INTRODUCTION TO MICROBIOLOGY (Lesson 1)

Microbiology

Is the study of microscopic / tiny organisms that are too small to be seen with the naked eye; and deals about with their reproduction, physiology, and participation in the process of nature that are either helpful or harmful relationship with other living things; and their significance in science and industry.

Subdivision of microbiology includes;

1. Bacteriology that deals with bacteria
2. Mycology deals about fungi
3. Virology deals about viruses.

History of Microbiology

Mankind has always been affected by diseases which were originally believed to be visitations by the godess and meant to punish evil doers

Hippocratus, father of medicine, observed that ill health had nothing to do with godess; instead, they resulted from a change in air, winds, water, climate, food, nature of soil and habits of people.

Antony Van Leeuwenhoek (1632-1723), Is known as the father of Microbiology for having discovered the use of hand lance to describe the shapes of bacteria.

Louis Pasteur (1822-1895) discovered;

i. Microbial theory of fermentation
ii. Principles and practice of sterilization and pasteurization
iii. Control of diseases of silk worms
iv. Development of vaccines against anthrax and rabies
v. Discovery of streptococci

Robert Koch (1843- 1910) observed and postulated that for ill health to occur;

1. Micro-organism must be found in every case of the disease under conditions which explain the pathological changes and clinical features
2. It must be possible to isolate the causative agent in pure culture from the lesion / wounds
3. And that when such pure culture is inoculated into appropriate laboratory animal, the lesion of the disease should be reproduced
4. It should be possible to re-isolate the bacterium in pure culture from the lesion produced in the experimental animal

Microorganisms are classified into two major categories

1. Prokaryotic cell (Simple cells)
2. Eukaryotic cell (Complex cells)

Features

Prokaryotic cells		**Eukaryotic cells**
Size	1μm	10μm
Nuclear membrane	Absent	Present
Chromosome	Single	Multiple
Nucleolus	Absent	Present
Histones	Absent	Present
Sexual reproduction	Absent	Present
Cytoplasmic ribosomes	70s	80s
Mitochondria	Absent	Present
Endoplasmic reticulum:	Absent	Present
Lysosomes	Absent	Present
Micro filaments and Tubules:	Absent	Present
Site of oxidative Phosphorylation:	Cell membrane	Mitochondria
Site of photosynthesis:	Cell membrane	Chloroplast
Peptidoglycan:	Present	Absent
Cell membrane		

composition: Phospholipids & Proteins Sterols

Bacterial Cell General Property

1. Are typical prokaryotic cell
2. Contain both DNA and RNA
3. Majority grow in artificial media
4. Replicate by binary fission
5. Almost all possess rigid cell wall
6. Sensitive to antimicrobial agent.

Classification of bacteria (Lesson 2)

1. **Classification based on Gram Stain property**

- Is laboratory staining procedure that classifies and differentiate clinically important bacteria into two group; either as **Gram positive or negative** based on their morphology and differential staining properties?

Gram staining techniques

. Specimen or culture sample is smeared on a glass slide and air dried.

.Dried slide is placed on a staining rack and sequentially stained with crystal violet, iodine, then decolorized with alcohol and counter-stained with safranin or neutral red.

.Stained slides are then dried and examined under microscopy for the presence of gram positive and gram negative bacteria.

- Gram positive bacteria stain blue-purple and Gram negative bacteria stain red.
- The difference between the two groups is believed to be due to a much larger peptidoglycan (cell wall) in Gram positives.

2. **Classified based on shapes / Morphology**
   A) Cocci: These types of bacteria are unicellular, spherical or elliptical shape. Either they may remain as a single cell or may aggregate together for various configurations.

They are as follows:

- **Monococcus:**– Also called micrococcus and represented by single, discrete round cell. Example: *Micrococcus flavus*.
- **Diplococcus:** – the cell of the Diplococcus divides ones in a particular plane and after division, the cells remain attached to each other. Example: *Diplococcus pneumonia*.
- **Streptococcus:** – here the cells divide repeatedly in one plane to form chain of cells. Example: – *Streptococcus pyogenes*.
- **Tetracoccus:** – this consists of four round cells, which defied in two planes at a right angles to one another. Example: – *Gaffkya tetragena.*

Staphylococcus: – here the cells divided into three planes forming a structured like bunches of grapes giving and irregular configuration. Example: – *Staphylococcus aureus*.

