# King Kong of bacterial kingdom

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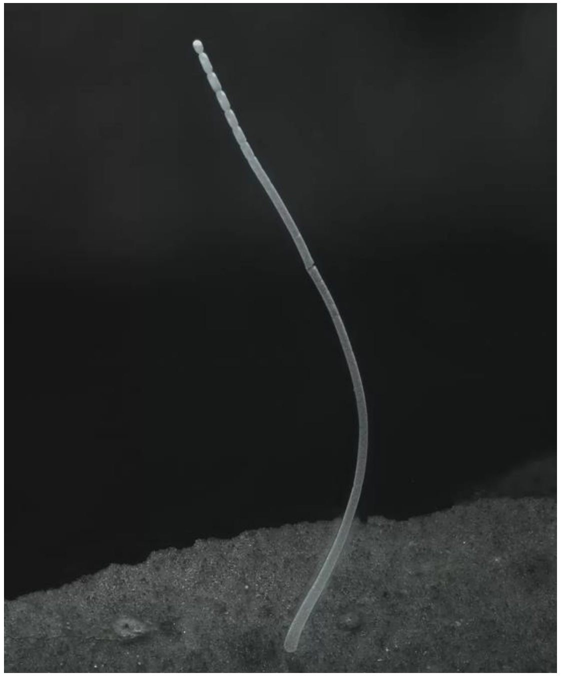
## Introduction

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

- It is the largest bacterium ever discovered.

- 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**.



- One of the discoverers Jean-Marie Volland said:

***"To put it into context, it would be like a human encountering another human as tall as Mount Everest"***

- *Thiomargarita magnifica* is a species of **sulfur-oxidizing gammaproteobacteria**, found growing underwater on the detached leaves of red mangroves from the Guadeloupe archipelago near Domonica, Carribean.

- 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.

- When these researchers first found *Thiomargarita magnifica* in 2009, they **didn’t realize it was a bacterium**.

- Due to its large size, researchers thought it was **possibly a species of eukaryote.**

- Almost after 5 years, they came to the conclusion that **it was actually a bacterium.**

- However, its amazing characteristics were **not evident till recently.**

**However:**

- *Thiomargarita magnifica* are **not the first giant bacteria** to be discovered.

- More than 20 years ago (1999) researchers discovered a giant sulfur-eating microbe roughly the size of a poppy seed near Namibia’s coast and named it ***Thiomargarita namibiensis***.

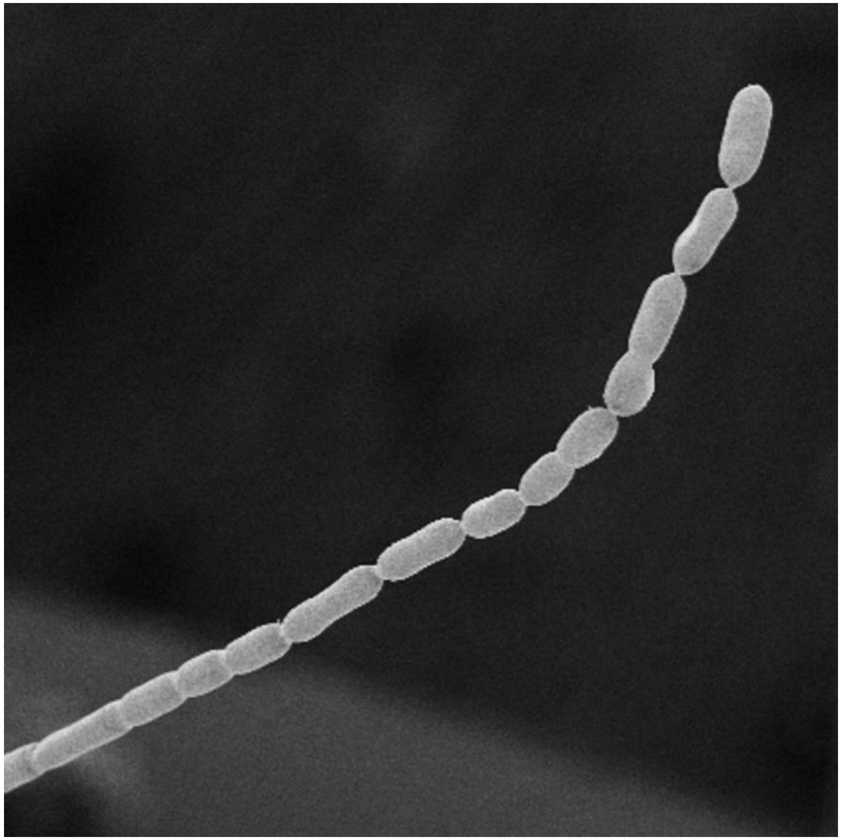
- Scientists have since found other large sulfur-eating bacteria, but their long filaments **consist of multiple cells**.

- All of these giant bacteria **have a huge sac**—presumably of water—that takes up nearly **70% of total volume**.

- That similarity and a genetic analysis led the research team to place this new bacterium in the **same genus as most of the other microbial giants** and proposed the name *Thiomargarita magnifica*.

Pennisi et al. Science. science.org. 24 February 2022.

- Thiomargarita means **"sulfur pearl"** in Latin. This refers to microscopic sulfur granules that scatter incident light, lending the cell a **pearly lustre**.



Ansede et al. El País. 1 March 2022.

