

Astrovirology – What's missing?

*NASA Astrobiology Institute
Workshop without Walls
19 September 2019*

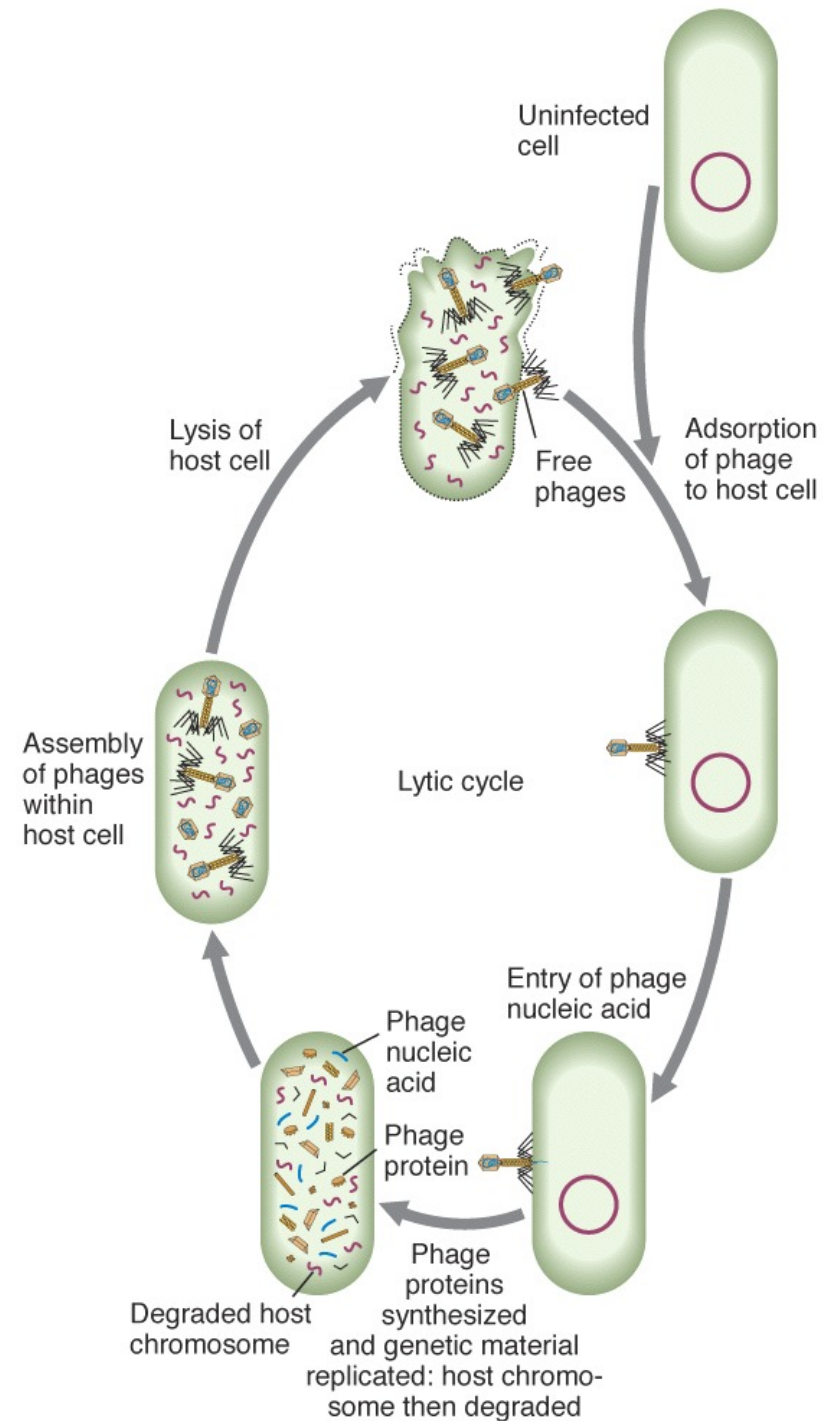


Portland State
UNIVERSITY

Ken Stedman

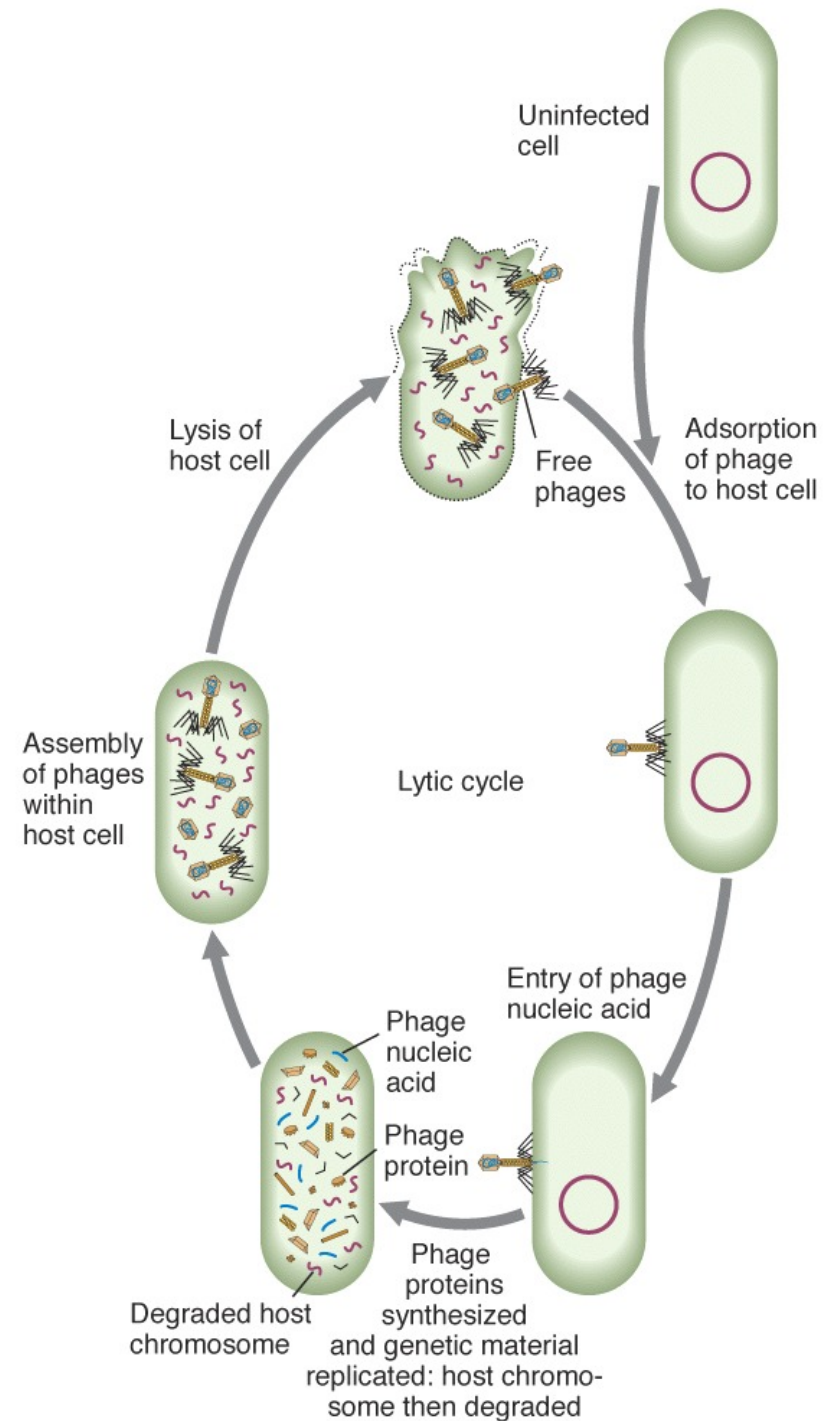
What is a “virus”? 1

- “Simply a piece of bad news wrapped up in a protein”. – Peter Medawar
- A “**very small**” infectious obligate intracellular parasite
- A bag of nucleic acid



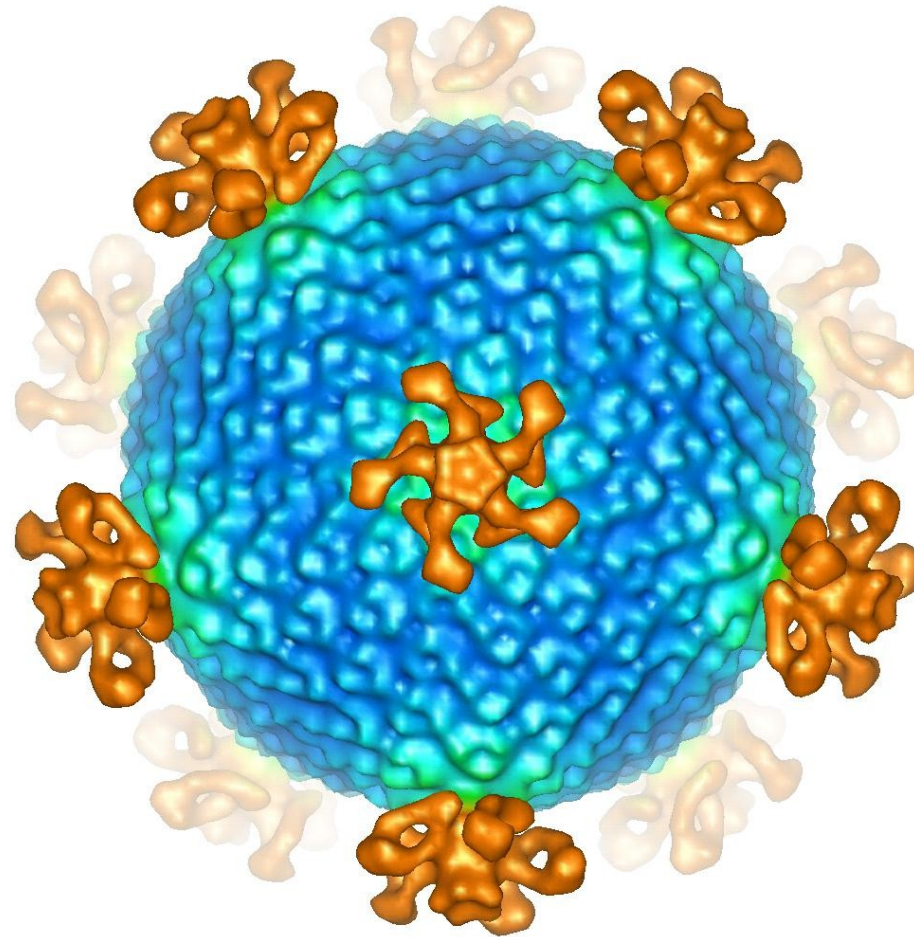
What is a virus? 2

- “Viruses are entities whose genomes are elements of nucleic acid that replicate inside living cells using the cellular synthetic machinery and causing the synthesis of specialized elements that can transfer the viral genome to other cells” – Luria, 1978

