(1) Q. P. Code :- 55375

USBT 103: Basic Life Sciences-I: Biodiversity and Cell Biology

SET-III

Q.1) Do as directed (attempt any fifteen) **15**

1. Define: life.

Define Life: A distinctive characteristic of a living organism from dead organism or non-living thing, as specifically distinguished by the capacity to grow, metabolize, respond (to stimuli), adapt, and reproduce.

2. State True or False: E. coli is an eukaryotic organism.

False

3. Mention two characteristics of gymnosperms.

They do not have an outer covering or shell around their seeds.

They do not produce flowers.

They do not produce fruits.

They are pollinated by the wind.

4. Define alternation of generation.

The occurrence of two or more forms differently produced in the lifecycle of a plant or animal usually involving the regular alternation between sexual and asexual forms.

5. Name any two fruiting bodies formed in fungi during reproduction.

Basidia, sporangia ,ascus.

6. What do you mean by naked virions?

Nonenveloped viruses.

7. Define: Viropexis.

Engulfment of whole virions by cells during phagocytosis

8. Explain the term eclipse period.

Period after infection of phage during which phages can be recovered.

9. Name any one filamentous phage.

fd, f1, M13, ØX174.

10. Give the function of delayed early genes in phage replication.

Code for enzymes which produce unique phage DNA constituents such as 5-hydroxy methylcytosines.

2

11. State the use of embryonated eggs in virology.

Cultivation of animal viruses.

Fill in the blanks

12. Reptiles have ___________chambered heart.

5

13. Crab belongs to the phylum

Arthropoda

14. Most organelles in a eukaryotic cell are found in the Mitochondria/Chloroplast/Golgi Complex/ Nucleus

15. Organism which lack mitosis division and use binary fission method for cell division are known as Prokaryotes

16. Some species of bacteria forms, chain or trichomes that are enclosed by a hollow tube called a Sheath

17. Riboporin is responsible for the association of ribosome with ER are also called as dictysomes.

18. Polysaccharide granules can be stained by Methylene blue

19. Tubulin **is the major protein of microtubules.**

20. One of the first viruses studied by electron microscopy was the

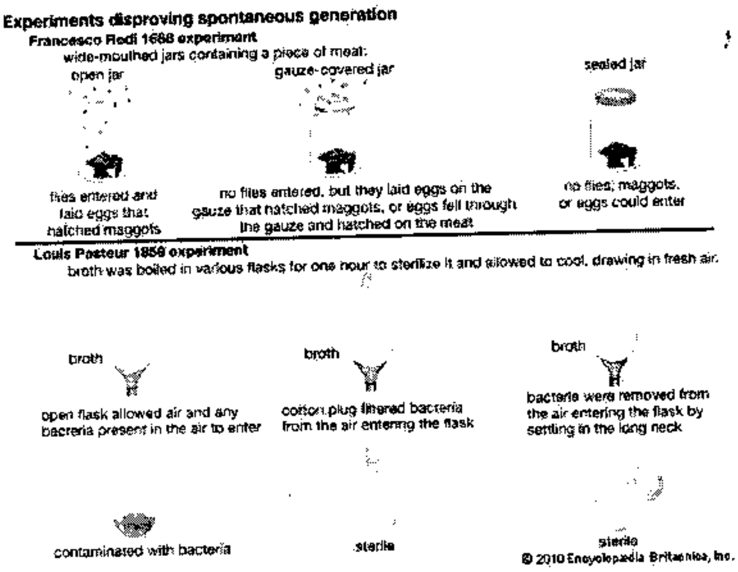
TMV

Q.2)

A) Describe the theory of Spontaneous generation **8**

Spontaneous generation, the hypothetical process by which living organisms develop from nonliving matter; also, the archaic theory that utilized this process to explain the origin of life. According to this theory, pieces of cheese and bread wrapped in rags and left in a dark corner, for example, were thus thought to produce mice, because after several weeks there were mice in the rags. Many believed in spontaneous generation because it explained such occurrences as the appearance of maggots on decaying meat. By the 18th century it had become obvious that higher organisms could not be produced by nonliving material. The origin of microorganisms such as bacteria, however, was not fully determined until Louis Pasteur proved in the 19th century that microorganisms reproduce.

3



B) Explain the salient features of Algae 7

Algae are eukaryotic organisms that have no roots, stems, or leaves but do have chlorophyll and other pigments for carrying out photosynthesis. Algae can be multicellular or unicellular.

Unicellular algae occur most frequently in water, especially in plankton.Phytoplankton is the population of free-floating microorganisms composed primarily of unicellular algae. In addition, algae may occur in moist soil or on the surface of moist rocks and wood. Algae live with fungi in lichens. The cell of an alga has eukaryotic properties, and some species have flagella with the "9-plus-2" pattern of microtubules. A nucleus is present, and multiple chromosomes are observed in mitosis. The chlorophyll and other pigments occur inchloroplasts, which contain membranes known as thylakoids.

Most algae are photoautotrophic and carry on photosynthesis. Some forms, however, are chemoheterotrophic and obtain energy from chemical reactions and nutrients from preformed organic matter. Most species are saprobes, and some are parasites.

Reproduction in algae occurs in both asexual and sexual forms. Asexual reproduction occurs through the fragmentation of colonial and filamentous algae or by spore formation (as in fungi). Spore formation takes place by mitosis. Binary fission also takes place (as in bacteria).

During sexual reproduction, algae form differentiated sex cells that fuse to produce a diploid zygote with two sets of chromosomes. The zygote develops into a sexual spore, which germinates when conditions are favorable to reproduce and reform the haploid organism having a single set of chromosomes. This pattern of reproduction is called alternation of generations.

(4)

OR

C) Describe general characteristics of Eumycota **8**

Fungi are eukaryotic organisms distinct from plants and animals and members of several other smaller kingdoms. Common fungi include mushrooms, conks corals, jellies, puffballs, stinkhorns, morels, cups, truffles, lichens, yeasts, rusts, smuts, bread molds, mildews, and molds on bathroom tiles.

