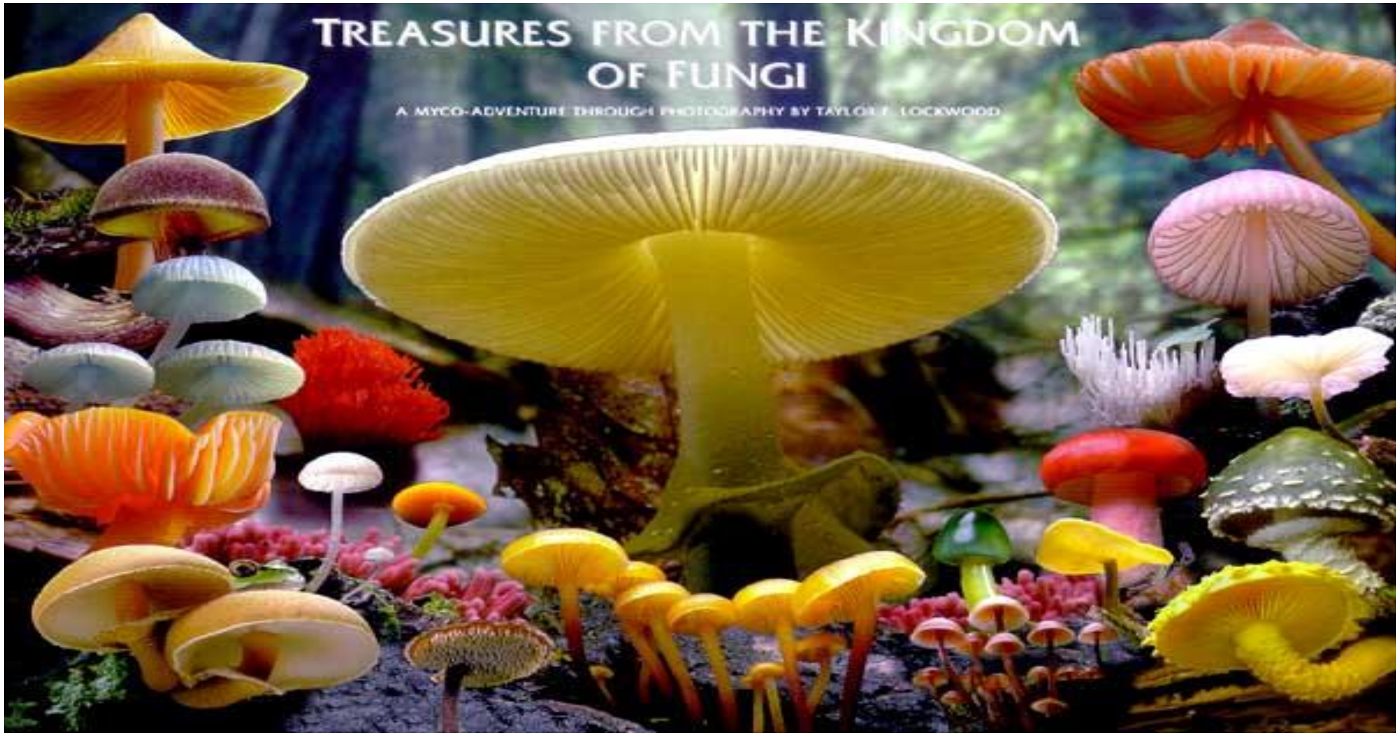
BIOLOGY AND DIVERSITY OF VIRUSES, BACTERIA AND FUNGI (PAPER CODE: BOT 501)



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OBJECTIVES

The main objective of the present lecture is to cover the topic and make it easy to understand and interesting for our students/learners.

BLOCK – III : FUNGI – I

Unit –11 : Ultra Structure of Cell and Cell Wall Composition

CONTENT

- Ultrastructure of fungi
  - The cell wall of fungal cell
  - The architecture of fungal cell wall
  - Synthesis of fungal cell wall
  - Protoplast
  - Nucleus
  - Somatic nuclear division
  - Flagella
- Cell wall composition
- Key points of the lecture
- Terminology
- Assessment Questions
- Bibliography

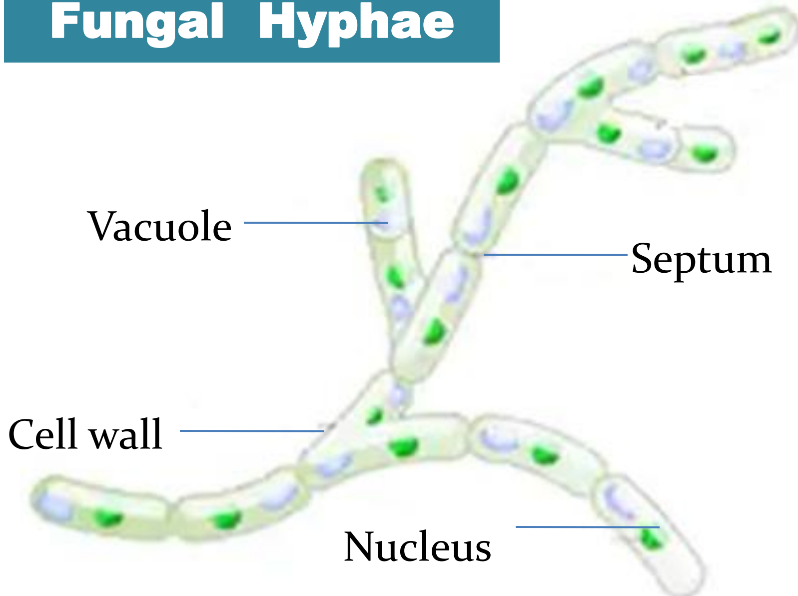
ULTRASTRUCTURE OF FUNGI

- Fungi are achlorophyllas, heterotrophic eukaryotic thallophytes.
- The ultrastructure of the fungi is discussed below:

