Strange Microbes
(Part 1)

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Note:

History of microbiology is not very old. Significant findings have been made which profoundly affected our lives, e.g., the antimicrobials and vaccines. But it seems that still we know very little about microbial world.

More than 90% microbes thought to be existing have not yet been cultivated. Everyday there are new discoveries which are so fascinating and keep challenging our dogmas.

In this lecture, I will introduce you to some strange microbes.

In **Part 1**, I will cover strange **Bacteria**.

Part 2 contents include strange **Archeae, Viruses, and Protists**.

Bacteria

Thiomargarita magnifica

- The King Kong of bacterial kingdom is *Thiomargarita magnifica*

- It is the **largest bacterium ever discovered**.

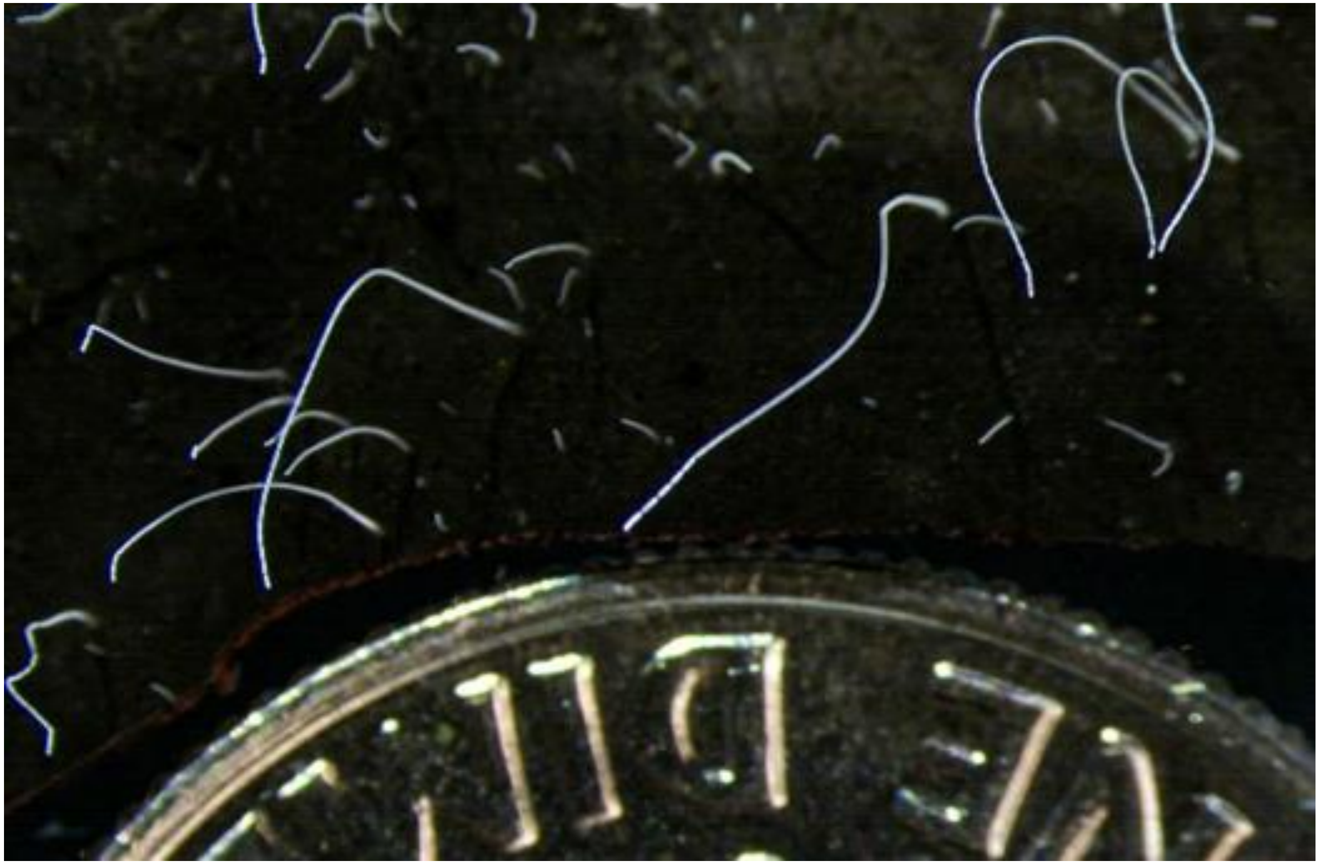
- Its average size is 10 mm which is **twenty times larger** than previously largest known bacterium *Epulopiscium fishelsoni*.

- At about **1cm long**, it is roughly **50 times larger** than all other known giant bacteria and **thousands of times bigger** than more familiar bacteria such as *Escherichia coli*.

- It is the **first bacterium** that is **visible with the naked eye**.

- The organism was discovered by Olivier Gros, a marine biology professor at the Université des Antilles in Guadeloupe, while searching for symbiotic bacteria in the mangrove ecosystem.

Volland et al., 2022. Science. 376 (6600): 1453–1458.

