Strange Microbes
(Part 2)

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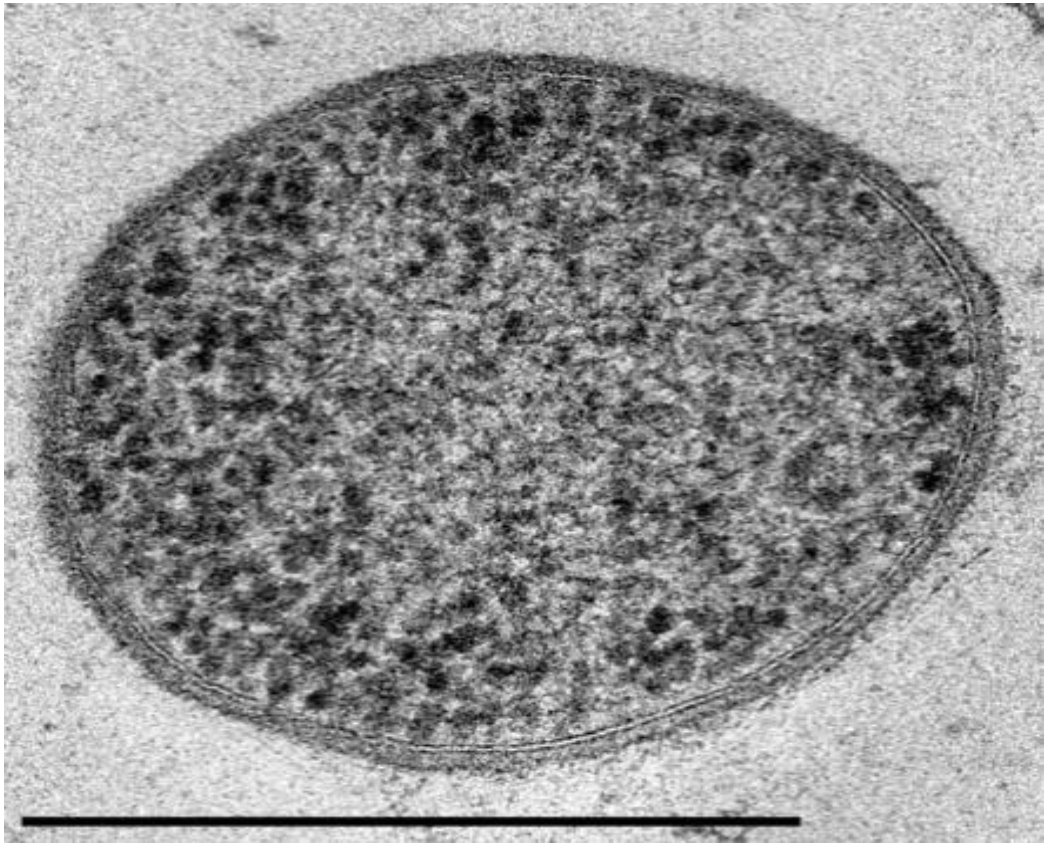
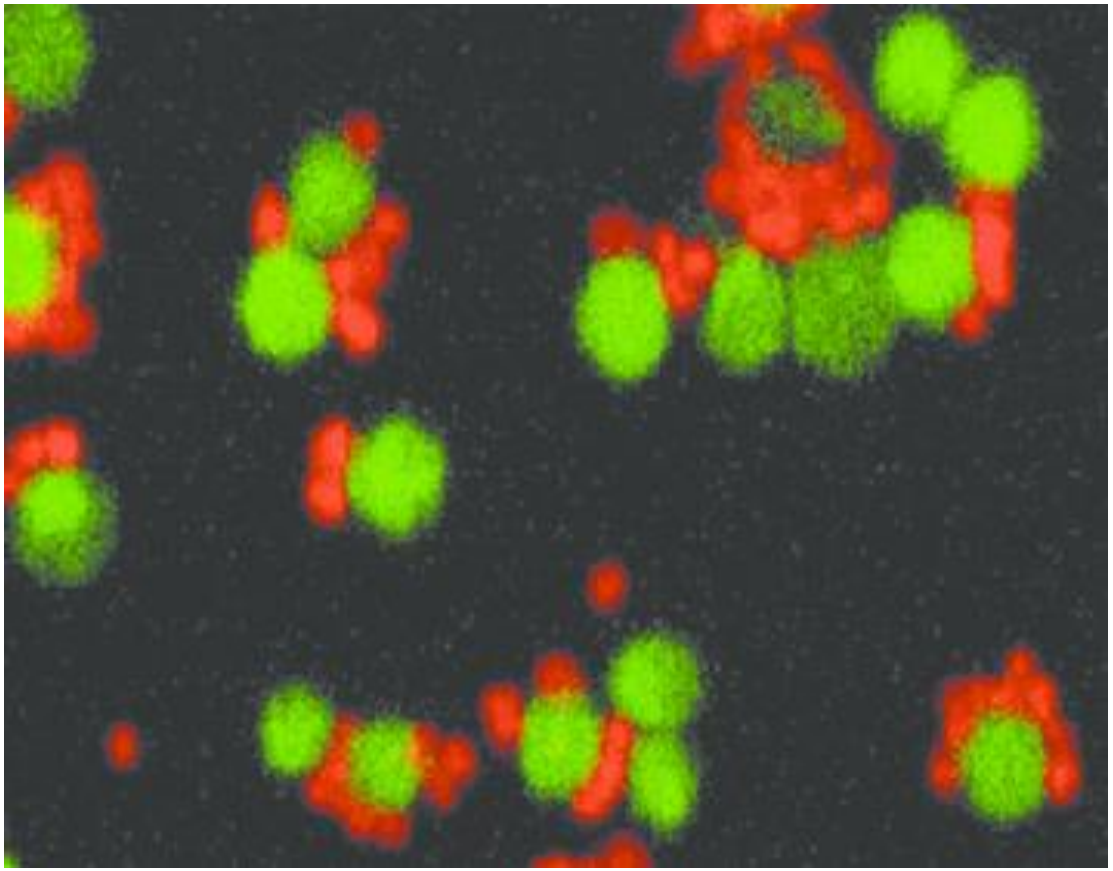
Archaea