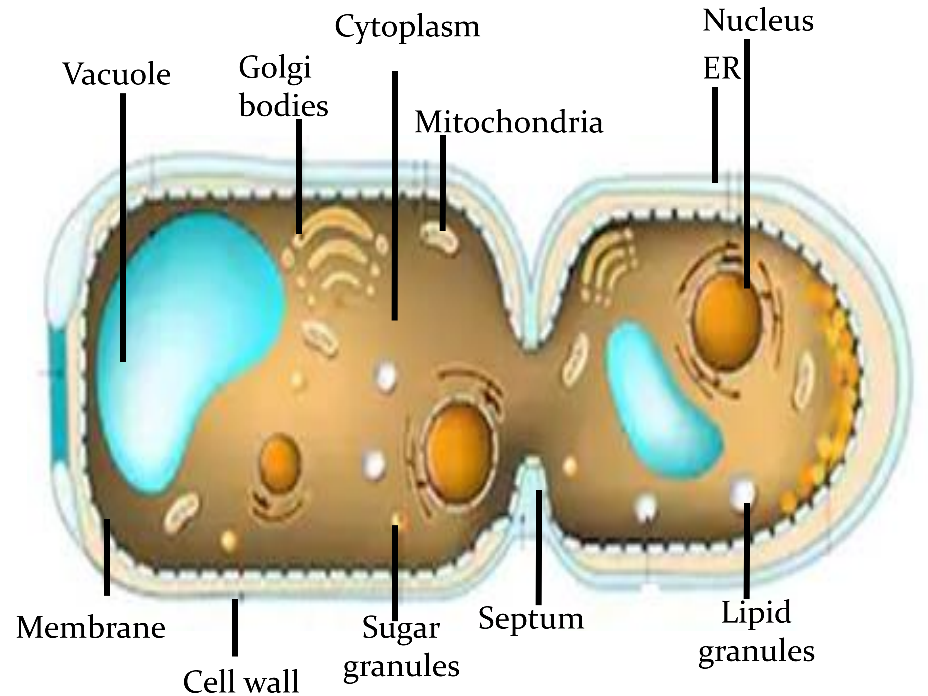
The Cell Wall of Fungal Cell:

- The composition of cell wall is variable among the different groups of fungi or between the different species of the same group.
- In the majority of fungi, the wall lacks cellulose but contains a form of chitin known as the fungus cellulose which is strictly not identical with insect chitin.
- The suggested formula for fungus chitin is $(C_{22} H_{54} N_{21})_n$. Electron microscope studies reveal that chitin occurs as elongated variously oriented microfibrillar units. These are laid down in layers and form the basis of the structural rigidity of fungal cell walls.
- The microfibril layers generally run parallel to the surface. Associated with the microfibrillar components is the nonfibrillar material. The chief chemical constituents are various polysaccharides, but proteins, lipids besides other substances have also been reported.
- In the lower fungi, the biflagellate Oomycetes are said to be distinct from all over fungi due to the cellulose nature of the cell wall.
- De Bary reported true cellulose in *Peronospora* and *Saprolegnia*. Precise analysis of the cell wall of *Phytophthora* and *Pythium* by Bartnicki-Garcia (1966), Mitchell and Sabar (1968) has revealed that cellulose is a minority component or even absent altogether.

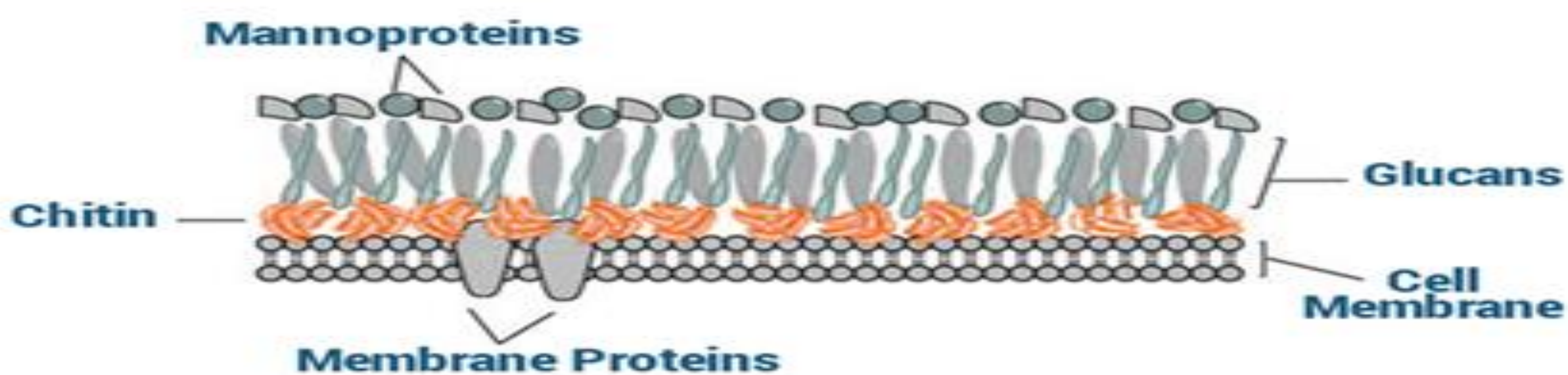
Fungal Hyphae



Ultra Structure of Fungal Cell



Fungal Cell Wall



- On the other hand, glucan predominates in their walls. Thus, the Oomycetes may be said to have cellulose in their cell walls but it may not be the predominant material.

- Chitin which had long been considered to be absent has recently been reported to be present even in the cell walls of some Oomycetes.

- The basic structural constituent of the cell wall in the Zygomycetes and higher fungi (Ascomycetes and Basidiomycetes) is chitin. It is a polysaccharide based on the nitrogen containing sugar (glucosamine).

- It is probable that more or less closely associated with chitin in the cell wall are pectic materials, protein, lipids, cellulose, callose and minerals.

- The clear evidence of such an association is, however, lacking. Burnet (1968) is of the opinion that insoluble B glucan forms the predominant structural material of the wall of Ascomycetes and Basidiomycetes.

- In addition chitin may as well be present in appreciable amounts. In the yeasts and a few other Hemiascomycetideae chitin is absent. Their walls are mainly composed of micro-fibrils of mannan and B glucan.

- Mannan is a polymer of hexose sugar mannose whereas glucan is polymer of glucose. Some investigators have reported the occurrence of lignin in several fungi It is doubtful whether this substance is chemically the same as the lignin of higher plants.

- It is obvious that our present knowledge of the chemical composition of the cell wall of fungi is incomplete like the cellulose wall; the chitin wall of most fungi is permeable both to water and substances in true solution.

❑The Architecture Of Fungal Cell Wall:

❖ Although the chemical composition of cell walls can vary considerably between and within different groups of fungi (Table), the basic design seems to be universal.

Table I.I. The chemical composition of cell walls of selected groups of fungi (dry weight of total cell wall fraction, in per cent). Data adapted from Ruiz-Herrera (1992) and Griffin (1994).