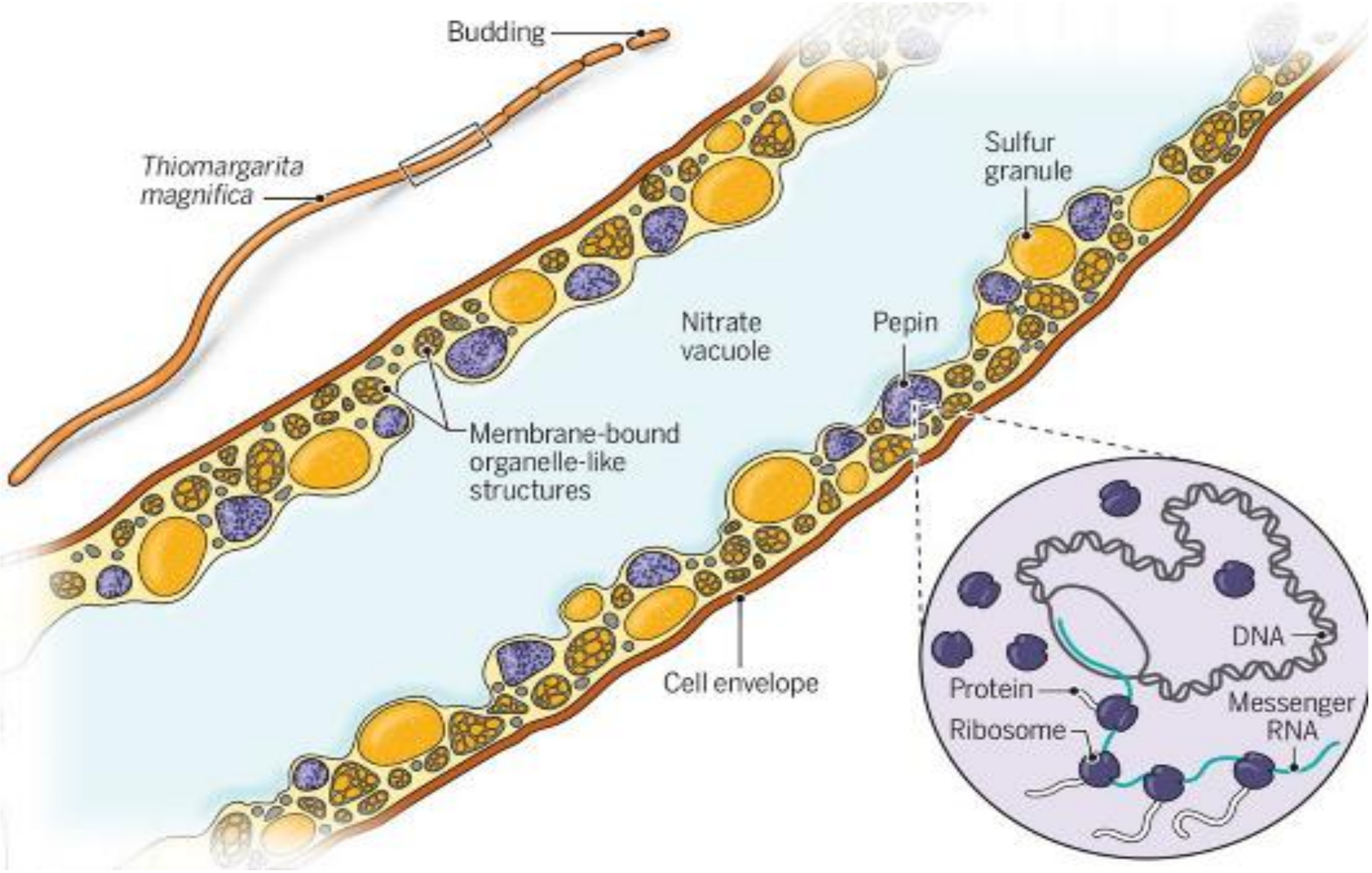


- Most of the cells are long enough to span the diameter of a penny.

- These giant bacteria have a **huge sac— filled with water and nitrates** —that takes up nearly *70% of total volume*.

- This sac **pushes the cell contents to the cell wall**, so that the diffusion can work.

- The life processes occur only **"along the edge"** of the cell.



Budding
Thiomargarita magnifica
Sulfur granule
Nitrate vacuole
Pepin
Membrane-bound organelle-like structures
Cell envelope
DNA
Protein
Ribosome
Messenger RNA

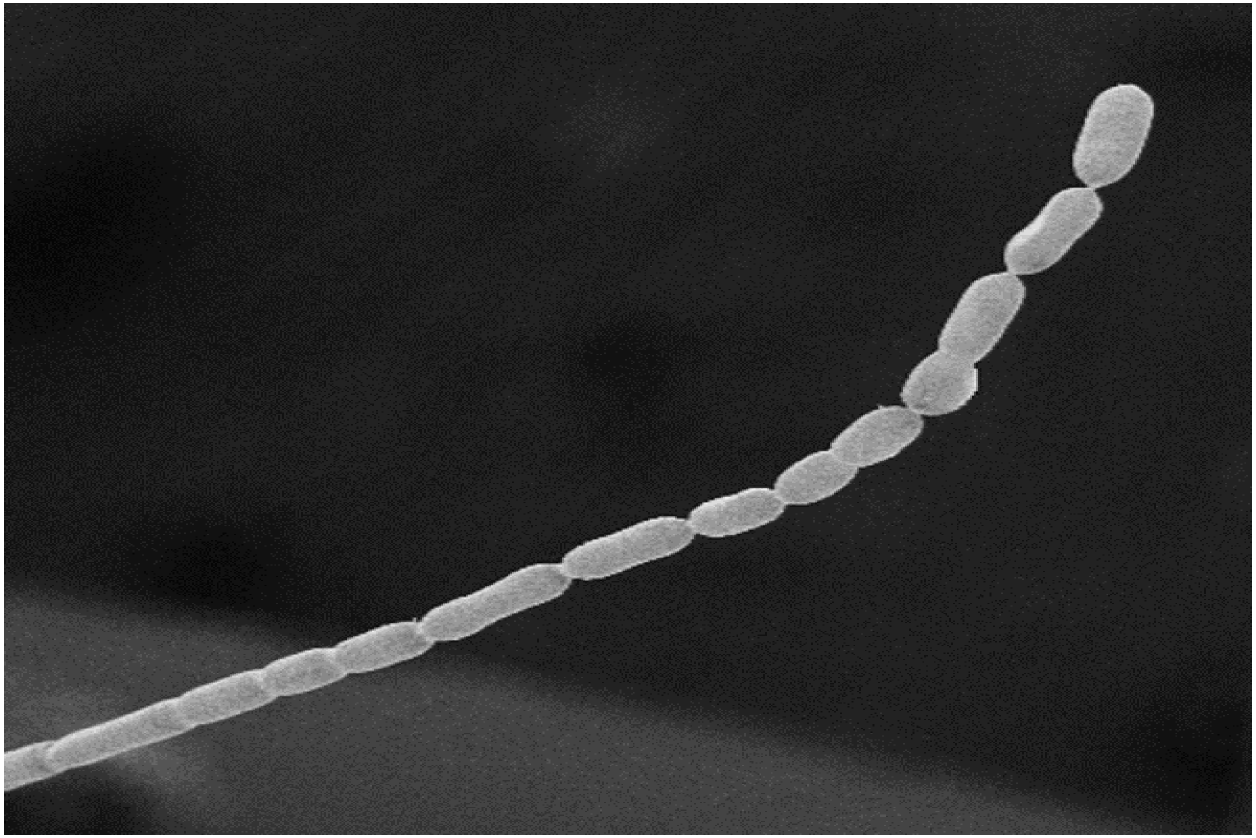
- *Thiomargarita magnifica* appears to keep its DNA more organised inside **cell membrane-bound compartments called pepins** throughout the cell.