The Eumycota consist of eukaryotic, nonchlorophyllous heterotrophs that absorb nutrients from dead or living organic matter, have cell walls composed of chitin , and store excess energy as glycogen . The kingdom contains four phyla: Chytridiomycota, Zygomycota, Ascomycota, and Basidiomycota. All true fungi have a definite cell wall throughout all developmental stages. Fungal cell walls are composed of chitin, the compound also found in arthropod exoskeletons (for example, lobster shells). Most fungi produce a vegetative mycelium (filamentous thallus) composed of hyphae that branch and extend via tip elongation, although some groups (like yeasts) consist only of individual cells. Hyphae (singular, hypha) are tube-like filaments with either single multinucleate cells (coenocytes) that lack septa (cross-walls) separating nuclei, or many septate cells containing one, two, or more nuclei.

D) Give an account of salient features Class Amphibia **7**

1) Amphibians are cold blooded vertebrates which can hue on land and in water.

2) Amphibians show four limbs with which they can swim in water and jump or walk on the land, (But In apoda limbs are absent.)

3) In Amphibians animals exoskeleton is absent. But in apoda animals small cycloid scales are present.

4) In Amphibians the adult animals lungs are present. Gills are absent. But In some urodelans the gills are present.

5)Amphibians Skin is a respiratory organ.

6) The Amphibians skull is dicondylic.

7) Amphibians Ribs are absent.

8)In Amphibians The body divisible into head and trunk Tail is present in, urodela animals.

9)Amphibians Digestive system is well developed. A well developed liver Is present

10) External ear is absent. Middle and inner ears are present, the middle ear columella auris Is present.

11)Amphibians Heart is 3 chambered with 2 auricles and 1 ventricle The blood contains R.B.C. They are nucleated. They contain hemoglobin.

12) Blood vascular system contain hepatic and renal portal systems.

13) Amphibians Kidneys are mesonephric. Urinary bladder is present. It stores urine.

14) Central nervous system is well developed. The brain occupies completely the cranial cavity. The brain is divided into fore, mid and hind brains. Brain continuous as spinal cord.

15)10 pairs of cranial nerves will arise.

16) Sexes are separate.

17) Male and female can be indentified - Sexual dimorphism.

18) In Amphibians the life history a larva stage may be present.

19) Amphibian Eggs are telolecithal, Cleavage is holoblastic unequal.

Q.3)

A) Differentiate between slime layer and Capsule **8**

1. Slime Layer and Capsule

[redacted]

[redacted]

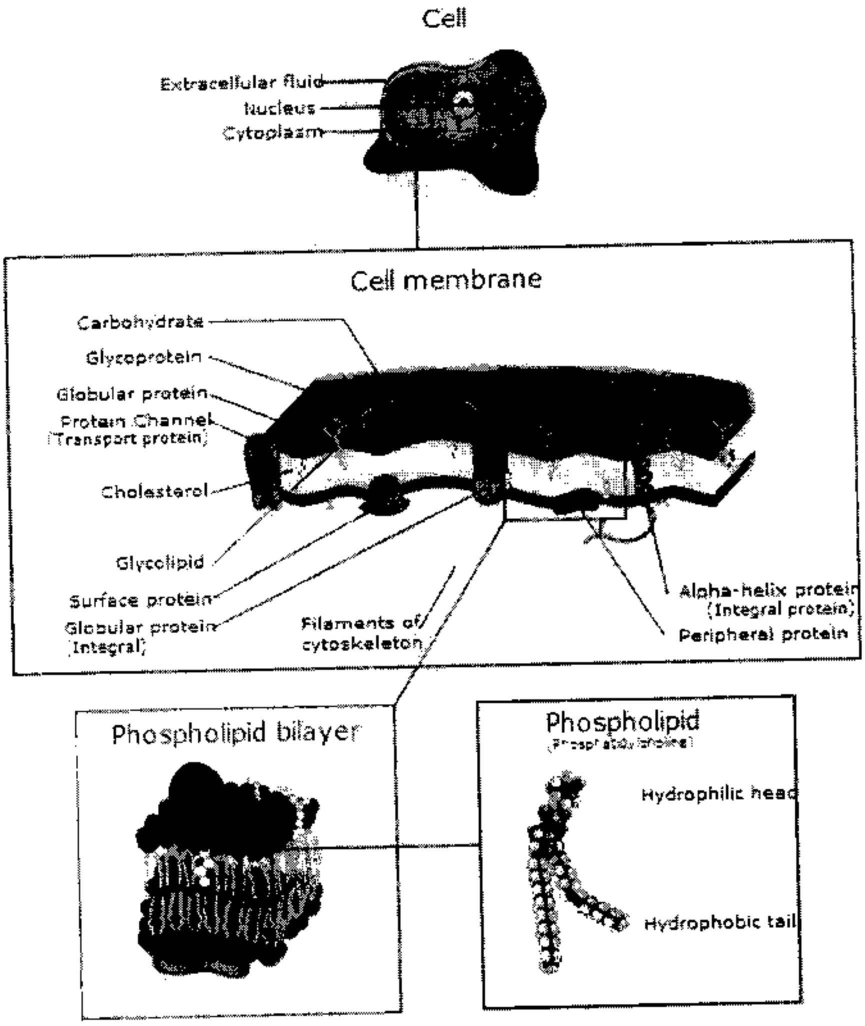
B) Describe the ultrastructure of Plasma membrane

The plasma membrane (also known as the cell membrane or cytoplasmic membrane) is a biological membrane that separates the interior of a cell from its outside environment.

The primary function of the plasma membrane is to protect the cell from its surroundings. Composed of a phospholipid bilayer with embedded proteins, the plasma membrane is selectively permeable to ions and organic molecules and regulates the movement of substances in and out of cells. Plasma membranes must be very flexible in order to allow certain cells, such as red blood cells and white blood cells, to change shape as they pass through narrow capillaries.

The plasma membrane also plays a role in anchoring the cytoskeleton to provide shape to the cell, and in attaching to the extracellular matrix and other cells to help group cells together to form tissues. The membrane also maintains the cell potential.

In short, if the cell is represented by a castle, the plasma membrane is the wall that provides structure for the buildings inside the wall, regulates which people leave and enter the castle, and conveys messages to and from neighboring castles. Just as a hole in the wall can be a disaster for the castle, a rupture in the plasma membrane causes the cell to lyse and die.



The plasma membrane: The plasma membrane is composed of phospholipids and proteins that provide a barrier between the external environment and the cell, regulate the transportation of molecules across the membrane, and communicate with other cells via protein receptors.