Group	Example	Chitin	Cellulose	Glucans	Protein	Lipid
Oomycota	*Phytophthora*	0	25	65	4	2
Chytridiomycota	*Allomyces*	58	0	16	10	?
Zygomycota	*Mucor*	9*	0	44	6	8
Ascomycota	*Saccharomyces*	1	0	60	13	8
	Fusarium	39	0	29	7	6
Basidiomycota	*Schizophyllum*	5	0	81	2	?
	Coprinus	33	0	50	10	?

❖ It consists of a structural scaffold of fibres which are crosslinked, and a matrix of gel-like or crystalline material.

❖ The degree of cross-linking will determine the plasticity (extensibility) of the wall, whereas the pore size (permeability) is a property of the wall matrix.

❖ The scaffold forms the inner layer of the wall and the matrix is found predominantly in the outer layer.

❖ In the Ascomycota and Basidiomycota, the fibres are chitin microfibrils, i.e. bundles of linear b-(1,4)-linked N-acetylglucosamine chains (Fig. A), which are synthesized at the plasma membrane and extruded into the growing cell wall around the apical dome.

- The cell wall becomes rigid only after the microfibrils have been fixed in place by crosslinking.
- These cross-links consist of highly branched glucans (glucose polymers), especially those in which the glucose moieties are linked by b-(1,3)- and b-(1,6)-bonds.
- Such b-glucans are typically insoluble in alkaline solutions (1M KOH). In contrast, the alkalisoluble glucan fraction contains mainly a-(1,3)- and/or a-(1,4)-linked branched or unbranched chains and does not perform a structural role but instead contributes significantly to the cell wall matrix.
- Proteins represent the third important chemical constituent of fungal cell walls. In addition to enzymes involved in cell wall synthesis or lysis, or in extracellular digestion, there are also structural proteins.
- Many cell wall proteins are modified by glycosylation, i.e. the attachment of oligosaccharide chains to the polypeptide.
- The degree of glycosylation can be very high, especially in the yeast *Saccharomyces cerevisiae*, where up to 90% of the molecular weight of an extracellular protein may be contributed by its glycosylation chains.
- Since mannose is the main component, such proteins are often called mannoproteins or mannans.
- In *S. cerevisiae*, the pore size of the cell wall is determined not by matrix glucans but by mannoproteins located close to the external wall surface.
- Proteins exposed at the cell wall surface can also determine surface properties such as adhesion and recognition.

- Structural proteins often contain a glycosylphosphatidylinositol anchor by which they are attached to the lumen of the rough endoplasmic reticulum (ER) and later to the external plasma membrane surface, or a modified anchor which covalently binds them to the b-(1,6)-glucan fraction of the cell wall.

- In the Zygomycota, the chitin fibres are modified after their synthesis by partial or complete deacetylation to produce poly-b-(1,4)-glucosamine, which is called chitosan (Fig. A)

- Chitosan fibres are cross-linked by polysaccharides containing glucuronic acid and various neutral sugars.

- The cell wall matrix comprises glucans and proteins, as it does in members of the other fungal groups.

- One traditional feature to distinguish the Oomycota from the 'true fungi' (Eumycota) has been the absence of chitin from their cell walls, even though chitin is now known to be produced by certain species of Oomycota under certain conditions.

- In Oomycota, the structural role of chitin is filled by cellulose, an aggregate of linear b-(1,4)-glucan chains (Fig. A).

- As in many other fungi, the fibres thus produced are cross-linked by an alkali-insoluble glucan containing b-(1,3)- and b-(1,6)-linkages. In addition to proteins, the main matrix component appears to be an alkali-soluble b-(1,3)-glucan.

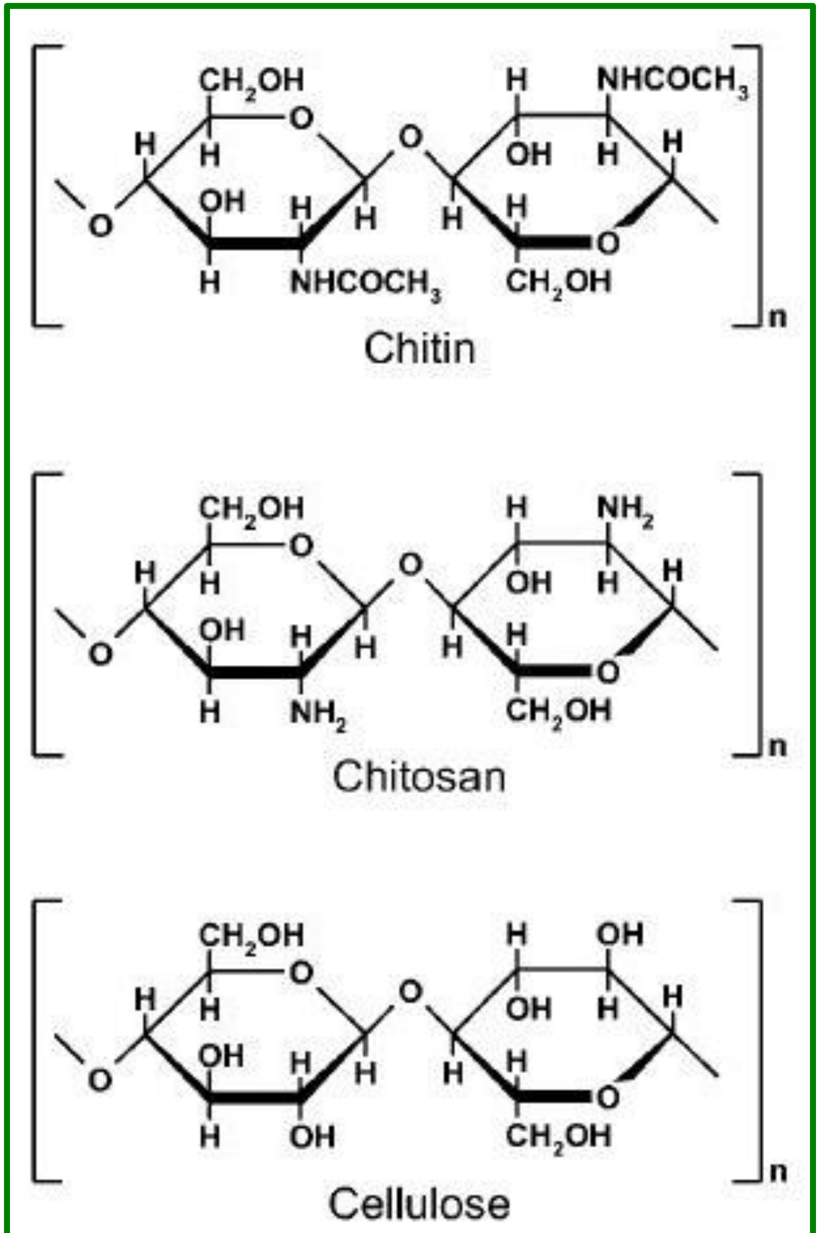


Fig. A: Structure formula of the principal fibrous components of fungal cell walls