- These **pepins look remarkably like human nuclei**.

- **Each** of the compartments, contains a **loop of DNA**.

- The **pepins** have their **own ribosomes** to build proteins.
- In other words, **each pepin is a separate identity**.
- Each pepin may make a **special** set of proteins **needed in its own region** of the bacterium.

- It **reproduces** by **pinching off its tip** into tiny new cells.



Metabacterium polyspora

- *Metabacterium polyspora* is an unusual **multiple endospore-producing bacterium** isolated from the cecum of guinea pigs.

- Bacteria of the genera **Bacillus** and **Clostridia** make "endospores" but they **do not increase the population**, because each cell makes only one spore.

- It merely results in a new type of cell, the resistant spore.

- But *Metabacterium polyspora* makes **multiple spores per cell**.

- It **rarely** undergoes the more "ordinary" process of **binary fission.**

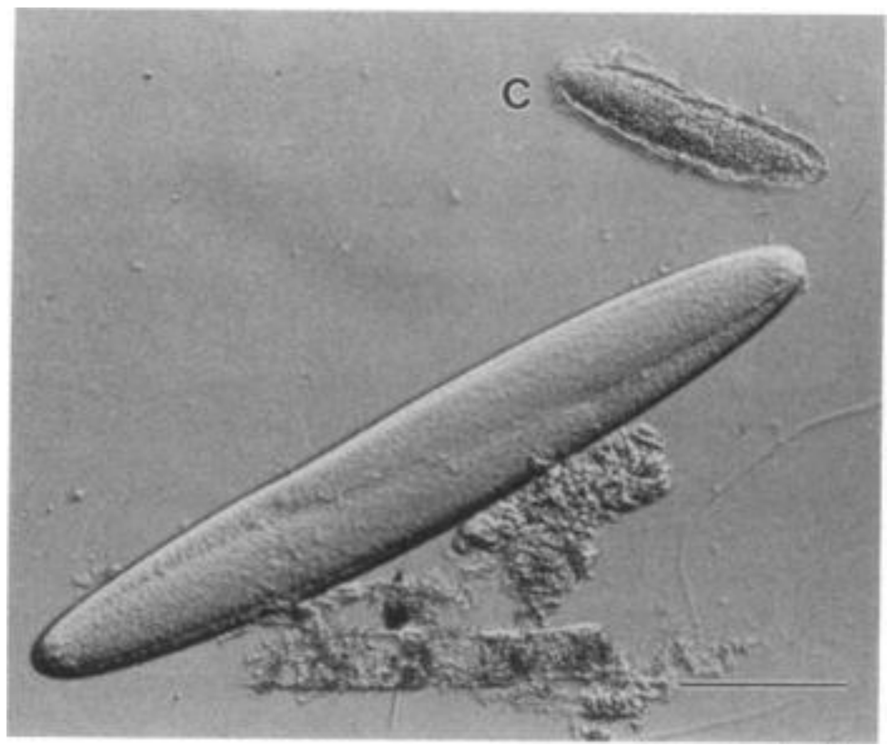
- Thus a **variation of ordinary endospore formation** has become the **primary means of reproduction**.

Metabacterium polyspora with four daughter spores. The individual spores are several μm long.

author.cals.cornell.edu/cals/...abacterium.cfm.

Epulopiscium fishelsoni

- *Epulopiscium fishelsoni* grows in the gut of certain fish.
- It as a large and peculiar **cigar-shaped** organism with an average length of 0.5 mm.



- It has a **complex life cycle**, which is coordinated with the daily rhythm of its host.

- An *Epulopiscium fishelsoni* cell contains **100,000 or so copies of its genome.**

- Thus it has **many times more DNA than a human cell**.

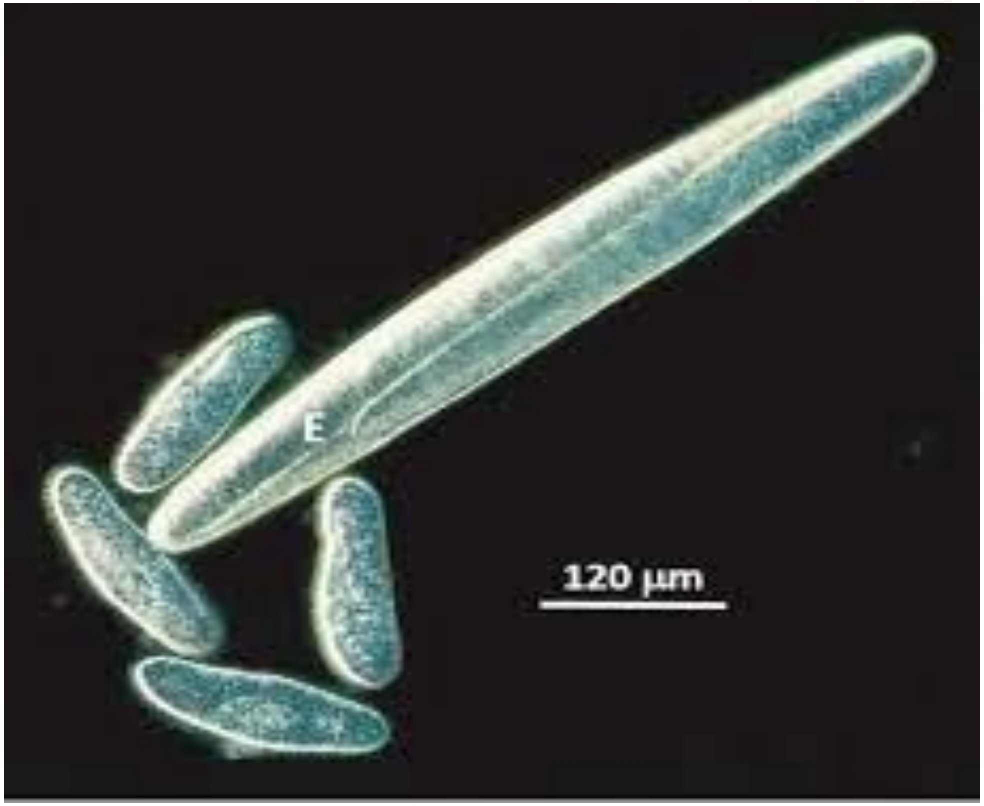
J E Mendell et al, Extreme polyploidy in a large bacterium. PNAS 105:6730-6734, 5/6/08. Online: http://www.pnas.org/content/105/18/6730.abstract.

