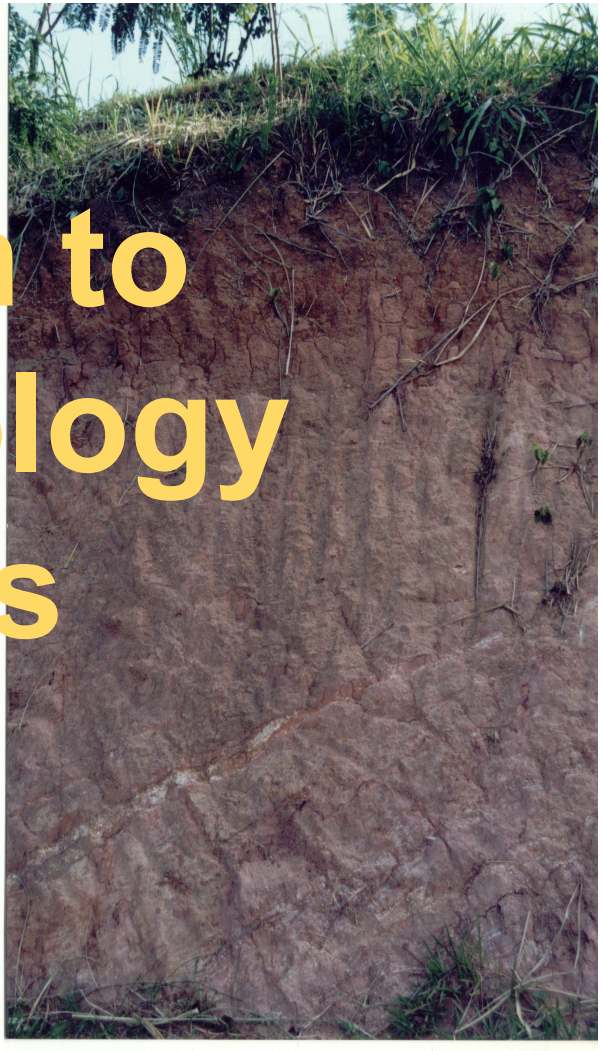


Introduction to microbial ecology and 'omics

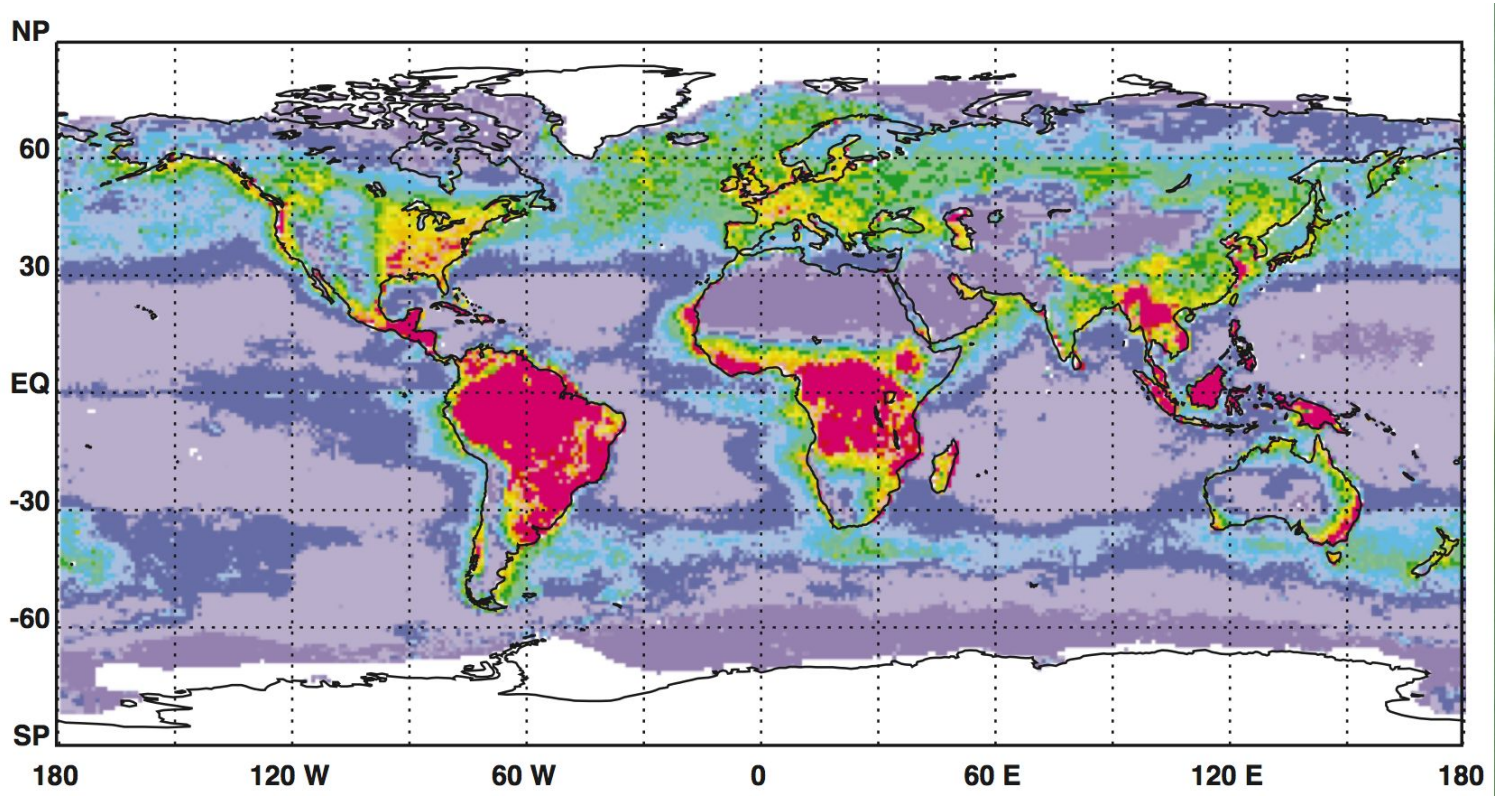
Daniel Lundin

Linnæus University
Centre
Ecology and Evolution in
Microbial model Systems

1 liter seawater:
20,000 “species”
10^9 cells

Microscopic phytoplankton in the sea carry out as much photosynthesis as green plants on land (~140 million tons of carbon per day).

Field et al. Science 1998

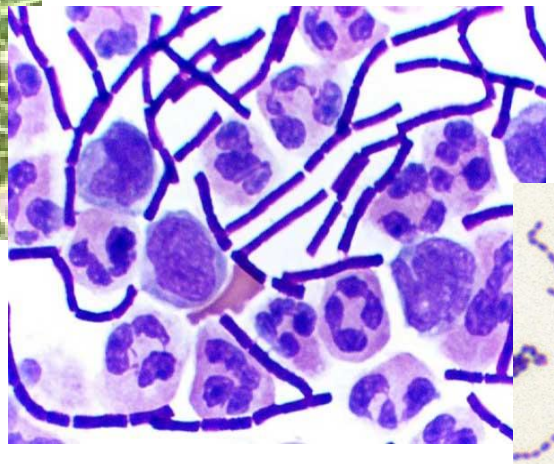