## Size

At about 1cm long, *Thiomargarita magnifica* is roughly **50 times** larger than all other known giant bacteria and more than **1000 times larger as compared to *E.coli*.**

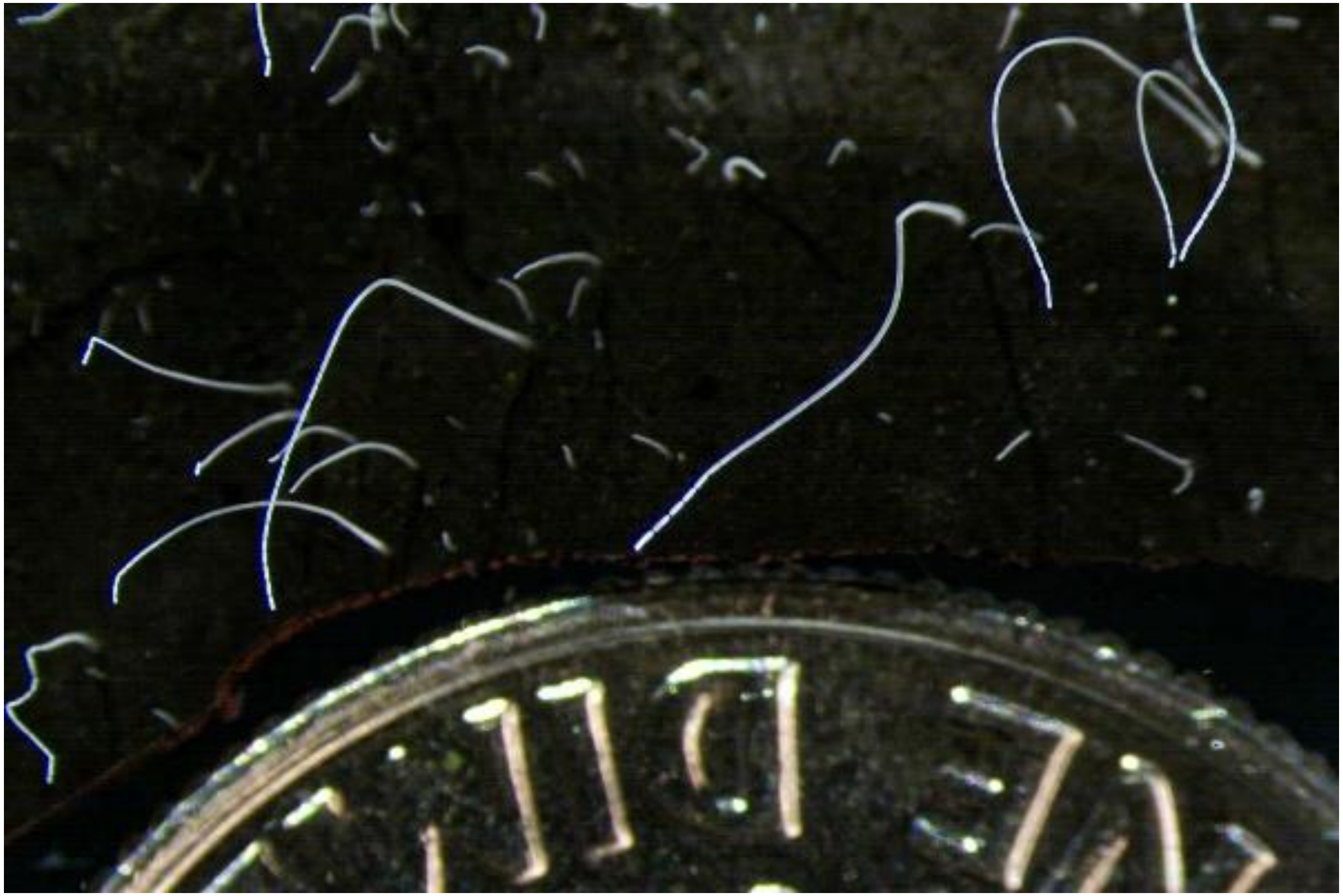
Volland et al., 2022. Science. 376 (6600): 1453–1458.

- This **filament-shaped** bacterium is the largest known bacterium.

- It has an average length of **10 mm.**

- **S**ome individual cells can reach **20 millimetres (0.79 in),** making the bacterium visible to the naked eye.

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



- The scientists at first wondered if these **noodle like filaments** were microscopic cells stuck together into chains.

- But when they peered inside these bacterial noodles with electron microscopes, they realized **each one was its own gigantic cell.**

## Cultivation

- Studies on *Thiomargarita magnifica* have moved slowly because Dr. Vallant and his colleagues have **yet to figure out** how to grow the bacteria in their lab.

- They have to gather a **fresh supply of the bacteria** each time the team wants to run a new experiment.
- They find them not just on **leaves**, but also **oyster shells** and **plastic bottles** sitting on the sulfur-rich sediments in the mangrove forest.
- But the bacteria seem to follow an **unpredictable life cycle**.

## Structure

- *Thiomargarita magnifica* has been found to contain **three times as many genes as most other bacteria.**

- It also has **hundreds of thousands of genome copies (polyploidy)** spread throughout each cell, making it unusually complex.

- Closer inspection also reveal a **strange internal structure**.

- The researchers used various microscopy techniques, such as **hard X-ray tomography**, **confocal laser scanning microscopy** and **transmission electron microscopy** to study the new bacterium.

In most bacteria, the DNA **floats around freely** inside the cell.