- We know that *Metabacterium polyspora* make multiple spores bypassing binary fission.

- But *Epulopiscium fishelsoni* goes **one step further**.

- **It gives birth to live young**.

- That is, they **develop new cells inside**, and then **liberate these vegetative daughter cells.**



Esther Angert, Beyond binary fission: Some bacteria reproduce by alternative means. Microbe 1:127

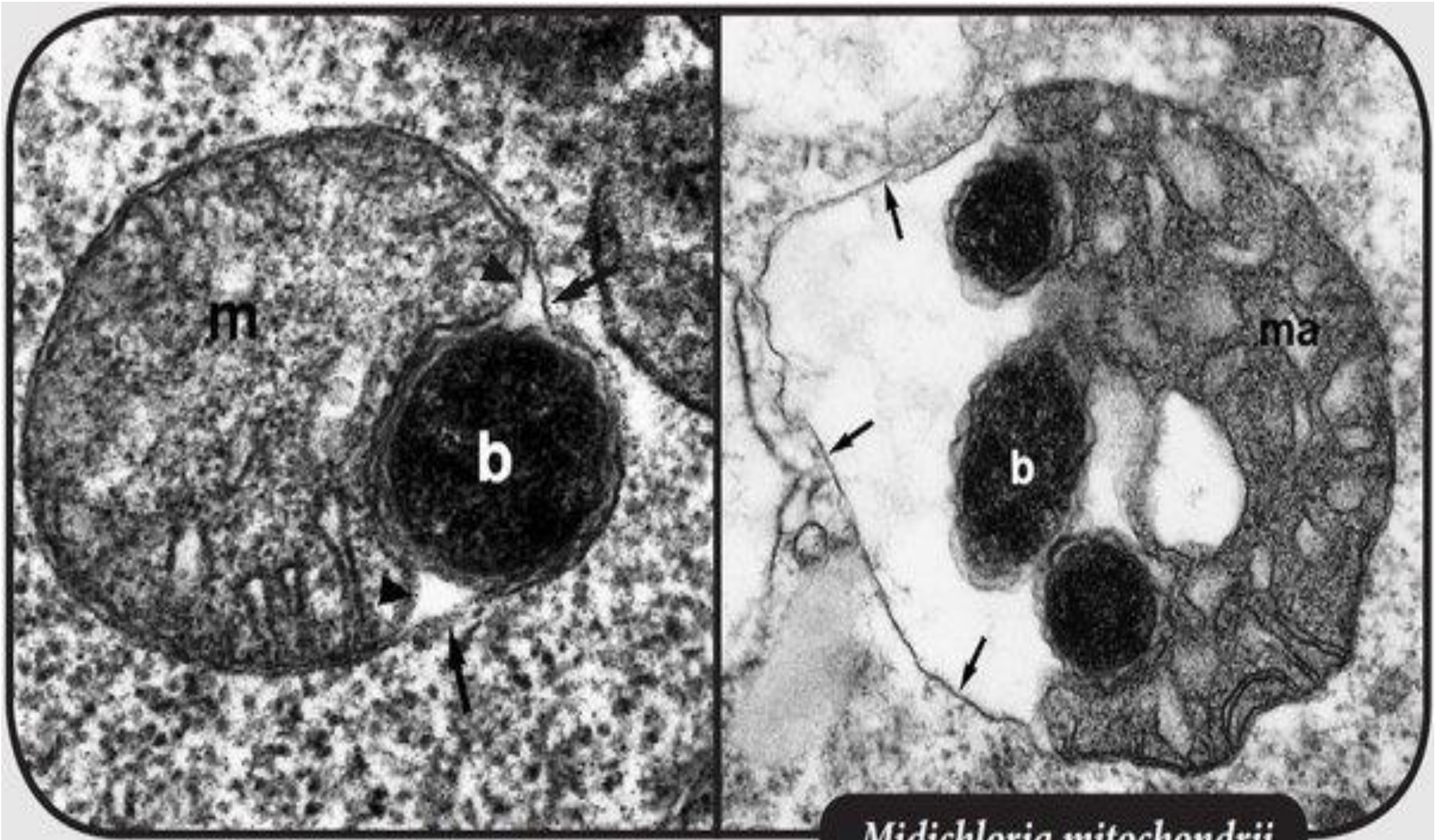
Midichloria mitochondrii

- They are **Gram-negative, non-endospore-forming bacilli** around 1.2 μm in length.

- Normally *Midichloria* live in the cells of the ovary of the females of tick species of the *Ixodidae* family.

- *M. mitochondrii* is so named **because it lives *within* the mitochondria of animals** (ticks, specifically).

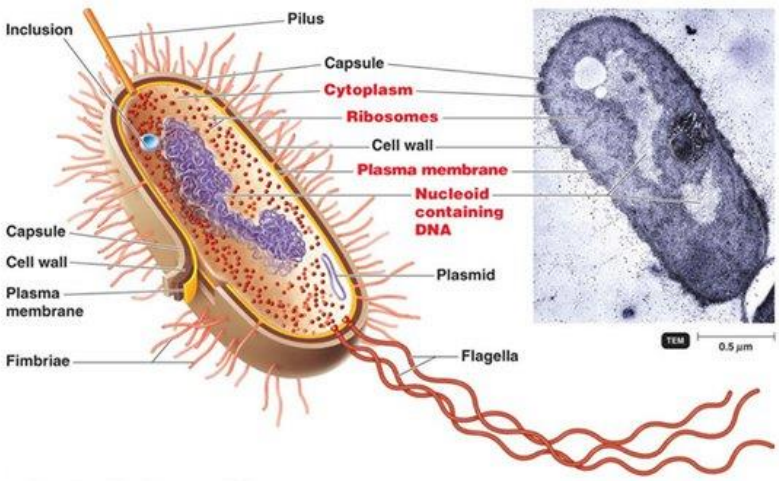
- In fact it's the **only organism in the world which does this.**

