

5. LAB refers to . . .
 1. Locally Available Bacteria
 2. Lactic Acid Bacteria
 3. *Lactobacillus* species
 4. Locally Active Bacteria
 6. LAB convert milk into curd and also improve quality by enhancing the content of . . .
 1. Vitamin B₆
 2. Protein
 3. Vitamin B₁₂
 4. Vitamin B₂
 7. Assertion(A): *Bacillus thuringiensis* can be called bioinsecticide.
Reason (R): It is used as biocontrol against insect pests
- LEVEL - II**
8. Biogas, which is used as a fuel produced by microbial activity is chemically . . .
 1. Ethane
 2. Methane
 3. Carbon -di-oxide
 4. Sulphur
 9. Exomicrobiology deals with . . .
 1. Study the microorganisms that grow only in outer space.
 2. Study of life in outer space.
 3. Use of microbes in the study of life in outer space.
 4. Study of microbes present on the surface of earth.
 10. Microorganisms growing in oceans can be referred to as . . .
 1. thermophilic organisms
 2. halophilic organisms
 3. acidiphilic organisms
 4. alkalophilic organisms
 11. Which of the following plants is in cultivation in our country that contains the toxin producing genes of *Bacillus thuringiensis*?
 1. Mango
 2. Rice
 3. Cotton
 4. Wheat

2.2. BACTERIA

SYNOPSIS

Introduction

- Unicellular microscopic prokaryotic cellular organisms that cause diseases in plants and animals are **Bacteria**.
- Bacteria were first observed and reported by **Anton van Leeuwenhoek**.
- Anton van Leeuwenhoek described bacteria as **Animalcules**.
- **Ehrenberg** first called them as **Bacteria**.
- The pathogenic nature of bacteria in case of plants, animals and human beings was observed by **Louis Pasteur and Robert Koch**.
- The Branch of science that deals with the study of bacteria is known as - **Bacteriology**.
- Bacteria are placed under the kingdom Monera in a single class Schizomycetes.

Distribution and Habitat

- Bacteria are ubiquitous (cosmopolitan in distribution)
- Root Nodules of legumes are formed by *Rhizobium*
- common inhabitant of human intestine is *E. Coli*
- *Thiomargarita namibiensis* forms *Streptococcus*.

Size

- Majority of the bacteria are in the range of **.0.5 - 1.0 × 2.0 - 5.0 μ** in length
- Bacteria are not visible under light microscope
- Huge bacterium is ***Epulopiscium fishelsoni*** (rod shaped) discovered in the intestine of Brown Surgeon fish
- A brown surgeon fish is *Acanthurus nigrofusus*.
- This bacterium ranges from **200 to 500 μm** in length.
- The largest bacterium is *Thiomargarita namibiensis* (spherical shaped)
- This bacterium has been discovered in Ocean sediment off the coast of Namibia

Shape

According to the shape, The bacteria are divided into the following types.

1. Coccus (Pl. Cocci)

- Spherical bacteria are called **Cocci**.
- Based on the number and arrangement of cells cocci bacteria are divided into 6 types as follows.
 - a) Monococcus : A single spherical bacterium.
 - b) Diplococcus : A pair of spherical bacterium.
 - c) Tetracoccus : A group of four spherical bacteria
 - d) Streptococcus : A chain of spherical bacteria arranged in a single row.
 - e) Staphylococcus : A group of cocci bacteria forming irregular shapes.
 - f) Sarcina : Cocci arranged in cubes of eight.

2. Bacillus

- Rod shaped bacteria are called **bacilli**. These are of three types.
 - a) Monobacillus : A single rod shaped - bacterium.
 - b) Diplobacillus : Rod shaped bacteria arranged in pairs.
 - c) Streptobacillus : A chain of rod shaped bacteria.

3. Vibrios Comma shaped bacteria are called - **Vibrios**

4. Spirillum (pl. Spirilli)

- Spiral shaped bacteria are called **spirilla**
- Flexible spirilla are referred to as '**Spirochaetes**'. eg: *Spirochaeta*, *Cristispira*
- Some bacteria are in the form of a thread (or) filament (Long chains) **Eg. Beggiotoa**.

- Bacteria which are known to change their shape depending upon the type of environment and nutrients available are called **Pleomorphic bacteria**.
Eg. *Acetobacter*.

Gram Stain

- Staining procedure using the crystal violet dye was developed by **Christian Gram**.
- Two major groups of bacteria based on their staining are **Gram positive and Gram negative**

Staining procedure

Bacteria stained by Crystal violet



Dye imparts violet/ purple colour to bacteria



Bacteria are transferred to Iodine solution



Finally to ethanol (or) acetone



Bacteria that **retain purple colour** after ethanol treatment is **Gram positive**

&

Bacteria that **lose the purple colour** and they are called **Gram negative**.

Structure of Bacterial cell

- Bacterium shows the structure of typical prokaryotic cell that has a nucleus without nuclear membrane.

Cell wall

- Bacterial cell is enclosed by a **definite cell wall**.
- Cell wall is made up of several layers of **Peptidoglycon** (mucopeptide)
- Teichoic acid is absent in **Gram negative bacteria**.
- Cell wall provides the bacteria a **definite shape**, protects them from **osmolytic lysis**.
- Wall also protects the cell from **Toxic substances**
- Glycocalyx** (structures present outside the cell wall)
- Layer lying outside the cell wall is **Glycocalyx**
- Glycocalyx is a loose sheath called Slime Layer.
- Slime layer protects the cells from **Loss of water and nutrients**.
- Thick and tough layer outside the cell wall is **Capsule**.
- Both capsule and slime layer are made up of **Polysaccharides but may contain proteins**.
- Function of glycocalyx **Aids bacterial attachment to host tissues or solid objects**.
- Layer responsible for giving gummy and sticky character to the cell is **Capsule**.
- Capsule contains Great deal of water and protect bacteria from dessication.