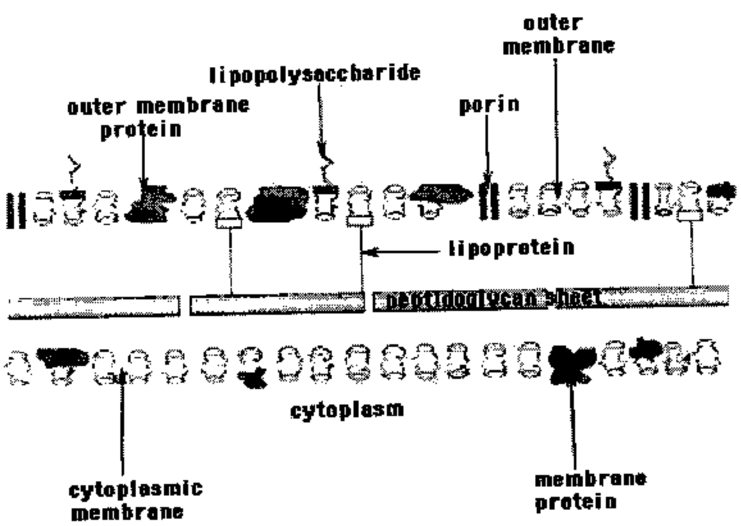
OR

C) Describe the structure of gram negative bacterial cell wall **8**

Most procaryotes have a rigid cell wall. The cell wall is an essential structure that protects the cell protoplast from mechanical damage and from osmotic rupture or lysis. Procaryotes usually live in relatively dilute environments such that the accumulation of solutes inside the procaryotic cell cytoplasm greatly exceeds the total solute concentration in the outside environment. Thus, the osmotic pressure against the inside of the plasma membrane may be the equivalent of 10-25 atm. Since the membrane is a delicate, plastic structure, it must be restrained by an outside wall made of porous, rigid material that has high tensile strength. Such a material is murein, the ubiquitous component of bacterial cell walls.

Murein is a unique type of peptidoglycan, a polymer of disaccharides (glycan) cross-linked by short chains of amino acids (peptide). Many types of peptidoglycan exist. All Bacterial peptidoglycans contain N-acetylmuramic acid, which is the definitive component of murein. The cell walls of Archaea may be composed of protein, polysaccharides, or peptidoglycan-like molecules, but never do they contain murein. This feature distinguishes the Bacteria from the Archaea.

In the Gram-negative Bacteria (which do not retain the crystal violet), the cell wall is composed of a single layer of peptidoglycan surrounded by a membranous structure called the outer membrane. The outer membrane of Gram-negative bacteria invariably contains a unique component, lipopolysaccharide (LPS or endotoxin), which is toxic to animals. In Gram-negative bacteria the outer membrane is usually thought of as part of the cell wall.



(8)

Figure: Structure of the Gram-negative cell wall. The wall is relatively thin and contains much less peptidoglycan than the Gram-positive wall. Also, teichoic acids are absent. However, the Gram negative cell wall consists of an outer membrane that is outside of the peptidoglycan layer. The outer membrane is attached to the peptidoglycan sheet by a unique group of lipoprotein molecules.

D) Write the structure and function of Microtubule 7

Microtubules are composed of the protein tubulin and are about 25nm in diameter. Microtubules (MTs) are the largest of the cytoskeletal elements. These are classified into two general groups.

MTs are straight, hollow cylinders with an outer diameter of about 25nm and inner 15nm. The MT wall consists of longitudinal arrays of liner polymers called protofilaments such 13 profilaments arranged side by side around the hollow centre/lumen. The basic subunit of protofilament is a heterodimer of the protein tubulin. The heterodimer that forms the bulk of protofilament are composed of one molecule of α-tubulin and one molecule of β-tubulin. Both these molecules are bind tightly to each other to produce an α-β-heterodimer that does not dissociate under normal condition.

Individual α and β tubulin molecule have diameter about 4-5nm and molecular weight of about 50,000da both these molecule have nearly identical 3D structure. Each protein folds into three domains; a GTP-binding domain at N-terminus, the middle domain to which the micro tubule poison like colchicines can bind, and the third domain at the C-terminus that interacts with MT associated proteins. Within a microtubule all of the tubulin dimers are oriented in the same direction; such that all of the α-tubulin subunits face the same end.

Microtubules serve a transportation function, as they are the routes upon which organelles move through the cell. They are most often found in all eukaryotic cells and, together with the microfilaments and intermediate filaments, form the cytoskeleton. Microtubules have many more jobs than just giving support to the cell. The microtubules also play a very important role during cell division. Their primary cell division function is to connect to the chromosomes, help those chromosomes complete their first split, and then move the new chromosomes to their places in the new daughter cells. This job is carried out by microtubules that make up the centrioles, organelles that have been given the specific job of helping cells divide. After cell division has finished, those same microtubules return to their functions in other parts of the cell. Some examples of microtubules that help with cell division are polar fibers and kinetochore fibers.

Other than support, organelle movement, and cell division, microtubules also play a part in forming large structures on the outside of the cells. Microtubules can combine in very specific bundles to form cilia and flagella for cell movement.

9

Q.4)

A) Explain in detail the mechanism of lysogeny **8**

Mechanism of Lysogeny

A good part of our knowledge on lysogeny comes from studies on the coliphage lambda (λ). It is generally considered to be typical of the temperate phages.

When a sensitive bacterium is infected by a temperate phage, two things may happen. In some of the infected cells, multiplication of the phage occurs and a lytic cycle takes place. In the other infected cells (ranging from a few to 100 percent, depending on both the host and the phage), the multiplication of the phage is repressed (because late genes required for phage multiplication and host lysis are switched off) and lysogenization occurs. Specifically, the temperate phage possesses a gene that codes for a repressor protein which makes the cell resistant to lysis initiated either by the prophage or by lytic infection by other viruses. (Radiation or chemicals may induce release of the prophage from the host genome so that a lytic cycle can ensue.)

The repressor protein (also called immunity repressor since the cell is resistant to lysis from externally infecting phage) from λ phage has been isolated and purified. It is an acidic protein with a molecular weight of 26,000. It reacts with two different operator sites on the λ phage genome to prevent the expression of phage lytic functions and the formation of mature phage particles. Thus the repression of phage genes is very much like the repression of bacterial operons (discussed in Chap. 12).

