**Bacterial nutrition**

The bacterial cell has the same general chemical pattern as the cells of other organisms. The bacterial cell contains water (80% of total weight), proteins, polysaccharides, lipids, nucleic acids, mucopeptides and low molecular weight compounds.

For growth and nutrition of bacteria, the minimum nutritional requirements are water, a source of carbon, a source of nitrogen and some inorganic salts. Water is the vehicle of entry of all nutrients into the cell and for the elimination of waste products.

**Nutrient Requirements:**

* + Carbon sources
  + Nitrogen sources
  + Inorganic salts and trace elements
  + Growth factors
  + Water

**A-**Bacteria can be classified nutritionally based on their energy requirements and on their ability to synthesise essential metabolites.

**1- phototrophs**.Bacteria which derive energy from sunlight

**2-chemotrophs**.Those that obtain energy from chemical reactions

**3-autotrophs**. Bacteria that can synthesise all their organic compounds .They are able to use atmospheric carbon dioxide and nitrogen. They are capable of independent existence in water and soil. They are of no medical importance.

**4-heterotrophs**.Some bacteria are unable to synthesise their own metabolites. They depend on preformed organic

compounds. These bacteria are unable to grow with carbon dioxide as the sole source of carbon.

**Microbial growth** – an increase in a population of microbes rather than an increase in size of an individual Result of microbial growth is discrete colony – an aggregation of cells arising from single parent cell Reproduction results in growth

**Bacterial growth curve:**

When a bacterium is seeded into a suitable liquid medium and incubated, its growth follows a definite course. If bacterial counts are made at intervals after inoculation and plotted in relation to time, a growth curve is obtained. The curve shows the following phases:

**Lag phase:**

Immediately following the seeding of a culture medium, there is no appreciable increase in number, though there may be an increase in the size of the cells. This initial period is the time required for adaptation to the new environment. The necessary enzymes and metabolic intermediates are built up in adequate quantities for multiplication to proceed. The maximum cell size is obtained towards the end of lag phase. The duration of the lag phase varies with the species, size of the inoculum, nature of the culture medium and environmental

factors such as temperature.

**Log (logarithmic) or exponential phase:**

Following the lag phase, the cells start dividing and their numbers increase exponentially or by geometric progression with time. If the logarithm of the viable count is plotted against time, a straight line will be obtained. In this phase, cells are smaller and stain uniformly.

**Stationary phase:**

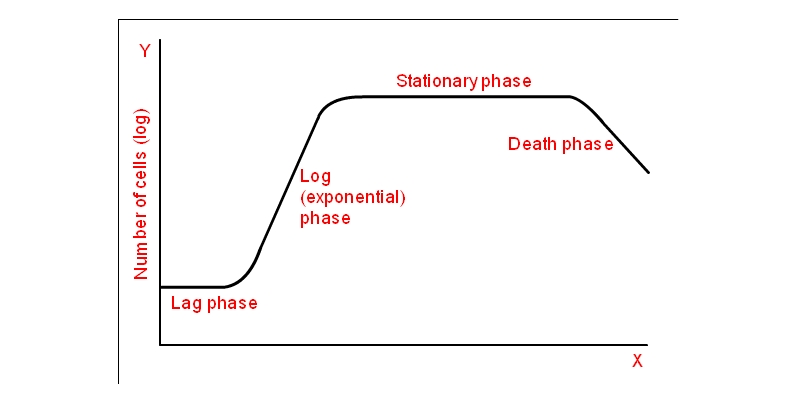
After a varying period of exponential growth, cell division stops due to depletion of nutrients and accumulation of toxic products. The number of

new cells formed is just enough to replace the number of cells that die. Equilibrium exists between the dying cells and the newly formed cells. So, the viable count remains stationary. In this phase, cells are frequently

gram variable and show irregular staining. Sporulation occurs at this stage.

**Phase of decline:**

This is the phase when the population decreases due to cell death. Besides nutritional exhaustion and toxic accumulation, cel death may also be caused by autolytic enzymes.



**Environmental Effects on Bacterial Growth:**

* **Temperature**
* **pH**
* **Osmotic pressure**
* **Oxygen classes**

**1-Temperature Requirements**:

Bacteria vary in their requirement of temperature for growth. For each species, there is a **“temperature range”**, and growth does not occur above the maximum or below the minimum of this range. The temperature at which growth occurs best is known as the **“optimum temperature”**. In the case of most pathogenic bacteria, the optimum temperature is 37ºC.