Flagella

- All the Cocci bacteria are non-motile
Few bacilla bacteria are non-motile
- Bacilli possess one to many flagella.
- All the **Cocci** and some **Bacilli** are devoid of flagella and hence non-motile.
- Depending upon the number and distribution of flagella, bacteria are differentiated into the following types.
 - A) **Atrichous** : Flagella are absent.
 - B) **Monotrichous** : A single flagellum is present on one side of the cell.
 - C) **Lophotrichous**: A tuft of flagella is present on one side of the cell
 - D) **Amphitrichous** : Two tufts of flagella or a single flagellum one on either end of the cell
 - E) **Peritrichous**: Many flagella are distributed all over the cell surface
- Bacterial flagella do not show **9+2 configuration**.
- Flagella possess - **three long coiled filaments**.
- Flagella are made up of a protein called - **flagellin**.
- Bacteria swim in water through **rotation of their flagella**.

Pili and fimbriae

- Many gram negative bacteria possess these structures.
- Fimbriae are **short, fine hair** like appendages and are in larger number around 1000 in a single bacterial cell.
- Fimbriae or pili attach bacteria to **solid surfaces and host tissues**.
- Gram positive bacteria with fimbriae is *Corynebacterium renale*.
- Sex pili are similar to fimbriae but differ from **being larger and few in number**.
- Sex pili help in bacterial conjugation in **binding the two conjugants**.
- Sex pili are usually Less in number(1-10)
- Sex pili acts as conjugation tube, since they possess hollow core.

i) Protoplasm

- It is differentiated into three regions.
They are 1) **Cell membrane**
2) **Cytoplasm** 3) **Nucleoid**.
- Cell membrane (or) plasma membrane is **lipoproteinaceous**.
- It functions as the differential membrane and maintain - **turgidity and osmoregulation**.
- Infoldings of the plasma membrane are called **mesosomes**.

- Mesosome function **helps in chromosomal replication and its distribution, formation of daughter cells during Binary fission, increase the absorption of nutrients.**

ii) Cytoplasm

- In green sulphur bacteria bacteriochlorophylls are present in vesicles called chlorosomes.
- Chlorosomes are attached to the plasma membrane.
- In purple sulphur bacteria, bacteriochlorophylls are located in invaginations of the plasma membrane.
- gas vacuoles are present in few aquatic bacteria Halobacterium.
- The matrix of the cytoplasm is chemically a complex one. It includes various ions and organic compounds.
- **Ribosomes, chromatophores and reserve food materials** are also embedded in the matrix.
- Ribosomes are of **70s type**. They are made up of two subunits **50s** and **30s**.
- Sometimes ribosomes unite to form **polysomes or polyribosomes**.
- Photosynthetic bacteria possess **chromatophores** which form the internal membrane systems.
- Reserve food materials are stored in the form of **glycogen or poly β -hydroxy butyrate (PHB)**

iii) Nucleoid

- Well developed nuclear envelope and nucleoplasm are absent.
- The nucleoid consists of a **single chromosome**.
- The region of the bacterial protoplasm containing the genetic material is termed as **nucleoid**

Chromosome

- It is circular double stranded DNA (**ds DNA**).
- **Histone proteins** are **absent**.
- Some bacteria may also possess a self replicating, naked, circular DNA in the cytoplasm and it is known as **plasmid (or) F factor**.
- Plasmids are of three types viz.,
 - (i) F plasmids or Sex plasmids useful for conjugation.
 - (ii) R plasmids is impart resistance to antibiotic
 - (iii) Col plasmids is produce toxins called colicins.
- Plasmids carry many genes that give their host bacteria a selective advantage like **drug resistance, develop new metabolic pathways and new pathogenic abilities.**

Nutrition

- Autotrophic bacteria absorb inorganic substances from the environment and convert them into organic substances. They derive carbon either from CO_2 or carbonates.

- Heterotrophs meet their carbon requirements from organic substances (Glucose and aminoacids)
- According to the source of energy the bacteria are divided into the following four types.

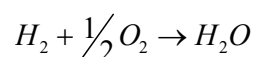
1. Photoautotrophs : Obtain energy from Sunlight and CO_2 from atmosphere

Eg: Purplesulphur Bacteria (***Chromatium***) Green sulphur bacteria (***Chlorobium***)

2. Photoheterotrophs : Obtain energy from Sunlight and Carbon from Organic substances

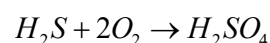
Eg: Non Sulphur bacteria (***Rhodospirillum***, ***Rhodopseudomonas***, ***Rhodomicrobium***)

3. Chemoautotrophs : Energy from oxidation of inorganic substances and Carbon from CO_2 .

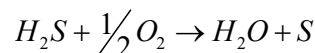


Ex: ***Hydrogenomonas***

Sulphur bacteria:



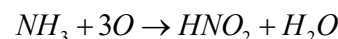
Eg. ***Thiobacillus thiooxidans***



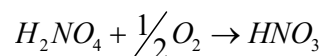
Eg. ***Beggiota***

Nitrifying bacteria

Nitrosomonas



Nitrobacter



4. Chemoheterotrophs : Energy and CO_2 from Organic substances

Eg: Organic Saprophytes (**some species of *Bacillus***)

Parasites (***Bdellovibrio bacteriovorus***)

Symbionts (***Rhizobium***, ***E. coli***)

Reproduction

- Bacteria reproduce by asexual method.
- True sexual reproduction is absent in bacteria.