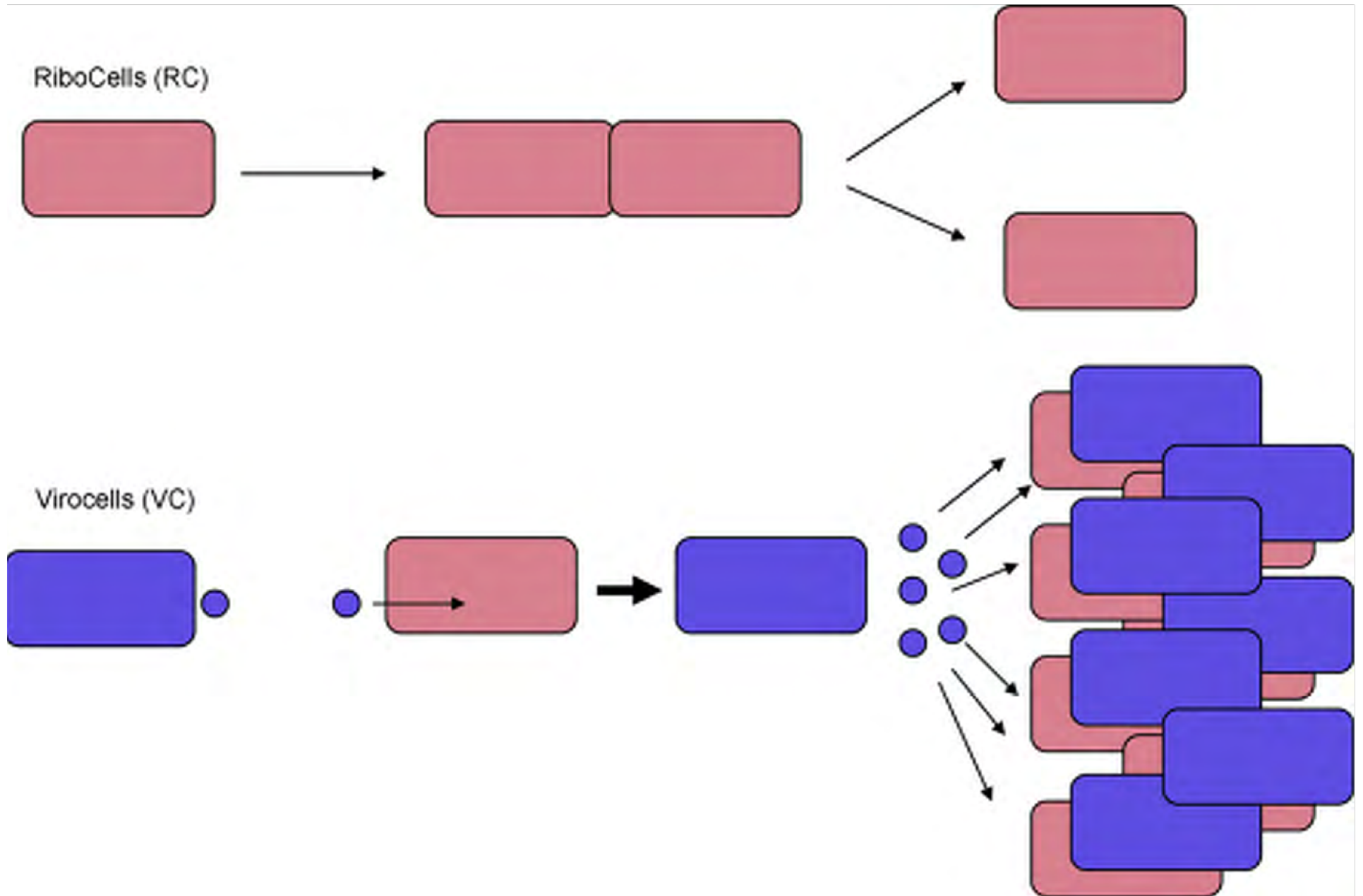




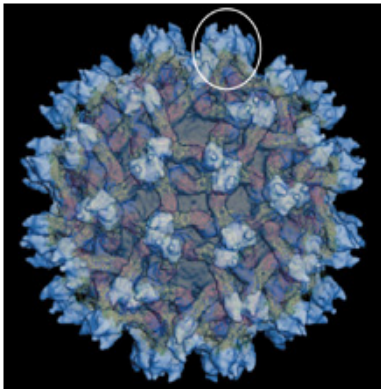
Ceci n'est pas une pipe.



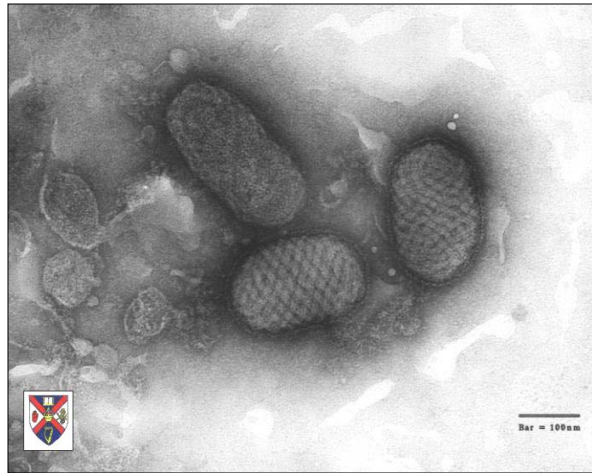
Ceci n'est pas un virus



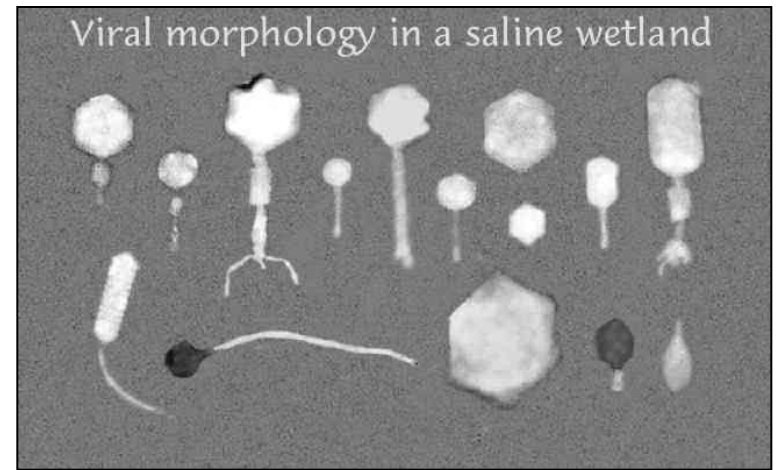
Virions have distinctive morphology



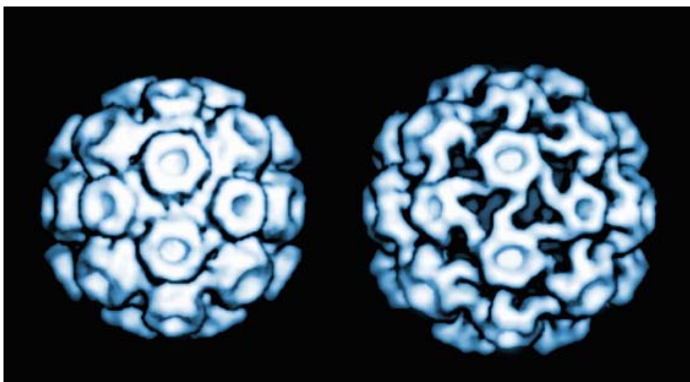
Dengue Virus



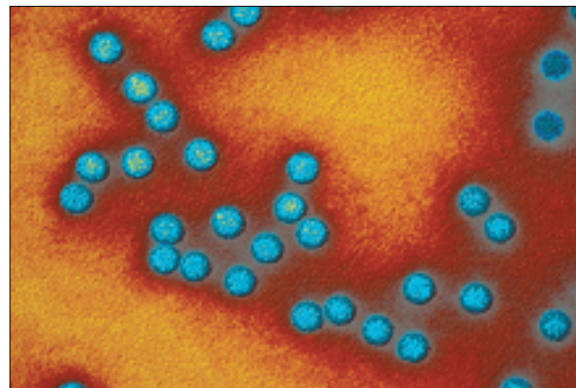
Myxoma Virus



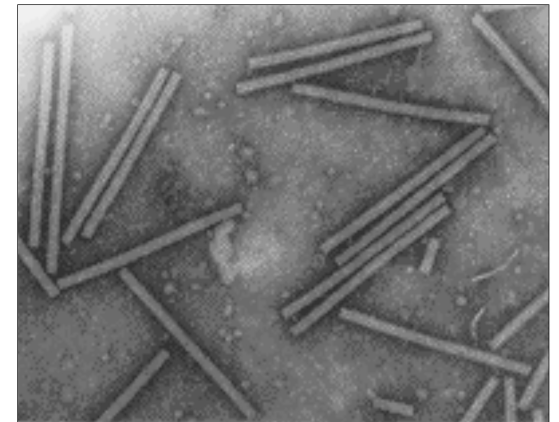
Virus Like Particles in Environment



Cowpea Chlorotic Mottle Virus

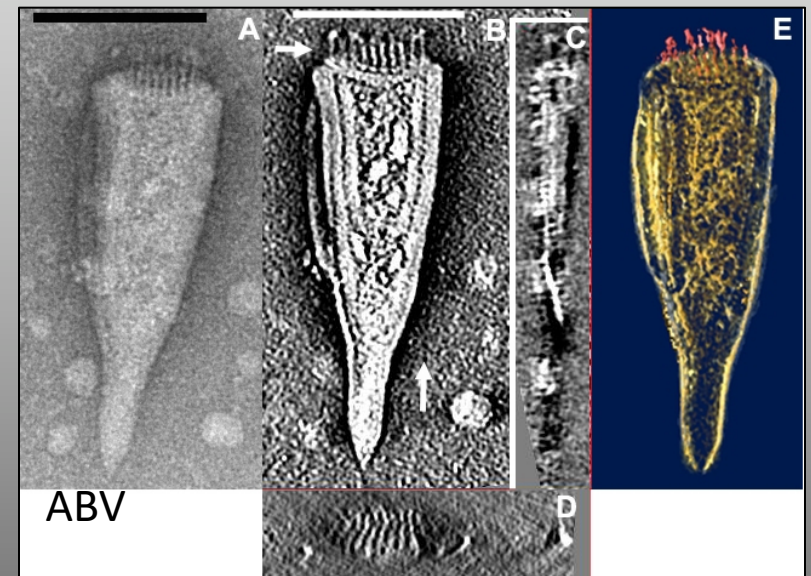
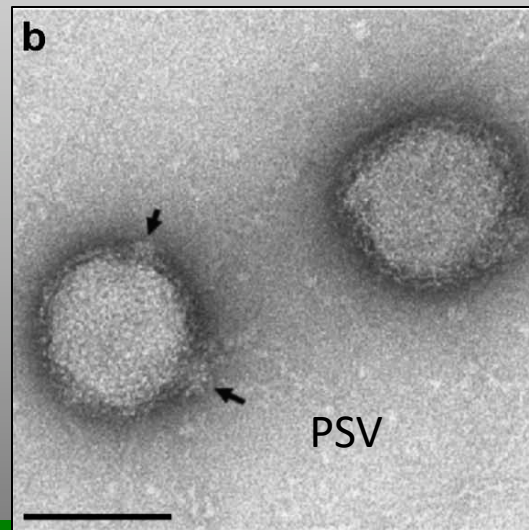
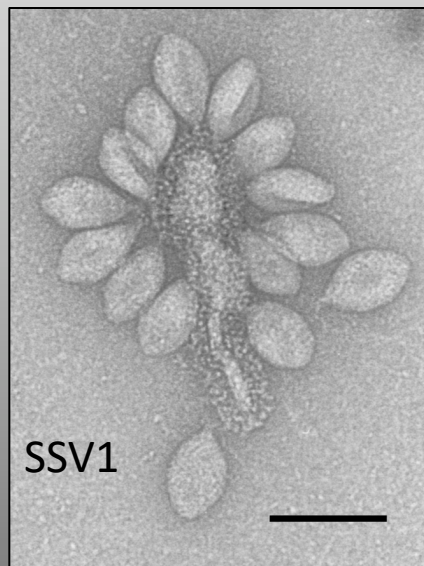
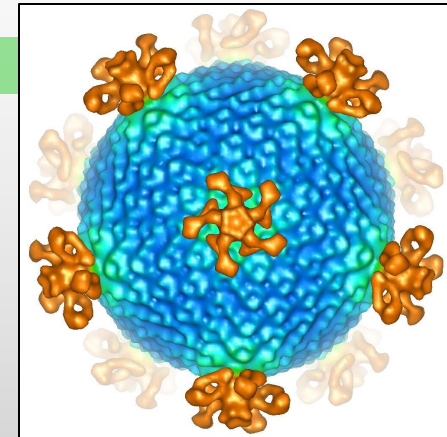
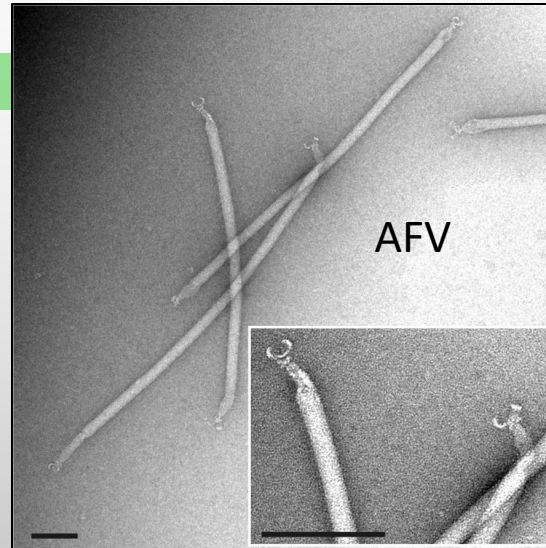
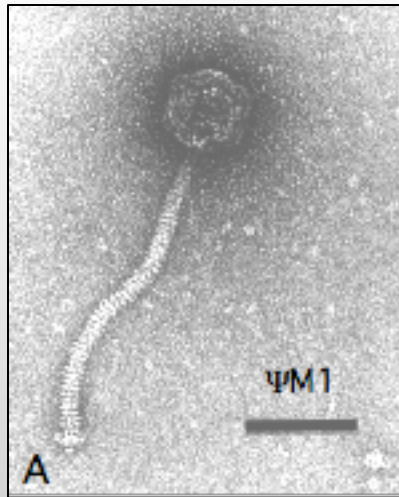