- **Sarcina:** -in this case the cells divide in three planes but they form a cube like configuration consisting of eight or sixteen cells but they have a regular shape. Example: –*Sarcina lutea*.

B) Bacilli: – Are rod shaped or cylindrical bacteria which either remain singly or in pairs. Example: –*Bacillus cereus*.

C) Vibro: – Are the curved, comma shaped bacteria and represented by a single genus. Example: – *Vibro cholerae*.

D) Spirilla: – Are spiral or spring like with multiple curvature and terminal flagella. Example: –*Spirillum volutans*.

3. Classified based on Mode of Nutritional requirements

1. **Phototrophs:** bacteria which gain energy from light.

Are further divided into two groups on the basis of source of electron.

- **Photolithotrophs:** these bacteria gain energy from light and uses reduced inorganic compounds such as H2S as electron source. Eg. *Chromatium okenii.*

- **Photoorganotrophs:** these bacteria gain energy from light and uses organic compounds such as succinate as electron source.

2. **Chemotrophs:** bacteria that gain energy from chemical compounds and cannot carry out photosynthesis.

   Are further divided into two groups on the basis of source of electron.

- **Chemolithotrophs:** they gain energy from oxidation of chemical compound and reduces inorganic compounds such as NH3 as electron source. Eg. *Nitrosomonas.*
- **Chemoorganotrophs:** they gain energy from chemical compounds and uses organic compound such as glucose and amino acids as source of electron. eg. *Pseudomonas pseudoflava.*

3. **Autotrophs:** Are bacteria which uses carbondioxide as sole source of carbon to prepare its own food.

   Are further divided into two types on the basis of energy utilized to assimilate carbondioxide. ie. Photoautotrophs and chemoautotrophs.

- **Photoautotrophs:** they utilized light to assimilate CO2. They are further divided into two group on the basis of electron sources. Ie. **Photolithotropic autotrophs** and **Photoorganotropic autotrophs**

- **Chemoautotrophs:** They utilize chemical energy for assimilation of CO2.

4. **Heterotrophs:**Those bacteria which uses organic compound as carbon source and lack the ability to fix CO2.

- Most of the human pathogenic bacteria are heterotropic in nature.
- Some heterotrops are simple, because they have simple nutritional requirement. However there are some bacteria that require special nutrients for their growth; known as fastidious heterotrophs.

4. Classified on the Basis of Temperature Requirement

a).Psychrophiles:

- Bacteria that can grow at 0°C or below but the optimum temperature of growth is 15 °C or below and maximum temperature is 20°C are called psychrophiles
- Psychrophiles have polyunsaturated fatty acids in their cell membrane which gives fluid nature to the cell membrane even at lower temperature.
- Examples: *Vibrio psychroerythrus, vibrio marinus, Polaromonas vaculata, Psychroflexus.*

b). Psychrotrops (facultative psychrophiles):

- Those bacteria that can grow even at 0°C but optimum temperature for growth is (20-30)°C

c). Mesophiles:

- Those bacteria that can grow best between (25-40)^{o} C but optimum temperature for growth is 37C
- Most of the human pathogens are mesophilic in nature.
- Examples: *E. coli*, *Salmonella*, *Klebsiella*, *Staphylococci.*

d). Thermophiles:

- Those bacteria that can best grow above 45C.
- Thermophiles capable of growing in mesophilic range are called facultative thermophiles.
- True thermophiles are called as Stenothermophiles, they are obligate thermophiles,
- Thermophils contains saturated fattyacids in their cell membrane so their cell membrane does not become too fluid even at higher temperature.
- Examples: *Streptococcus thermophiles*, *Bacillus stearothermophilus*, *Thermus aquaticus.*

e). Hypethermophiles:

- Those bacteria that have optimum temperature of growth above 80C.
- Mostly Archeobacteria are hyperthermophiles.
- Monolayer cell membrane of Archeobacteria is more resistant to heat and they adopt to grow in higher remperature.
- Examples: *Thermodesulfobacterium*, *Aquifex*, *Pyrolobus fumari*, *Thermotoga.*

5. Classified based on the Basis of Oxygen Requirement

Obligate Aerobes:

- Require oxygen to live.
- Example: *Pseudomonas*, common nosocomial pathogen.

