

Brahmavart P.G. College, Mandhana, Kanpur

Department of Botany

Question Bank

Section-A

B.Sc. 1st Semester

Title: Microbiology & Plant Pathology

Course Code: B040101T

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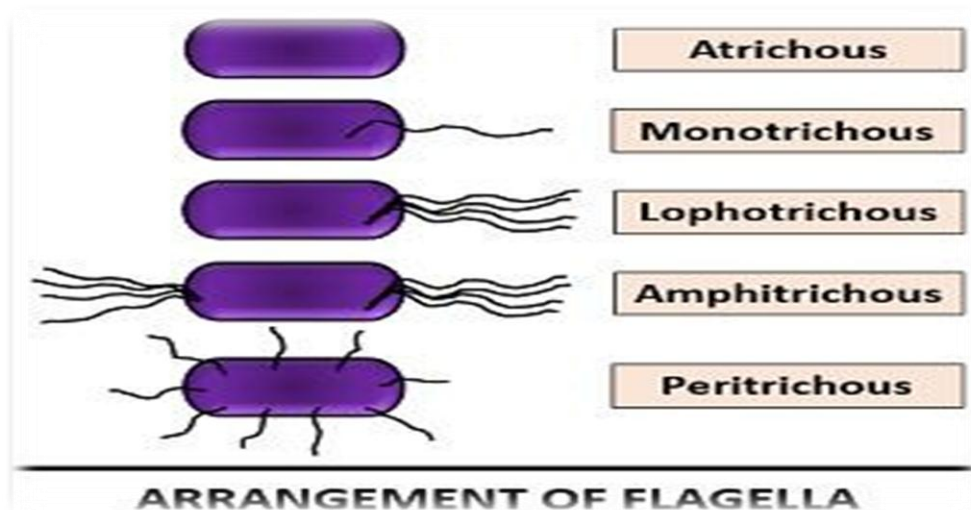
Brahmavart P.G. College, Mandhana, Kanpur
Department of Botany
B.Sc. 1st Semester (Microbiology & Plant Pathology: B040101T)
Question Bank (Section-A)

Q.1. Mention different kinds of flagellation in Bacteria.

Ans. Bacteria are classified into different types of flagellation based on the number and arrangement of flagella on their cell surface.

Types of Bacterial Flagellation

1. **Monotrichous:** A single flagellum is present at one end (pole) of the bacterial cell. *Example: [Vibrio cholerae](#).*
2. **Amphitrichous:** A single flagellum (or a single pair) is present at both opposite poles/ends of the cell. *Example: [Aquaspirillum serpens](#).*
3. **Lophotrichous:** A tuft or cluster of multiple flagella is attached to one or both ends of the cell. *Example: [Pseudomonas fluorescens](#).*
4. **Peritrichous:** Numerous flagella are distributed uniformly all over the entire surface of the bacterial cell. *Example: [Escherichia coli](#).*
5. **Atrichous:** The bacteria completely lack flagella and are typically non-motile. *Example: [Lactobacillus](#) species.*



Q.2. Describe morphology and economic importance of Agaricus.

Ans. *Agaricus* is a large genus of edible and poisonous basidiomycete fungi that features an underground vegetative mycelium and an above-ground umbrella-shaped fruiting

body.

Morphology (Physical Structure)

The body of *Agaricus* is divided into two primary parts: the vegetative mycelium and the reproductive fruiting body (basidiocarp).

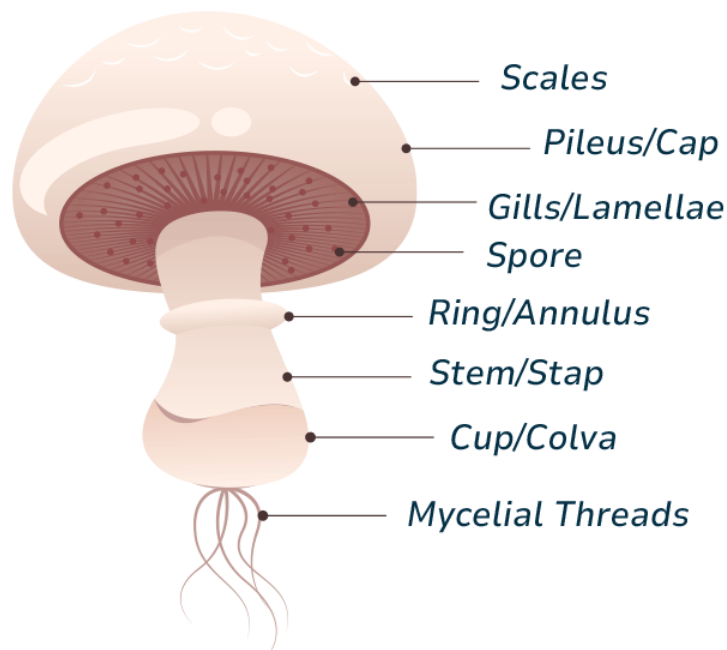
1. Vegetative Mycelium:

Consists of a branching network of septate hyphae (cells divided by cross-walls) hidden underground or inside organic substrates. Absorbs water and digested organic food from decaying matter as a saprotroph.

2. Fruiting Body (Basidiocarp):

The familiar umbrella-shaped mushroom seen above ground, developed from the secondary dikaryotic mycelium.

- A. **Cap (Pileus):** The fleshy, umbrella-like top that protects the spore-bearing structure underneath. It changes from hemispherical to flat as it matures.
- B. **Gills (Lamellae):** Vertical, radiating plates on the underside of the cap that turn chocolate-brown at maturity and produce microscopic sexual spores called basidiospores.
- C. **Stipe (Stalk):** The central cylindrical stem that supports the cap.
- D. **Annulus (Ring):** A ring-like remnant of the partial veil left on the upper stipe after the gills break open.



Economic Importance of *Agaricus*

Agaricus holds massive ecological, nutritional, and industrial value globally:

1. Human Nutrition and Food Industry:-

- a) **Dietary Value:** Species like *Agaricus bisporus* (button mushroom) and *Agaricus campestris* (field mushroom) are packed with high-quality, easily digestible

proteins, dietary fiber (chitin), vitamins (B-complex, D2), and minerals (selenium, potassium, copper).

- b) **Low Calorie/Fat:** They offer a low-calorie, cholesterol-free addition to global cuisine (soups, salads, pizzas).

2. Commercial Cultivation and Economy:-

- a) **Global Crop:** *Agaricus bisporus* is the most widely cultivated and consumed edible mushroom in the world, farmed across dozens of countries.
- b) **Employment Generation:** Industrial and indoor controlled-environment farming creates large-scale employment and boosts local rural economies.

3. Sustainable Waste Management:-

- **Recycling Agriculture Waste:** Cultivation relies on composted organic byproducts like wheat straw, corn cobs, and poultry manure. This repurposes agricultural refuse into high-value protein food.

4. Medicinal and Pharmacological Properties:-

- a) **Bioactive Compounds:** Fruiting bodies contain antioxidants (such as ergothioneine), polysaccharides, and β -glucans that exhibit antitumor, anti-inflammatory, antibacterial, and immunomodulatory activities.
- b) **Cosmetics and Enzymes:** Tyrosinase extracted from *Agaricus* serves research, medicinal, and cosmetic applications.

5. Ecological Role:-

- **Decomposers:** As saprophytic fungi, they break down complex organic matter and dead wood, enriching soil fertility and cycling nutrients back into the ecosystem.

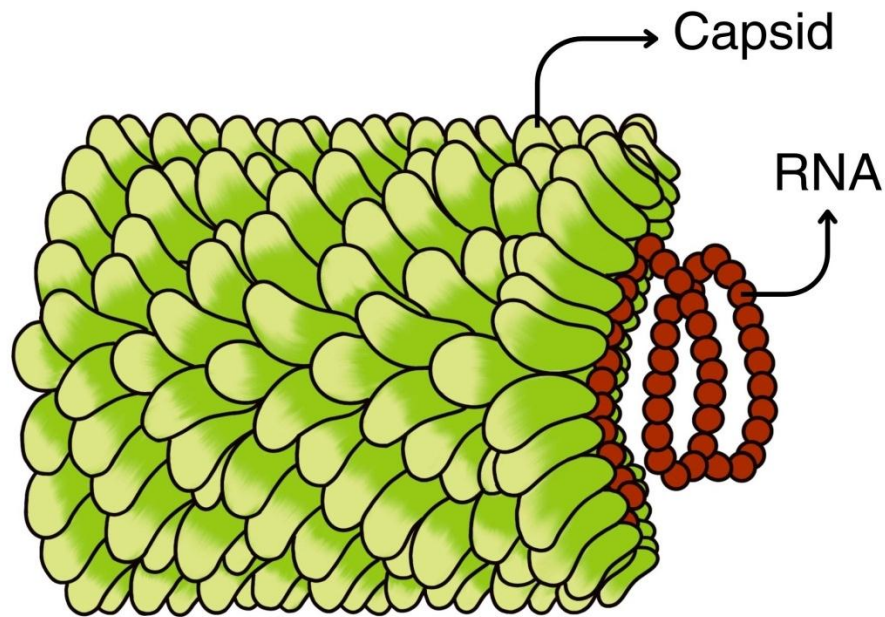
Q.3. Describe the general Characters & symptom of plant Virus with example.

Ans. General Characteristics of Plant Viruses

Plant viruses are sub-microscopic, obligate intracellular parasites. They lack independent metabolic machinery. They completely rely on the host plant cell's resources to replicate.

- **Acellular Nature:** They lack a cellular structure, cytoplasm, and cell organelles.
- **Chemical Composition:** Consist simply of a core of **nucleic acid** (genetic material) enclosed inside a protein shell called a **capsid**.
- **Genetic Material:** Most plant viruses (~78%) utilize single-stranded RNA (**ssRNA**) as their genome (e.g., *Tobacco Mosaic Virus*). A small minority utilize DNA (e.g., *Cauliflower Mosaic Virus*).

