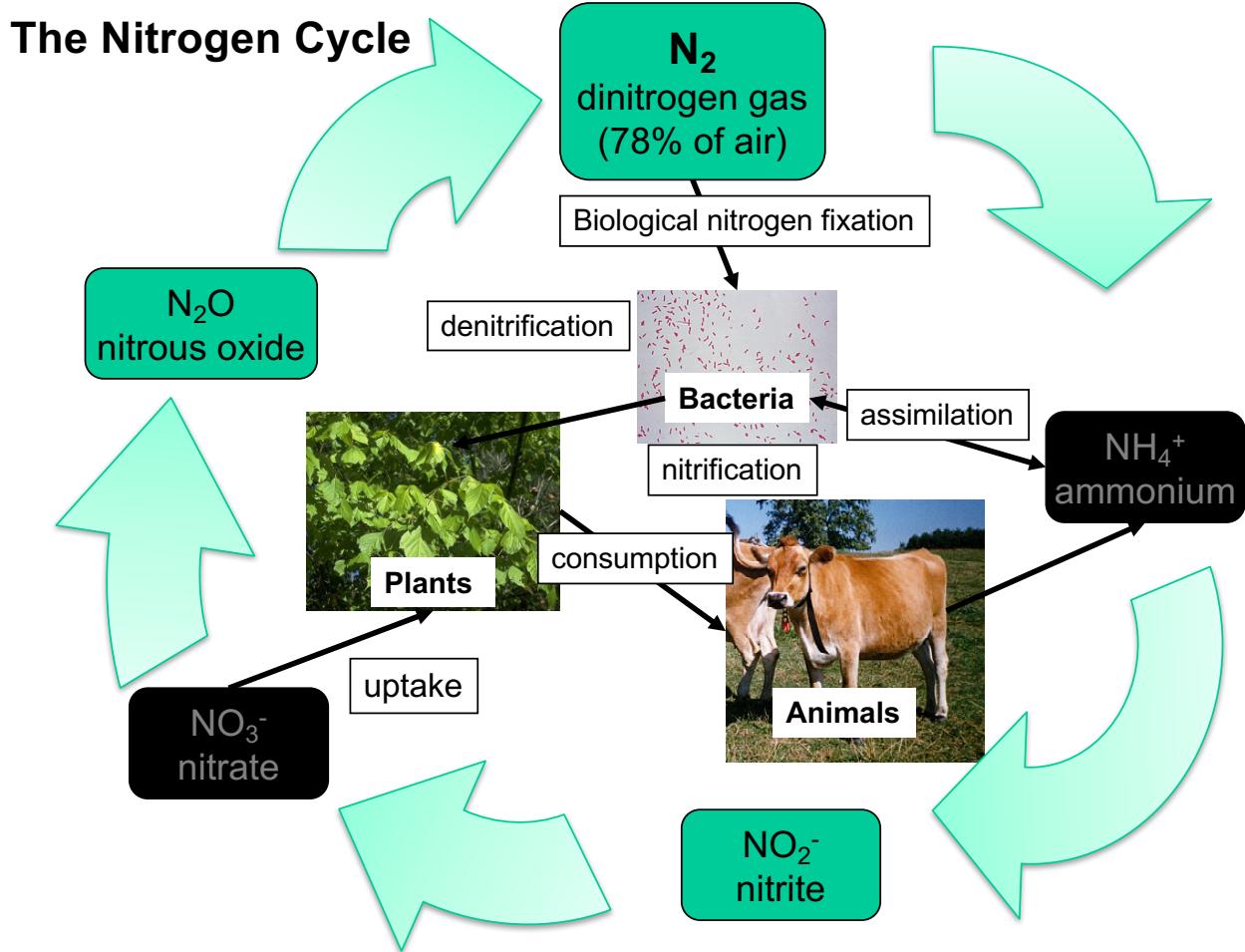
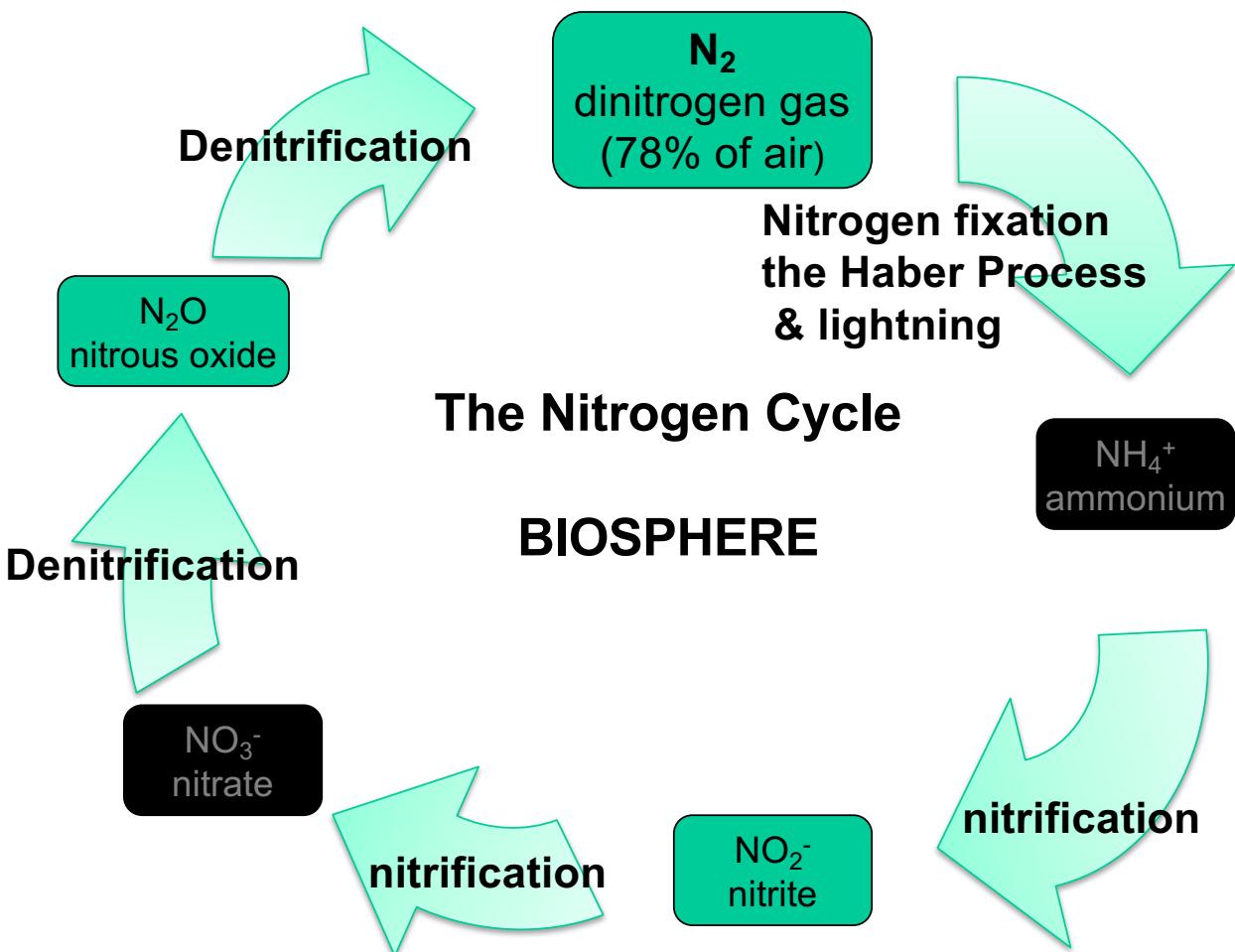
AR Offre P, et al. 2013.
Annu. Rev. Microbiol. 67:437–57

