Archaebacteria

Introduction

- **Archaebacteria** are a type of **single-cell organisms** which are so different from other modern life-forms that they have challenged the way scientists classify life.

- **Traditionally** Archae were **considered as bacteria**.

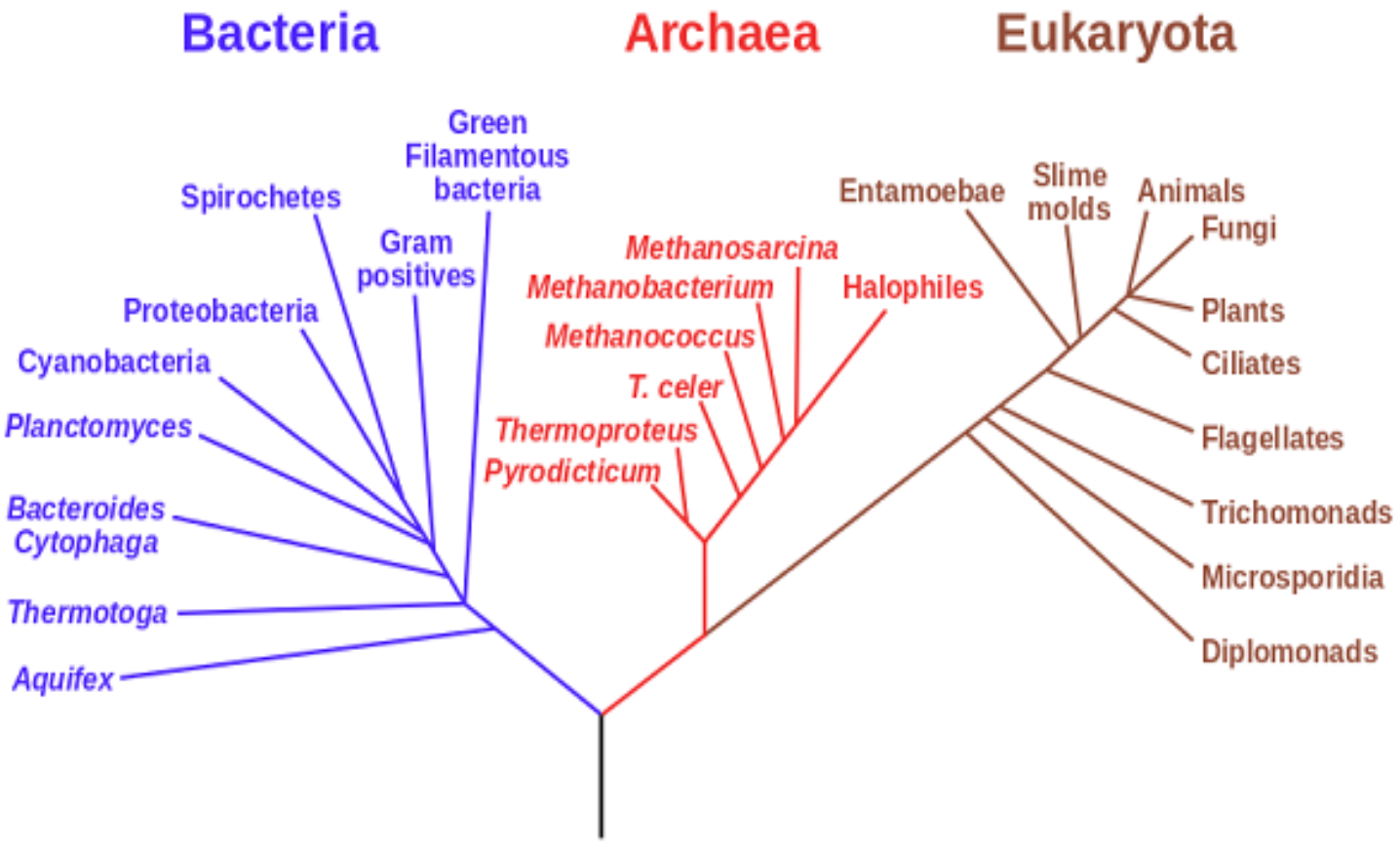
- However, genetic and biochemical studies showed that they were **very different** from “modern” bacteria, and indeed from all other modern life forms.