- **Obligate Intracellular Parasites:** They have no independent metabolism and can only replicate by hijacking a living host cell's machinery. They cannot grow on artificial nutrient media.
- **Morphology:** They typically present as rigid rods, flexible filaments, or spherical/icosahedral shapes.
- **Transmission:** Unlike animal viruses, they cannot actively breach intact plant cell walls. They rely on physical damage (mechanical transmission) or biological **vectors** like aphids, whiteflies, or thrips.



TOBACCO MOSAIC VIRUS (TMV)

External Symptoms of Plant Virus Infection

When a virus infects a plant, it disrupts normal metabolism and chlorophyll synthesis. Symptoms can be local or systemic. They are categorized based on anatomical changes:

1. Color Changes & Discoloration (Hypoplasia)

- **Mosaic Pattern:** Alternating patches of light-green, yellow, and normal dark-green on a leaf blade.
- **Mottling:** Irregular, diffuse patches of light and dark colors without sharp borders.
- **Vein Clearing:** The veins and veinlets of leaves lose chlorophyll and turn yellow or translucent while the rest remains green.
- **Vein Banding:** Bands of dark-green tissue develop along the main veins while the rest of the blade turns chlorotic.

- **Chlorosis:** General yellowing of the leaf due to the destruction or failure of chloroplast development.
- **Flower Breaking:** Streaks or variegations of alternate colors in petals, turning solid-colored flowers into bi-colored patterns.

2. Malformation & Distortion

- **Leaf Curling/Rolling:** Leaves curl upward, downward, or roll along the edges due to unequal growth rates across the lamina.
- **Shoe-string Effect:** Severe reduction of the leaf lamina so that only the thin, string-like central vein remains.
- **Stunting / Dwarfing:** Severe shortening of internodes and reduction in overall plant size.
- **Witches' Broom:** Proliferation of axillary buds producing dense, bushy clusters of thin twigs.

3. Necrosis (Death of Tissue)

- **Local Lesions:** Small, localized brown or black dead spots at the initial point of virus entry.
- **Ringspots:** Concentric chlorotic or necrotic rings on leaves, stems, or fruits.

<u>Virus Name</u>	<u>Visual Symptom</u>	<u>Vector/Transmission Method</u>
Tobacco Mosaic Virus (TMV)	Blister-like green-and-yellow Mosaic pattern	Mechanical sap abrasion
Bhendi Yellow Vein Mosaic Virus (BYVMV)	Striking yellow Vein clearing across okra leaves	Whitefly (<i>Bemisia tabaci</i>)
Tomato Leaf Curl Virus (ToLCV)	Severe inward leaf Curling and stunting	Whitefly (<i>Bemisia tabaci</i>)
Banana Bunchy Top Virus (BBTV)	Crowded, narrow " Bunchy " top leaves due to stunting	Banana Aphid (<i>Pentalonia nigronervosa</i>)

Q.4. Give Classification of Fungi given by Alexopolus.

Ans. The comprehensive classification of fungi proposed by **C.J. Alexopoulos** and **C.W. Mims (1979)** in their influential book *Introductory Mycology* places slime molds and true

fungi under the Kingdom Myceteae of the Superkingdom Eukaryonta. This system is widely prescribed in B.Sc. Botany syllabi.

Alexopoulos and Mims' Classification

The Kingdom **Myceteae** is divided into **3 major Divisions**, which are further categorized into Subdivisions and Classes based on nutrition, flagellation, and mode of reproduction:

I. Division Gymnomycota

Organisms lack a true cell wall during their somatic (growth) phase; they are phagotrophic (ingest food).

- **Subdivision 1. Acrasiogymnomycotina**
 - Class: Acrasiomycetes (cellular slime molds)
- **Subdivision 2. Plasmodiogymnomycotina**
 - Class 1: Protosteliomycetes
 - Class 2: Myxomycetes (true slime molds)

II. Division Mastigomycota

Fungi possess absorptive nutrition and produce flagellated motile cells (zoospores) with centrioles.

- **Subdivision 1. Haplomastigomycotina**
 - Class 1: Chytridiomycetes (uni-flagellate, whiplash flagellum)
 - Class 2: Hyphochytridiomycetes (uni-flagellate, tinsel flagellum)
 - Class 3: Plasmodiophoromycetes (bi-flagellate)
- **Subdivision 2. Diplomastigomycotina**
 - Class: Oomycetes (water molds, dual flagella)

III. Division Amastigomycota

Fungi lack flagella and centrioles entirely; somatic phase is filamentous with a chitinous cell wall.

- **Subdivision 1. Zygomycotina**
 - Class 1: Zygomycetes (e.g., *Mucor*, *Rhizopus*)
 - Class 2: Trichomycetes (commensalists in arthropods)
 - **Subdivision 2. Ascomycotina (Sac Fungi)**
 - Class: Ascomycetes (e.g., *Yeast*, *Penicillium*, *Aspergillus*)
 - **Subdivision 3. Basidiomycotina (Club Fungi)**
 - Class: Basidiomycetes (e.g., Mushrooms, Smuts, Rusts)
 - **Subdivision 4. Deuteromycotina (Fungi Imperfecti)**
 - Form-Class: Deuteromycetes (sexual stage absent or unknown)
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Q.5. Short notes on Koch Postule.

Ans. German bacteriologist **Robert Koch** (1843-1910) suggested that when an animate pathogen (living disease causing organism) of a disease is isolated or identified, its pathogenicity must be proved to confirm the actual cause of disease.

Koch's postulates consist of following steps to be followed:

1. The pathogen in question must invariably be found associated with a particular symptom.
 2. It must be isolated, grown and studied in pure culture.
 3. The pathogen grown in pure culture should be able to reproduce identical disease symptoms when inoculated on a healthy plant of the same kind from which it was isolated.
 4. The artificially produced disease should yield the same pathogen on re-isolation.
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Q.6. Short notes on Rhizopus.

Ans. Systematic Position

Mycota (= Fungi)

Eumycotina

Zygomycotina

Zygomycetes

Mucoraceae

Rhizopus

(Black mold of Bread)

or

(Bread mold)

Habitat

Rhizopus is a saprophytic fungus, living on dead organic matter. In laboratory it can be easily grown within 2-3 days on a moist-piece of bread, covered by a belljar. Its mycelium is made up of thin, white hyphae growing on pickles, vegetables, neglected shoes specially in rainy season. Later the fungus becomes black due to development of zygospores. Its common species is *Rhizopus nigricans* (*R. stolonifer*). It may become parasitic under some conditions causing soft rot in sweet potato.

Features of Rhizopus

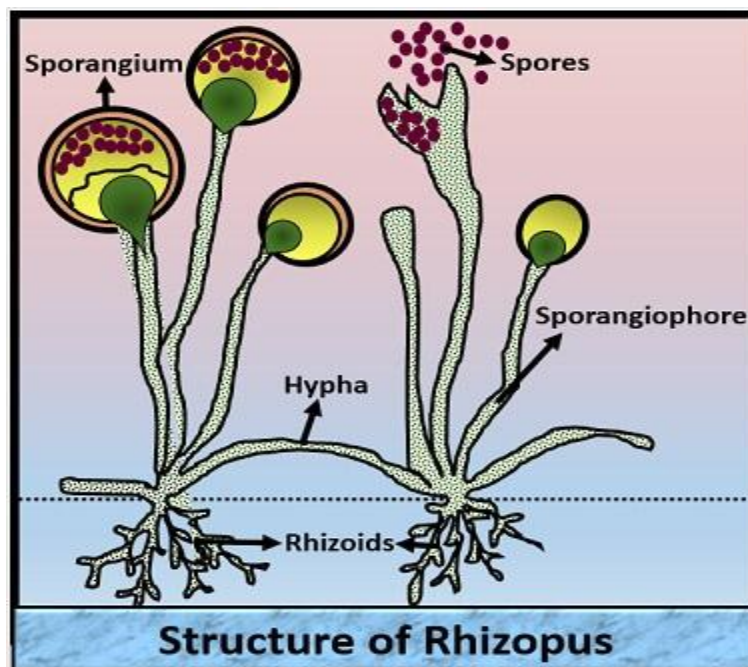
There are some important characteristics of the Rhizopus species:

- The mode of nutrition is **saprobic** and **parasitic** in Rhizopus, in which a majority of them are saprophytic, and few are parasitic viz. *R. artocarp*, *R. arrhizus* etc.

- In Rhizopus, the **mycelium** is coenocytic, tubular, multinucleated, vacuolated and consists of cytoplasmic materials like Golgi body, mitochondria etc.
- The reserve food material is in the form of **glycogen** and **oil droplets**.
- A cell wall of the thallus is **non-cellulose** and made of chitin.
- The hyphae of Rhizopus differentiates into three distinctive parts, namely **stolon** (intermodal region), **rhizoids** (nodal region) and **sporangiophores**.
- For the growth of Rhizopus, the most important factor is **moisture** or water availability.
- Its digestion is **extracellular**.
- These are the opportunistic fungi that commonly cause “**Zygomycosis** or **Mucormycosis**”.

Structure of Rhizopus

The morphology of Rhizopus includes the following components:



Microscopic Features

Rhizopus consists of two kinds of hyphae, namely **vegetative** and **reproductive hyphae**. Vegetative hyphae differentiate into two types, namely stolon and rhizoids and the reproductive hyphae turn into sporangiophores.

A. Vegetative Hypha: It typically includes:

1. **Stolon:** It is the intermodal region called **Runner**. A stolon is the aerial hyphae that grow horizontally, and it is found attached to the substratum. Stolons are aseptate, branched and non-septate (lacks cross-wall).

2. **Rhizoids:** It is the nodal region that eventually forms by the contact between the stolon to the surface of the substratum. Rhizoid is the much-branched structure that forms under the substratum. Its main function is to invade all the nutrients from the substratum.
- B. Reproductive Hypha:** It consists of sporangiophores that grow vertically from the stolon. Sporangioophores are unbranched, elongated, columellate, and they give rise to the reproductive structures called sporangiospores. Its cell wall is composed of chitin chitosan, lipids, proteins etc. Its **protoplasm** consists of many nuclei, mitochondria, endoplasmic reticulum and other cytoplasmic inclusions like the ribosome, oil droplets, vacuoles etc.
- C. Columella:** It arises from the sporangiophore and appears **dome** or **umbrella-shaped**. The surface of columella can be smooth or rough. The columella is hygroscopic in nature, and its primary function is water absorption.
- D. Sporangium:** It attaches with the columella and a long sporangiophore. The shape of the sporangium is spherical or globose. It carries the reproductive structures called sporangiospores. The size of the sporangium is 0.2mm.
- E. Sporangiospores:** These are the asexual spores that are globose to ovoid and unicellular. The colour of sporangiospores is hyaline to brown.

