
UBC
a place of mind
THE UNIVERSITY OF BRITISH COLUMBIA

Viruses, carbon sequestration and the biological pump

Curtis A Suttle

Departments of Earth, Ocean & Atmospheric Sciences, Botany, and Microbiology & Immunology

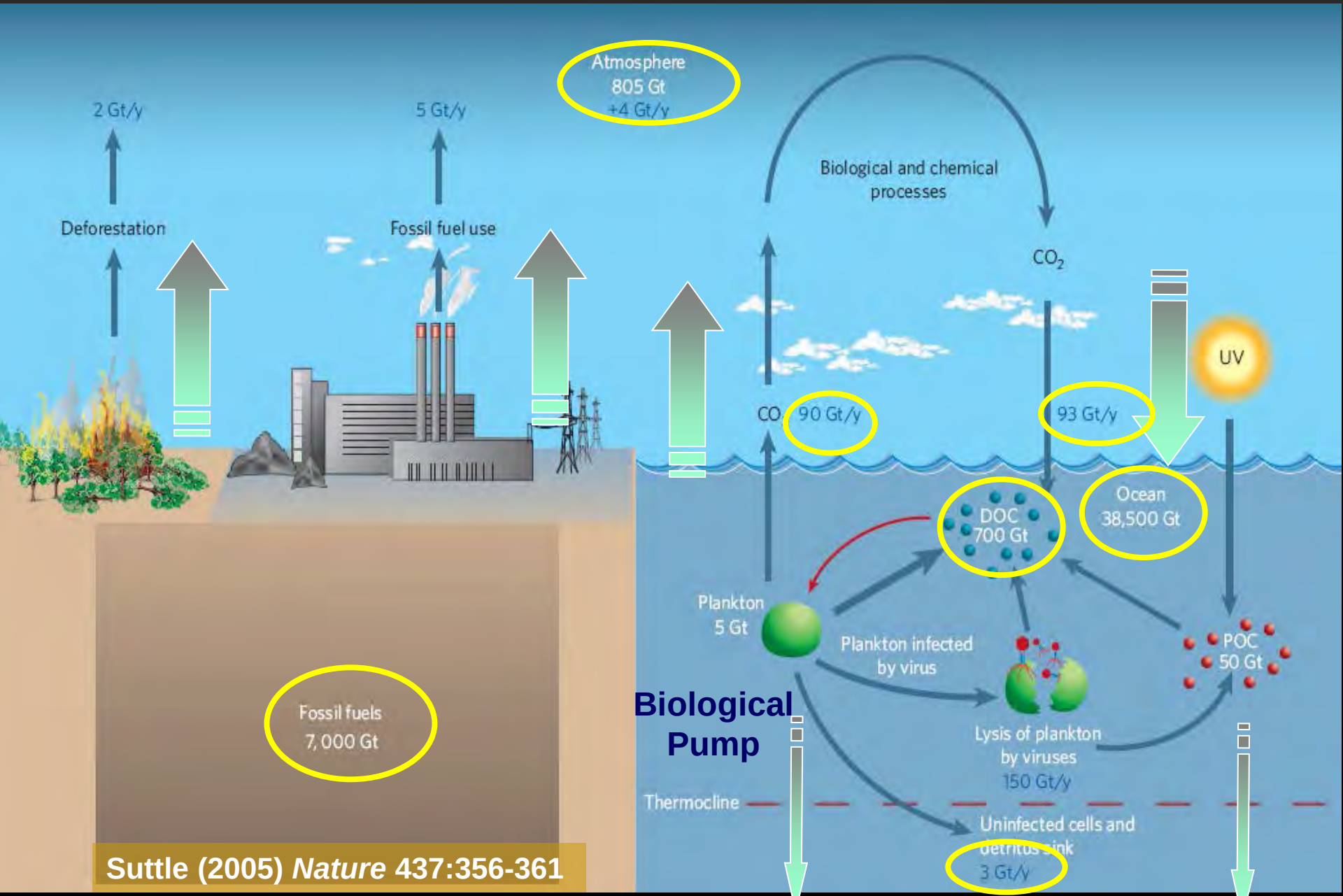
Institute of the Oceans and Fisheries

University of British Columbia

Scenario

- This reservoir of *dissolved organic carbon* (DOC) is as large as that of CO_2 in the atmosphere
- Its average age is ~5000y and hence can be a mechanism of carbon sequestration
- Viruses are major players in nutrient cycling in the ocean and in the formation of DOC

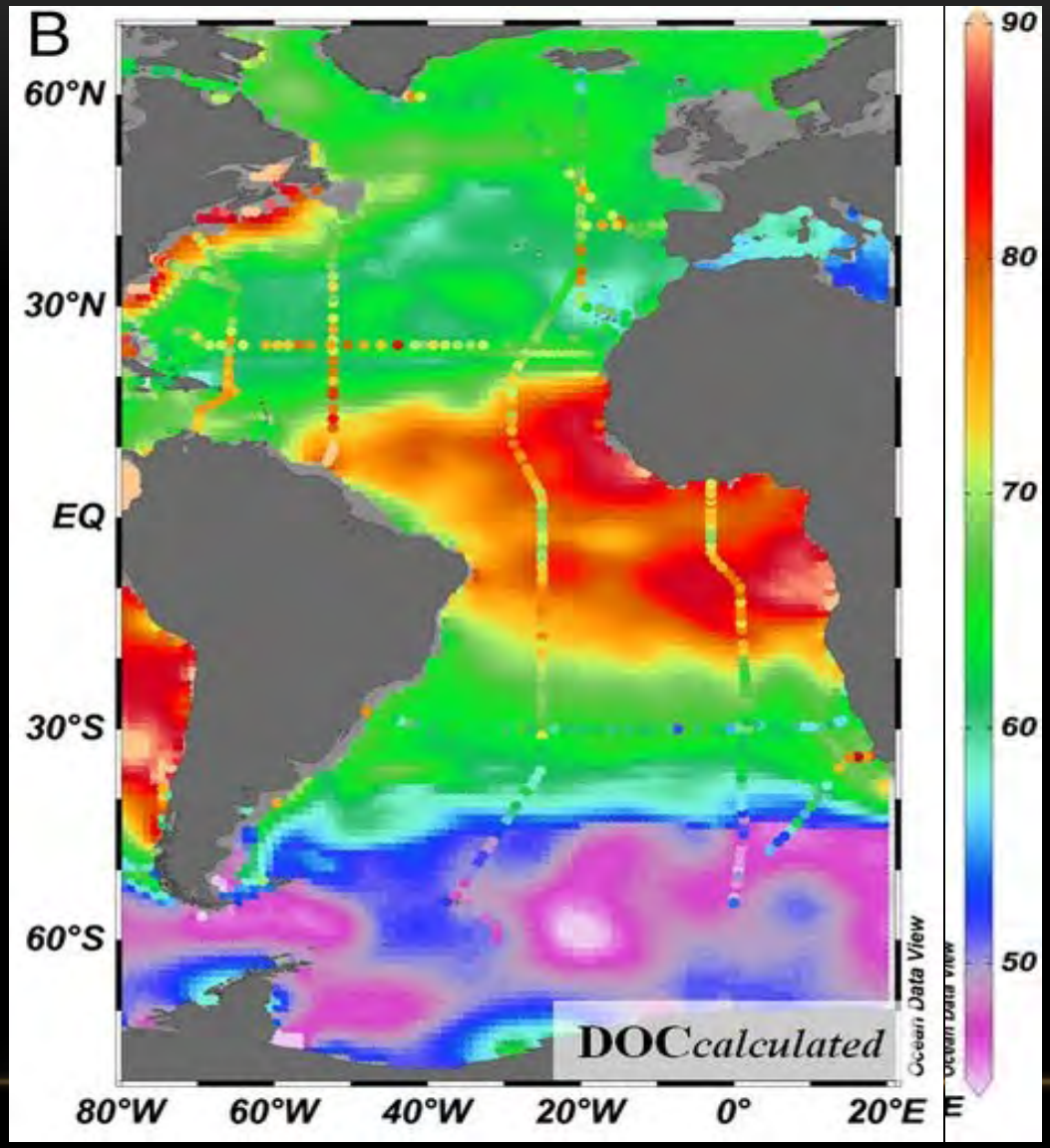
Global reservoirs of carbon



Suttle (2005) *Nature* 437:356-361

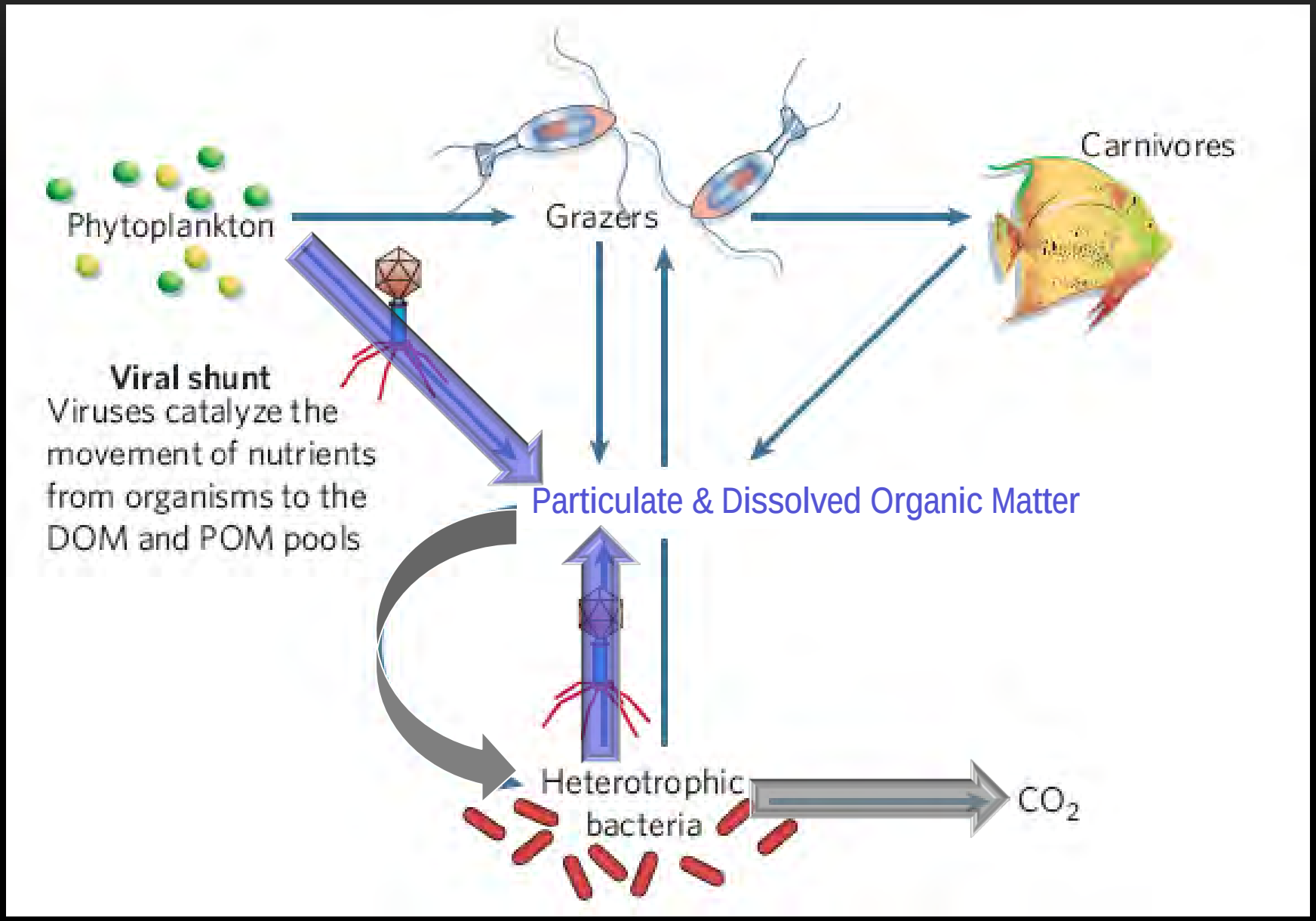
DOC in Atlantic surface waters

µmolC/kg



Cristina Romera-Castillo et al. PNAS 2016;113:10497-10502

Viruses catalyze the movement of nutrients



Suttle 2005 *Nature* 437, 356-351 - based on Wilhelm and Suttle 1999 *Bioscience* 47, 781-788

