Microbiology

→ Study of microorganisms below 1mm dimension.
→ Se'dillot (1878) → coined term microbes for microorganisms.
→ living organisms of microscopic dimension.
→ Not seen by nacked eye. → Seen with help of compound microscope.

→ 1590 → Jenser & Jenser developed compound microscope.
→ 1676 → Leeuwenhoek → developed own microscopes.
→ 1830 → Robert Hooke → improved microscopes.

Branches of Microbiology

- Virology → study of Viruses
- Bacteriology → study of Bacteria.
- Micro Phycology → Study of microscopic algae.
- Micro Mycology → study of microscopic fungi.
- Protozoology → Study of Protozoans.

Actions of Microbes

→ Source of food.
→ Increase fertility of soil.
→ source of medicines.
(Transformation of chemical structure of drugs).
→ Sewage treatment → Decay dead waste materials.
→ extraction of metals from ore → Copper, Uranium.
→ cause diseases.
→ Spoilage of food.

Bacteria

→ microscopic organism. → seen by Electron Microscope.
→ study under Microbiology. → scientists called as Microbiologist
→ Prokaryotic unicellular living organisms.
→ simple nucleus – no nucleolus & nuclear membrane
→ A teaspoon of soil contains billions of bacteria.
→ A gram of good soil contains atleast 5 million bacteria.
→ Progenote → Ancestor of Bacteria. → First form of life on earth
→ Louis Pasteur → Father of Bacteriology.

Size

→ Smallest → [redacted] → (Cocci → 0.1 μ to 10 μ)
→ (μ = μm = micron = 0.001 mm).

[redacted] → 100 μm → Actinomycetes.
→ 500 μm → Oscillatoria (Cyanobacteria)
→ 600 μm → Epulopsicum fishelsoni (found in intestine of surgeon fish).

→ largest. → several cm long → Ex → Beggiatoa miralilis.

Habitat

→ omnipresent → present everywhere → in soil, air & water. → Freely disperse by air current
→ Grows well in organic humus containing soil → in Acidic medium
→ Also tolerate high salt conc or alkaline medium.

→ survive at very low temp. → Psychrophillic → in
- Icebergs
- deep ocean's floor.
- → in Liquid oxygen (−190°C).

→ survive at high temp. – Thermophillic → in
- hot springs
- deserts

→ Found at 16 ft low in soil.
→ Found in [redacted] hundred feet up in Atmosphere
- Found in hail stone also.

→ Endophyte → absorbs in cattle (Cow, Buffaloes) → guts of cattle. → rumen → Anaerobic.
→ convert → CO_2 into methane as biogas from dung.
Ex: Methanogens

Colour

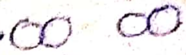
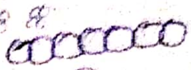
→ Generally colourless, but → Yellow → Sulphur Bacteria
→ Brown → Iron Bacteria.

Morphological Types of Eubacteria — (unicellular + filamentous (Actinomycetes))

① <u>Coccus</u> — spherical

— ⓐ Micrococci → 

due to non-separation of daughter cells:

- ⓑ Diplococcus → 
  - (b-1) Tetracoccus
- ⓒ Streptococcus → 
- ⓓ Strephyllococcus →  — clusters
- ⓔ Sarcina →  — bacterial cells form cubical mass. (clusters)

② <u>Bacillus</u> — rod-shaped. — majority of bacteria are rod-shaped.

Ⓐ flagellate (Trichous) — flagella for swimming.

- ⓐ Monotrichous →
- ⓑ Lophotrichous →
- ⓒ Amphitrichous (Bipolar) →
- ⓓ Peritrichous →

Ⓑ Non-flagellate (Atrichous)

- ⓐ microbacilli
- ⓑ Diplobacillus
- ⓒ Streptobacillus
- ⓓ Strephyllobacillus.

③ <u>Spirillum</u> → spiral shaped — spirochaete, spirillum

- ⓐ Flagella present
- ⓑ flagella absent.

④ <u>Vibrio</u> → comma shaped, curved — flagellate, monotrichous.

→ mycelial or filamentous → Actinomycetes.

⑤ Mycelial (Actinomycetes) — Filamentous (remain in chain of rod-shaped) — very hard cell-wall.

SQ: ⑥ Fusiform — stalked. — Iron Bacteria — sometimes forms rosettes — eg caulobacter

⑦ Helical — thin cell wall, flagella absent. eg: Jaundice, Syphilis bacteria.