Macroscopic Features

- **Growth:** The growth of mycelium is rapid.
- **Appearance:** They appear as dense cottony colonies.
- **Colour:** The colour of mycelium is generally white, and after sporulation, it turns grey or golden brown.

Reproduction in Rhizopus

It reproduces by **vegetative**, **asexual** and **sexual** methods.

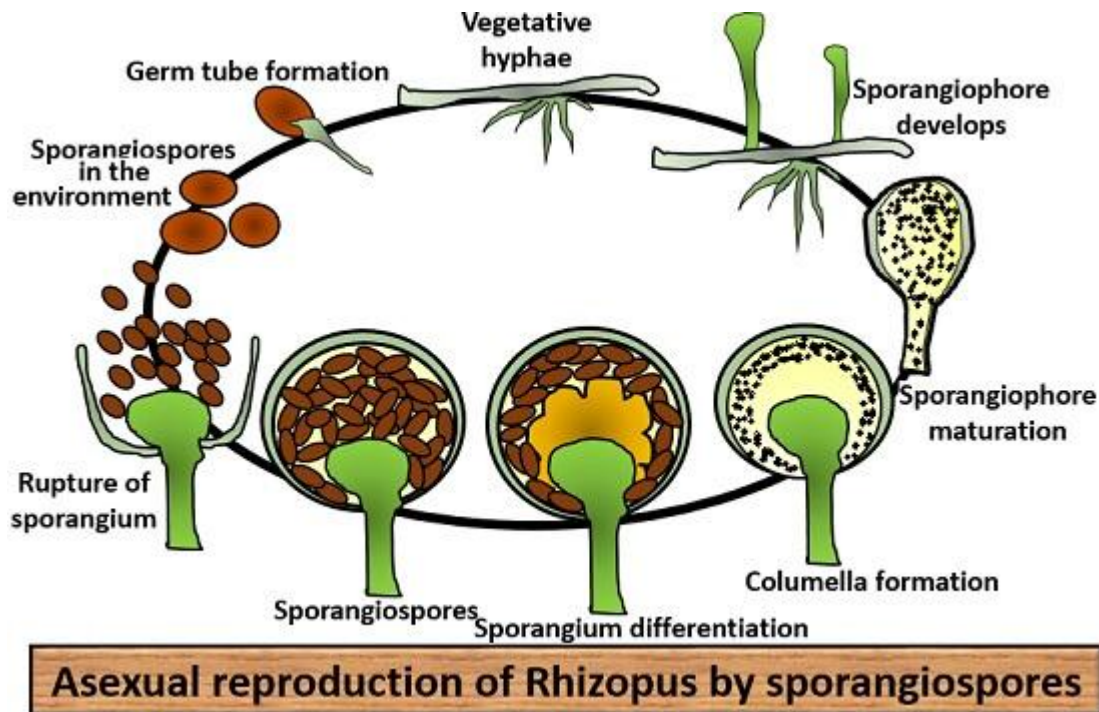
Vegetative Reproduction in Rhizopus-

Sometimes the thallus of the Rhizopus breaks accidentally or due to some other factors into the few fragments, after which each fragment give rise to a new thallus on favourable conditions.

Asexual Reproduction in Rhizopus

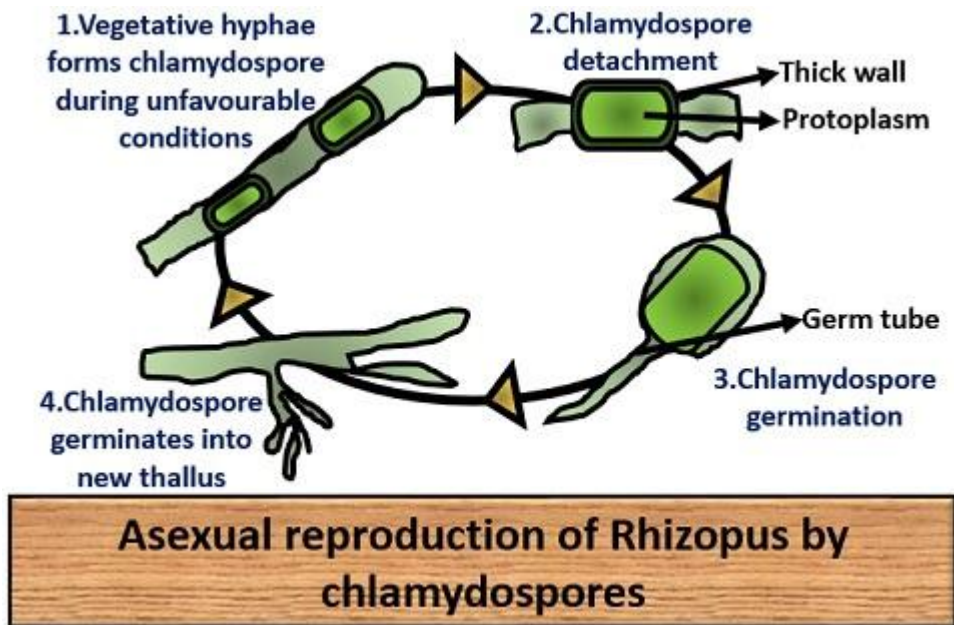
The asexual reproduction can take place through both sporangiospores and chlamydospores.

Asexual reproduction through sporangiospores: It includes the following steps:



1. First, the vegetative hypha grows to form **sporangiphore** that is long and slender.
2. Then, the sporangiphore develops and enlarges at the apical region to form **columella** of variable shape and size.
3. This columella gives rise to the large and round **sporangium** by pushing its cytoplasmic material to the peripheral wall.
4. After that, differentiation of sporangia occurs that gives rise to the formation of spore sac in between the sporangia and columella. A spore sac carries the sporangiospores that are oval, unicellular, multinucleate and non-motile.
5. These sporangiospores multiply their number within the spore sacs, and the sporangial wall **ruptures** during the extreme conditions and facilitates the release of sporangiospores out of the wall.
6. In the environment, the sporangiospores remain in a **dormant** or a **resting** state.
7. When favourable conditions return, these sporangiospores form germ tube or undergo **germination** to develop new vegetative hyphae.

Asexual reproduction through chlamydospores: It includes the following steps:



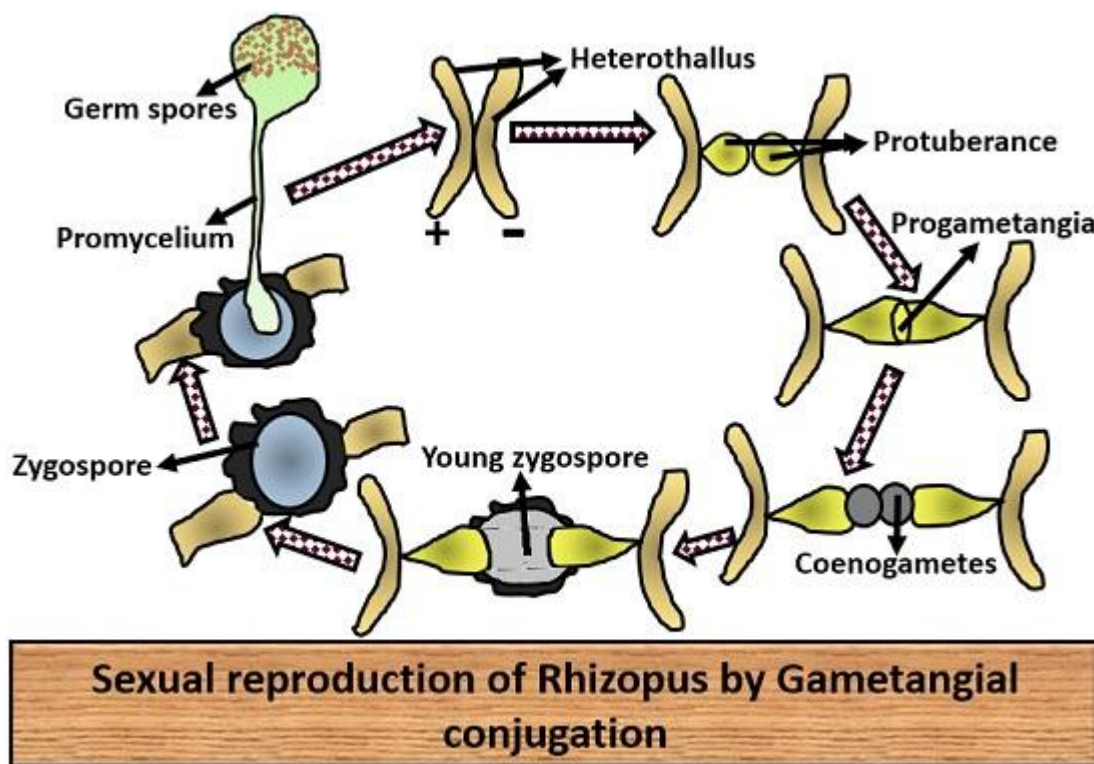
1. During unfavourable condition like insufficient food material and water, the protoplasm is surrounded by a thick and nutrient-rich wall called **chlamydospore**.
2. This chlamydospore then **detaches** from the vegetative hyphae and remains in the resting phase.
3. When this chlamydospore gets **moisture**, it forms a germ tube or undergoes **germination process** to develop a new thallus.

Sexual Reproduction in Rhizopus

In *Rhizopus*, sexual reproduction occurs by the method of **gametangial conjugation**. It includes the following steps:

1. First, the (+) and (-) thallus comes in contact with each other.
2. Then **conjugation** occurs between the positive and negative thalli through an **outgrowth** developed by positive and negative thalli.
3. The septum develops between the progametangium, and eventually, plasmogamy occurs that results in the formation of **coenogametes**.
4. Then, karyogamy occurs by which the gametes of both the (+) and (-) thallus fuse with each other to form a **zygote**.
5. A zygote goes through the maturation phase and becomes encircled by a thick-walled structure called **zygospore**. There are two layers, namely an outer and inner layer that surrounds the zygospore.

