Microbiology

Microbiology is the science dealing with study of very small organisms that cannot be seen with naked eye these organisms are called microorganisms, and require a microscope to be seen. This includes fungi and protozoa (eukaryote), bacteria (prokaryote), and viruses.

History of microbiology

The science of microbiology started with the invention of the microscope.

The microscope was available during the mid-1600s.

- In the 1600's the first microscopes were crafted by Robert Hooke and van Leeuwenhoek.

- Van Leeuwenhoek (1632 -1723) (the father of Microbiology) developed simple microscopes and first to observe microbes. He examined a drop of rainwater using a single-lens microscope which contained tiny creatures he called "animalcules". The animalcules that van Leeuwenhoek observed included: fungi, protozoa, algae, and bacteria (1676).

- The English scientist Robert Hooke is the first person used a microscope for academic study in 1660. He observed "cells" using a simple microscope.

- Ferdinand Julius Cohn (1898) His classification of bacteria into four groups based on shape (sphericals, short rods, threads, and spirals) is still in use today.

- Christian Ehrenberg introduced the name (bacterium) in 1838.

    - Louis Pasteur demonstrated in 1859 that the fermentation of food is caused by the growth of microorganisms. He suggested that mild heating at 62.8°C (145°F) for 30 minutes destroy the undesirable organisms without ruining the taste of the product, the process was called Pasteurization.

- Robert Koch demonstrated the role of bacteria in causing disease.

- Paul Ehrlich (in 1910), developed the first antibiotic.

- Fleming (in 1928) Discovered fungi produced penicillin which killed bacteria.

- Then, after World War II, the antibiotics were introduced to medicine.

- In the 1940s, the electron microscope was developed.

- With the development of vaccines in the 1950s and 1960s, such viral diseases as polio, measles, mumps, and rubella came under control.

Important Theories in Microbiology

1- Spontaneous generation (Abiogenesis)

Aristotle and others believed that living organisms could develop from non-living materials. This theory disproved by Louis Pasteur

2- Biogenesis

Louis Pasteur proved that living organisms can arise only from pre-existing living organisms.

Five Kingdom Classification System

Haeckel (1866) was the first to create a natural Kingdom for the microorganisms.

1. **Animalia** Multicellular, and move with the aid of cilia, flagella, or muscle. No chloroplasts or cell walls.
2. **Plantae :** Plants are multicellular and most don't move. Chloroplasts are present.
3. **Protista**
   Single-celled, move by cilia, flagella, or by amoeboid mechanisms. No cell wall. They have organelles including a nucleus and may have chloroplast.
4. **Fungi**
   Fungi are multicellular, with a cell wall, organelles including a nucleus, but no chloroplasts.
5. **Monera (includes Eubacteria and Archaebacteria)**
   single-celled, may move or not, have a cell wall, have no organelles, and have no nucleus.

Overview of Bacteriology

Basic Characteristics of bacteria

- Single-celled organisms
- Prokaryotic
- Distinctive cell walls, which contain a peptidoglycan layer
- Tiny; measured in units called micrometers (μm)
- Lack a true nucleus; instead, have a region called the ‘nucleoid region' (DNA)
- DNA is free floating
- Rapid growth and cell division
- Adapt quickly to changing environments

Bacterial Colony

bacterial colony is a cluster of identical cells. These colonies often form and grow on the surface of a solid medium, usually derived from a single parent cell.

Bacterial sizes

The basic unit of measurement is the micrometer ($\mu = 10^{-3}$mm) .

1. The largest bacteria is about 700 μm. It found living in the gut of surgeonfish species.
2. The smallest bacteria is 100 to 200 nm (0.1- 0.2 μm), the size of the largest viruses.

Bacteria shape (Morphology)

1- Spherical, called “coccus”

2- Rod-shaped, called bacilli (single: bacillus)

3- Ovoid cells are something in between cocci and bacilli known as coccobacilli

4- Curved (comma-shaped) called Vibrio.

5- Spiral

6- Filamentous

Classification of bacteria according to different factors

A. Temperature

1- Psychrophiles

Minimum temp.= 0◦C

Optimum temp. =15◦C or lower

Maximum temp.= 20◦C.

2- Mesophiles

Minimum = (15 - 20)◦C

Optima = (20 - 45)◦C

Maximum = 45◦C or lower.

Almost all human pathogens are mesophiles.

3- Thermophiles

Minimum = 45◦C

Optimum = 55°C

Maximum temp. = 80°C

They found in many habitats like hot springs.

B. pH

1. Neutrophiles grow best at a pH range of (5 – 8).

2. Acidophiles grow best at a pH < 5.5.

3. Alkaliphiles grow best at a pH > 8.5.

C. Nutrient source

- **Autotroph -** the only type can use CO_2 as their source of carbon by photosynthesis.
- **Heterotroph** – derive carbon from organic nutrients such as sugar (most pathogenic bacteria are heterotrophs).

d. O_2 requirement (Respiration)

Respiration is the process by which organisms break down organic substances (such as sugars) to produce energy.