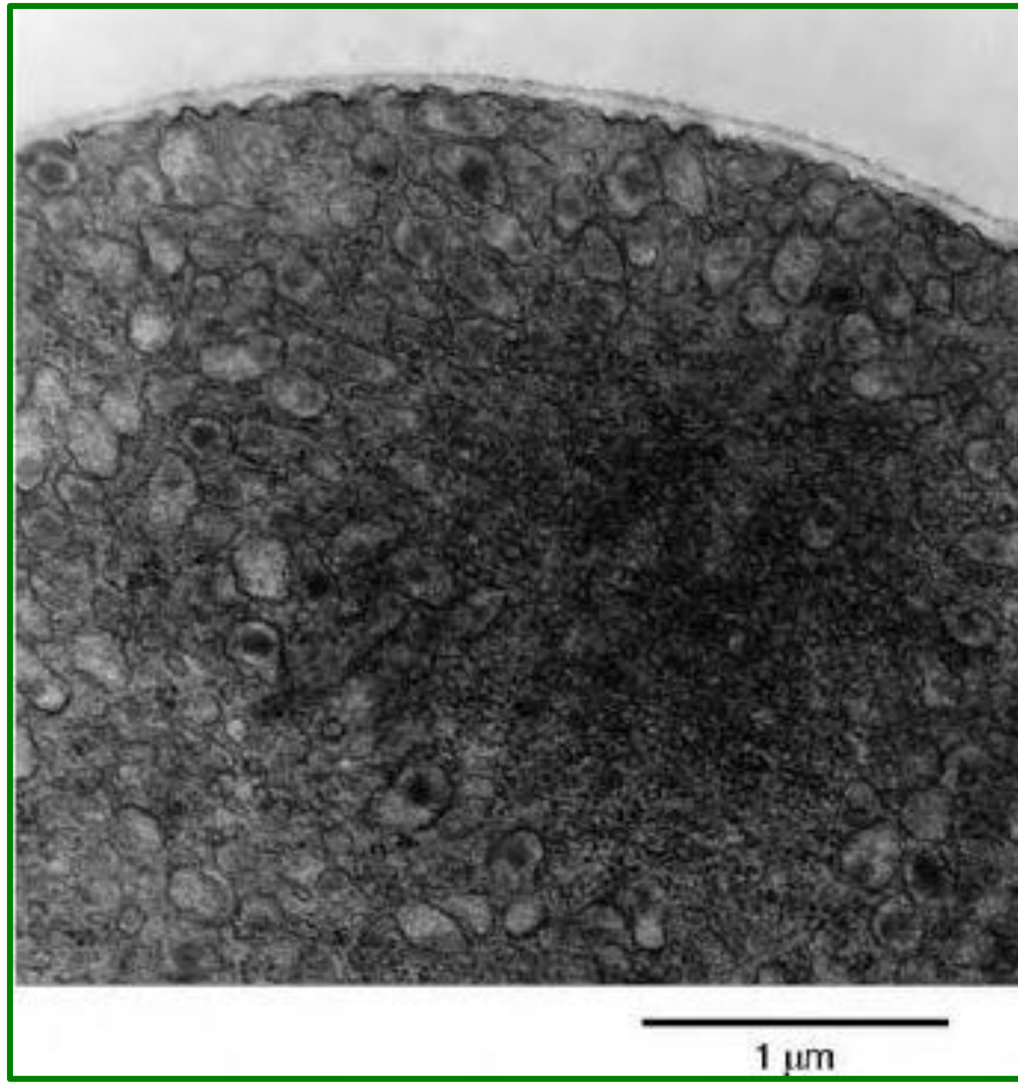


Fig. B: Spitzenkorper of *Botrytis cinerea* which is differentiated into an electron-dense core consisting of microvesicles and an outer region made up of larger secretary vesicles, some of which are located close to the plasma membrane. [Reprinted from Weber and Pitt (2001), with permission of Elsevier]

❑ Synthesis of The Cell Wall:

- ❖ The synthesis of chitin is mediated by specialized organelles termed chitosomes, in which inactive chitin synthases are delivered to the apical plasma membrane and become activated upon contact with the lipid bilayer.

- ❖ Microvesicles, visible especially in the core region of the Spitzenkorper, are likely to be the ultrastructural manifestation of chitosomes (Fig. B).

- ❖ In contrast, structural proteins and enzymes travel together in the larger secretory vesicles and are discharged into the environment when the vesicles fuse with the plasma membrane (Fig. B).

- ❖ Whereas most proteins are fully functional by the time they traverse the plasma membrane, the glucans are secreted by secretory vesicles as partly formed precursors and undergo further polymerization in the nascent cell wall, or they are synthesized entirely at the plasma membrane.

- ❖ Cross-linking of glucans with other components of the cell wall takes place after extrusion into the cell wall have provided experimental evidence to support a model for cell wall synthesis in Schizophyllum commune (Basidiomycota).

- ❖ The individual linear b-(1,4)-Nacetylglucosamine chains extruded from the plasma membrane are capable of undergoing self-assembly into chitin microfibrils, but this is subject to a certain delay during which crosslinking with glucans must occur.

- ❖ The glucans, in turn, become alkali-insoluble only after they have become covalently linked to chitin. Once the structural scaffold is in place, the wall matrix can be assembled.

- ❖ Hyphal growth occurs as the result of a continuously replenished supply of soft wall material at the apex, but there is good evidence that the softness of the apical cell wall is also influenced by the activity of wall-lytic enzymes such as chitinases or glucanases.

