**COMPARATIVE CHARACTERS OF PROKARYOTES AND EUKARYOTES**

**PROKARYOTES**

 A prokaryote is a [unicellular organism](https://en.wikipedia.org/wiki/Unicellular_organism) that lacks a [membrane](https://en.wikipedia.org/wiki/Biological_membrane)-bound [nucleus](https://en.wikipedia.org/wiki/Cell_nucleus) (karyon), [mitochondria](https://en.wikipedia.org/wiki/Mitochondrion), or any other membrane-bound organelle. The word *prokaryote* comes from the [Greek](https://en.wikipedia.org/wiki/Greek_language)  (*pro*) "before" and (*karyon*) "[nut](https://en.wikipedia.org/wiki/Nut_%28fruit%29) or [kernel](https://en.wikipedia.org/wiki/Seed)". Prokaryotes can be divided into two [domains](https://en.wikipedia.org/wiki/Domain_%28biology%29), [archaea](https://en.wikipedia.org/wiki/Archaea) and [bacteria](https://en.wikipedia.org/wiki/Bacteria). In contrast, species with nuclei and organelles are placed in the domain [Eukaryota](https://en.wikipedia.org/wiki/Eukaryote%22%20%5Co%20%22Eukaryote).

**EUKARYOTES**

Eukaryote is any [organism](https://en.wikipedia.org/wiki/Organism) whose cells have a [cell nucleus](https://en.wikipedia.org/wiki/Cell_nucleus) and other [organelles](https://en.wikipedia.org/wiki/Organelle) enclosed within [membranes](https://en.wikipedia.org/wiki/Biological_membrane). Eukaryotes belong to the [taxon](https://en.wikipedia.org/wiki/Taxon) Eukarya or Eukaryota. The presence of a nucleus gives eukaryotes their name, which comes from the [Greek](https://en.wikipedia.org/wiki/Greek_language) (*eu*, "well" or "true") and (*karyon*, "nut" or "kernel"). Eukaryotic cells also contain other membrane-bound organelles such as [mitochondria](https://en.wikipedia.org/wiki/Mitochondrion) and the [Golgi apparatus](https://en.wikipedia.org/wiki/Golgi_apparatus).

Eukaryotes [[Animals](http://en.wikipedia.org/wiki/Animal), [plants](http://en.wikipedia.org/wiki/Plant), [fungi](http://en.wikipedia.org/wiki/Fungus)] are different from one another; they do have three general parts that allow them to carry out these processes of life. These are:

1. Cell membrane, 2. Nucleus, 3. Other organelles. The organelles are very important to the cell’s functioning.

Organelles include:

1. **Mitochondria,** which transfer energy from organic compounds to ATP.
2. **Ribosomes** organize the synthesis of proteins (which is used to get energy).
3. **Rough endoplasmic reticulum** prepares proteins for export smooth endoplasmic reticulum regulates calcium levels, breaks down toxic substances, and synthesizes steroids
4. **Golgi body** processes and packages substances produced by the cell.
5. **Lysosomes** digest molecules.
6. Other little parts to the cells which aid in all of this. These include microfilaments, cilia, flagella (those two assist in transportation)
7. Nucleus.

Plant contain cell wall, the vacuole, and the plastid. All of these organelles are used to carry out the life processes

**Comparison of Prokaryotes and Eukaryotes**

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| --- | --- |
| **PROKARYOTES** | **EUKARYOTES** |
| * These have prokaryotic cells e.g. bacteria
* Nucleus without membrane and chromosomes are present in cytoplasm, no mitosis occurs
* Membrane bounded organelles are absent, mitochondria absent.
* Ribosomes are small-sized
* Cell-Wall composed of peptidoglycan or murine. Cellulose is absent.
* Cell- membrane lack sterols compounds
* Cells are small-sized and simple average diameter 0.5-10mm.
* The prokaryotes are dependent on other similar cells and different cells in order to form what’s necessary for the life processes, while each eukaryotic cell has all the organelles it needs to carry

out the processes of life | * These have eukaryotic cells e.g. fungi, plants and animals.
* Chromosomes are present in membrane-bounded nucleus , mitosis occurs
* Membrane bounded organelles are present, mitochondria present.
* Ribosomes are large-sized
* Cell-Wall is composed of cellulose in plants and in fungi it is made up of chitin
* Cell membrane having sterols compounds
* Cells are larger and complex with average diameter 10-100mm.
* This entire system carries out one important life process. This is the major difference between the prokaryotes and the eukaryotes