1- Aerobic Respiration (aerobic bacteria)

Aerobic respiration is respiration in the presence of oxygen.

2- Anaerobic Respiration (anaerobic bacteria)

Respiration which lack oxygen. It is typically slower.

3- Facultative Anaerobic Respiration (Facultative anaerobic bacteria)

Facultative anaerobes are able to perform either aerobic respiration or anaerobic respiration.

Structure of Bacterial Cells

Cell Cytoplasm: Dense gelatinous solution of sugars, amino acids, salts and 70-80% water.

Nucleoid

It is a single, double-stranded DNA molecule that contains all the genetic information required by a cell. central region. It isn't bounded by a membrane.

It is an irregularly shaped region that DNA is located which contains all genetic material.

Ribosomes

It is smaller than the ribosomes in eukaryotic cells.

They play an active role in the process of protein synthesis.

Inclusions or storage bodies

Nutrients and reserves may be stored in the cytoplasm in the form of glycogen or lipids.

Endospores

Some bacteria form spores which are metabolically inactive and can survive a long time under very harsh conditions. Once the hazard is removed, the spore return to growth to create a new population.

Function of spores

Can with stand very high or low temperatures, lack of water, acids, bases, dyes, disinfectants, antibiotics and toxic chemicals. This makes them difficult to kill during sterilization.

Cell membrane

The cell membrane or plasma membrane is a biological membrane composed of 60% protein and 40% phospholipid. It is selectively permeable to ions, nutrients and waste.

Cell wall

It is strong, rigid and includes several layers. The chemical companions of the cell wall differ between different bacterial species, the basal composition is the peptidoglycan (protein + polysaccharides).

Cell wall structure

In the Gram-positive bacteria, the cell wall is thick, consisting of several layers of peptidoglycan.

In the Gram-negative bacteria, the cell wall is thin and composed of a single layer of peptidoglycan surrounded by a membranous structure called the outer membrane. The outer membrane of Gram-negative bacteria contains a lipopolysaccharide, which is toxic to animals.

Function

1. Determines cell shape

2. Responsible for the strength and rigidity of the cell

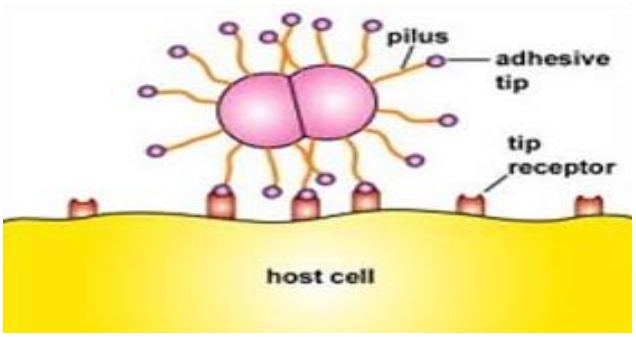
Capsule: is a large structure common to many bacteria. It is a polysaccharide layer that lies outside the cell envelope. It protects the bacteria from the host's defences and it can be the cause of various diseases.

Cell Appendages

1- Pili: are thin, protein tubes originating from the cytoplasmic membrane of many bacteria. they are able to stick bacteria to surfaces and composed of a protein called pilin. It has 2 types:

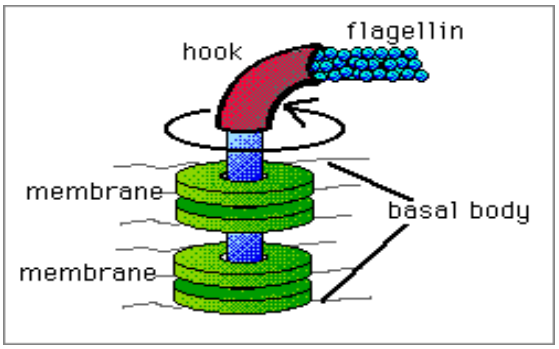
a. Sex pili: Attach two cells and allow transfer of DNA

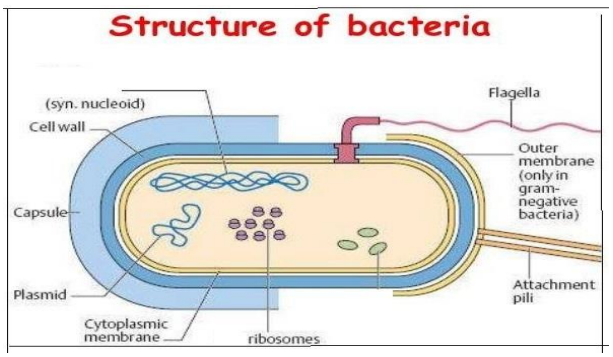
b. Attachment pili: Help bacteria adhere to surfaces.