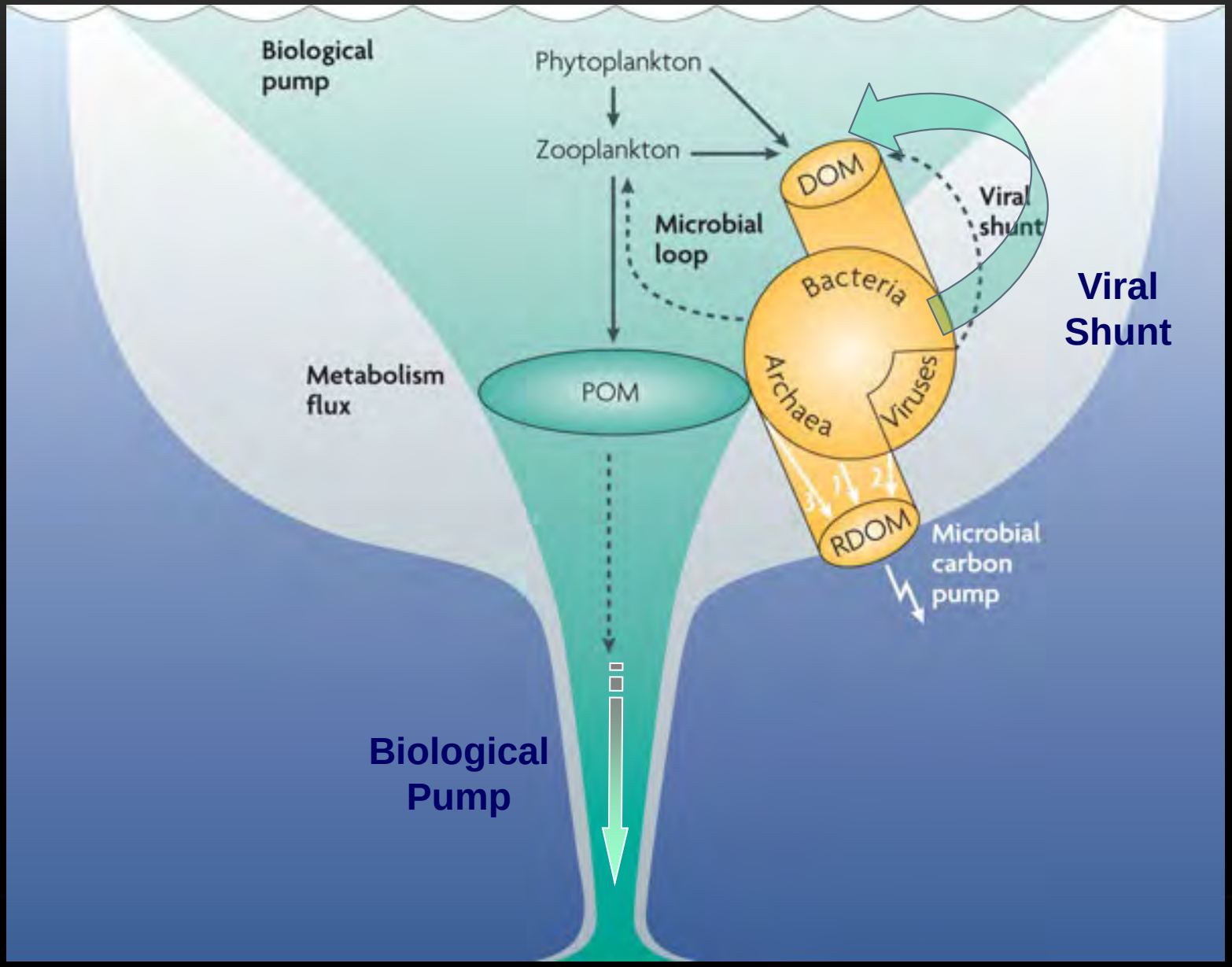
The Viral Shunt is a major player in DOC formation

→ >95 % of the biomass in the oceans is microbial

→ ~20% of marine microbes are killed each day by viruses

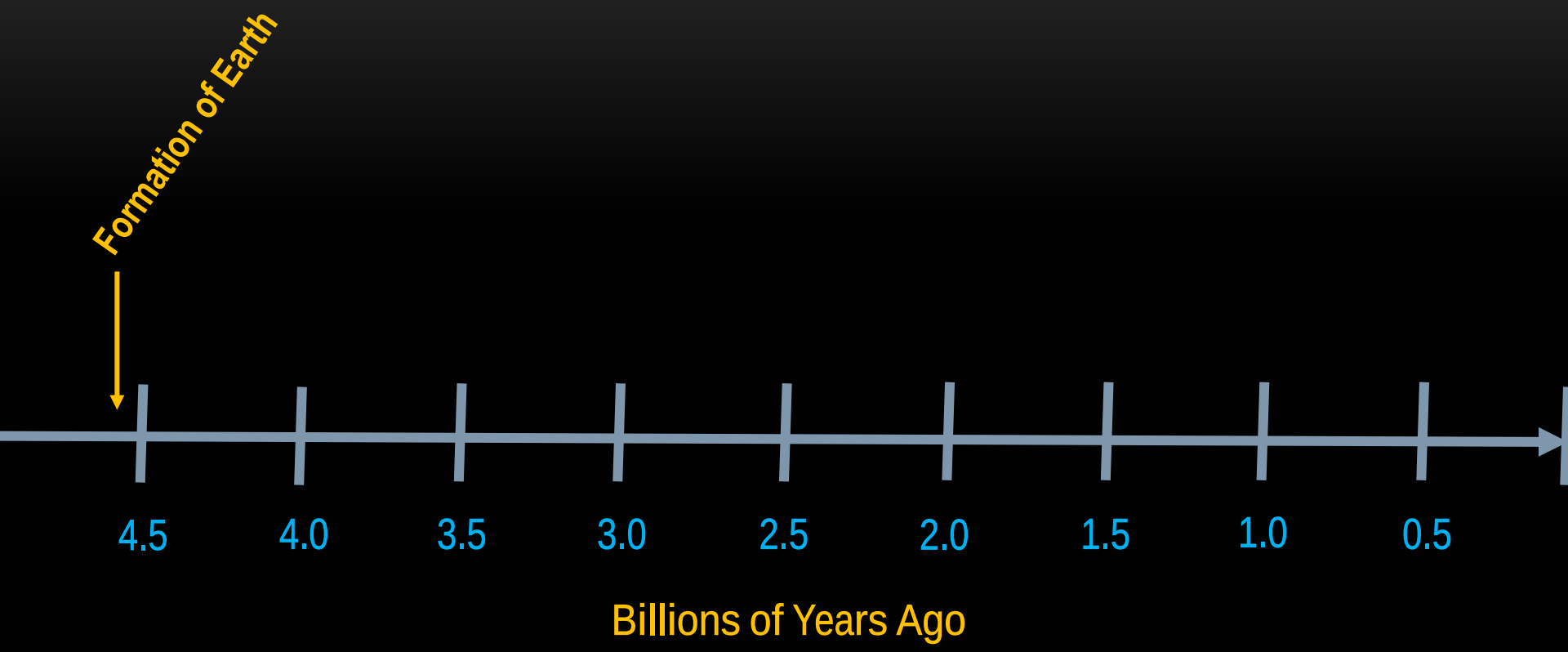
→ This drives nutrient cycles and the formation of DOC

This DOC feeds the Microbial Carbon Pump



Jiao et al 2010. Nature Rev Microbiol 8:593-599

Earth's evolution and the microbial carbon pump



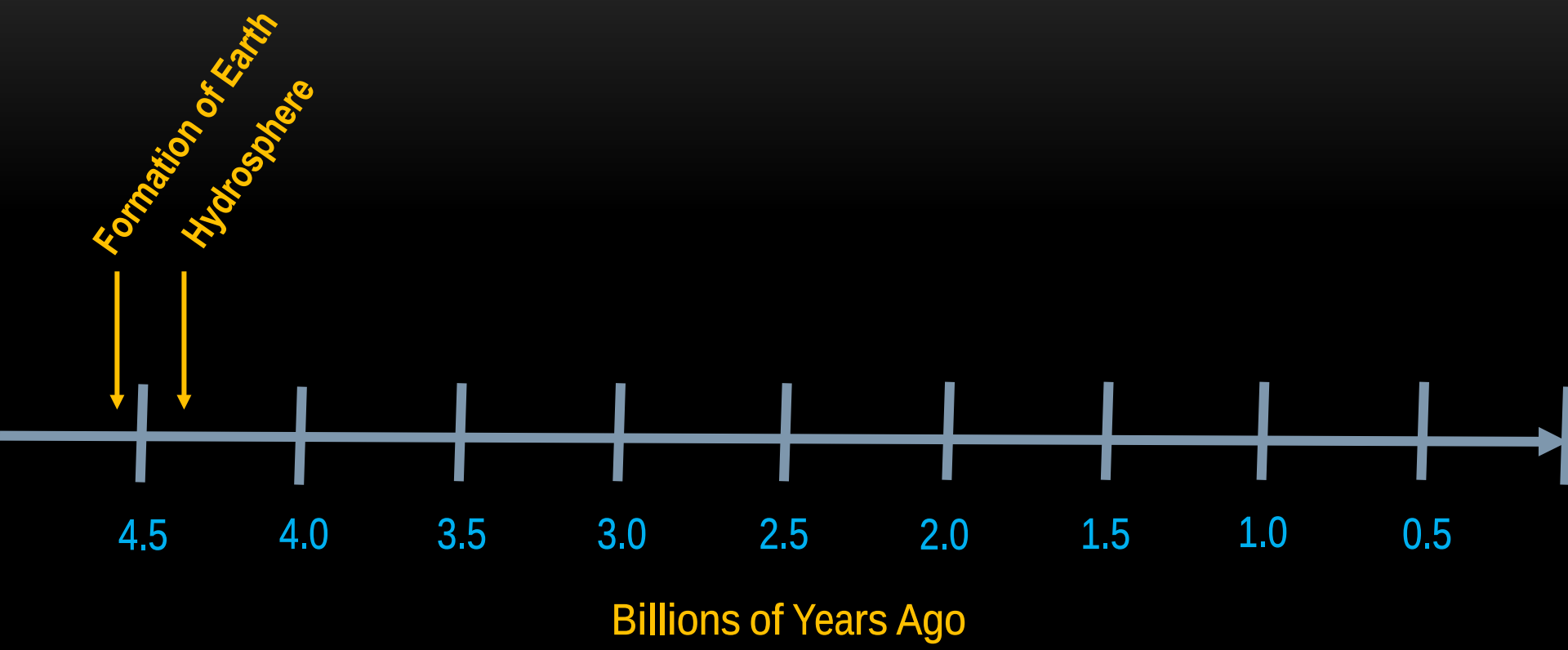
The Earth ~4.4 billion years ago

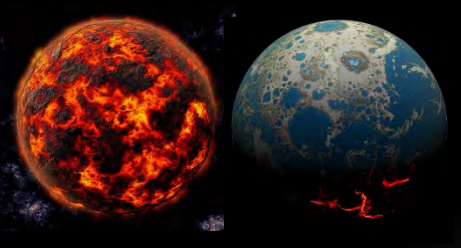
http://www.sciencemag.org/news/2015/03/researchers-may-have-solved-origin-life-conundrum