Nanoarchaeum equitans

- Its cells are **only 400 nm** in diameter, making it the **smallest known living organism**, and the smallest known archaeon.



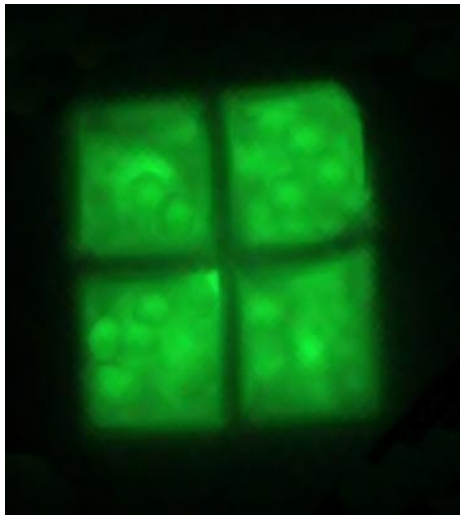
- It **cannot synthesize lipids** but obtains them from its host *Ignicoccus hospitalis*



Fluorescence in situ hybridization: *N. equitans* (red) *and I. hospitalis* (green)

Haloquadratum walsbyi

- Bacteria or Archae are round or rods with rounded ends.
- But *Haloquadratum walsbyi* are **square archae with sharp corners** which were discovered in 1980 in concentrated salt solutions.
- They are not only square, but **also very thin** -- about 200 nm (0.2 μm) thick.