6. The zygospore lives in a resting phase for some time. On favourable conditions, zygospore forms a germ tube and germinates by forming a new vegetative body.



Therefore, a *Rhizopus* reproduces through vegetative, asexual and sexual means to form differentiated hyphae, i.e. vegetative and reproductive hyphae.

Q.7. Write short note on Nitrogen Fixation.

Ans. Nitrogen fixation is the chemical or biological process that converts inert atmospheric nitrogen gas (N_2) into bioavailable forms like ammonia (NH_3), which plants can absorb and use.

Introduction

Nitrogen makes up about 78% of Earth's atmosphere, but plants and animals cannot use it directly. This is because the two nitrogen atoms in (N_2) are held together by a strong triple covalent bond that requires high energy to break. Nitrogen fixation transforms this unusable gas into reactive compounds required for synthesizing amino acids, proteins, and nucleic acids.

Types of Nitrogen Fixation

1. Biological Nitrogen Fixation (BNF)

Carried out exclusively by specialized prokaryotes (bacteria and archaea) known as diazotrophs using the [nitrogenase](#) enzyme complex.

- **Symbiotic Fixation:** Mutualistic association where microbes provide fixed nitrogen and the host plant provides carbohydrates. Classic examples include [Rhizobium](#) forming root nodules in legumes (Fabaceae family) and [*Frankia*] in actinorhizal plants.
- **Free-Living (Asymbiotic) Fixation:** Conducted by independent soil organisms like [*Azotobacter*], [*Clostridium*], and cyanobacteria like [*Nostoc*] and [*Anabaena*].

2. Industrial Nitrogen Fixation

- Handled artificially via the high-pressure and high-temperature Haber-Bosch process, combining atmospheric nitrogen and hydrogen gas to produce synthetic ammonia for fertilizers.

3. Atmospheric (Abiotic) Fixation

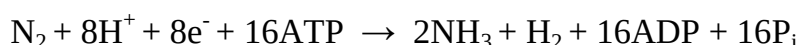
- Natural phenomenon where high-energy events like lightning break (N₂) molecules, allowing them to bond with oxygen to form nitrogen oxides that dissolve in rain as nitrates.

Mechanism of Biological Nitrogen Fixation

The enzymatic reduction of dinitrogen to ammonia is mediated by the [nitrogenase enzyme complex](#), which consists of two proteins:

- **Iron (Fe) Protein:** Acts as an electron donor.
- **Molybdenum-Iron (Mo-Fe) Protein:** Contains the active site FeMoco (iron-molybdenum cofactor) where (N₂) reduction happens.

The overall energetic reaction requires significant cellular input:



- Each fixed molecule of N₂ requires the hydrolysis of at least 16 ATP equivalents and strict anaerobic or microaerophilic protection (often via leghemoglobin in root nodules) because oxygen irreversibly inhibits the nitrogenase enzyme.

Q.8. Write short notes on Quarantine.

Ans. QUARANTINE:- Plant quarantine is essential for cultivation of crop and avoid the inoculum from one place to other and from one country to other country. A quarantine can be defined as a legal restriction on the movement of agricultural commodities for the purpose of exclusion prevention or delay in the establishment of plant pests and diseases in areas where they are not known to occur. As early as 1946, Central Directorate of Plant

Protection quarantine and storage was established under the ministry of Food and Agriculture, Govt. of India Under this Directorate, plant quarantine stations are working at seaports of Bombay (1949), Madras (1950). Cochine (1955), Kolkata (1956), Vishakhapatnam (1957) and Kadla (1961) and at airports of New Delhi, Mumbai, Chennai, Kolkata, Amritsar etc. Besides certain diseases chiefly viral diseases must be controlled by controlling insect vectors. Thus, exclusion of inoculum may be practiced by following measures.

Plant Quarantine Services

1. Plant Quarantine clearance of the imported plants/plant materials at the port of entry is mandatory under the provisions of Destructive Insects and Pests Act, 1914 and the Plants, Fruits and Seeds (Regulation of Import into India) (PFS) Order, 1989.
 2. There are twenty six Plant Quarantine stations in the country to regulate Import and Export of Plants and Plant materials.
 3. India is a Signatory to International Protection Convention, 1951 of FAO. Under the Convention Phytosanitary Certificate (PSC) for export of plants and plant materials at required to be issued by the notified National Authorities.
 4. Phytosanitary Certificate is not necessary in respect of processed plant materials.
 5. Phytosanitary Certificate issued by other than these authorised officers is treated as illegal.
 6. Post Entry Quarantine (PEQ) facilities established by the importers are required to be verified by the Designated Inspection Authorities (DIAs).
 7. The Import Permits (IPs) for plants/plant materials meant for propagation are issued by the notified officers.
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Q.9. White rust of Crucifers.

Ans. White rust (also known as white blister) is a destructive plant disease affecting cruciferous crops such as mustard, radish, cabbage, cauliflower, and rapeseed. It is caused by *Albugo candida*, an obligate oomycete (water mold) rather than a true fungus.

Key Symptoms

The disease manifests in two distinct phases: localized and systemic.

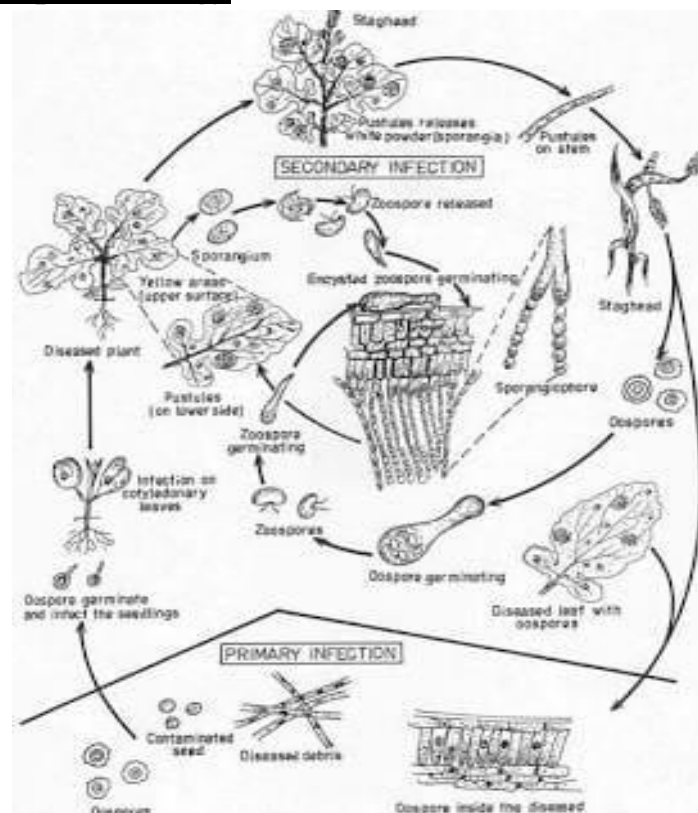
Localized Infection:

Shiny, raised white-to-creamy pustules (sori) appear mainly on the lower surface of leaves, stems, and floral parts. Corresponding upper leaf surfaces show chlorotic (yellowish) patches. Sori rupture as they mature, releasing a chalky white powder consisting of sporangia.

Systemic Infection:

Severe infection leads to hypertrophy (excessive cell size) and hyperplasia (excessive cell division). Causes severe distortion of inflorescences, stems, and seed pods, forming swollen, sterile, twisted structures known as "stagheads."

Disease Cycle & Epidemiology



Causal Agent: *Albugo candida* (Class: Oomycetes).

Primary Source of Infection: Thick-walled, sexual oospores surviving in soil or plant debris from previous seasons, or contaminated seeds.

Secondary Spread: Air-borne or splash-dispersed sporangia that germinate to release flagellated zoospores in cool, high-moisture environments.

Favorable Conditions: Temperatures between 10°C–20°C with high relative humidity (>80%) and leaf wetness (dew or rain).

Management Strategies

Cultural Practices:

1. Practice crop rotation with non-cruciferous plants for at least 2–3 years.
2. Collect and destroy infected plant debris after harvest to reduce soil oospore load.
3. Adjust sowing times to avoid periods of high humidity during flowering.
4. Ensure optimum plant spacing for adequate air circulation.

Host Resistance:

Plant resistant or tolerant cultivars suitable for your region (e.g., specific resistant lines in mustard/rapeseed).

Chemical Control:

1. **Seed Treatment:** Treat seeds with systemic fungicides like Metalaxyl (e.g., Apron at 6 g/kg seed).
2. **Foliar Spray:** Apply systemic fungicides like Metalaxyl + Mancozeb (Mancozeb 75 WP or Ridomil Gold) at early appearance of symptoms, repeated at 10–14 day intervals if conditions remain favorable.

Q.10. Differentiate between Gram + positive and Gram – negative bacteria.

Ans: Comparison Table

Feature	Gram-Positive Bacteria	Gram-Negative Bacteria
Color after Gram Stain	Purple or blue	Pink or red
Peptidoglycan Layer	Thick (many layers)	Thin (single layer)
Outer Membrane	Absent	Present
Lipopolysaccharide (LPS)	Absent	Present (acts as endotoxin)
Teichoic Acids	Present	Absent
Toxin Type	Exotoxins	Endotoxins
Antibiotic Resistance	Lower (easier to treat)	Higher (harder to treat)
Common Examples	<i>Staphylococcus</i> , <i>Streptococcus</i>	<i>Escherichia coli</i> , <i>Salmonella</i>

Difference Between Gram-Positive and Gram-Negative Bacteria		
Characteristics	Gram-Positive Bacteria	Gram-Negative Bacteria
Cell Wall	Thick (20-80 nm)	Thin (7-8 nm)
Peptidoglycan Layer	Multiple layers, make up 70-90% of the cell wall	Single or few layers, make up 10-20% of the cell wall
Outer Membrane	Absent	Present
Teichoid Acids	Present in the cell wall	Absent
Periplasmic Space	Usually absent or very small	Present between the inner and outer membranes
Staining	Retains crystal violet stain, appears purple	Does not retain crystal violet, and appears pink/red
Lipid Content	Low (1-4%)	High (11-22%)
Susceptibility to Penicillin	More susceptible due to lack of outer membrane	Less susceptible due to protective outer membrane
Endotoxins	Absent	Present (lipopolysaccharides in the outer membrane)
Examples	Staphylococcus aureus, Bacillus species	Escherichia coli, Salmonella species

Q.11. Autotrophic Bacteria.