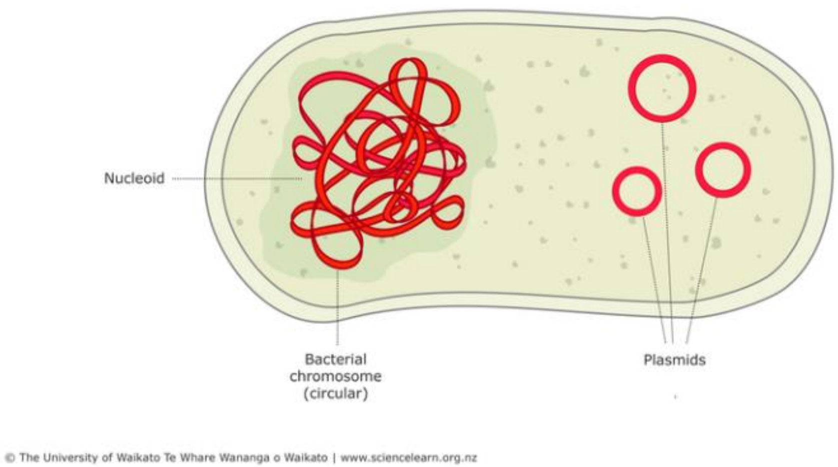


PHOTOS BY L. SACCHI ET AL., TISSUE CELL 36(1):43-53

Bacteria with "atypical" chromosomes

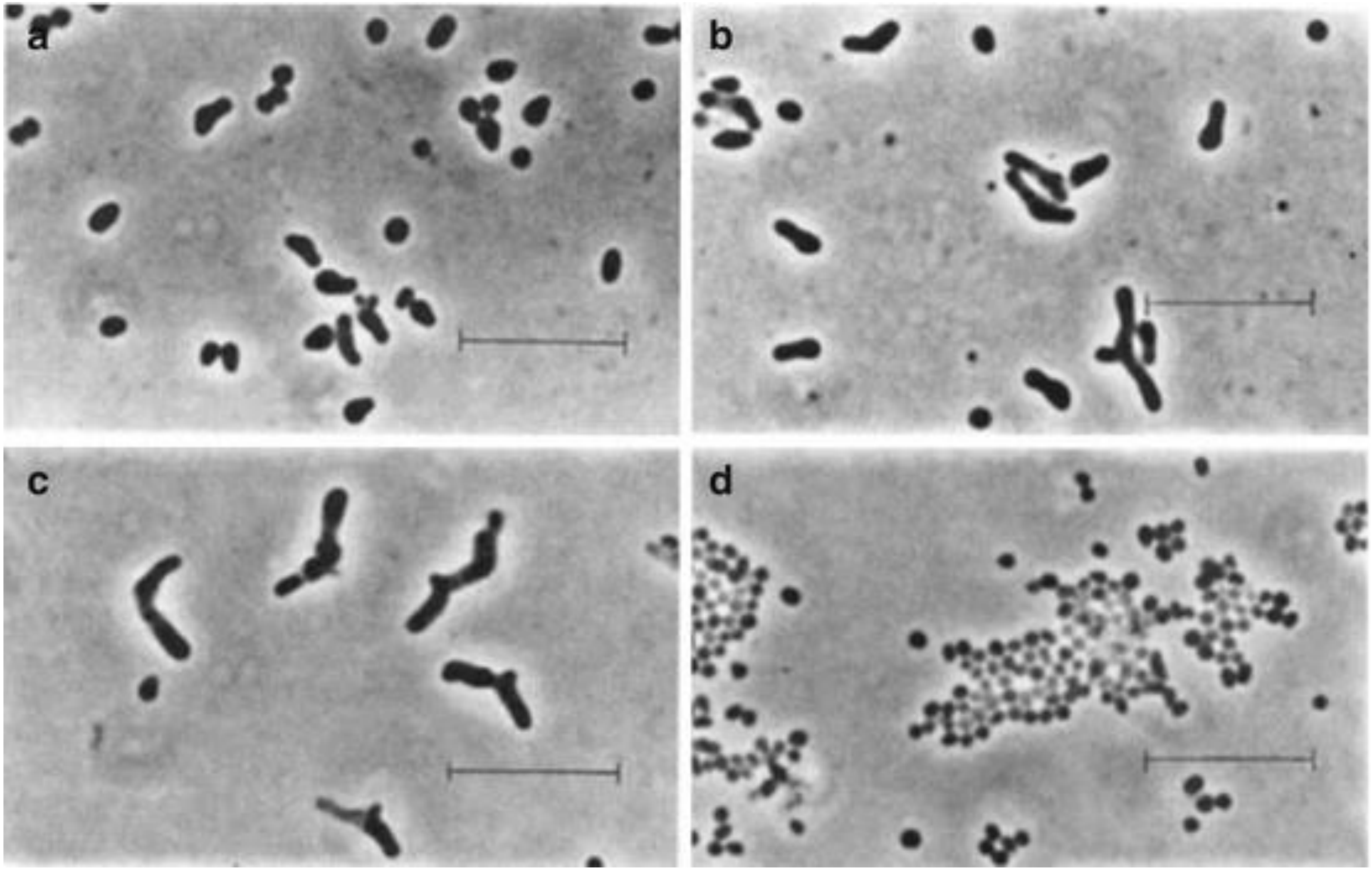
We know that bacteria have **only one chromosome**, and it is **circular**.





- But now we know that a **single chromosome and its circular shape are both not universal.**

- Bacteria with **multiple chromosomes** have been found in diverse prokaryotic phyla including *Actinobacteria*, *Chloroflexi*, *Deinococcus-Thermus*, *Fibrobacteres*, *Firmicutes*, *Proteobacteria* (α-, β- and γ-classes), and *Spirochaetes*, suggesting that they have arisen independently, many times in the course of evolution.



Actinobacteria

- Also, there are bacteria which have **linear chromosomes** instead of normal circular chromosomes.