Polio Virus



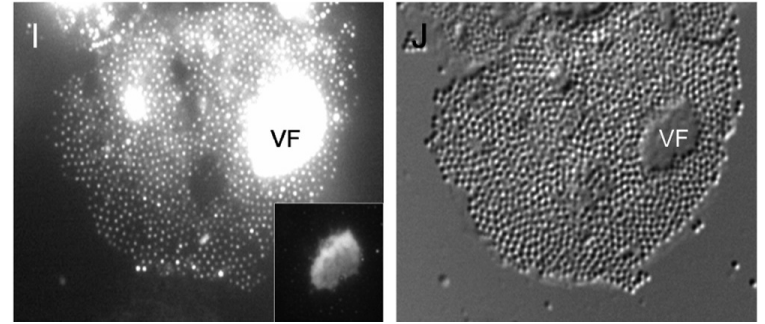
Tobacco Mosaic Virus

Archaeal virions are highly diverse!

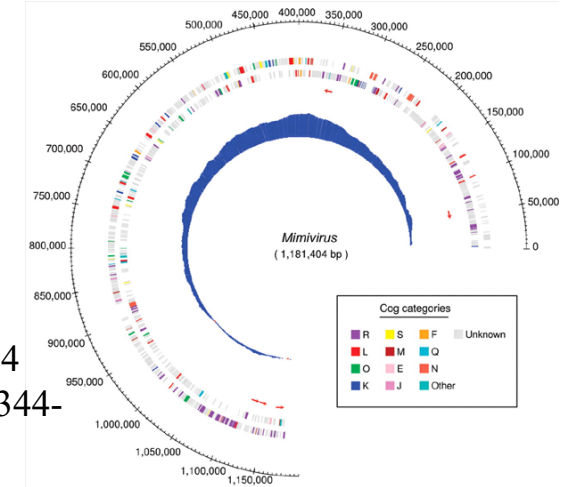


“Giruses”

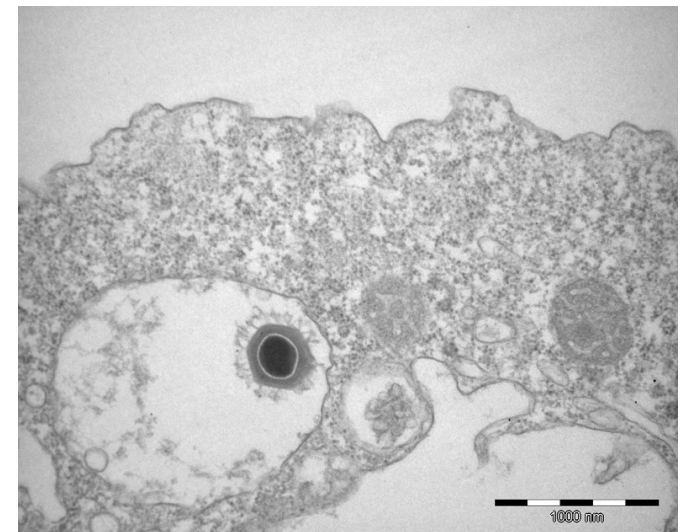
- Virions as big as (or bigger than) cells
- Amoebal virus
 - Mimivirus
 - Sputnik
- LARGE genome



Suzan-Monti M, et al. (2007) *PLoS ONE* 2(3): e328.



Raoult et al.,
Science. 2004
306(5700):1344-50.

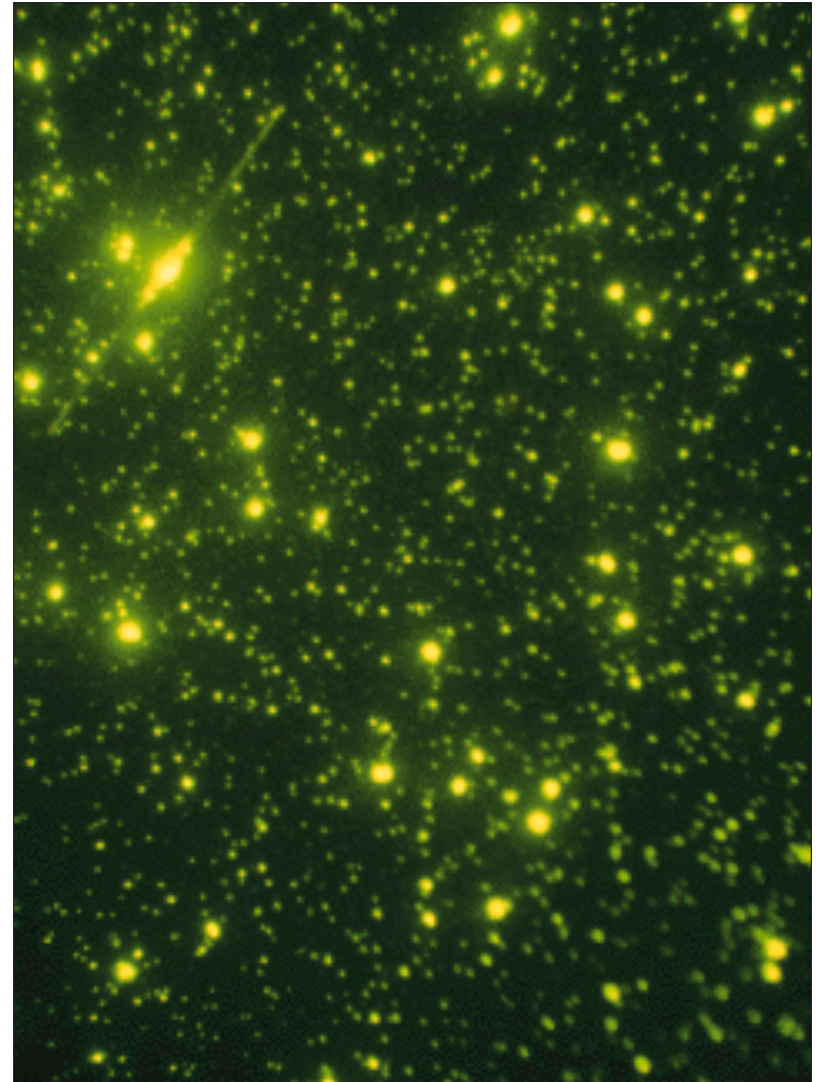


<http://www.giantvirus.org/gallery.html>

Where are virions?