Asexual reproduction

- Bacteria reproduce asexually by
- A) Binary fission B) Endospores
- A) Binary fission**
- It is the most common method of reproduction in Bacteria.
- It takes place under favourable conditions.
- Bacterial cell divides into **two equal daughter cells**.
- At first the constriction appears in the nucleoid.
- Later the constrictions are formed in the plasma membrane and cell wall.
- The plasma membrane invaginates and grows **centripetally**.

- Cell wall is laid down in between the **plasma membrane**.
- If the conditions continue to be favourable for the bacterium, it undergoes binary fission for every **18-20 minutes**.
- For every binary fission the number of cells becomes **double**.

Endospores

- Asexual reproduction takes place by - **endospores** during unfavourable conditions. (Dry and nutrient deficient conditions).
- Rod shaped bacteria such as *Clostridium* (**C.tetani**) form highly resistant, dormant endospores.
- Generally a bacterial cell produces a **single endospore**.
- Production of two endospores in a cell is not common.
- The endospore is **spherical or oval** in shape.
- It consists of DNA surrounded by dense cytoplasm.
- This protoplasmic mass is covered by a delicate **spore wall**.
- Spore wall is enveloped by a thick layer called **cortex**.
- Multilayered structure present external to the cortex is called **spore coat**.
- Spore coat is made up of several Layers of protein
- Thin delicate layer around spore coat is **exosporium**.
- When the endospore matures, the bacterial cell wall breaks down liberating the endospore.
- Endospores may be produced **terminally, sub-terminally (or) centrally**.
- Endospore is dispersed by wind and remains dormant for months or years.
- Under favourable environmental conditions the endospore germinates and gives rise to a bacterial cell

Sexual reproduction

- True sexual Reproduction is absent in Bacteria. However, the exchange of genetic material, the essence of sexual reproduction is reported through other methods.
- Three types of genetic recombinations are reported in different species of bacteria. They are

1) Transformation

2) Conjugation

3) Transduction

Transformation

- Transformation was first reported by **Alfred Griffith (1928)** in *Streptococcus pneumoniae*.

Conjugation

- The transfer of genetic material through cell to cell direct contact between **donor and acceptor** bacteria is called **Conjugation**.
- It was first reported by **Lederberg and Tatum (1946)** in *Escherichia coli*.
- In *E.coli*, in addition to the nucleoid (containing DNA) another circular DNA strand occurs in the cytoplasm. This is called **Plasmid or 'F' factor (Fertility factor)**
- *E.coli* cells having F factor are called **F⁺ cells or donor cells**.
- Cells without 'F' factor are called **F⁻ cell or acceptor cells or recipient cells**.
- F⁺ cells have - **sex pili**.
- During conjugation F⁺ and F⁻ cells come close to each other, contact physically and bind to each other with the help of **sex pili**.
- A conjugation tube is formed between them through which - **'F' factor of donor cell (F⁺) is transmitted to the cytoplasm of acceptor cell**.
- After conjugation **the acceptor cell (F⁻) becomes - F⁺** as it receives the 'F' factor.

Transduction

- The transfer of genetic material from one bacterium to another bacterium through bacteriophage is known as **transduction**.
- It was discovered in 1951 by **Lederberg and Zinder** in *Salmonella typhimurium*.
- Transduction occurs during the **lytic and lysogenic** cycles of bacteriophages.
- During lysis all the bacteriophages including phages containing bacterial DNA are released.
- If the phage containing bacterial DNA infects another healthy bacterium, the DNA is transferred.

Economic importance

- Bacteria cause diseases in plants animals and human beings. There are many bacteria which are directly or indirectly beneficial to man. Therefore bacteria can be considered both as **"friends and foes"** of man.

1. Beneficial activities

- Some bacteria are important to man in areas of agriculture, industry, medicine and biotechnology.

A) Bio-chemical cycles

- Bacteria not only help in the recycling of nutrients (bio-geochemical cycles) but also clean the environment.
- Bacteria can be regarded as the **Scavengers of nature**.

B) Agriculture

- Bacteria play an important role in maintaining the **fertility of the soil**.
- Saprophytic ammonifying bacteria convert the proteins, amino acids and nucleic acids of the dead bodies into ammonia

Eg. Bacillus.

- Ammonia is oxidised to easily available nitrates by - **Nitrosomonas and Nitrobacter**. This process is called - nitrification and the above bacteria are called **Nitrifying bacteria**.
- Symbiotic bacteria like **Rhizobium**, non-symbiotic bacteria like **Azotobacter**, Azospirillum, Clostridium and Photosynthetic bacteria like Rhodospirillum, Rhodospirillum and Chlorobacterium fix atmospheric nitrogen and enrich the soil.
- **Bacillus thuringiensis** is used as biocontrol agent against larvae of insects, hence known as **Bioinsecticide**.

C) Industry

- Industrially, bacteria are employed in a number of processes, such as retting, curing and fermentation.
- Bacteria used in retting of sun hemp and flax fibres are **Clostridium butyricum** and **C. felcinium** respectively
- Bacteria that ferment the dung anaerobically and produce methane (Gobar gas) are **Methano bacillus** and **Methano coccus**.