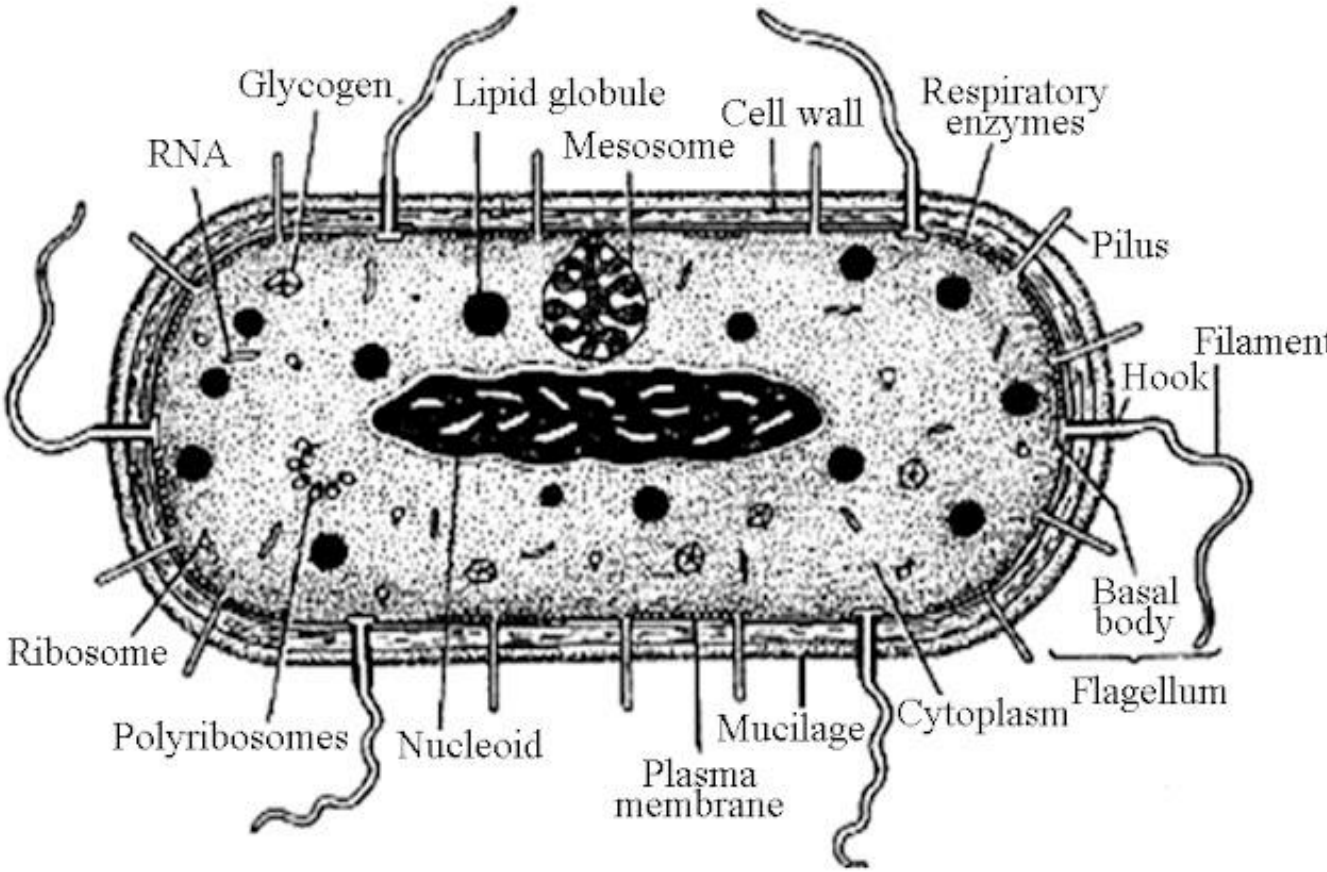
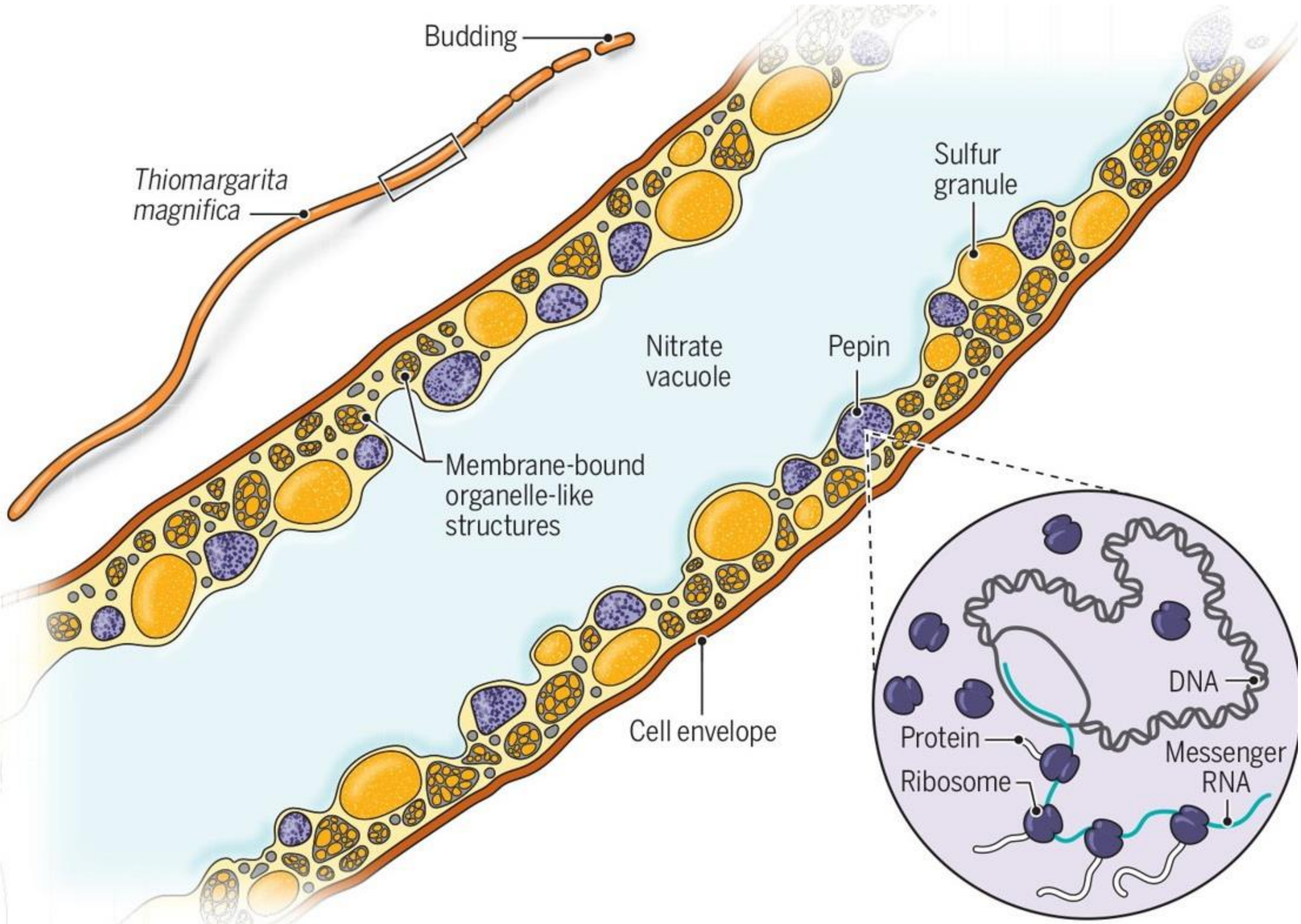