Evidence for continental crust and oceans

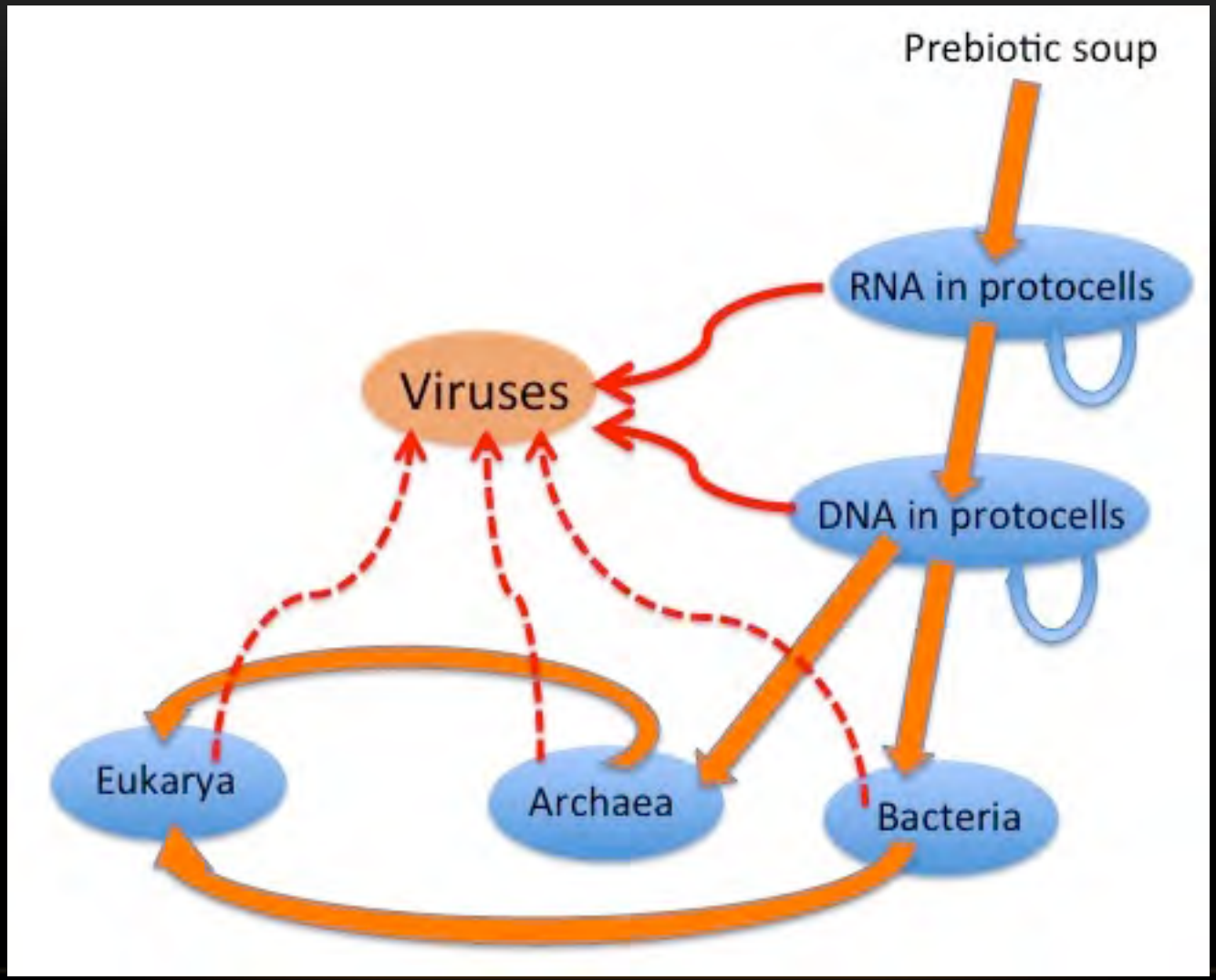
Wilde et al. 2001. *Nature* 409:175-178

Earth's evolution and the microbial carbon pump





The origin of Life



https://rybicki.files.wordpress.com/2008/03/virus-descent.jpg

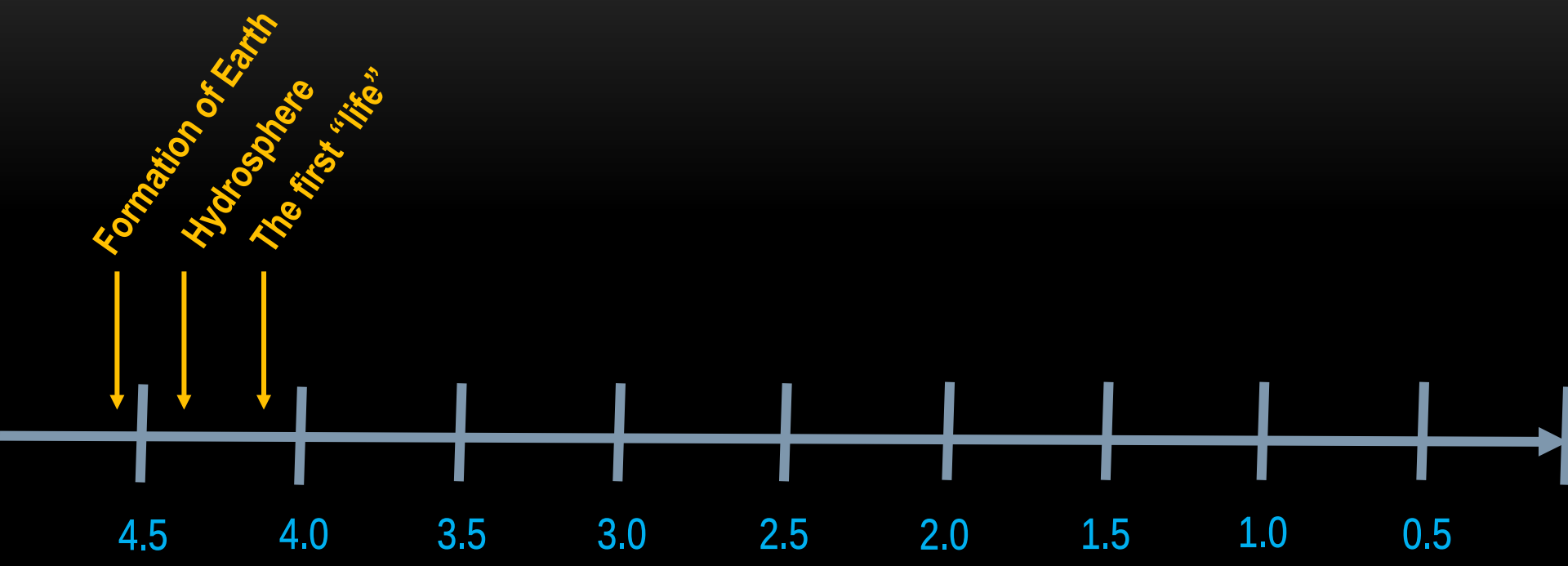
The Earth ~4.1 billion years ago

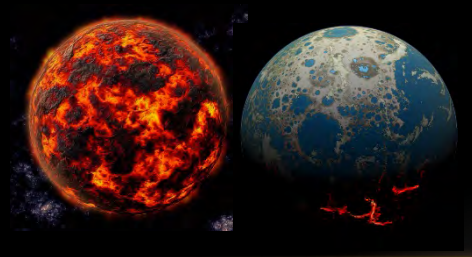
Ron Miller – Black Cat Studios

Evidence for biogenic carbon

Bell et al. 2015. *PNAS* 112: 14518–14521

Earth's evolution and the microbial carbon pump



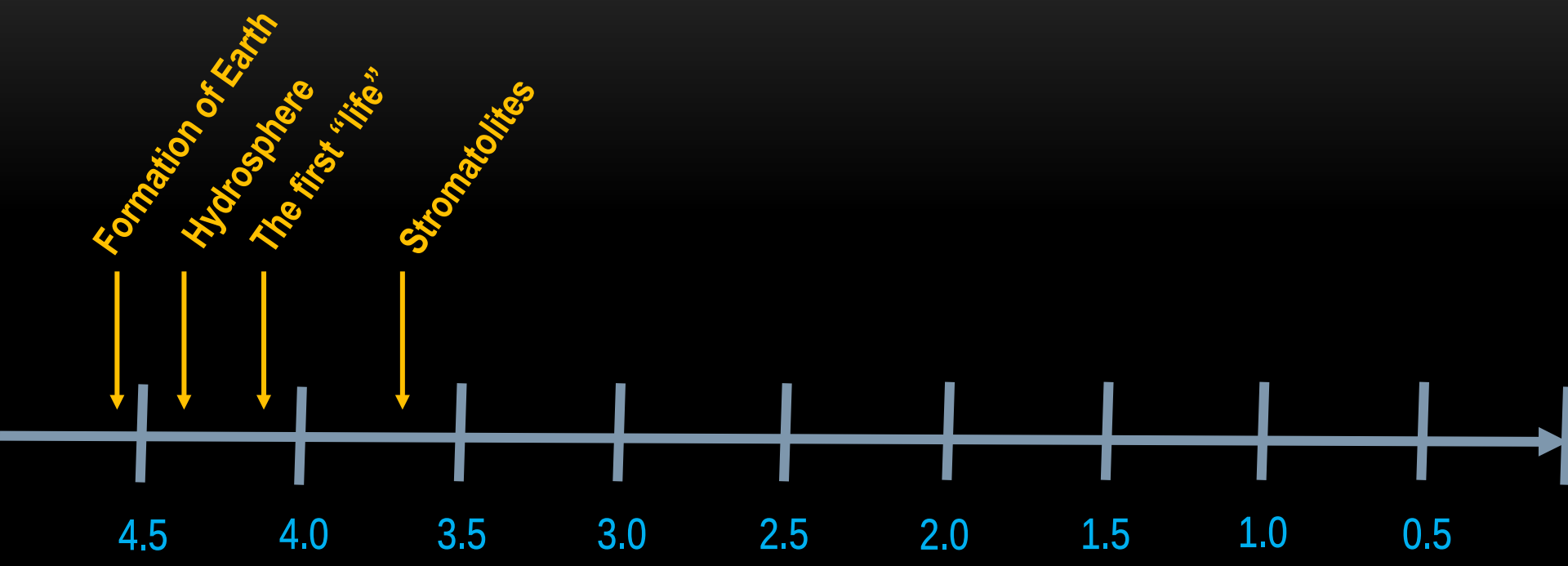


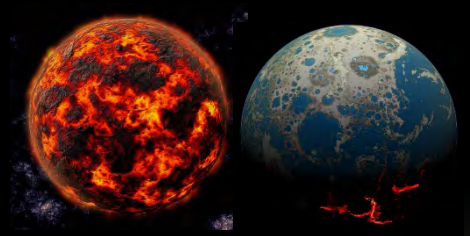
The Earth ~3.7 billion years ago

Evidence for Stromatolites

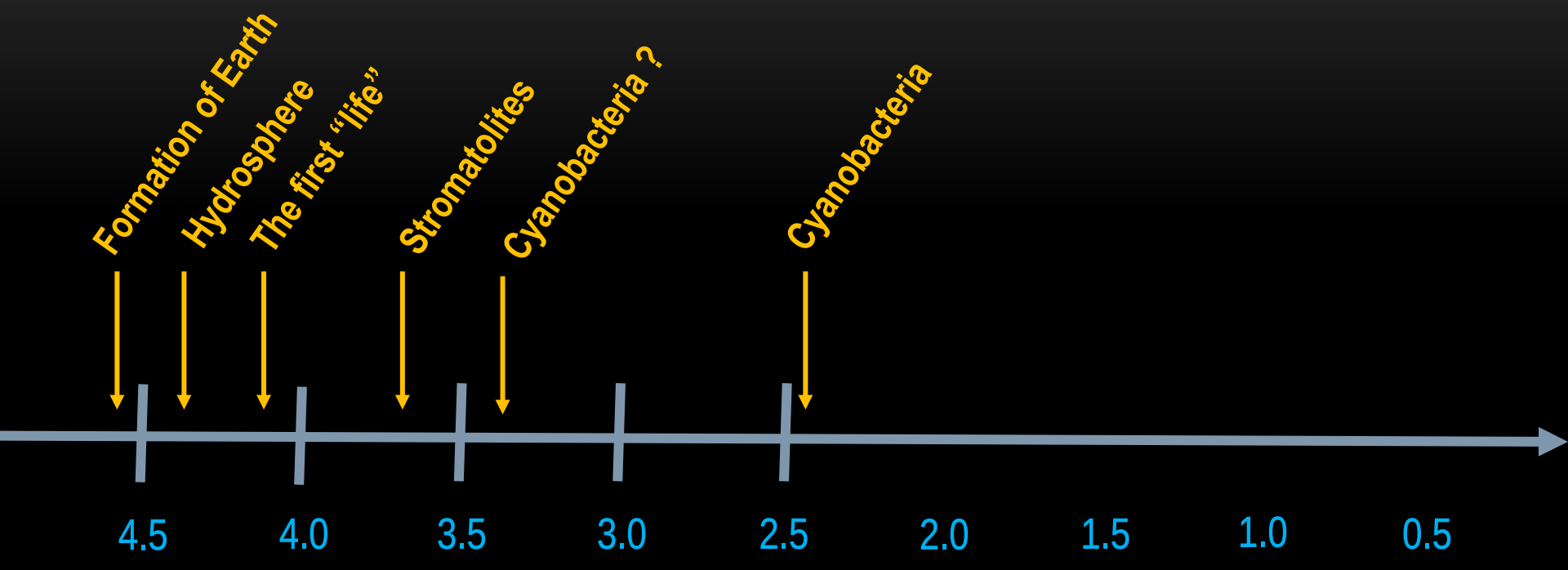
Nutman et al. 2016. *Nature* 537: 535-538

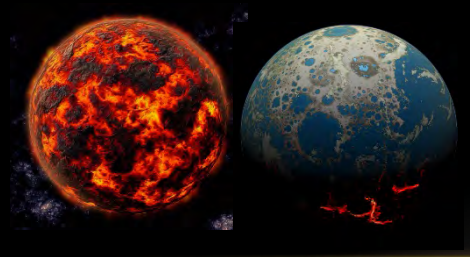
Earth's evolution and the microbial carbon pump



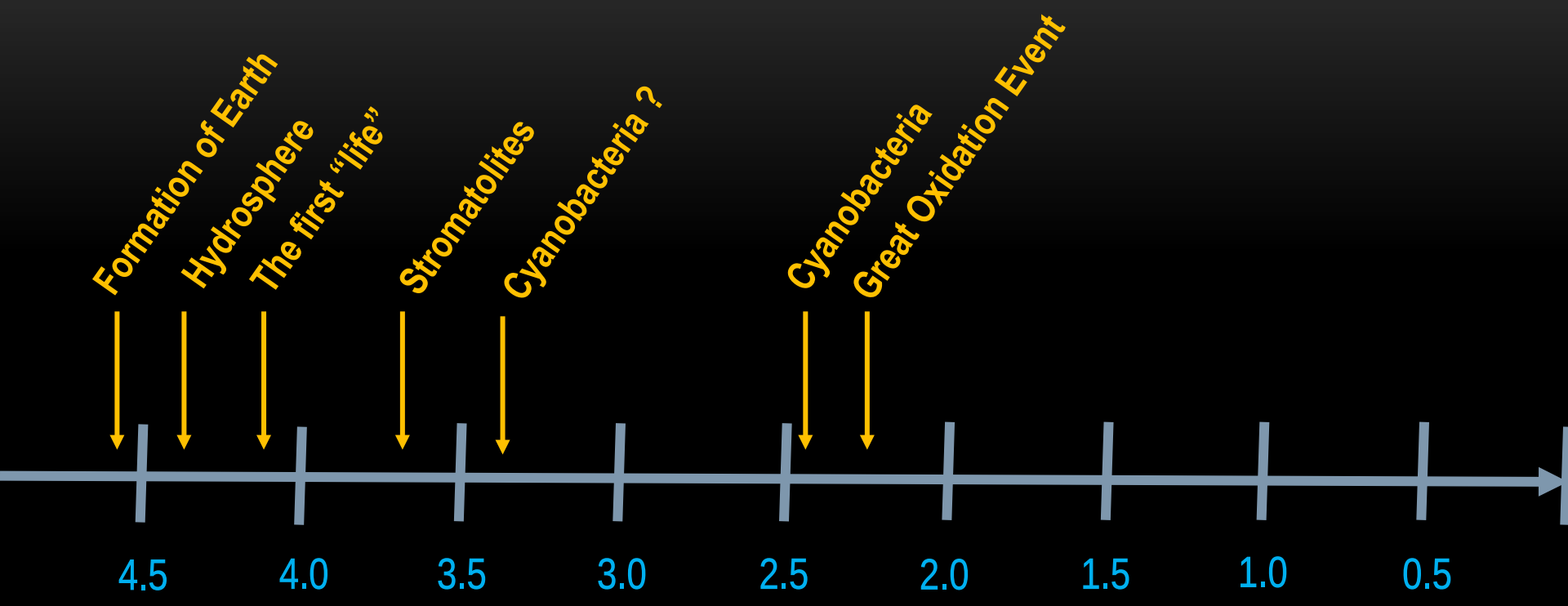


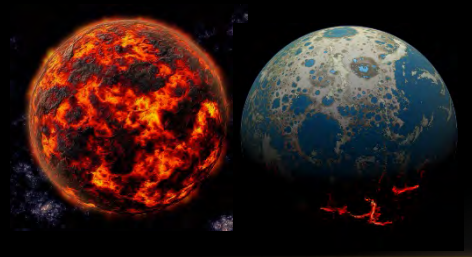
Earth's evolution and the microbial carbon pump