And around 50% of the organic matter produced is processed by marine bacteria!

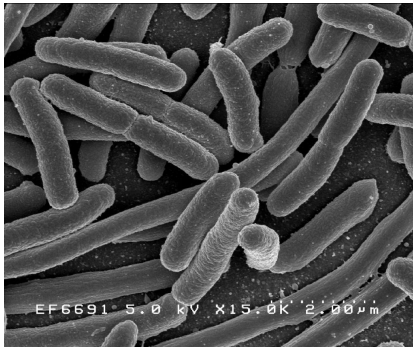
The microbial phenotype – what does it consist of?

Filamentous cyanobacteria

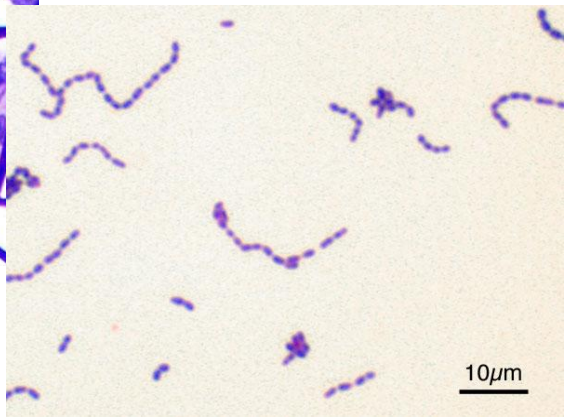
- Microbes are ultrastructurally similar
- Lifestyle (trophic strategy) and metabolic potential varies enormously!



Bacillus anthracis



Escherichia coli



Streptococcus mutans

How can we study microbes in natural environments?