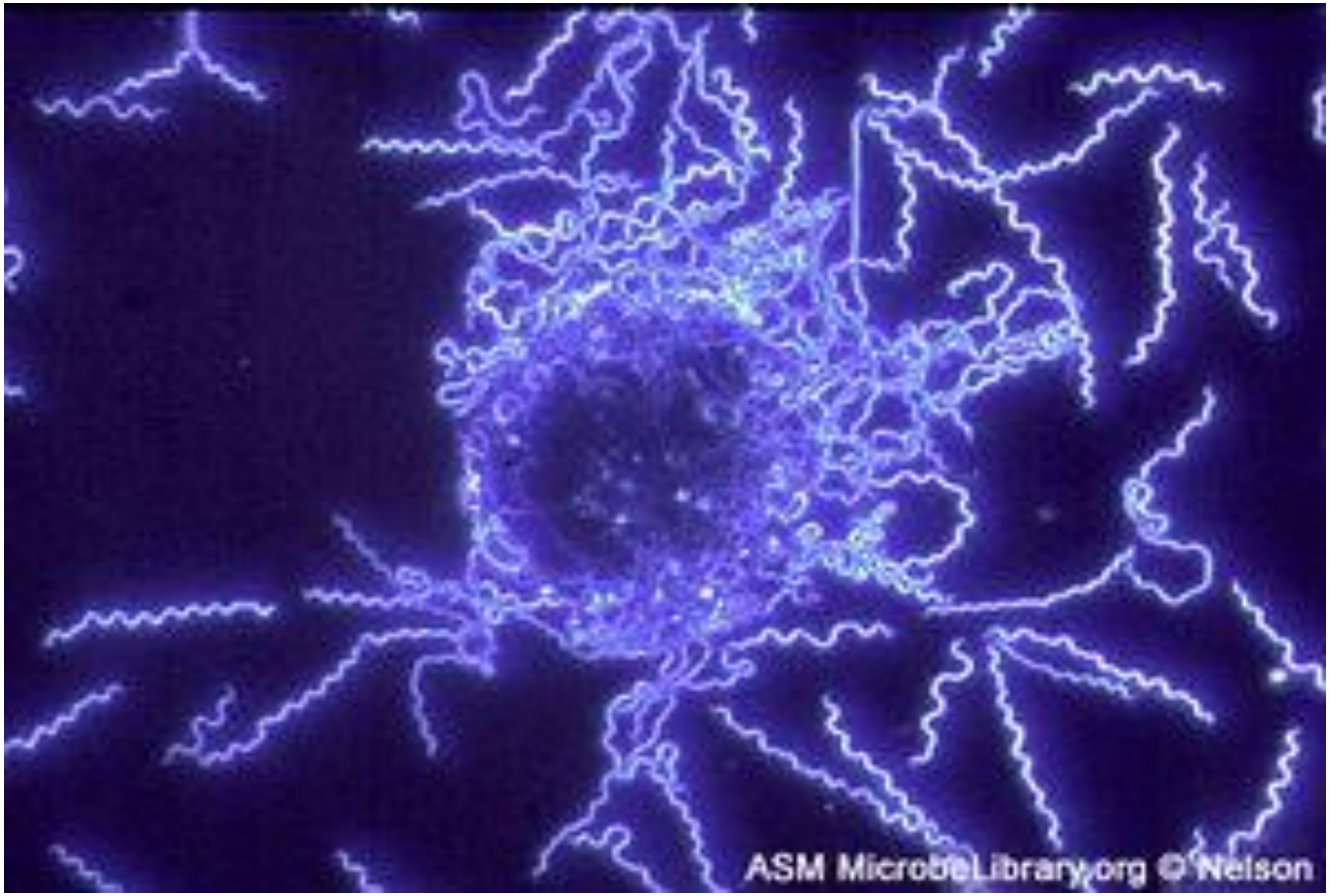
These include:

Borrelia afzelii (pathogenic spirochaetes)

Borrelia burgdorferi

Borrelia garinii

Agrobacterium tumefaciens

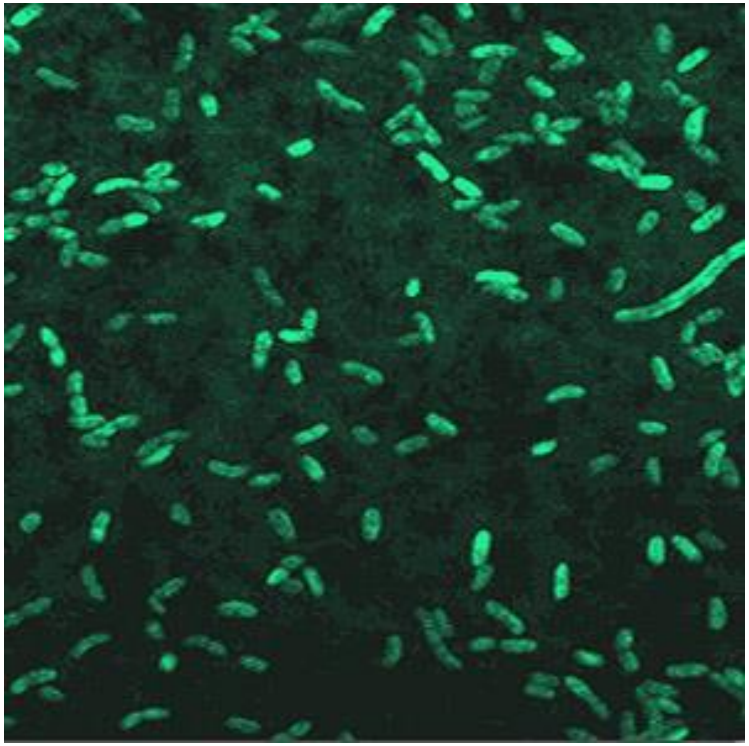


Borrelia afzelii

http://www.sci.sdsu.edu/~smaloy/MicrobialGenetics/topics/chroms-genes-prots/chromosomes.html.

Bacteria having sense of numbers

- Some bacteria can **emit light --** more or less as fireflies do. The phenomenon is called **bioluminescence**.
- These include *Vibrio harveyi* and *Photorhabdus luminescens*.



- But the light from a single bacterial cell would be too dim to be of any use. So, **isolated bacteria do not emit light**.