- Further, when certain Oomycota grow under conditions of hyperosmotic stress, their cell wall is measurably softer due to the secretion of an endo-b-(1,4)-glucanase, thus permitting continued growth when the turgor pressure is reduced or even absent.
- Since, in higher Eumycota, both cell wall material and synthetic as well as lytic enzymes are secreted together by the vesicles of the Spitzenkorper, the appearance, position and movement of this structure should influence the direction and speed of apical growth directly.
- Cell wall-lytic enzymes are also necessary for the formation of hyphal branches, which usually arise by a localized weakening of the mature, fully polymerized cell wall.
- An endo-b-(1,4)-glucanase has also been shown to be involved in softening the mature regions of hyphae in the growing stipes of Coprinus fruit bodies, thus permitting intercalary hyphal extension.
- Indeed, the expansion of mushroom-type fruit bodies in general seems to be based mainly on non-apical extension of existing hyphae, which is a rare exception to the rule of apical growth in fungi.
- The properties of the cell wall depend in many ways on the environment in which the hypha grows.
- Thus, when Schizophyllum commune is grown in liquid submerged culture, a significant part of the b-glucan fraction may diffuse into the liquid medium before it is captured by the cell wall, giving rise to mucilage.
- In addition to causing problems when growing fungi in liquid culture for experimental purposes, mucilage may cause economic losses when released by *Botrytis cinerea* in grapes to be used for wine production.

- On the other hand, secreted polysaccharides, especially of Basidiomycota, may have interesting medicinal properties and are being promoted as anti-tumour medication both in conventional and in alternative medicine.

- Another difference between submerged and aerial hyphae is caused by the hydrophobins, which are structural cell wall proteins with specialized functions in physiology, morphogenesis and pathology.

- Some hydrophobins are constitutively secreted by the hyphal apex. In submerged culture, they diffuse into the medium as monomers, whereas they polymerize by hydrophobic interactions on the surface of hyphae exposed to air, thereby effectively impregnating them and rendering them Hydrophobic.

- When freeze fractured hydrophobic surfaces of hyphae or spores are viewed with the transmission electron microscope, polymerized hydrophobins may be visible as patches of rodlets running in parallel to each other.

- Other hydrophobins are produced only at particular developmental stages and are involved in inducing morphogenetic changes of the hypha, leading, for example, to the formation of spores or infection structures, or aggregation of hyphae into fruit bodies.

- Some fungi are wall-less during the assimilative stage of their life cycle. This is true especially of certain plant pathogens such as the Plasmodiophoromycota , insect pathogens and some members of the Chytridiomycota.

- Since their protoplasts are in direct contact with the host cytoplasm, they are buffered against osmotic fluctuations. The motile spores (zoospores) of certain groups of fungi swim freely in water, and bursting due to osmotic inward movement of water is prevented by the constant activity of water-expulsion vacuoles.

❑The Protoplast of Fungal Cell:

❖ The living substance of the cell within the cell wall is the protoplast. It lacks the chloroplasts but is differentiated into the other usual cell parts such as plasma or cell membrane, vacuolated cytoplasm, cell organelles and one or more nuclei.

➢ **Cell Membrane:** It is a delicate, extremely thin, living membrane which closely invests the protoplast.

- The cell or plasma membrane is pressed against the cell or hyphal wall except for occasional invaginations in some regions.
- The Invagination is either in the form of an infolded convoluted pocket or a pouch enclosing granular or vesicular material.
- Moore and Mc Lear (1961) named it lomasome. Actually the plasma membrane is the surface layer of the protoplast altered to perform special functions.
- It is differentially permeable and shows a typical tripartite structure under the electron microscope. There is an electron dense layer on either side of the less dense central region.

➢ **Cytoplasm:** Within the plasma membrane is the colorless cytoplasm in which sap-filled vacuoles may occur.

- In young hyphae and hyphal tips, the cytoplasm appears rather uniform and homogeneous. Immersed in the cytoplasm are structures known as the organelles and inclusions.
- The organelles are living structures, each with a specific function. The inclusions are dead, have no specific function and thus are not essential to cell survival.

- Amongst the cell organelles are included the endoplasmic reticulum, mitochondria, ribosomes, Golgi apparatus and vacuoles.
- Lomasomes which are membranous structures lying between the cell wall and plasma membrane are common. Examples of inclusions are the stored foods (glycogen, and oil drops) pigments and secretary granules.

(i) **Endoplasmic Reticulum:** The presence of endoplasmic reticulum in the fungal cytoplasm has been demonstrated by the use of electron micro-scope.

- It is composed of a system of membranes or microtubular structures usually beset with small granules which by some scientists are likened to the ribosomes.
- In many fungi, the endoplasmic reticulum is highly vesicular. Usually it is loose and more irregular than in the cells of green plants.

(ii) **Mitochondria:** The cytoplasm contains small, usually spherical bodies known as the mitochondria.

- Each mitochondrion is enveloped by a double membrane. The inner membrane is infolded to form the cristae which are in the form of parallel flat plates or irregular tubules.
- The cristae contain the same fluid that fills the space between the two membranes.
- The mitochondria function as the power house of the cell.
- There is no fundamental difference between the mitochondria of fungi and those of green plants. However, Hawker (1965) holds that the cristae of fungal mitochondria are fewer, flatter and more irregular than those of the green plants.

- Moore and Muhlethaler (1963) reported a golgi apparatus consisting of three flattened sacs surrounded by many bubble-like structures in Saccharomyces cells.

(iii) Golgi Apparatus (Dictyosomes): With the exception of Oomycetes there is less certainty of the occurrence of structures similar to those of the golgi apparatus (dictyosomes) in fungi.

- Moor and Muhlethaler (1963) reported a golgi apparatus consisting of three flattened sacs surrounded by many bubble like structured in *Saccharomyces* cells.

(iv) Vacuole: The cytoplasm of young hyphae or fungal cells and hyphal tips lacks vacuoles.

- They appear further back or in the old cells. With age, they enlarge and show a tendency to coalesce and ultimately reduce the cytoplasm to thin lining layer immediately within cell wall.

(v) Inclusions: The cytoplasm contains various kinds of inclusions. Examples of stored foods are lipid globules, granules of glycogen, oils and the carbohydrate trehalose, proteinaceous material and volutin.

- The glycogen may occur in vacuoles. There are no starch grains. Of the pigments, the fungi lack chlorophyll. Carotenoids are often conspicuous by their presence and may occur throughout the cytoplasm or concentrated in the lipid granules or distributed in the cell wall.

- The cytoplasm, in addition, secretes several kinds of ferments, enzymes and organic acids.

❑ Nucleus:

❖ The cytoplasm in the individual cells contains one, two or more globose or ellipsoid nuclei which in the somatic portion are small and usually range from 1-2 or 3μ in diameter. They cannot be seen without special techniques. Structurally the nucleus consists of:

- A central, dense body with a clear area around it.
- Chromatin strands
- The whole structure surrounded by a definite nuclear, membrane.