- In the most modern version of **“phylogenetic tree of life”** – animals, plants, fungi, and protists constitute the domain of **“Eukaryota”.**

- The more common and modern branching of **bacteria** constitutes **“Prokarya”.**

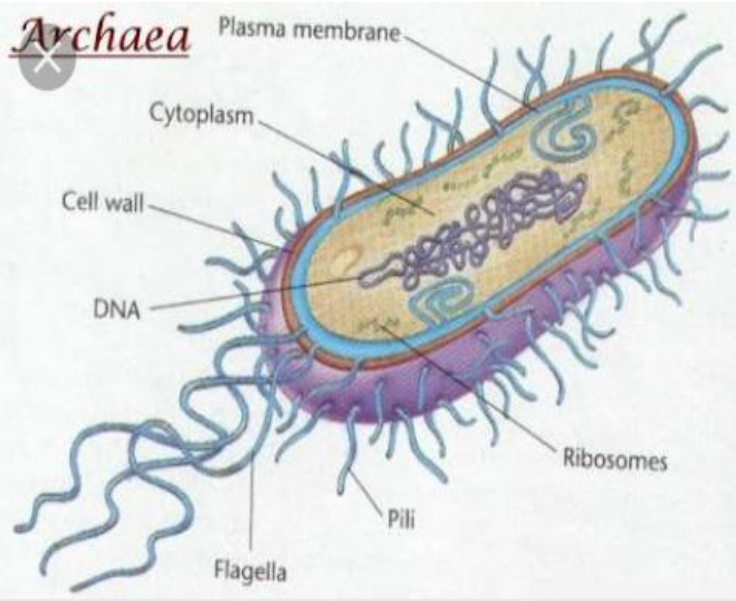
- Archaebacteria constitute their own domain altogether – the domain of **“Archaea.”**