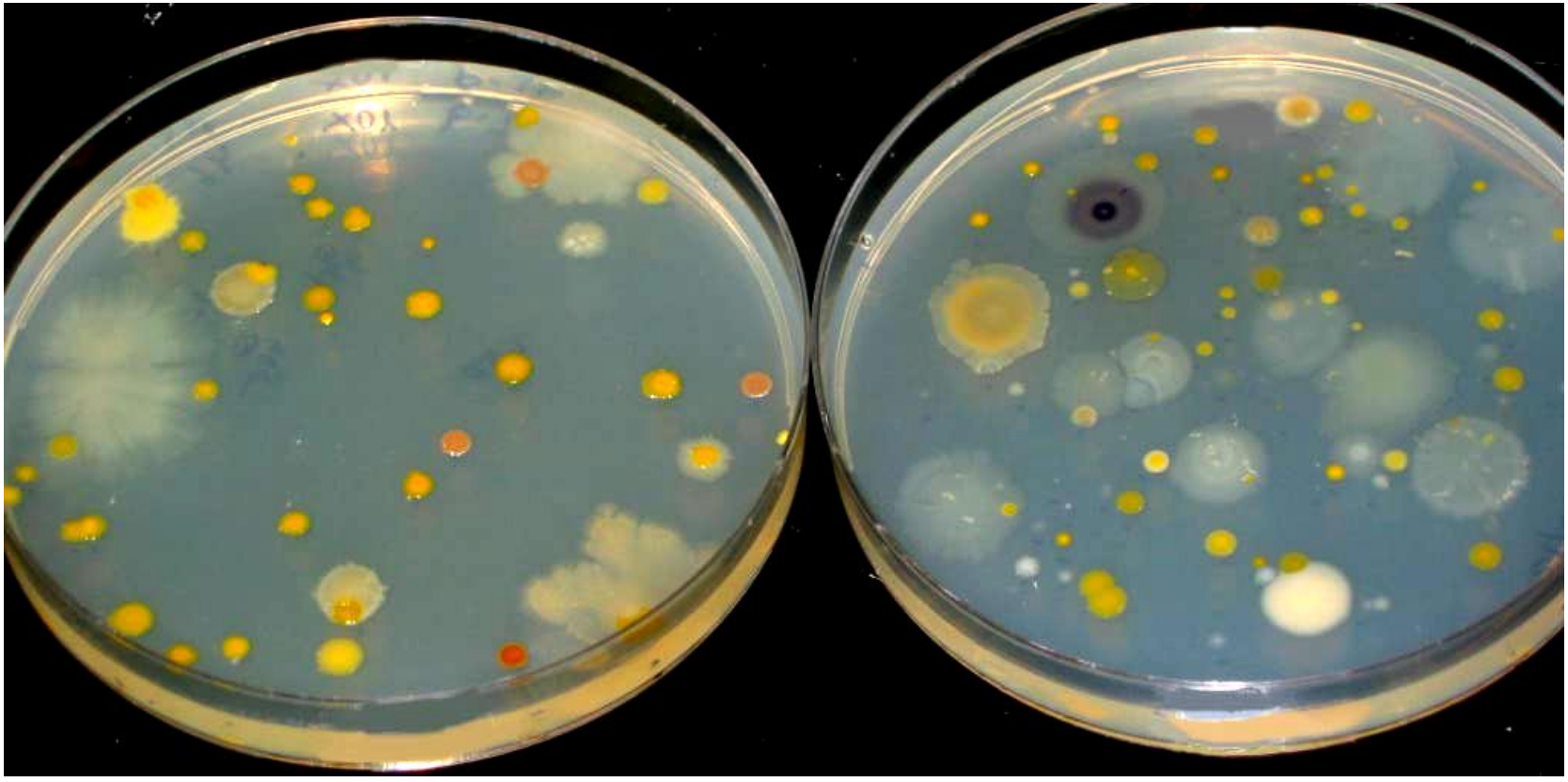


Photo: Jarone Pinhassi

1%

E. coli growth (Wikimedia commons)

Natural community experiments

- Primary production/CO_2 uptake
- Bacterial (heterotrophic) production/uptake of organic carbon
- Respiration
- Substrate utilization: carbohydrates, carboxylic acids, amino acids, nucleotides etc.
