## Archea or archaebacteria

- They are single celled microorganisms. They are prokaryotes, ie., they have no cell nucleus.
- Archaea and bacteria are generally similar in size and shape
- Despite this morphological similarity to bacteria, archaea possess genes and several metabolic pathways that are more closely related to those of eukaryotes, notably the enzymes involved in transcription and translation.
- Archaebacteria differ from true bacteria in their cell wall structure and lack peptidoglycans.

- They are inhabited mostly in extreme environments.
- Based on their habitat, all Archaeans can be divided into the following groups: methanogens (methane-producing organisms), halophiles (archaeans that live in salty environments), thermophiles (archaeans that live at extremely hot temperatures), and psychrophiles (cold-temperature Archaeans).
- Archaeans use different energy sources like hydrogen gas, carbon dioxide, and sulphur.
- Some of them use sunlight to make energy, but not the same way as plants do.
- They absorb sunlight using their membrane pigment, bacteriorhodopsin. This reacts with light, leading to the formation of the energy molecule adenosine triphosphate (ATP).

- Asexual reproduction and horizontal gene transfer

Nutritional types in archaeal metabolism

| Nutritional type | Source of energy | Source of carbon | Examples |
|---|---|---|---|
| Phototrophs | Sunlight | Organic compounds | *Halobacterium* |
| Lithotrophs | Inorganic compounds | Organic compounds or carbon fixation | *Ferroglobus*, *Methanobacteria* or *Pyrolobus* |
| Organotrophs | Organic compounds | Organic compounds or carbon fixation | *Pyrococcus*, *Sulfolobus* or *Methanosarcinales* |

## Habitat

Archaea exist in a broad range of habitats as found in geysers, black smokers, and oil wells; very cold habitats and highly saline, acidic, or alkaline water, but archaea also include mesophiles that grow in mild conditions, in swamps and marshland, sewage, the oceans, the intestinal tract of animals, and soils

## Applications

- Archaea recycle elements such as carbon, nitrogen and sulfur through their various habitats.
- Mutualism and commensalism.

- Extremophile archaea, particularly those resistant either to heat or to extremes of acidity and alkalinity, are a source of enzymes that function under these harsh conditions
- For example, thermostable DNA polymerases, such as the Pfu DNA polymerase from *Pyrococcus furiosus*, revolutionized molecular biology by allowing the polymerase chain reaction to be used in research as a simple and rapid technique for cloning DNA.
- In industry, amylases, galactosidases and pullulanases in other species of *Pyrococcus* that function at over 100 °C (212 °F) allow food processing at high temperatures, such as the production of low lactose milk and whey.

- Enzymes from these thermophilic archaea also tend to be very stable in organic solvents, allowing their use in environment friendly processes in green chemistry that synthesize organic compounds.
- This stability makes them easier to use in structural biology. Consequently, the counterparts of bacterial or eukaryotic enzymes from extremophile archaea are often used in structural studies.

**Eubacteria:**

- Bacteria are a type of biological cell.
- They constitute a large domain of prokaryotic microorganisms.
- Typically a few micrometres in length, bacteria have a number of shapes, ranging from spheres to rods and spirals.
- Bacteria were among the first life forms to appear on Earth, and are present in most of its habitats.
- Bacteria inhabit soil, water, acidic hot springs, radioactive waste, and the deep portions of Earth's crust. Bacteria also live in symbiotic and parasitic relationships with plants and animals.

| Nutritional type | Source of energy | Source of carbon | Examples |
|---|---|---|---|
| Phototrophs | Sunlight | Organic compounds (photoheterotrophs) or carbon fixation (photoautotrophs) | Cyanobacteria, Green sulfur bacteria, Chloroflexi, or Purple bacteria |
| Lithotrophs | Inorganic compounds | Organic compounds (lithoheterotrophs) or carbon fixation (lithoautotrophs) | Thermodesulfobacteria, *Hydrogenophilaceae*, or Nitrospirae |
| Organotrophs | Organic compounds | Organic compounds (chemoheterotrophs) or carbon fixation (chemoautotrophs) | *Bacillus*, *Clostridium* or *Enterobacteriaceae* |

**Applications:**

- Bacteria, often lactic acid bacteria, such as *Lactobacillus* and *Lactococcus*, in combination with yeasts and moulds, have been used for thousands of years in the preparation of fermented foods, such as cheese, pickles, soy sauce, vinegar, wine and yogurt
- The ability of bacteria to degrade a variety of organic compounds is remarkable and has been used in waste processing and bioremediation. Bacteria capable of digesting the hydrocarbons in petroleum are often used to clean up oil spills.
- Bacteria are also used for the bioremediation of industrial toxic wastes.
- In the chemical industry, bacteria are most important in the production of enantiomerically pure chemicals for use as pharmaceuticals or agrichemicals.

- Bacteria can also be used in the place of pesticides in the biological pest control. This commonly involves *Bacillus thuringiensis* (also called BT), a gram-positive, soil dwelling bacterium. Subspecies of this bacteria are used as a Lepidopteran-specific insecticides under trade names such as Dipel and Thuricide. Because of their specificity, these pesticides are regarded as environment friendly, with little or no effect on humans, wildlife, pollinators and most other beneficial insects.