More specifically, the lysogenic state is governed by the activity of the regulatory region of the λ phage genome, which both bestows immunity to externally infecting phages and causes integration of the phage genome into cellular DNA. This region is termed the immunity operon. Upon infection by λ phage, the phage cro gene is transcribed, resulting in the synthesis of a protein repressor that *inhibits* the synthesis of the immunity repressor. Thus the basic mechanism in the production and maintenance of the lysogenic state is the antagonism of two repressors—the immunity repressor and the *cro* repressor, which prevents immunity.

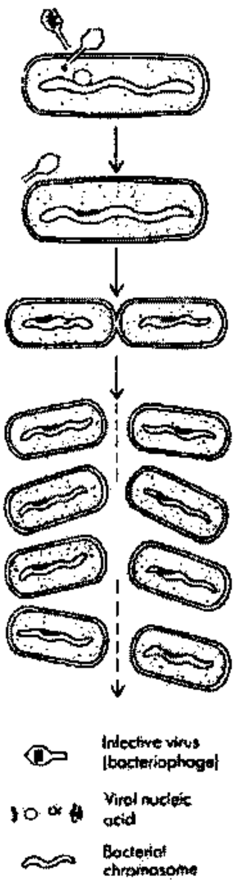


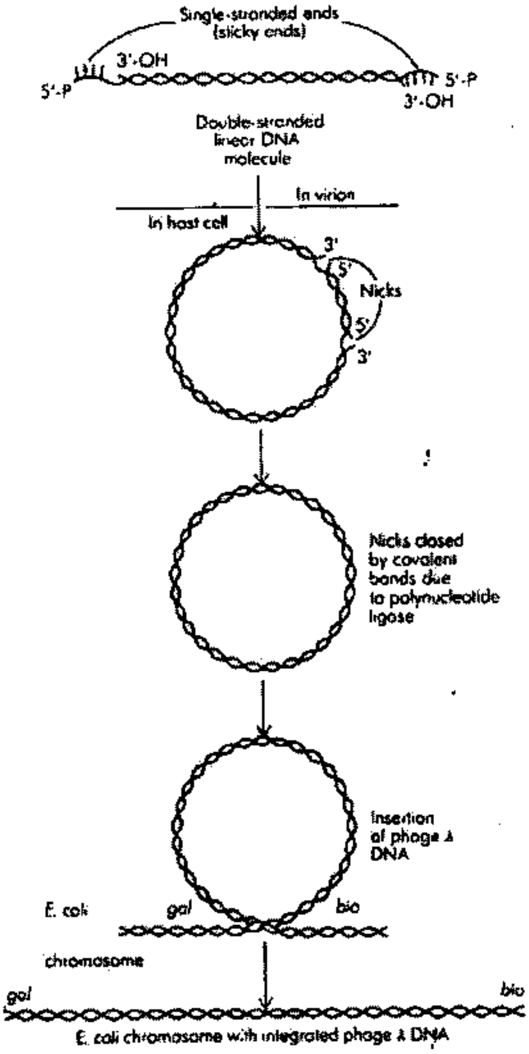
Figure 20-18. Lysogeny is a process in which the viral nucleic acid does not usurp the functions of the host bacterium's synthetic processes but becomes an integral part of the bacterial chromosome. As the bacterium reproduces, viral nucleic acid is transmitted to the daughter cells at each cell division. In the lysogenic state the virus is simply one of the bacterial genes. Under certain natural conditions or artificial stimuli (such as exposure to ultraviolet light), the synthesis of virus may take over, and lysis occurs.

(10)

As previously mentioned, the lytic cycle of bacteriophage λ can be induced by radiation, e.g., ultraviolet light. At the molecular level, this induces the synthesis of a host cell protein encoded in the *recA* gene of *E. coli*. This protein has proteolytic activity; once induced to accumulate, it cleaves the immunity repressor, preventing the latter from binding to the λ prophage. It is suggested that spontaneous induction of lysis may involve the same mechanism.

No RNA phages have yet been shown to be temperate. It is possible that temperate RNA phages exist; the phage could form a DNA copy of the RNA genome, which can then be integrated into the bacterial chromosome.

Figure 20-19. Conversion of phage λ linear DNA molecule into covalently closed ring and its insertion into the *Escherichia coli* chromosome.



(11)

B) Discuss in detail the structure of Phage 7

Phage Structure

Most phages occur in one of two structural forms, having either cubic or helical symmetry. In overall appearance, cubic phages are regular solids or, more specifically, polyhedra (singular, polyhedron); helical phages are rod-shaped.

Polyhedral phages are icosahedral in shape. (The icosahedron is a regular polyhedron with 20 triangular facets and 12 vertices.) This means that the capsid has 20 facets, each of which is an equilateral triangle; these facets come together to form the 12 corners. In the simplest capsid, there is a capsomere at each of the 12 vertices; this capsomere, which is surrounded by five other capsomeres, is termed a penton. (See Fig. 20-5A.) For example, the phage ϕX174 exhibits the simplest capsid. In larger and more complex capsids, the triangular facets are subdivided into a progressively larger number of equilateral triangles. Thus a capsid may be composed of hundreds of capsomeres but it is still based on the simple icosahedron model.

The elongated heads of some tailed phages are derivatives of the icosahedron. For example the head of the T2 and T4 phages is an icosahedron elongated by one or two extra bands of hexons.

Rod-shaped viruses have their capsomeres arranged helically and not in stacked rings (Fig. 20-5B). An example is the bacteriophage M13.

Some bacteriophages, such as the T-even coliphages (T2, T4, and T6), have very complex structures, including a head and a tail. They are said to have binal symmetry because each virion has both an icosahedral head and a hollow helical tail (Fig. 20-6).