HST Deep Field

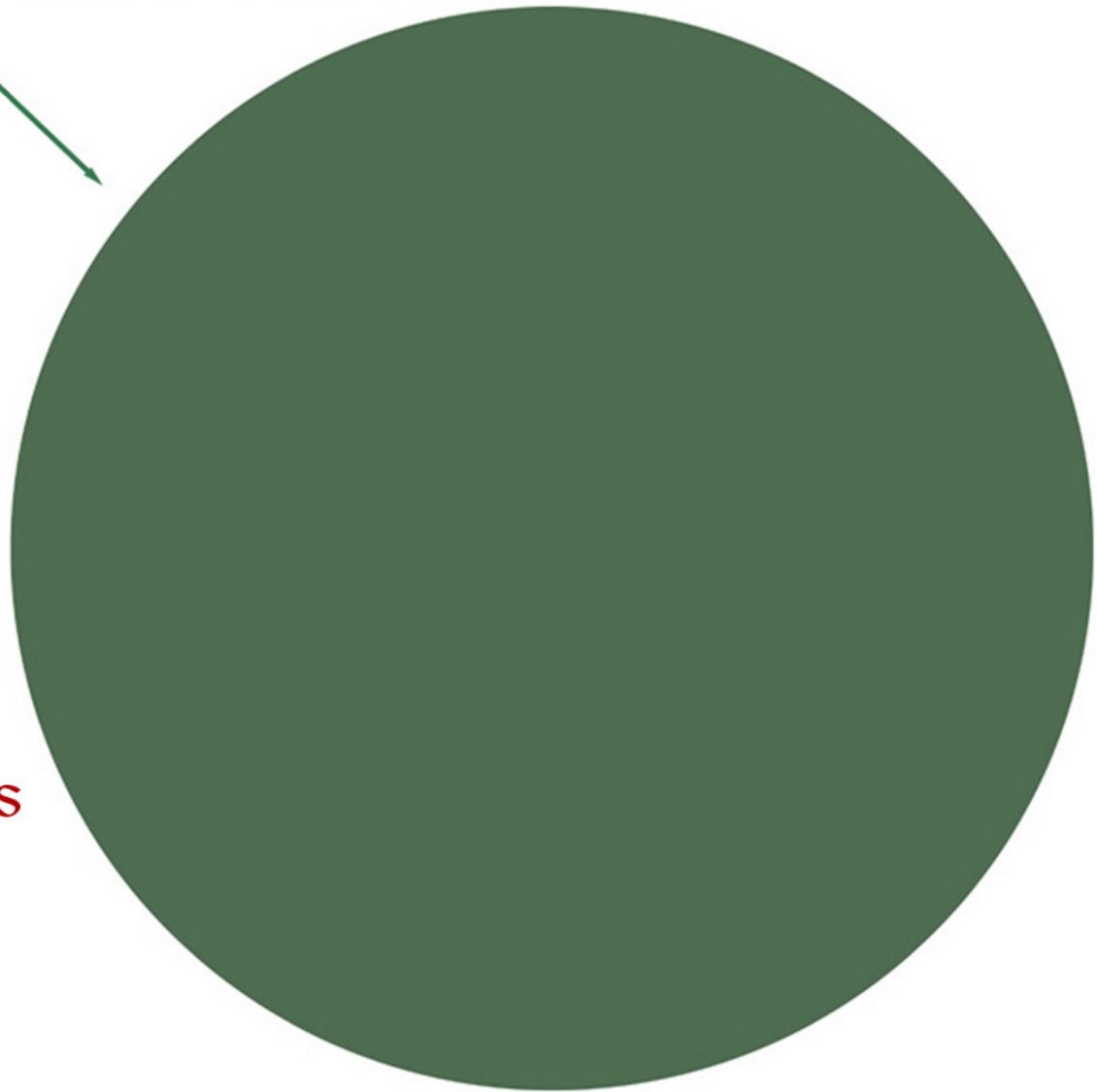


Sea water - Nucleic Acid stain
J. Fuhrman, Nature 1999

Earth with 10^{31} beetles

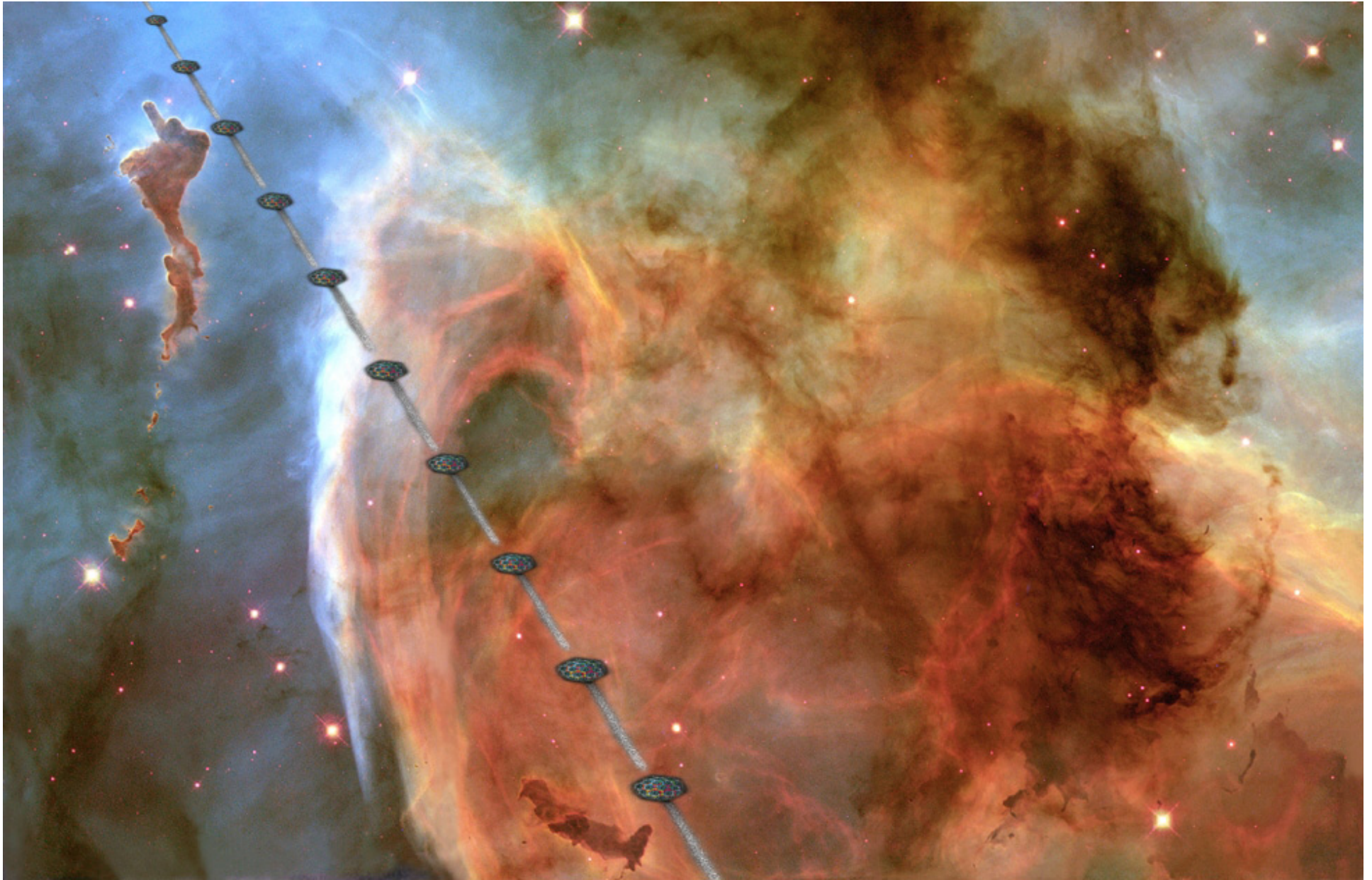


Earth with 10^{31} phages

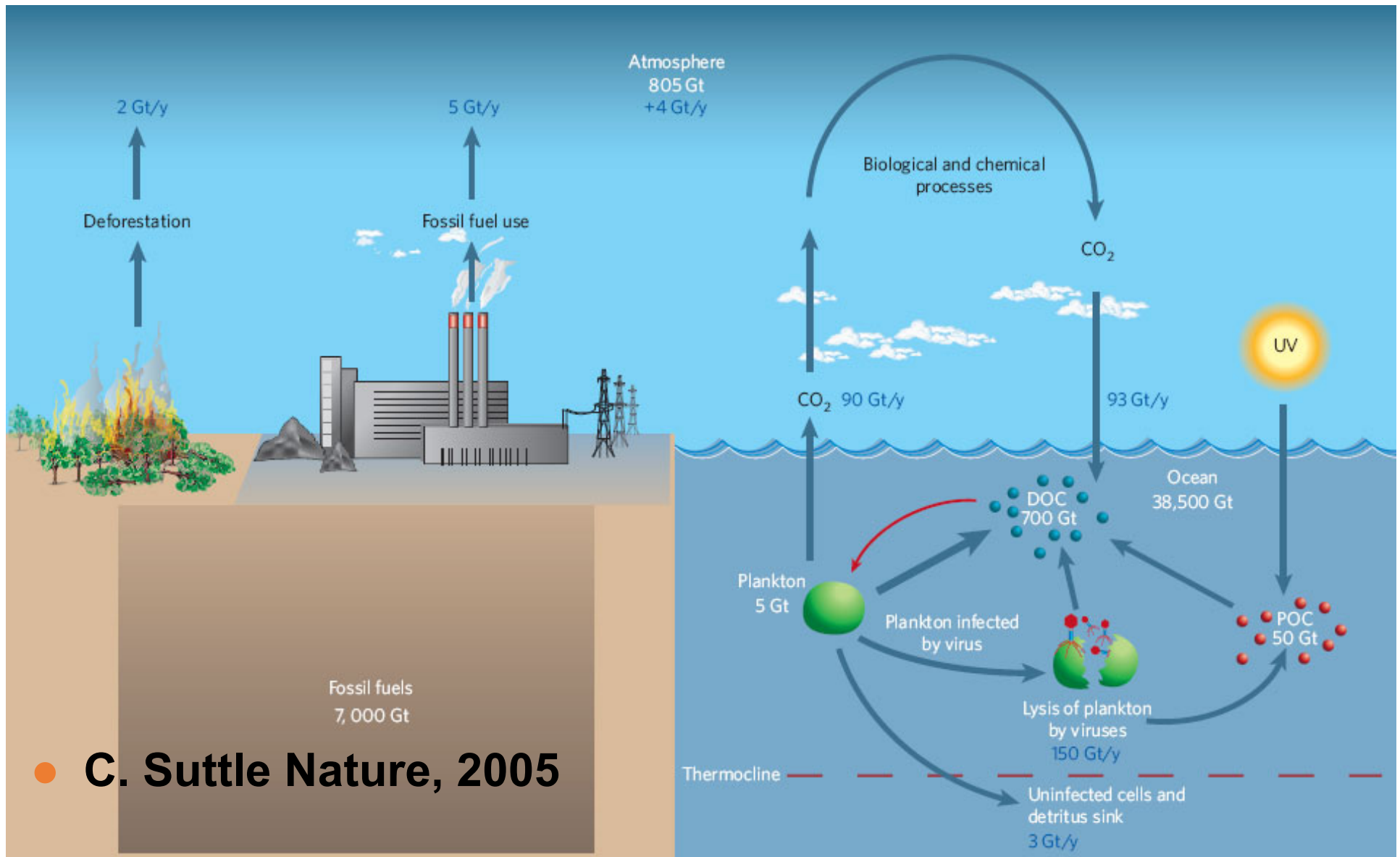


“The creator must have an inordinate fondness for beetles” JBS Haldane

- 10^{31} Phage end to end $\sim 2 \times 10^7$ light years!