Chemicals produced by bacteria are

Chemical	Bacterium
• Acetone, Butanol	- <i>Clostridium acetobutylicum</i>
• Ethanol	- <i>Zymomonas mobilis</i> <i>Thermoanaerobacter ethanolicus</i>
• Lactic acid	- <i>Lactobacillus delbruckii</i>
• Propionic acid	- <i>Propionibacterium propionum</i>
• Vinegar	- <i>A. aceti</i> , <i>Acetobacter pasteurianum</i>

D) Medicine

- **Corynebacterium glutamicum** produces essential amino acids like **lysine and glutamic acid**.
- Species of **Streptomyces and Bacillus** produce important antibiotics.
- Antibiotics produced by bacteria are.

Antibiotic	Bacterium
• Streptomycin, Cycloheximide	- <i>Streptomyces griseus</i>
• Chloramphenicol	- <i>S. venezulae</i>
• Neomycin	- <i>S. fradiae</i>

• Kanamycin	- <i>S. Kanamyceticus</i>
• Amphotericin	- <i>S. nodosus</i>
• Oxyteracycline	- <i>S. rimosus</i>
• Polymyxin - B	- <i>Bacillus polymyxa</i>
• Bacitracin	- <i>B. licheniformis</i>

E) Biotechnology

- With the help of recombinant DNA technology it was made possible to produce insulin hormone from **Escherichia coli**.
- **E. coli** was employed to decipher many secrets in **biochemistry, molecular biology, genetics and physiology**.
- Bacteria that store proteins are used as a source of **Single cell protein (SCP)**
- **Agrobacterium tumefaciens** is used as vector in **genetic engineering**
- **Bdellovibrio bacteriovorus** parasitic bacteria that purifies the water in the river Ganges.

Harmful activities

- A few saprophytic and all parasitic bacteria carry on some processes which are harmful to man.

A) Spoilage of food materials

- The following bacteria grow on different types of food materials and make them unsuitable for human consumption
- Some of the above bacteria produce powerful toxins while growing on the food materials
Clostridium botulinum
→ produces a very potent toxin botulin, which causes **botulism** a type of food poisoning.

B) Denitrification

- Anaerobic soil bacteria like **Thiobacillus denitrificans** converts the available soil nitrates into non available gaseous nitrogen.
- Thus the fertility of the soil is reduced. This process is known as **denitrification**.
- Such bacteria are called **denitrifying bacteria**.

C) Plant diseases

- A number of species of bacteria are reported to cause different plant diseases. Bacteria cause plant diseases like Leafspots, Cankers, wilts, rots, warts, tumors, etc.,

Some important crop diseases caused by bacteria are

Plant Disease	Bacterium
• Angular leaf spot of cotton	- <i>Xanthomonas malvacearum</i>
• Blight of rice	- <i>X.oryzae</i>
• Citrus canker	- <i>X.axonopodis</i> P.v. <i>citri</i>
• Crown gall of apple	- <i>Agrobacterium tumefaciens</i>
• Fire blight of apples	- <i>Erwinia amylovora</i>
• Wilt of solanaceae members	- <i>Pseudomonas solanacearum</i>

Some important human diseases caused by bacteria are

Disease	Bacterium
• Cholera	- <i>Vibrio cholerae</i>
• Dysentery	- <i>Bacillus dysentery</i>
• Diphtheria	- <i>Corynebacterium diphtheriae</i>
• Gonorrhoea	- <i>Neisseria gonorrhoea</i>
• Leprosy	- <i>Mycobacterium leprae</i>
• Pneumonia	- <i>Diplococcus pneumoniae</i> (<i>Streptococcus</i>)
• Plague	- <i>Pasteurella pestis</i>
• Syphilis	- <i>Treponema pallidum</i>
• Tuberculosis	- <i>Mycobacterium tuberculosis</i>
• Typhoid	- <i>Salmonella typhi</i>

Some important animal diseases

caused by bacteria are:

Diseases	Bacterium
• Anthrax of sheep	- <i>Bacillus anthracis</i>
• Actinomycosis of cattle	- <i>Mycobacterium bovis</i>
• Tuberculosis of cattle & dogs	- <i>M. tuberculosis</i>
• Vibriosis	- <i>Vibrio tetus</i>

DISCOVERY

LEVEL - I

- Assertion(A): Bacteria are placed under kingdom Monera.
Reason (R): Bacteria are prokaryotes.
- Who said "Dear God, what marvels there are in so small a creature"?
1) Ehrenberg 2) Robert Koch
3) Leewenhoek 4) Schulz
- What was the name given by Ehrenberg to the creatures first observed by Leewenhoek ?
1) Animalcules 2) Bacteria
3) Microorganisms 4) Viruses

LEVEL - II

- Assertion (A) : Some scientists placed bacteria in Schizomycetes.
Reason (R) : Bacteria reproduces sexually by fission
- Assertion (A):Bacteria and cyanobacteria are referred to as prokaryotes.
Reason (R) : They exhibit similar cell structure and nuclear organisation with nuclear membrane.