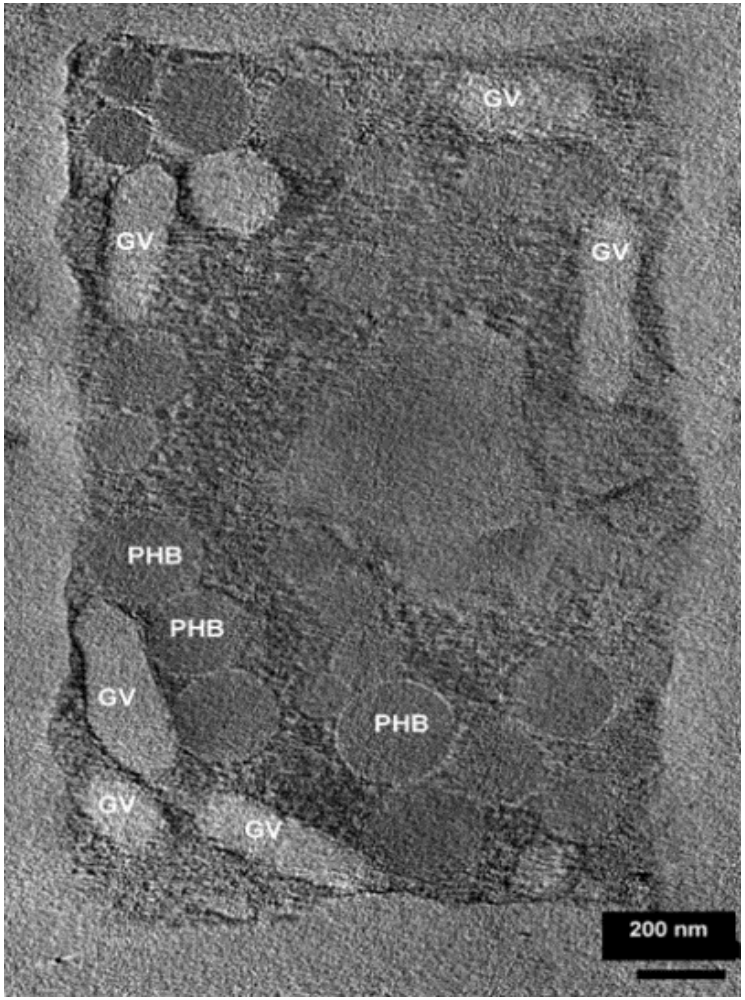


A E Walsby, A square bacterium. Nature 283:69, 1/3/80

- They seem to **grow as two dimensional objects**, increasing the size of their squares, but not their thickness.

- Caught in the act of division, they look like a **sheet of postage stamps.**

It is not known why they are square or how they achieve their squareness.



Electron Tomographic image of a single square cell of H, walsbyi. gas vesicles (GV) recognized by their spindle shape are found at the borders of the cell.

H Bolhuis et al, BMC Genomics 7:169, 7/4/06.

Extreme Thermophiles

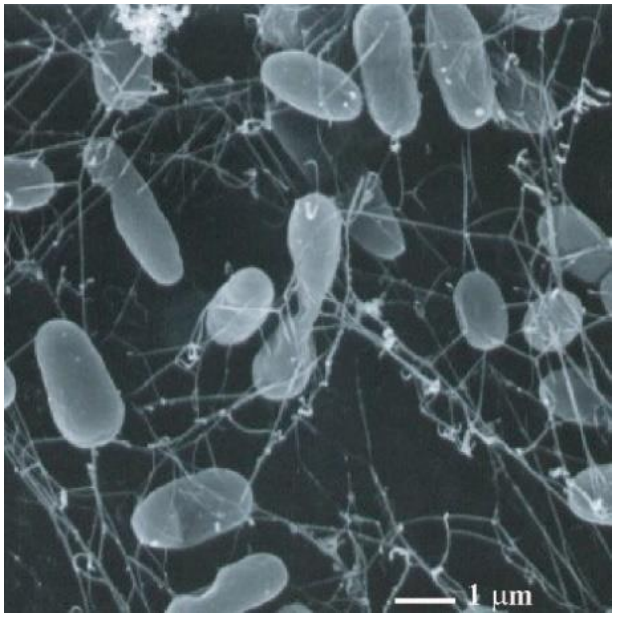
- What is the highest temperature at which life is possible?
- Now we know that the **known maximum is at least 113° C, and perhaps even 121° C**.
- These extreme thermophiles are **archaea** which were identified as a separate group from bacteria in 1977.

- Among bacteria, *Thermus aquaticus* has a **maximum growth temperature of about 80° C**.

- Its discovery in 1969 started a new era of the commercialization of enzymes from thermopiles because of their heat stability.

- The **"Taq" DNA polymerase** from *Thermus aquaticus* made the polymerase chain reaction -- PCR -- practical.