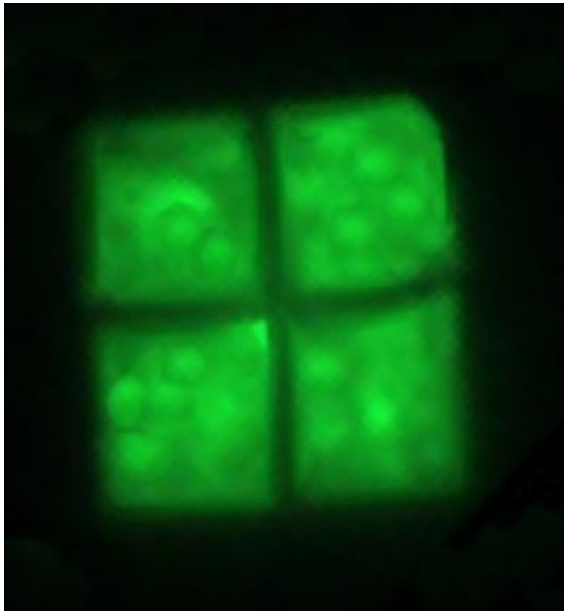
Phylogenetic Tree of Life



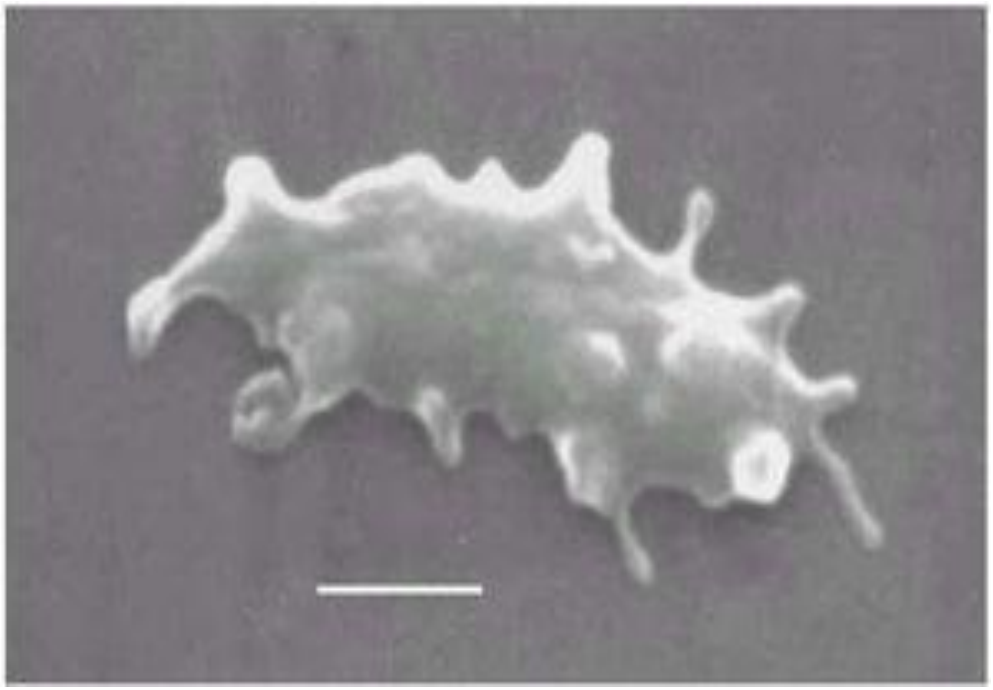
Archaea or **Archaebacteria** differ from true bacteria in their cell wall structure and **lack of peptidoglycan**.

Some of them can occur in unique shapes such as **square or almost flat.**





Some scientists propose that the archaebacteria ***Thermoplasma*** may in fact be **ancestors of the nuclei of our own eukaryotic cells**, which are believed to have developed through the process of **endosymbiosis.**



- Another remarkable trait of archaebacteria is their ability to survive in **extreme environments**, including very salty, very acidic, and very hot surroundings.

- Many Archaebacteria have been recorded surviving temperatures as high as **80°C**, and acidities as high as **0.9 pH**.

- The domain of Archaea include **both aerobic and anaerobic species,** and can be found living in common environments such as soil as well as in extreme environments.