Facultative Anaerobes:

- Can use oxygen, but can grow in its absence.
- They have complex set of enzymes.
- Examples: *E. coli*, *Staphylococcus*, yeasts, and many intestinal bacteria.

Obligate Anaerobes:

- Cannot use oxygen and are harmed by the presence of toxic forms of oxygen.
- Examples: *Clostridium* bacteria that cause tetanus and botulism.

Aerotolerant Anaerobes:

- Cannot use oxygen, but tolerate its presence.
- Can break down toxic forms of oxygen.
- Example: *Lactobacillus* carries out fermentation regardless of oxygen presence.

Microaerophiles:

- Require oxygen, but at low concentrations.
- Sensitive to toxic forms of oxygen.

- Example: *Campylobacter*.

6. Classified based on the Basis of pH of Growth

1. **Acidophiles:**

- These bacteria grow best at an acidic pH.
- The cytoplasm of these bacteria are acidic in nature.
- Some acidopiles are thermophilic in nature, such bacteria are called Thermoacidophiles.
- Examples: *Thiobacillus thioxidans, Thiobacillus, ferroxidans, Thermoplasma, Sulfolobus*

2. **Alkaliphiles:**

- These bacteria grow best at an alkaline pH.
- Example: *Vibrio cholerae* optimum ph of growth is 8.2.

3. **Neutrophiles:**

- These bacteria grow best at neutral pH (6.5-7.5).
- Most of the bacteria grow at neutral pH.
- Example: *E. coli*

7. Classified based on the Basis of Osmotic Pressure Requirement

Halophiles:

- Require moderate to large salt concentrations.
- Cell membrane of halophilic bacteria is made up of glycoprotein with high content of negatively

charged glutamic acid and aspartic acids. So high concentration of Na+ ion concentration is required to shield the –ve charge.

- Ocean water contains 3.5% salt. Most such bacteria are present in the oceans.
- *Archeobacteria, Halobacterium, Halococcus.*

Extreme or Obligate Halophiles:

- Require a very high salt concentrations (20 to 30%).
- Bacteria in Dead Sea, brine vats.

Facultative Halophiles:

- Do not require high salt concentrations for growth, but tolerate upto 2% salt or more.

8. Classified based on the Basis of Number of Flagella

On the basis of flagella the bacteria can be classified as:

1. **Atrichos: –** These bacteria has no flagella. Example: *Corynebacterium diptherae*.
2. **Monotrichous:** – One flagellum is attached to one end of the bacteria cell. Example: – *Vibro cholerae*.
3. **Lophotrichous: –** Bunch of flagella is attached to one end of the bacteria cell. Example: *Pseudomonas*.
4. **Amphitrichous:** – Bunch of flagella arising from both end of the bacteria cell. Example: *Rhodospirillum rubrum.*

5. **Peritrichous :** – The flagella are evenly distributed surrounding the entire bacterial cell.
   Example: *Bacillus.*

9. Classification of Bacteria on the basis of Spore Formation

1. **Spore forming bacteria:**

- Those bacteria that produce spore during unfavorable condition.
- These are further divided into two groups:

i) Endospore forming bacteria: Spore is produced within the bacterial cell.

Examples. *Bacillus, Clostridium, Sporosarcina* etc

ii) Exospore forming bacteria: Spore is produced outside the cell.

Example. *Methylosinus*

2. **Non sporing bacteria:**

- Those bacteria which do not produce spores. Eg. *E. coli, Salmonella.*