- Because of their ability to quickly grow and the relative ease with which they can be manipulated, bacteria are the workhorses for the fields of **molecular biology, genetics and biochemistry.** By making mutations in bacterial DNA and examining the resulting phenotypes, scientists can determine the function of genes, enzymes and metabolic pathways in bacteria, then apply this knowledge to more complex organisms. This aim of understanding the biochemistry of a cell reaches its most complex expression in the synthesis of huge amounts of enzyme kinetic and gene expression data into mathematical models of entire organisms.

**Cyanobacteria / Blue Green Algae**

- They are a phylum of bacteria that obtain their energy through photosynthesis, and are the only photosynthetic prokaryotes able to produce oxygen.
- The name "cyanobacteria" comes from the color of the bacteria.
- Cyanobacteria have internal membranes which are flattened sacs called thylakoids where photosynthesis is performed.
- Cyanobacteria can be found in almost every terrestrial and aquatic habitat—oceans, fresh water, damp soil, temporarily moistened rocks in deserts, bare rock and soil, and even **Antarctic** rocks. They can occur as **planktonic** cells or form **phototrophic** biofilms. They are found in almost every **endolithic** ecosystem.

**Applications:**

- The unicellular cyanobacterium *Synechocystis* sp. PCC6803 was the third prokaryote and first photosynthetic organism whose genome was completely sequenced. It continues to be an important model organism.
- *Cyanothece* ATCC 51142 is an important diazotrophic (nitogen fixing) model organism.
- Recent research has suggested the potential application of cyanobacteria to the generation of renewable energy by converting sunlight into electricity. Internal photosynthetic pathways can be coupled to chemical mediators that transfer electrons to external electrodes. Currently, efforts are underway to commercialize algae-based fuels such as diesel, gasoline, and jet fuel.
- Spirulina's extracted blue color is used as a natural food coloring in gum and candy.

**Health risks:**

- Cyanobacteria can produce neurotoxins, cytotoxins, endotoxins, and hepatotoxins (e.g., the microcystin-producing bacteria genus microcystis), which are collectively known as cyanotoxins.
- Specific toxins include, anatoxin-a, anatoxin-as, aplysiatoxin, cyanopeptolin, cylindrospermopsin, domoic acid, nodularin R (from *Nodularia*), neosaxitoxin, and saxitoxin. Cyanobacteria reproduce explosively under certain conditions.

**Actinomycetes**

- They are gram positive and anaerobic bacteria and have mycelium in a filamentous and branching growth pattern. They resemble fungi.
- Some actinobacteria can form rod- or coccoid-shaped forms, while others can form spores on aerial hyphae.
- Actinomycetes bacteria can be infected by bacteriophages, which are called actinophages.
- Actinomycetes can range from harmless bacteria to pathogens with resistance to antibiotics
- They may possess a highly niche-dependent phenotype. Eg *Nocardia* contains several phenotypes first believed to be distinct species before their differences were shown to be entirely dependent on their growth conditions

**Habitat and applications**

- Actinomycetes can be found mostly in soil and decaying organic matter, as well as in living organisms such as humans and animals.
- They form symbiotic nitrogen fixing associations with over 200 species of plants, and can also serve as growth promoting or biocontrol agents, or cause disease in some species of plants.
- Actinomycetes can be found in the human urogenital tract as well as in the digestive system including the mouth, throat, and gastrointestinal tract in the form of Helicobacter without causing disease in the host.

- They also have wide medicinal and botanical applications, and are used as a source of many antibiotics and pesticides.
- Many species of Actinomycetes produce antimicrobial compounds under certain conditions and growth media.
- Streptomycin, actinomycin, and streptothricin are all medically important antibiotics isolated from Actinomycetes bacteria. Almost two-thirds of the natural antimicrobial drug compounds used currently are produced by different species of Actinomycetes.

**Eumycota / True Fungi :**

- The members of the division Eumycota are called true fungi.
- The thalli of Eumycota usually do not posses Plasmodia or pseudoplasmodia.
- Members are unicellular or filamentous with definite cell wall.
- Spores of many fungi act as common contaminants of our food. They cause diseases of both plants and animals including human beings. They are also useful in many respects.

## 16 Potential Applications of Fungi

Fungi are extremely useful in making high value products like mycoproteins and acts as plant growth promoters and disease suppressor. Fungal secondary metabolites are important to our health and nutrition and have tremendous economic impact. In addition to this, fungi are extremely useful in carrying out biotransformation processes. Recombinant DNA technology, which includes yeasts and other fungi as hosts, has markedly increased market for microbial enzymes.

Today, fungal biotechnology is a major participant in the global industry due to its mind blowing potential.

**1) Designing of vectors :**Yeast vectors are used in genetic engineering. E.g., shuttle vectors are used for expression of desirable gene in both prokaryotic and eukaryotic systems. YAC, YRP, YIP, YEP are some other yeast vectors.

**2) Fungi as a food:** Fungi are used as high cost food because of its high protein and low calorific value. Europe, America, Australia and Japan are very playing industries in mushroom cultivation.