❖ The central body takes heavy iron haematoxylin stain and is usually Feulgen-negative.

❖ In electron micrographs, it appears as an amorphous or granular mass.

❖ Mycologists usually designate it as the nucleolus. Bakerspigel (1960) stated that it contains RNA.

❖ During nuclear division, the chromatin strands become organised into chromosomes which are extremely small and difficult to count.

❖ Under the electron microscope, the nuclear membrane is seen to consist of inner and outer layers of electron dense material and the middle one of electron transparent substance.

❖ The nuclear membrane has pores. At certain points, the nuclear membrane is continuous with the endoplasmic reticulum.

❑ Somatic Nuclear Division:

❖ The older mycologist believed that the somatic nuclear division in most fungi differ markedly from normal mitosis. Moor termed it Karyochorisis in contradiction to normal mitosis or karyokinesis. Lu (1974), however state that in fungi mitosis occur more less normally and the fungal nucleus passes through the stages characterstics of mitosis . The cell division is closed thus termed intranuclear. It means the nuclear membrane remains more or less intact and does not disorganised during prophase. Centrioles appear in close association with the nuclear membrane. They appear in pair and each migrates to the opposite poles of the nucleus to control the formation of spindle.

❑ Fungal flagella:

- ❖ The higher fungi lack motile cells in their life cycle. With the exception of zygomycetes , they are characteristics of the lower fungi. The motile cells (zoospores and gametes) in the lower fungi are furnished with one or two fine, protoplasmic fine, whip like threads known as flagella. These are thin, hair like emergences of the cell cytoplasm which functions as propelling or locomotors structure of the cell.

- ➢ **Structure of Flagellum:** Forming the core of the flagellum is a central or axial filament known as the axoneme (A- C).

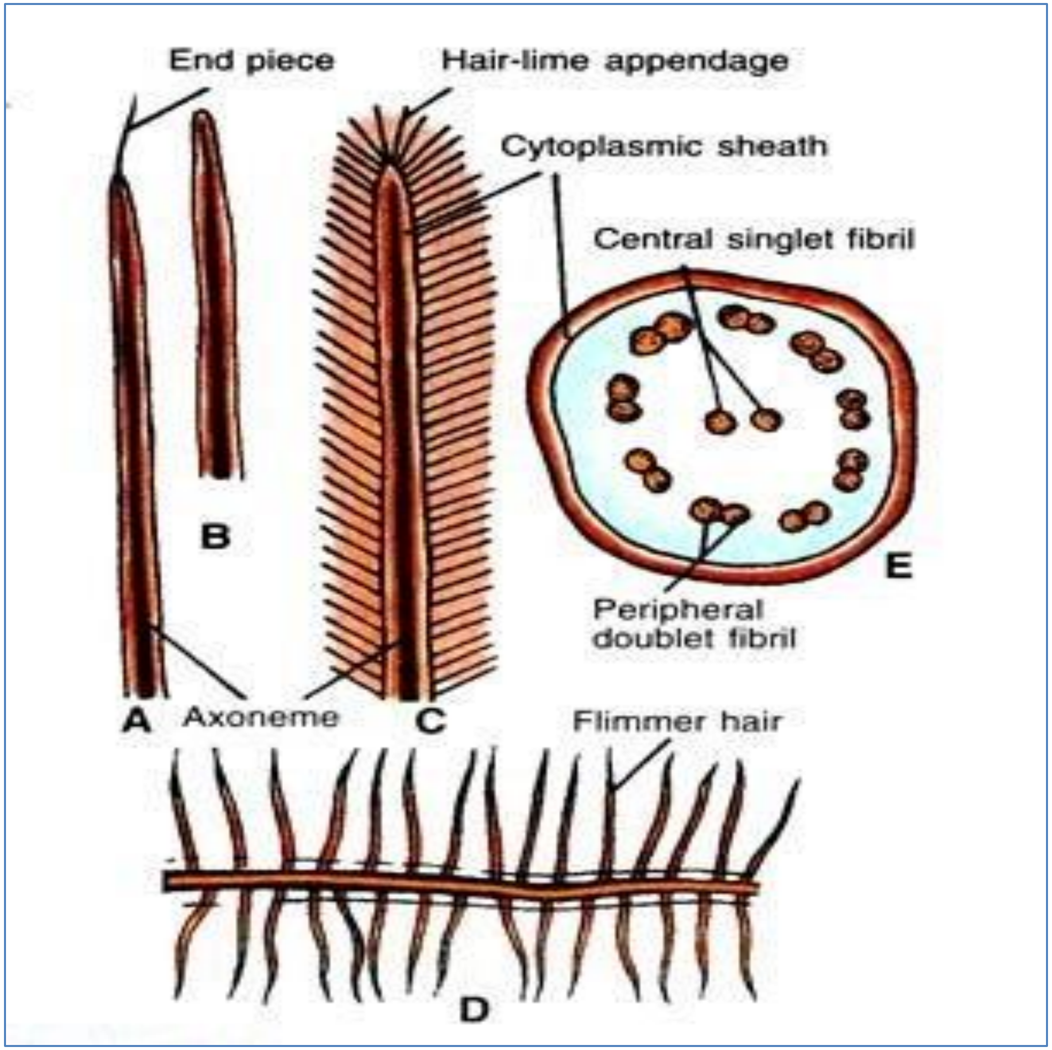
- ❖ The axoneme is surrounded by a double cytoplasmic sheath or membrane which is an extension of the plasma membrane of the motile cell. In a cross section, the axoneme it seen to be composed of eleven fibrils (E).

- ❖ Of these, two are central and nine peripheral. The two central single fibrils lie side by side and form an elastic axial thread which is sometimes enclosed by a subsidiary sheath of. Its own. Of the nine peripheral fibrils, each consists of two thin fibrils.

- ❖ The nine peripheral doublet fibrils surround the central pair of singlet fibrils. The entire growth of 9+2 fibrils is enclosed by a double cytoplasmic sheath. This 9+2 arrangement of fibrils is the basic structure of a eucaryotic flagellum found in the motile cells of all organisms except the bacteria.

- ➢ **Kinds of Flagella:** The fungal flagella are reported to be of the following three kinds:

(i) Whiplash flagellum with an end piece (Fig. A): It has a smooth surface and narrows abruptly towards the tip to form a distinct end piece. The end piece is a thin extension of variable length. It is flexible.