Archaebacteria Characteristics

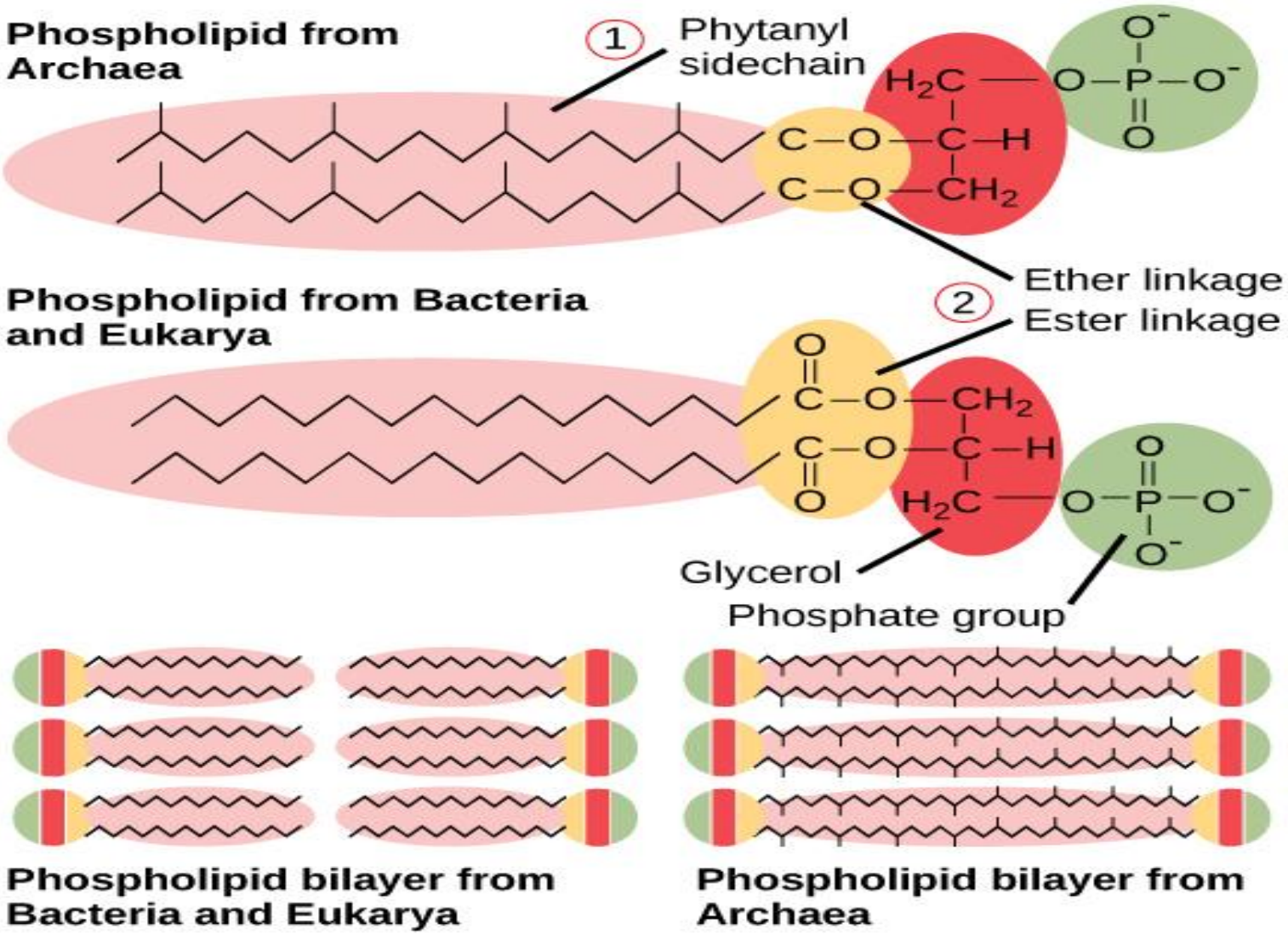
Archaebacteria have a number of characteristics **not seen in more "modern" cell types.**

These include:

1. **Unique cell membrane chemistry:**

a. **Archaebacteria** have cell membranes made of **ether-linked phospholipids,** while **bacteria and eukaryotes** both make their cell membranes out of **ester-linked phospholipids**.

b. Phosphate backbone of lipids is **glycerol-1-phosphate in archaea** but **glycerol-3-phosphate in bacteria.**


Phospholipid from Archaea
1
Phytanyl sidechain
Ether linkage
Phospholipid from Bacteria and Eukarya
2
Ester linkage
Glycerol
Phosphate group
Phospholipid bilayer from Bacteria and Eukarya
Phospholipid bilayer from Archaea

2. Unique cell wall chemistry:

Archaebacteria use a sugar (usually **pseudomurein**) that is **similar to, but not the same as,** the **peptidoglycan** sugar used in bacterial cell walls.

3. Unique protein structure:

In Archeae, first amino acid in protein synthesis is **methionine**. In bacteria, it is **formylmethionine**.

4. Presence of histones:

In **Archeae, histones are present** but in bacteria these proteins are absent.

5. Unique gene transcription:

- Archaebacteria have a **single, round chromosome like bacteria**, but their **gene transcription is similar to that which occurs in the nuclei of eukaryotic cells.**

- This leads to the strange situation that **most genes involving most life functions**, such as production of the cell membrane, are more closely shared by **Eukarya and Bacteria**.