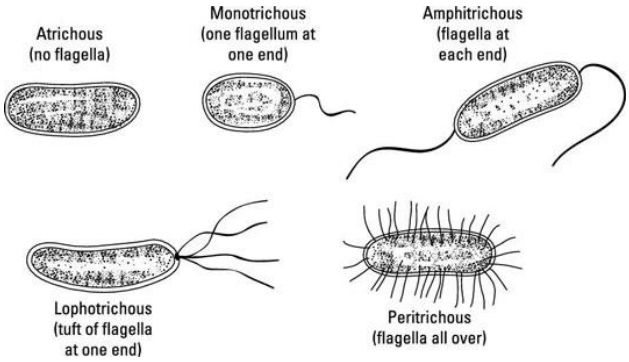
2- Flagella: exterior protein filaments that rotate and cause bacteria to be motile.

Structure of flagellum





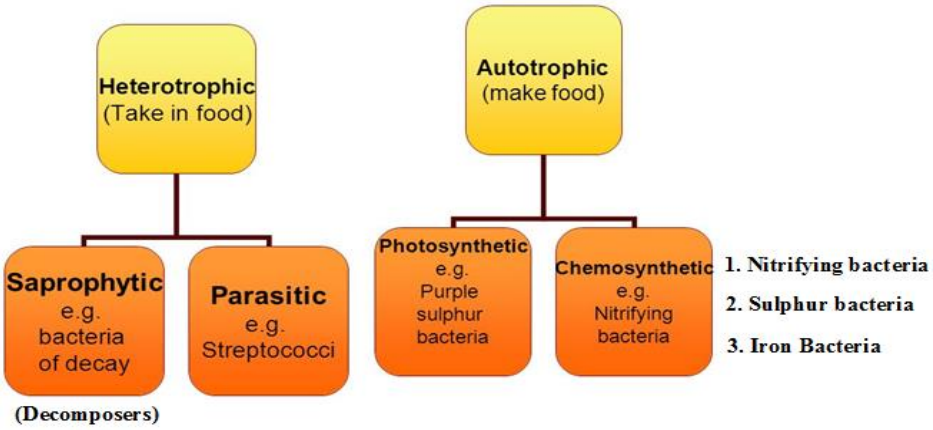
Flagellar Arrangements



Bacterial Nutrition

Nutrition is the way in which an organism gets it food.

Modes of nutrition in bacteria



Nutritional requirements of bacteria

1- Water

In the preparation of most culture media, the first ingredient added is water. Cells require an aqueous environment because enzymatic reactions and transport need water. When preparing media, it is essential to always use distilled water, because tap water can contain minerals such as Ca, P, and Mg ions that could react with the medium component and cause unwanted precipitates and cloudiness.

2- Source of carbon: CO_2 and organic compounds

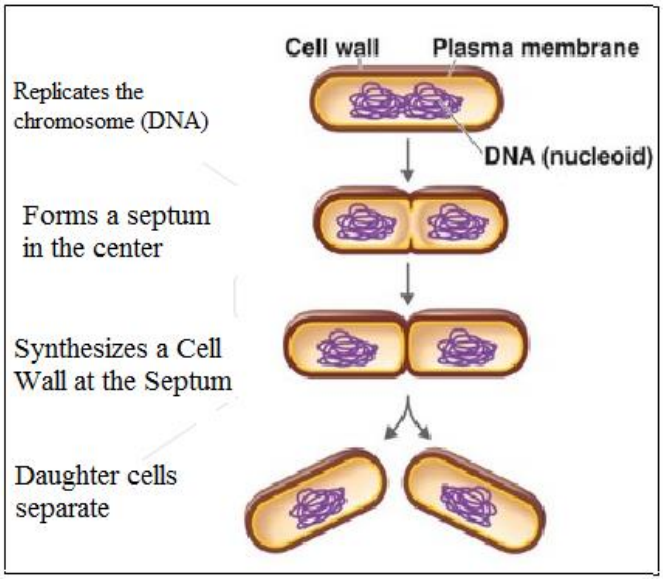
3- Source of other elements (H, O, N, S, etc)

Bacterial Growth and Reproduction

Bacterial growth is the division of one bacterium into two daughter cells in a process called binary fission.

1- Asexual reproduction (Binary Fission)

Binary Fission steps (under good growing conditions):



2- Bacterial sexual reproduction: Bacteria use it for genetic variation.

1- Conjugation

One bacterium connects itself to another through a pilus. Genes are transferred from one bacterium to the other through it.

2- Transformation

Some bacteria are capable of taking up DNA of dead bacterial cells from their environment.

3. Transduction

Exchanging of bacterial DNA through a virus infects bacteria which introduces foreign DNA into bacterial chromosome.