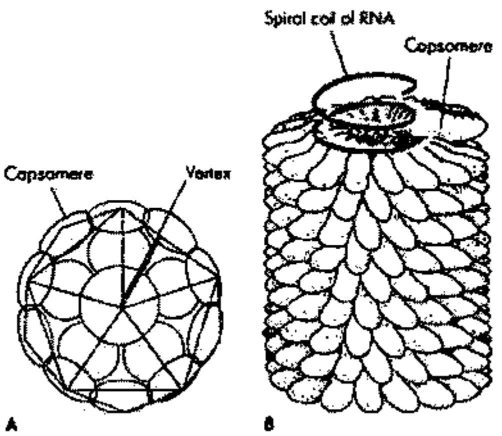


Figure 20-5. (A) Diagram of the simplest icosahedral capsid. The colored triangular outlines delineate the icosahedral symmetry. The circles represent capsomeres. (B) Diagram of a rod-shaped virus with helical symmetry. The capsomeres are arranged helically around a hollow core containing a spiral coil of RNA.

Figure 20-6. The morphology of phage lambda as seen by electron microscopy (X297,000). (Courtesy of H. W. Ackermann, Laval University.)

12

OR

C) Describe the morphology of Plant and Animal Viruses **8**

STRUCTURE AND COMPOSITION

Like bacteriophages, animal and plant viruses are composed of a central core of nucleic acid surrounded by a capsid, which is made up of capsomeres. Most plant and animal viruses exhibit a characteristic symmetry: (1) icosahedral in the case of spherical viruses, (2) helical in the case of the rod-shaped viruses, and (3) complex in the case of a miscellaneous group. This symmetry is a basic criterion of viral classification, which will be discussed later. But in some animal viruses the nucleocapsid (nucleic acid and capsid) is covered by an outer membranelike structure called the envelope, which is made of lipoproteins and conceals this symmetry. Virions that have envelopes are sensitive to lipid solvents such as ether and chloroform. Their capacity to infect cells is inactivated by these solvents. Nonenveloped viruses are referred to as naked virions. Such viruses are not affected by lipid solvents.

Morphology

Icosahedral Symmetry

In searching for a simple, stable architectural structure, R. Buckminster Fuller, the American architect, engineer, and inventor, discovered that an icosahedral shell (discussed in Chap. 20) is easy to assemble and provides an enclosure possessing minimum stress. This is the idea behind Fuller's geodesic domes, the design of which he patented in 1947. These domes usually look spherical and cover more space with less material than any other buildings ever designed. These domes are actually subtriangulated icosahedra constructed of almost

Figure 21-12. Vaccinia virus, a poxvirus with complex morphology. (A) Whole (coated) virus showing surface tubules (X200,000). (*Courtesy of Margaret Gommersoll, McGill University.*) (B) Immature virion obtained from an infected cell showing a bounding membrane with subunit projections (X160,000). (*Courtesy of K. B. Easterbrook, Dalhousie University.*)

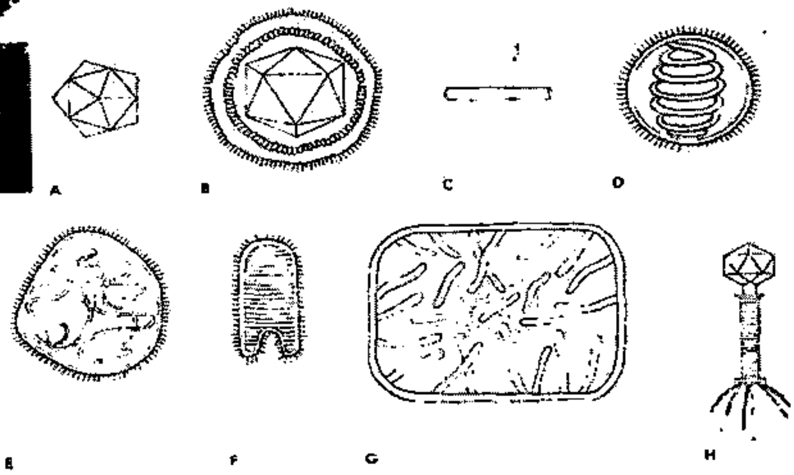


Figure 21-13. Morphology of some well-known viruses. Icosahedral symmetry: (A) polio, wart, adeno, rota; (B) herpes. Helical symmetry: (C) tobacco mosaic; (D) influenza; (E) measles, mumps, parainfluenza; (F) rabies. Complex or uncertain symmetry: (G) poxviruses; (H) T-even bacteriophages. (*Redrawn by Erwin F. Lessel after a drawing by Frances Doane, University of Toronto.*)

Complex-Structured Viruses

There are viruses with complex or uncertain symmetries. For example, the poxviruses, such as smallpox and molluscum contagiosum, have the most complex virion structure known (Fig. 21-12). They consist of many different proteins and lipoproteins. [The tailed phages discussed in Chap. 20 may be considered to be complex-structured viruses.]

A schematic representation of the morphology of viruses is given in Fig. 21-13.

(13)

D) Elaborate on different modes of cell division in Bacteria. 7

REPRODUCTION

Modes of Cell Division

Binary Fission

The most common, and no doubt the most important, mode of cell division in the usual growth cycle of bacterial populations is **transverse binary fission**, in which a single cell divides after developing a transverse septum (crosswall) (Fig. 7-1 A, B, C). Transverse binary fission is an asexual reproductive process. (Infrequently, in some species, binary fission may be preceded by a mating or conjugation of cells; this sexual process is discussed in Chap. 12.)

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116 MICROORGANISMS—BACTERIA

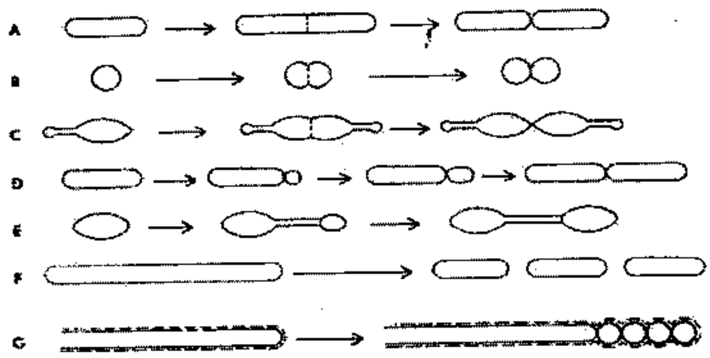

Figure 7-1. Schematic drawing of modes of cell division in various bacteria. Transverse binary fission occurs in *Bacillus subtilis* (A), *Streptococcus faecalis* (B), and the prosthecate bacterium *Prosthecobacter fusiformis* (C); in the latter species the small round area at the tip of each prostheca is a holdfast—a means of attachment to surfaces. Budding occurs in *Rhodopseudomonas acidophila* (D) and *Hyphomicrobium vulgare* (E); in the latter species the mother cell produces a prostheca on which a terminal bud forms; this bud develops into a daughter cell. (F) Fragmentation occurs in the filamentous cells of a *Nocardia* species. (G) Formation of conidiospores by a *Streptomyces* species. A hypha that gives rise to spores is covered by a sheath (represented here by a dashed line); septation occurs at the hyphal tip to produce a chain of conidiospores still enclosed by the sheath.