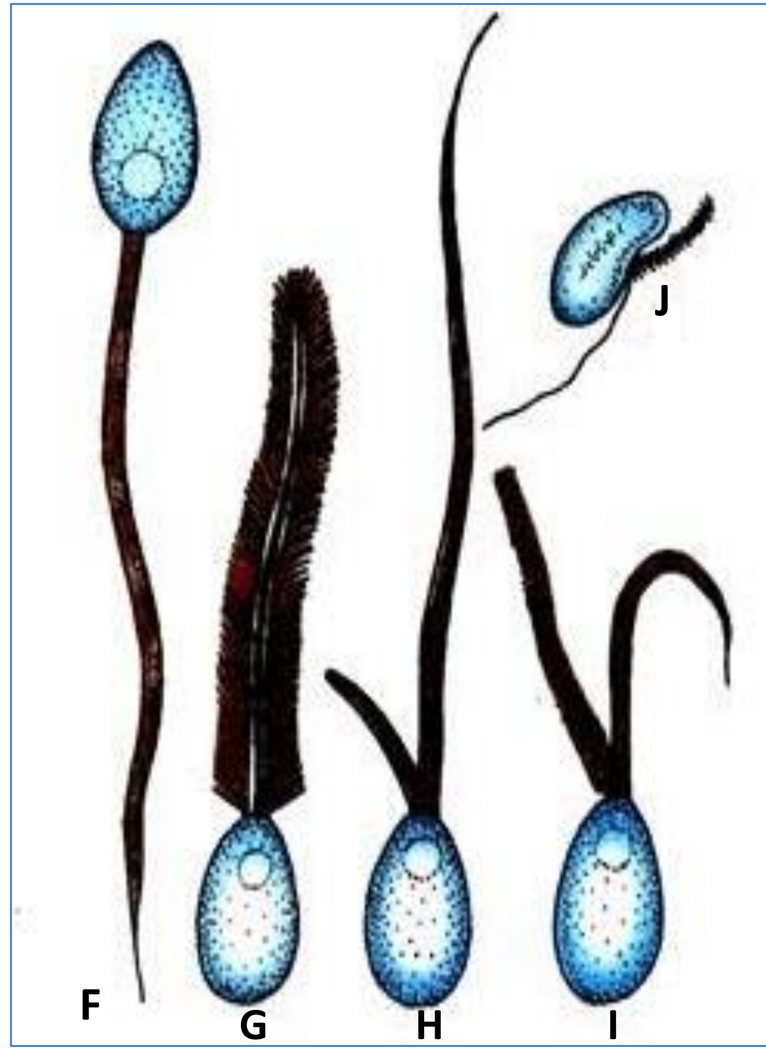


Fig: Fungal Flagella. (A). L.S. upper portion of an acronematic of whiplash flagellum with a drawn out pointed tip or end piece: (B). L.S. whiplash flagellum with blunt tip: (C): L.S. Pantonematic or tinsel flagellum: (D). Diagrammatic representation of a part of the tisel flagellum from an electron micrograph (Based on Manton et al): (E). T.S. eukaryotic flagellum showing 9+2 arrangement of fibrils. Fig. (F-J) represent the flagellation in the lower fungi.

(ii) Whiplash flagellum with a blunt tip (Fig. B): The blunt whiplash flagellum has smooth surface but lacks the narrow tip (end piece).

(iii) Tinsel flagellum (Fig. C and D): It does not obviously end in a narrow tip like the blunt whiplash type flagellum but bears fine lateral hair-like appendages known as the flimmer hairs or mastigoneme (C). The flimmer hairs on the tinsel flagellum arise from the axoneme (D).

❖ The tinsel flagellum is also known by other names such as pantonematic, flimmer or flimmergeisel flagellum. The other names of the whiplash flagellum are acronematic or peitchgeisal flagellum.

➢ **Flagellum in the Lower Fungi:** The number, kind and position of flagella on the motile cell constitutes its flagellation. Flagellation plays an important role in the taxonomy of the Lower Fungi (Phycomycetes). It is constant in each class of the Lower Fungi and differs from class to class. The Higher Fungi and Zygomycetes lack flagella.

❖ In class Chytridiomycetes furnished with a single whiplash flagellum with a pointed tip (F). It is inserted at the posterior end (opisthocont). The class Hyphochytridiomycetes posses a single flagellum of tinsel type (G) which inserted at the anterior end.

❖ In the class Plasmodiophoromycetes, the motile cells are biflagellate. The flagella are inserted at the anterior end. Both the them are of whiplash type but one of them is several times longer than the other (heterokont). The longer whiplash flagellum has a sharply pointed tip characteristic of the class Oomycetes.

❖ In the motile cells of this class with a pyriform shape, the two flagella are inserted at the anterior end (I) whereas in the kidney-shaped motile cells, the flagella arise from the depression. One of these is of tinsel type and the other whiplash with a sharply pointed tip. In motion, the tinsel flagellum is directed forward and the whiplash is directed backward.

KEY POINTS OF THE LECTURE

- The composition of cell wall is variable among the different groups of fungi or between the different species of the same group.
- In the majority of fungi, the wall lacks cellulose but contains a form of chitin known as the fungus cellulose which is strictly not identical with insect chitin.
- De Bary reported true cellulose in *Peronospora* and *Saprolegnia*. Precise analysis of the cell wall of *Phytophthora* and *Pythium* by Bartnicki-Garcia (1966), Mitchell and Sabar (1968) has revealed that cellulose is a minority component or even absent altogether.
- Chitin which had long been considered to be absent has recently been reported to be present even in the cell walls of some Oomycetes.
- The basic structural constituent of the cell wall in the Zygomycetes and higher fungi (Ascomycetes and Basidiomycetes) is chitin. It is a polysaccharide based on the nitrogen containing sugar (glucosamine).
- Although the chemical composition of cell walls can vary considerably between and within different groups of fungi, the basic design seems to be universal.
- The degree of cross-linking will determine the plasticity (extensibility) of the wall, whereas the pore size (permeability) is a property of the wall matrix.
- The cell wall becomes rigid only after the microfibrils have been fixed in place by crosslinking.
- Proteins represent the third important chemical constituent of fungal cell walls. In addition to enzymes involved in cell wall synthesis or lysis, or in extracellular digestion, there are also structural proteins.