Growth phases of bacteria

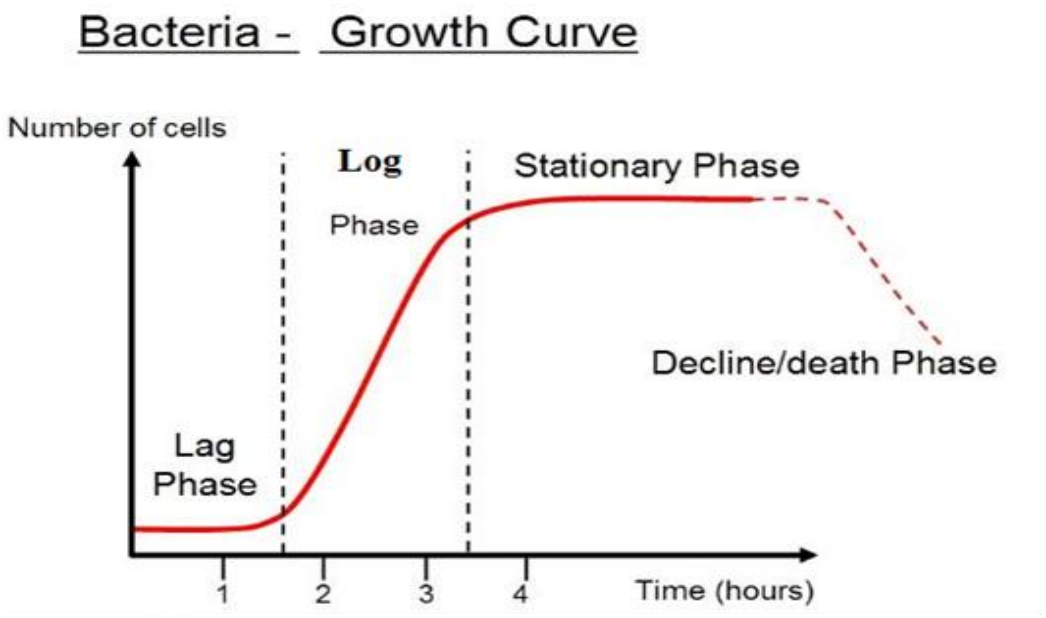
1. **Lag phase:** there is no increase in cell number and the bacteria are busy replicating proteins and DNA in preparation for the next phase.
2. **Log phase:** the bacteria become extremely active and begin the process of dividing.
3. **Stationary phase:** the growth rate is equal to the death rate. Why?

   Because 2 factors limit the growth of a bacteria:

   a. Food begins to run out b. Poisonous waste products
4. **Death phase:** The number of dead or dying bacterial cells begins to outnumber the new ones. This can be because of:

1. Food begins to run out
2. Poisonous waste products
3. Changes in the environmental conditions.

Cells in the bacterial colony will die off.



Archaea

Archaea were separated from Eubacteria after discovery of their specifics in cell outer membrane that usually not affected by common antibiotics.

Archaea are also the oldest organisms that have been discovered.

General characteristics of Archaea

1- It has metabolic pathways that are similar to eukaryotes.

2- Has three RNA polymerases (an enzyme that produces RNA), (Bacteria have one).

3- Archaea rely on ether lipids in their cell membrane for survival. (Ester bond in bacteria)

4- Can survive in extreme conditions, such as extremely hot, cold or extremely salty water.

5- Archaea cell walls lack peptidoglycan (Bacteria have peptidoglycan).

6- Archaea reproduce by binary fission, fragmentation or budding.

7- Archaea do not produce spores. (Some bacteria produce spore).

<u>Archaea are subdivided into 3 groups based on their habitat</u>

1- Methanogens

- Live in anaerobic environments
- Obtain energy by changing H_2 and CO_2 gas into methane gas.
- Found in marsh, sewage, digestive tracts of animals.

2- Extreme Halophiles

Live in very salty water found in the Dead Sea. They use salt to generate ATP.

3- Thermoacidophiles

- Live in extremely hot (110^0C) and acidic (pH= 2) water.
- Found in hot springs and in volcanic vents.

The Important Impacts of Microbes on Ecosystems

1. Generate Oxygen in the Atmosphere by cyanobacteria.

2. Decaying of organic substance

Most of the bacteria are very useful in decomposition of dead organic matter of plants and animals by the secretion of enzymes. The enzymes convert the fats, carbohydrates and nitrogenous compounds into simpler forms, such as, CO_2, water, NH_3, H_2S, PO_4, NO_3 that are used as raw material by the green plants. These bacteria not only decompose the organic compounds but also remove the harmful waste from the earth.

3. Pest control

Some bacteria can also be used in the place of pesticides in the biological pest control. These bacterial pesticides are regarded as environmentally friendly, because of little or no effect on humans, wildlife, pollinators, and most other beneficial insects.

4- Fiber ratting

Some *Clostridium* is used to separate fibers of some plants. The plants are immersed in water and when they swell, inoculated with bacteria which hydrolyze pectic substance of the cell walls and separate the fibers.

5. Fertilize the soil

Some bacteria increase the fertility of the soil by converting insoluble materials into soluble ones.

(1) Ammonification

Some bacteria decompose the proteinous compounds into amino acids in a process called deamination, which are converted into ammonia (NH_3), this release of NH_3 is called ammonification. The free ammonia is disappears in dry soil, but it is soluble in moist soil to form ammonium salts (NH_4+).

(2) Nitrification

Some bacteria convert ammonium salts (NH_4+) into nitrates, which are absorbed by the plants. The nitrifying bacteria are :

a. Nitrosomonas convert the NH_4+ into nitrites (NO_2) in the soil.

b. Nitrobacter converts the NO_2 into nitrates (NO_3).

This conversion of ammonium salts into nitrates is called nitrification.