- …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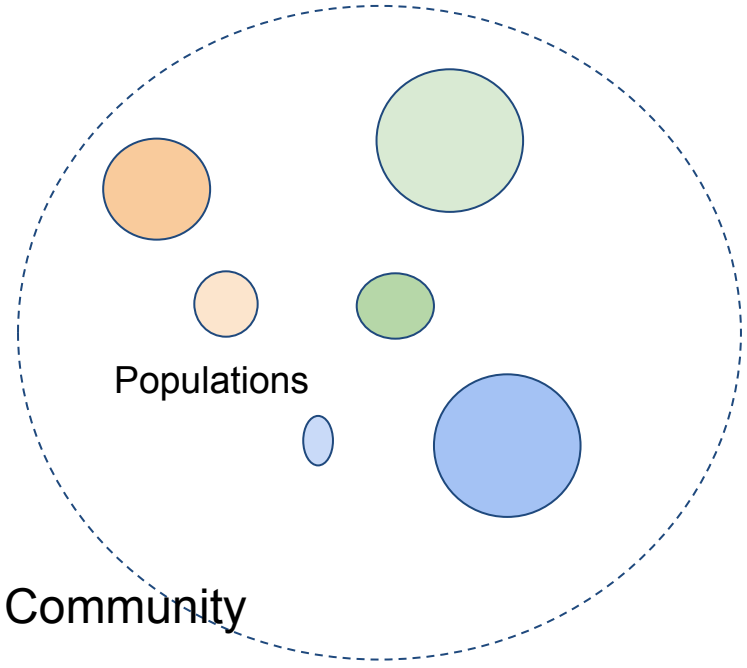
Scientific questions

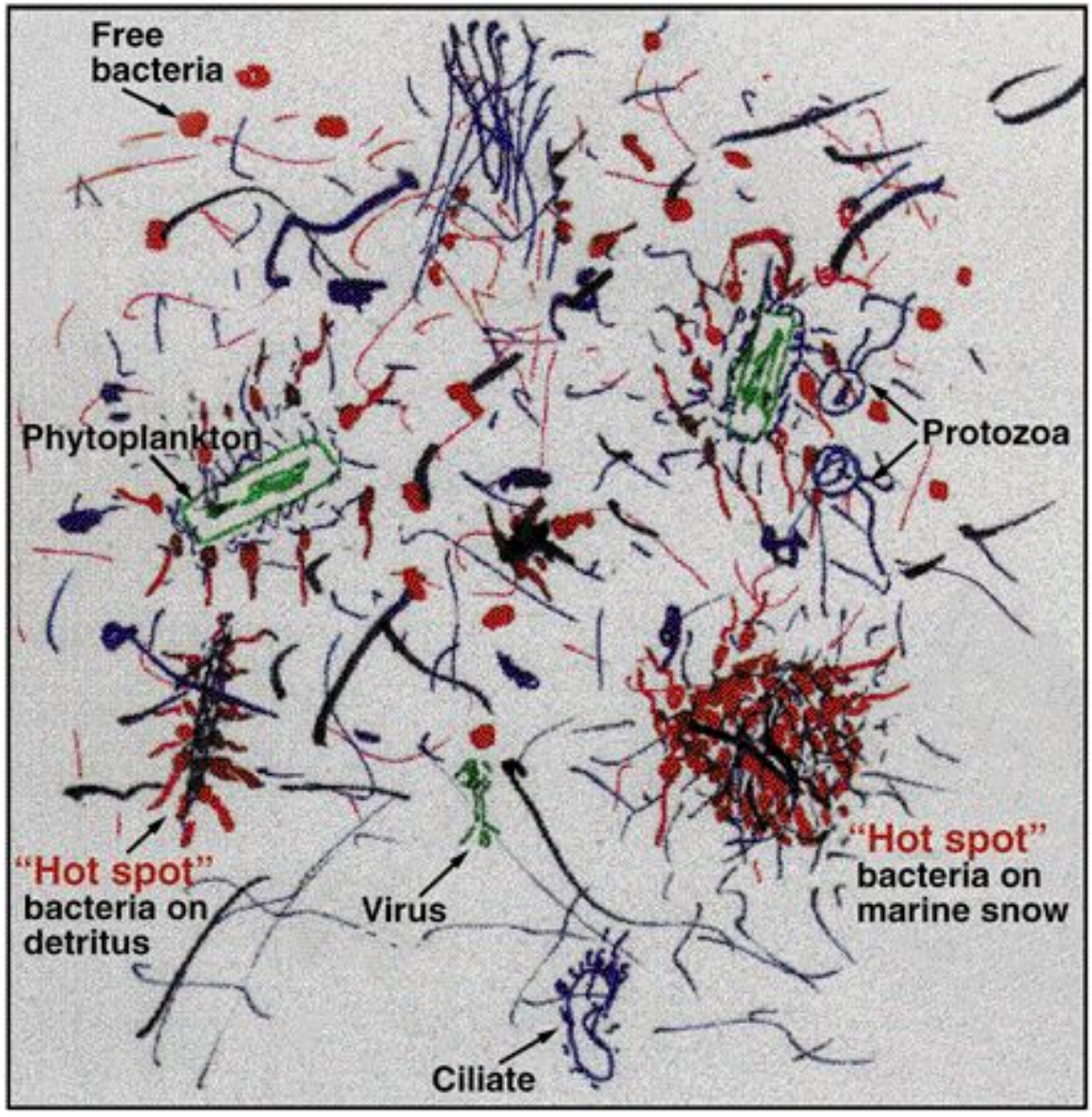
- **Community composition**: *Who* are there?
- **Genetic potential**: What are they *capable of doing*?
  - Community as a whole vs. specific members
- **Expression of transcripts**: What are they *actually doing*?
  - Community as a whole vs. specific members