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**BACTERIA**

*Noun, singular: bacterium, plural: Bacteria*

The word *bacteria* is the plural of the [New Latin](https://en.wikipedia.org/wiki/New_Latin) *bacterium*, which is the [latinisation](https://en.wikipedia.org/wiki/Latinisation_%28literature%29%22%20%5Co%20%22Latinisation%20%28literature%29) of the [Greek](https://en.wikipedia.org/wiki/Greek_language) (*bakterion*) , (*bakteria*), meaning "staff, cane" because the first ones to be discovered were rod-shaped.

“Bacteria are extremely minute, rigid, unicellular micro-organisms without definite nucleus i.e. the nuclear material is not bounded by nuclear membrane wall but have a single circular chromosome and have no chloroplasts and mitochondria. “

**General characteristics of bacteria**

* Bacteria are microscopic organisms, which are often known as **‘germs’** and **‘microbes’**.
* They are among the simplest forms of life known, and, hence show the characteristics of both plants and animals.
* Bacteria are among the smallest of living organisms.
* They are unicellular (some multicellular) or thalloid living organisms.
* Belonging to [Kingdom](http://www.biology-online.org/dictionary/Kingdom) [Monera](http://www.biology-online.org/dictionary/Monera) that possess a [prokaryotic](http://www.biology-online.org/dictionary/Prokaryotic) type of [cell](http://www.biology-online.org/dictionary/Cell) structure.
* Their [DNA](http://www.biology-online.org/dictionary/DNA) (usually circular) can be found throughout the [cytoplasm](http://www.biology-online.org/dictionary/Cytoplasm) rather than within a membrane-bound [nucleus](http://www.biology-online.org/dictionary/Nucleus).
* They reproduce by [fission](http://www.biology-online.org/dictionary/Fission) or by forming [spores](http://www.biology-online.org/dictionary/Spores).
* They can inhabit all kinds of [environment](http://www.biology-online.org/dictionary/Environment), such as in air and [soil](http://www.biology-online.org/dictionary/Soil), [acidic](http://www.biology-online.org/dictionary/Acidic), hot springs, radioactive waste, seawater, deep in the Earth's [crust](http://www.biology-online.org/dictionary/Crust), and even in the bodies of other [organisms](http://www.biology-online.org/dictionary/Organisms).
* Some species of bacteria are parasites. They attack the living cells of other plants or of animals and secure their food from that source.
* But most bacteria grow as saprophytes on dead remains or the products of plant and animal life without a direct relationship with living cells.
* Parasitic bacteria are responsible for some of the diseases of plants and animals, whereas, the saprophytic kinds may be beneficial in one way or the other.
* Some are very helpful to humans. For example, bacteria in the intestine help in digestion and we often use bacteria to make food products (yoghurt).

**Types of Bacteria**

1. Psychrophilic--active at 0°-50 ° F.
2. Mesophilic--operate in 50°-100 ° F. range.
3. Thermophilic--optimum 100°-200 ° F. range

**STRUCTURE**

* Surface appendages e.g. flagella which are used for locomotion.
	+ Surface adherents e.g. capsule.
	+ Cell-wall which is thin, hard and made up of hemi-cellulose and pectin.
	+ Cytoplasm and cell organelles.

**MORPHOLOGICAL SHAPES**

Bacteria have three basic shapes i.e.

1. Coccus: these are round or Spherical e.g. micro-coccus.

a - Monococcus: Single coccus is called monococcus.

 b - Diplococcus: If cocci occur in group of two then it is called diplococcus.

c - Staphylococcus: If large no. of cocci occurs in groups.