(3) Nitrogen Fixation These bacteria take up nitrogen from the atmosphere and convert it into organic nitrogen compounds. It is known as nitrogen fixation.

The nitrogen-fixing bacteria are of two types.

1- **Azotobacter** which live freely in the soil and fix nitrogen of the air in their bodies in the form of nitrogenous organic compounds.

2- Rhizobium lives in the roots of leguminous plants and forms nodules. These bacteria absorb free nitrogen from the air and fix nitrogen to be incorporated into plant protein. The leguminous plants thus enrich the fertility of the soil.

Economic Importance of Bacteria

Useful Bacteria

1- Biotechnology

Biotechnology: is the application of microorganism such as bacteria, fungi and algae

A- Fermentation processes, such as baking, cheese, vinegar, and yogurt.

B- Chemical manufacturing such as ethanol, acetone, organic acid, perfumes and drugs.

2- Genetic engineering: It is the manipulation of genes.

The examples are production of human insulin (used against diabetes).

3- Vitamin synthesis: *E. coli* that live in the intestine synthesize vit B for human use.

4- In agriculture or in soil fertility

Harmful bacteria

1. Plant pathogenic bacteria

2. Animal Pathogenic Bacteria

3. Soil Fertility destroying Bacteria

These are denitrifying bacteria in the soil, which reduce the nitrates, and the ammonium salts to free nitrogen, which escapes into the atmosphere. This process is known as denitrification, which decreases the fertility of the soil, e.g., *Bacillus denitrificans*.

(4) Food destroying Bacteria

Food microbiology

Microorganism Growth in Foods: there many factors affecting microbial growth in food

A. Intrinsic Factors

The conditions naturally present in the food, they include:

1- Hydrogen ion concentration (pH)

Most bacteria are killed in strong acid or strong alkaline environment

Optimum enzyme activity at pH 7.

2- Moisture content

Fresh meats and milk have high water content which supports microbial growth.

Water activity(a_w): the amount of free water in a food medium.

In general, lower water activity (humidity) inhibits microbial growth.

3- Nutrients content of the food

Foods such as milk, meat and eggs contain a number o f nutrients that are required by microorganisms. So these foods are susceptible to microbial spoilage.

4- Biological structure

Some foods have biological structures that prevent microbial entry.

For example, meat has fascia that prevent microbial entry.

Eggs have shell. Outer skin of vegetables and fruits slows microbial growth

5- **Presence of antimicrobial substances**

B. Extrinsic Factors

1- Temperature

It is measured that temperature between 0 and 60^0C are the most helpful for microbe growth.

High temperature is harmful for the survival of microbes **because** any rise in surrounding temperature above 60 ^{0}C can quickly destroy both the microbes and their enzyme excretions.

2- Relative humidity

Higher levels of humidity help microbial growth.

Relative humidity is the amount of moisture in the atmosphere or food environment.

Storing food in an atmosphere where humidity is less than 70% will help prevent spoilage.

3- Storage time of food: the longer the storage time of the food, the more chance have the microbes to grow and spoil the food.

Food preservation principles

(1). Inhibition principle

The inhibition principle can be achieved by any of the following methods:

(a) Food preservation by lowering pH

The lowering of pH can be achieved by

1. Addition of acids 2. Fermentation.

(b) Food preservation by lowering water activity

Lowering of water activity can be achieved by:

1. Addition of high content of salt: Sodium chloride.
2. Addition of high content of sugar
3. Drying: sun/air drying; electrical drying.

(c) Use of preservatives, e.g. sodium benzoate

(d) Food preservation by use of low temperatures

Two methods are employed to stop microbial growth and multiplication.

These are **chilling** (cold storage) and **freezing**.

- Chilling is keeping food at temperatures between 0-8^{o}C.
- Freezing is keeping food at temperatures between 0^{o}C and -18^{o}C.

Effect of low temperatures

1- Prevent chemical reactions

2- Actions of food enzymes

3- Slow down or stop the growth and activity of microorganisms in the food.

(2). Killing principle

Methods of killing principle

1. **Heat treatment**: through pasteurization or sterilization.
2. **Irradiation:** kill microorganisms by destruction of DNA
3. **Use of gases**: by use of ozone. The gases destroy both vegetative cells and spores.

Food-borne infections

Food borne diseases (FBD) are acute illnesses due to ingestion of microorganisms, followed by growth, tissue invasion and/or release of toxins.

Classification of food borne diseases

Food borne diseases are classified into:

1. Food borne infections
2. Food borne intoxications

Infections	Intoxications
✓ Bacterial / Viral / parasite	✓ toxins (natural / bacterial / chemical)
✓ Invade lining of intestine	✓ No invasion
✓ Incubation period- hours to days	✓ Incubation period- minutes to hours
✓ Spreads from person to person.	✓ Not communicable (not spread).

Antibiotics

Antibiotics: is the substances that are produced or derived by one microorganism (fungi, bacteria, and others), that can kill or inhibit the growth of another microorganisms.

Antimicrobial is a substance that kills or inhibits the growth of microorganisms such as bacteria, fungi, or protozoans.