Budding

Some bacteria, such as *Rhodopseudomonas acidophila*, reproduce by **budding**, a process in which a small protuberance (bud) develops at one end of the cell; this enlarges and eventually develops into a new cell which separates from the parent (Fig. 7-1D). In some budding bacteria, such as *Hyphomicrobium* species, the bud may develop at the end of a prostheca (Fig. 7-1E).

Fragmentation

Bacteria that produce extensive filamentous growth, such as *Nocardia* species, reproduce by **fragmentation** of the filaments into small bacillary or coccoid cells, each of which gives rise to new growth (Fig. 7-1F).

Formation of Conidiospores or Sporangiospores

Species of the genus *Streptomyces* and related bacteria produce many spores per organism by developing crosswalls (septation) at the hyphal tips; each spore gives rise to a new organism (Fig. 7-1G).

New Cell Formation (Macromolecular Synthesis)

A bacterial cell inoculated into a fresh medium selectively takes up nutrients from its environment. Many biochemical syntheses then take place. The nutrients are converted into cell substance—RNA, DNA, proteins, enzymes, and other macromolecules. Cell mass and cell size increase, and new cell wall building blocks are synthesized. Subsequently, the process of binary fission is initiated, ultimately resulting in the formation of two new cells.

Septum Formation

In transverse binary fission, septum formation does not begin until the chromosome content of the cell has been doubled; i.e., cell division is triggered by completion of DNA replication (discussed in Chap. 11). The first step is an inward growth of the cytoplasmic membrane at the middle of the cell; a mesosome is usually attached to the cytoplasmic membrane at this location, particularly in Gram-positive cells, and may have a role in the synthesis of new membrane material. The next step is the inward growth of the cell wall to form a septum that ultimately splits to allow separation of the two daughter cells.

For example, during growth of the Gram-positive coccus *Streptococcus faecalis*, all of the new wall material formed by the dividing cell is made during synthesis of the septum. Septum formation begins beneath an equatorial ridge in the cell wall (see Figs. 7-2 and 5-26). New cell-wall material is synthesized in this region and, as the septum forms, this material becomes one half of the wall of each daughter cell. Some plasticity must be present in order for the new wall to achieve its final, more or less hemispherical shape; this is believed to be due to two factors: (1) the turgor pressure of the protoplast against the newly synthesized wall and (2) a certain amount of reorganization of the peptidoglycan due to breakage of some of the chemical bonds by hydrolytic enzymes and subsequent formation of new bonds at a different location.

In Gram-positive rods such as *Bacillus subtilis*, the transverse septum is formed in a manner similar to that for *S. faecalis*, although no ridge is present at the middle of the cell. Moreover, only about 15 percent of the new wall of a daughter cell is derived from formation of the septum. The remainder is synthesized along the cylindrical part of the cell; since a bacillus grows mainly by elongation rather than just by septum formation as does a coccus. Perhaps there are just a few discrete regions where new wall is synthesized and inserted into old wall, or perhaps new wall is made and inserted into old wall all along the length of the cell, but this is a question yet unanswered. However, there is strong evidence that the youngest portion of the cylindrical wall is that layer which is immediately adjacent to the cytoplasmic membrane. During growth and extension of the wall, the older, outer layers of the wall become more thinly spread out. They are eventually destroyed by degradative enzymes located in the cell wall and are replaced from below by the newer wall material. Thus the wall is not static like a plastic coating; rather, it is in a dynamic state, with old, outer material continually being destroyed and new, inner material continually being added as the cell elongates.

The stages of septum formation in Gram-negative bacilli such as *Escherichia coli* are depicted in Fig. 7-3.

A number of basic questions remain to be answered concerning transverse binary fission:

1 What ensures that each daughter cell will receive a complete genome? That is, during septum formation in any bacterial cell, it is essential that the DNA be precisely distributed to the daughter cells so that each receives a complete genome.

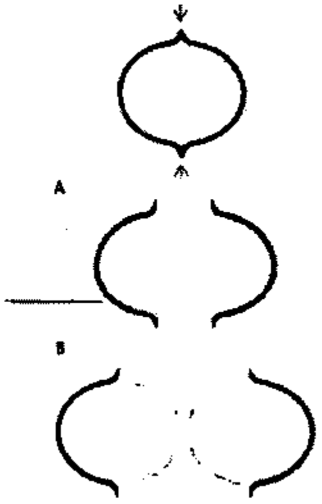

Figure 7-2. Schematic diagram illustrating septum formation in Gram-positive cocci such as *Streptococcus faecalis*. (A) Synthesis of new wall begins at the equatorial ridge (arrows). (B) From this site new wall grows peripherally, pushing apart the hemispheres of old wall. Half of the entire wall of each daughter cell is derived from the septum.

Q.5) Write short notes on (any three) 15

A) Actinomycetes

- Actinomyces is a genus of the Actinobacteria class of bacteria.
- They are all gram-positive. Actinomyces species are facultatively anaerobic (except A. meyeri and A. israelii both obligate anaerobe), and they grow best under anaerobic conditions.
- Actinomyces species may form endospores, and, while individual bacteria are rod-shaped, Actinomyces colonies form fungus-like branched networks of hyphae.
- Actinomyces species are ubiquitous, occurring in soil and in the microbiota of animals, including the human microbiota.

- They are known for the important role they play in soil ecology; they produce a number of enzymes that help degrade organic plant material, lignin, and chitin. Thus their presence is important in the formation of compost.
- Certain species are commensal in the skin flora, oral flora, gut flora, and vaginal flora[2] of humans and livestock. They are also known for causing diseases in humans and livestock, usually when they get an opportunity to gain access to the body's interior through wounds.