1. Bacillus: These are elongated Rod-shaped e.g. *Bacillus*
2. Spirillum: These are Spiral coiled filaments thread-like e.g. *Streptomyces*

**Size of Bacteria**

Bacteria vary greatly in size according to the species. Regardless of their size, bacteria can be clearly seen without the aid of a microscope. The bacteria most frequently studied in the laboratory measure approximately 0.5 to 10 µm in diameter.

Staphylococci and streptococci may have diameters ranging from 0.75 to 1.25µm. Rod (bacillus) forms, such as typhoid and dysentery bacteria often have a width bet­ween 0.5 and 1 µm and a length of 2 to 3 µm. Some filamentous forms may exceed 100 µm in length and diameter between 0 5 and 1.0 µm.

**NUTRITION**

1. **Autotrophic:** Those bacteria which are able to synthesize complex organic compounds from simple inorganic salts e.g. green sulfur bacteria. These are further divided into two groups
2. **Photo-autotrophs** which use light as energy source and co2 as carbon source e.g. photosynthetic bacteria.
3. **Chemo-autotrophs** which use chemicals as energy source and co2 as carbon source .e.g. Chemotosynthetic bacteria.
4. **Heterotrophic:** these require organic matter to prepare food for their growth and survival. These are further divided into two groups.
5. **Photo-heterotrophs** which use light as energy source and an organic compound as carbon source e.g. Purple and green bacteria.
6. **Chemo-heterotrophs** which use chemicals as energy source and an organic compound as carbon source. e.g. all Plant Pathogenic bacteria

**Reproduction of Bacteria**

**Reproduction is of two types**

1. By asexual means
2. By sex-like process

**Asexual Reproduction**

Asexual reproduction does not involve the union of two compatible genetic materials

1. **Fission:** Bacterial cells divide into two, four or more cells. In one day about one million bacterial cells are produced by fission depending upon food availability and environment conditions.
2. **Binary fission:** Single cell produces two cells which are identical to their parents
3. **Endospores:** These are hard structures formed during the life-cycle of bacteria.
4. **Cyst:** It is similar to endospore and have lesser resistance than endospore and even survive during winter and summer
5. **Fragmentation-like process:** Group of bacterium known as actinomycetes are placed in fungi because of their way of reproduction like fungus.
6. **Conidia:** It is the reproductive unit in bacterium or fungus. Normally this term is used for fungus.

**Sex-like processes**

1. **Transformation:** The genetic alteration of a bacterium by the introduction or absorption of extraneous free DNA, especially by means of a plasmid. It consist of 3 steps:

a) External binding of the DNA fragments in to the cell membrane.

b) Penetration of the DNA fragments through the cell envelop.

c) Gene expression in the state of independent or integrated into the chromosomes of other cell.



1. **Transduction:** Transfer of DNA from one bacterium to another through a virus called bacteriophage. When this phage is released from the host; they carry a very small portion of the host chromosome. This phage infects other cell; crossing over takes place between a fragment of chromosome of the donor cell and the homologous chromosome of the recipient cell.
2. **Conjugation: The ability of bacterial cells to transfer DNA between cells those are in physical contact.** It is the transfer of DNA from one bacterium to another through physical cellular contact with specific structure called sex pili.

The sex plasmid genes are responsible for the synthesis of special pili called [sex pili](http://www.slic2.wsu.edu:82/hurlbert/micro101/pages/Chap3.html#Pili). Sex pili are thin long, hollow protein tubes that have "sticky" receptors on their ends that bind firmly to molecules on recipient cell walls. The recipient cell receives DNA from donor bacterium through contact.



**4- Genetic Recombination**: When DNA enters the recipient cell by any of three mechanisms. It can synapse the homologous region of recipient genome and undergo recombination to give new genome or new DNA different from original one.

**Nitrogen Fixation**

“Nitrogen fixation is a process by which [nitrogen](https://en.wikipedia.org/wiki/Nitrogen) in the [Earth's atmosphere](https://en.wikipedia.org/wiki/Earth%27s_atmosphere) is converted into [ammonia](https://en.wikipedia.org/wiki/Ammonia) (NH3) or other molecules available to living organisms. Atmospheric nitrogen or molecular dinitrogen (N2) is relatively inert. It does not easily react with other chemicals to form new compounds.”