DISTRIBUTION

LEVEL - I

- Bacterium normally present in human intestine is
1) *Azotobacter venilindi*
2) *Clostridium botulinum*
3) *Bacillus subtilis* 4) *Escherichia coli*
- Match the following

Habitat	Type
A) Extreme low temperature	I) Thermophilic
B) High salt concentration	II) Psychophilic
C) High pH	III) Halophilic
D) High temperature	IV) Alkalophilic

The correct match is

	A	B	C	D
1)	I	II	III	IV
2)	III	III	I	IV
3)	II	III	IV	I
4)	II	III	I	IV

SIZE

LEVEL - I

- Who discovered the largest bacterium ?
1) Ehrenberg 2) Leeuwenhoek
3) Heidi Schulz 4) Robert Koch

20. *Acanthurus nigrofusus* is a habitant of
 1) Red sea 2) Brown sea
 3) Namibian coast
 4) Intestine of an aquatic fish

LEVEL - II

21. Identify the correct ascending order of following bacteria based on size
 I) *Eupulopiscium fishelsoni*
 II) *Thiomargarita namibienses*
 III) *Escherichia coli*
 1) I,II,III 2) III,II,I 3) II,III,I 4) III,I,II

SHAPE**LEVEL - I**

22. Shape of *Cristispira* is . . .
 1) Rod 2) Spherical
 3) Comma 4) Spiral

LEVEL - II

23. Study the following table

Bacteria	Shape of cells	Number of cells
I) <i>Sarcina</i>	Rod	Eight
II) <i>Diplobacillus</i>	Round	Two
III) <i>Staphylococcus</i>	Irregular	Many
IV) <i>Streptococcus</i>	Round	Many

Which two bacteria show the correct combination of characters?

- 1) I & II 2) II & III
 3) III & IV 4) II & IV
24. Assertion (A): *Acetobacter* occur as small rods long rods, ellipsoid (or) chain of small rods.
 Reason (R): *Acetobacter* change their shapes due to changes in the environment and availability of nutrients.

25. List - I

- I) Rod shaped Bacteria
 II) Spherical shaped Bacteria
 III) Filamentous bacterium
 IV) Rod shaped bacterium

List -II

- A) *Beggiatoa*
 B) *E.coli*
 C) *Eupulopiscium fishelsoni*
 D) *Thiomargarita namibiensis*

The correct match is

	I	II	III	IV
1)	C	D	B	A
2)	B	D	A	C
3)	A	B	D	C
4)	C	D	B	A

LIVING MAGNETS**LEVEL - I**

26. Which of the following is known as a magnetotactic bacterium ?
 1) *Agrobacterium tumefaciens*
 2) *Eupulopiscium fishelsoni*
 3) *Aquaspirillum magnetotactim*
 4) *Thiomargarita namibienses*

LEVEL - II

27. Which of the following characters is/are applicable to a bacterium that orients itself in earth's magnetic field ?
 A) Spiral shape B) Lives in water
 C) It exists as a long chain (filament)
 1) B & C only 2) B only
 3) A & C only 4) A & B only

BACTERIA**STRUCTURE OF BACTERIAL CELL****LEVEL - I**

28. Assertion (A) : Mesosomes are finger like protrusions found in gram positive bacteria
 Reason (R) : They are produced from bacterial cell wall .
29. Assertion(A): Some bacteria have capsule or slime layer outside their cell walls
 Reason (R): The polysaccharide layer that is loosely present is capsule and tough layer is slime layer.
30. In bacteria, the reserve food materials are
 I) Starch II) Glycogen
 III) Poly β -hydroxy butyrate.
 1) I only 2) Both I & II
 3) Both II and III 4) All are correct
31. Identify the correct descending order of the following bacteria with reference to the number of flagella.
 I) Amphitrichous II) Peritrichous
 III) Lophotrichous IV) Monotrichous
 1) II,I,IV,III 2) II,I,III,IV
 3) IV,III,II,I 4) IV,III,I,II
32. The bacterial genome contains
 1) DNA and histone 2) DNA or histone
 3) DNA without histone
 4) Neither DNA nor histone
33. In many bacteria, the cell membrane becomes invaginated and folded to form
 1) cristae 2) mesosomes 3) fimbriae 4) flagella
34. Plasmids are
 1) chromosomal segments
 2) extra chromosomal circular DNA segments
 3) infoldings of cell membrane
 4) cell wall out growth

35. Pathogenic nature of bacteria is contributed by
 1) Entire cell wall
 2) Certain cell wall components
 3) Capsule
 4) Glycocalyx layer
36. Which of the following bacterial genera shows gas vacuoles?
 1) *Bacillus*
 2) *Halobacterium*
 3) *Thiomargarita*
 4) *Pseudomonas*
37. Colicins are produced by
 1) F plasmids
 2) Col plasmids
 3) R plasmids
 4) Sex plasmids
38. Sex pili in bacteria differ from fimbriae in
 1) being smaller with a hollow core
 2) being larger & in more numbers
 3) being smaller without hollow core
 4) being larger & in less numbers