**mesophilic** :Bacteria which grow best at temperatures of 25-40ºC are called, for example *Escherichia coli*.

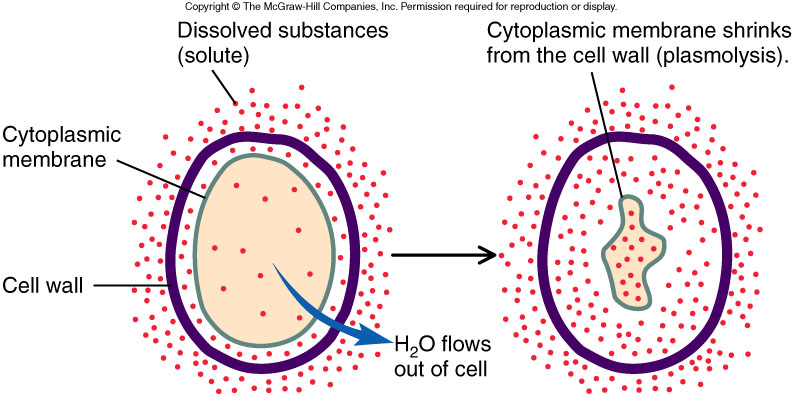
**Psychrophilic:** bacteria are those that grow best at temperatures below 20ºC. They are soil and water saprophytes and may cause spoilage of refrigerated food.

**Thermophilic**: bacteria are those which grow best at high temperatures, 55-80ºC. They may cause spoilage of underprocessed canned food. Some thermophiles, for example form spores that are highly thermoresistant.

**2-pH influences the growth:**

Bacteria-prefer a pH range of 6.5-7.5 The acidity or alkalinity of an environment can greatly affect microbial growth. Most organisms grow best between pH 6 and 8, but some organisms have evolved to grow best at low or high pH. The internal pH of a cell must stay relatively close to neutral even though the external pH is highly acidic or basic. **Acidophiles :** organisms that grow best at low pH ( *Helicobacter pylori*) **Alkaliphiles** : organismsa that grow best at high pH ( *Vibrio cholera*)