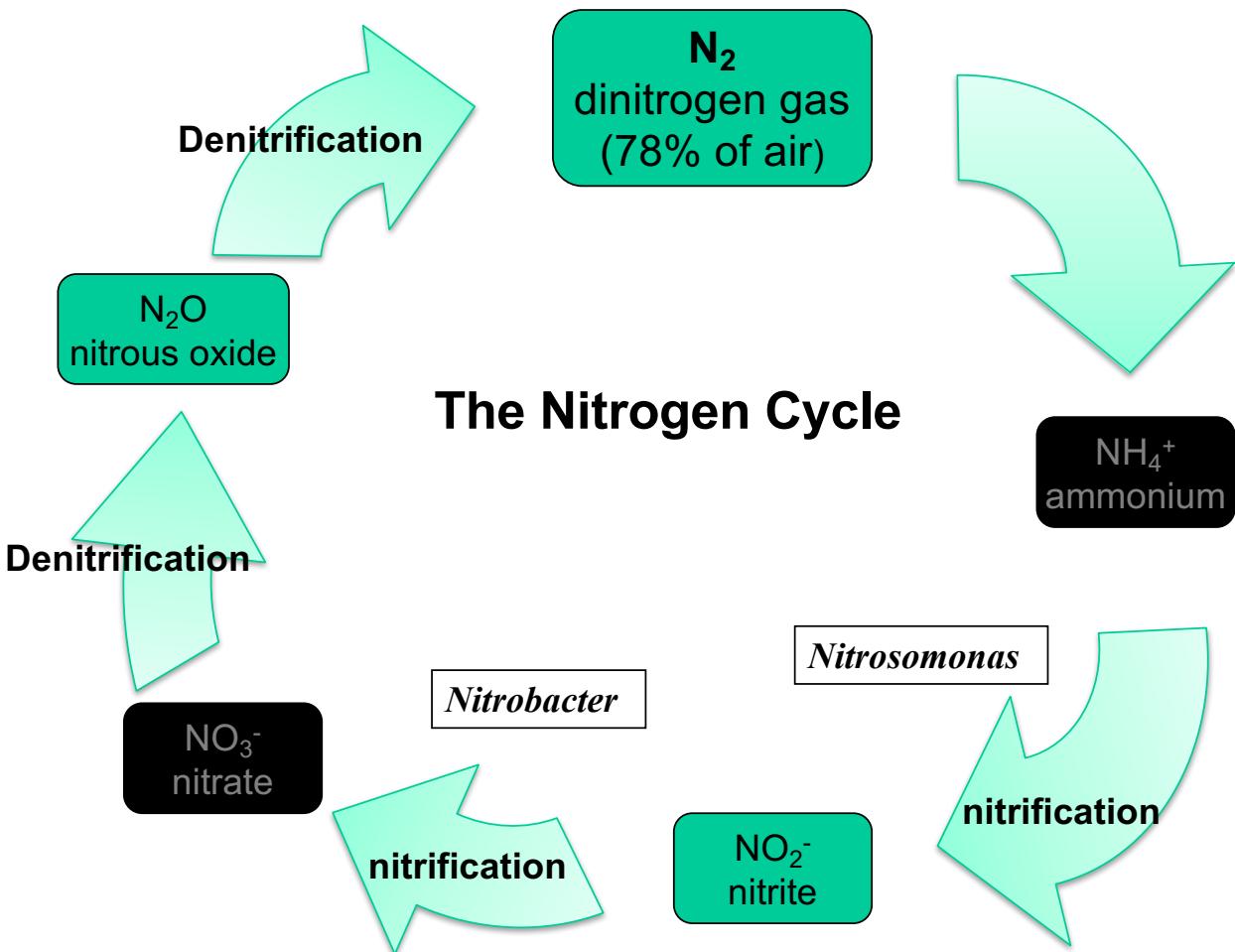
Annual Reviews



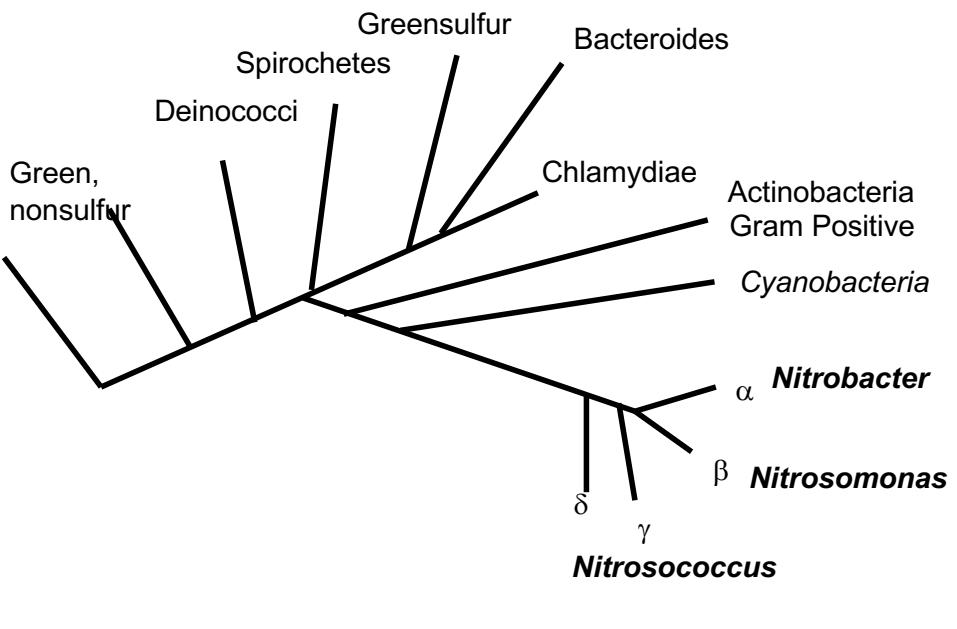
Alternative electron acceptors



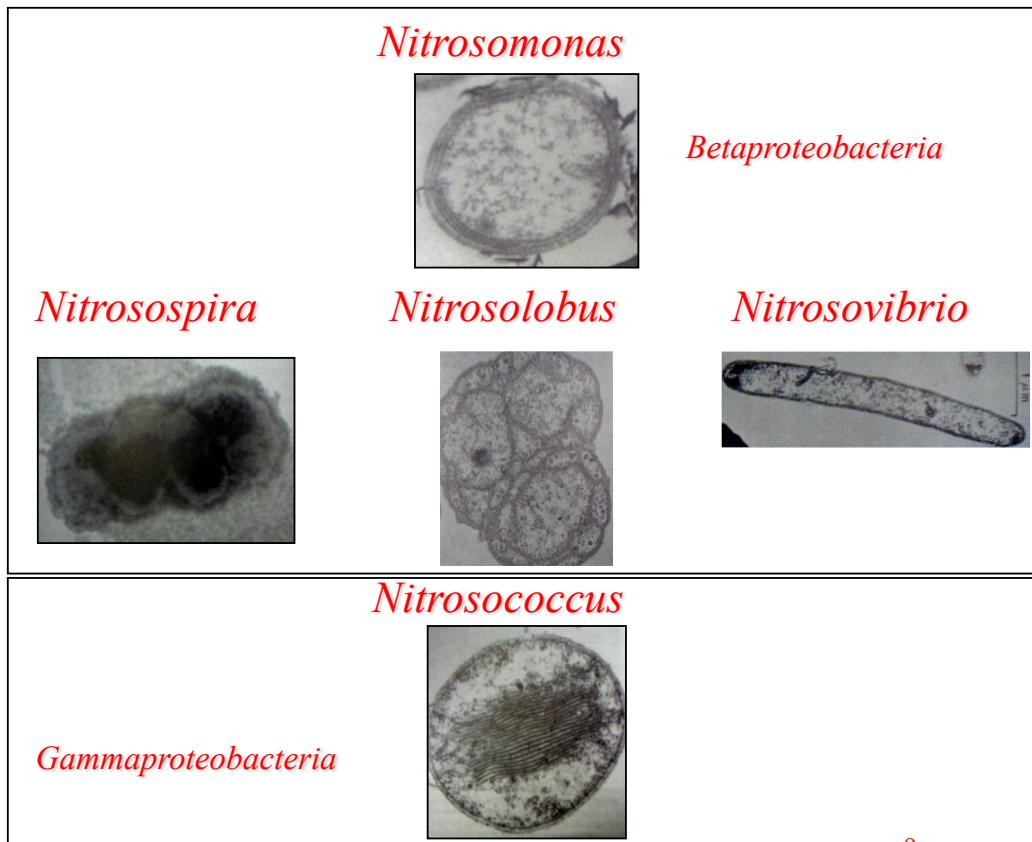




Bacteria taxonomy



Ammonia oxidiser taxonomy



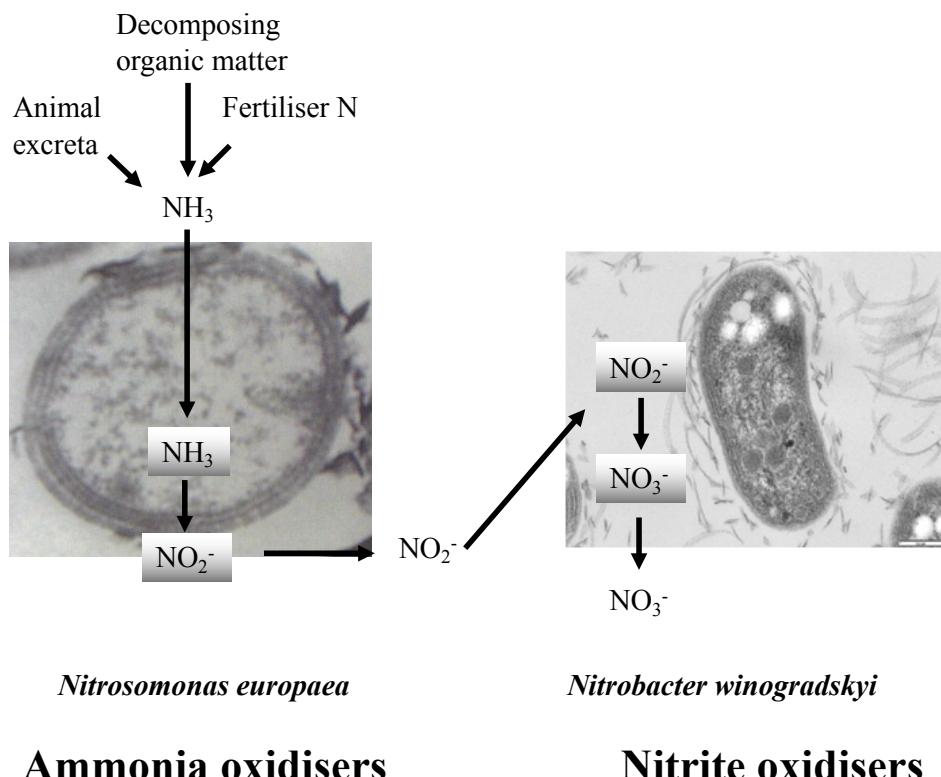
9

Bergey's Manual: Gram Negative Chemolithotrophic Bacteria

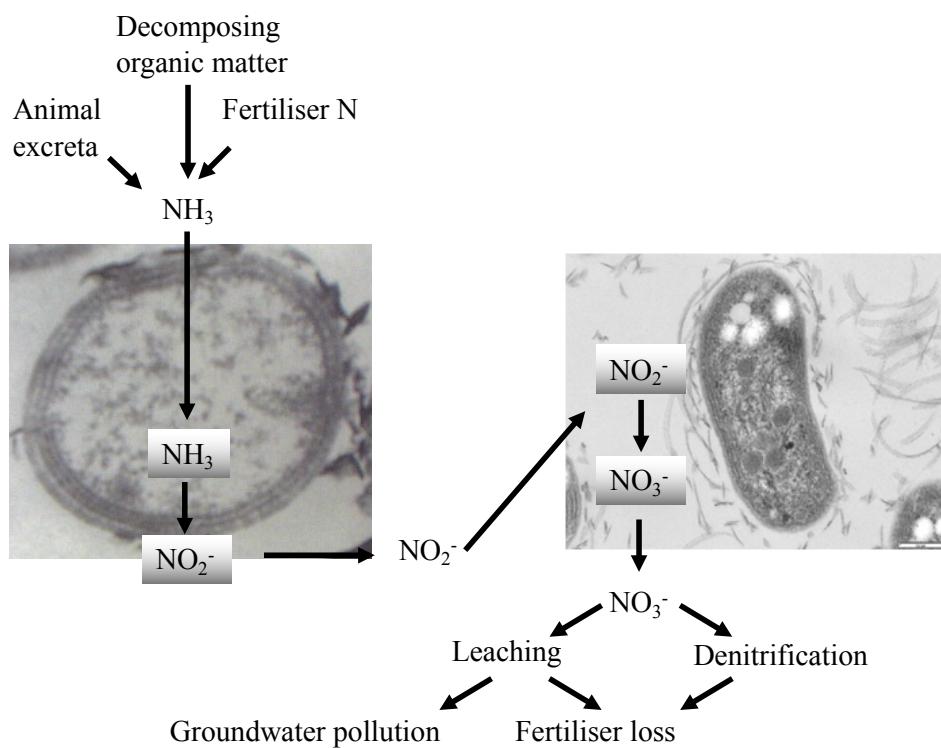
Family I Nitrobacteraceae