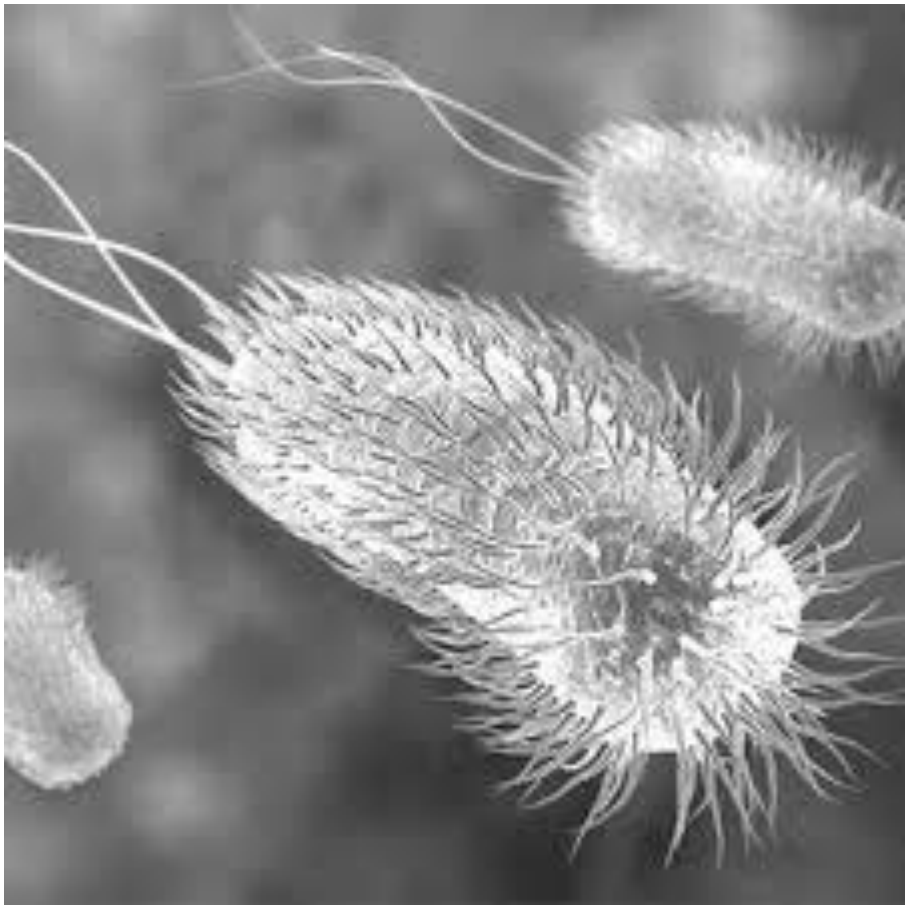
- Over the following years work on extreme thermophiles intensified.
- In 1997, *Pyrolobus fumarii*, which **grows up to 113° C** was discovered.
- This archaeon has been **widely accepted as having the highest known T_{max}.**



- In 2003, an archaeon was reported that **could grow at 121° C**.

- It is the **normal operating temperature of an autoclave** commonly used to kill even the most resistant forms of life.

- This organism is simply called **Strain 121** for now.