**3- Osmotic environment influences growth:**

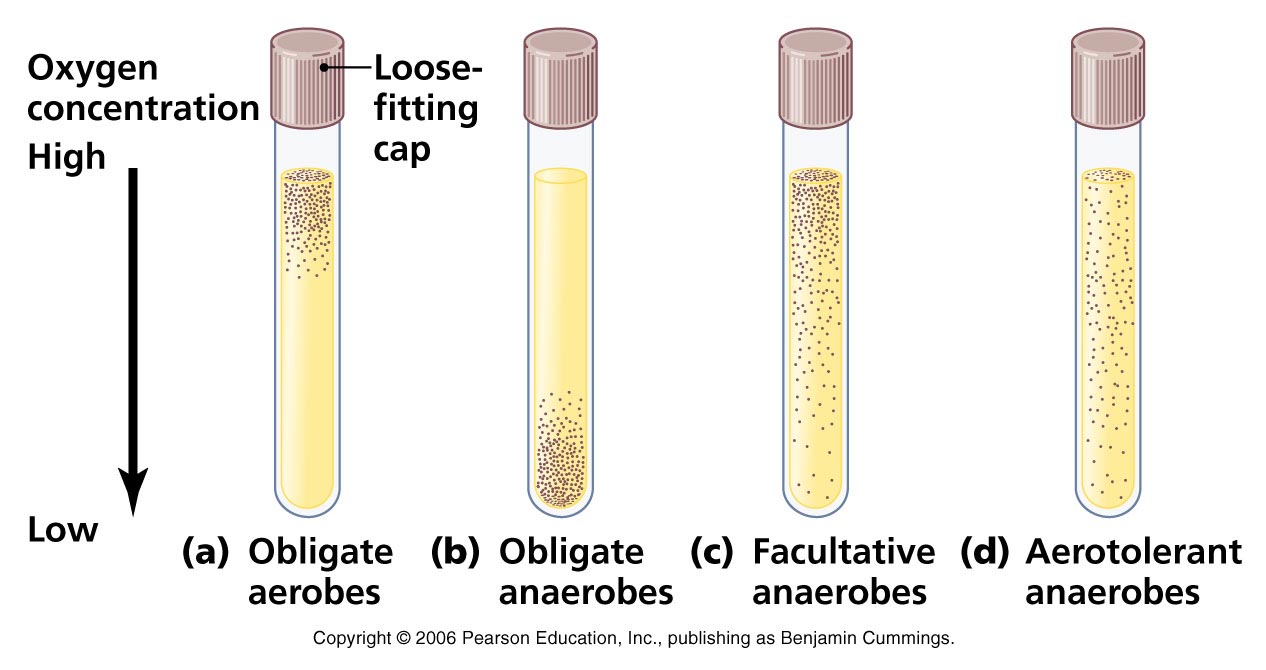


**B-Gaseous Requirements**

**Aerobes** require oxygen to live, whereas **anaerobes** do not and may even be killed by oxygen**.**

**Facultative organisms** can live with or without oxygen**. Aerotolerant** anaerobes can tolerate oxygen and grow in its presence even though they cannot use it**.**

**Microaerophiles** are aerobes that can use oxygen only when it is present at levels reduced from that in air.



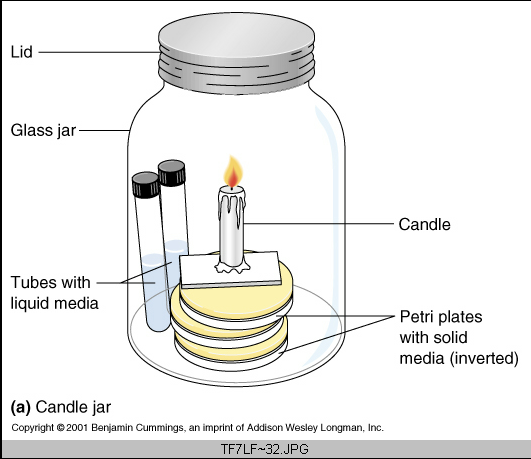
In case of aerobes, atmospheric oxygen is the final electron acceptor in the process of respiration (aerobic respiration). In this case, the carbon and energy source may be completely oxidised to carbon dioxide and water. Energy is provided by the production of energy-rich phosphate bonds and the conversion of adenosine diphosphate (ADP) to adenosine triphosphate (ATP). This process is called **oxidative phosphorylation**.

Anaerobic bacteria use compounds like nitrates or sulphates instead of oxygen as final electron acceptors in the process of respiration (anaerobic respiration). A more common process used by these bacteria in anaerobic metabolism is **fermentation**. It is defined as the process by which complex organic compounds, such as glucose, are broken down by the action of enzymes into simpler compounds without the use of oxygen. This process leads to the formation of several organic end

products such as organic acids and alcohols, as well as of gas (carbon dioxide and hydrogen). For example, *Escherichia coli* ferments glucose with the production of acid and gas. It also ferments lactose. During the process of fermentation, energy-rich phosphate bonds are produced by the introduction of organic phosphate into intermediate metabolites. This process is known as **substrate-level phosphorylation**. The energy-rich phosphate groups so formed are used for conversion of ADP to ATP.

All bacteria require some amounts of carbon dioxide for growth. This is obtained from the atmosphere or from the cellular metabolism of the bacterial cell. Some bacteria like *Brucella abortus* require much higher levels of carbon dioxide (5-10%) for growth. They are called **capnophilic**.





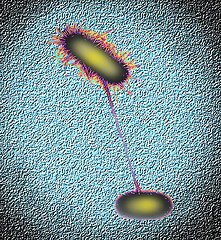
**Bacteria can reproduce in one of two ways:**

**Sexually Conjugation**

plasmid copies itself

passes through pili (cytoplasmic bridge) into recipient cell

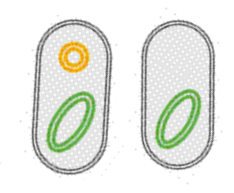
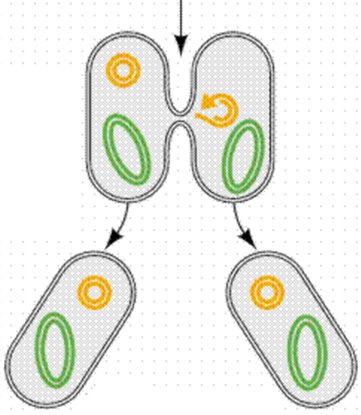
cells separate with both cells containing the plasmid