**Fig**: Ultrastructure of bacterial cell.

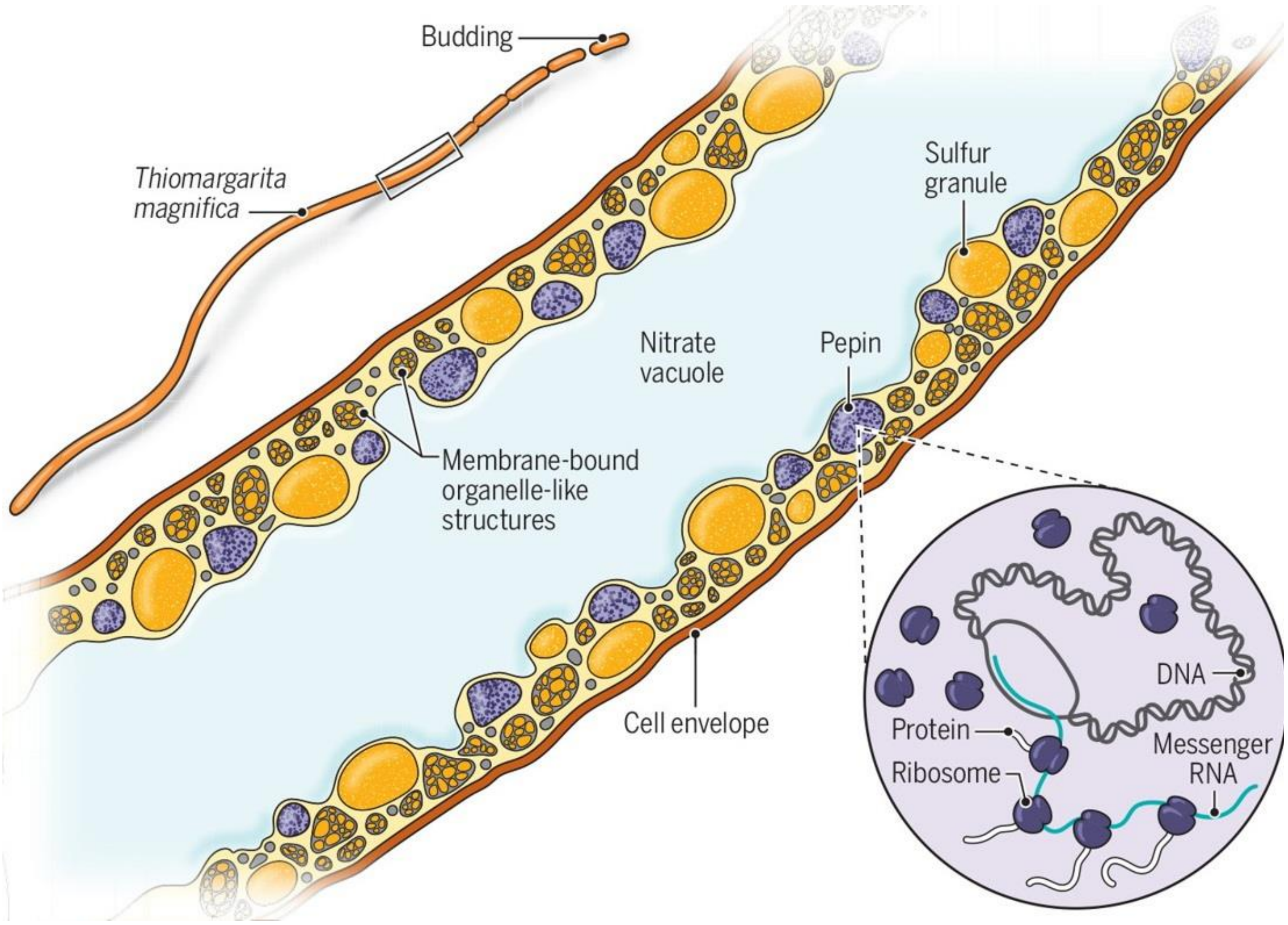
- But *Thiomargarita magnifica* appears to **keep its DNA more organised inside cell membrane-bound compartments** throughout the cell.

- The researchers named these compartments **"pepins"** after the small seeds found in fruits (also called **pips**).