B) Genetic diversity

Genetic diversity refers to the diversity(or genetic variability) within species.Each individual species possesses genes which are the source of its own unique features: In human beings, for example, the huge variety of people's faces reflects each person's genetic individuality. The term genetic diversity also covers distinct populations of a single species, such as the thousands of breeds of different dogs or the numerous variety of roses.Any change in the environment - natural or human induced causes a selection of events that only the fittest survive. Anthropogenic impact is particularly apparent in the coastal zone and increases the number of changes occurring to individual and populations. Such pressure is exerted by

- artificial selection (harvesting, aquaculture)
- degradation of habitats (leading to a reduction of total stocks and thus increasing the likeliness of inbreeding) and
- the release of farmed fish into the wild. These activities reduce the sum of genes available, thus leaving behind a population that is less capable of tolerating any further natural or anthropogenically caused changes in environment. These activities reduce the sum of genes available, thus leaving behind a population that is less capable of tolerating any further natural or human disturbances in environment The huge variety of different gene sets also define an individual or a whole population's ability to tolerate stress from any given environmental factor.

Extinction is not only the loss of whole species, but is also preceded by a loss of genetic diversity within the species.

This loss reduces the species ability to perform its inherent role in the whole ecosystem.

- Furthermore, the loss of genetic diversity within a species can result in the loss of useful and desirable traits (e.g. resistance to parasites). Reduced diversity may eliminate options to use untapped resources for food production, industry and medicine.

C) Phagocytosis

Phagocytosis, or "cell eating", is the process by which a cell engulfs a particle and digests it. The word phagocytosis comes from the Greek phago-, meaning "devouring", and -cyte, meaning "cell". Cells in the immune systems of organisms use phagocytosis to devour bodily intruders such as bacteria, and they also engulf and get rid of cell debris. Some single-celled organisms like amoebas use phagocytosis in order to eat and acquire nutrients.

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The cell that will perform phagocytosis is activated. This can be a phagocyte, which is a cell in the immune system that performs phagocytosis, or an organism such as an amoeba, which behaves in a similar way to phagocytes when it carries out phagocytosis. In the case of immune cells, activation occurs when the cells are near bacterial cells or parts of bacterial cells. Receptors on the surface of the cells bind to these molecules and cause the cells to respond.

In the immune system, chemotaxis may occur. Chemotaxis is the movement of phagocytes toward a concentration of molecules. Immune cells pick up chemical signals and migrate toward invading bacteria or damaged cells.

The cell attaches to the particle that it will ingest. Attachment is necessary for ingestion to occur. Some bacteria can resist attachment, making it harder for them to be taken into the cell and destroyed.

The cell ingests the particle, and the particle is enclosed in a vesicle (a sphere of cell membrane with fluid in it) called a phagosome. The phagosome transports the particle into the cell.

A lysosome fuses with the phagosome and the particle is digested. Lysosomes are vesicles that contain hydrolytic enzymes that break down molecules. A phagosome fused with a lysosome is called a phagolysosome.

Cellular waste, such as broken down molecules that the cell cannot reuse, is discharged from the cell by the process of exocytosis. Exocytosis is the opposite of endocytosis; it is when cellular waste products travel in vesicles to the surface of the cell membrane and are released, thereby exiting the cell.

D) Autophagy

Autophagy is intracellular digestion in which enzymes produced by the cell breakdown molecules and parts of cytoplasmic organelles of the cell itself, i.e., digestion of endogenous material.

Electron micrographs have shown that many cellular components such as mitochondria and RER are constantly removed from the cell by lysosomes. Organelles are surrounded by membranes of SER, then the lysosomal enzymes are discharged into the autophagic vacuoles and the organelles are digested.

Autophagy is a general property of eukaryotic cells and is related to the normal renovation and turn over of cellular components. Worn out or defective organs are digested in the autophagic vacuoles. This is a mechanism by which parts of the cell are broken down to facilitate survival. Autophagy is therefore a mechanism for removing dead or injured cells.

Autophagy may be greatly increased in certain condition (adverse conditions). For example, in protozoa deprived of nutrients or in the liver of a starving animal, many autophagic vacuoles appear. Autophagy is also induced as a pathological response. Actinomycin D and Puromycin (metabolic inhibitors) have been reported to cause increased autophagy this helps to remove the injured area and prevents the degenerative process from spreading. Autophagy has been observed in tissues undergoing physiological remodeling, e.g., during embryonic development and metamorphosis. Autophagy may bring about cellular digestion on the death of a cell or with cellular injury.

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E) Types of bacteria based on their nutritional requirements.

NUTRITIONAL TYPES OF BACTERIA

From the generalizations in the preceding paragraphs, it is apparent that bacteria can be divided into many groups on the basis of their nutritional requirements. The major separation is into two groups, phototrophs and chemotrophs.

Phototrophs

Among the phototrophic bacteria are species that use inorganic compounds as their source of electrons (i.e., photolithotrophs). For example, *Chromatium okenii* uses H_2S as its electron donor, oxidizing it to elemental sulfur:

$$H_2S \rightarrow S + 2e^- + 2H^+$$

Some phototrophic bacteria use organic compounds such as fatty acids and alcohols as electron donors and are therefore photoorganotrophs. For example, *Rhodospirillum rubrum* can use succinate as an electron donor:

$$\text{Succinate} \rightarrow \text{fumarate} + 2e^- + 2H^+$$

Certain phototrophic bacteria are not restricted to being phototrophic. As indicated before, chemotrophs rely on chemical compounds rather than light for their energy, and under some circumstances a phototrophic bacterium can grow as a chemotroph. For example, in the absence of O_2 (i.e., under anaerobic conditions) *R. rubrum* is dependent on light as its source of energy and lives as a photoorganotroph; however, in the presence of O_2 it can grow in the dark as a chemoorganotroph.