- Genus I Nitrobacter
- Genus II Nitrospina
- Genus III Nitrococcus
- Genus IV Nitrosomonas
- Genus V Nitrospira
- Genus VI Nitrosococcus
- Genus VII Nitrosolobus

Soil Nitrobacteriacea – role in nitrification

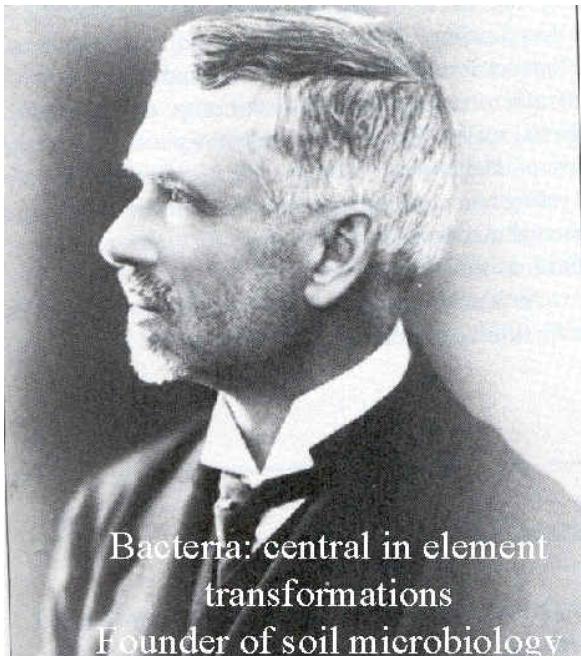


Soil Nitrobacteriaceae – role in nitrification



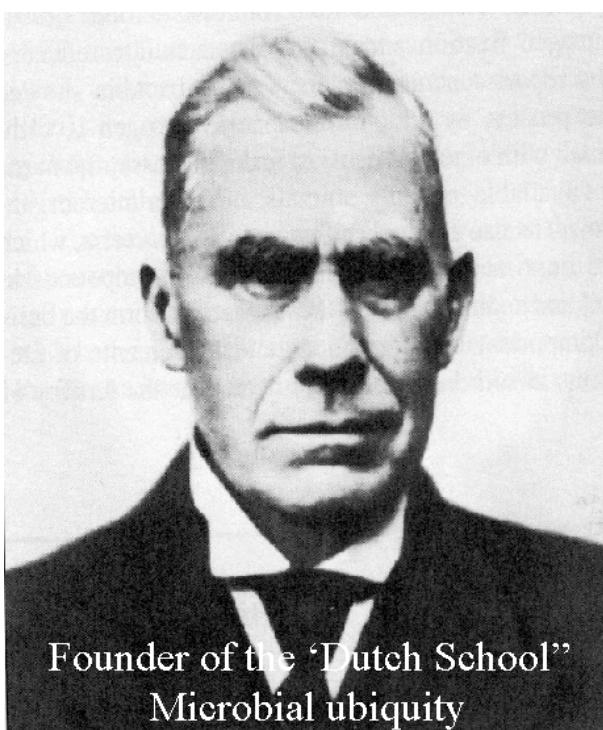
Sergei Winogradsky

(1856-1953)