- But **genes involved in the process of gene transcription** are most closely **shared by Eukarya and Archaea**.

- This has led some scientists to propose that eukaryotic cells arose from a **fusion of archaebacteria with bacteria**, possibly when an archaebacteria began living endosymbiotically inside a bacterial cell.

- Other scientists believe that **eukaryotes descended directly from archaebacteria**, based on the findings of archaebacteria species, ***Lokiarcheota***.

- It is thought that ***Lokiarcheota*** may be a **transitional form** between Archaea and Eukaryota.

6. Only archaebacteria are capable of methanogenesis

Methanogenesis is a form of anaerobic respiration that produces **methane**.

Archaebacteria use other forms of cellular respiration as well, but **methane-producing cells are not found in Bacteria or Eukarya.**

7. Differences in ribosomal RNA

It suggests that they **diverged from both Bacteria and Eukarya** at a point in the distant past.

8. Antibiotic resistance:

Archeae are **resistant** to antibiotics. Fortunately they are non-pathogenic.

Trait	Bacteria	Archaea	Eukarya
Carbon linkage of lipids	Ester	*Ether*	Ester
Phosphate backbone of lipids	Glycerol-3-phosphate	*Glycerol-1-phosphate*	Glycerol-3-phosphate
Metabolism	Bacterial	Bacterial-like	Eukaryotic
Nucleus	No	No	Yes
Organelles	No	No	Yes
Spliceosomal introns	No	No	Yes
Telomeres	No	No	Yes
Chromosome shape	Mostly circular	Circular	Linear
DNA replication	Bacterial	Eukaryotic-like	Eukaryotic
Transcription	Bacterial	Eukaryotic-like	Eukaryotic
Translation	Bacterial	Eukaryotic-like	Eukaryotic

	Archaea	Bacteria
Cell type	Prokaryotic	Prokaryotic
Cell wall	No peptidoglycan	Contains peptidoglycan
Membrane lipids	Ether linked	Ester linked
First amino acid in all proteins	Methionine	Formylmethionine
Antibiotic sensitivity	No	Yes
DNA organization	Circular with histones	Circular
Known for	Extreme environments, none infect humans	Both helpful and harmful relationships with humans

Types of Archaebacteria

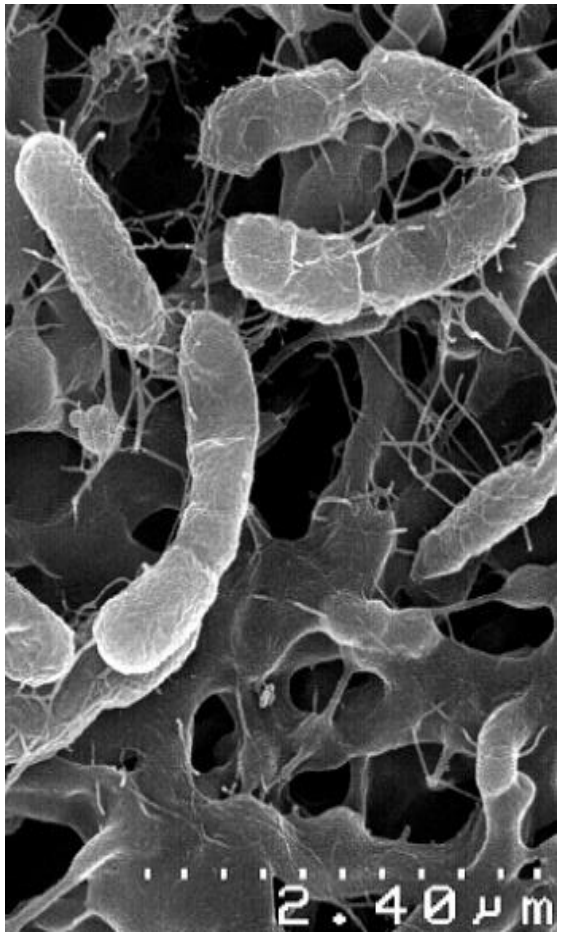
There are **three** main types of archaebacteria.