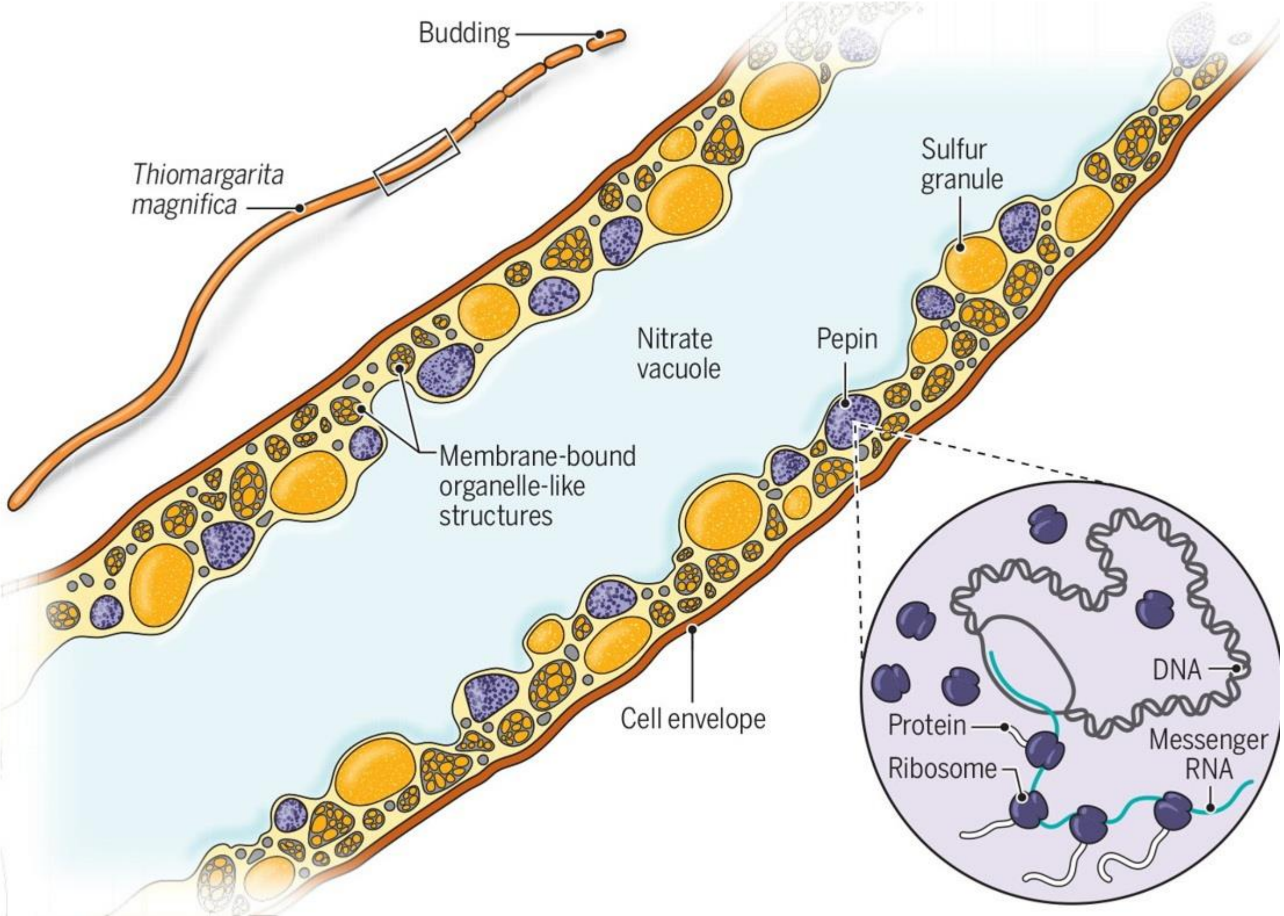


Budding
Thiomargarita magnifica
Sulfur granule
Nitrate vacuole
Pepin
Membrane-bound organelle-like structures
Cell envelope
DNA
Protein
Ribosome
Messenger RNA

- These **pepins look remarkably like human nuclei**.
- Each of the compartments, contains a **loop of DNA**.



- While a typical bacterial cell has **just one loop of DNA**, *Thiomargarita magnifica* has **hundreds of thousands** of them, **each tucked inside its own pepin**.



- When the DNA in these **pepins** was sequenced, it was found that the **genome was huge**.

- There were **11 million bases** harboring some **11,000 clearly distinguishable genes.**

- Typically, bacterial genomes average about **4 million bases** and about **3900 genes**.

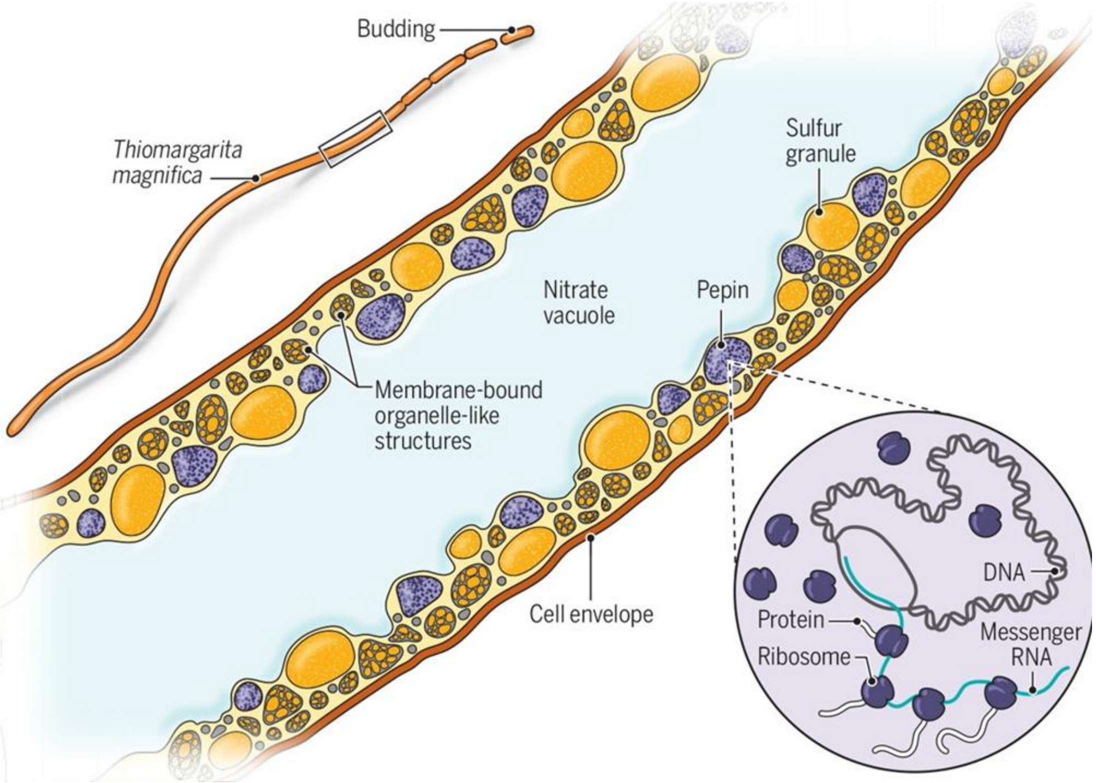
Volland et al., 2022. Science. 376 (6600): 1453–1458.