Bacterial cell structure

→ Prokaryotic unicellular organism without nucleus & nuclear membrane.
→ Seen by Electron Microscope.
→ All membrane bound cell organelle are absent.
(Mitochondria, Golgi body, ER, Plastid, Endoplasmic reticulum, Lysosome absent)
→ Non-histone protein only found in nucleic acids (Histone absent)

① **Flagella** → Made up of flagellin protein. → are 2 or more in number.
→ Attached with cell membrane. → Larger than bacterial cell.
→ For movement, reverse attachments with tether during reproduction.

② **Pilli or Fimbriae** → made up of Pilin protein.
→ Specially present in Gram(-) bacteria.
→ Cover all layer of bacterial cell envelop.

③ **Glycocalyx** → Made up of Mucopolysaccharide (Glycosaccharide)
(most of the bacteria have Gummy cover)

(A) **Slime layer** → Loose Glycocalyx → Slime. → Protective & for adhesion.
→ Gummy & Sticky character. → Protects cell from loss of water & nutrients.
→ Found in aquatic bacteria.

(B) **Capsule** (Protein + Polysaccharides) → Hard Glycocalyx → Tough → Found in terrestrial bacteria
→ Thick → Macrocapsule
→ Thin → Microcapsule. → Protects bacteria from Phagocytosis.

④ **Cell wall** → Hard, rigid, permeable
→ Outer layer of cell wall is made up of Lipopolysaccharide (help in adhesion)
→ made up of Murein or Chitin → Mucopeptide or Peptidoglycan (Protein + Mucopolysaccharide) (Protein + Acetyl acid)
→ well protected cell wall, protects cell form collapse or burst in hypotonic solution.
→ Cellulose is found in Acetobacter cell wall.
→ Muramic acid & Amino acid → present in cell wall of E.coli.

⑤ **Cell membrane**
→ A complex cell wall with periplasmic spaces.
→ Lipids + Teichoic Acid → may remain present in cell wall.
→ Peptidoglycan - repeating frame work of long glycan strands cross linked by short peptide bonds.
→ N-acetyl muramic acid
→ N-acetyl glucosamine

⑥
→ Bacteria without wall ⇒ Mycoplasma.
→ L-form - Spheroplast - reproduce as damaged cell wall.
→ Protoplast - bounded by plasmalemma.
→ PPLO - Pleuro-pneumonia like organisms

⑦ **Cell membrane** (Protein + Phospholipid) → Cytoplasmic membrane is made up of Lipoprotein.
→ Contains → respiratory enzymes.

⑧ **Photosynthetic apparatus** → Lamella & chromatophores (Thylakoid)
- Also called as Bacteriochlorophyll.
- found in photosynthetic forms.
→ only light reaction no dark reaction.

⑦⑧ **Mesosome** → Plasma membrane forms mesosome.
→ functions - Respiration, cell plate formation during reproduction.

⑨⑩ **Ribosome** - 70 S (Sedimentation co-efficient) ribosome found free in protoplasm → functions for protein synthesis.
→ appears scattered in protoplasmic matrix.
→ Protoplasm remain granular due to presence of ribosome.

⑨⑥ **Protoplasm** → Granular.

(10) Bacterial chromosome

→ Also called as Nucleoid or Nucleophore.
→ a naked, circular and coiled segment of double helical DNA remain present as bacterial chromosome.
→ Remain attached to cell membrane at a point.
→ 1.2 mm long in E. Coli
→ Function as nucleus.
→ Nuclear membrane & nucleolus absent.
→ Made up of DNA with Histone protein ~~(Non-histone)~~
→ Bacterial chromosome is a covalently closed, circular structure, consisting of several loops of supercoiled DNA.
→ Positively charged ions of protein help them to counter balance the negative charge of phosphate groups of DNA.

(11) Extra ~~Nuclear~~ Chromosomal nucleid acids :→ Both DNA & RNA prese

(a) DNA → Extra chromosomal DNA also present.

(i) Plasmid :- Extra-chromosomal DNA segment is called as Plasmid. → F-gene-plasmid - rapid sexual tendency
- Sexual gene in E. coli
→ Plasmid forms sheath against drug.

(ii) Cosmid - circular Plasmid.

(iii) Episome - Plasmid associated with bacterial chromosome

(b) RNA → RNA present in protoplasm.