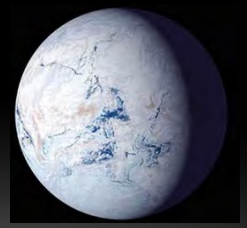




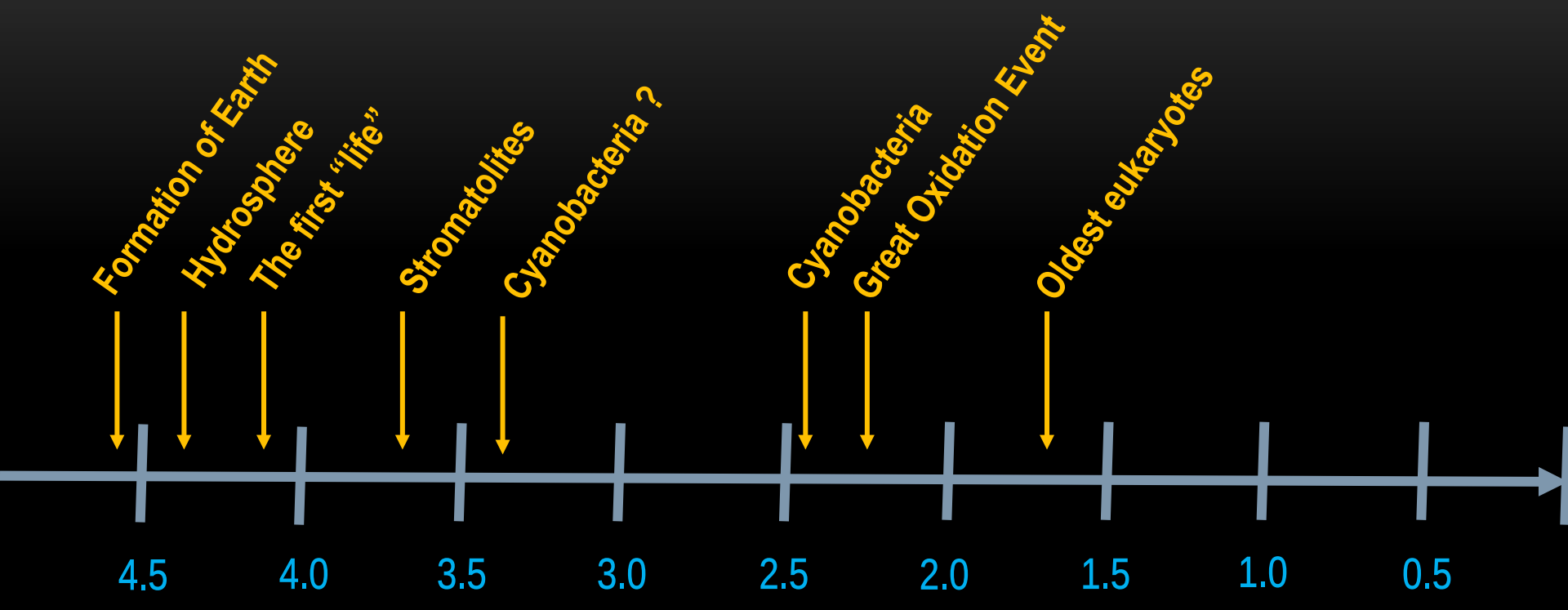
Earth's evolution and the microbial carbon pump

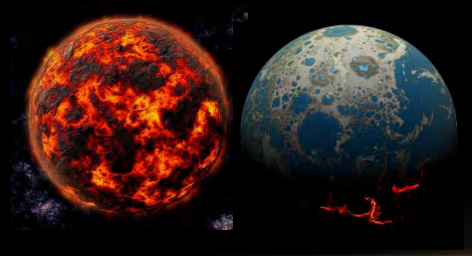


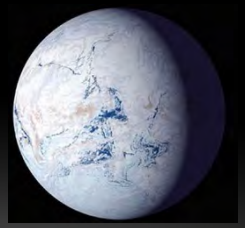




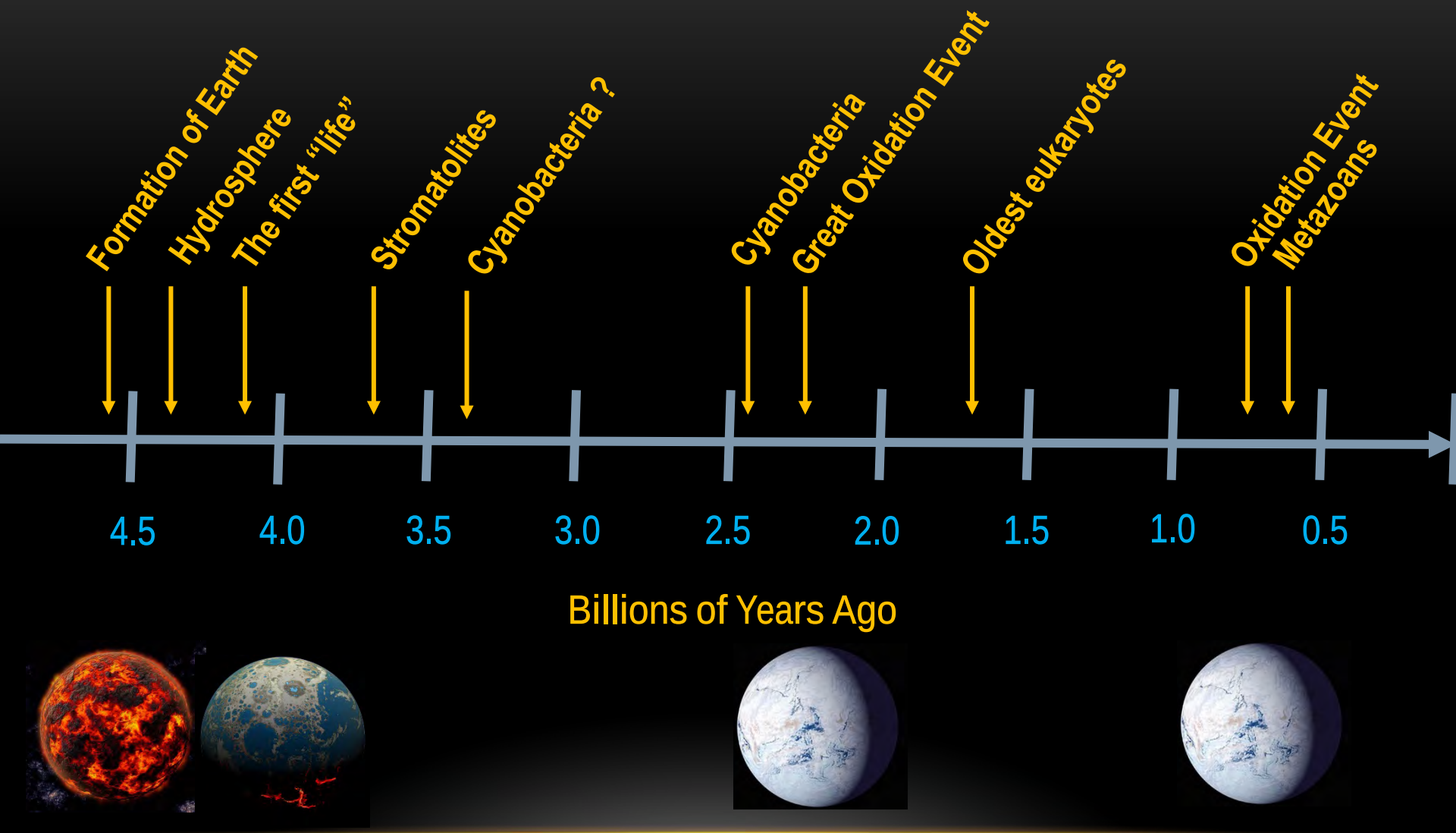
Earth's evolution and the microbial carbon pump



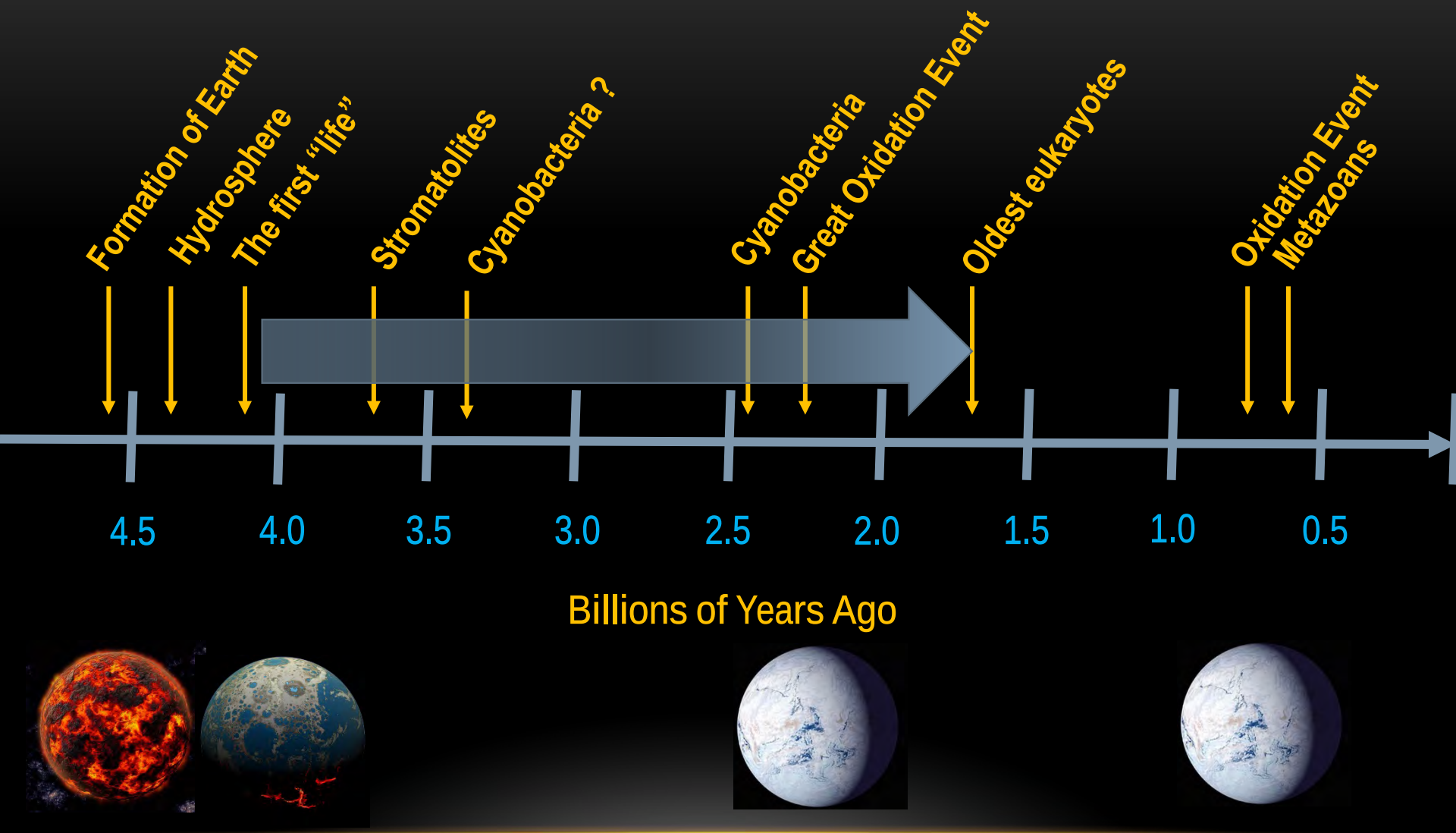




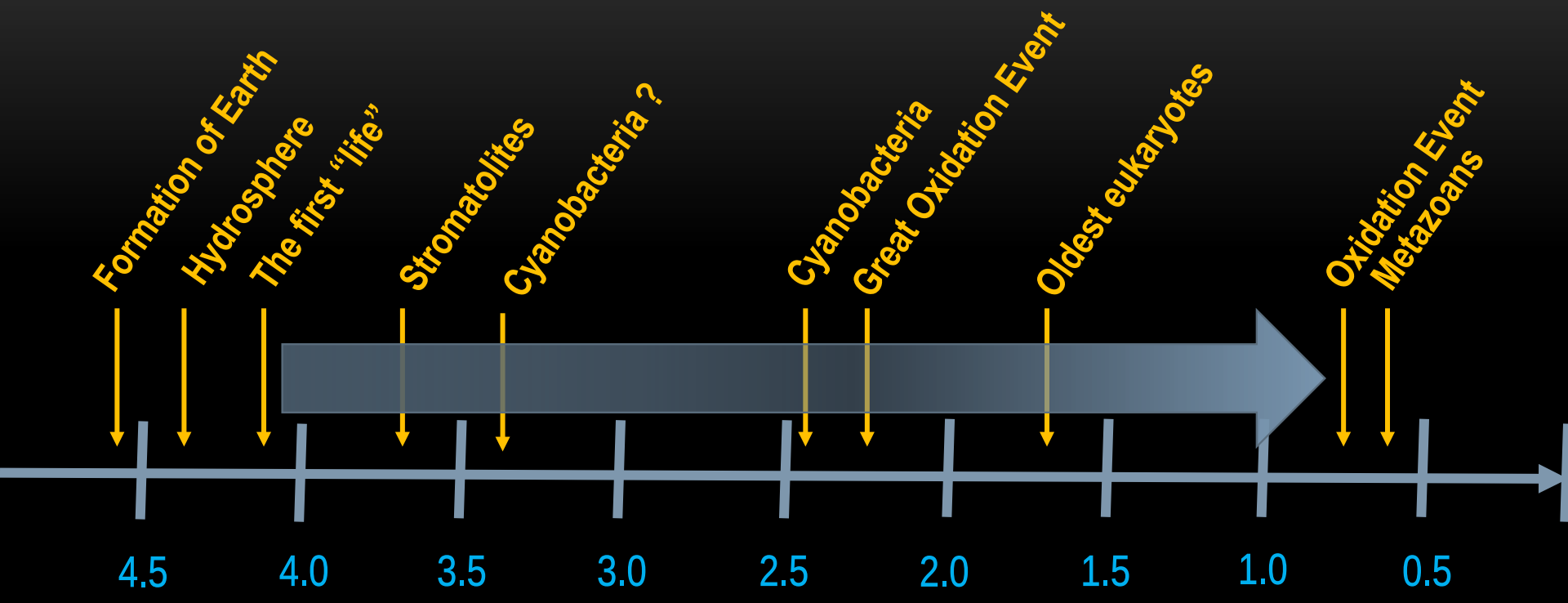
Earth's evolution and the microbial carbon pump