Methodology

- Metagenomics: **shotgun** sequencing of environmental **DNA**
- Metatranscriptomics: **shotgun** sequencing of environmental **RNA**
- Amplicon sequencing: sequencing of PCR products (DNA or RNA)

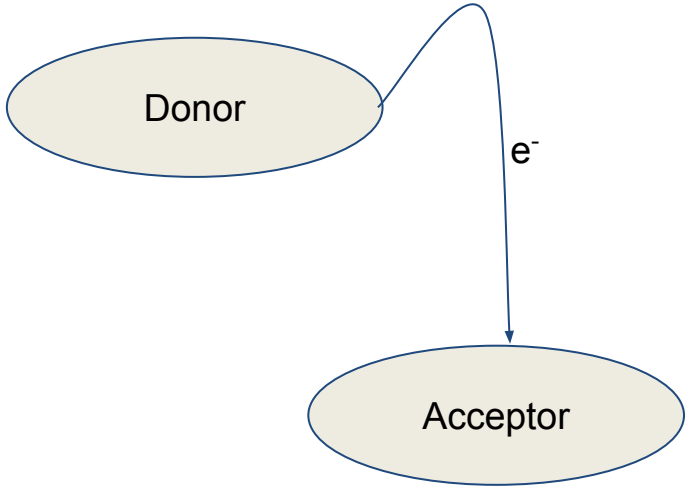
Communities and populations



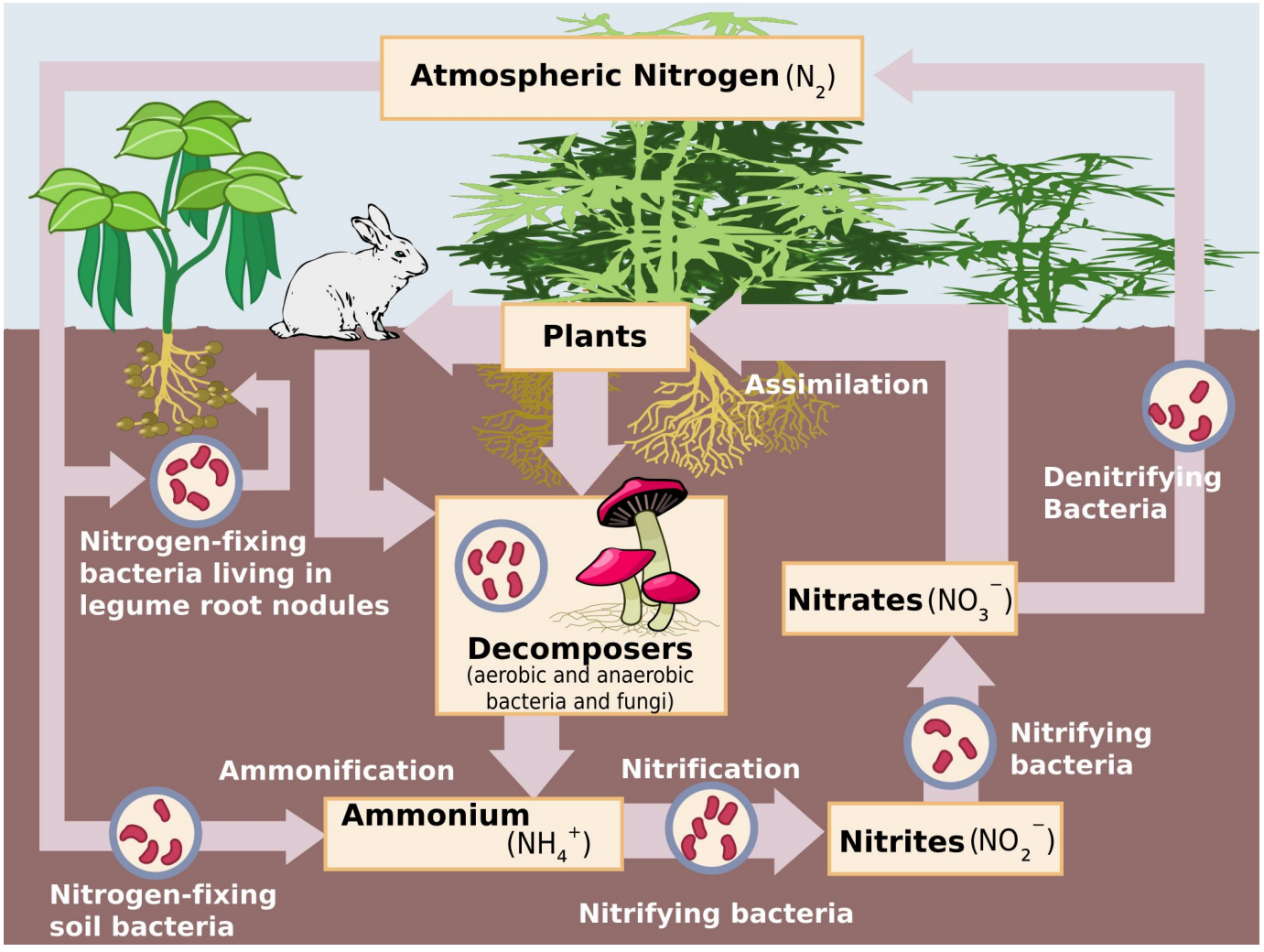

Free bacteria
Phytoplankton
Protozoa
"Hot spot" bacteria on detritus
Virus
"Hot spot" bacteria on marine snow
Ciliate

	CO_2 as carbon source	Organic carbon
Chemical energy	Chemoautotroph	(Chemo)**heterotroph**
Sunlight	**Photoautotroph**	Photoheterotroph

Oxygen and other electron acceptors

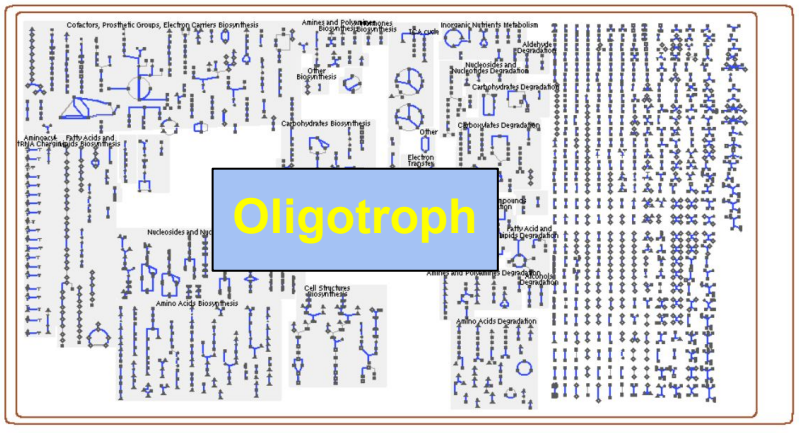