Types of action of antibacterial

1- Bacteriostatic drugs: antibacterial, prevent the active multiplication of bacteria.

2- Bactericidal drugs: Antibacteria kill bacteria.

Some bacteristatic agents become bactericidal when used at higher concentration.

- **Broad-spectrum antibiotics**

Antibiotics which are designed to work against a wide range of bacteria.

- **Narrow-spectrum antibiotics**-

Antibiotics which are only effective against a small range of bacteria.

Mechanisms of antibacterial action

1- Inhibition of cell metabolism

2- Inhibition of bacterial cell wall synthesis.

3- Inhibition of plasma membrane function

4- Inhibition of protein synthesis

5- Inhibition of nucleic acid synthesis

Complications of antibacterial chemotherapy

1- Development of drug resistance 2- Drug toxicity 3- Hyper sensitivity

Antimicrobial Pesticides

Antimicrobial Pesticides divided into three categories:

1- Sterilizers (Sporicides): Will remove all bacteria, fungi, spores, and viruses.

2- Disinfectants: Destroy or inactivate microorganisms (bacteria, fungi, viruses,) but may not act as sporicides.

3-Sanitizers: Reduce the number of microorganisms, but may not kill all of them.

Normal flora

The normal flora is the population of microorganism found growing on the body of healthy individuals. The normal flora include: bacteria, fungi, protozoa, viruses and arthropods.

Sites that harbour a normal flora

Skin and mucus membranes / Respiratory tract / Conjunctiva

Urogenital Tract / Human Oral Cavity / Gastrointestinal Tract

Bacterial Toxins

- ✓ Poisonous substances produced by bacteria.
- ✓ May be named according to what type of cells they attack **Types of Toxins**

1. Endotoxins: part of the outer cell wall of Gram (-) bacteria

2. Exotoxins: secreted outside the bacterial cellmostly seen in Gram (+) Bacteria

Types of Exotoxins

1. Cytotoxins: kill cells

2. Neurotoxins: interfere with normal nerve impulses.

3. Enterotoxins: effect cells lining the gastrointestinal tract (G.I.T).

Mycology

Mycology is the study of fungi (yeast and molds) including their genetic, biochemical properties, taxonomy, their use to humans, food, and poisoning or infection. It is a branch of biology.

Fungus

- A fungus (plural: fungi or funguses) is a member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds (British English: moulds).
- These organisms are classified as a kingdom, Fungi, which is separate from plants, animals, and bacteria. One major difference is that fungal cells have cell walls that contain chitin, unlike the cell walls of plants, which contain cellulose.

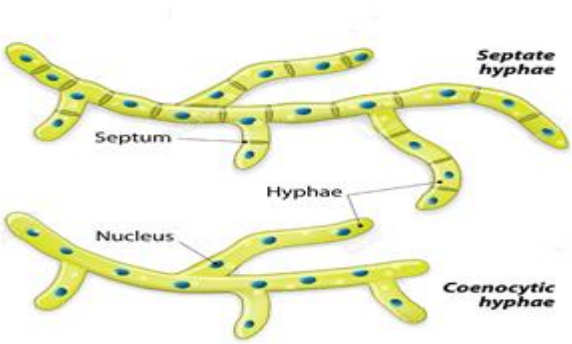
General Characteristics of Fungi

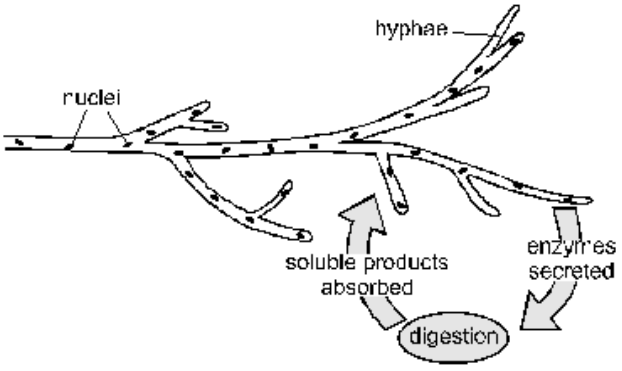
1. All are eukaryotic
2. Most are filamentous and some are unicellular, e.g. yeasts.
3. Protoplasm of a hypha or cell is surrounded by a rigid wall composed primarily of chitin and glucans (some species contain cellulose).
4. Many reproduce both sexually and asexually.
5. Their nuclei are haploid and hyphal compartments are often multinucleate Although some yeasts possess diploid nuclei.
6. All are achlorophyllous: They lack chlorophyll pigments and are incapable of photosynthesis.
7. Possess range of storage compounds such as glycogen and lipids.
8. May be free-living or may form relationships with other organisms

Molds

Hyphae can be either septate or coenocytic:

- **Septate** hyphae are divided into compartments separated by cross walls called septa, that are formed at right angles to the cell wall giving the hypha its shape
- Each hypha compartment containing one or more nuclei;
- **Coenocytic** hyphae are not compartmentalized.
- Septa have pores that allow cytoplasm, organelles, and sometimes nuclei to pass through.