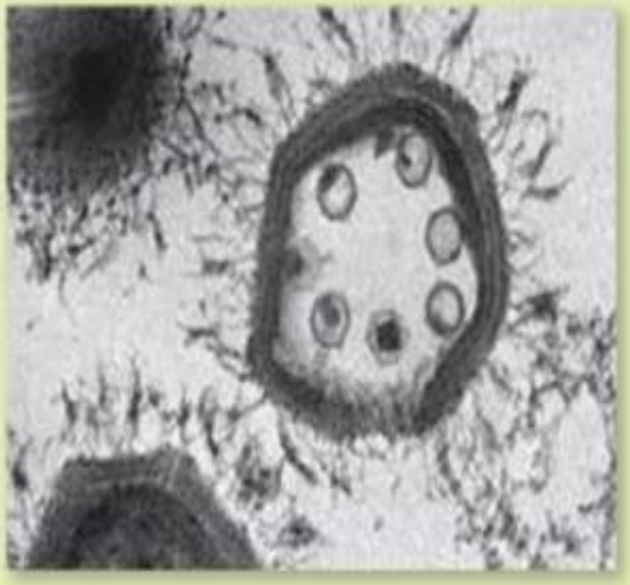


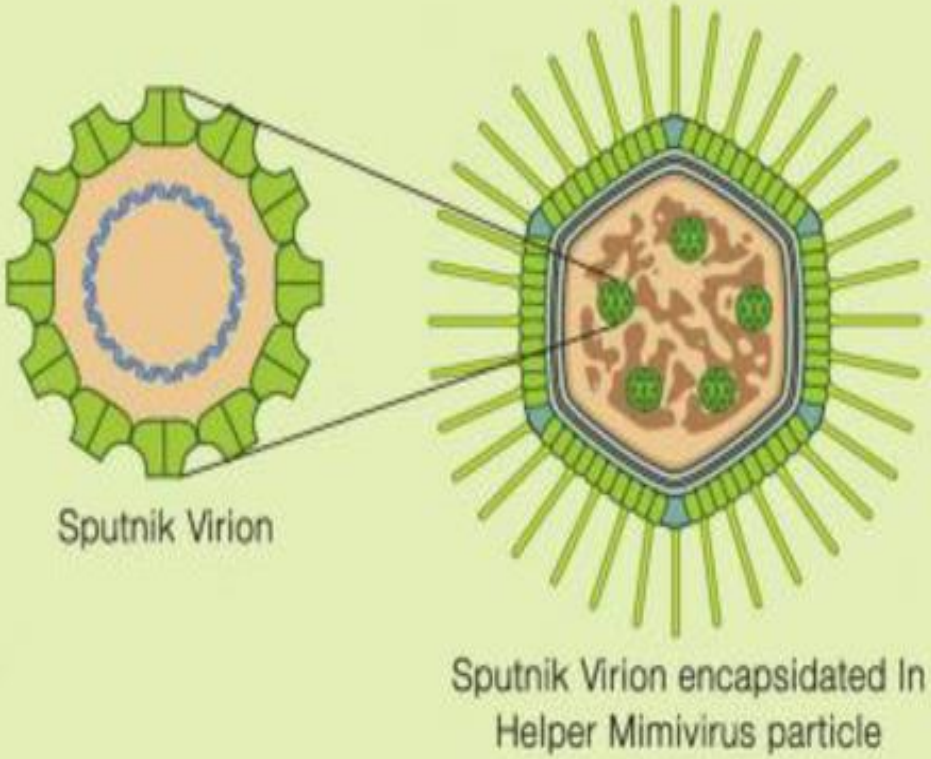
*The first report of **Strain 121**. K Kashefi & D R Lovley, Extending the upper temperature limit for life. Science 301:934, 8/15/03. Online at http://www.sciencemag.org/content/301/5635/934.full.*

Viruses

Sputnik virophage

- The Sputnik virophage is a **parasite** of other viruses especially the giant virus *Mamavirus*.
- *Mamavirus* in turn parasitizes the protozoan *Acanthamoeba*, which itself is a parasite of an animal.
- This makes Sputnik **a parasite of a parasite of a parasite**.

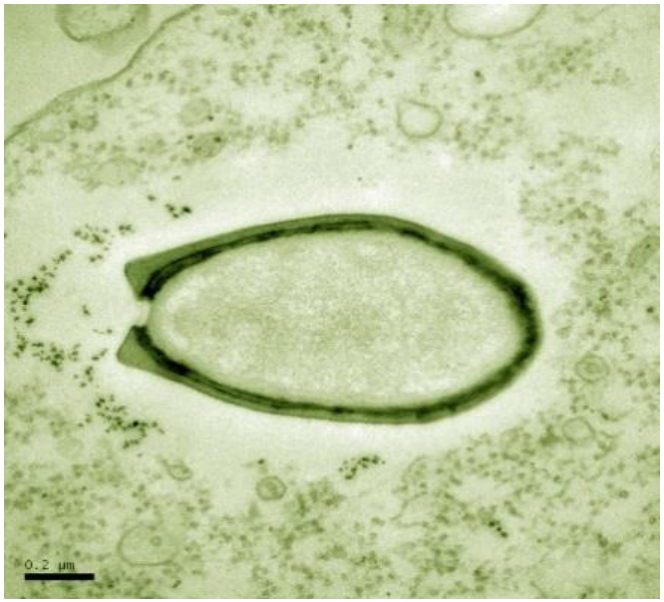



Sputnik Virion
Sputnik Virion encapsidated In
Helper Mimivirus particle

(A) (B) (C)

Pithovirus

- It was discovered in 2014 when a viable specimen was found in a **30,000-year-old ice core** harvested from permafrost in **Siberia, Russia**.
- It measures approximately **1.5 µm** (1500 nm) in length and **0.5** µm (500 nm) in diameter, making it the **largest virus yet found**.