Ans: Autotrophic bacteria are bacteria that synthesize their own organic molecules from simple inorganic carbon sources (typically carbon dioxide, CO_2), using energy derived from either light or chemical reactions. They are primary producers in many ecosystems, forming the base of food webs where other organisms depend on their fixed carbon.

Key types and energy sources

- **Photoautotrophs:** Use light energy to fix CO_2 . Example groups include cyanobacteria (oxygenic photosynthesis producing O_2) and some purple/green sulfur bacteria (anoxygenic photosynthesis using H_2S or organic electron donors instead of water).
- **Chemoautotrophs (chemolithoautotrophs):** Derive energy from inorganic chemical reactions (oxidation of H_2 , NH_3 , NO_2^- , H_2S , Fe_2^+ , etc.) and use that energy to fix CO_2 . Examples: nitrifying bacteria (Nitrosomonas, Nitrobacter), sulfur-oxidizers (Beggiatoa, Thiobacillus), iron-oxidizers (Gallionella), and many deep-sea vent microbes.

Q.12. Comments upon commercial products of algae.

Ans: COMMERCIAL PRODUCTS OF ALGAE

Algae are economically very important as they produce a large number of commercially valuable products.

1. Food and Food Supplements:

- As human food: In Japan, China, Philippines - *Porphyra* (Nori), *Laminaria* (Kombu), *Undaria* (Wakame), *Monostroma* are eaten directly. 20-25% protein, rich in vitamins A, B, C, D, E.
- Single Cell Protein (SCP): *Chlorella* and *Spirulina* (actually cyanobacterium) - 50-60% protein, cultured in tanks. *Spirulina* tablets are a superfood.
- Laver: Made from *Porphyra*.

2. Phycocolloids / Hydrocolloids – Most important commercial products: These are mucilaginous substances extracted from cell walls.

- **Agar-Agar:** Obtained from *Gelidium*, *Gracilaria*, *Pterocladia*.
Uses: Culture medium for microbes, solidifier in food (jams, ice-cream), cosmetics, paper and textile industry.
- **Alginates / Alginic Acid:** From brown algae - *Laminaria*, *Macrocystis*, *Fucus*, *Ascophyllum*.
Uses: Ice-creams, flame-proof fabrics, in medicines as emulsifier, for making artificial fibres, as adhesive.
- **Carrageenan:** From *Chondrus* (Irish moss), *Eucheuma*, *Gigartina*.
Uses: Stabilizer in milk products, toothpaste, paints, shaving creams, shoe polish.

3. Medicines and Antibiotics:

- Agar is laxative.
- Carrageenan is blood anticoagulant.
- Chlorellin from *Chlorella* - antibiotic.
- Extracts from *Laminaria*, *Fucus* used for goitre treatment due to iodine.
- *Corallina*, *Codium* - effective against intestinal worms.

4. Agriculture:

- **Fertilizer:** Large brown and red algae used as manure - *Laminaria*, *Fucus*, *Ascophyllum*. They have K, N, and trace elements. Concentrated extract called seaweed liquid fertilizer (SLF).
- **Fodder:** *Rhodomenia*, *Ascophyllum*, *Sargassum* used as cattle feed.

5. Industrial Products:

- **Iodine:** *Laminaria*, *Fucus*, *Ecklonia* are rich sources. Japan is major producer.
- **Bromine, Potash:** From ash of kelps (large brown algae).
- **Funori:** Glue from *Gloiopeltis*.

- **Diatomite:** Fossil deposits of diatom frustules (SiO₂). Used as filter, in polishes, toothpaste, insulation.

6. Sewage disposal and Energy:

- Chlorella, Chlamydomonas used in sewage oxidation ponds.
 - Algae are source of Biofuel - *Botryococcus*, *Chlorella* produce hydrocarbons.
-

Q.13. Discuss the mode of nutrition in fungi.

Ans: MODE OF NUTRITION IN FUNGI

Fungi are heterotrophic, achlorophyllous, eukaryotic organisms. They cannot synthesize their own food because of absence of chlorophyll. So they depend on external sources for organic nutrition.

They show absorptive mode of nutrition. They secrete extracellular enzymes over the food, digest it externally and then absorb the digested soluble products.

Based on the source of food, fungi are of 3 main types:

1. Saprophytic / Saprobic Fungi (Saprophytes)

About 80% of fungi are saprophytes. They obtain nutrition from dead and decaying organic matter.

Mechanism: They secrete hydrolytic enzymes like cellulase, amylase, protease etc. which digest the complex organic matter into simple soluble form, which is then absorbed by the hyphae.

Examples: *Mucor*, *Rhizopus* (bread mould), *Aspergillus*, *Penicillium*, *Agaricus*, *Morchella*.

Types of Saprophytes:

- **Obligate saprophytes:** Always saprophytic, never parasitic - e.g. *Mucor*.
- **Facultative parasites:** Normally saprophytic but can become parasitic under certain conditions - e.g. *Fusarium*.

Importance: They are natural scavengers and help in mineral cycling by decomposition.

2. Parasitic Fungi (Parasites)

They obtain nutrition from living hosts - plants, animals, or other fungi (mycoparasite).

Mechanism: They develop specialized absorbing structures called haustoria which penetrate the host cells to absorb food. The mycelium may be intercellular or intracellular.

Examples: *Puccinia* (rust), *Ustilago* (smut), *Phytophthora*, *Albugo*, *Erysiphe*.

Types of Parasites:

- **Obligate parasites:** Cannot grow without a living host. e.g. *Puccinia*, *Erysiphe*. They are biotrophs.
- **Facultative saprophytes:** Normally parasitic but can also live as saprophytes. e.g. *Phytophthora*, *Pythium*.
- **Ectoparasites:** Mycelium remains outside host, only haustoria enter inside - e.g. *Erysiphe*.
- **Endoparasites:** Mycelium inside host tissue - e.g. *Albugo*, *Pythium*. They cause many diseases in plants and animals.

3. Symbiotic Fungi

Living in mutual beneficial association with other organisms.

a) Lichens: Association of fungus (mycobiont) with alga (phycobiont).

Fungus provides shelter, absorbs water and minerals; alga prepares food by photosynthesis and shares it. e.g. *Parmelia*.

b) Mycorrhiza: Symbiotic association between fungus and roots of higher plants.

Fungus gets food from plant, in return it helps plant to absorb water and minerals (especially phosphorus) from soil and protects from pathogens. e.g. Many Basidiomycetes with forest trees. Two types - Ectomycorrhiza and Endomycorrhiza.

c) Symbiosis with insects: Some ants and termites cultivate fungi in their nests for food.

4. Special Modes:

a) Predacious / Carnivorous Fungi: Some soil fungi are predacious. They capture small nematodes, amoebae etc. They develop trapping devices like constricting rings, adhesive knobs, nets. e.g. *Arthrobotrys*, *Dactylella*, *Zoophagus*.

b) Coprophilous Fungi: Growing on dung - e.g. *Pilobolus*, *Podospora*. They are also saprophytic.

Q.14. Various types of vegetative reproduction in Lichens.

Ans: VEGETATIVE REPRODUCTION IN LICHENS

Vegetative reproduction is the most common method of multiplication in lichens. It occurs by fragmentation or by formation of specialized propagules containing both algal and fungal partners, so that the new thallus formed is identical to parent.

1. FRAGMENTATION:

This is accidental method. Thallus breaks into small fragments due to mechanical injury, animal biting, or death and decay of older parts. Each fragment containing both mycobiont and phycobiont grows into a new thallus. Common in filamentous lichens like *Usnea*, *Letharia*, *Ramalina* and in *Parmelia*, *Cladonia* etc.

2. BY FORMATION OF SPECIALIZED PROPAGULES:

a) Soredia:

Most efficient and common method (in ~30% lichens). Soredia are small, rounded, bud-like outgrowths produced on upper surface or margins of thallus in specialized structures called soralia. Each soredium consists of one or few algal cells surrounded by loosely interwoven fungal hyphae. No cortex. Greyish white. They are easily detached by wind, water, animals and germinate to form new thallus in suitable habitat. Example: *Parmelia*, *Lecanora*, *Physcia*.

b) Isidia:

Isidia are small, coral-like, cylindrical or branched, stalked outgrowths of the thallus. Unlike soredia, they are corticate - i.e. covered by a cortex on outside, internally containing both algal and fungal components continuous with parent thallus. They are photosynthetic, increase thallus surface. They get detached and form new thallus. Function: Both vegetative reproduction and photosynthesis. Example: *Parmelia*, *Peltigera*, *Xanthoria*.

d) Lobules / Phyllidia / Schizidia / Blastidia:

- **Phyllidia / Lobules:** Small dorsiventral leaf-like outgrowths on thallus margin or surface, with both partners. Found in *Peltigera*, *Parmelia*.
- **Schizidia:** Small scale-like flakes formed by separation of upper cortex with attached algal layer. e.g. *Ramalina*.
- **Blastidia:** Yeast-like budding of thallus formed at margins. e.g. *Physcia*, *Xanthoria*. All these detach and form new thalli.

3. DEATH AND DECAY OF OLDER PARTS:

In creeping lichens where older central parts die, the peripheral lobes become separated and each lobe grows independently into a new thallus. Common in crustose and foliose lichens.

4. BY CONIDIOMATA:

Some lichen mycobionts produce conidia-like structures called pycnoconidia from pycnidia, but this method is doubtful because conidia without algal partner cannot form new lichen unless they contact suitable alga.

Q.15. Define disease and mention its various causes with example.

Ans: A plant disease is defined as any physiological or structural abnormality caused by continuous irritation from a harmful agent, resulting in altered growth, development, or function of the plant.