These are classified based on their **phylogenetic relationship** and members of each type tend to have certain characteristics.

* Phylogenetic relationships are the relationships that show how far back two species shared a common ancestor.

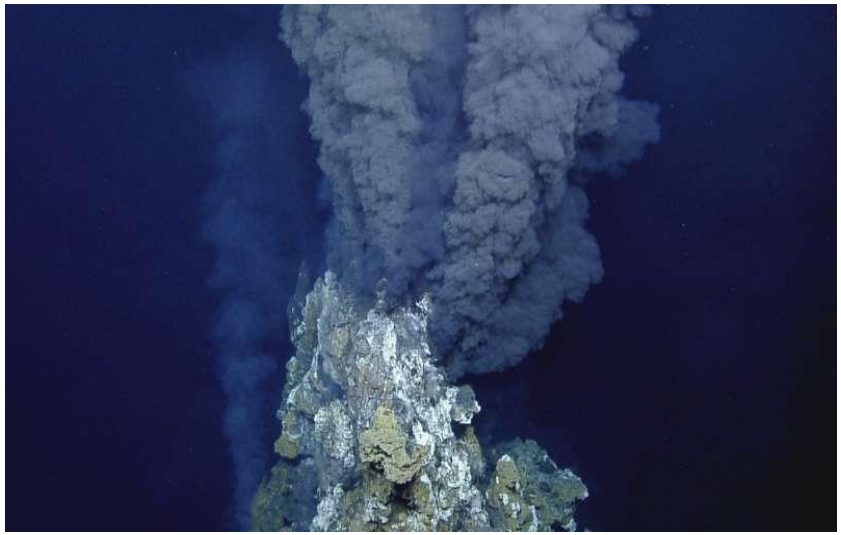
1. Crenarchaeota

- Crenarchaeota are **extremely heat-tolerant.**
- They have **special proteins** and other biochemistry that can continue to **function at temperatures as high as 110°C!**
- Many Chrenarchaeota can also survive in **very acidic environments.**



- Many species of Crenarchaeota have been discovered living in **hot springs and around deep sea vents**, where water has been **superheated** by magma beneath the Earth's surface.

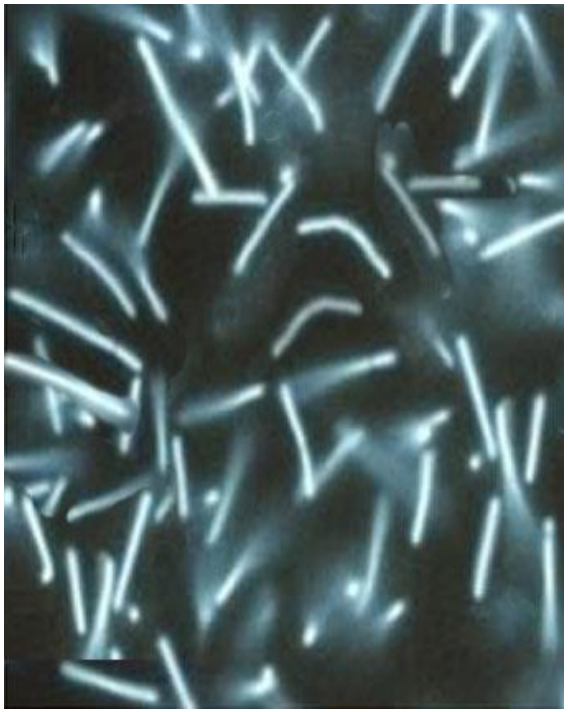
- One theory of the origin of life suggests that **life may have originally started around deep sea vents**, where high temperatures and unusual chemistries could have led to the formation of the first cells.