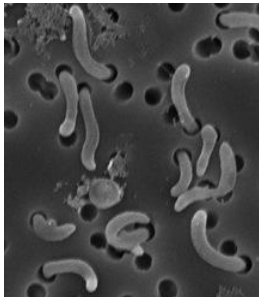
Donor	Product	Redox potential
O_2	H_2O	+0.82
Fe^{3+}	Fe^{+2}	+0.75
NO_3^-	NO_2^-	+0.40
SO_4^{2-}	HS^-	-0.22
CO_2	CH_4	-0.25
S^0	HS^-	-0.27
CO_2	Acetate	-0.30


Atmospheric Nitrogen (N_2)
Plants
Assimilation
Denitrifying Bacteria
Nitrogen-fixing bacteria living in legume root nodules
Decomposers
(aerobic and anaerobic bacteria and fungi)
Nitrates (NO_3^-)
Nitrifying bacteria
Ammonification
Nitrification
Ammonium (NH_4^+)
Nitrites (NO_2^-)
Nitrogen-fixing soil bacteria
Nitrifying bacteria

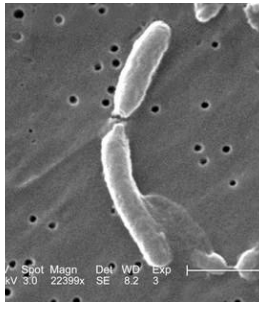
Anammox: The ultimate in weird redox chemistry