- They **only emit light when there are many of them together**, so that the cumulative light is useful.

- It is intriguing that **how do bacteria count** their population size?

- To make light, they need an **"inducer" --** a substance that turns on the light-producing system.

- They make an inducer, and **secrete it into the external environment.**

- When the **amount of this inducer** in surrounding atmosphere reach a **critical threshold**, they **start emitting light**.

- Unless there is sufficient number of bacteria secreting the inducer, this **threshold is not reached**.

- This is an example of **quorum sensing**.

- That is, the bacteria check to see if a **quorum is present** before emitting light.

- In this case, the bacteria are communicating their population size to their **own kind**.

- But more broadly, bacteria are signaling their presence -- and numbers -- to **other types of bacteria too**.

Magnetic Bacteria

- This group of bacteria was discovered in 1963 by Salvatore Bellini, and was rediscovered independently in 1974 by Richard Blakemore.

- Blakemore also identified **magnetosomal magnetic particles** for the first time, which were referred to as **"iron-rich particles"**

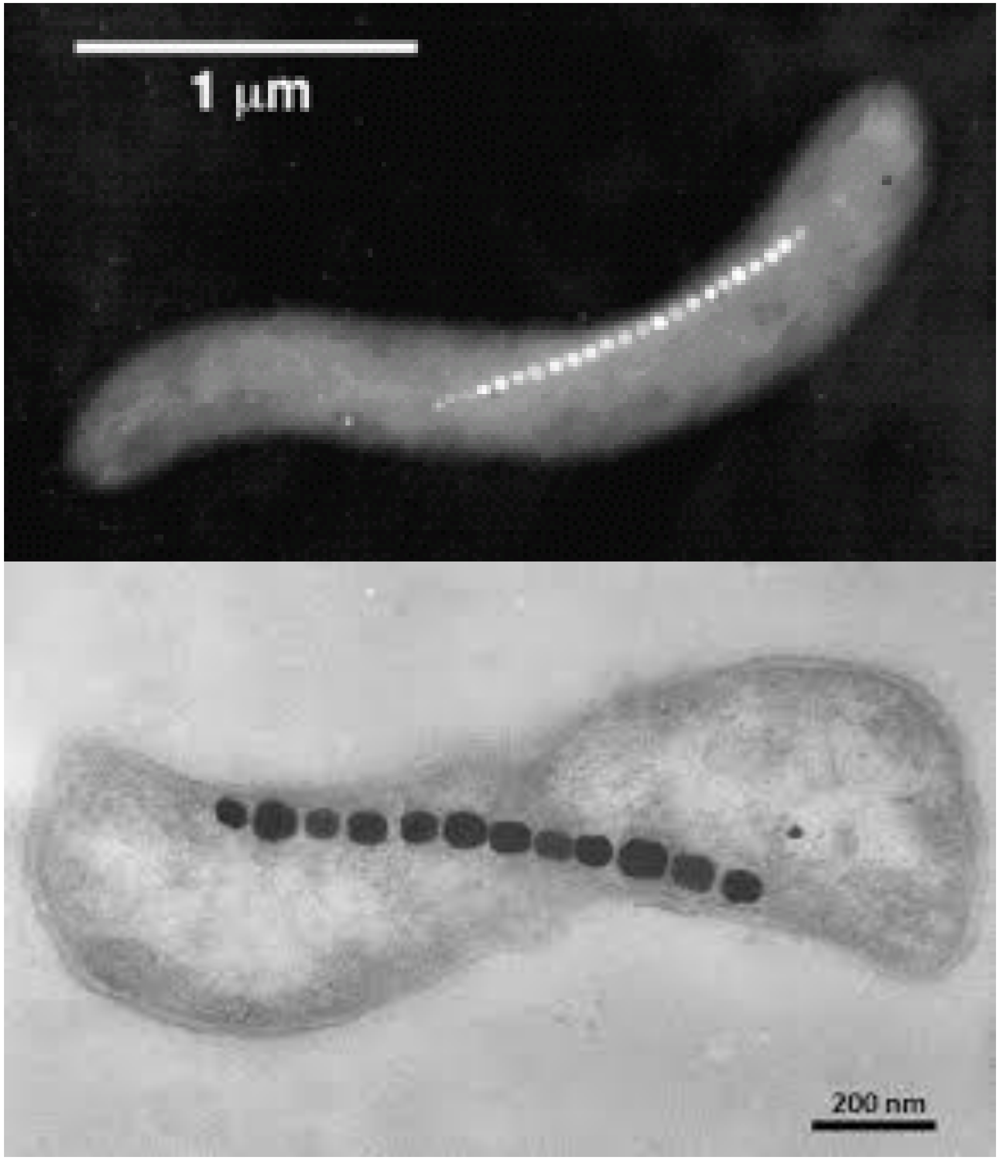
An example is *Magnetobacterium bavaricum*.

- The magnetic particles are **not dispersed at random**.

- They are **enclosed in a sheeth and organized in a straight line**.

- Each individual magnetosome in the chain is approximately **45 nm** across.

- Magnetosomes consist of a **nano-sized crystal of a magnetic iron mineral** that is **enveloped by a lipid bilayer membrane**.



Magnetotactic Bacteria Photo Gallery. www.calpoly.edu/~rfrankel/mtbphoto.html.

Why do these bacteria use a magnet to guide their swimming?