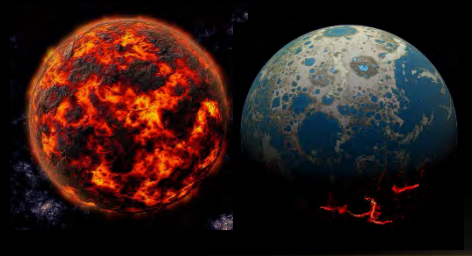


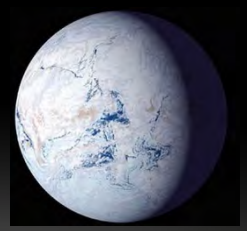
Earth's evolution and the microbial carbon pump

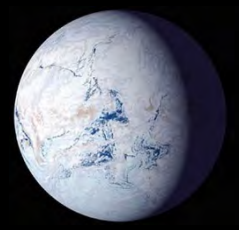


Earth's evolution and the microbial carbon pump





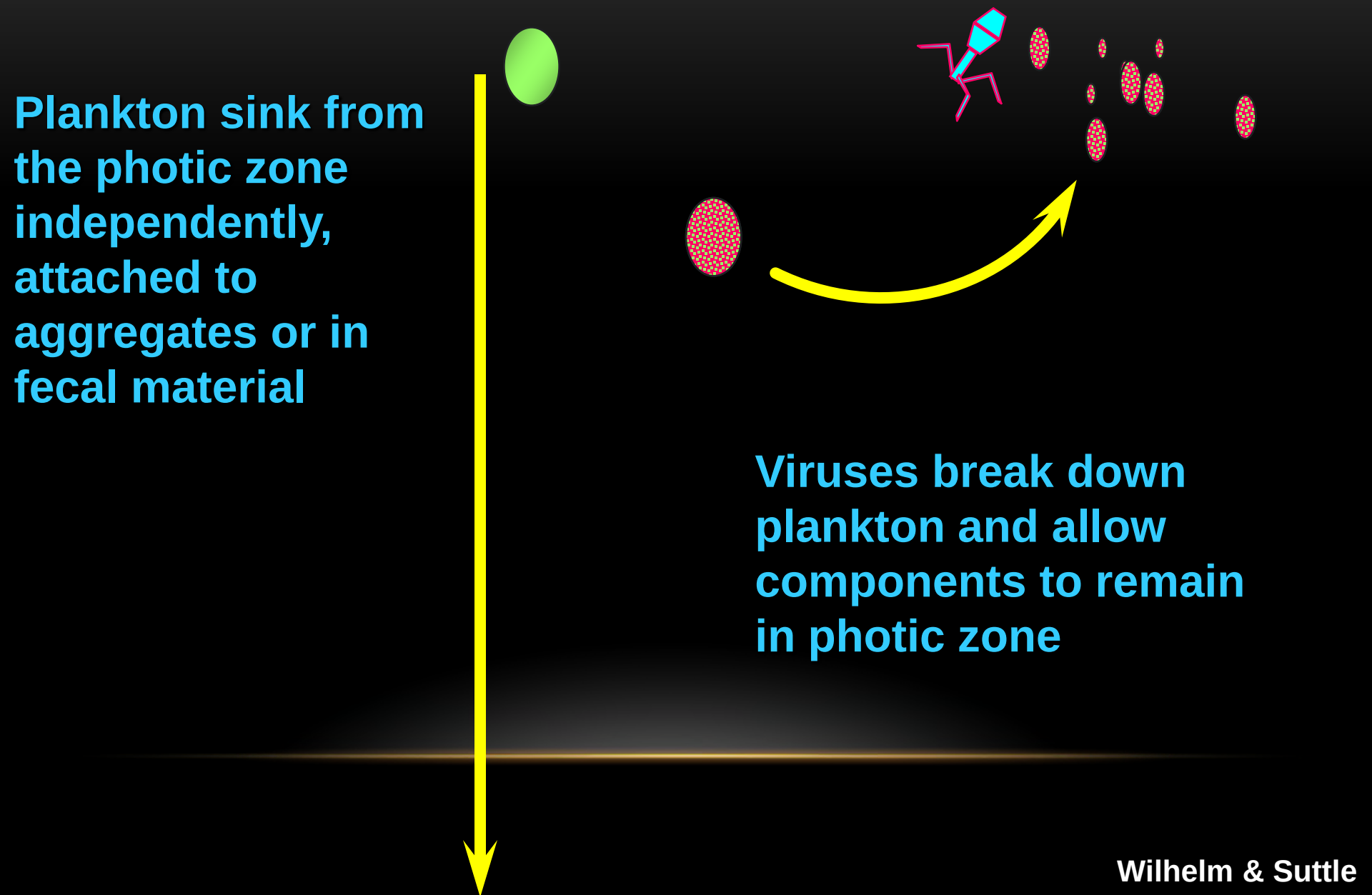




Global ecosystem

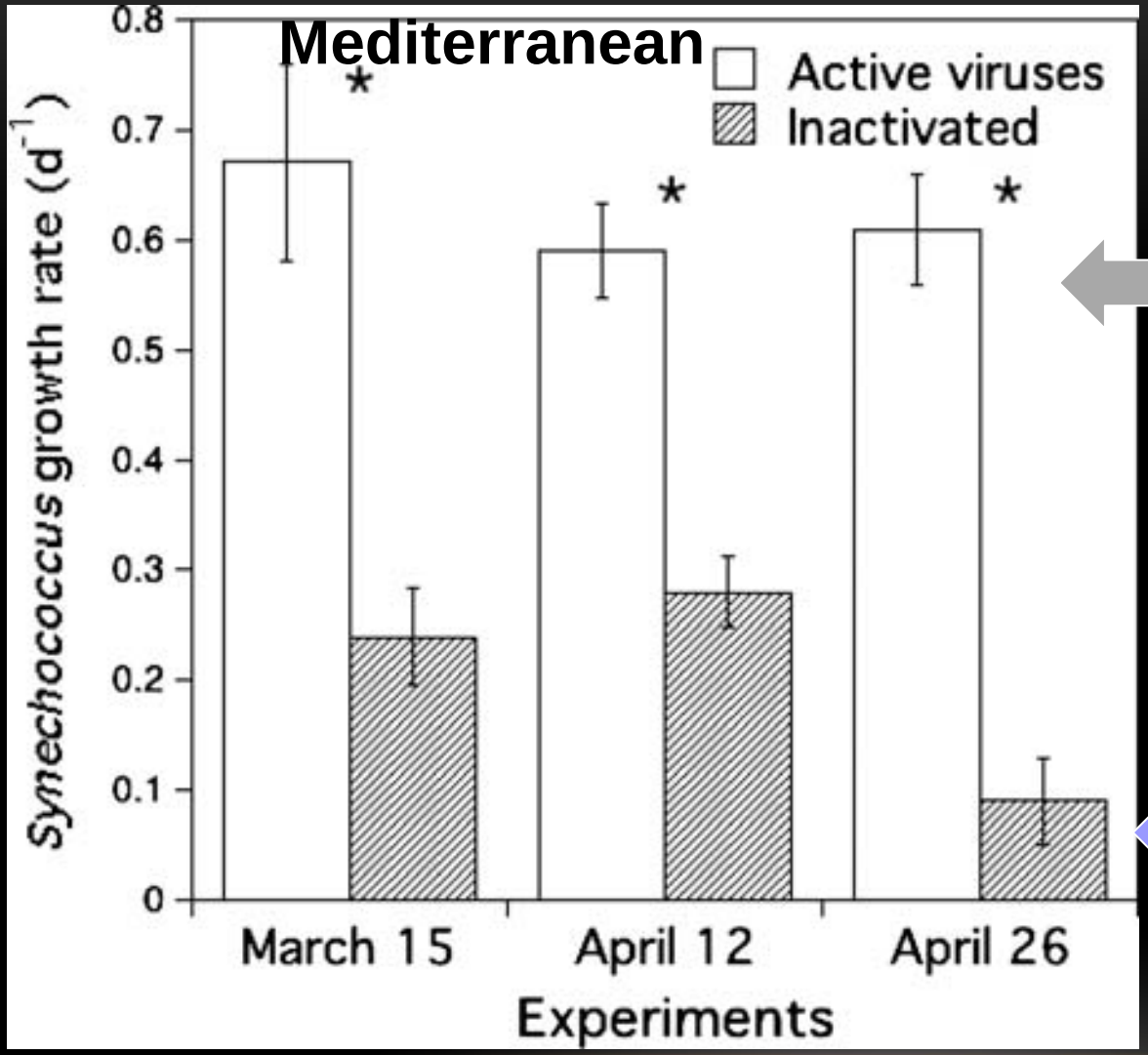
- For ~ 2 billion years after life emerged
  - It was only aquatic
  - It comprised only bacteria, archaea and viruses
  - Viruses were the primary (maybe the only) biological mortality agents
  - It took another billion years for complex multicellular life to emerge
  - Hence, carbon and nutrient cycles were entirely microbial