Viruses in the Global C-cycle



- C. Suttle Nature, 2005

The Human Genome

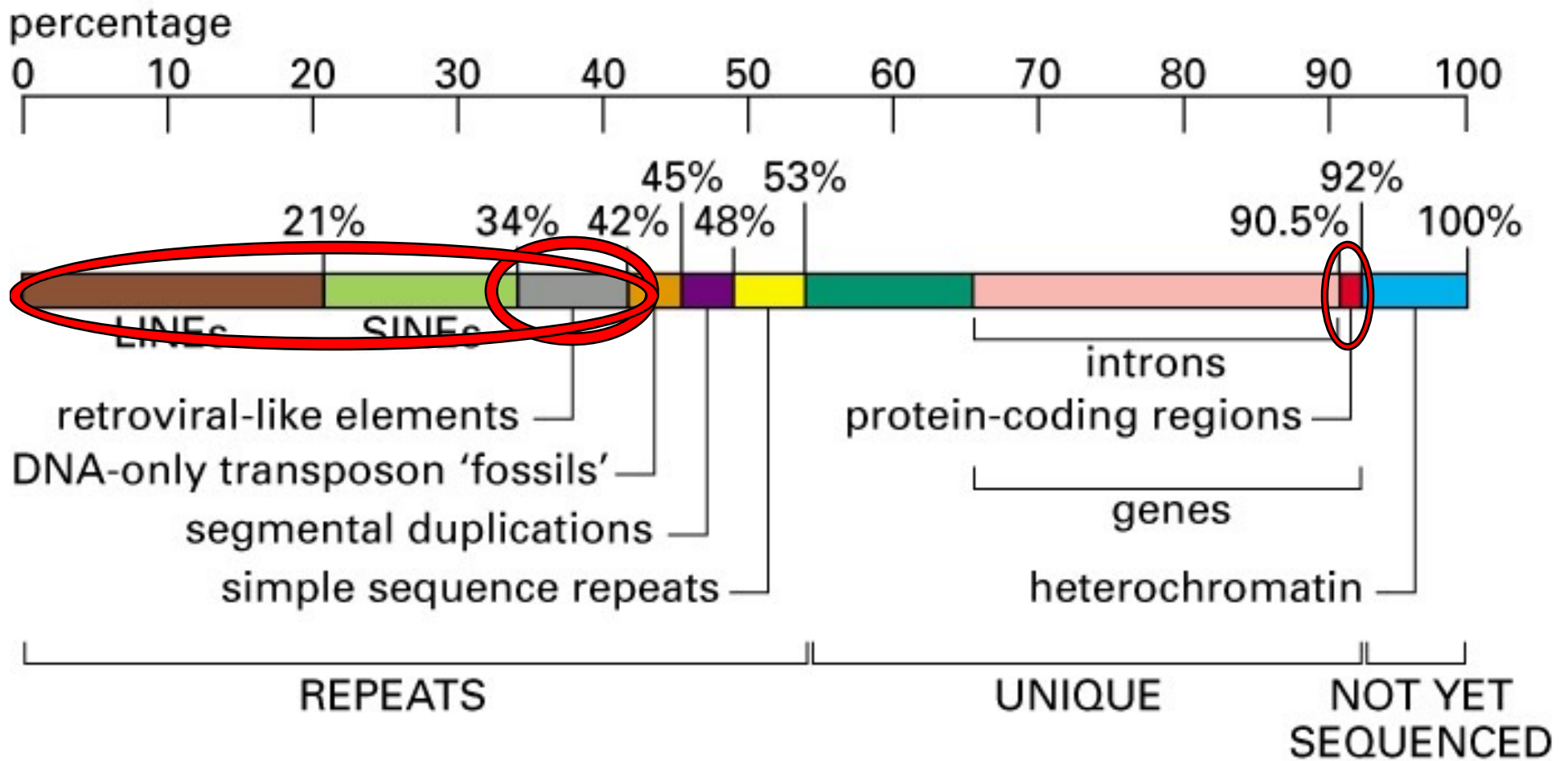
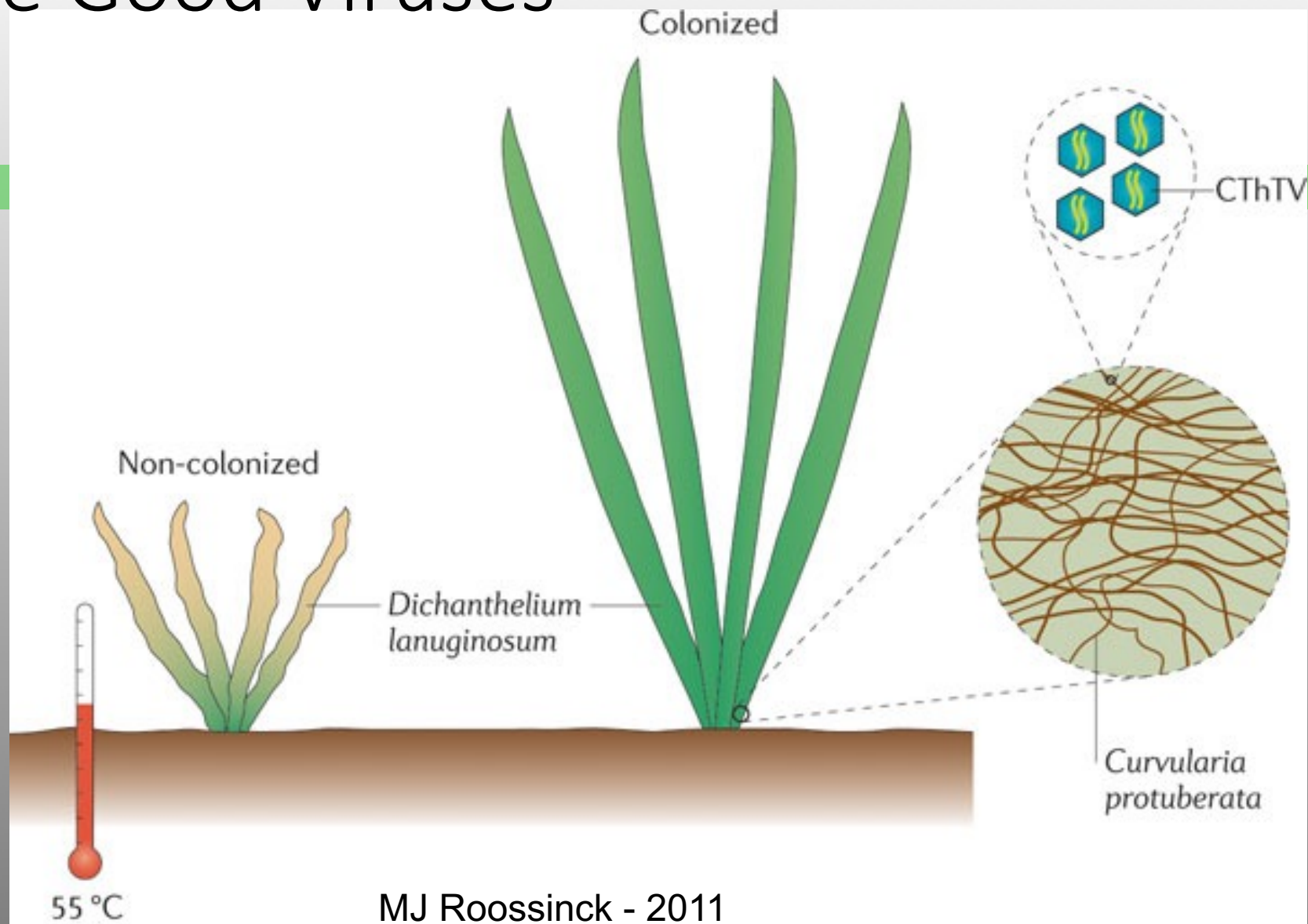


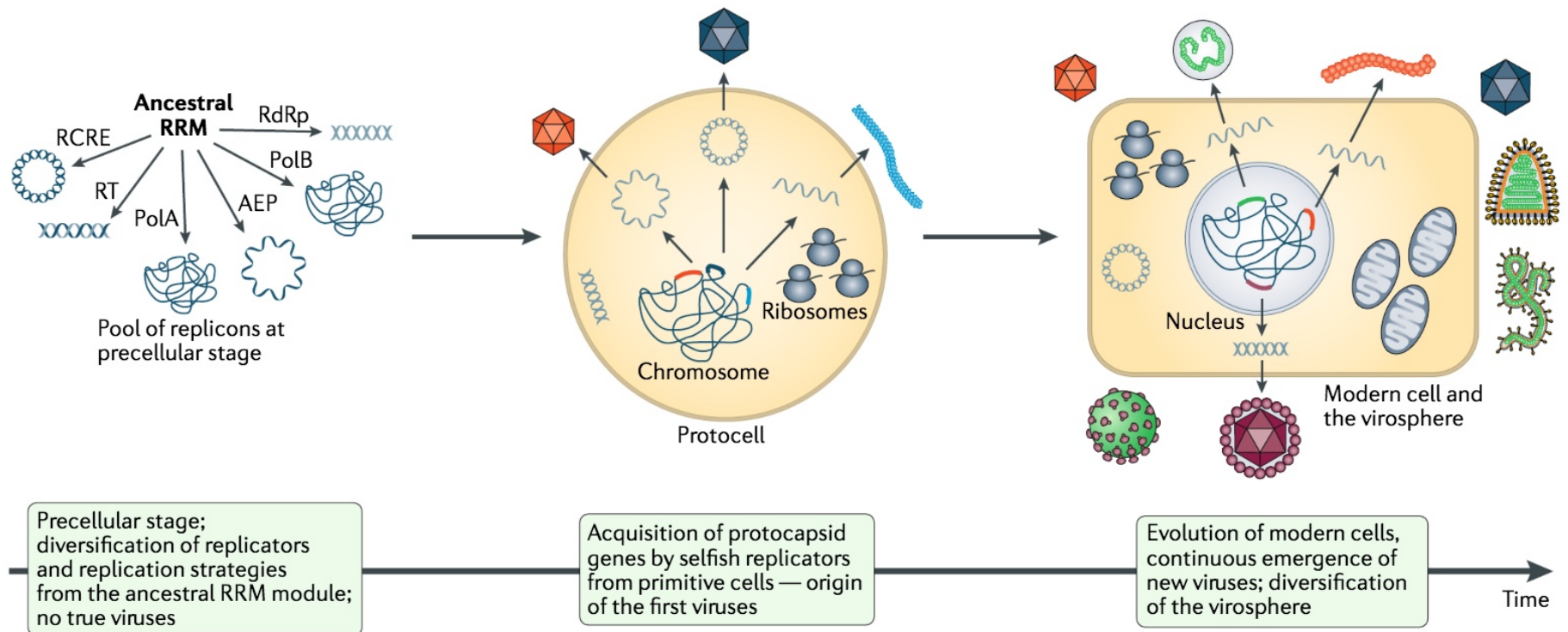
Figure 4-17. Molecular Biology of the Cell, 4th Edition.

The Good Viruses



MJ Roossinck - 2011

Origin of viruses?

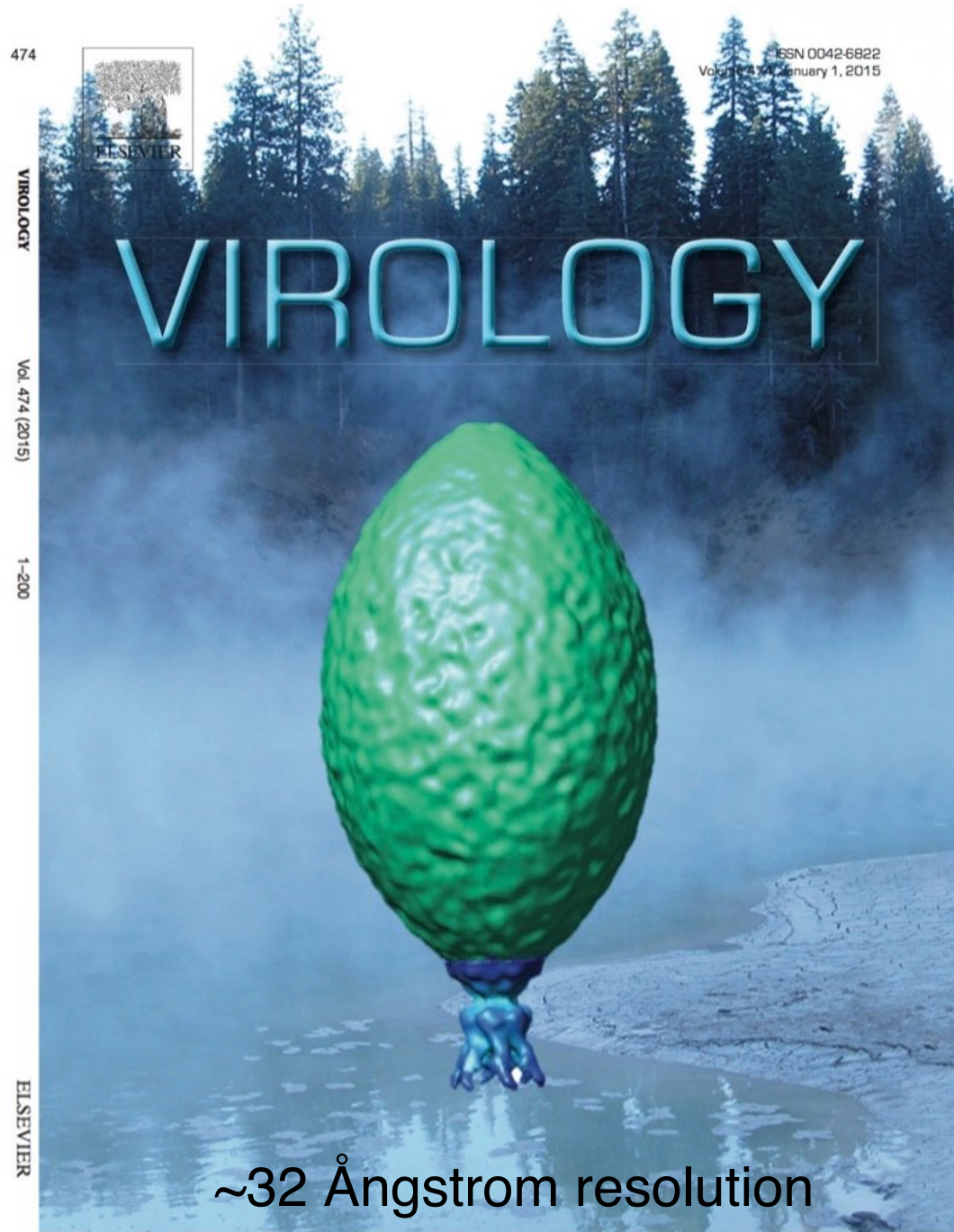


Krupovic, Dolja, Koonin, NRM, 2019

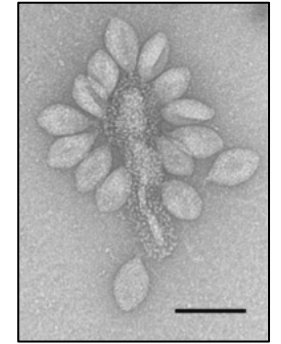


地獄ウイルス

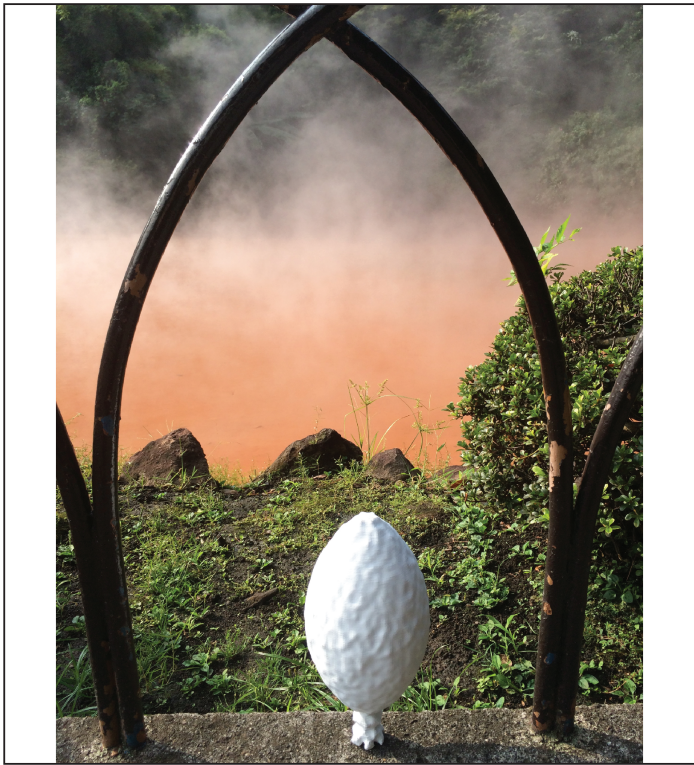
Chinoike Jigoku, Beppu, Oita, Japan, 9/2016