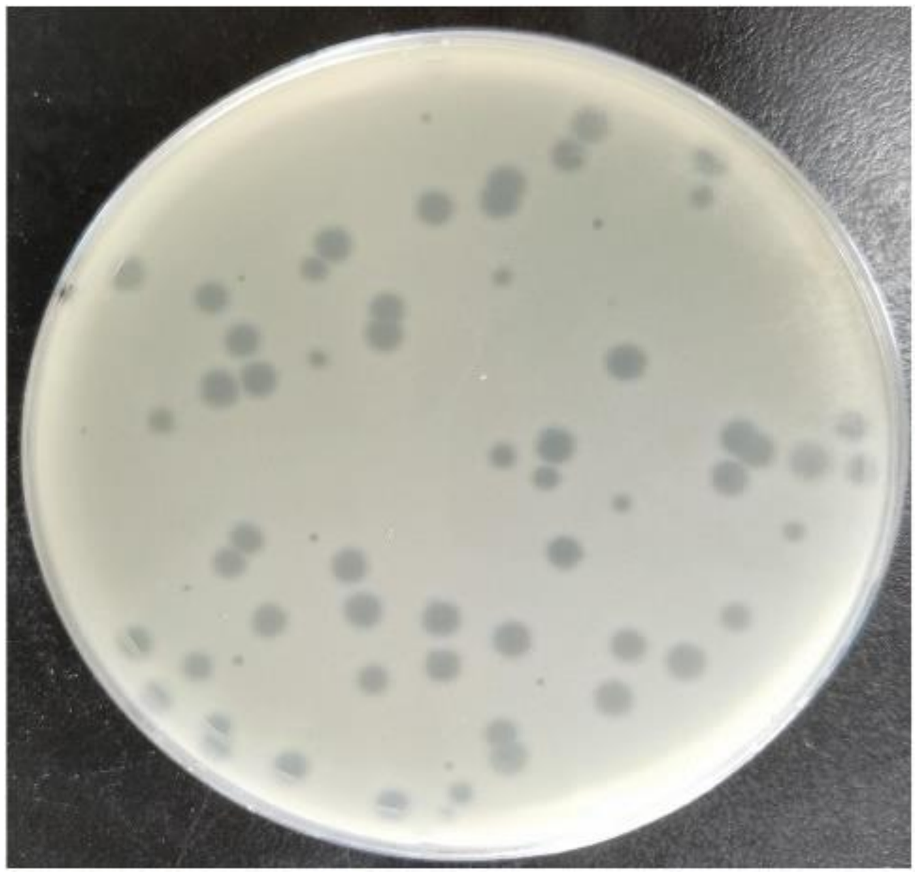
- A common idea, not yet proven, is that these bacteria **benefit from following the earth's magnetic lines of force**. Doing that leads them "down" into the mud, which seems good for their lifestyle.

- Consistent with this, it has been found that **--** for some types of magnetic bacteria -- those in the **northern hemisphere swim north**, whereas those in the **southern hemisphere swim south**.

Bacteria that eat other bacteria

- The most common predatory bacteria are **Bdellovibrio.**
- They **obligatory** lives within other bacterial cells.

- Since they kill the bacteria that they infect, Bdellovibrios form **clear regions on a lawn** of dense bacterial growth, **much like bacterial viruses form plaques.**



- They are cellular, with rather ordinary bacterial cells.
- But their **way of growth is unusual**.
- They **burrow into a bacterial cell**, and grow there.
- There is a suggestion that perhaps **mitochondria originated by a predation event that led to symbiosis in a similar manner**.

E Jurkevitch, Predatory behaviors in bacteria -- diversity and transitions. Microbe 2:67, 2/07.

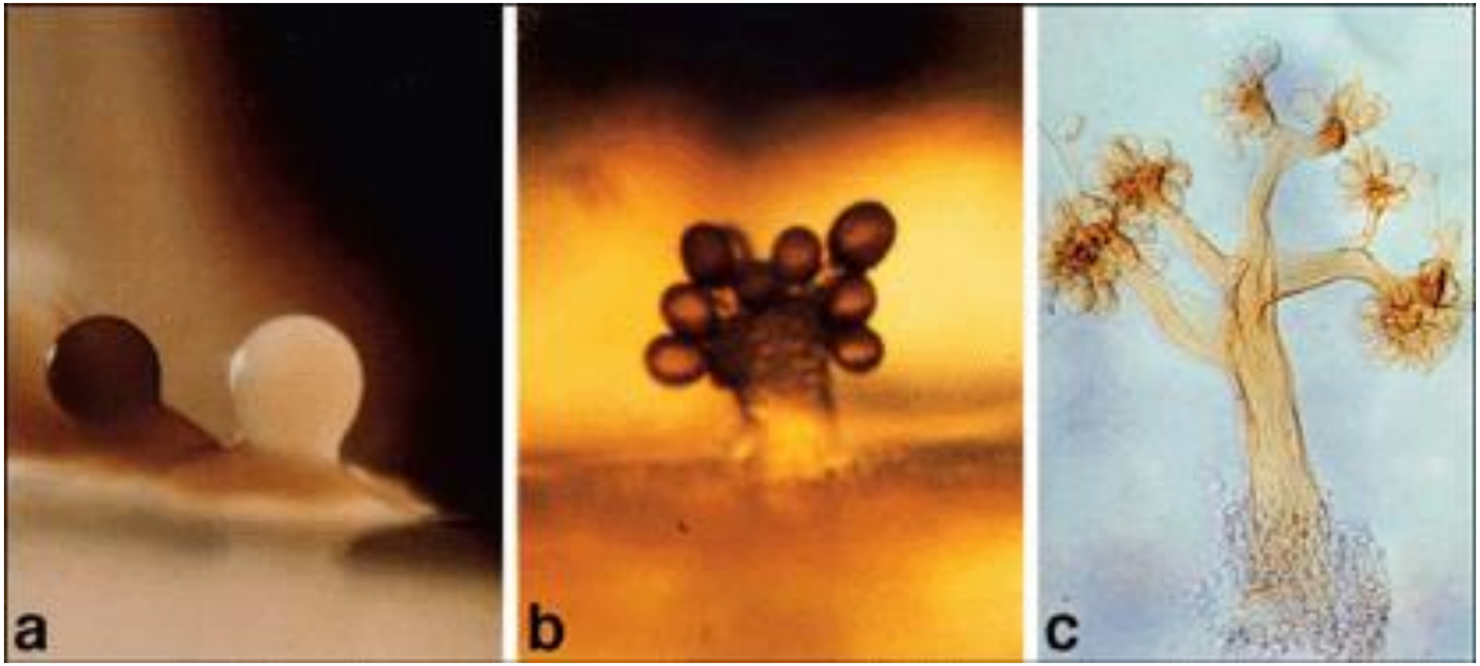
Multicellular bacteria

- We know that bacteria are unicellular and they divide and grow by binary fission.

- But some bacteria are more complex.

- The **myxobacteria** probably have the **most complex** bacterial life cycle.

- They spend **part of their life** as free-living **individual** bacterial cells.
- Then they **aggregate** to form a fruiting body, **an organized multicellular structure visible to the naked eye**.




Thank You!