Plant diseases are broadly categorized into two main groups based on their causative agents:

Biotic (Infectious) and **Abiotic** (Non-infectious) causes.

1. Biotic Causes (Infectious Factors)

These are caused by living organisms (pathogens) that attack plant tissues and spread from one plant to another.

- **Fungi:** Responsible for the vast majority of plant diseases. They enter plants through stomata or wounds, disrupting vascular systems and nutrient flow.
Example: Late Blight of Potato (*Phytophthora infestans*) or Wheat Rust (*Puccinia graminis*).
- **Bacteria:** Single-celled prokaryotes that enter through natural openings or wounds, causing rot, spots, or wilting.
Example: Citrus Canker (*Xanthomonas citri*) or Bacterial Blight of Rice (*Xanthomonas oryzae*).
- **Viruses & Viroids:** Microscopic infectious agents that hijack the host plant's cellular machinery to replicate, causing stunting, mosaic patterns, or leaf curling.
Example: Tobacco Mosaic Virus (TMV) or Tomato Yellow Leaf Curl Virus.
- **Nematodes:** Microscopic roundworms that attack plant roots, inhibiting water and nutrient uptake.
Example: Root-Knot Disease of vegetables (*Meloidogyne* spp.).
- **Parasitic Flowering Plants:** Vascular plants that attach to a host plant via haustoria to drain nutrients.
Example: Dodder (*Cuscuta* spp.) on various crops, or Mistletoe on trees.

2. Abiotic Causes (Non-Infectious Factors)

These are non-living, environmental, or chemical factors that alter normal plant metabolism. They cannot spread from plant to plant.

- **Nutritional Deficiencies:** Lack of essential macro or micronutrients required for metabolic processes.
Example: Iron Deficiency Chlorosis (yellowing of young leaves due to low available iron).
- **Extreme Environmental Factors:** Adverse temperatures, water logging, drought, or extreme light exposure.
Example: Sunscald in fruit trees due to intense solar radiation or Blossom End Rot in tomatoes caused by irregular watering and calcium uptake issues.

- **Chemical Hazards & Toxicity:** Soil salinity, air pollution (e.g., ozone or sulfur dioxide), or improper application of herbicides/pesticides.
Example: Leaf Tip Burn caused by excess soil salinity or chlorine toxicity.
-

Q.16. How will you identify a smut, a rust and a wilt disease.

Ans: IDENTIFICATION OF SMUT, RUST AND WILT DISEASES

These three are important fungal diseases of crop plants but can be easily identified in the field by their characteristic symptoms.

1. SMUT DISEASE

Causal organism: *Ustilago* spp. (Basidiomycetes)

Identification Characters:

- **Black sooty powdery mass:** Main symptom is conversion of floral parts especially grains/ovary into black, powdery mass of chlamydospores (smut spores). Looks like plant parts are burnt to soot/coal.
- **Site of infection:** Mostly attacks ovary of cereals - Wheat, Barley, Maize, Sorghum, Sugarcane.

Types of Smut:

- **Covered smut:** Spore mass covered by a membrane. e.g. Covered smut of Barley.
- **Loose smut:** Spore mass naked and exposed, easily blown by wind. e.g. Loose smut of Wheat.
- **Whip smut:** Long whip-like structure arises from shoot apex. e.g. Sugarcane.
- **No yellowing or spots:** Plant may be stunted but no leaf spots or pustules.
- **No wilting:** Roots remain healthy.

Example: Loose smut of wheat - *Ustilago tritici*

2. RUST DISEASE

Causal organism: *Puccinia* spp. (Basidiomycetes) - Obligate parasite

Identification Characters:

- **Rusty pustules:** Small, powdery, reddish-brown / orange-yellow / black pustules (uredosori and teleutosori) appear on leaves and stems. When touched, a rust-like powder sticks to fingers.
- **Site of infection:** Mainly on leaves and stem, sometimes both surfaces but more on lower surface of leaf.
- **Pustules burst through epidermis:** The epidermis of host ruptures due to pressure of spores.

- **Polymorphic life cycle:** May show different spore stages - pycnia, aecia (cup shaped), uredia (brown) and telia (black).
- **No systemic blackening of grains unlike smut.**
- **Plant shows yellow spots first, then rusty pustules.**

Example: Black stem rust of wheat - *Puccinia graminis tritici*

3. WILT DISEASE

Causal organism: *Fusarium oxysporum*, *Verticillium* etc. (Deuteromycetes / Ascomycetes)

Identification Characters:

- **Wilting and drooping:** Gradual or sudden drooping of leaves, branches and whole plant, even when water is available. Loss of turgor.
- **Yellowing (Chlorosis):** Leaves become yellow, then brown, but remain attached.
- **Vascular browning:** This is confirmatory test. If you cut the stem/roots transversely or longitudinally, the vascular bundles (xylem) show brown/black discolouration due to blockage by fungal mycelium and toxins.
- **No external spore mass on leaves** like rust or smut. Roots may show rot.
- **Soil-borne:** Disease starts from roots and moves upward. Plant dies. No sooty powder, no rusty pustules.

Example: Wilt of Pigeon pea (Arhar) - *Fusarium udum*, Wilt of cotton.

TABLE FOR QUICK IDENTIFICATION

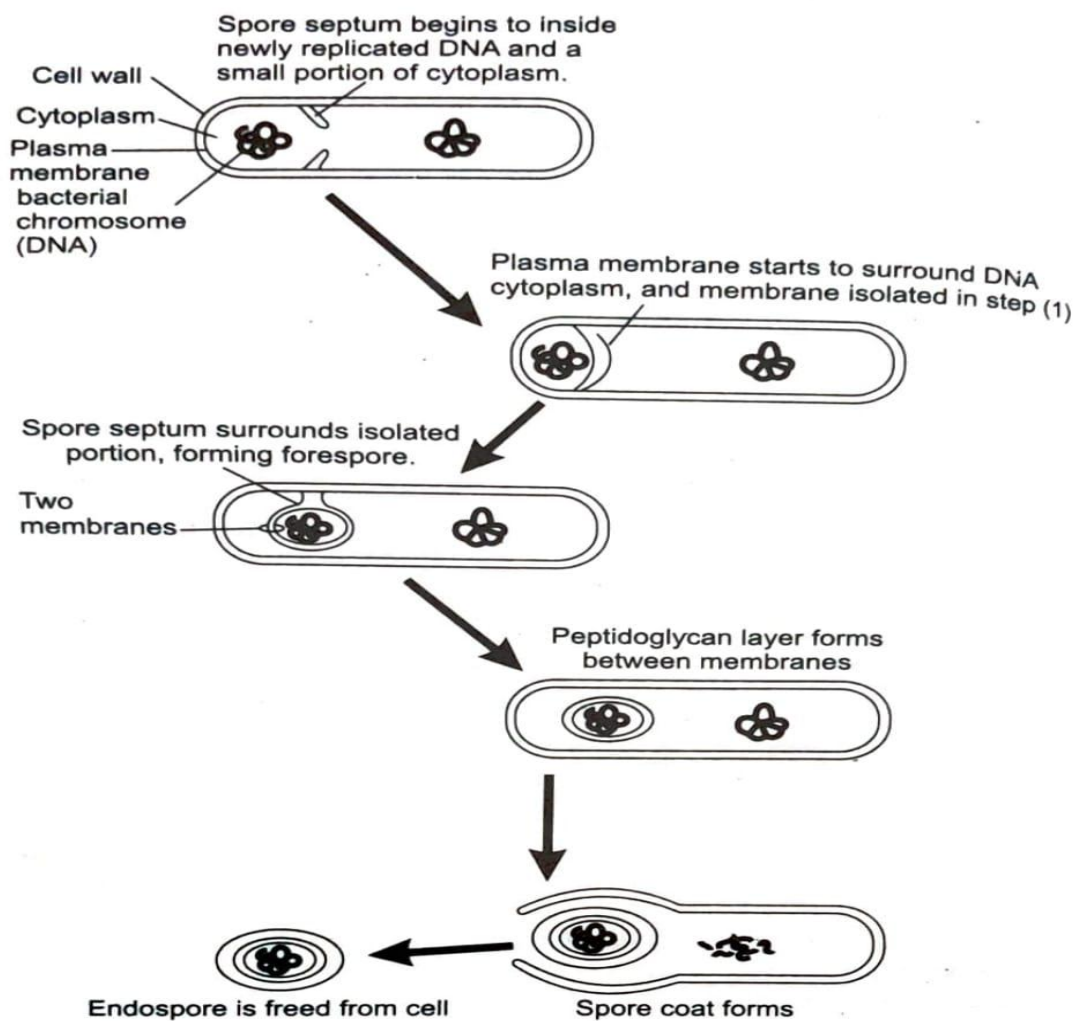
Character	Smut	Rust	Wilt
Main Symptom	Black powdery mass in place of grains	Brown/red powdery pustules on leaves/stem	Drooping, yellowing and death of whole plant
Spores seen by	Naked eye as soot	As rust powder on fingers	Not visible externally
Vascular browning	Absent	Absent	Present – confirmatory
Nature	Seed and flower borne	Air borne	Soil borne

Q.17. Sporulation.

Ans: Sporulation: The process of formation of endospore within a vegetative cell is called as sporulation or sporogenesis. The factors responsible for initiating sporulation are

not shown. In the first observable age, a newly replicated bacterial chromosome and a small portion of cytoplasm are isolated by an ingrowth of the cell membrane called as spore septum. The septum becomes double severed and surrounds the chromosome and cytoplasm. This structure enclosed within parent cell is referred to as forespore. Thick layers of peptidoglycan are formed between the two membrane layers. Now a thick spore coat of protein forms around the outside membrane. This coat protects the endospore against many harsh chemicals and environmental conditions. The endospores may be terminal (at one end), subterminal (near one end) or central inside the vegetative cell. At maturity of endospore, vegetative parent cell wall dissolves (lyses) and endospore is freed.

The water present in the forespore cytoplasm is almost eliminated by the time sporulation is complete, endospores do not carry out any metabolic reactions. The endospore core contains DNA, small amount of RNA, ribosomes, enzymes, and a few important small molecules. The latter include large amount of an organic acid called DPA (dipicolinic acid), components are necessary for resuming metabolism later.