2. **Euryarchaeota**

- They are able to survive in **very salty habitats.**

- They are also able to produce **methane**, which no other life form on Earth is able to do!



- Euryarchaeota are the only form of life known to be able to perform **cellular respiration using carbon as their electron acceptor.**

- This gives them an important ecological niche because the breakdown of complex carbon compounds into the simple molecule of methane is the final step in the **decomposition of most life forms.**

- Without methanogens, the **Earth's carbon cycle** would not be complete.

- Wherever **methane gas** is produced by living organisms, Euryarchaeota are responsible.

- Methanogen archaebacteria can be found in **marshes and wetlands**, where they are responsible for “swamp gas” and part of the marsh’s **distinctive smell**.

- They are also found in the **stomachs of ruminants** such as cows, where they break down sugars found in grass that are undigestible to eukaryotes by themselves.

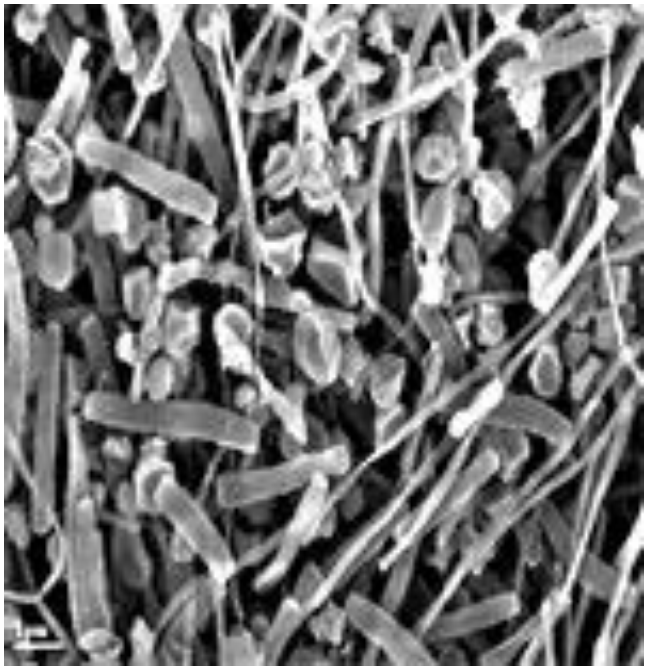
- Some methanogens live in the **human gut** and assist us in the same way.

- They can also be found in **deep sea sediments**, where they produce pockets of methane beneath the ocean floor.

3. **Korarchaeota**

- These are the l**east-understood**, and thought to be the **oldest** lineage of archaebacteria.

- This makes them possibly the **oldest surviving organisms** on Earth!



- Korarchaeota can be found in **hydrothermal environments** much like Crenarchaeota.

- However, Korarchaeota have many genes found in **both** Crenarchaeota and Euryarcheaota, and also genes which are **different** from both groups.

- To scientists, this suggests that both other types of archaebacteria may have **descended from a common ancestor similar to Korarchaeota.**

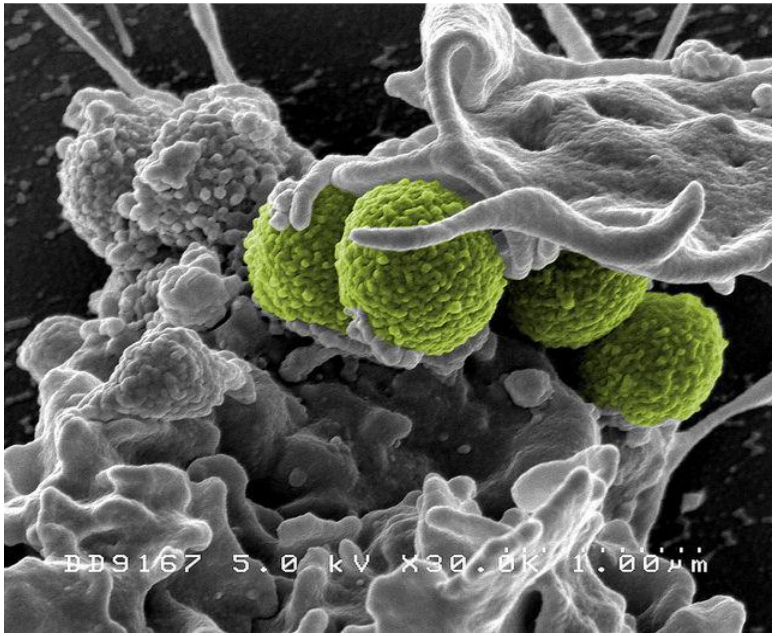
- Korarchaeota are **rare in nature**, perhaps because other, newer forms of life are better adapted to survive in modern environments than they are.