- The  genome is **so big** because there are **more than 500,000 copies of the same stretches of DNA (polyploidity).**

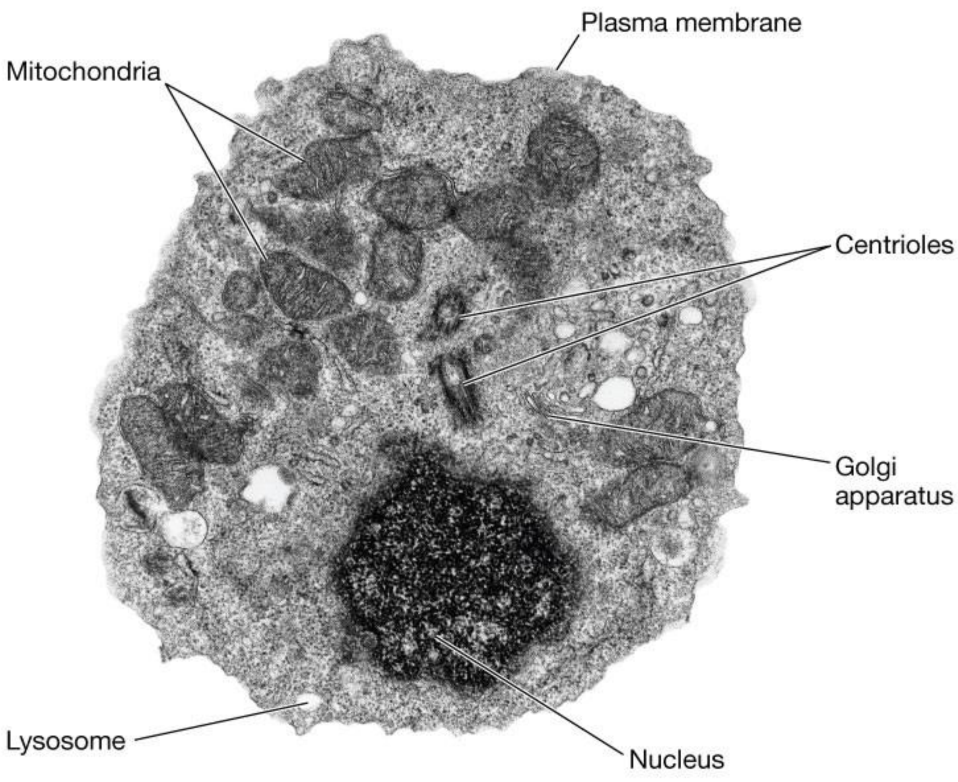
- The size of this bacterium and its **extreme polyploidity** are partially explained by its genome, **which lacks many common bacterial cell division genes.**

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

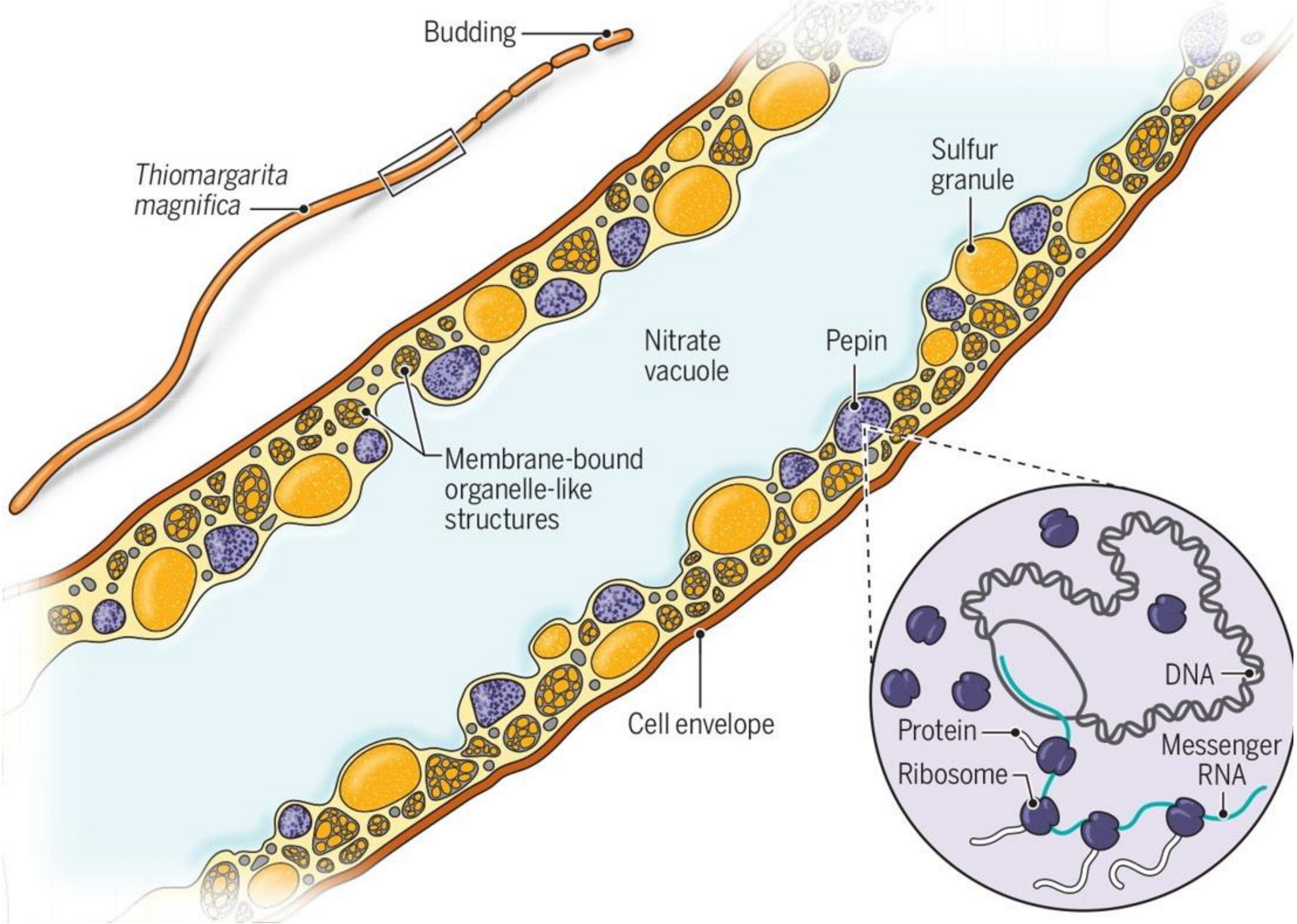
- The **pepins** have their **own ribosomes to build proteins**.
- In other world, **each pepin is a separate identity**.
- Each pepin may make a special set of proteins needed in its **own region of the bacterium**.