* Nitrogen fixation is essential for all forms of life because inorganic nitrogen compounds are required for the [biosynthesis](https://en.wikipedia.org/wiki/Biosynthesis) of the basic building blocks of plants, animals and other life forms, e.g., [nucleotides](https://en.wikipedia.org/wiki/Nucleotides) for [DNA and RNA](https://en.wikipedia.org/wiki/DNA_and_RNA).
* Coenzyme [nicotinamide adenine dinucleotide](https://en.wikipedia.org/wiki/Nicotinamide_adenine_dinucleotide) for its role in metabolism (transferring electrons between molecules), and [amino acids](https://en.wikipedia.org/wiki/Amino_acid) for [proteins](https://en.wikipedia.org/wiki/Protein).
* Therefore, as part of the [nitrogen cycle](https://en.wikipedia.org/wiki/Nitrogen_cycle), it is essential for [agriculture](https://en.wikipedia.org/wiki/Agriculture) and the manufacture of [fertilizer](https://en.wikipedia.org/wiki/Fertilizer).
* Nitrogen fixation is carried out naturally in the [soil](https://en.wikipedia.org/wiki/Soil) by nitrogen fixing [bacteria](https://en.wikipedia.org/wiki/Bacteria) such as *[Azotobacter](https://en.wikipedia.org/wiki/Azotobacter%22%20%5Co%20%22Azotobacter)*.
* Some nitrogen-fixing Bacteria have [symbiotic](https://en.wikipedia.org/wiki/Symbiotic) relationships with some [plant](https://en.wikipedia.org/wiki/Plant) groups, especially [legumes](https://en.wikipedia.org/wiki/Legume).

**Non-Biological Natural Nitrogen Fixation**

* Nitrogen can be fixed by [lightning](https://en.wikipedia.org/wiki/Lightning) converting nitrogen and oxygen into [NOx](https://en.wikipedia.org/wiki/NOx) (nitrogen oxides), if there is oxygen in the air.
* NOx may react with water to make [nitric acid](https://en.wikipedia.org/wiki/Nitric_acid), which seeps into the soil, where it makes [nitrate](https://en.wikipedia.org/wiki/Nitrate), which is of use to growing plants.

**Biological Nitrogen Fixation**

* Biological nitrogen fixation was discovered by the German agronomist [Hermann Hellriegel](https://en.wikipedia.org/wiki/Hermann_Hellriegel)and Dutch microbiologist [Martinus Beijerinck](https://en.wikipedia.org/wiki/Martinus_Beijerinck%22%20%5Co%20%22Martinus%20Beijerinck)
* Biological nitrogen fixation (BNF) occurs when atmospheric nitrogen is converted to ammonia by an enzyme called a [nitrogenase](https://en.wikipedia.org/wiki/Nitrogenase%22%20%5Co%20%22Nitrogenase).
* The overall reaction for BNF is:

N2 + 8 H+ + 8 e− → 2 NH3 + H2

* The process is coupled to the [hydrolysis](https://en.wikipedia.org/wiki/Hydrolysis) of 16 equivalents of [ATP](https://en.wikipedia.org/wiki/Adenosine_triphosphate) and is accompanied by the co-formation of one molecule of H2.
* The conversion of N2 into ammonia occurs at a [cluster](https://en.wikipedia.org/wiki/Metal_cluster) called [FeMoco](https://en.wikipedia.org/wiki/FeMoco%22%20%5Co%20%22FeMoco), an abbreviation for the iron-molybdenum cofactor.
* The mechanism proceeds via a series of [protonation](https://en.wikipedia.org/wiki/Protonation) and reduction steps wherein the Fe Moco [active site](https://en.wikipedia.org/wiki/Active_site) [hydrogenates](https://en.wikipedia.org/wiki/Hydrogenate) the N2 substrate