- Still, Korearchaeota can be found in **hot springs**, and around deep sea vents.

Examples of Archaebacteria

Lokiarcheota

Lokiarcheota is a **hyperthermophile** discovered at the deep sea vent called **Loki's Castle**, which some scientists think has unique evolutionary significance.



- It has a **highly unique genome**, consisting of roughly **26% proteins** that are known to be found in **other archaebacteria**.

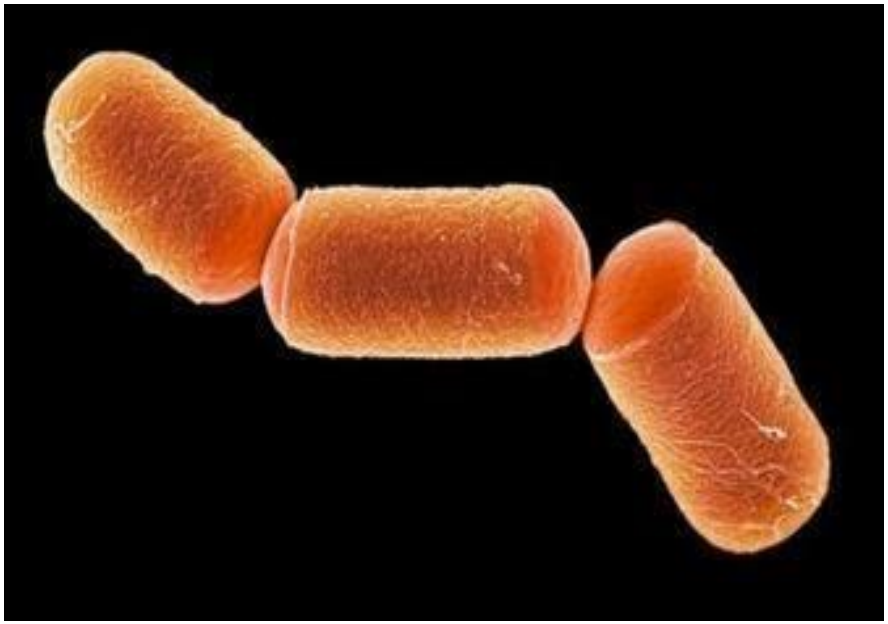
- They have **29% proteins** that are known to be **found in bacteria**, **32%** genes that **do not correspond to any known protein**, and – **3.3% genes** that correspond to those **only found in eukaryotes**.

- Scientists think that *Lokiarchaeota* and humans probably shared a common ancestor around 2 billion years ago.

Methanobrevibacter smithii

- *Methanobrevibacter smithii* is a **methane-producing** archaebacteria that lives in the **human gut.**

- This member of *Euryarchaeota* helps us to **break down complex plant sugars** and extract extra energy from the food we eat.



- The microorganisms in our guts – including members of *Euryarchaeota* – also have a **complex relationship** with our health.

- Some studies show that many people with **obesity and colon cancer** have above-average levels of *Euryarchaeota* in their guts.

- But *Euryarchaeota* also help people who don't have enough food to produce **more energy**, and some types of these archaebacteria appear to protect against colon cancer.


Thank You!