~32 Ångstrom resolution

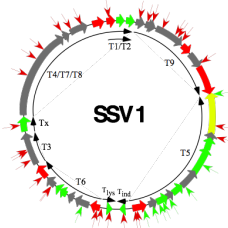


Stedman, DeYoung, Saha, Sherman, and Morais, Virology, 2014



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for
Microbiology**

Journal of Virology



AMERICAN
SOCIETY FOR
MICROBIOLOGY

JVI

MAY 2017, VOLUME 91, NUMBER 10



Eric Iverson

Iverson et al., *J. Virol.* 91(10), 2017

A photograph of Boiling Springs Lake, a geothermal feature. The lake's water is a milky, light green color. In the background, a dense forest of tall, dark green coniferous trees covers a hillside under a clear blue sky. A small, dark-colored motorboat is visible on the water in the lower right quadrant. The text 'Boiling Springs Lake' is overlaid in a large, red, serif font with a white outline.

Boiling Springs Lake

Microbial Observatory

50-95°C, pH ~2

Bacteria

Archaea

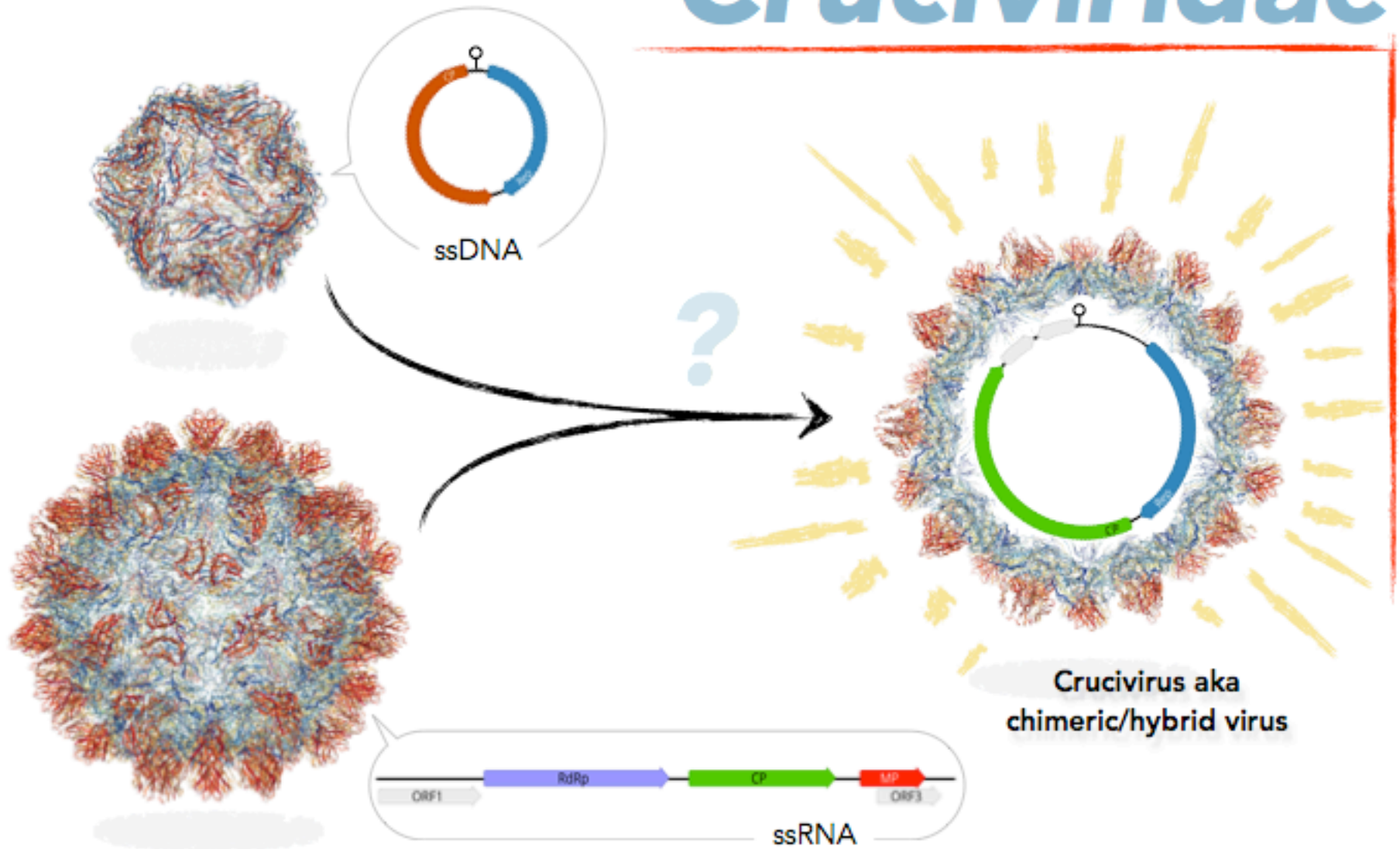
Eukarya

VIRUSES

<http://bslmo.research.pdx.edu>



Cruciviridae

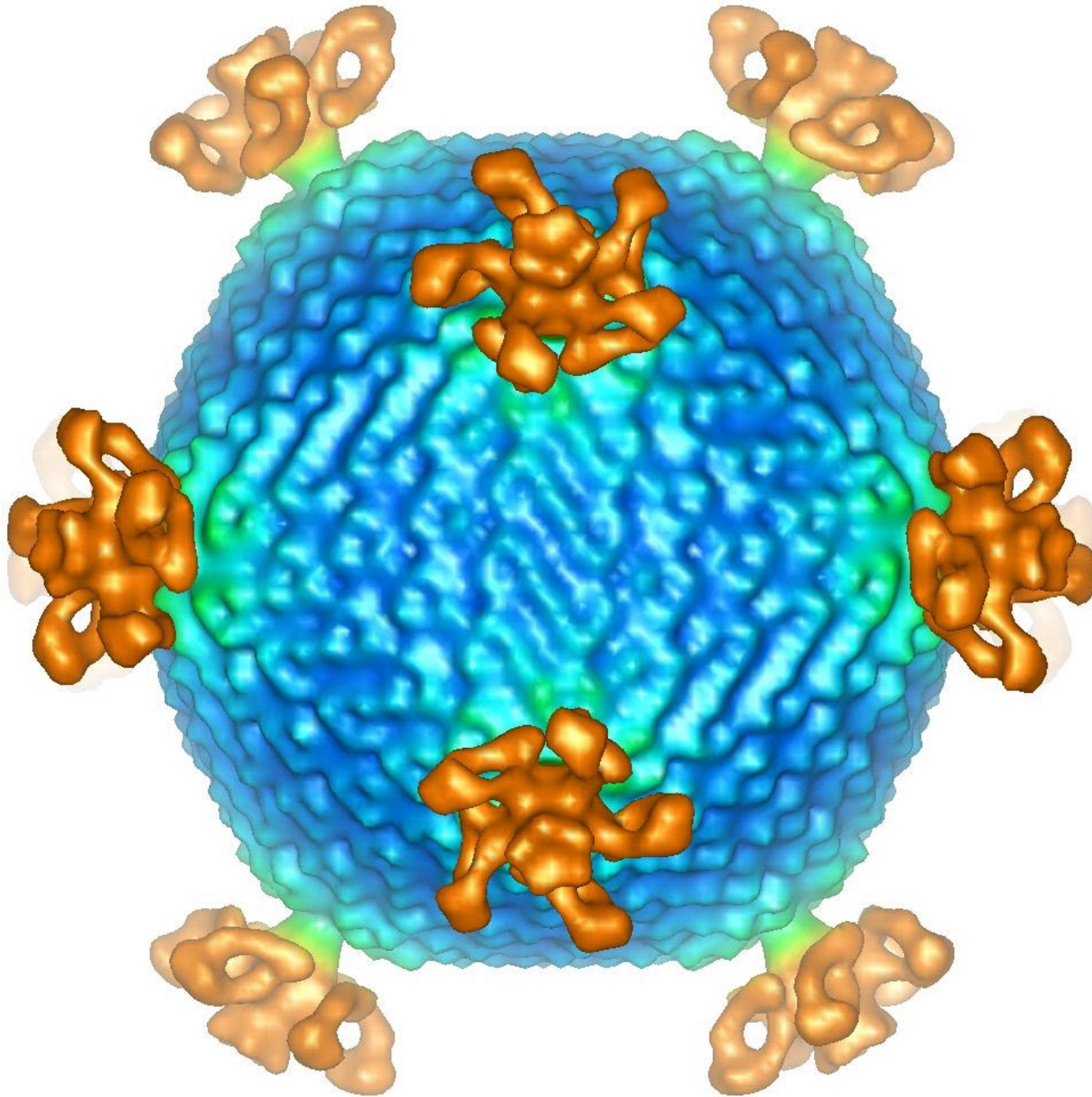




85°C, pH⁺ = 3.5

Rabbit Creek, Yellowstone National Park, U.S.A.