Viruses change pathways of nutrient cycles



Wilhelm & Suttle

Viruses can enhance phytoplankton growth

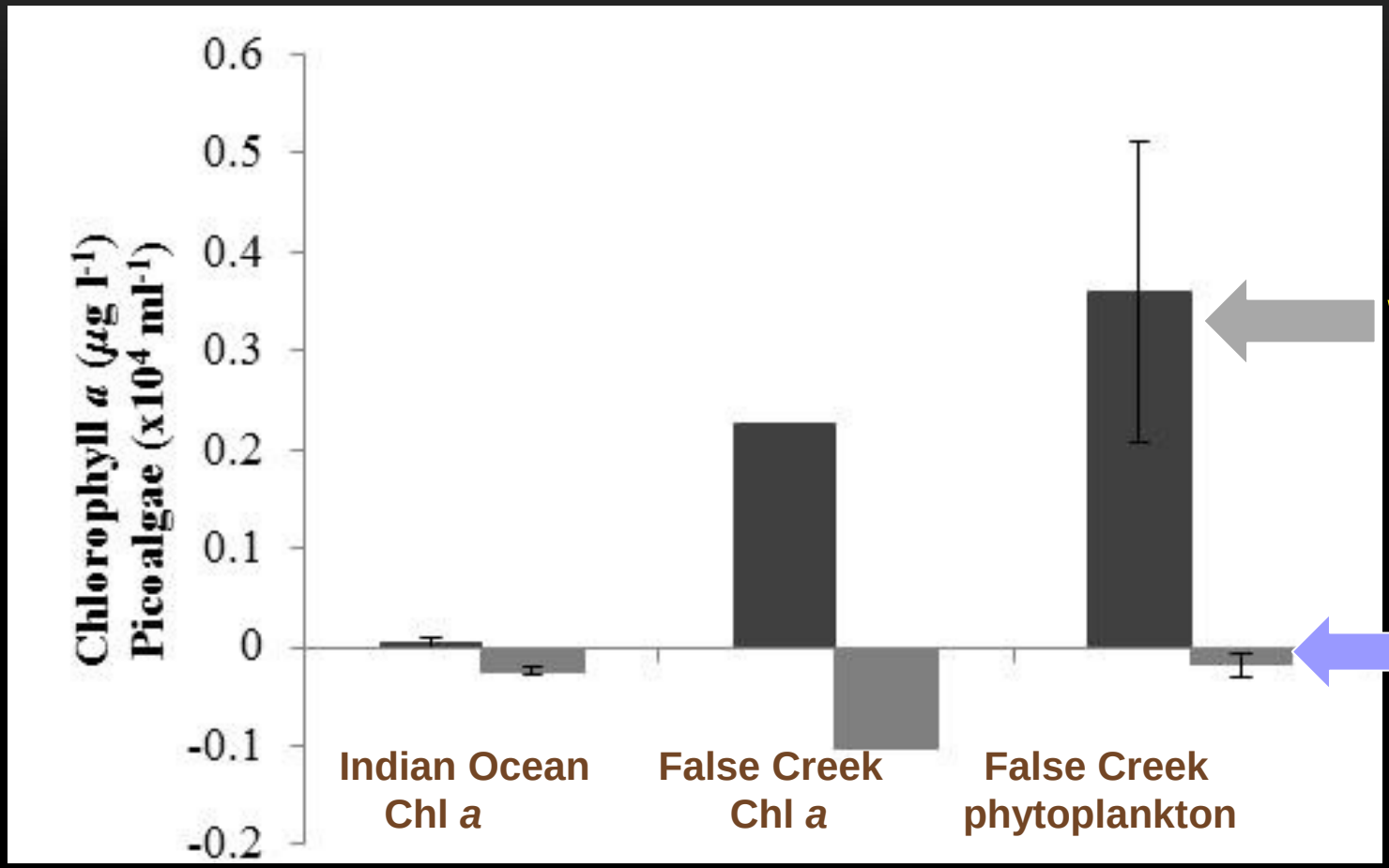


Markus Weinbauer
Steven Wilhelm

without viruses

Weinbauer et al 2011 *J Plank Res* 33, 1465-1476

Viruses enhance phytoplankton growth rate



Emma Shelford

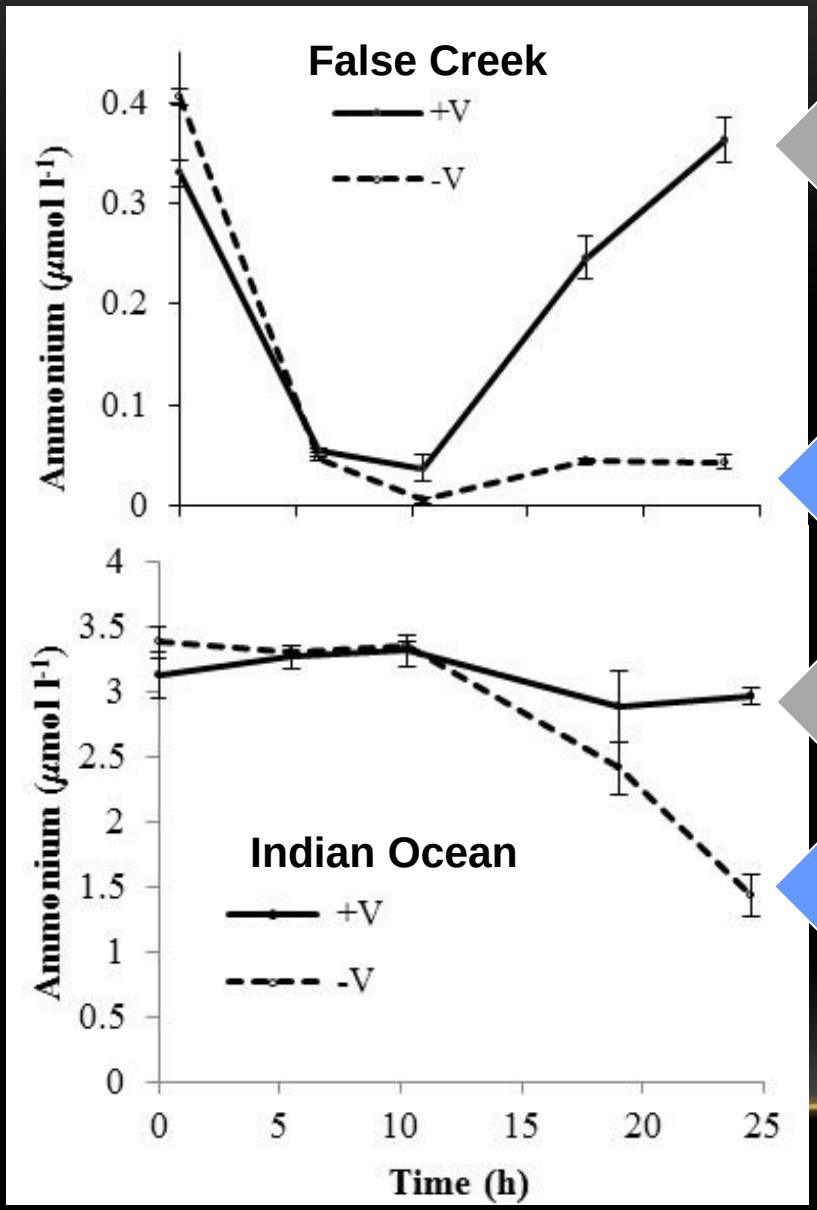
wit

S

Mathias Middleboe

Shelford et al 2012 *Aquat Microb Ecol* 66, 41-46

Viruses increase ammonium production



with viruses

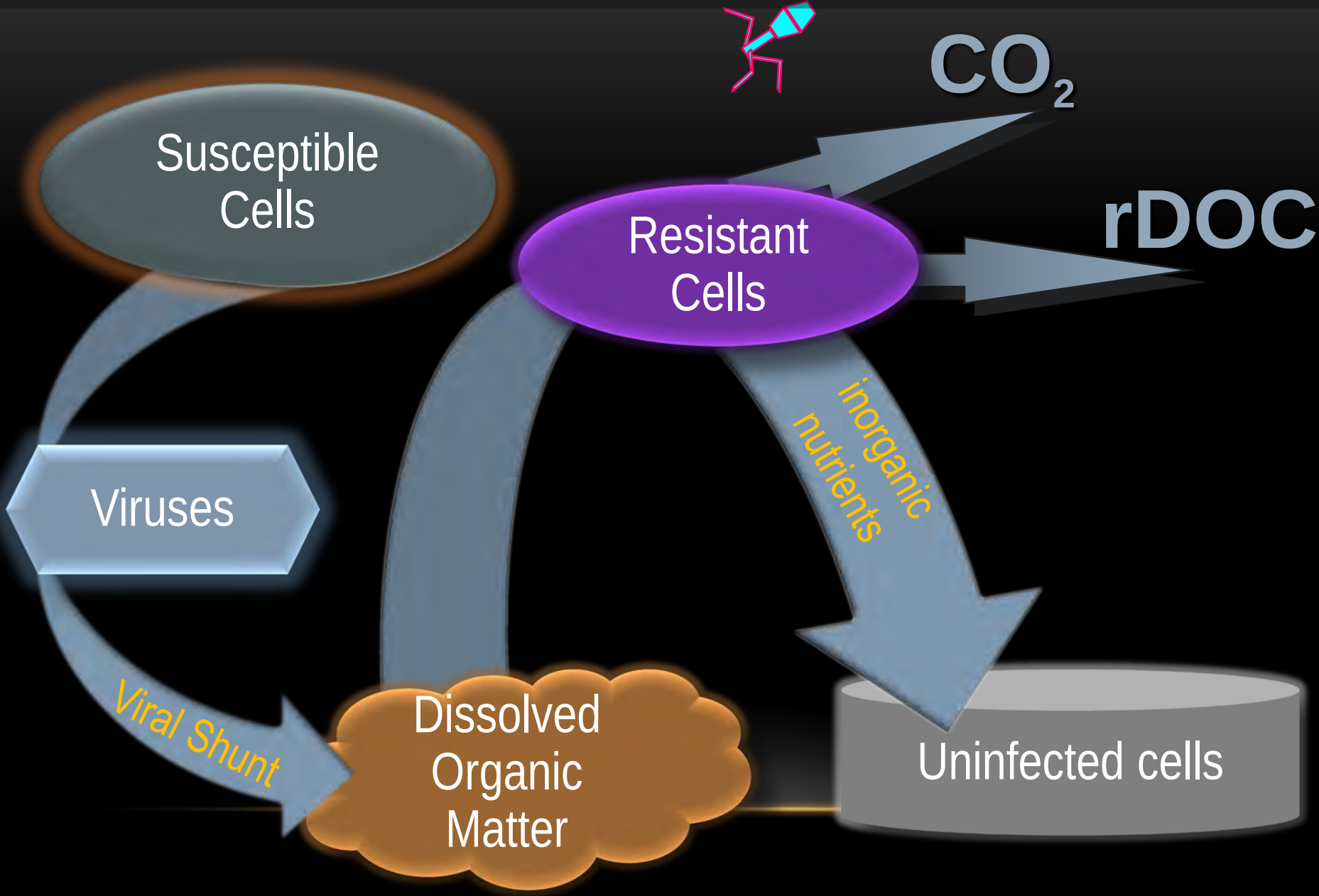
with viruses removed

with viruses

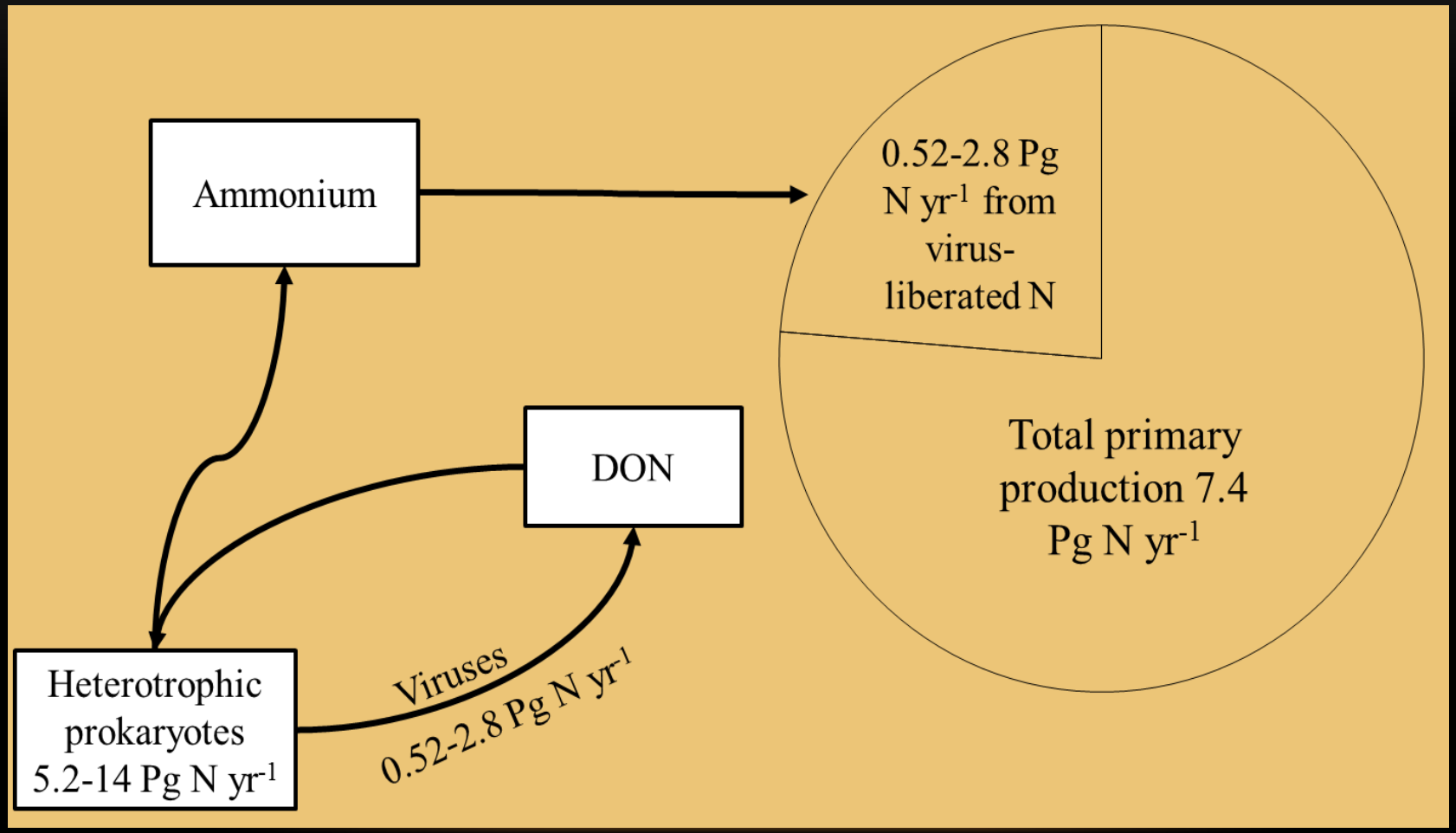
with viruses removed

Shelford et al 2012 *Aquat Microb Ecol* 66, 41-46