(12) Vacuoles :-

(i) Liquid vacuoles :-

(a) Reserve food vacuole.
→ Volutin granules, oil granules, sulphur granules
→ Glycogen, Protein (Non-histone)

(b) Excretory vacuole

(ii) Gas Vacuole :-

Bacterial Techniques

⇒ **Bacterial Culture** (Robert Koch) Technique

→ Louis Pasteur → Father of Bacteriology.
→ developed culture technique & method of pasteurization.

→ A pure culture is one that contains multiple copies of a single kind of bacteria.

⇒ Pure culture → Group of bacterial of same strain is called as Pure Bacterial colony.

⇒ Mixed culture → Group of different strains of bacteria is called as "Mixed Bacterial colony".

⇒ **Gram Staining Technique** → Christian Gram (1884).

— Technique of staining of bacterial cell wall to classify bacteria into Gram(+) and Gram(−) strains.

Bacterial Colony ⇒ Stained with weak alkaline solution of Crystal violet or Gentian Violet dye ⇒ All Bacteria Blue coloured ⇒ Treated with 5% Iodine (KI or KOH) Solution

⇓

Washed by water

⇓

Washed by different liter gradually increasing conc. of Alcohol or Acetone upto absolute.

⇒ Bacteria differentiate into two colours.

→ Retain colour → Gram(+)
→ less resistant more susceptible.
→ Thick cell wall (20–80 nm thick) with less lipid. made up of Peptidoglycan (Polysaccharide + Polypeptide)
→ Also have tightly bounded Teichoic acid.

→ Loose colour → Gram(−)
→ After further staining with Safranin.
→ cell wall double layered. → Thin cell wall with more lipid.
— outer → Lipopolysaccharide + Porein protein. (for adhesion purpose).
— Inner → Thin → Protein & Peptidoglycan.

Bacteria

Life Style (mode of nutrition) →
→ Nutrients → materials used for building and organising the structure of organisms.

(A) Autotrophic : →
→ Live on inorganic compounds as source of carbon and forms organic compound (Lithotroph)

(i) Photosynthetic → use radiant energy → 730 nm wavelength light is most suitable for bacterial photosynthesis

(a) oxygenic → Release O_2 gas.
→ Ex - cyanobacteria, Rhodospirillum
$CO_2 + H_2O \xrightarrow{light}$ Sugar $+ O_2 \uparrow$

(b) Anoxygenic → Release sulphur, water, other oxidised compounds
→ Ex - Rod, Cocci, Spirilla, Sulphur bacteria.
→ Found at low level of pond, where H_2S remain present
$CO_2 + H_2S$ (or a form some other) $\xrightarrow{light}$ Sugar + Sulphur & organic compounds

(ii) Chemosynthetic → use chemical energy, energy from oxidation of inorganic substances (not light energy) for synthesis of food.

(B) Heterotrophic : →
→ Live on organic compound as source of carbon (Organotroph)
→ Vast majority of bacteria are heterotrophs.

(i) Symbiotic → Rhizobium, E. coli, cyanobacteria.
→ cyanobacteria with fungi.
→ bacteria with body wall of legume.

(ii) Parasitic → Pathogenic - cause diseases of plants & animals.

(iii) Saprophytic → Decay dead organic matter.

→ Specific bacteria are involved in the oxidation of specific inorganic substances

(a) Nitrifying bacteria
→ Ammonia (NH_3) + $1\frac{1}{2}$ ammonia O_2 → HNO_2^- (Nitrite) + H_2O + H^+ + energy → Nitrosomonas
→ NO_2 (Nitrite) + $\frac{1}{2} O_2$ → NO_3^- (Nitrate) + energy. → Nitrobacter.

(b) Denitrifying bacteria
→ $NO_3^- \rightarrow N_2 \uparrow$ → Bacillus denitrificans (anaerobic)

(c) Sulphur bacteria → Thiogenic → Photoautotrophic
$S + H_2O + 1\frac{1}{2} O_2 \rightarrow H_2SO_4$ + energy → Thiobacillus thio-oxidans.
$H_2S + O \rightarrow H_2O + S$ + energy → H_2S - Hydrogen donor - Beggiatoa

(d) Iron bacteria → Prrogenic
Fe^{++} (Ferrous) → $Fe^{+++} + e^-$ (Ferric) → Ferrobacillus.