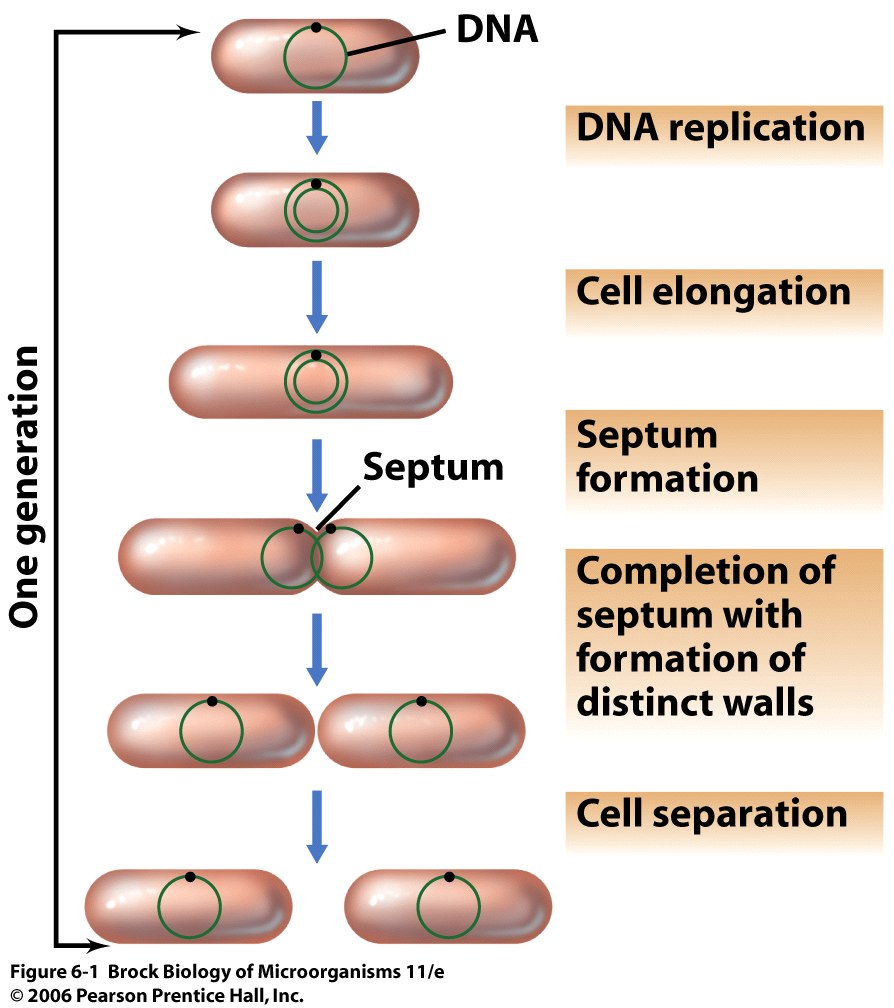
**Donor recipient**

**cell (+) cell ( -)**

**plasmid**

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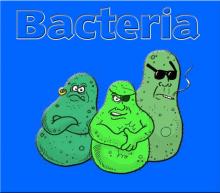
**Asexually:Binary fission**

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**Sterilization & Disinfection:**

**Sterilization:** The complete elimination or destruction of all forms of life by a chemical or physical means. This is an absolute not a relative term.

**Disinfection:** A procedure of treatment that eliminates many or all pathogenic microorganisms with the exception of bacterial spores.



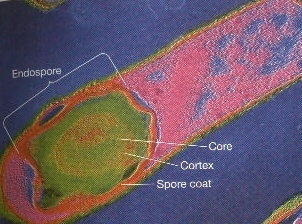
**Spore Formation:**

-Form endospore whenever when habitat conditions become harsh (little food) .Able to survive for long periods of time as endosperm .

-Resistant to harsh conditions(loss of nutritional requirement, dessication, intense heat, radiation and attack by most enzymes and chemical agents)

Bacillus-

Clostridium -



**Disinfectant:** A germicide that inactivates virtually all recognized pathogenic microorganisms but not necessarily all microbial forms. They may not be effective against bacterial spores.