- It is **50% larger** in size than the Pandoraviridae, the previous largest-known viruses, and is **larger than Ostreococcus, the smallest eukaryotic cell.**

- It is a **DNA based virus** and is a member of the nucleocytoplasmic large DNA viruses clade.

Sirucek S (3 March 2014). "Ancient "Giant Virus" Revived From Siberian Permafrost". National Geographic. Archived from the original on 4 March 2014.

Pandoravirus

- Although **smaller than Pithovirus**, at 1 micrometer in diameter, Pandoviruses are **ten to twenty times** the size of a typical virus.

- It has the **largest genome among viruses having 2.5 million base pairs** in their genome of DNA.

- Most viruses have **only a few thousand base pairs**.

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Yong E (3 March 2014). "Giant virus resurrected from 30,000-year-old ice : Nature News & Comment". Nature. doi:10.1038/nature.2014.14801. S2CID 87146458.

Protists

Valonia ventricosa

- This is a **species of algae** found in oceans throughout the world in tropical and subtropical regions, within the phylum *Chlorophyta*.

- This is also known as **bubble algae, sea grape**, or **sailor's eyeballs.**

- They can be **bright green**, **teal**, **silver** or even **black**, depending on how many chloroplasts they have.

- This algae is **one of the largest single-celled organisms in the world**, as it can grow to be **up to 5 centimeters** in diameter.

Tunnell, John Wesley; Chávez, Ernesto A.; Withers, Kim (2007). Coral reefs of the southern Gulf of Mexico. Texas A&M University Press. p. 91. ISBN 978-1-58544-617-9.

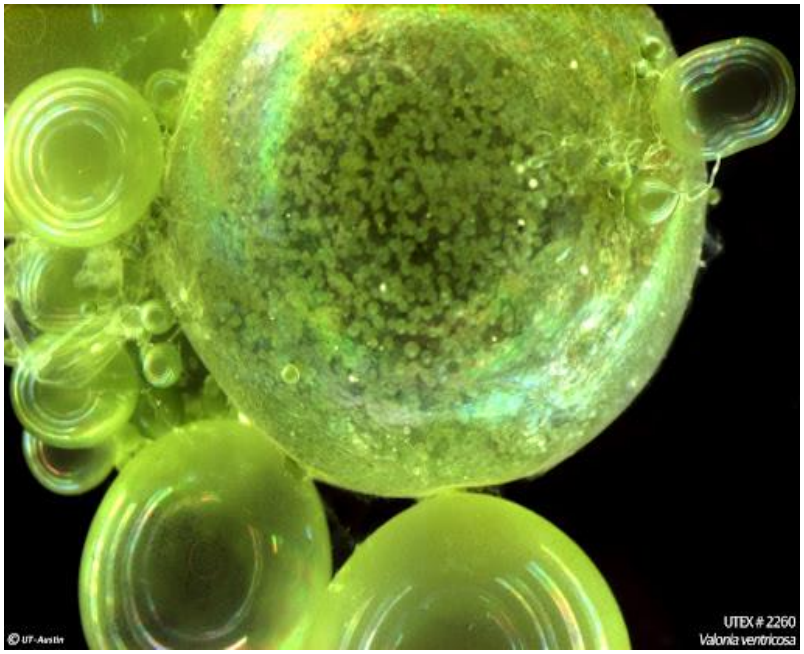
- To adapt to this huge size, *Valonia ventricosa* has a coenocytic structure with **multiple nuclei and chloroplasts**.

- This organism possesses a **large central vacuole** that is multilobular in structure (lobules radiating from a central spheroid region).

- The entire cell contains **several cytoplasmic domains**, with **each domain having a nucleus and a few chloroplasts**.

- Cytoplasmic domains are **interconnected by cytoplasmic "bridges"** that are supported by microtubules.