Mold Nutrition

Fungi secure food through the action of enzymes (biological catalysts) secreted into the surface on which they are growing; the enzymes digest the food, which then is absorbed directly through the hyphal walls. Food must be in solution in order to enter the hyphae.

Reproduction of Molds

Molds reproduce primarily by means of asexual reproductive spores

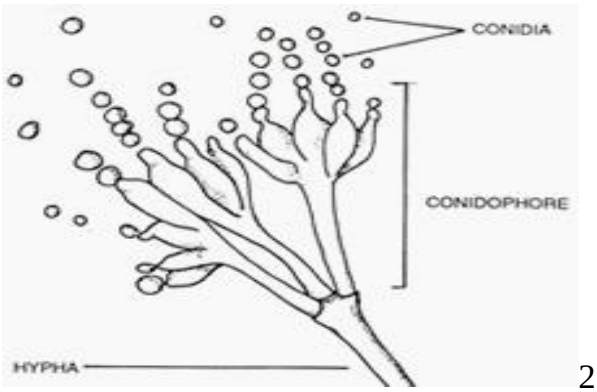
1. Asexual reproductive spores:

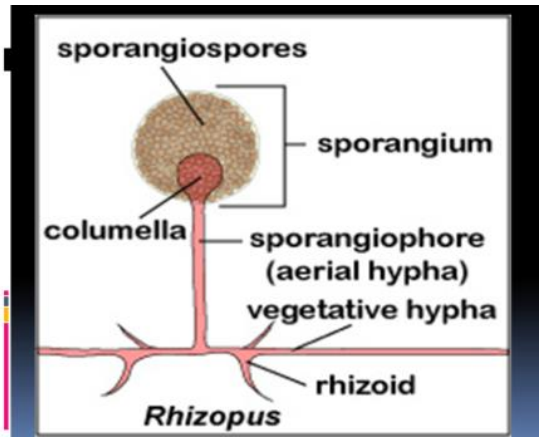
a. Conidiospores (conidia): Spores borne externally on an aerial hypha called a conidiophore

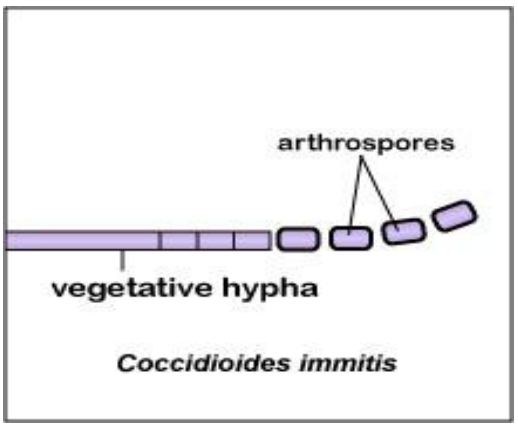
b. Sporangiospores: Spores borne in a sac on an aerial hypha called a sporangiophore.

c. Arthrospores: spores produced by fragmentation of a vegetative hypha.

d. Chlamydospore

1. 

2. 

3. 

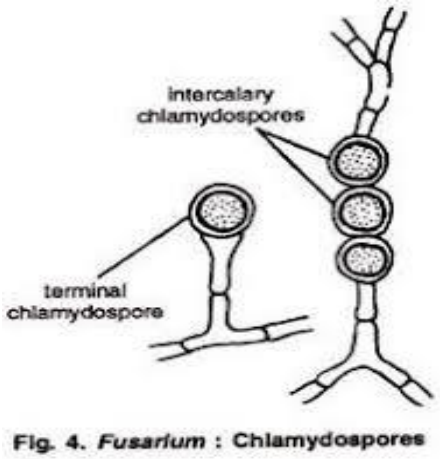
4. 

Fig. 4. *Fusarium* : Chlamydospores

Yeasts

Yeasts are eukaryotic microorganisms. They are unicellular, although some species with yeast forms may become multicellular through the formation of a string of connected budding cells known as pseudohyphae, or false hyphae, as seen in most molds.

Nutrition

Yeasts use organic compounds as a source of energy and do not require sunlight to grow. Carbon is obtained mostly from sugars such as glucose, fructose, sucrose, and maltose.

Growth requirements

Respiration (O_2): Yeast species either require oxygen for aerobic cellular respiration (obligate aerobes) or are facultative anaerobes. Unlike bacteria, there are no known yeast species that grow only anaerobically (obligate anaerobes).

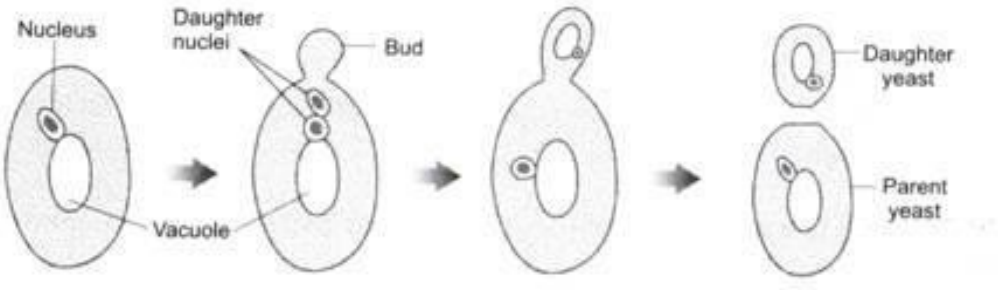
pH : Yeasts grow best in a neutral or slightly acidic pH environment.

