



## **An introduction to Bacterial, Archaea and Eukaryotes detected in soils on the Falkland Islands using 16S rRNA gene and 18S rRNA gene sequencing**

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*Microbiology is an active and evolving research field, and therefore these descriptions are prepared to best of the current understanding. It can however not be excluded that the knowledge will change over time.*

### **Archaea**

Domain of life that was discovered in 1977 through sequence analysis of ribosomal DNA. They are single-celled organisms that lack organelles and a nucleus that would separate the DNA from the rest of the cell content. The DNA is a single string of nucleotides. They can be found in all environments on Earth but are particularly common in extreme environments. All Archaea have 16S rRNA gene in their DNA, which encodes the small subunit of the ribosomal RNA needed during DNA duplication (Slonczewski & Foster 2020, Woese & Fox 1977). There are several major phyla including **Crenarchaeota**, **Euryarchaeota**, and **Thaumarchaeota**. Some archaea groups are important for the nitrogen cycling in aquatic and terrestrial environments. **Thaumarchaeota** are able to oxidize ammonia to nitrite, and Crenarchaeota are able to perform nitrification, which is the conversion of ammonia to nitrite and/or nitrate). More information on the classification and physiology of Archaea can be found in the *Bergey's Manual of Systematics of Archaea and Bacteria*.

### **Bacteria**

Bacteria are single-celled or filamentous organisms that lack organelles and have no nucleus. The DNA is a single string of nucleotides. All bacteria have 16S rRNA gene in their DNA, which encodes the small subunit of the ribosomal RNA needed during DNA duplication (Slonczewski & Foster 2020). More information on the classification and physiology of Archaea can be found in the *Bergey's Manual of Systematics of Archaea and Bacteria*.

### **Acidobacteria**

They can be found in many environments. Acidobacteria are often acidophilic, which is the ability to grow well under high acidic environments (low pH). Many acidobacteria, that have been isolated in culture to date, have a heterotrophic aerobic physiology, which means that they gain their energy from sugars that they obtain from the environments.

### **Actinobacteria**

They are very common in soils but can also be found in other environments. They have heterotrophic aerobic physiology and in soils they are thought to be important for decomposition and humus formation.

### **Bacteroidetes**

They have rod-shaped cells and are heterotrophic with aerobic and anaerobic species. They very common in the environment as well as the human and animal gut.

### **Candidate Divisions FCPU426, GAL15 and WPS-2 and Candidate Phyla Patescibacteria and Rokubacteria**

New bacteria are discovered all the time. Some species are first discovered by DNA sequencing and it can take many years or might never be possible to obtain to isolate these species and grow them as strains in the laboratory. These distinct but uncultured groups of bacteria are called candidate divisions or candidate phyla because there is insufficient information available to carry out a taxonomic classification of these new bacteria groups to give them a species name (Becraft et al. 2019; Herrmann et al. 2019; Hugenholtz et al. 2011).

### **Chlamydia**

They are a diverse group of bacteria that are mostly known to be pathogens to humans and animals, including sheep, as well as symbionts of protists.

### **Chloroflexi**

They are anoxygenic photosynthetic organisms and use bacteriochlorophylls are use for light-harvesting, but they do not produce oxygen. They use reduced sulfur compounds e.g. hydrogen sulfide as electron donor to do photosynthesis. They can be aerobic and anaerobic. They can be thermophiles and therefore grow well at high temperatures as found in geothermal springs.

### **Cyanobacteria**

They are oxygenic photosynthetic organisms and produce oxygen. Their name origins from the greek word for blue, which is "Cyano". They have a pigment that is called phycocyanin, which is blue and helps to grow at low light conditions. Photosynthesis is carried out in the thylakoids that are in each cell, where carbon dioxide is converted into oxygen and sugars for energy. They can be found in many environments and particular good in growing in extreme environments with low nutrients, little water and can be important for the formation of biofilms. Cyanobacteria were the first organisms to do photosynthesis on Earth and evolved approximately 2.5 billion years ago.

### **Firmicutes**

They tend to have around or rod-shaped cells and can be found in many environments ranging from soils to human gut. They also have several different types of physiology ranging from heterotrophy to photosynthesis. Some species grow in the presence and some only in the absence of oxygen.

### **Gemmatimonadetes and Verrucomicrobia**

They are common in soils but only few strains have been isolated in the lab to date. Therefore, our knowledge on their morphology and physiology is limited (DeBruyn et al. 2011, Bergmann et al. 2011)

### **Nitrospirae**

They are important for the nitrogen cycle because they do nitrification, which is the production of nitrate through the oxidation of nitrite or ammonia. They are widespread in water and soil. There are anaerobic and aerobic species.

### **Proteobacteria**

The species in this phyla can be aerobic, anaerobic, heterotrophic and phototrophic species. They are abundant in freshwater, marine and soil environments. There are some groups including Rhizobiales that are able to colonise root nodes where they can perform the fixation of dinitrogen to bioavailable ammonia.

### **Planctomycetes**

They are often found in water ranging from sea, brackish to freshwater environments but can also be detected in terrestrial environments. They have aerobic and anaerobic species. Some species are important for the nitrogen cycle because they can convert nitrite and ammonium to dinitrogen.

### **Spirochaetes**

They got their name from their spiral shape. They can be found in many environments. They often have chemoheterotrophic physiology which means that they use inorganic electron sources for energy production to grow.

### **Eukaryotes**

Eukaryotes have a nucleus that contains the DNA and the DNA is organized into chromosomes. The process of nuclear division in eukaryotes is called mitosis. The cells have organelles within which specific cellular functions occur. All animals and plants are eukaryotes, but there are also microbial eukaryotes including ciliate, algae, amoeba and fungi. All eukaryotes have mitochondria and photosynthetic eukaryotes also have a chloroplast which contains chlorophyll. All eukaryotes have 18S rRNA gene in their DNA, which encodes the small subunit of their ribosomal RNA needed during DNA duplication (Slonczewski & Foster 2020).

**Fungi** are eukaryotes that have a heterotrophic physiology which entails gaining their energy from organic matter generated by other organisms. Fungi cannot do photosynthesis. There are macrofungi that are known for forming large macroscopic fruiting structures and there are microfungi that are nearly invisible to the naked eye. Fungi include symbionts of plants, animals, or other fungi and also parasites. Fungi are important for the decomposition of organic matter such as leaf litter. One of those groups of fungi are **Archaeorhizomycetaceae**, but there are many additional groups of fungi that decompose organic matter in soils. Some fungi form symbiotic relationships with plants roots, where the fungi help the plant to access nutrients from the soil environments. One of the groups of fungi that is able to interact with plant roots are **Glomeraceae fungi**. There are also fungi that are pathogens of animals,

plants and even humans, and pathogenic fungi can be found in the fungi group called **Olpidiaceae** (Deacon 2013; Dighton J, White JK 2017, Rosling et al. 2011).

## References

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