Viruses affect pathways of nutrient cycling

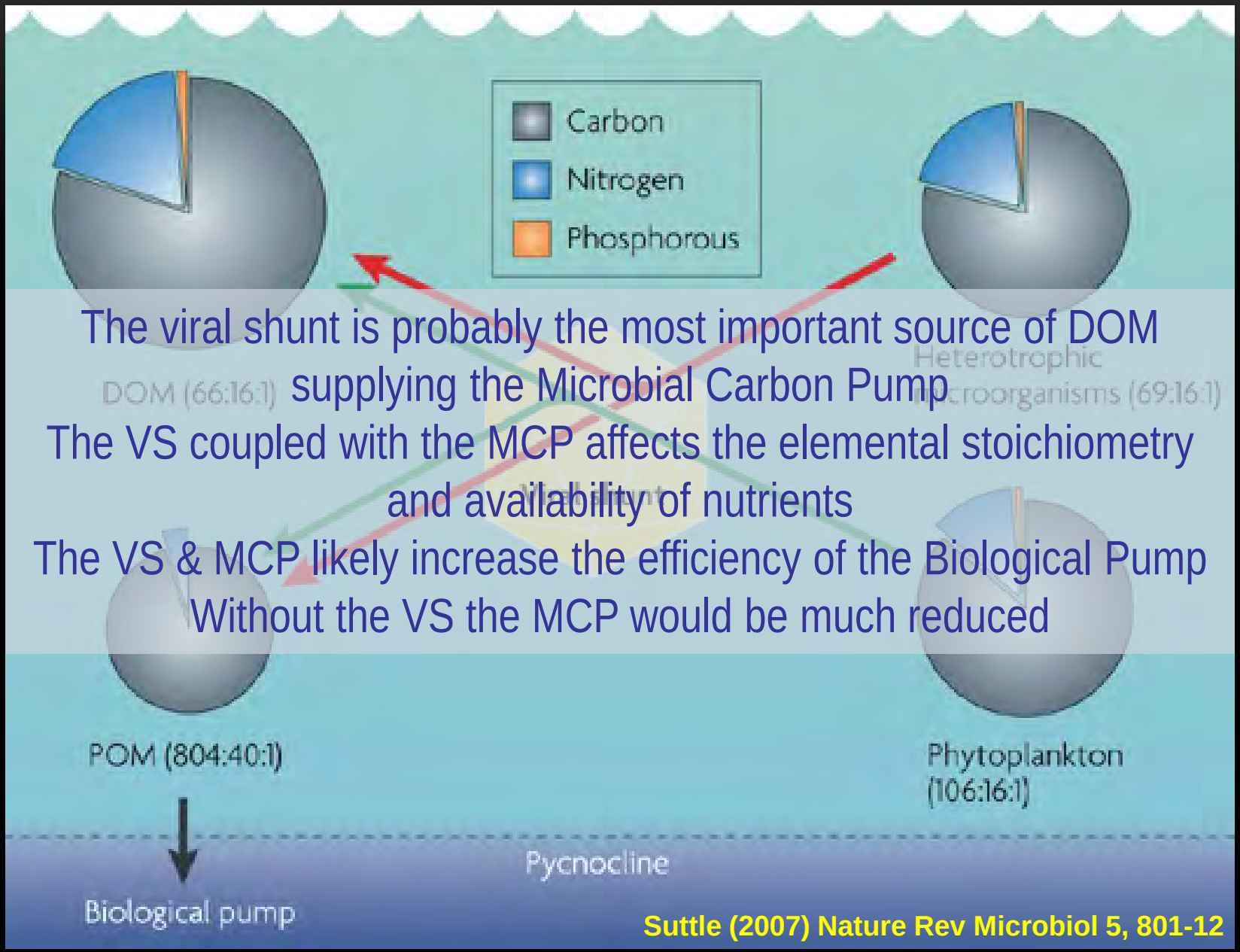


The viral shunt has major effects



Shelford and Suttle 2017. *Biogeosciences Discussion*

Shunt and pump



The viral shunt is probably the most important source of DOM supplying the Microbial Carbon Pump

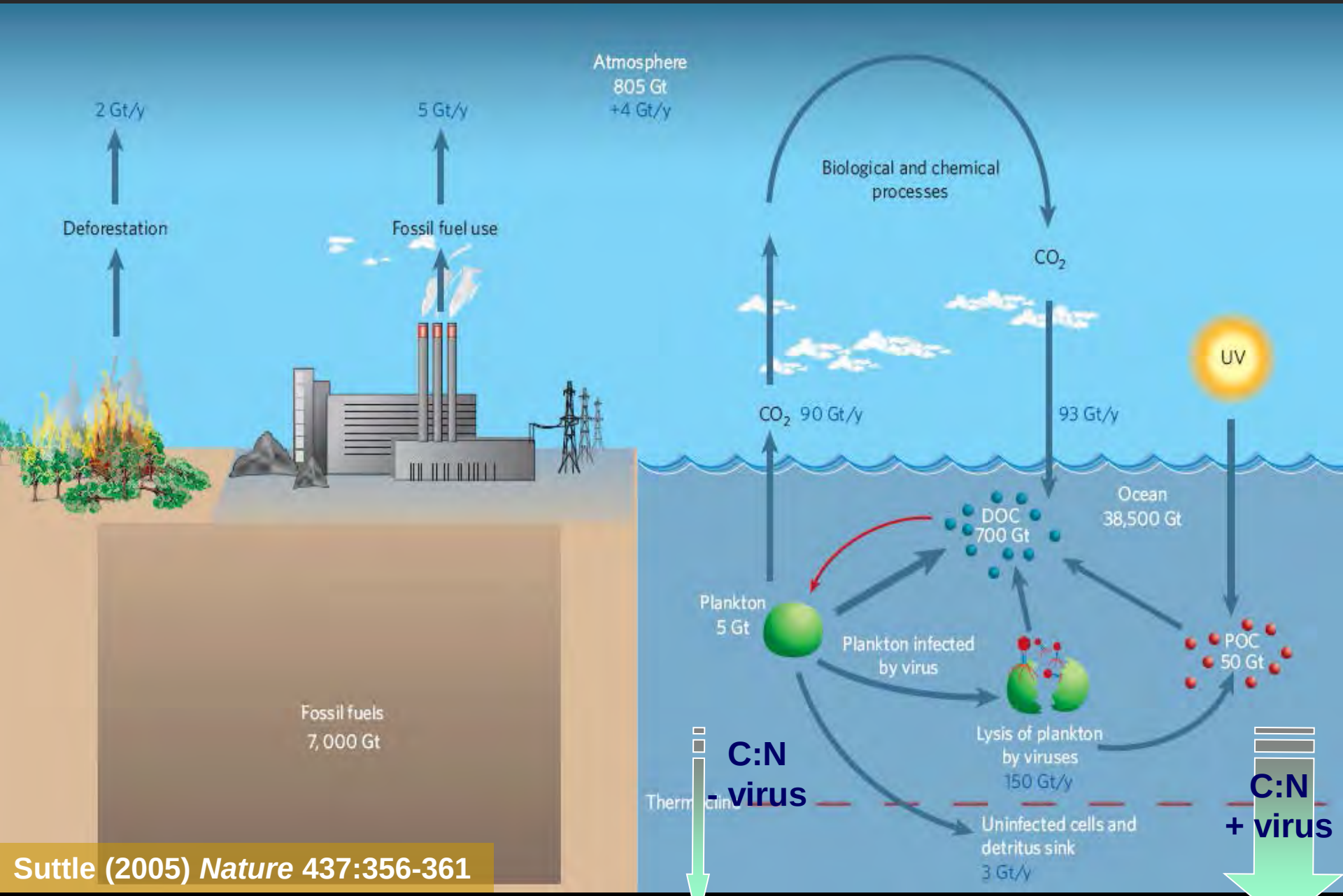
The VS coupled with the MCP affects the elemental stoichiometry and availability of nutrients

The VS & MCP likely increase the efficiency of the Biological Pump

Without the VS the MCP would be much reduced

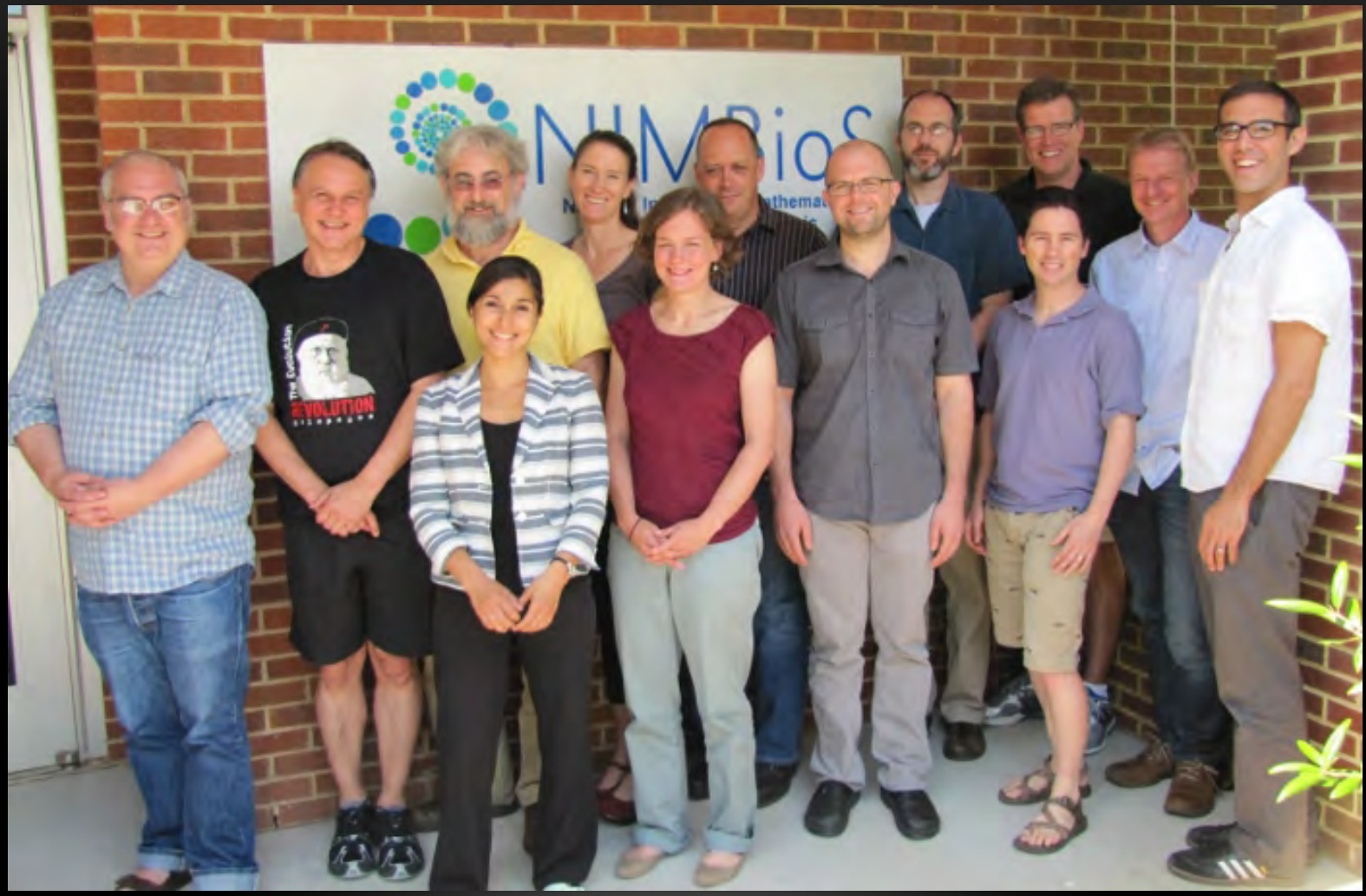
Suttle (2007) Nature Rev Microbiol 5, 801-12