Q.18. Why viruses are called ‘nucleoproteins’?

Ans: Definition:

Viruses are obligate parasites, ultra-microscopic, infectious agents which are intermediate between living and non-living. Chemically, they are Nucleoprotein particles.

1. Chemical Composition -

On chemical analysis of a purified virus particle (virion), we get only two constituents:

VIRUS = NUCLEIC ACID [Nucleo-] + PROTEIN [-protein] = NUCLEOPROTEIN

Part%	Weight	Chemistry	Function
1. Nucleic acid (Core)	5 - 40%	Either DNA or RNA (never both)	Genetic material, Infective part, Controls heredity
2. Protein (Capsid)	60 - 95%	Made of Capsomeres (polypeptides)	Protective coat, Gives shape, Helps in attachment

Except this, there is no protoplasm, no cell wall, no cell membrane, no ribosome, no mitochondria, no enzymes for energy metabolism.

Therefore, structurally a virus is just a Nucleic acid wrapped in Protein.

2. Explanation of Two Parts:

A) Nucleo part - Nucleic acid:

- The core of virus. In Plant viruses, mostly ssRNA is present.
- e.g. Tobacco Mosaic Virus (TMV) - Single stranded RNA (6%)
- e.g. Cauliflower Mosaic Virus (CaMV) - Double stranded DNA - Exception in plants
- e.g. Bacteriophage – dsDNA
- It is the living part. Pure nucleic acid alone can cause infection in host.

B) Protein part - Capsid:

- Outer shell made of many identical sub-units called Capsomeres.
- TMV has 2130 capsomeres arranged helically around RNA.
- In TMV, protein is 94% by weight.

Functions:

- Protects RNA from nucleases.
- Gives shape to virus - TMV = Rod shaped / Helical, Polyhedral viruses = Spherical.
- Responsible for antigenic properties.
- In bacteriophage, proteins of tail help in attachment to bacterial cell wall.

Some phytophages like Wound Tumour Virus also have a Lipoprotein envelope outside capsid, but basic structure is Nucleoprotein.

Q.19. What is Bacteriophage?

Ans: Bacteriophage

- A bacteriophage is a virus that infects and kills bacteria.
- The term Phage was coined by Felix d'Herelle (1917) - means "Eater of bacteria".
- It was first discovered by Twort (1915) and d'Herelle (1917) independently.
- It is also an obligate parasite, made up of Nucleoprotein, just like other viruses.

General Characters:

- Ultra-microscopic, filterable.
- Obligate parasite of bacteria only, does not infect plants or animals.
- Made up of DNA + Protein (Mostly dsDNA). RNA phages are rare.
- Can be crystallized.
- Shows both living (replicates inside bacteria) and non-living (inert outside) characters.
- Host specific - One phage infects only one species of bacteria.
- Causes lysis of bacterial cell - hence used in phage therapy.

Structure of a Bacteriophage (T4 Phage - Most Studied):

T4 phage infects E. coli bacteria. It has complex structure, also called Tadpole-shaped virus.

Mainly 3 parts:

1. Head / Capsid:

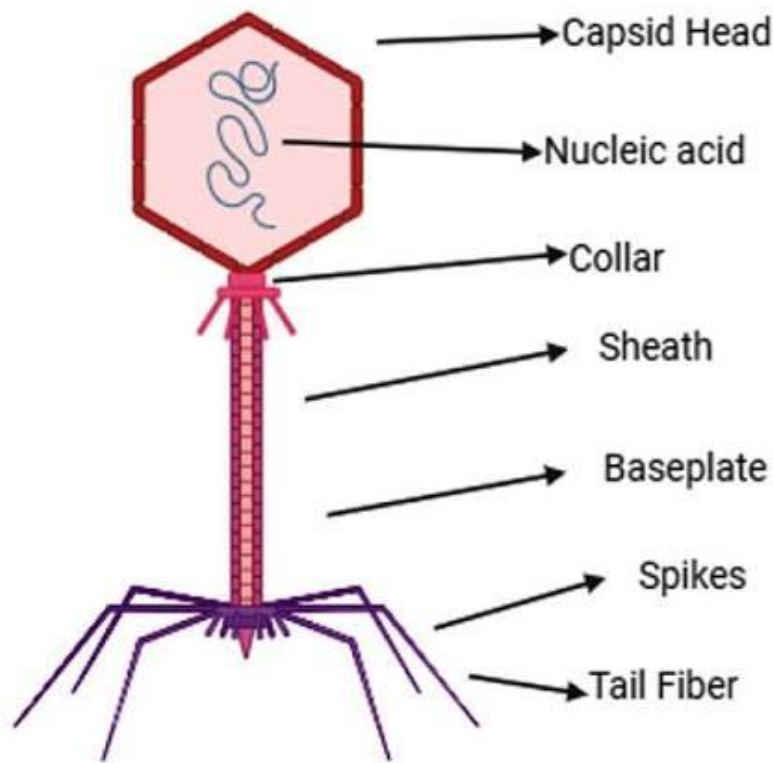
- Polyhedral (icosahedral), made of capsomeres (Protein).
- Inside, tightly coiled dsDNA is present (about 50,000 base pairs).
- Head is 95 nm long and 65 nm wide.

2. Tail:

- Cylindrical, hollow, made of protein.
- It has - Collar, Sheath (contractile), Central core, Base plate.
- At the end of base plate, there are Tail fibres (6) and Spikes - help in attachment to bacterial cell wall.

3. Nucleic Acid:

- Double stranded DNA - highly coiled.
- Protected by protein head.



Types of Bacteriophage - On the basis of Life Cycle:

1. Virulent or Lytic Phage (T4, T3, T2):

- After infection, multiplies inside bacteria and lyses (kills) the host cell immediately.
- Releases about 100-200 new phages.
- This cycle is called Lytic Cycle.

2. Temperate or Lysogenic Phage (Lambda phage λ):

- After infection, its DNA integrates with bacterial DNA and remains dormant as Prophage. Does not kill host immediately.
- Bacterial cell continues to divide with prophage.
- Under stress conditions, it becomes virulent and enters lytic cycle.
- This cycle is called Lysogenic Cycle.

Life Cycle in Short (Lytic Cycle):

Adsorption: Phage attaches to bacteria with tail fibres.

Penetration: Tail sheath contracts, DNA is injected into bacterial cell. Protein coat remains outside.

Replication: Phage DNA takes over bacterial metabolism and produces phage DNA and proteins.

Maturation: New heads and tails are assembled, DNA packed.

Lysis: Bacterial cell wall bursts due to lysozyme, new phages released.

Q.20. What is Prophage?

Ans: Prophage is the dormant, inactive form of a temperate bacteriophage, in which its DNA gets integrated into the bacterial chromosome.

Term given by Lwoff (1953).

The bacteria carrying prophage is called Lysogenic Bacterium or Lysogen.

e.g. *E. coli* (λ) means *E. coli* carries lambda prophage.

Formation of Prophage - Lysogenic Cycle

This is shown by Temperate Phages like Lambda phage (λ), P1, P2 which infect *E. coli*.

- 1.**Infection:** Phage DNA injected into bacterial cell.
- 2.**Integration:** Phage DNA integrates with bacterial circular DNA at specific site (between gal and bio genes in *E. coli*) by enzyme integrase. This integrated DNA is PROPHAGE.
- 3.**Repression:** A protein called Repressor protein (coded by cI gene) stops the lytic genes of phage, so no new phages are formed.
- 4.**Co-replication:** Bacterial cell divides normally. Prophage DNA replicates with bacterial DNA and goes to all daughter cells. Thus one lysogen produces millions of lysogens.
- 5.**Induction:** Under UV light, X-rays, Mitomycin C, repressor is destroyed, prophage detaches and starts Lytic cycle and lyses the cell.

Main Characters of Prophage

1. Only phage DNA, no protein coat, hence non-infective.
2. Cannot multiply independently, replicates only with host chromosome.
3. Gives immunity to host from infection by same phage.
4. Causes Lysogenic Conversion - gives new property to bacteria.
 - *Corynebacterium diphtheriae* makes Diphtheria toxin only when β -prophage is present.
 - *Streptococcus pyogenes* becomes pathogenic due to prophage.

Difference - Phage vs Prophage

Bacteriophage	Prophage
Free particle - DNA + Protein capsid	Only naked DNA integrated in host chromosome
Infective	Non-infective, dormant
Lyses the bacteria	Does not lyse, replicates with host

Q.21. What is Capsid?

Ans: Definition:

Capsid is the outer protein coat which encloses the nucleic acid (DNA or RNA) of a virus. The virus particle consisting of nucleic acid + capsid is called Virion.

1. Structure:

Capsid is made up of many identical protein subunits called Capsomeres.

Each capsomere is made of polypeptide chain.

Capsomeres are arranged in definite symmetry.

Types of symmetry in plant viruses:

a) **Helical**: Rod-like, capsomeres arranged spirally around RNA.

Example - Tobacco Mosaic Virus (TMV) - 2130 capsomeres, 158 amino acids in each capsomere, length 300 nm.

b) **Polyhedral / Icosahedral**: Spherical, 20 triangular faces, 12 corners.

Example - Turnip Yellow Mosaic Virus, Cucumber Mosaic Virus.

c) **Complex**: Head + Tail type.

Example - Bacteriophages.

2. Chemical Nature:

Capsid is purely protein (Nucleoprotein particle). No lipid or carbohydrate in naked plant viruses.

3. Functions -

a) **Protective**: Protects viral RNA from nucleases and environmental damage.

b) **Infectivity**: Protein helps in transmission by vectors (aphids) and in attachment to host plant cell.

c) **Shape**: Gives characteristic shape and size to virus.

d) **Antigenic**: Causes antibody formation, helps in serological identification of plant viruses.

e) **Genetic information is NOT in capsid**: Capsid is coded by viral nucleic acid, synthesized inside host cell.

4. Special Note:

In enveloped animal viruses like HIV, envelope is present outside capsid, but all plant viruses are naked, they have only capsid, no envelope.

Q.22. What is Cyanophage?