LEVEL - II

39. Assertion(A): Mitochondria are similar to bacteria in having some cellular components
 Reason (R): Mitochondria have 70s ribosomes and circular DNA
40. Assertion(A): Plasmid is a small circular DNA molecule present in prokaryotic cells.
 Reason (R): It is a component of bacterial nucleus.
41. The cell organelle found in the protoplasm of bacteria is
 1) Endoplasmic reticulum
 2) Chloroplast
 3) Ribosome
 4) Mitochondrion
42. In bacteria the genes for drug resistance are located in
 1) nucleoid
 2) cytoplasm
 3) plasmid
 4) ribosome
43. In *Chromatium* bacteriochlorophyll pigments are located in
 1) cytoplasm
 2) plasma membrane
 3) chloroplast
 4) cell wall
44. List - I
 A) A single polar flagellum
 B) Tufts of flagella on either end of the cell
 C) Many flagella distributed all over the cell surface
 D) Tuft of flagella on the pole of the cell
- List - II
 I) Peritrichous
 II) Monotrichous
 III) Amphitrichous
 IV) Lophotrichous
- The correct match is
- | | A | B | C | D |
|----|-----|-----|----|-----|
| 1) | IV | III | II | I |
| 2) | II | III | I | IV |
| 3) | II | IV | I | III |
| 4) | III | IV | II | I |
45. Assertion (A): Bacteria is a prokaryote.
 Reason (R) : Plasmids are present in bacteria
46. Assertion (A): *Corynebacterium renale*. It is a Gram + Ve bacterium
 Reason (R) : *Corynebacterium* has pili
47. Read the following statements
 A) Slime layer is a loose sheath
 B) Capsule is a thick and tough layer
 C) Capsule protects the bacteria against desiccation.
 D) Gummy and sticky character of the bacteria is due to presence of glycocalyx, present between cell and cell membrane.
 1) A, B, C & D are correct
 2) B, C & D are incorrect.
 3) D alone is incorrect.
 4) D alone is correct.
48. Identify the correct statements
 A) Bacterial flagella do not show 9 + 2 configuration in their ultra structure.
 B) Bacterial flagella composed of both proteins and carbohydrates.
 C) All the cocci and bacilli are non - motile .
 D) Flagellar movement in bacteria is rotation
 1) Except D
 2) B and C
 3) Except A & C
 4) A and D
49. I) Pili are found in *E. coli*
 II) Teichoic acid is absent in gram -Ve bacteria
 III) Mesosomes increases the absorption of the nutrients in Gram -ve bacteria.
 IV) Spherical shaped bacteria do not form chains.
 Identify the incorrect statement.
 1) IV only
 2) III & I
 3) III and IV
 4) I & IV
50. Read the statements:
 A) In Gram +Ve bacteria infoldings of cell membrane are called mesosomes.
 B) Mesosomes help in the formation of daughter cells during endospore formation.
 C) Mesosomes help in chromosomal replication and its distribution to daughter bacteria.
 D) Mesosomes increases the absorption of gases.
 Select the incorrect statements
 1) A , B & D
 2) A, C, & D
 3) A & C
 4) B & D

51. I) Some bacteria possess plasmids as self-replicating, circular ds DNA in the cytoplasm.
 II) Plasmids can exist independently in the cytoplasm (or) may be integrated with nucleoid.
 III) Plasmids are also called F - Factors.
 IV) Drug resistance, metabolic pathways and new pathogenic abilities are exhibited by plasmids due to presence of genes.
 1) I, II, III are only correct 2) All statements are correct
 3) I & II are only correct 4) IV alone is correct

NUTRITION**LEVEL - I**

52. Assertion(A): Nitrosomonas and Nitrobacter are nitrifying bacteria
 Reason (R): Oxidation of ammonia into nitrates is called nitrification.
53. Photoautotrophic bacteria synthesize food material by using
 I) Chemical energy in organic substances
 II) CO₂ III) Organic form of carbon
 IV) Light energy
 1) I and II are correct 2) II & IV are correct
 3) II & III are correct 4) I & IV are correct

LEVEL - II

54. Assertion (A): Rhodospirillum is a photoautotroph
 Reason (R): It utilizes carbon of organic compounds and energy from light.

55. Study the following table

Organism	Group	Process
I) <i>Rhodospirillum</i>	Non-sulphur bacterium	Photo heterotroph
II) <i>Bacillus</i>	Purple sulphur Bacteria	Chemo autotroph
III) <i>Xanthomonas</i>	Parasitic bacterium	Chemo heterotroph
IV) <i>Rhizobium</i>	symbiont bacterium	Photo heterotroph

Which two taxa shows the correct combination?

- 1) I and II 2) I & III
 3) I & IV 4) III & IV
56. Photosynthetic bacteria which help in nitrogen fixation is / are
 I) *Rhodospirillum* II) *Azospirillum*
 III) *Clostridium* IV) *Chlorobacterium*
 1) I alone is correct 2) I & III are correct
 3) II & III 4) I & IV

List - I

- I. Purple sulphur bacterium
 II. Purple non-sulphur bacterium
 III. Non-purple sulphur bacterium
 IV. Green sulphur bacterium

The correct match is

	I	II	III	IV
1)	D	A	C	B
2)	B	A	C	D
3)	C	B	A	D
4)	D	C	B	A

List-I

- A. Oxidation of Hydrogen
 B. Oxidation of H₂S
 C. Oxidation of ammonia
 D. Oxidation of ferrous ions

List - II

- I. *Ferrobacillus*
 II. *Nitrosomonas*
 III. *Beggiatoa*
 IV. *Hydrogenomonas*

The correct match is

	A	B	C	D
1)	I	III	IV	II
2)	IV	III	II	I
3)	IV	II	III	I
4)	I	II	III	IV

Type

Type	Example	Role
I. Sulphur Bacterium	<i>Thiobacillus thio-oxidans</i>	Oxidation of elemental sulphur
II) Nitrogen fixing Bacterium	<i>Nitrobacter</i>	Oxidation of nitrites
III. Iron Bacterium	<i>Thiobacillus thiooxidans</i>	Oxidation of Ferric salts to ferrous ions
IV) Hydrogen Bacterium	<i>Hydrogenomonas</i>	Oxidation of H ₂