**Legume Family**

* In a symbiotic relationship with the soil bacteria known as 'rhizobia', legumes form nodules on their roots (or stems to 'fix' nitrogen into a form usable by plants).
* The process of biological nitrogen fixation was discovered by the Dutch microbiologist Martinus Beijerinck.
* Rhizobia (e.g., Rhizobium, Mesorhizobium, Sinorhizobium) fix atmospheric nitrogen or dinitrogen, N2 into inorganic nitrogen compounds, such as ammonium NH4+ which is then incorporated into amino acids, which can be utilized by the plant.
* Because legumes form nodules with rhizobia, they have high levels of nitrogen available to them. Their abundance of nitrogen is beneficial not only to the legumes themselves, but also to the plants around them.

**Non-leguminous**

 Although by far the majority of plant species able to form nitrogen-fixing root nodules are in the legume family [Fabaceae](https://en.wikipedia.org/wiki/Fabaceae%22%20%5Co%20%22Fabaceae), there are exceptions:

* *Parasponia*, a tropical genus in the [Cannabaceae](https://en.wikipedia.org/wiki/Cannabaceae%22%20%5Co%20%22Cannabaceae) also able to interact with rhizobia and form nitrogen-fixing nodules.
* [Actinorhizal plants](https://en.wikipedia.org/wiki/Actinorhizal_plant) such as [alder](https://en.wikipedia.org/wiki/Alder) and [bayberry](https://en.wikipedia.org/wiki/Bayberry) can also form nitrogen-fixing nodules
* Plants cannot fix nitrogen on their own, but need it in one form or another to make amino acids and proteins.

**Taxonomic status of Bacteria**

* No one system for the classification of bacteria is generally accepted. The three most widely used classifications are those of Lehmann and Neumann, Migula, and Bergey.
* A comprehensive classification was published by Lehmann and Neumann in 1896. Almost the same time Erwin Frink.
* A fresh system of classification was sug­gested by Migula in 1900.
* Later Bergey in 1923 in Manual of Determinative Bac­teriology introduced a new system of classification of bacteria. Bergey’s system of classification attracted attention of a large number of workers.
* Subsequently, in 1948 an abridged classification was prepared by a committee appointed by the Society of American Bacteriologists.
* This committee, known as the Board of Editor-Trustees, has the co-operation of a group of approximately 65 bacteriologists interested in developing the systematic relationship of the various groups of bacteria.
* The work of the committee was published under the title of **‘Bergey’s Manual of Determinative Bacteriology’** in honour of Dr. D. H. Bergey who was responsible for developing the first edition of the manual.

In Bergey’s manual, bacteria were separated into five orders which may be briefly characterized as follows:

* Eubacteriales

#### Actinomycetales

#### Chlamydobacteriales

#### Myxobacteriales

#### Spirochaetales

But in course of time bacteria were further grouped into ten orders based on the morphology of vegetative cells and nature of flagellation:

1. Eubacteriales
2. Pseudomonadales
3. Caryophanales
4. Actinomycetales
5. Chlamydobacteriales
6. Myxobacteriales
7. Beggiatoales
8. Hyphomicrobiales
9. Spirochaetales
10. Mycoplasmatales

There are 13 families of bacteria out of them 4 are important

|  |  |  |
| --- | --- | --- |
| Taxonomic category | Genus / species | Diseases caused |
| Order: PseudomonadalesFamily: *Psedomonadaceae* | *Xanthomonas compestris* pv. *malvacearm**X. compesrtis* pv. *citri**X. oyzae* pv. o*yza**Psedomonas solanacearm* | Angular leaf spot of cottonCitrus cankerBrown leaf spot of riceWilt of salacious plant |
| Order: EubacterialesFamily: *Enterobacteriaceaee* | *Erwinia corotovora**E. amylovora* | Root and crown rotsSoft rot |
| Order: EubacterialesFamily: *Rhizobiaceae* | *Agrobacterim tumefaciens* | Crown Gall  |
| Order*:* Actinomycetales*Family: Streptomycetaceae* | *Streptomyces scabies* | Potato scab |

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