KEY POINTS OF THE LECTURE

- ❖ In the Zygomycota, the chitin fibres are modified after their synthesis by partial or complete deacetylation to produce poly-b-(1,4)-glucosamine, which is called chitosan
- ❖ In Oomycota, the structural role of chitin is filled by cellulose, an aggregate of linear b-(1,4)-glucan chains
- ❖ As in many other fungi, the fibres thus produced are cross-linked by an alkali-insoluble glucan containing b-(1,3)- and b-(1,6)-linkages. In addition to proteins, the main matrix component appears to be an alkali-soluble b-(1,3)-glucan.
- ❖ The synthesis of chitin is mediated by specialized organelles termed chitosomes, in which inactive chitin synthases are delivered to the apical plasma membrane and become activated upon contact with the lipid bilayer.
- ❖ In contrast, structural proteins and enzymes travel together in the larger secretory vesicles and are discharged into the environment when the vesicles fuse with the plasma membrane.
- ❖ The properties of the cell wall depend in many ways on the environment in which the hypha grows.
- ❖ Some fungi are wall-less during the assimilative stage of their life cycle. This is true especially of certain plant pathogens such as the Plasmodiophoromycota , insect pathogens and some members of the Chytridiomycota.
- ❖ The living substance of the cell within the cell wall is the protoplast. It lacks the chloroplasts but is differentiated into the other usual cell parts such as plasma or cell membrane, vacuolated cytoplasm, cell organelles and one or more nuclei.

KEY POINTS OF THE LECTURE

- Cell Membrane is a delicate, extremely thin, living membrane which closely invests the protoplast.
- The cell or plasma membrane is pressed against the cell or hyphal wall except for occasional invaginations in some regions.
- Within the plasma membrane is the colorless cytoplasm in which sap-filled vacuoles may occur.
- In young hyphae and hyphal tips, the cytoplasm appears rather uniform and homogeneous. Immersed in the cytoplasm are structures known as the organelles and inclusions.
- ER in fungi is composed of a system of membranes or microtubular structures usually beset with small granules which by some scientists are likened to the ribosomes.
- The cytoplasm contains small, usually spherical bodies known as the mitochondria.
- Each mitochondrion is enveloped by a double membrane. The inner membrane is infolded to form the cristae which are in the form of parallel flat plates or irregular tubules.
- A golgi apparatus consisting of three flattened sacs surrounded by many bubble like structured in *Saccharomyces* cells.
- Vacuole appear further back or in the old cells. With age, they enlarge and show a tendency to coalesce and ultimately reduce the cytoplasm to thin lining layer immediately within cell wall.
- The cytoplasm contains various kinds of inclusions. Examples of stored foods are lipid globules, granules of glycogen, oils and the carbohydrate trehalose, proteinaceous material and volutin.

KEY POINTS OF THE LECTURE

- The glycogen may occur in vacuoles. There are no starch grains. Of the pigments, the fungi lack chlorophyll. Carotenoids are often conspicuous by their presence and may occur throughout the cytoplasm or concentrated in the lipid granules or distributed in the cell wall.
- The cytoplasm in the individual cells contains one, two or more globose or ellipsoid nuclei which in the somatic portion are small and usually range from 1-2 or 3µ in diameter. They cannot be seen without special techniques.
- During nuclear division, the chromatin strands become organised into chromosomes which are extremely small and difficult to count.
- The higher fungi lack motile cells in their life cycle. With the exception of zygomycetes , they are characteristics of the lower fungi. The motile cells (zoospores and gametes) in the lower fungi are furnished with one or two fine, protoplasmic fine, whip like threads known as flagella.
- Forming the core of the flagellum is a central or axial filament known as the axoneme.
- The nine peripheral doublet fibrils surround the central pair of singlet fibrils. The entire growth of 9+2 fibrils is enclosed by a double cytoplasmic sheath.
- The fungal flagella are reported to be of the following three kinds: Whiplash flagellum with an end piece, Whiplash flagellum with a blunt tip and Tinsel flagellum.
- The number, kind and position of flagella on the motile cell constitutes its flagellation. Flagellation plays an important role in the taxonomy of the Lower Fungi (Phycomycetes). It is constant in each class of the Lower Fungi and differs from class to class. The Higher Fungi and Zygomycetes lack flagella.

TERMINOLOGY

- **Ascomycetes:** A - Class of fungi that produce their spores in sac-like cells called asci
- **Ascospores:** Sexual spores produced in the asci of ascomycetes fungi
- **Ascus:** (Pl., asci) the spore-producing cell of an ascomycetes fruitbody
- **Basidiocarp:** Fruitbody of a basidiomycete fungus
- **Basidiomycetes:** A - Class of fungi that produce their spores on basidia
- **Basidiocarp:** Fruitbody of a basidiomycete fungus
- **Basidiospores:** Sexual spores produced on the basidia of basidiomycetes fungi
- **Basidium:** (Pl., basidia) spore-producing cell of a basidiomycete fungus
- **Cellulose:** Component of plant cell walls and of wood composed of glucose units
- **Cuticle:** The surface layer of the cap or stem of a fruitbody
- **Deuteromycetes:** Obsolete term for a group fungi not known to reproduce sexually
- **Dichotomous:** Forking/divided into pairs – as in logical decision-making trees
- **Dikaryon:** A pair of closely associated, sexually compatible nuclei
- **Hyphae:** (Pl., hyphae) filamentous thread of fungal mycelium
- **Mycelium:** Body of a fungus, most of which is underground or hidden within wood
- **Myxomycetes:** A large and commonly encountered group within the slime moulds
- **Organelle:** A differentiated (separate) structure within a cell
- **Septate:** (Describing hyphae) partitioned by cross walls known as septa
- **Septum:** (Pl., septa) a cross wall separating cells of a hyphal thread
- **Spore:** Reproductive structure of a fungus, usually a single cell
- **Superior:** (Describing a ring) located near the top of the stem
- **Taxonomy:** The - Classification of organisms based on their natural relationships
- **Thallus:** (Pl., thalli) the body of a fungus or a lichen
- **Zygomycota:** A - Class of simple fungi whose hyphae generally lack cross walls

SOME QUESTIONS RELATED TO THE LECTURE

- **Question 1:** Write a note on cell wall of fungus.
- **Question 2:** Describe the architecture of fungal cell wall.
- **Question 3:** Discuss the synthesis of cell wall of fungi.
- **Question 4:** Write a note on protoplast of fungal cell.
- **Question 5:** Write a short note on fungi nucleus.
- **Question 6:** Discuss the somatic nuclear division in fungi.
- **Question 7:** Write a short note on fungi flagella.
- **Question 8:** Discuss the types of flagellum of fungi.
- **Question 9:** Write a short note on flagellum of lower fungi.
- **Question 10:** Discuss the ultra structure of fungi in detail.

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