Chemotrophs

Among the chemotrophic bacteria are species that use inorganic compounds as

Table 6-2. Vitamin Requirements for Some Bacteria

Vitamin	Species Exhibiting Requirement (or Growth Stimulation)
Thiamine (B_1)	*Bacillus anthracis*
Riboflavin	*Clostridium tetani*
Niacin (nicotinic acid)	*Brucella abortus*
Pyridoxine (B_6)	*Lactobacillus* spp.
Biotin	*Leuconostoc mesenteroides*
Pantothenic acid	*Morganella morganii*
Folic acid	*Leuconostoc dextranicum*
Cobalamin (B_{12})	*Lactobacillus* spp.
Vitamin K	*Bacteroides melaninogenicus*

their source of electrons (i.e., chemolithotrophs). For example, bacteria of the genus *Nitrosomonas* use ammonia as their electron source, obtaining energy by oxidizing ammonia to nitrite:

$$NH_4^+ + 1\tfrac{1}{2}\,O_2 + H_2O \rightarrow NO_2^- + 2H_3O^+$$

This reaction involves a net transfer of 6 electrons, causing a valence change of the nitrogen atom from −3 to +3.

Many other chemotrophic bacteria use organic compounds, such as sugars and amino acids, as electron donors and are therefore chemoorganotrophs.

Certain bacteria can grow as either chemolithotrophs or chemoorganotrophs. For example, *Pseudomonas pseudoflava* can use either the organic compound glucose or the inorganic compound H_2 as its source of electrons:

$$\underset{\text{glucose}}{C_6H_{12}O_6} + 6H_2O \rightarrow 6CO_2 + 24H^+ + 24e^-$$

$$H_2 \rightarrow 2H^+ + 2e^-$$

Autotrophs and Heterotrophs

Autotrophs

As indicated before, the chemolithotrophic bacteria of the genus *Nitrosomonas* are able to oxidize ammonia to nitrite, thereby obtaining sufficient energy to assimilate the carbon of CO_2 into cell components (CO_2 fixation):

$$CO_2 + 4e^- + 4H^+ \rightarrow (CH_2O) + H_2O$$

where (CH_2O) represents carbohydrate. Organisms that can use CO_2 as their sole source of carbon for assimilation are termed autotrophs.

Until recently it was thought that all chemolithotrophic bacteria were autotrophs. Although this is true for most chemolithotrophs, a few are now recognized as being chemolithotrophic heterotrophs (*mixotrophs*); i.e., they obtain energy by utilizing inorganic electron donors, but obtain most of their carbon from organic compounds. One such organism is *Desulfovibrio desulfuricans*, which uses electrons from H_2 for the reduction of sulfate, yet derives most of its carbon from organic compounds in the culture medium.

Some autotrophs are facultative autotrophs; i.e., they can either live as autotrophs, deriving their carbon from CO_2, or they can live as heterotrophs, deriving their carbon from organic compounds. For example, *P. pseudoflava* can live as a heterotroph, using glucose as a source of carbon for assimilation (and also as its source of electrons, as mentioned above); however, if H_2 is provided as the electron source, then it can use CO_2 as its sole carbon source and can grow as an autotroph.

Table 6-3. Medium for *Nitrosomonas europaea*

Ingredient	Amount
NH_4Cl*	0.6 g
$MgSO_4 \cdot 7H_2O$	0.2 g
K_2HPO_4	0.015 g
$CaCl_2 \cdot 2H_2O$	0.02 g
Chelated iron	0.001 g
$MnCl_2 \cdot 4H_2O$	0.0002 g
$Na_2MoO_4 \cdot 2H_2O$	0.0001 g
$ZnSO_4 \cdot 7H_2O$	0.0001 g
$CuSO_4 \cdot 5H_2O$	0.00002 g
$CoCl_2 \cdot 6H_2O$	0.000002 g
Distilled water	1,000 ml
Atmospheric CO_2†	

* The ammonium salt serves not only as the nitrogen source for this organism but also as the electron donor. The organism obtains energy by oxidizing ammonium ions to nitrite ions.

† Carbon dioxide is the sole carbon source.

Cultivation of Autotrophs. In terms of chemical complexity of nutrient substances required for growth, the autotrophic bacteria exhibit the simplest requirements. For example, a medium of the composition shown in Table 6-3 supports the growth of *Nitrosomonas europaea*. (Because this medium is composed of known chemical compounds, it is called a **chemically defined** or **synthetic medium**.) The fact that an organism can grow and reproduce in such a mixture of inorganic compounds indicates that it has an elaborate capacity for synthesis. That is, the organism can transform these compounds into the carbohydrates, proteins, nucleic acids, lipids, vitamins, and other complex organic substances that constitute the living cell.

Table 6-4. Minimal Nutritional Requirements of Some Heterotrophic Bacteria

Bacteria	Inorganic Salts	Organic Carbon	Atmospheric N_2	Inorganic Nitrogen	One Amino Acid	Two or More Amino Acids	One Vitamin	Two or More Vitamins
Azospirillum brasilense	+	+	+					
Escherichia coli	+	+		+				
Salmonella typhi	+	+		+	+			
Proteus vulgaris	+	+		+	+		+	
Staphylococcus aureus	+	+		+		+	+	
Lactobacillus acidophilus	+	+		+		+		+

Heterotrophs

Heterotrophic bacteria have been studied more extensively than the autotrophs because heterotrophs, in a sense, are of more immediate concern to us: it is here that we find all the species that cause diseases of human beings, other animals, and plants, as well as those that constitute the greater part of the microbial population in our immediate environment. However, we need to emphasize this does not mean that autotrophs are less important. On the contrary, they are of utmost importance in less conspicuous but indispensable processes in nature such as the cycling of elements through biological systems.

Cultivation of Heterotrophs. The heterotrophic bacteria, although they constitute one major nutritional group, vary considerably in the specific nutrients required for growth, particularly with respect to their organic carbon sources, nitrogen sources, and vitamin requirements. As indicated in Table 6-4, the requirements may be relatively simple or complex, depending on the species. This is shown more specifically in Table 6-5, where chemically defined media for the growth of *Escherichia coli* and lactobacilli are compared. From this table it is evident that *E. coli* has much simpler nutritional requirements than lactobacilli. Organisms such as lactobacilli that have elaborate requiremnts for specific nutrients, i.e., vitamins and other growth-promoting substances, are designated **fastidious heterotrophs.**

Obligate Parasites

Some bacteria have not yet been successfully cultivated on an artificial medium, and their nutritional and physical requirements are not understood. At present, such bacteria can be propagated only in association with a living host which, in a sense, serves as the medium. One example is the bacterium that causes leprosy, *Mycobacterium leprae*, which can be cultivated by infecting mice or armadillos. Other examples include the rickettsias, the chlamydias, and the spirochete that causes syphilis, *Treponema pallidum*.

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