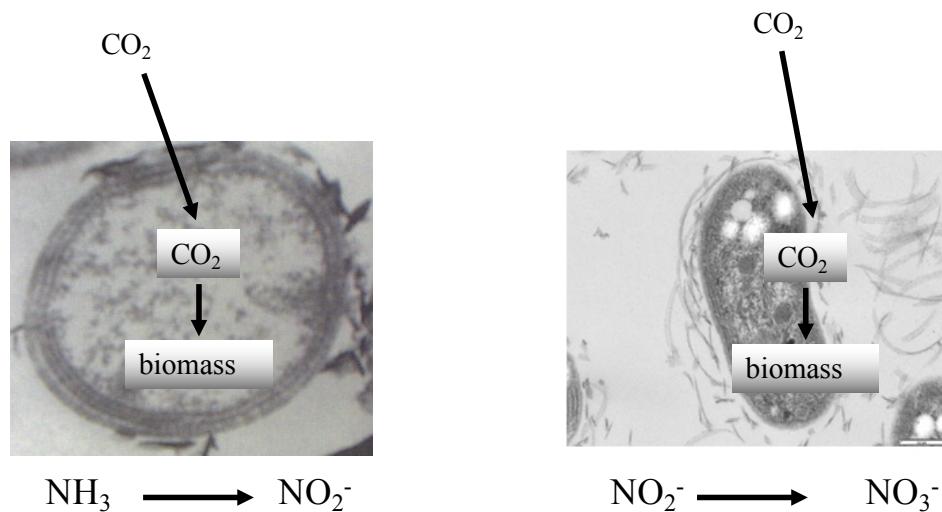
- Described oxidation of hydrogen sulfide, sulfur, ferrous iron
- Isolated nitrifying bacteria
- **Winogradsky column:** microbial communities develop along a gradient of oxygen tension; method still used today
- All leading to concept of **chemoautotrophy** – deriving energy from chemical oxidation of inorganic compounds and carbon from CO₂

Martinus Beijerinck (1851-1931)

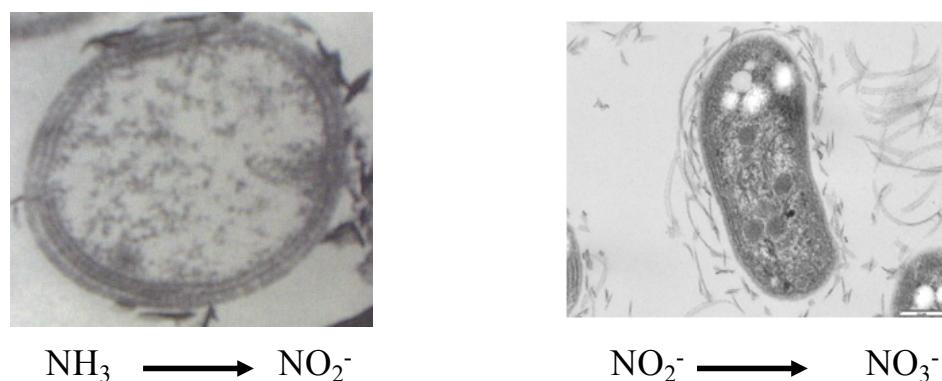


- Isolated N fixers and S reducers
- Enrichment culture: growth medium tailored to suit particular metabolic function
- **‘Microbial ubiquity’:** “**everything is everywhere, the environment selects.**”
- With Winogradsky, recognized that microbes are the major players in element transformations
- Led the field of biogeochemistry
- Characterized distribution, nutrition and taxonomy of luminescent bacteria.

Soil Nitrobacteriaceae –chemolithoautotrophic bacteria

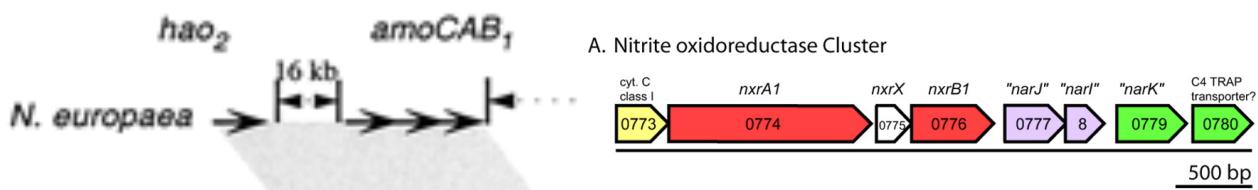


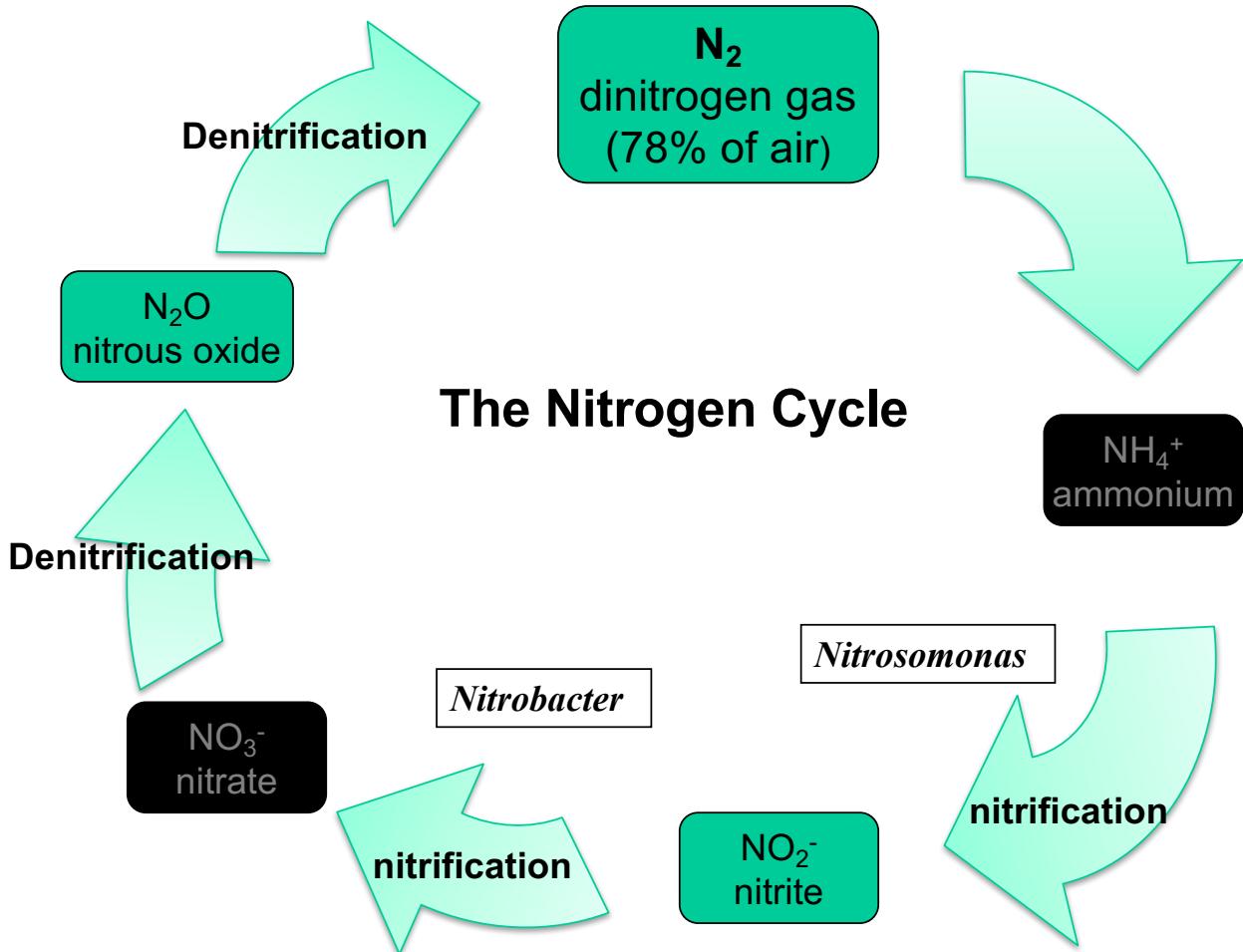
Soil Nitrobacteraceae – role in nitrification