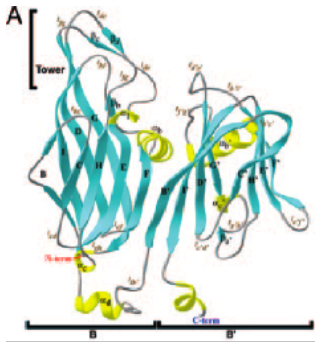
10.20.2000 14:5



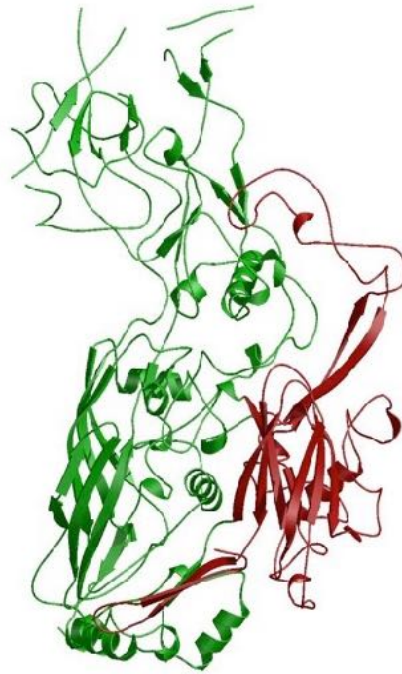
STIV

L.Tang, J.
Johnson

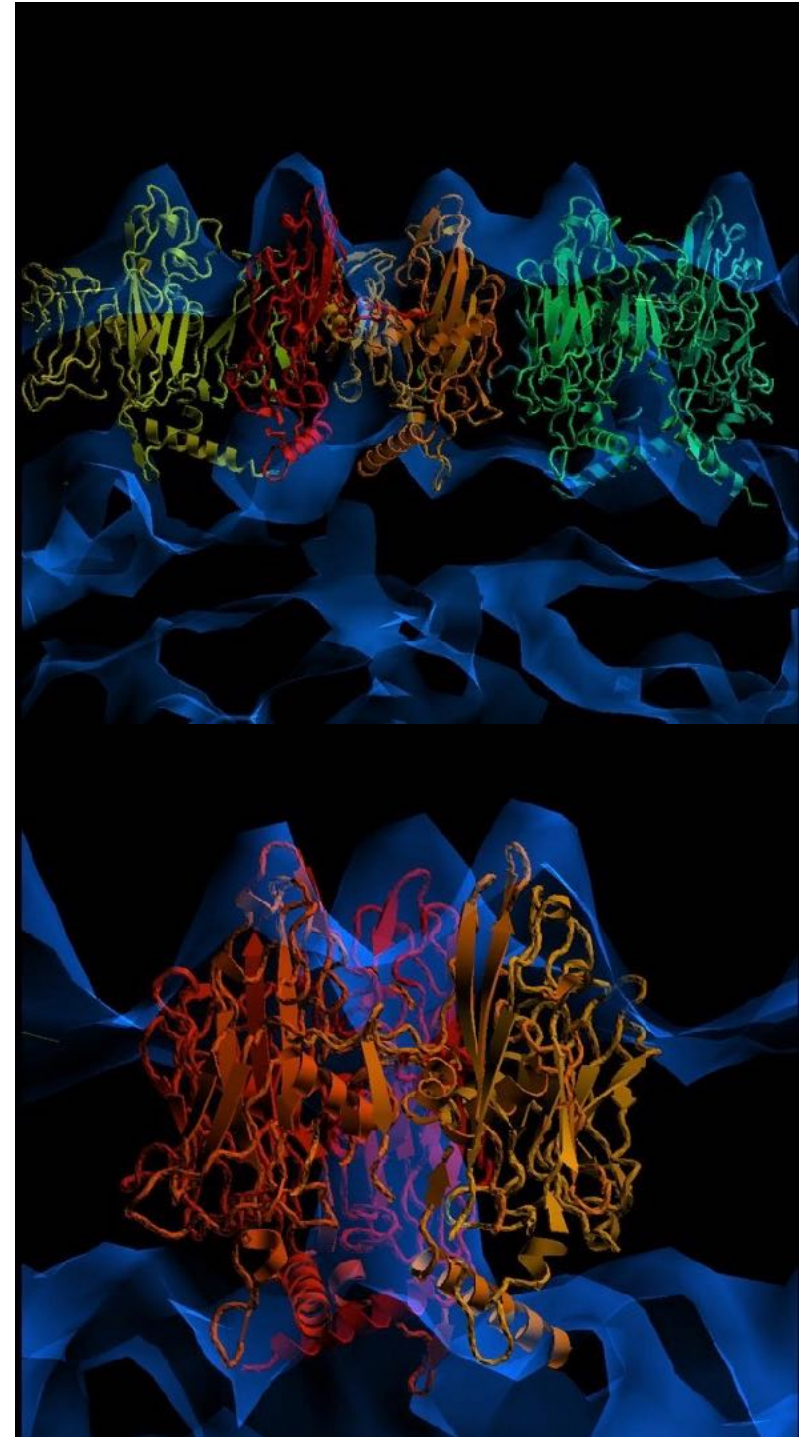
PRD1 Coat Protein Fits STIV



PRD1

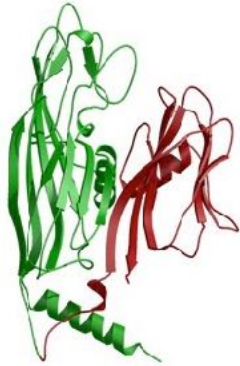


Adenovirus

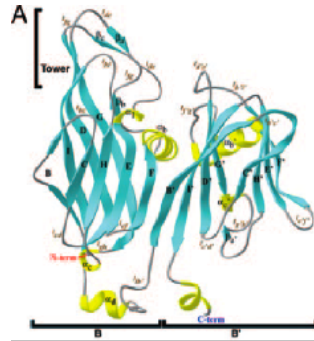


- HGT?
- Convergent Evolution?
- **Common Ancestor?**
- Rice et al., PNAS *May 2004*
- Khayat et al., PNAS, 2005

Virus Capsid Protein Folds are Ancient!



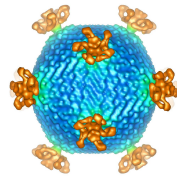
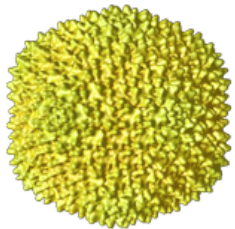
B A



E

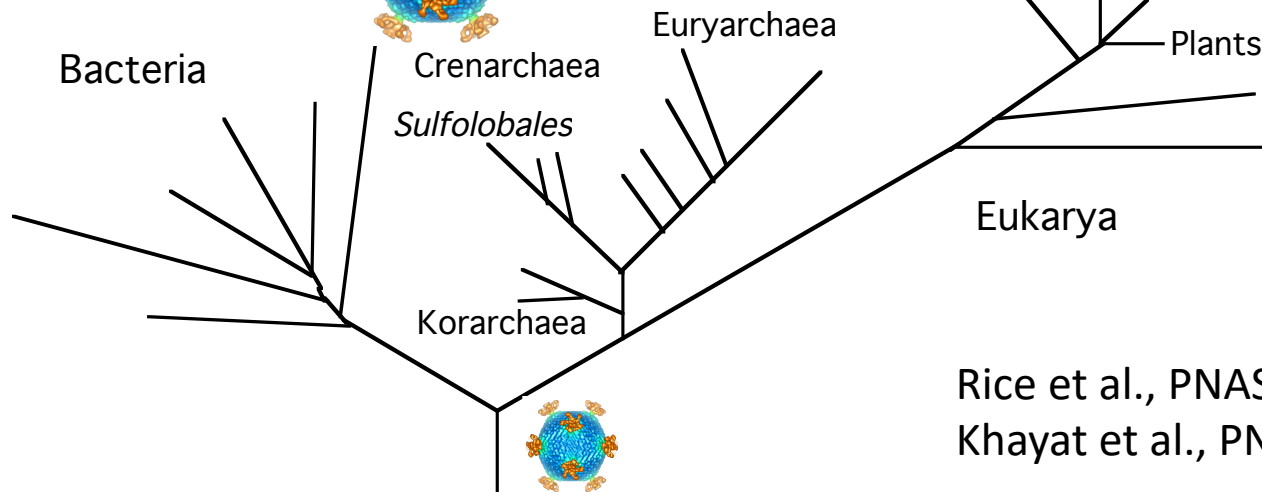
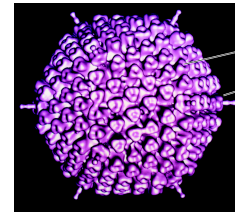


PRD1 (Bamford *et al.*)



STIV
Archaea

Adenovirus (Stewart *et al.*)



Rice *et al.*, PNAS May 2004
Khayat *et al.*, PNAS, 2005

How ancient are viruses?