**Bacteriocidal** (microbiocidal) - -cidal means kill

**Bacteriostatic** (microbiostatic) - -static means inhibition of growth and multiplication

**Bactericidal:-** is that chemical that can kill or inactivate bacteria. Such chemicals may be called variously depending on the spectrum of activity, such as bactericidal, virucidal, fungicidal, microbicidal, sporicidal, tuberculocidal or germicidal

**Bacteriostasis:-** is a condition where the multiplication of the bacteria is inhibited without killing them.



**Physical methods:**

**a- Heat 1- Hot-air sterilizer**

**b- Autoclaving**

**2- Radiation**

**3- Filtration**

**4- Ultrasound**

**5- Dryness**

**6- Low temperature**

**7- Sunlight**

**Chemical agents:**

**Phenolics**

**Alcohols**

**Iodine**

**Gluteraldehyde**

**Antiseptic**

**Halogens**

**Detergents**

**Aldehydes**

**Physical methods**

**Heat:** Heat is considered to be most reliable method of sterilization of articles that can with stand heat. Heat acts by oxidative effects as well as denaturation and coagulation of proteins

**DRY HEAT:**

**Red heat:** Articles such as bacteriological loops, straight wires, tips of forceps and searing spatulas are sterilized by holding them in Bunsen flame till they become red hot

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**MOIST HEAT:**

Pasteurization: This process was originally employed by Louis Pasteur. Currently this procedure is employed in food and dairy industry. There are two methods of pasteurization, the holder method (heated at 63oC for 30 minutes) and flash method (heated at 72oC for 15 seconds) followed by quickly cooling to 13oC.

Boiling: Boiling water (100oC) kills most vegetative bacteria and viruses immediately. Certain bacterial toxins such as Staphylococcal enterotoxin are also heat resistant

**At temperature above 100oC:**

Autoclave: Sterilization can be effectively achieved at a temperature above 100oC using an autoclave. Water boils at 100oC at atmospheric pressure, but if pressure is raised, the temperature at which the water boils also increases.

In an autoclave the water is boiled in a closed chamber. As the pressure rises, the boiling point of water also raises.

At a pressure of 15 lbs inside the autoclave, the temperature is said to be 121oC. Exposure of articles to this temperature for 15 minutes sterilizes them. To destroy the infective agents associated with spongiform encephalopathies (prions), higher temperatures or longer times are used; 135oC or 121oC for at least one hour are recommended.

**Radiation:**

Ionizing radiation is not used for general laboratory sterilization, however ultraviolet radiation (U.V.) is used to control airborne microorganisms and environmental surface decontamination. Ultraviolet sources are used in biological safety cabinets for *partial* contamination control and should be turned on only when cabinets or enclosures are not in use.

**FILTRATION:**

Filtration does not kill microbes, it separates them out. Membrane filters with pore sizes between 0.2-0.45 μm are commonly used to remove particles from solutions that can't be autoclaved.



**Chemical agents**

**Sunlight:** The microbicidal activity of sunlight is mainly due to the presence of ultra violet rays in it. It is responsible

**Phenolics:**

Phenolics are phenol (carbolic acid) derivatives. These biocides act through membrane damage and are effective against enveloped viruses, rickettsiae, fungi and vegetative bacteria.

**Alcohols:**

In the healthcare setting, "alcohol" refers to two water-soluble chemicals: ethyl alcohol and isopropyl alcohol. These alcohols are rapidly bactericidal rather than bacteriostatic against vegetative forms of bacteria (Gram + and Gram -); they also are tuberculocidal, fungicidal, and virucidal against enveloped viruses. Alcohols are not effective against bacterial spores and have limited effectiveness against nonenveloped viruses. Their cidal activity drops sharply when diluted below 50%

concentration and the optimum bactericidal concentration is in the range of 60-90% solutions in water (volume/volume).

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**Iodine:**

Iodine and iodophors are well established chemical disinfectants. These compounds have been incorporated in time release formulations and in soaps (surgical scrubs). Simple iodine tinctures (dissolved in alcohol) have limited cleaning ability. These compounds are bactericidal, sporicidal, virucidal and fungicidal but require a prolonged contact time.

**Gluteraldehyde:**

Aldehydes have a wide germicidal spectrum. Gluteraldehydes are bactericidal, virucidal, fungicidal, sporicidal and parasiticidal. They are used as a disinfectant or sterilant in both liquid and gaseous forms. Gluteraldehydes are very potent disinfectants, which can be highly toxic.

**Antiseptic:**

Typically an antiseptic is a chemical agent that is applied to living tissue to kill microbes. Note that not all disinfectants are antiseptics because an antiseptic additionally must not be so harsh that it damages living tissue. Antiseptics are less toxic than disinfectants used on inanimate objects. Due to the lower toxicity, antiseptics can be less active in the destruction of normal and any pathogenic flora present.