ammonium oxidase – “amo” genes

Nitrite oxidoreductase – “nar” genes





Identification of *amoA* and *amoB* in a Crenarchaeal fosmid

Environmental Microbiology (2005) 7(12), 1985–1995

doi:10.1111/j.1462-2920.2005.00906.x

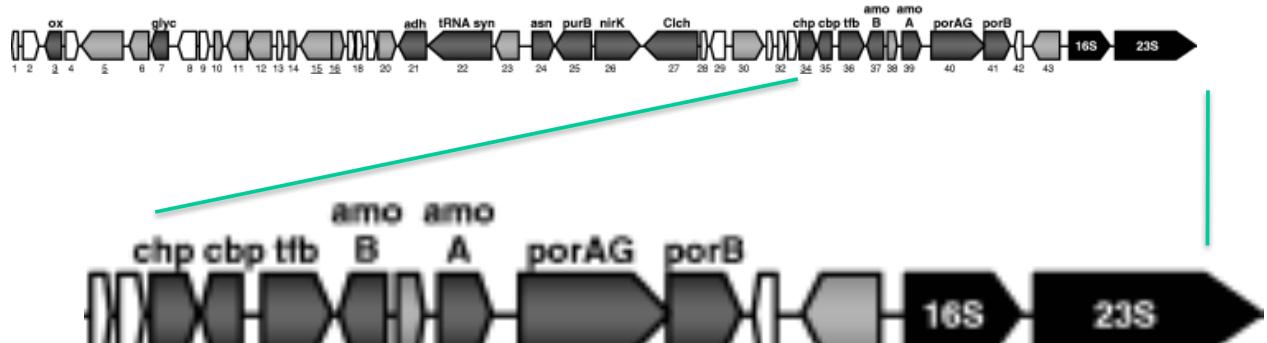
Novel genes for nitrite reductase and Amo-related proteins indicate a role of uncultivated mesophilic crenarchaeota in nitrogen cycling

Alexander H. Treusch,¹ Sven Leininger,¹
Arnulf Kletzin,² Stephan C. Schuster,³ Hans-Peter
Klenk² and Christa Schleper^{1*}

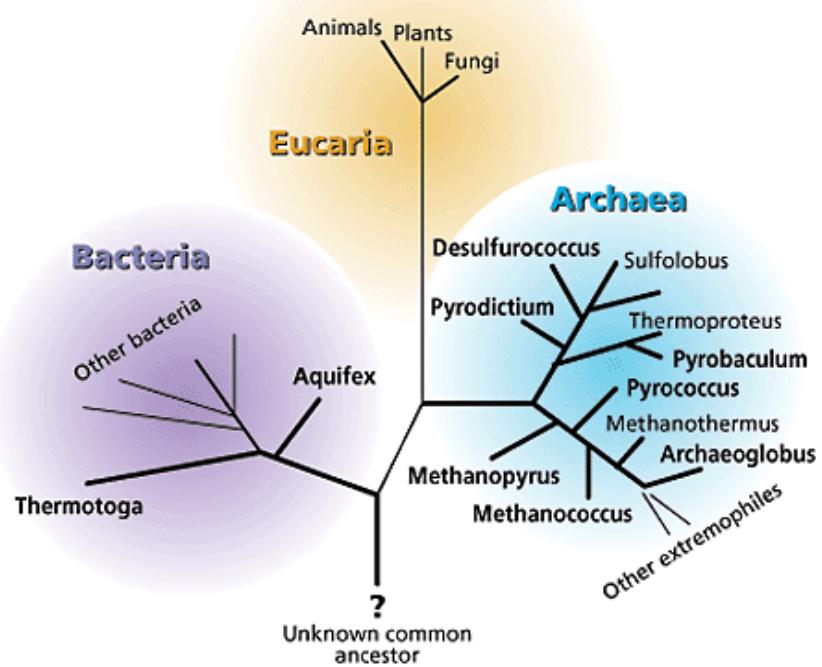
Introduction

Microorganisms play a crucial role in the global nitrogen cycle in biological systems, both in oxidation (nitrification)

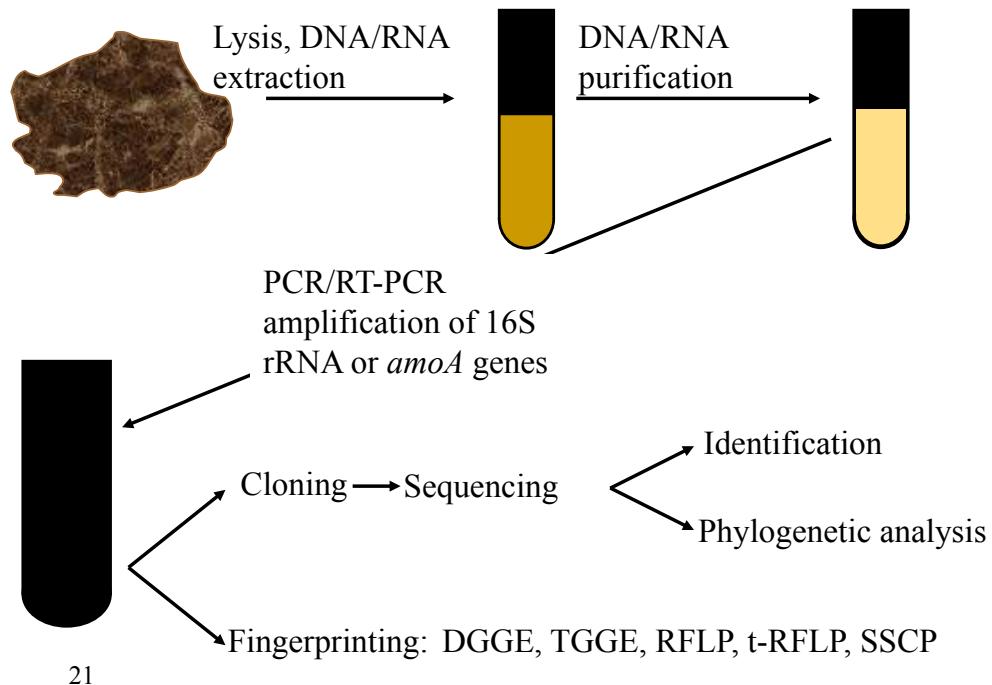
Identification of *amoA* and *amoB* in a Crenarchaeal fosmid