The correct combination is

- 1) II & III 2) I & II only
 3) I & IV only 4) I, II & IV

List - I

List - I	List - II	List - III
I) Ammonifying Bacterium	<i>Bacillus</i>	Converts Proteins into NH ₃
II) Nitrifying Bacterium	<i>Nitrosomonas</i>	Oxidation of ammonia
III) Nitrogen fixing Bacterium	<i>Chlorobacterium</i>	Fix dinitrogen

IV) Nitrifying *Nitrobacter* Oxidation of
Bacterium nitrite

- 1) II & IV only are correct
2) II, III & IV are correct
3) II alone is correct 4) All are correct

REPRODUCTION

LEVEL - I

61. Phage mediated transfer is
I) Transduction II) Transformation
III) Conjugation
1) I and II are correct 2) II and III are correct
3) III alone are correct 4) I alone is correct

LEVEL - II

62. Assertion(A): Most common method of reproduction in bacteria is by binary fission
Reason (R): Binary fission takes place during favourable conditions
63. Assertion(A): Endospores are formed especially in humid environment.
Reason (R): *Bacillus megatherium* and *Clostridium tetani* reproduce by endospores.
64. Endospores are formed in the following bacteria
I) *Bacillus megatherium* II) *Clostridium tetani*
III) *Beggiatoa* IV) *Pasteurella*
1) I & II are correct 2) II & III
3) I & IV 4) II & IV
65. The resting spores produced by bacteria in unfavourable conditions are called
1) conidia 2) endospores
3) exospores 4) chlamydo spores
66. Assertion(A): In $F^+ \times F^-$ mating, the acceptor cell becomes donor cell
Reason (R): Some times, only one strand of the F factor (plasmid) enters into the acceptor cell.
67. Identify the correct statements.
I) During binary fission, the bacterial cell divides into two unequal daughter cells.
II) In binary fission, the size of population is doubled in every generation.
III) Bacterium undergoes binary fission for every 18-20 minutes.
IV) Any bacterial cell can participate in binary fission once only in its life.
Which of the above are correct
1) Except II all are correct
2) Except I & IV all are correct
3) Except I all are correct 4) All are correct

68. I) Generally number of endospores per cell is one.
II) The production of two endospores within a cell is not uncommon.
III) Endospores are disseminated by wind and remain dormant for months (or) years.
IV) The position of endospores in a cell is centre (or) sub-terminal (or) terminal.
Identify the correct statements related to endospore in bacteria.

- 1) I, II, & III 2) I, II, III & IV
3) II & IV 4) III & II
69. Select the correct sequence of the protective coverings of endospore found in a species of *Bacillus* from inside to outside
I) Cortex II) Spore wall
III) Spore coat IV) Exosporium
1) IV, III, I, II 2) II, I, III, IV
3) III, IV, II, I 4) I, II, III, IV
70. Which of the following is the correct sequence of events during binary fission of bacteria?
I) New cell wall is laid
II) Appearance of constriction
III) Invagination of plasma membrane
IV) DNA replicates
1) IV, I, II, III 2) I, IV, III, II 3) IV, III, II, I 4) IV, III, I, II
71. If a bacterial cell divides in every twenty minutes how many bacteria will be formed in two hours?
1) 4 2) 8 3) 16 4) 64
72. Assertion(A): Sex pili help in bacterial conjugation in binding two conjugates and also act as conjugation tube.
Reason (R): Sex pili possess hollow core
73. Assertion(A): True sexual reproduction is absent in bacteria
Reason (R): Genetic recombinations are reported in bacteria.

HARMFUL ACTIVITIES

LEVEL - I

74. Study the following table

BACTERIA	HOST DISEASE
I) <i>Xanthomonas oryzae</i>	Paddy Blight
II) <i>Pasteurella pestis</i>	Plant Plague
III) <i>Treponema pallidum</i>	Sheep Syphilis
IV) <i>Mycobacterium bovis</i>	Cattle Actinomycosis

Which two taxa shows the correct combination
1) I & II are correct 2) I & III are correct
3) II & IV are correct 4) I & IV are correct

75. List - I

- A) Crown gall of apple
B) Wilt of Solanaceae members
C) Blight of rice
D) Citrus canker

List - II

- I) *Pseudomonas*
II) *Xanthomonas malvacearum*
III) *Xanthomonas axonopodis pv citri*
IV) *Agrobacterium tumefaciens*
V) *Xanthomonas oryzae*.

The correct match is

	A	B	C	D
1)	IV	I	V	III
2)	I	IV	V	II
3)	V	IV	I	II
4)	I	V	IV	III

76. Assertion(A): Botulism is a kind of food poisoning

Reason (R): It is due to release of toxin produced by *Clostridium tetani*

77. Assertion(A): *Thiobacillus denitrificans* is an anaerobic bacterium

Reason (R): Reduction of nitrate into ammonia is called denitrification

78. Diseases

- I. Blight of Rice
II. Citrus Canker
III. Fire blight of apples
IV. Wilt of tomato

Bacteria

- A). *X. axonopodis* P.v. citri
B) *Erwinia amylovora*
C) *Pseudomonas solanacearum*
D. *X. oryzae*

The correct match is

	I	II	III	IV
1)	A	D	C	B
2)	D	A	B	C
3)	A	B	C	D
4)	D	A	C	B

79. Bacterium

- I. *X. malvacearum*
II. *Vibrio tetus*
III. *Bacillus anthracis*
IV. *Mycobacterium bovis*

Disease

- A. Anthrax of sheep
B. Vibriosis
C. Angular leaf spot of cotton
D. Actinomycosis