- *Thiomargarita magnifica's* **huge supply of DNA** may **let it create the extra proteins it needs to get big.**
- These pepins **blur the boundary between prokaryotes and eukaryotes**, where the DNA is surrounded by the nuclear envelope.



- Their membranes also have **many different other kinds of compartments embedded in them.**



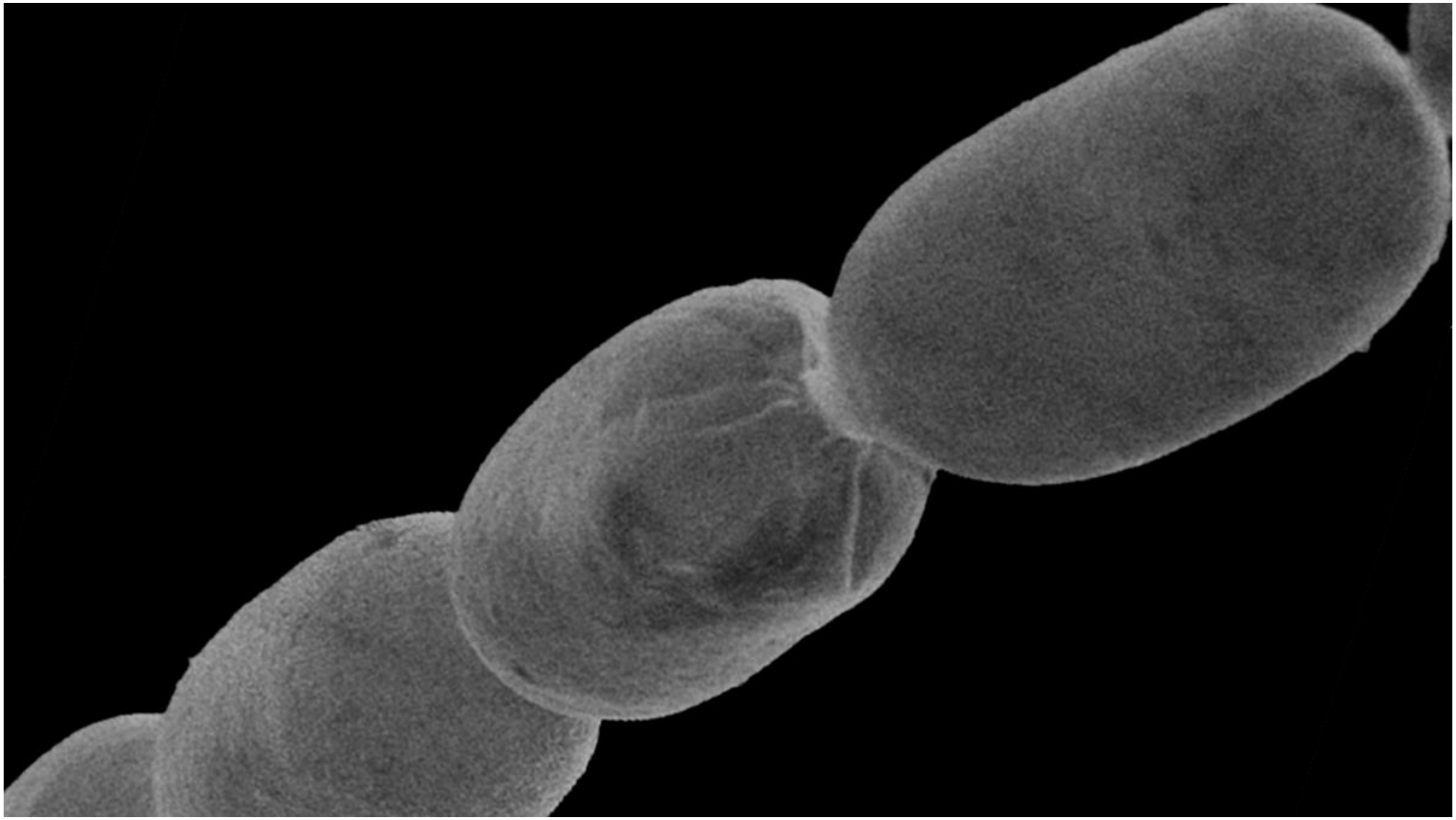
- These compartments are **unlike those in our own cells**, but they may allow *Thiomargarita magnifica* to grow to huge sizes.

- Some of the compartments seem to be **fuel-generating factories**, where the microbe can **tap the energy in nitrates and other chemicals** it consumes in the mangrove.

## Reproduction and life cycle

- Much like all prokaryotes, *Thiomargarita magnifica* **reproduces asexually**.

- However, **contrary to equally splitting its cells (binary fission)** seen in other bacteria, it **reproduces by pinching off its tip into tiny new cells.**



- Each of these cells contains **hundreds of compartments packed with DNA.**

- But **only some of the parent 'pepins' are transferred.**

- So these daughter cells have to prepare many of them **de novo.**

## Metabolism

- In terms of metabolism, it does **chemosynthesis**, which is a process analogous to photosynthesis for plants.

- Metabolism in common bacteria can only occur through the diffusion of molecules **in and out of the bacterium**.

- This **places an upper limit on the size** of bacteria.