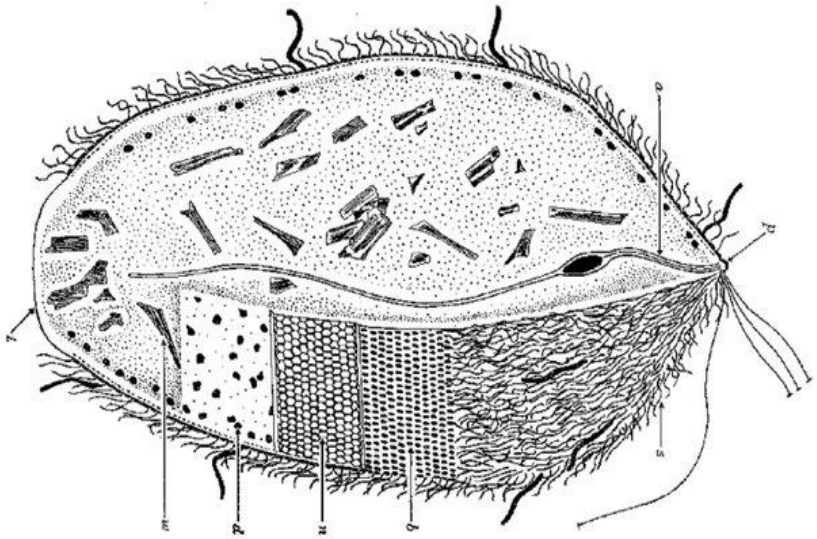
- The peripheral cytoplasm (whose membrane is overlaid by the cell wall) is only about **40 nm thick**.



Mixotricha paradoxa

- This protozoan, which lives inside termites *Mastotermes darwiniensis*, **isn't just one organism - it's five different ones**.

- *Mixotricha paradoxa* is more or less **pear-shaped**, with **four flagella** at its narrower end.



- Mixotricha means '**mixed hairs**' – because it has both flagella and cilia.

- On the **surface** of its cell, countless **symbiotic bacteria of three different species act as mini flagella**, aiding locomotion. These give it a “furry” appearance.

- Meanwhile, a **fourth species** of bacterial symbiote **lives inside the cell**, helping digest the protist’s food.

- It only **lives inside its termite hosts**, where it joins a community of other microbes that **digest cellulose and lignin from the wood** and other plant matter that termites eat.

- **Both partners benefit**: the termite can eat wood (digested by the *Mixotricha*), while the *Mixotricha* is protected, carried around, and fed by the termite.

This is a **classic symbiosis**.

- But inside *Mixotricha* are more symbionts **with at least five genomes.**

- **Genome 1** comprises the genes and other DNA in the **nucleus of *Mixotricha* itself**. It control much of its physiology and morphology.

- **Genomes 2 and 3 comprises the genes and DNA in two species of spherical bacteria** that live inside the *Mixotricha* cell. These **produce energy** for the *Mixotricha* in much the **same way that mitochondria produce energy** in other plant and animal cells.

- **Genomes 4 and 5** comprise the genes and DNA in **two species of bacteria** that **almost completely cover the surface** of the *Mixotricha* cell.

Trichomonas vaginalis

- *Trichomonas vaginalis* is a common **sexually-transmitted** protist (protozoan).

- These are microbes with **too many genes**.

- Humans have **22,000** genes but Trichomonas vaginalis has three times more, i.e, about **60,000 genes**.

- These are the **most genes known in any microbe**.

The significance of this number of genes count is unclear.

J M Carlton et al, Draft genome sequence of the sexually transmitted pathogen Trichomonas vaginalis. Science 315:207, 1/12/07

Polychaos dubium (Amoeba dubia)

- These are **microbes with too much DNA**.
- *Polychaos dubium* is a **freshwater amoeboid** and one of the larger species of single-celled eukaryote.
- Like other amoebozoans, *P. dubium* moves by means of temporary projections called **pseudopods**.

- This protist is the organism with the **largest known genome**.

- It has **670 billion base pairs of DNA. That is about 200 times more than humans.**

What is the significance of this finding?

Is this really a measure of the haploid genome size?

Casey L McGrath; Laura A Katz (1 January 2004). "Genome diversity in microbial eukaryotes". Trends in Ecology & Evolution. 19 (1): 32–38. doi:10.1016/J.TREE.2003.10.007

- It is not only *Polychaos dubium* genome, **many other organisms have genomes much larger than humans.**

http://www.genomesize.com/statistics.php.


Thank You!