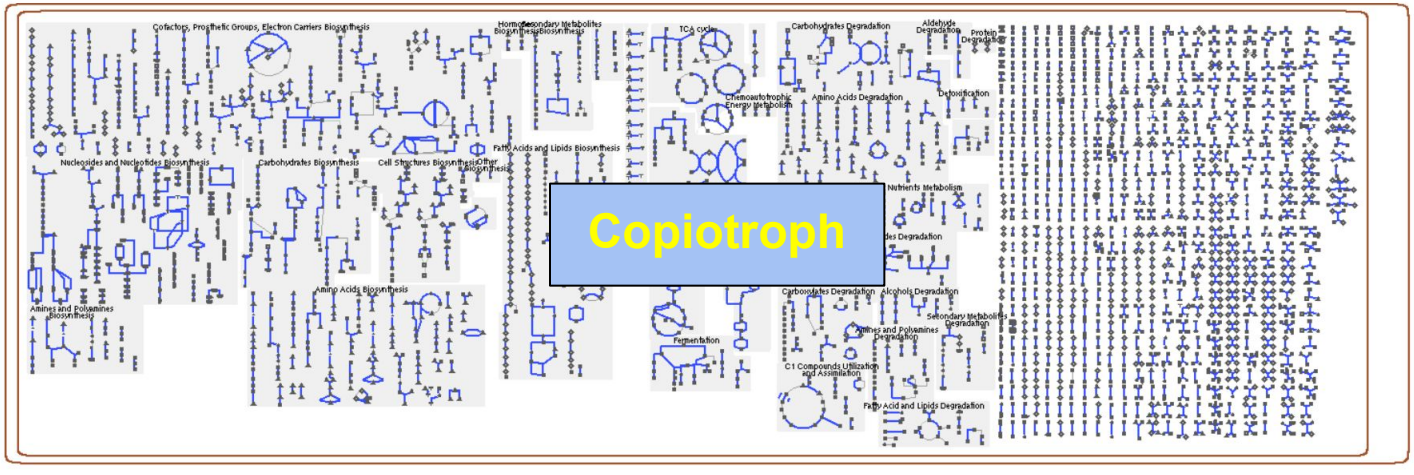
$$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$$





Candidatus Pelagibacter ubique: 1415 genes





Photobacterium angustum, 4743 genes

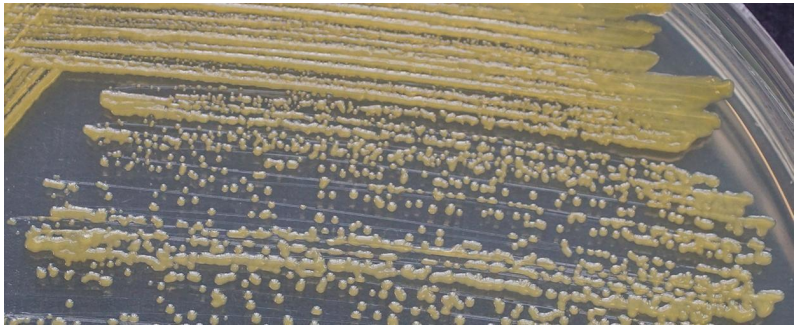
"Cellular overviews" from http://www.biocyc.org

How do we know all this?