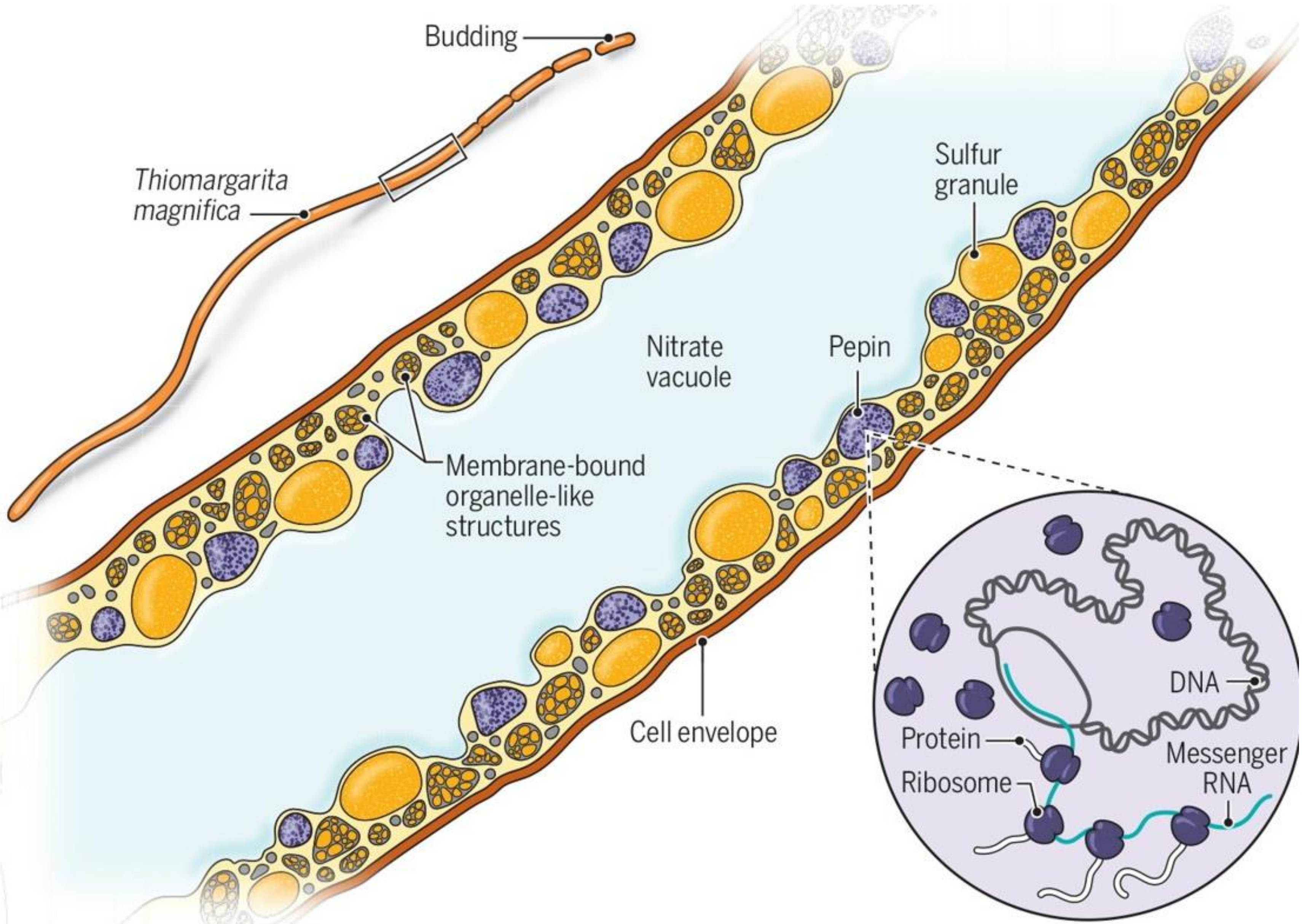
- However, when *T. namibiensis* was discovered in 1999, a **unique feature** was discovered which explained the extraordinary size.
- They have a **large sac filled with water and nitrates**.
- This sac **pushes the cell contents to the cell wall**, so that the diffusion can work.
- The life processes **occur only "along the edge"** of the cell.

- *T. magnifica*'s cell includes a **similar vacuole that occupies most of the cell (65–80% by volume).**

- **It pushes the cytoplasm to the periphery of the cell.**

- The **thickness** of cytoplasm varies from **1.8 to 4.8 microns**.

Pennisi et al. Science. science.org. 24 February 2022.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Thiomargarita magnifica
Membrane-bound organelle-like structures
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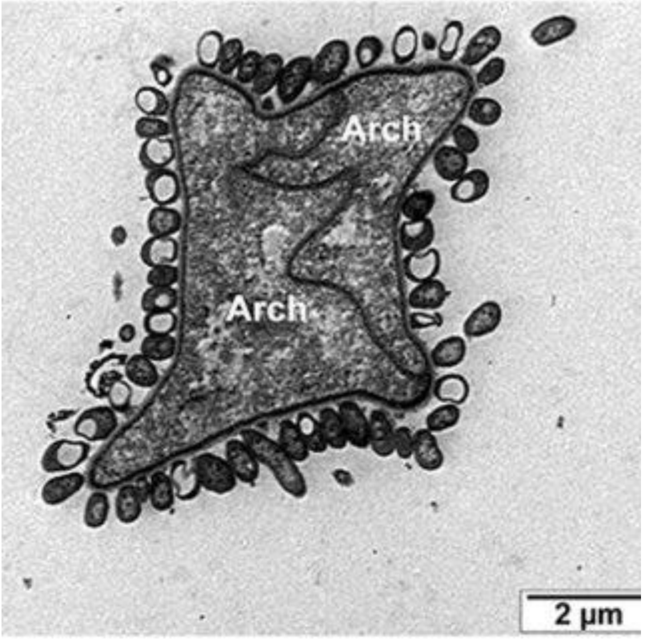
- The outside of the cell **lacks epibiotic bacteria**.




- Their "surprising absence" can be explained by *T. magnifica* possibly producing **biologically active or even antibiotic chemical compounds.**

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

# Evolution

- Before the discovery of these giant bacteria scientists had suggested an **upper possible size limit** for bacteria **about 100 times smaller than *T. magnifica*.**

- With most of the bacterial world yet to be explored, it is entirely possible that **even bigger, even more complex** bacteria are waiting to be discovered.

- Scientists are **not yet sure** how the bacteria evolved to be so big.

- One possibility is that it was done to **evade predation**.

- However, becoming big would have meant **losing some of bacteria's traditional advantages**, including being **uniquely able to move around** and **colonise new niches**.

- Presence of **membrane bound pepins** show that *Thiomargarita magnifica* have evolved a **higher level of complexity.**

- So this bacterium could be a **missing link in the evolution of complex cells from prokaryotes to eukaryotes.**


Thank You!