Domains of Life



DNA/RNA-targeted molecular analysis of ammonia oxidiser communities



**Ammonium oxidising microbes:
Archaea (AOA) outnumber Bacteria (AOB)**

nature

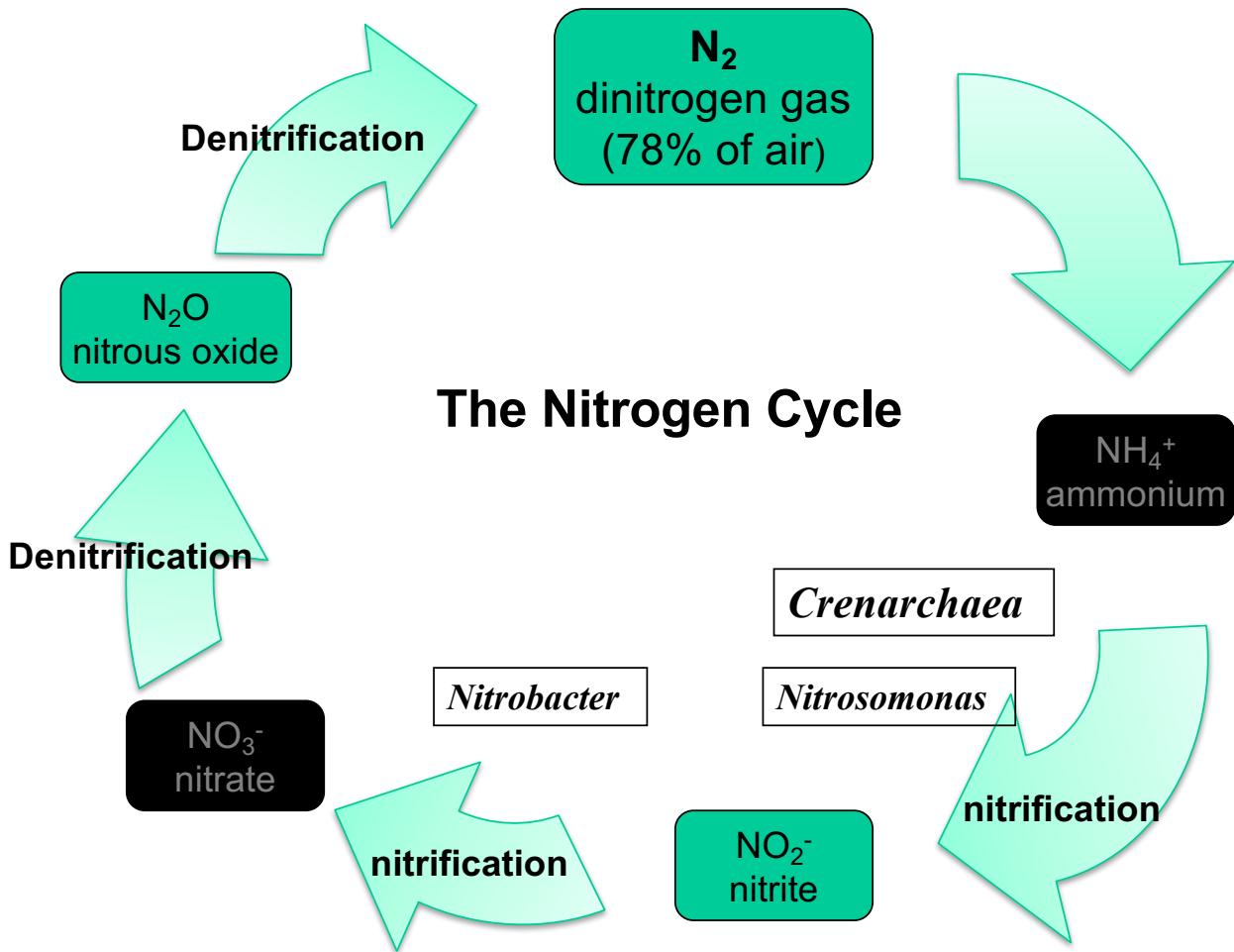
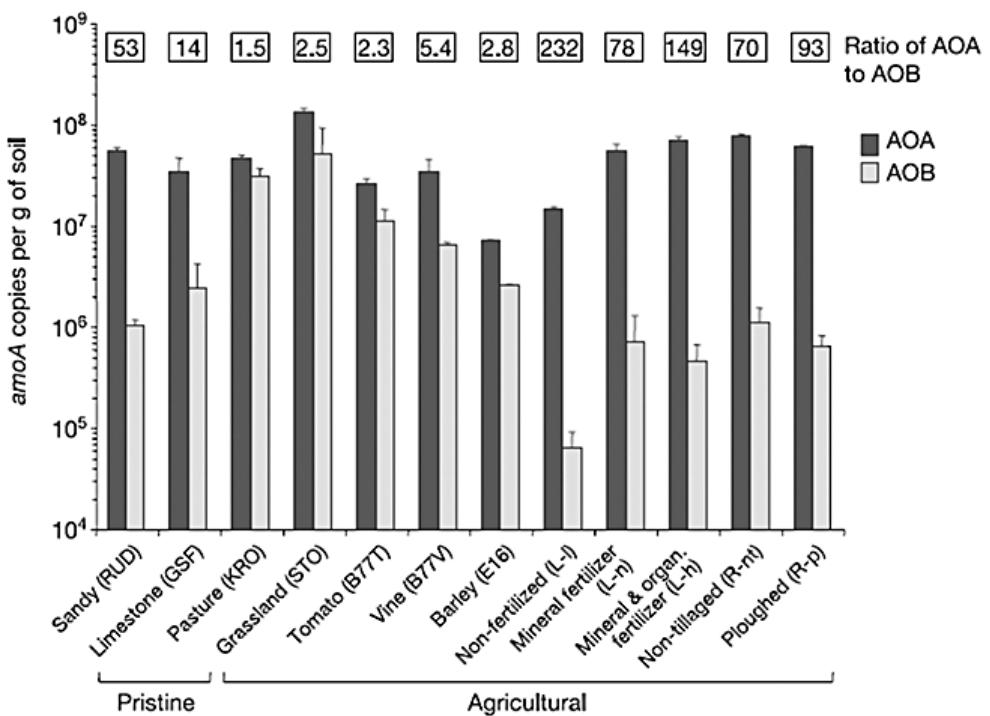
Vol 442 | 17 August 2006 | doi:10.1038/nature04983

LETTERS

Archaea predominate among ammonia-oxidizing prokaryotes in soils

S. Leininger¹, T. Urich¹, M. Schloter², L. Schwark³, J. Qi⁴, G. W. Nicol⁵, J. I. Prosser⁵,
S. C. Schuster⁴ & C. Schleper¹

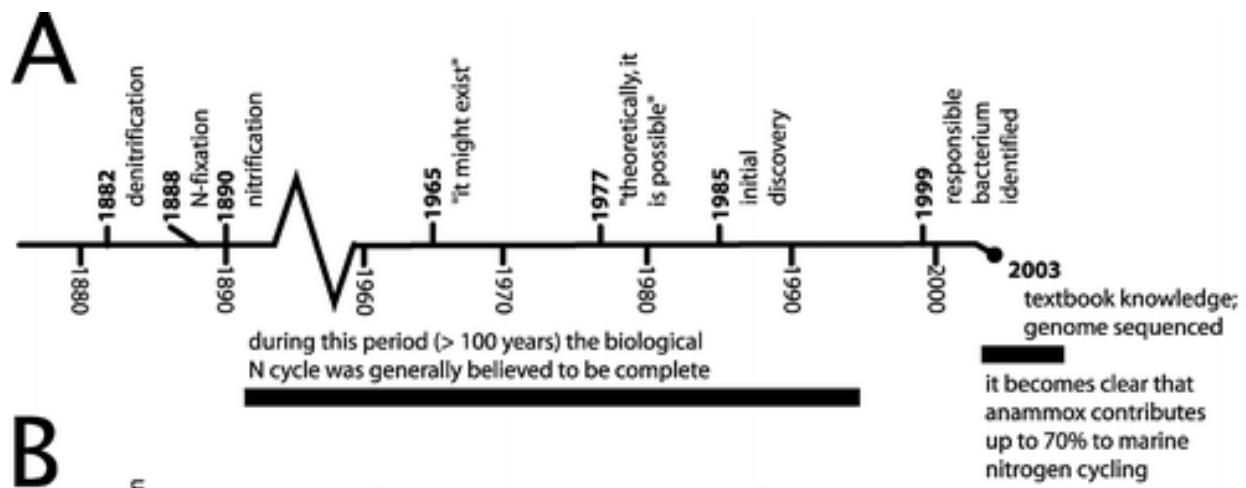
Ammonium oxidising microbes: Archaea (AOA) outnumber Bacteria (AOB)



Conclusion

- New methods are identifying new microbes involved in nutrient cycles
- The major players may not be the microbes that we can readily cultivate
- New approaches are required to properly understand the activities of microbes in nutrient cycles

Nitrogen Cycle time-line (to 2004)