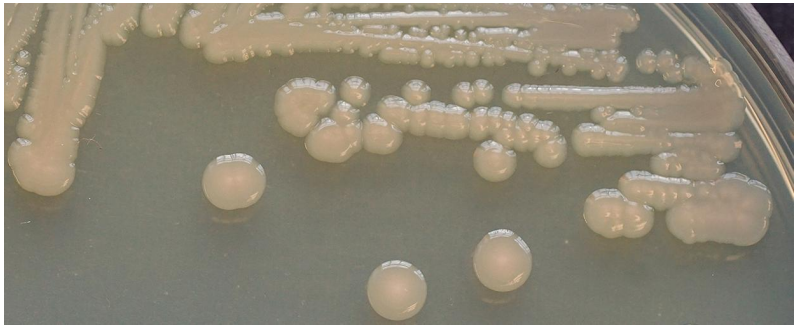
Examples of marine model bacteria

Ruegeria pomeroyi DSS-3

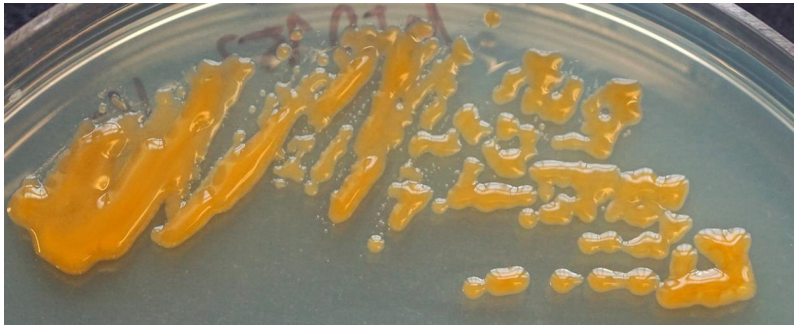
Dokdonia sp. MED134



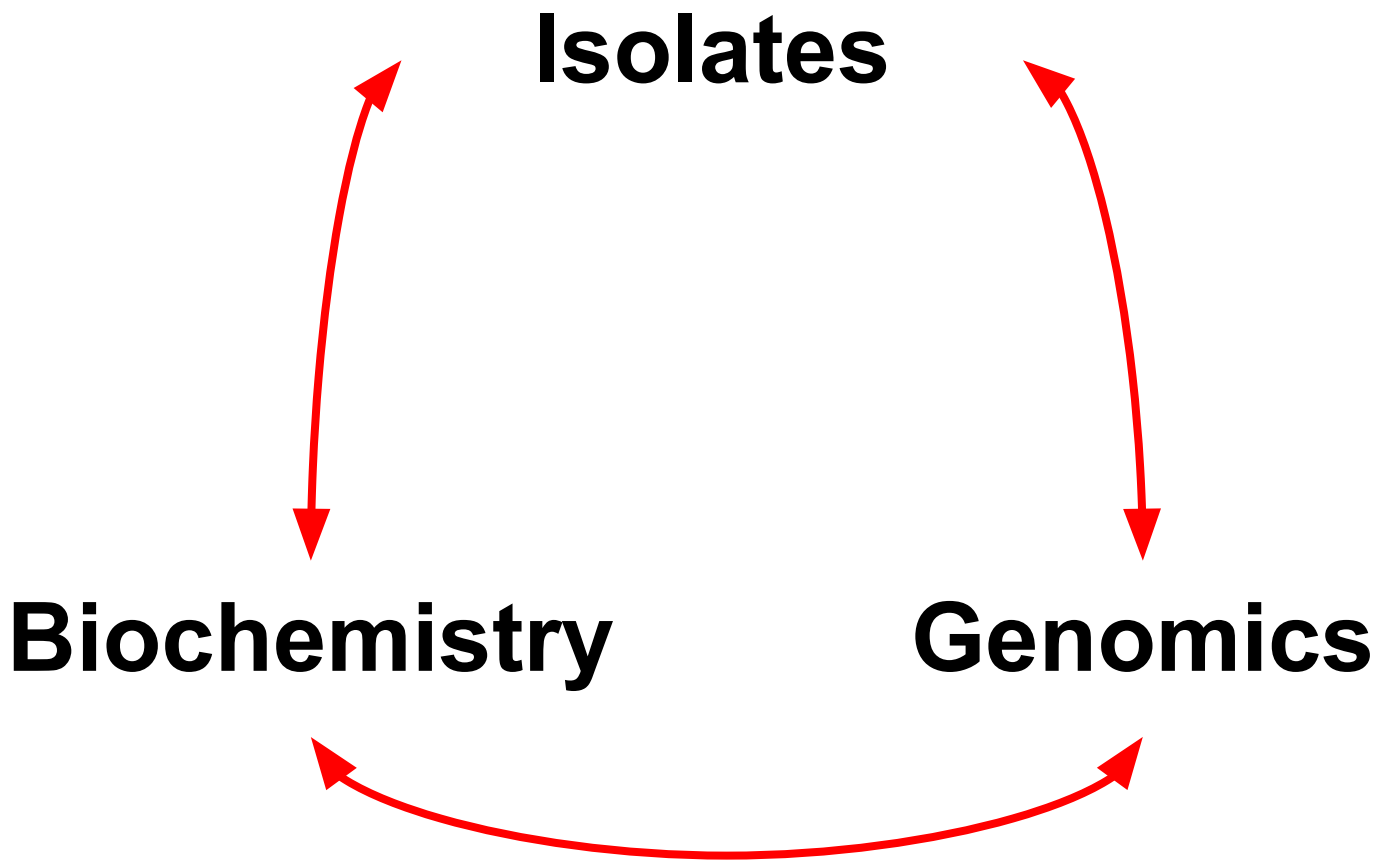
Vibrio sp. AND4



Polaribacter sp. MED152



Photographs by Shalabh Sharma


Isolates
Biochemistry
Genomics

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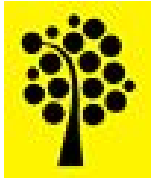


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