VS + MCP increase the efficiency of the BP

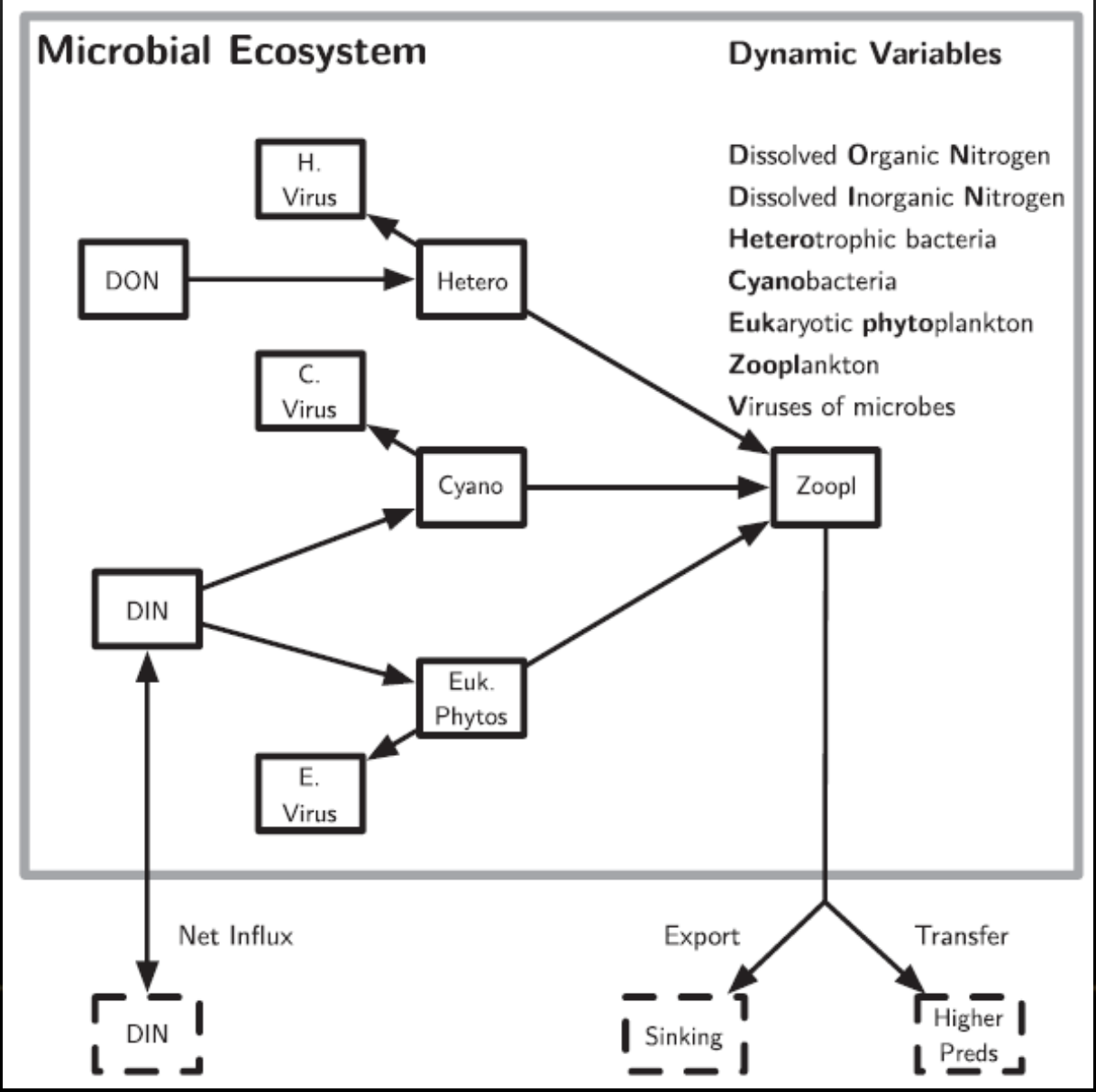


Suttle (2005) *Nature* 437:356-361

NIMBioS Working Group – Viral Dynamics

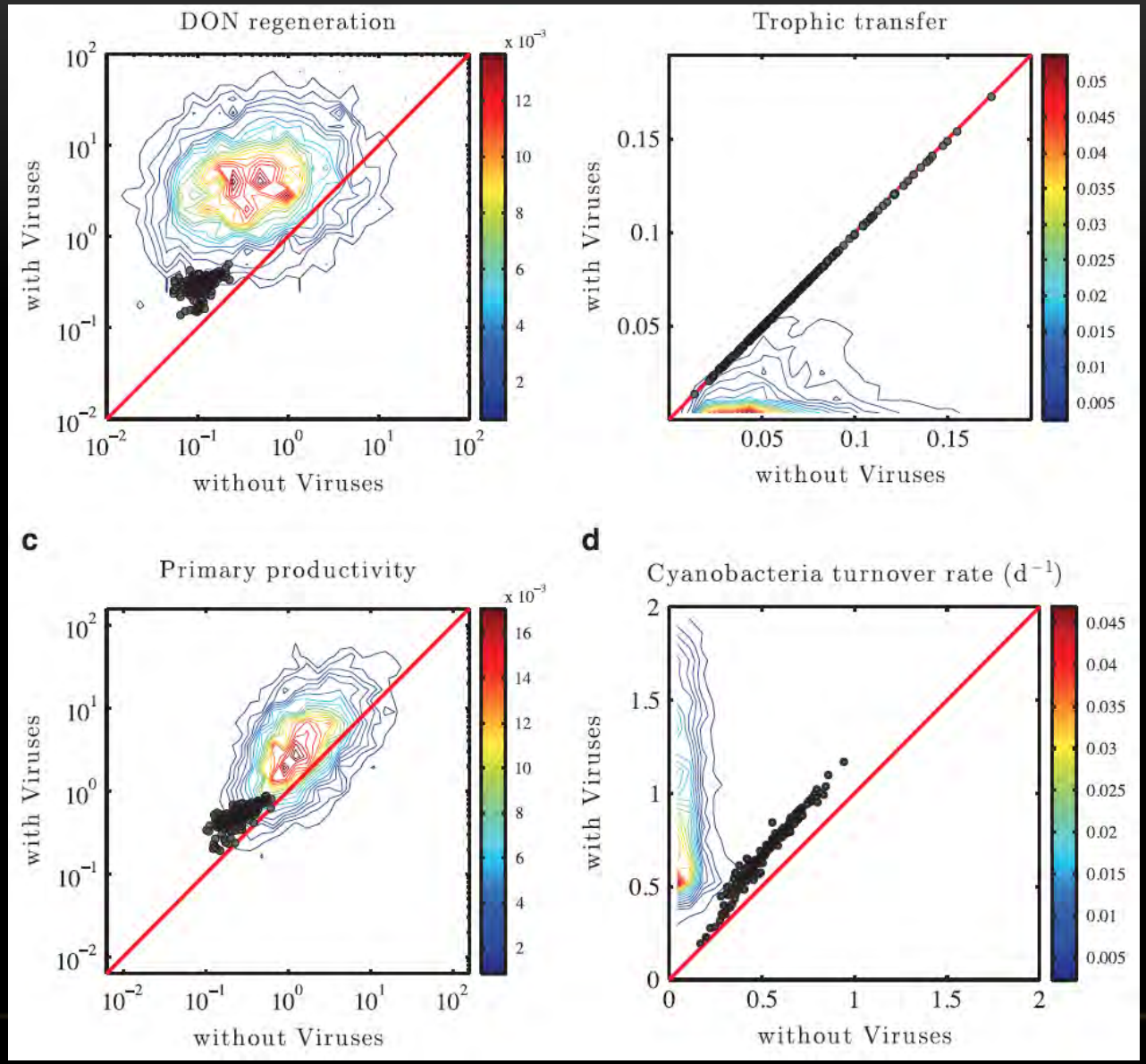


Effects of marine viruses



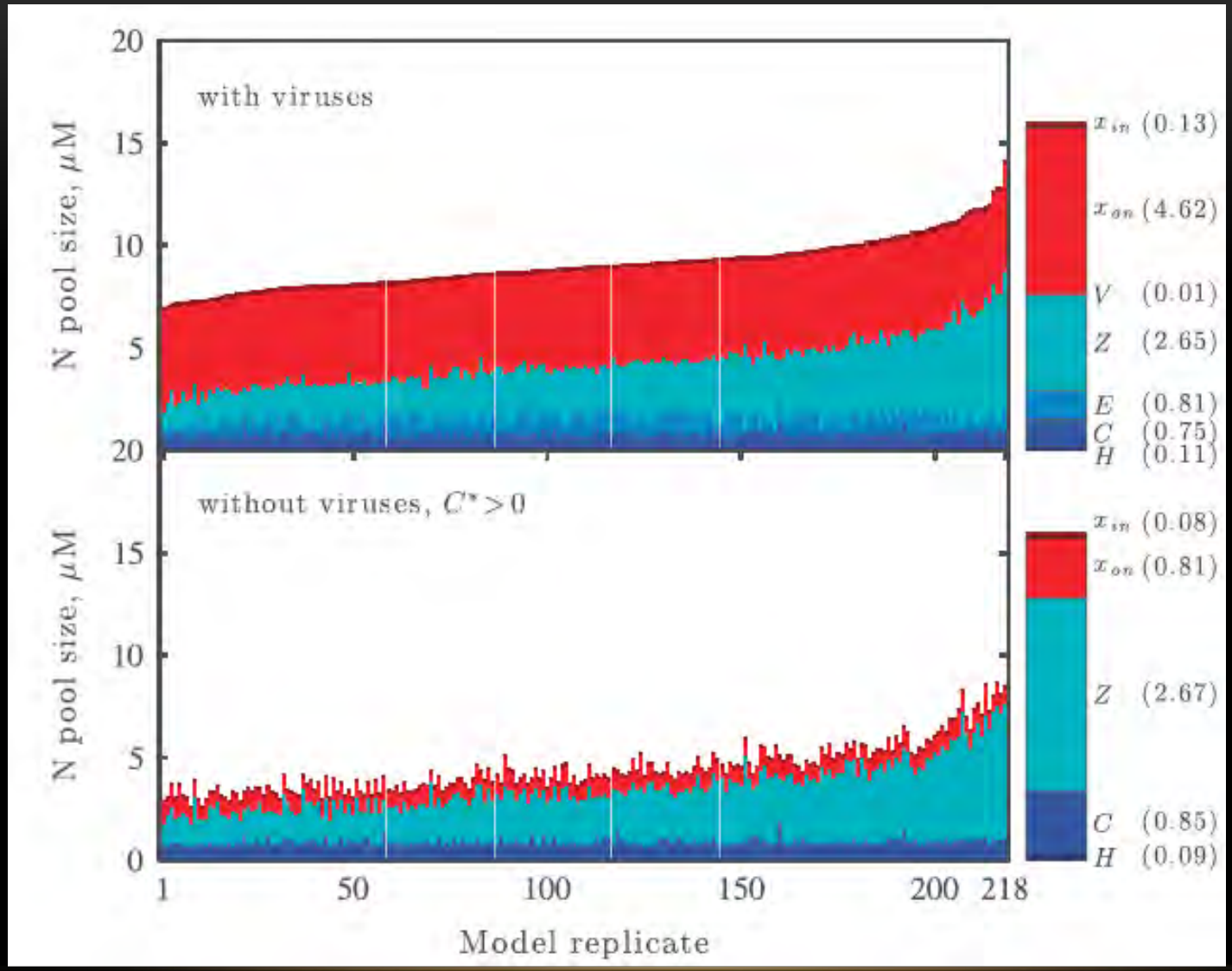
Weitz et al. (2015) ISMEJ 9: 1352-64

Effects of marine viruses



Weitz et al. (2015) ISMEJ 9: 1352-64

Effects of marine viruses



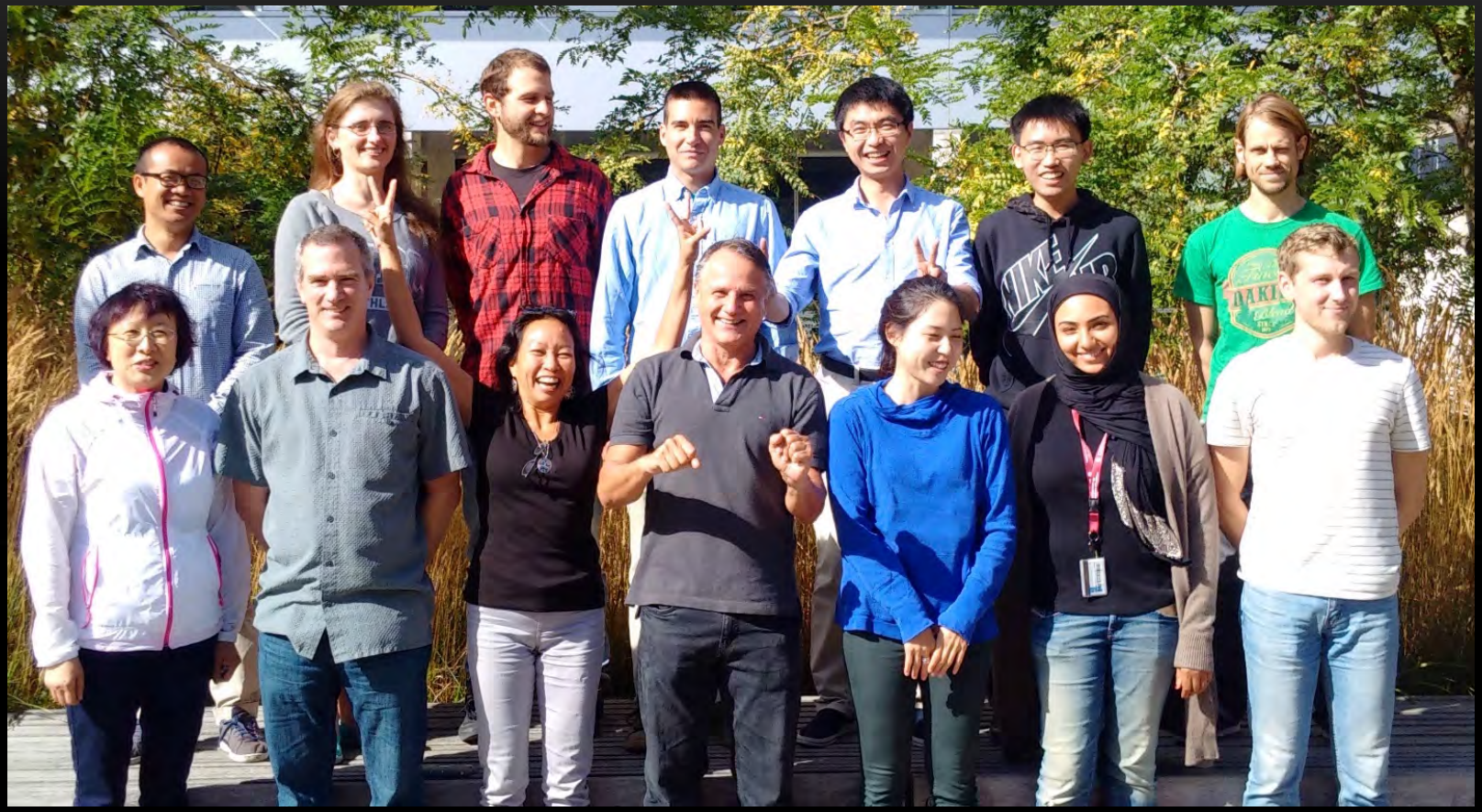
Point: ***Viruses affect accumulation of DOM***

Weitz et al. (2015) ISMEJ 9: 1352-64

Take home points

- For the first two billion years the “foodweb” was only microbial
- Viruses were the predators in the system
- Viruses “fuel” the microbial carbon pump
- Together the “shunt and pump” are major players in nutrient cycling, affect the elemental stoichiometry of recycled nutrients (e.g. MCP) and likely increase the efficiency of the “biological pump

Thanks to the people and the sponsors



NSERC CRSNG

Tula FOUNDATION

PACIFIC SALMON FOUNDATION

CIFAR
CANADIAN INSTITUTE for ADVANCED RESEARCH

Gordon and Betty MOORE FOUNDATION

Mitacs

Genome BritishColumbia

GenomeCanada

CSA ASC

Thank you!