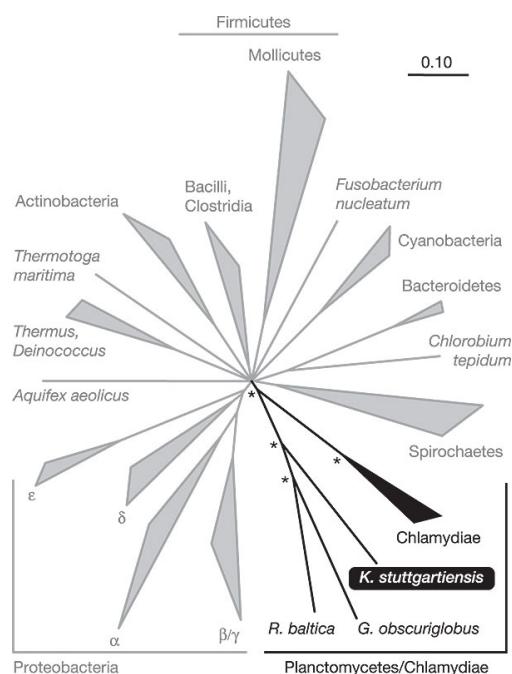
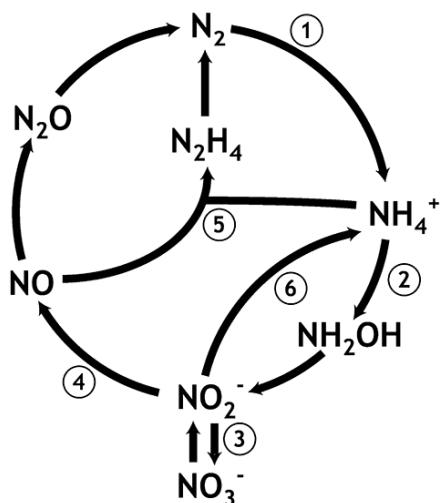


Identification of Anoxic Ammonium Oxidation

1994-2004: 10 years of research on the anaerobic oxidation of ammonium

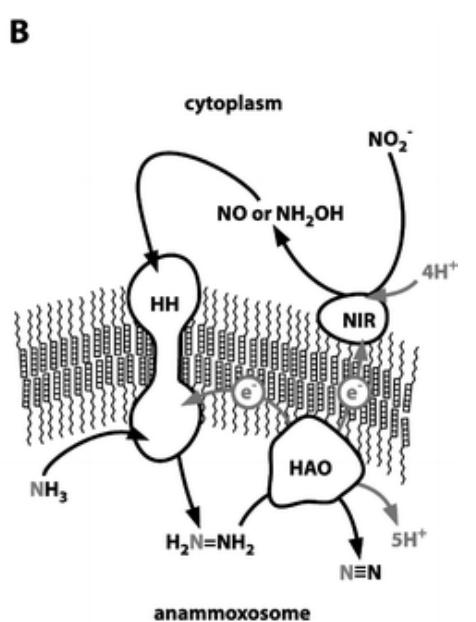
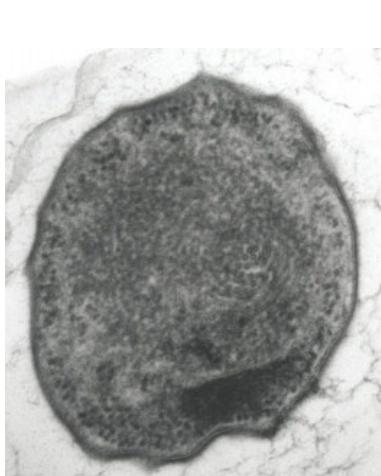
M.S.M. Jetten^{a†}, I. Cirpus^b, B. Kartal^b, L. van Niftrik^b, K.T. van de Pas-Schoonen^b, O. Slielkens^{b‡}, S. Haaijer^b, W. van der Star^b, M. Schmidt^b, J. van de Vossenberg^b, I. Schmidt^{b§}, H. Harhangi^b, M. van Loosdrecht^b, J. Gijss Kuenen^b, H. Op den Camp^b and M. Strous^b

^aDepartment of Microbiology, RU Nijmegen NL, Toernooiveld 1, 6525 ED Nijmegen, The Netherlands, and ^bDepartment of Biotechnology, TU Delft, The Netherlands



Kuenenia stuttgartiensis

Anammoxosome: organelle in *Planctomyces*



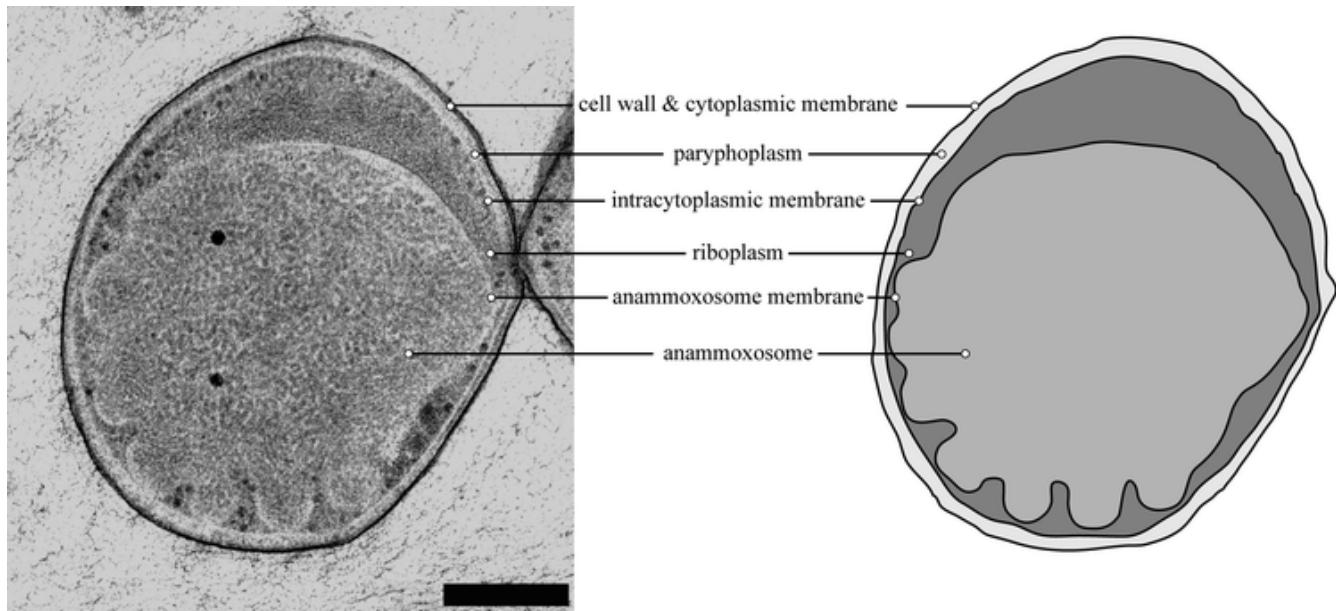
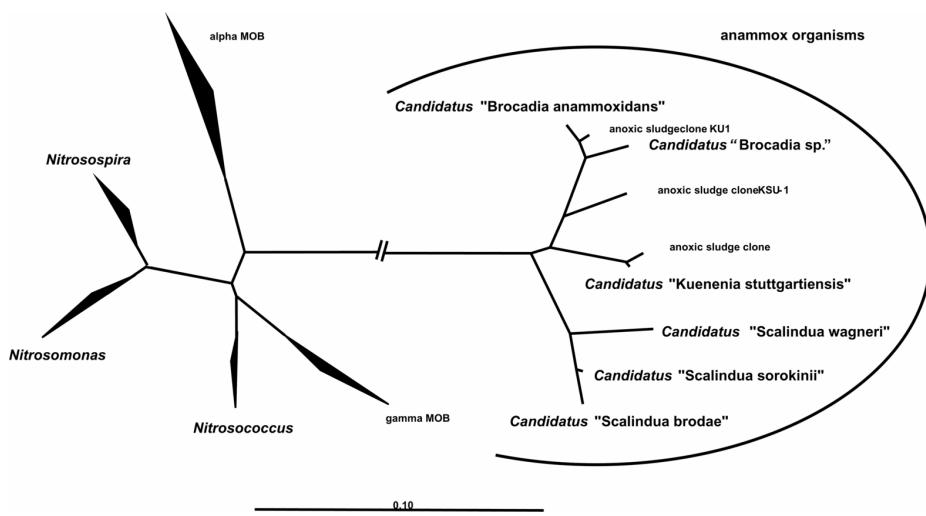
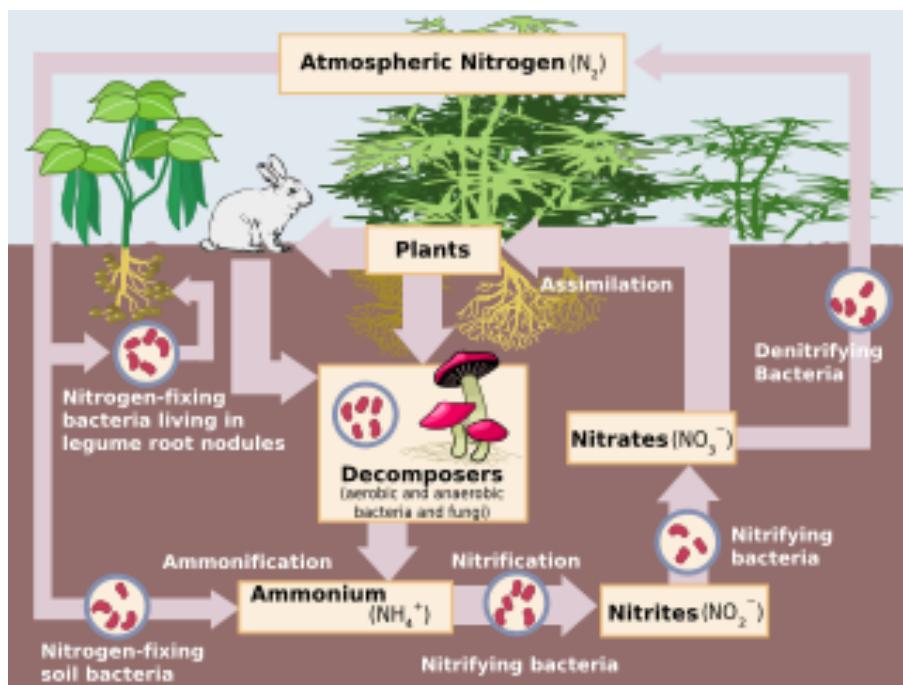