Some of the edible fungi (Mushrooms)are given as below.

- Agaricus compestris
- Volvariella (paddy straw mushroom)
- Morchella (Temperate zone mushroom)
- Pleurotus sp. (oyster mushroom)
- Agaricus bisporus (white button mushroom)

**3) Fungi as a rich source of SCP:**

Fungi are used as the rich sources of Single Cell Proteins. Some of the fungi for SCP are given as

Yeast (*S. cerevisae*) ,*Aspergillus niger, Penicillium chrysogenum, Fusarium avenacum, Neurospora sitoplila*

**4) Isolation of fungal metabolites of pharmaceutical importance:** Aspergillus nidulans and other fungi are used for isolation of secondary metabolites. The secondary metabolites are used as drug. Ergot alkaloids (Ergometrin and Ergotoin) and Lovastatin, a popular cholesterol-lowering drug are the secondary metabolites. Fungal metabolites have antitumour, antiviral, antibacterial and immunosuppressants activities.

**5) Fungal pathogens as nibblers:**

Fungal pathogens are use as root nibblers to produce many root fibers that increase the maximum uptake of nutrients and water for more yield. *Trichoderma viridae* and *fusarium* has shown increased number of root fibres in Tomato & Maize plants.

**6) Fungi in improving the quality of produce:**

It is evidence that some fungal diseases can enhance the nutritional quality of food & feed. E.g. smutted corn and rust infected wheat grains have more carbohydrate and phosphorus contents as compare to healthy plants.

**7) Fungi as biofertilizes:**

Vesicular arbuscular mycorrhizae are the mutualistic symbiosis between the roots of higher plants and certain fungi. The mycorrhizae help in the phosphate nutrition of plants and protect the roots by forming the mantle.

**8) Fungi as 'Microbial weed killer '(Bioherbicides):** Fungi are known for its quite specific & effective action and have low residual effects in comparison with synthetic pesticides. Here are given some fungi as bioherbicides with their targets in brackets. These are

- *Septagloeum gillis (Mistletoes)*
- *Wallrothiella arecuthobii (Mistletoes)*
- *Colletotrichum gloeosporiordes(Mistletoes)*
- *Phyllosticta (Glycosmis)*
- *Leptosphaerulina trifolia(Passiflora)*
- *Puccinia chondrillina(Rush weed)*
- *Cercospora ageratinae(Pamakani weed)*

**9) Cellulose degradation by fungi:** Heap of agricultural residues, forest residues deposited ample of celluloses in the soil. Only fungal cellulases are involved in degradation of deposited cellulose. *Fusarium, Trichoderma, Penicillium* derived cellulases are involved in degradation of celluloses. Some of the other fungal enzymes are gluconase and glucosidase (cellobiase).

**10) Bioconversion of lignin:** White Rot fungi such as Coriolus versicolor, Polyporus ance and Brown Rot fungi like *Poria monticola, Lenzitis trabea* are used in depolymerization and degradation of lignin to low molecular weight Petroleum products. These fungi are also used in softening of wood in paper making industries.

**11) Entamopathogenic fungi:** This group of fungi secretes the toxin, which possesses the entemocidal properties i.e., acts as parasites of insects and kills them. Eg. *Beauveria bassiana* kills grasshoppers.

**12) Industrial Applications of fungi:** Fungi are widely used in fermentative industries for the production of ethanol, organic acids, antibiotics and enzymes like fungal cellulases, gluconase and glycosidase. Certain fungi like *P. notatum*, *P. crysogenum* and *Cenococcum* Sp. are used in antibiotics production where as *S.cerevisae* and *Monilia* Sp. are used in ethanol production. Fungi are also useful in ripening of cheese and processing of other products.

**13) Biodegradation of pesticides/ Toxic chemicals and petroleum:** White Rot fungi have the potential role in degradation of toxic pesticides like DDT, PCB and Lindane. In addition to this, it can degrade certain toxic chemicals like dioxin, benzopyrene, cyanides, azides, CCl4 and Pentachlorophenol (PCP). *Aspergillus, Penicillium, Paecilomyces and Fusarium* has found to be involved in petroleum degradation at 30°C in contaminated soil.

**14) Biodegradation of Azo dye and Hydrocarbons:** Peroxidase enzyme of *Penicillium crysosporium* & *Streptomyces* sps. have potential biodegradable activities that degrade Amaranth dye, Orange G, heterocyclic dyes like, Azure B and Lip dye. The filamentous fungi are also having role in degradation of toxic hydrocarbons.

**15) Fungi in Hazardous waste remediation:** Fungi help in remediation of explosive contaminated soil by its lignin degrading Enzymes. TNT, RDX, HMX are some of the potential explosives that contaminates soil and water. Other degradable nitro explosives by *Pleurotus ostreatus* are Nitrobenzene and 4-Nitrophenol

**16) Biomineralization of Heavy Metals:** The fungi have eminent role in the removal & recovery of heavy metals from wastewater and industrial effluents. Hg, Cu, Ni, Pb, Cd are extracted at pH 2-5 by myceliar beads of *Penicillium.*