(e) Carbon Monoxide Bacteria → Carboxydomonas → $2CO + O_2 \rightarrow 2CO_2$ + Energy.

(f) Hydrogen Bacteria → Hydrogenomonas → $4H_2 + CO_2 \rightarrow CH_4 + 2H_2O$ + energy

(g) Methane bacteria → Methanococcus → Anaerobic
$CH_4 \rightarrow CO_2$ (anaerobic)

(h) Luminescence bacteria → Produces Lucifein → a light emitting substance.

Bacterial Respiration

1) Anaerobic → In absence of O_2 gas, molecules O_2 is used in oxidation of food (fermentation)
   $C_6H_{12}O_6$ → [illegible]
   → [illegible]
2) Aerobic → O_2 is essential → [illegible]
   → [illegible]
3) Facultative or obligate → can survive in both conditions

Classification of Bacteria

- → All Bacteria represents Monera Kingdom
- → [illegible] species reported.
- → Classification is based on homology, phylogeny, ecological role, structural, physiological characters and chemotaxonomy (Biochemical & molecular structures)

- → Leeuwenhoek (1675) - discovered bacteria [illegible]
- → Ehrenberg (1829) - coined the term bacteria
- → Cohn (1872) - called it [illegible]

(1) Archaebacteria

→ Commonly called as 'Ancient bacteria'.
→ Anaerobic bacteria (CO_2 → methane, CH_4).
→ Myxobacteria - movement by gliding ?
→ Have rigid cell wall to adapt with adverse conditions of habitat

Habitat
→ Halophiles → salty areas
→ Thermoacidophiles → hot springs
→ Methanogens → marshy areas

(2) Eubacteria

→ Commonly called as 'True bacteria'
→ [illegible]
→ Cell wall is made up of murein with additional covering layer of lipids.

(3) Cyanobacteria

→ Commonly called as 'Blue Green algae'.
→ Photosynthetic bacteria → Photosynthetic autotroph
→ Oscillatoria (Nostoc) → Filamentous (looks like a multicellular org.)
→ Nostoc - Colonial, Anabaena, [illegible]
→ Spirulina - Solitary, Chlorella
→ Spirochete - movement by gliding.

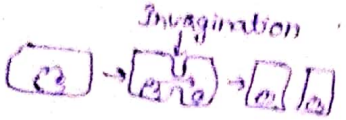
→ Fixes N_2 with the help of - Heterocyst cells.
[illegible]

Bacterial Reproduction

→ Bacteria reproduce by all the known methods of reproduction
— by quick reproduction → quick spread of diseases & rapid spoilage of food.

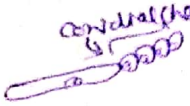
Ⓐ Asexual Reproduction → By following methods:—

① Fission → Most common method of reproduction in bacteria
— In favourable condition, at every 20 minutes, bacteria divide by cell division after replication of DNA
→ By Binary or Transverse fission
→ Bacteria is also called as 'Fission Fungi'
→ In — Coccus, Bacillus.



② Fragmentation → After break by external force.

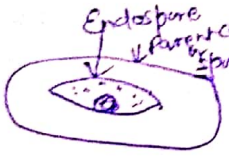
③ Bud formation → Solitary bud (spore) is formed.
— In Rhodomicrobium, Rigidi bacterium.



④ Conidia formation → conidia (spore) formed in chain
→ In Actinomycetes (Filamentous form).

Ⓑ In unfavourable condition bacteria reproduce asexually →

① Endospore formation



→ one spore (endospore) is formed, after dissolution of flagella, centrally by one bacteria within parent cell.
→ Now parent cell is called as Sporangium.
→ In suitable condition imbibe water & becomes active.
→ very resistant spore → survive at even 100°C, drought, high pH and acidic conditions.
→ In Clostridium tetani.

② ~~Cyst formation~~ Zoospore formation → In Rhizobium.
→ Motile zoospores produced after death of host.

③ Cyst formation → Whole cell forms cyst.
→ A rigid layer covering cell-wall is formed in adverse conditions
→ Less resistant than Endospore.
→ In Mycelial bacteria → Produced in hundreds in number
→ In Myxococcus, Azetobacter.