Temperature: Yeasts vary in what temperature range they grow best. The cells can survive freezing under certain conditions.

Asexual Reproduction

1- Budding

The daughter cell produced smaller than the mother cell.



2- Fission: creating two identically sized daughter cells.

Kinds of fungi (Classification)

They classified according to their structure and method of reproduction into:

1- Basidiomycota (Club fungi): Ex. Mushroom.

2- Zygomycota (Thread like fungi) : Ex. Bread mold

3- Ascomycota (Sac fungi) Ex. *Penicillium*

4- Deuteromycota (Imperfect fungi)

The Fungi imperfect or imperfect fungi, also known as Deuteromycota, are fungi which do not fit into the commonly taxonomic classifications of fungi because their sexual form of reproduction has never been observed; hence the name "imperfect fungi."

Only their asexual form of reproduction is known, meaning that this group of fungus produces their spores asexually.

Viruses

A **virus** is a small infectious agent that can replicate only inside the living cells of organisms.

Biological (living) characteristics of viruses

1- They multiply within host cells.

2- They possess genetic material, either DNA or RNA.

3- They exhibit mutations.

1- All viruses are obligate parasites

2- They are smaller than bacteria

7- Viruses are effective in very small doses.

Non-living Characters of Viruses

1- They can be crystallized.

2- Outside the cell, they behave like inert chemicals.

3- They do not show growth, development, nutrition, reproduction, etc.

4- Metabolic activities like respiration, photosynthesis are not exhibited by them.

5- Absence of protoplasm and enzyme system

Virus structure

A complete virus particle, known as a **virion**.

- Virion consists of

1- Genetic material (either DNA or RNA).

2- Capsid: a protective coat of protein surrounding the g. m.

- Capsids are formed from protein called capsomeres.

3- Viruses can have Lipid envelope:

Classification of viruses

Viruses classified according to:

1- **Presence or absence of an envelope**

1- Naked 2- Enveloped viruses

2-Nature of the nucleic acid

1- DNA 2- RNA

3- Shape of capsid

Spherical – Rod shape

4-Nature of the host

1- Animal virus 2- plant viruses 3- Bacteriophages.

Types of viruses

1- Phytophages (Plant virus): the viruses which infect plants.

- Most of the plant viruses contain RNA as the genetic material.

- Examples are potato leaf roll virus.

2- Zoophages (Animal virus)

- Animal viruses which infect animals.

- Most of the animal viruses contain DNA as genetic material.

- Examples are Smallpox virus.

3-Bacteriophages also called **phage**, or **bacterial virus**: is any virus that infects bacteria.

- The nucleic acid may be either DNA or RNA.

- Nucleic acid may be double-stranded or single-stranded.

Bacteriophage replication

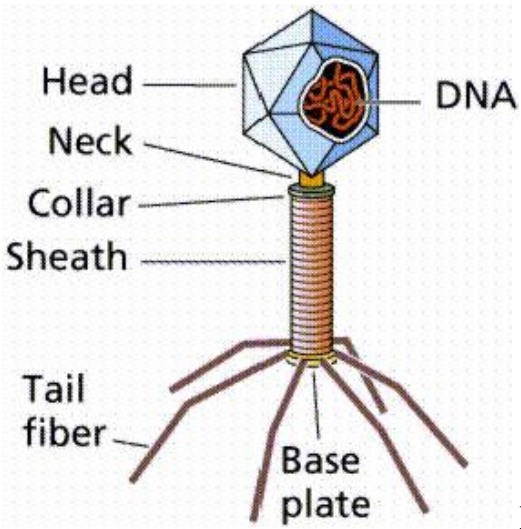
1- Attachment

2- Penetration (DNA injection)

3- After this, a phage follows one of two life cycles.

a. Lytic (virulent): destroy, or lyses, the cell, releasing new phage particles.

b. Lysogenic (temperate): incorporate their nucleic acid into the chromosome of the host cell and replicate with it as a unit without destroying the cell.



Bacteriophage

Vaccine

A **vaccine** is a biological preparation that provides active acquired immunity to a particular disease. A vaccine typically contains an agent that resembles a disease-causing microorganism and is often made from weakened or killed forms of the microbe, its toxins or one of its surface proteins. The agent stimulates the body's immune system to recognize the agent as a threat, destroy it, and recognize and destroy any of these microorganisms that it later encounters.

Types

Inactivated

Some vaccines contain inactivated, but previously virulent, micro-organisms that have been destroyed with chemicals, heat, radiation, or antibiotics. Examples are influenza, cholera and polio.

Attenuated

Some vaccines contain live, attenuated microorganisms. Many of these are active viruses that have been cultivated under conditions that disable their virulent.