The correct match is

	I	II	III	IV
1)	C	B	A	D
2)	B	C	A	D
3)	C	B	D	A
4)	A	B	C	D

80. Disease

- A. Syphilis
B. Gonorrhoea
C. Tetanus
D. Leprosy

Bacterium

- I. *Neisseria*
II. *Treponema Pallidum*
III. *C. tetani*
IV. *M. leprae*

The correct match is

	A	B	C	D
1)	IV	II	III	I
2)	II	I	IV	III
3)	I	II	IV	III
4)	II	I	III	IV

BENEFICIAL ACTIVITIES

LEVEL - I

81. Assertion(A): Some bacteria are treated as

'Scavengers of nature'

Reason (R): Dead bodies of plants and animals are decomposed by some bacteria

82. Assertion(A): In biotechnology, *Agrobacterium tumefaciens* plays a very important role.

Reason(R): It is used as a vector in genetic engineering

83. Assertion(A): Symbiotic bacteria are pathogenic in nature

Reason (R): *E. coli* is a common symbiont found in human intestine

84. Bacteria used in retting of sun hemp

- I) *Clostridium felicinum*
II) *Clostridium butyricum*
III) *Clostridium tetani*
IV) *Clostridium acetobutylicum*

- 1) II only
2) II & III are correct
3) I & IV are correct
4) III & IV are correct

85. Lysine, an essential amino acid is produced by

- I) *Corynebacterium glutamicum*
II) *Corynebacterium diphtheriae*
III) *Corynebacterium renale*

- 1) I alone is correct
2) II & III are correct
3) I & III are correct
4) III alone is correct

86. List - I

- A) Neomycin
B) Oxytetracycline
C) Chloramphenicol
D) Amphotericin

List - II

- I) *S. venezuelae*
II) *S. nodosus*
III) *S. rimosus*
IV) *S. griseus*
V) *S. fradiae*

The correct match is

	A	B	C	D
1)	II	I	III	V
2)	V	I	II	IV
3)	III	II	I	V
4)	V	III	I	II

87. The bacteria useful in retting of sunhemp & flax and curing of tobacco & tea respectively are

A) *Micrococcus*
 B) *Clostridium felcinium*
 C) *Bacillus megatherium*
 D) *Clostridium butyricum*

The correct answer is

- 1) B & D and C & A 2) B & D and A & C
 3) D & B and C & A 4) D & B and A & C

LEVEL - II

88. Assertion(A): Methanobacillus species produce methane from dung

Reason (R): They produce methane by using oxygen.

89. **List - I** **List - II**
 A) Symbiotic N_2 - fixing bacteria I. Azospirillum
 B) Associate Symbiotic N_2 - fixing bacteria II. Rhizobium
 C) Anaerobic free living N_2 - fixing bacteria. III. Chlorobacterium
 D) Photosynthetic N_2 - fixing bacteria. IV. Clostridium

The correct combination is

- | | A | B | C | D |
|----|-----|----|-----|-----|
| 1) | II | I | IV | III |
| 2) | I | II | IV | III |
| 3) | IV | II | III | I |
| 4) | III | IV | II | I |

90. Antibiotic Bacteria
 I. polymyxin - B A. *S. fradiae*
 II. Amphotericin B. *S. nodosus*
 III. Neomycin C. *B. Polymyxa*
 IV. Bacitracin D. *B. licheniformis*

The correct match is

- | | I | II | III | IV |
|----|---|----|-----|----|
| 1) | A | E | D | C |
| 2) | C | D | A | E |
| 3) | C | B | A | D |
| 4) | D | C | A | E |

91. Assertion (A) : Bacteria are considered as friends and foes of man.

Reason (R) : Bacteria exhibit both beneficial and harmful activities

LEVEL - III

92. Sequential steps involved in Gram staining technique'

I) Treated with ethanol
 II) Stained with crystal violet
 III) Treated with iodine solution

- 1) II, I, III 2) II, III, I 3) I, II, III 4) III, II, I

93. The bacteria, which obtain energy from sunlight are

I) Purple sulphur bacteria
 II) Non-sulphur purple bacteria
 III) Non-green sulphur bacteria
 IV) Rhizobium

- 1) III only 2) III & IV only
 3) I & II only 4) I only

94. Find out the correct features related to the Bacteria involved in purification of water from the river Ganges

I) It is a parasite II) It is saprophyte
 III) It grows over harmful bacteria IV) Symbiont
 1) I and II 2) I and III
 3) II and III 4) III and IV

95. From the following choose the bacterial disease

A) Cholera B) Polio
 C) Tetanus D) Vibriosis
 E) Rice tungro F) Plague
 1) A, B, E, F 2) B, E, C, D
 3) A, B, C, D, E 4) A, C, D, F

96. Anaerobic bacterium is

I) Methanobacillus II) Methanococcus
 III) Azotobacter IV) Thiobacillus

- 1) I and II only correct 2) I, II, IV only correct
 3) III & IV only correct
 4) I, II, III, IV are correct

97. The number of morphological types of bacteria and cells respectively found in a test tube which contains 20 Monococci, 10 Monobacilli, 10 Diplococci, 30 Tetrads and 10 Sarcinae are

- 1) 5 and 300 2) 2 and 250
 3) 2 and 320 4) 4 and 330

98. Anaerobic bacteria are

I) Denitrifying bacteria II) Clostridium
 III) Rhodospirillum
 IV) Thermoanaerobacter ethanolicus

- 1) II, III and IV only 2) I, II, III, IV
 3) II and IV only 4) II and IV only