Genetic recombination in bacteria

→ The genetic information of bacteria is stored in
(a) A single main chromosome, carrying a few thousand genes
(b) Episomes and plasmids — they exist in bacterial cytoplasm
- Plasmids are highly variable in size having three genes to several hundred genes.
- As many as 11 different plasmids are found

→ The chromosome of bacteria are not enclosed in N.M.
→ Nuclear region of bacteria is called Nucleoid.
→ The bacterial chromosome do not go through mitotic or meiotic
→ Recombination is important in the evolution of bacteria

⇒ On the basis of the mode of transfer of DNA from one cell to another in bacteria, there are following processes:—

(1) Transformation
(2) Conjugation
(3) Transduction
(4) Sex-duction

Scanned with CamScanner

(1) Transformation

→ Involves the uptake of naked DNA molecules from the environment (the donor) by another bacterium (recipient) enzymatically digested

→ cell called competent

→ Firstly discovered by Griffith in 1928 in Streptococcus pneumoniae

→ The process of transformation can be divided into several steps

(A) Reversible binding of double stranded DNA to receptor sites

(B) Irreversible uptake of the donor DNA

(C) Conversion of the double stranded donor DNA molecules to single stranded molecules by nucleolytic degradation of one strand

(D) Integration of the single strand of donor DNA into the chromosome of the recipient.

→ DNA translocase pulls one strand of donor DNA into the cell using energy derived from the degradation of the complementary strand.

(E) The segregation & phenotypic expression of the integrated donor gene or genes in the recombinant (transformed) cells.

(1) Conjugation

→ Here gene is shifted in male cell is transferred to a recipient or female cell through a specialized tube called conjugation tube.

→ cell contact is required

→ discovered in 1946 by J. Lederberg and E. Tatum.

→ During conjugation, DNA is transferred from a donor cell to a recipient cell through a specialized intercellular connection or conjugation tube, that forms between them.

→ The donor and recipient cells are sometimes referred to as male and female cells, respectively.

→ The transfer of genetic information is thus a one-way transfer during conjugation, just as in transformation and transduction, rather than a reciprocal exchange of genes or material.

→ cells carrying an F factor or sex factor or fertility factor are termed — form conjugation tube and initiate with transfer after making contact with cells not carrying an F-factor, called F⁻ cells (recipient cells).

→ F factor can exist in autonomous state (replicate independently or integrated state, and replicate with host chromosome.

→ A donor cell containing the F-factor in the autonomous state is called an F⁺ cell. When an F⁺ donor cell conjugates with an F⁻ recipient cell, only the autonomous F-factor is transferred. Both become F⁺ ~~because~~. Thus, raising a population of F⁺ cells with a population of F⁻ results in virtually all of the cells in the new population becoming F⁺.

→ A cell carrying an integrated F factor is called an Hfr.

Recombination

→ conjugative transfer of donor chromosomal genes carried by F factor to recipient cell is called Sex-duction.

→ occasionally, excisions of the F factor from Hfr chromosome occur, producing recombinant F factor called F' factor, that carry chromosomal genes.

→ the new DNA strand displaces a segment of the recipient chromosome and the displaced segment dissolves.

(c) Transduction

→ Occurs when bacterial genes are carried from a donor cell to a recipient cell by a bacteriophage

→ Cell contact is not required

→ discovered by N. Zinder and J. Lederberg in 1952

→ Bacteriophage particle carries a segment of the chromosome from one bacterium (donor) to another bacterium (recipient)

Types :-

(1) Generalized transduction

Any portion of the donor genome is transferred

→ transfers any gene of the donor cell to the recipient cell [illegible]

→ transducing particle contains only one segment of host DNA

→ After a transducing particle (phage) injects a fragment of host DNA into a recipient cell, that DNA may either

(1) be integrated into the host, or

(2) remain free in the cytoplasm

- If it is not integrated, it will not replicate and will be transmitted to only one progeny cell during each division

- non-integrated genes may be expressed

(2) Specialized transduction (restricted transduction)

→ only some genetic markers are transferred

→ S.T. transducing particles always contain both phage and bacterial DNA

→ bacteriophage lambda usually mediates transduction of only the 'gal' and 'bio' genes of E. coli.

→ is mediated by temperate bacteriophages whose chromosomes are able to integrate into the host chromosome, i.e. they are examples of genetic elements called episomes

G.T. [→ recombination replaces a segment of the recipient's chromosome with a segment of the donor's chromosome

→ In S.T., the segment of donor DNA and the phage chromosome to which it is covalently attached are added to the recipient's chromosome, producing a partially diploid transductant.