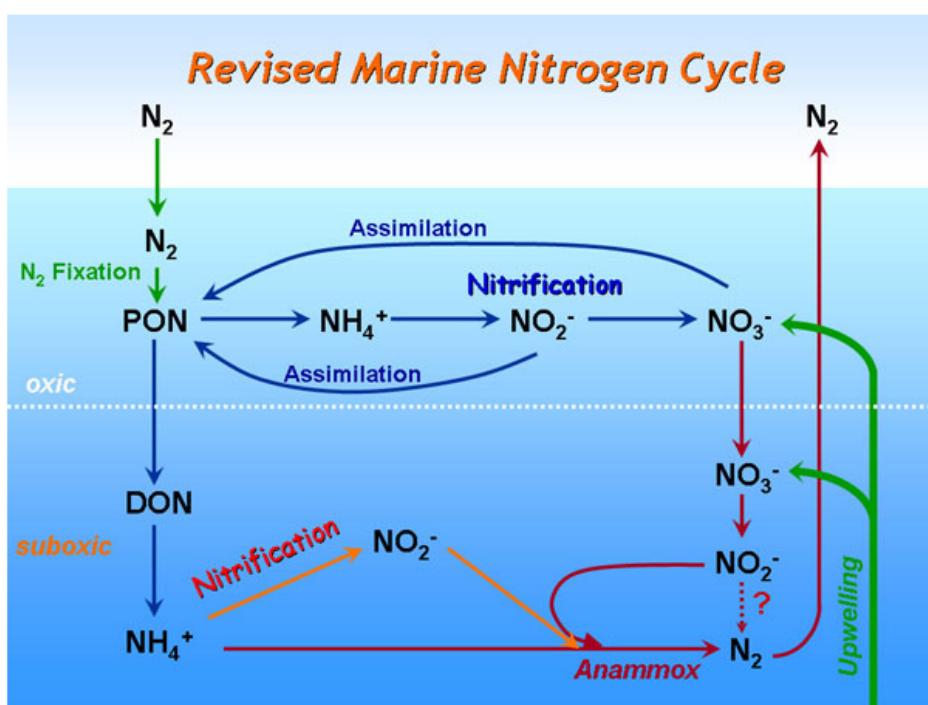
Figure 3 Phylogenetic relation of anammox bacteria in comparison with aerobic AOB

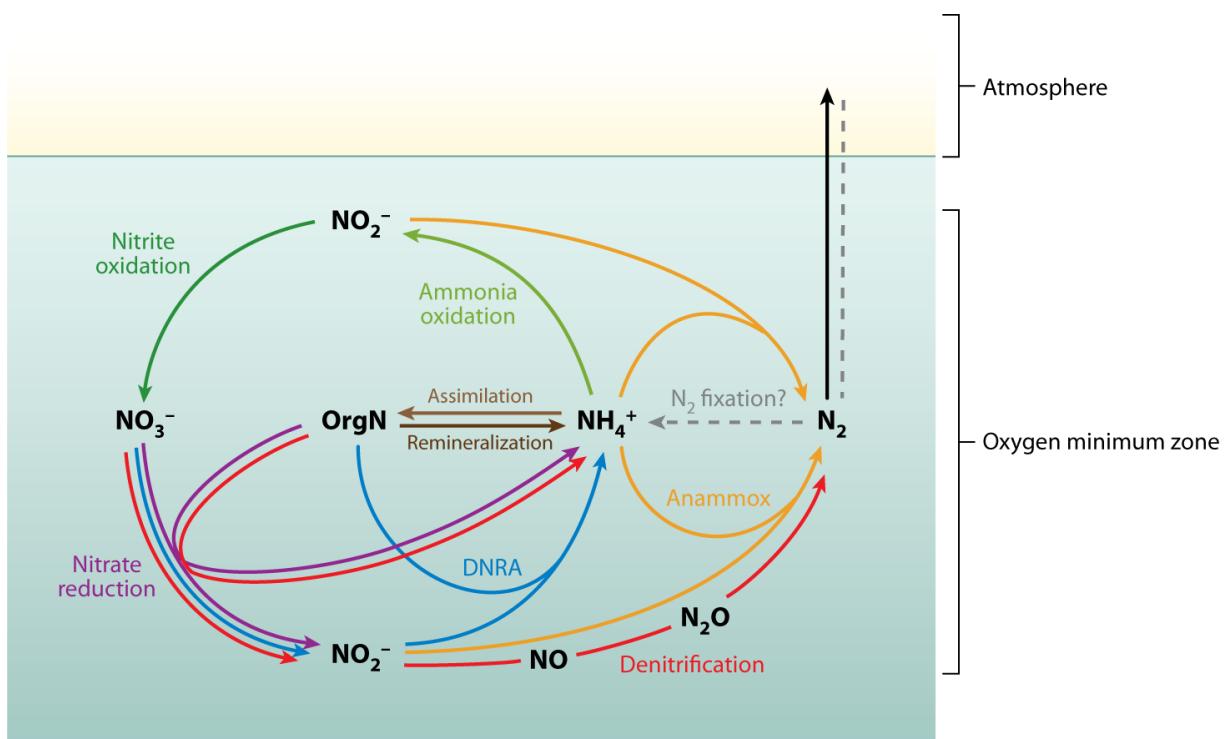


The Nitrogen cycle



Marine Nitrogen Cycle





AR Lam P, Kuypers MMM. 2011.
Annu. Rev. Mar. Sci. 3:317–45

Annamox Bacteria