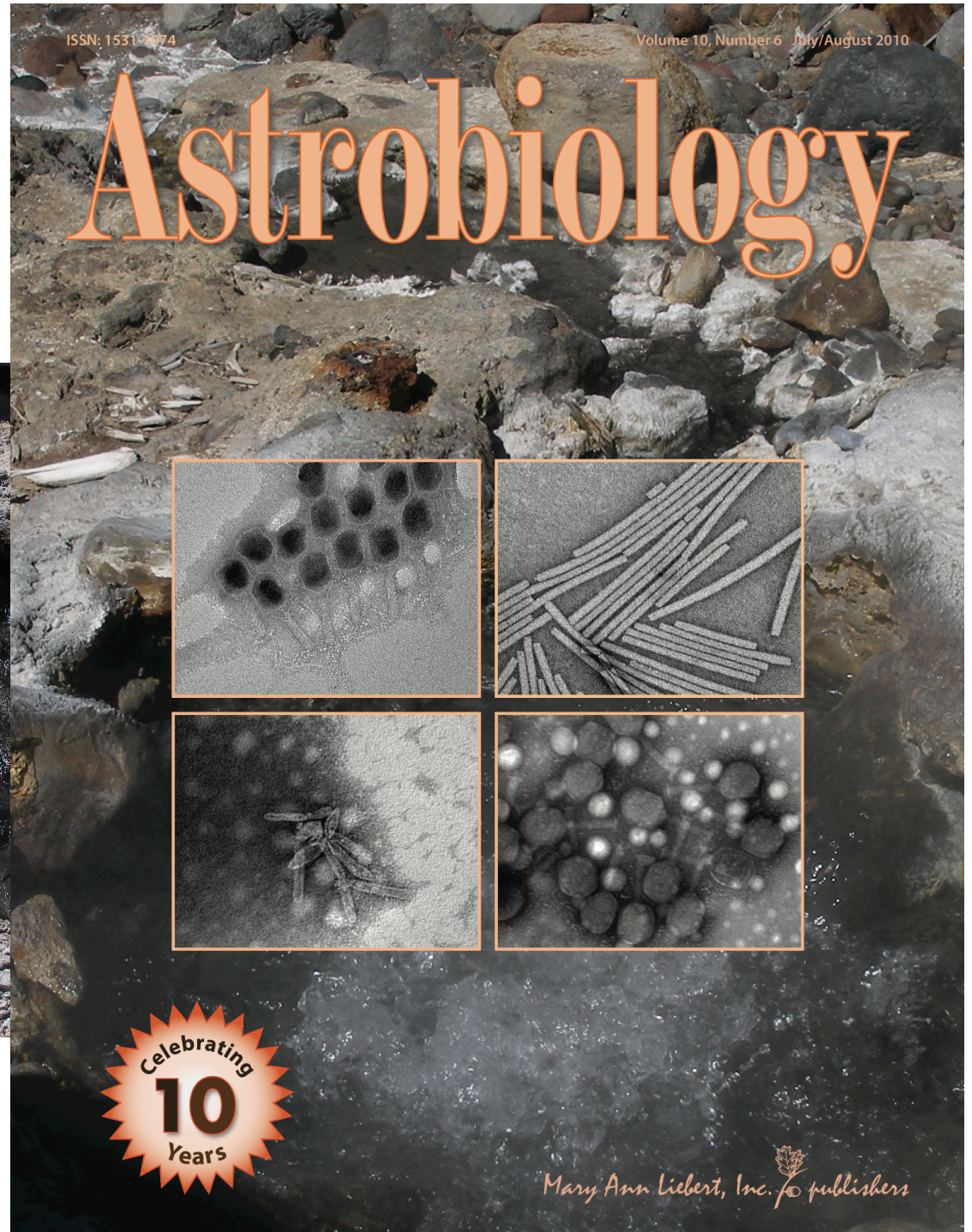


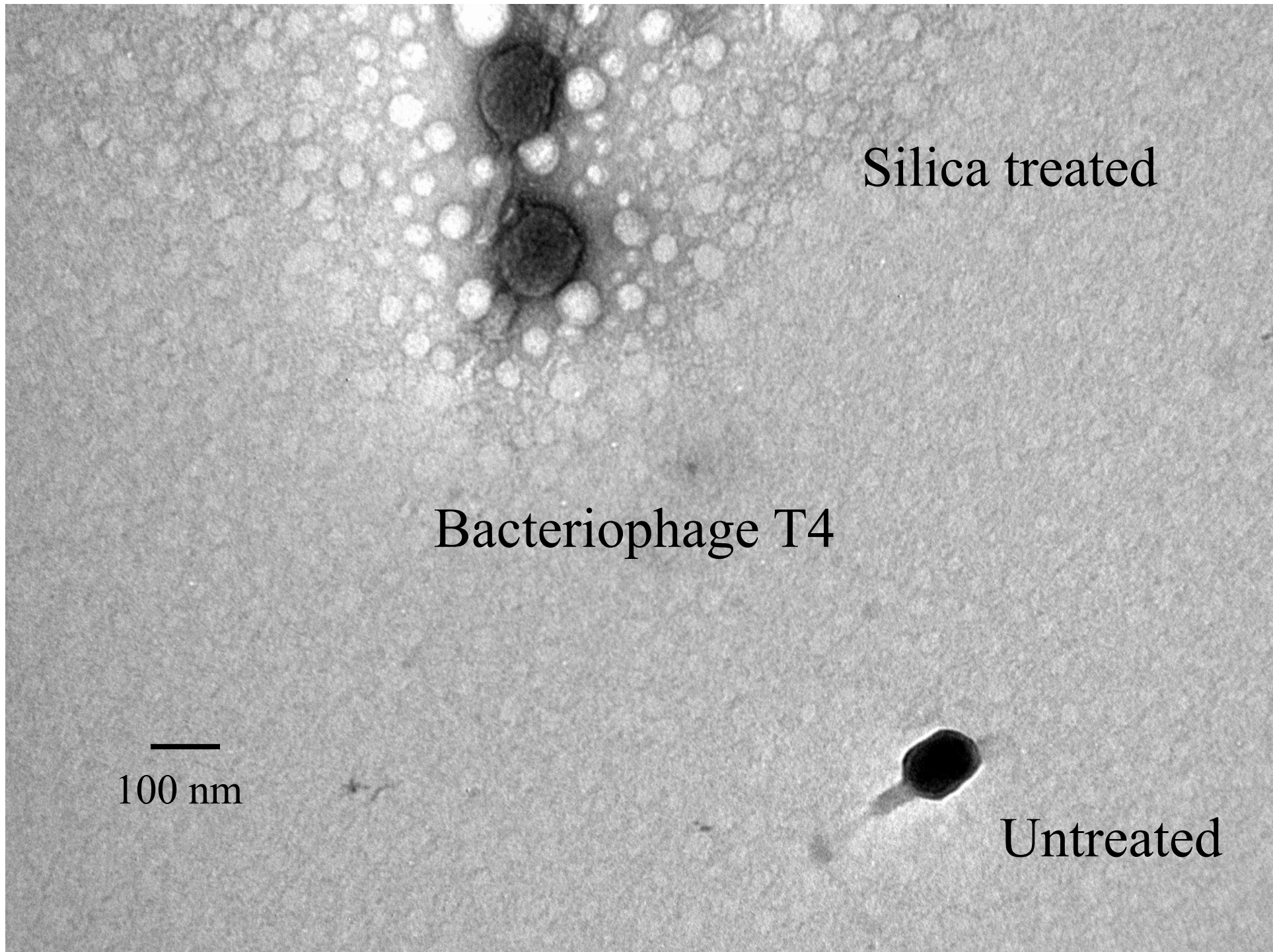
Jim Laidler, M.D., Ph.D.

Silicification in hot spring water



Laidler and Stedman, 2010





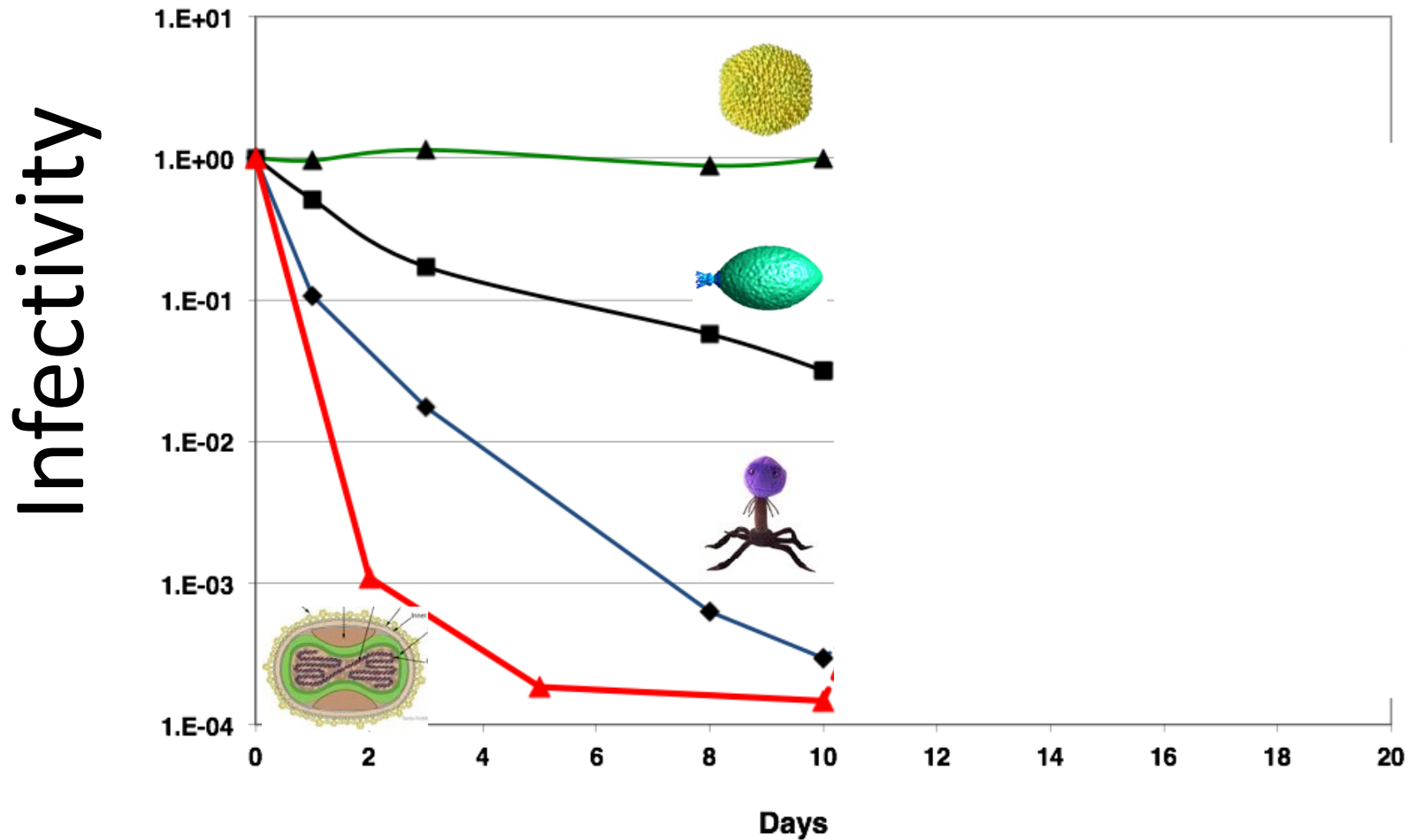
Silica treated

Bacteriophage T4

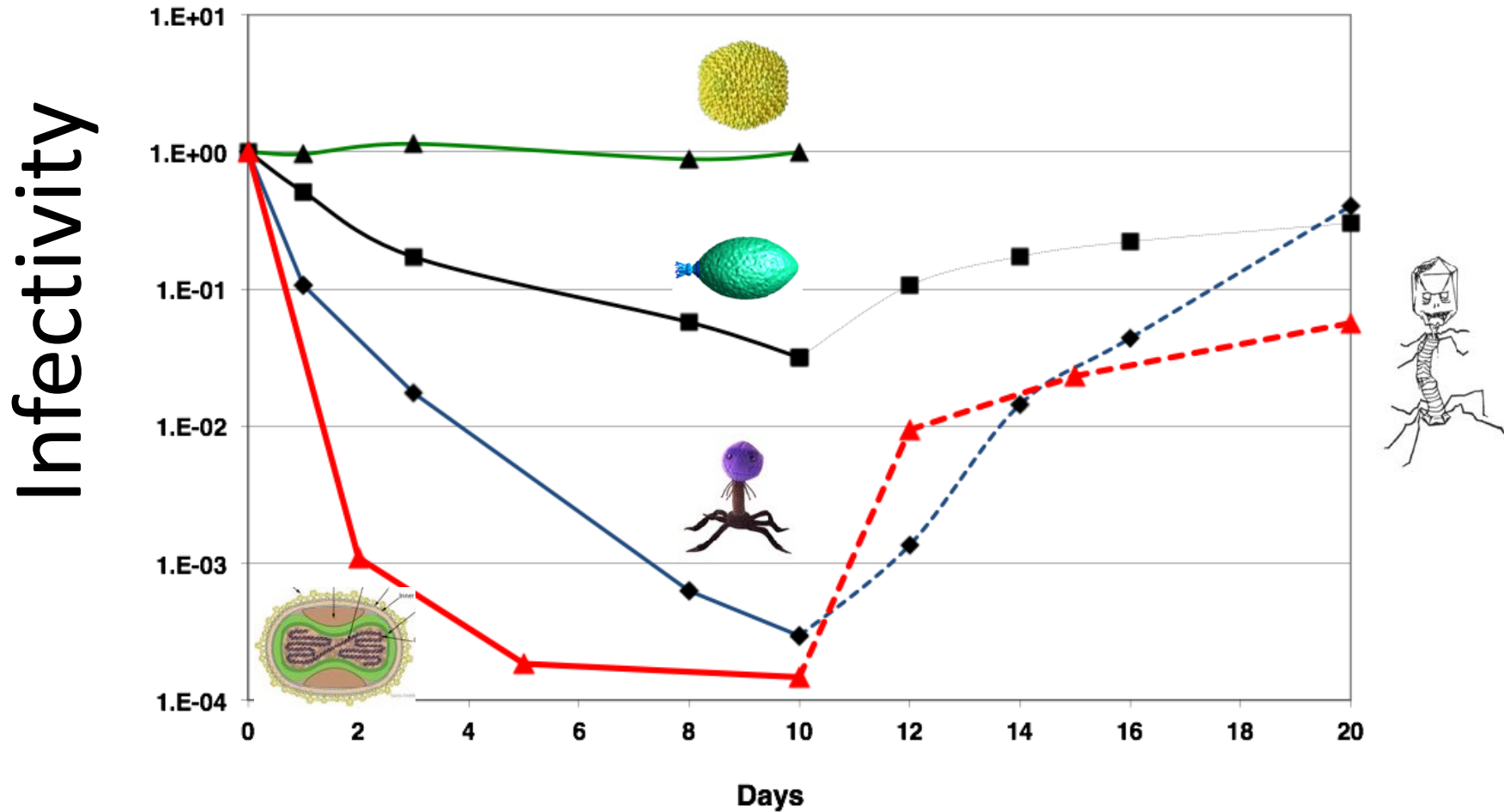
100 nm

Untreated

Silicified viruses lose infectivity.



Desilicified viruses are active.



Astrovirology Strategy?

- Validation of virus biosignatures
- Virus detection experiments for missions to Europa and/or Enceladus
- Inclusion of viruses in models for ancient oceans and extra terrestrial systems
- Isotope fractionation by AMGs?
- Exposure studies
- Unknown, abundant cosmopolitan viruses
- Roles of viruses in the origin and evolution of early life
- Outreach

Berliner et al.,
Astrobiology, 2018