Ans: Cyanophage is a virus that infects and lyses Blue-Green Algae i.e. Cyanobacteria.

- It is similar to bacteriophage but host is cyanobacteria, not bacteria.
- First discovered by Safferman and Morris in 1963 from sewage water. First cyanophage was LPP-1 which infects *Lyngbya*, *Plectonema* and *Phormidium*.
- The term Cyanophage was given by Safferman.

Structure:

1. Morphologically similar to T4 bacteriophage - Tadpole shaped.
2. Has 3 parts:
 - Head / Capsid: Polyhedral, icosahedral, made of protein, contains dsDNA.
 - Tail: Hollow, cylindrical, contractile, helps in injection of DNA.
 - Tail fibres / Base plate: For attachment to cyanobacterial cell wall. Size: 50-100 nm head, tail 100-200 nm long.
3. Nucleic Acid: Double stranded DNA (dsDNA). Some may have ssDNA or ssRNA.

Types:

On basis of host:

- LPP-1 group: Infects *Lyngbya*, *Plectonema*, *Phormidium* - Most common.
- AS-1 group: Infects *Anacystis*, *Synechococcus*.
- N-1 group: Infects *Nostoc*, *Anabaena*.

On basis of life cycle:

- Lytic Cyanophage: Lyses the host cell immediately - e.g. LPP-1
- Lysogenic Cyanophage: DNA integrates as prophage - e.g. *Plectonema* phage.

Life Cycle (Lytic):

- 1) **Adsorption:** Cyanophage attaches to cyanobacterial cell wall.
- 2) **Penetration:** DNA injected into host.
- 3) **Replication:** Phage DNA takes over host machinery, forms many copies of DNA and proteins.
- 4) **Maturation:** New phage particles assembled.
- 5) **Lysis:** Cell wall breaks, 50-200 new cyanophages released.

Lytic cycle completes in 12-24 hours.

Importance / Significance :

- a) **Control of Water Blooms:** Cyanobacteria form water blooms in ponds, lakes causing pollution. Cyanophages lyse them and control blooms - Biological control.
 - b) **Ecological Role:** Maintains balance of cyanobacteria in aquatic ecosystem.
 - c) **Genetic Engineering:** Used as cloning vector for gene transfer in cyanobacteria, like bacteriophage in *E.coli*.
 - d) **Evolution:** Helps to understand origin and evolution of virus and blue-green algae.
 - e) **Photosynthesis Research:** Some cyanophages contain photosynthesis genes (*psbA*), helps in research.
-

Q.23. What is Prions?

Ans: Prions are infectious protein particles without any nucleic acid (DNA or RNA).

Term Prion = Proteinaceous Infectious particle given by Stanley B. Prusiner in 1982. He got Nobel Prize in 1997.

Prions are smallest infectious agents, smaller than viruses.

Discovered while studying Scrapie disease in sheep.

In plants, true prions are not found, but Prion-like proteins are reported in plants which show similar behavior in stress response.

Structure and Nature:

1. Only Protein: No DNA or RNA. Chemically glycoprotein.
2. Molecular Weight: 27,000-30,000 daltons.
3. Two forms of same protein:
 - PrP^c = Cellular Prion Protein (Normal): Present in normal brain of mammals, soluble, easily digested by protease, rich in alpha-helix (40%).
 - PrP^{sc} = Scrapie Prion Protein (Infective): Abnormal, insoluble, resistant to protease, rich in beta-sheet (45%), causes disease. It converts normal PrP^c into PrP^{sc}.
4. Resistant to heat (90°C), formaldehyde, UV radiation and nucleases because no nucleic acid. Sensitive to urea, phenol and autoclaving.

Multiplication:

- Prion does NOT replicate like virus. It acts by converting normal host protein PrP^c into infectious PrP^{sc}.
- PrP^{sc} + PrP^c (normal) → 2 PrP^{sc} → 4 PrP^{sc} → Chain reaction.
- PrP^{sc} accumulates in brain, forms amyloid fibers and plaques, brain becomes sponge-like.

Diseases Caused by Prions:

No disease in plants. Important in animals and humans:

- **In Animals:** Scrapie in sheep/goat, Mad Cow Disease (BSE) in cattle.
- **In Humans:** Kuru, Creutzfeldt-Jakob Disease (CJD), Gerstmann-Sträussler Syndrome.

All are Neurodegenerative diseases - loss of memory, tremors, death.

Q.24. What do you understand by F⁺, F⁻ and Hfr?

Ans: Bacterial Conjugation

These terms are related to Bacterial Conjugation discovered by Lederberg and Tatum (1946) in *E.coli*. F stands for Fertility Factor.

1. F⁺ Strain - Male / Donor:

- Bacteria containing F-factor (F-plasmid) in cytoplasm, free in nature.
- F-factor is a circular dsDNA of 100 kilobases, having 19 genes - responsible for sex pilus formation.
- Forms sex pilus for conjugation.
- Acts as Donor, transfers its genes.

Formula: $F^+ = \text{Bacterial Chromosome} + \text{Free F-plasmid}$.

Example: *E.coli* F^+

2. F- Strain - Female / Recipient:

- Bacteria which does NOT contain F-factor.
- No sex pilus formation.
- Acts as Recipient in conjugation.
- Can become F^+ if it receives F-factor from F^+ .

Conjugation $F^+ \times F^-$:

F^+ makes pilus, contacts F^- , F-plasmid replicates and one copy goes to F^- .

Result: Both become F^+ . Bacterial genes NOT transferred, only F-plasmid transfers. High frequency of transfer.

3. Hfr Strain - High Frequency Recombination:

- Full form: High Frequency Recombinants.
- Discovered by William Hayes in 1953.
- When free F-factor integrates into bacterial chromosome, that strain is called Hfr.
- Hfr = Bacterial Chromosome integrated with F-factor.

Conjugation Hfr x F- :

1. Hfr pilus contacts F^- .
2. Integrated F-factor tries to transfer, so it drags bacterial chromosomal genes along with it.
3. Transfer starts from origin (O) of F-factor, chromosomal genes transfer linearly according to order.
4. Usually conjugation breaks before whole chromosome transfers.
5. **Result:** F^- remains F^- but becomes Recombinant with some new genes of Hfr.
Recombination is very high (hence name Hfr).

Difference:

F^+	F^-	Hfr
Contains free F-plasmid	No F-plasmid	F-plasmid integrated in chromosome
Donor, forms sex pilus	Recipient, no pilus	Donor with high gene transfer
$F^+ \times F^- = 2 F^+$	Becomes F^+ after receiving F	Hfr x F^- = Recombinant F^- but F^- remains F^-

Q.25. What is sexduction?

Ans: Sexduction or F-duction was discovered by Adelman and Burns in 1960 in *E.coli*.

Definition:

- Sexduction is a type of bacterial gene transfer where F' plasmid carrying some bacterial genes is transferred from donor to recipient by conjugation.
- It is combination of Sex (Conjugation) + Transduction = Sexduction.

Formation of F' - Basis of Sexduction

1. In Hfr strain, F-factor is integrated in bacterial chromosome.
2. Sometimes, due to improper excision, F-factor comes out of chromosome and while coming out, it carries some adjacent bacterial genes with it.
3. This F-factor with bacterial genes is called F' factor (F-prime factor).
4. F' = F-factor + Some Bacterial Genes (e.g. lac genes, gal genes)
5. Bacteria containing F' factor is called F' strain.

Mechanism of Sexduction - F' x F- Cross:

- **Donor is F'** : Example - F' (lac+)
- **Recipient is F-** : Example - F- (lac-)
- F' forms sex pilus, attaches to F-.
- F' plasmid replicates and transfers its copy along with bacterial genes (lac+) to F-.
- Recipient becomes Partial Diploid / Merozygote - It has its own chromosome (lac-) + F' plasmid with extra lac+ genes. Result: F- (lac-) becomes lac+ even though its own chromosome is lac-. The recipient is Phenotypically dominant for those genes carried on F'.
- F' transfers at high frequency like F+ strain.

Difference from Conjugation and Transduction:

F+ x F- (Conjugation)	Hfr x F-	F' x F- (Sexduction)
Only F-factor transfers	Chromosomal genes transfer, F- remains F-	F-factor + some chromosomal genes transfer
No bacterial gene transfer	High recombination	Stable partial diploid formed

Q.26. What is a Coenobium and name of the alga which is a non-motile coenobium that consists of coccoid unicells.

Ans: Definition: Coenobium is a colony of algae having definite number, shape, size and arrangement of cells, which behave as a single unit. The number of cells is fixed in a

coenobium. All cells originate from a single mother cell by successive divisions and remain in a common mucilage. It is a characteristic of Order - Volvocales (Chlorophyceae).

Characteristics of Coenobium:

1. **Definite number of cells:** e.g. 4, 8, 16, 32, 64 etc. Not irregular.
2. **Definite shape and arrangement:** Spherical, flat, curved etc.
3. **Mucilage envelope:** Whole colony surrounded by common mucilage.
4. **Co-ordinated behavior:** Motile coenobia show co-ordinated flagellar movement, like a single organism.
5. **Asexual reproduction** by formation of daughter coenobia (autocolony formation).

Types of Coenobium:

1. **Motile Coenobium:** Cells have flagella, colony motile.
 - **Volvox:** 1000-50,000 cells, spherical, hollow.
 - **Pandorina:** 8,16,32 cells, compact sphere.
 - **Eudorina:** 16,32,64 cells, hollow sphere.
 - **Gonium:** 4,8,16 cells, flat plate.
2. **Non-motile Coenobium:** Cells without flagella, colony non-motile, cells are coccoid (spherical non-motile).
 - **Hydrodictyon:** Net-like coenobium - 5-6 cells join to form hexagon, many hexagons form net. Called water net. Each cell is cylindrical.
 - **Pediastrum:** Star-like disc coenobium. This is the best example.
 - **Scenedesmus:** Most common - 2,4,8 cells in a linear row.
 - **Coelastrum:** 8,16,32 cells in hollow sphere.

Q. 27 - Non-motile coenobium that consists of coccoid unicells.

Ans: Pediastrum and Scenedesmus and Hydrodictyon - All are correct.

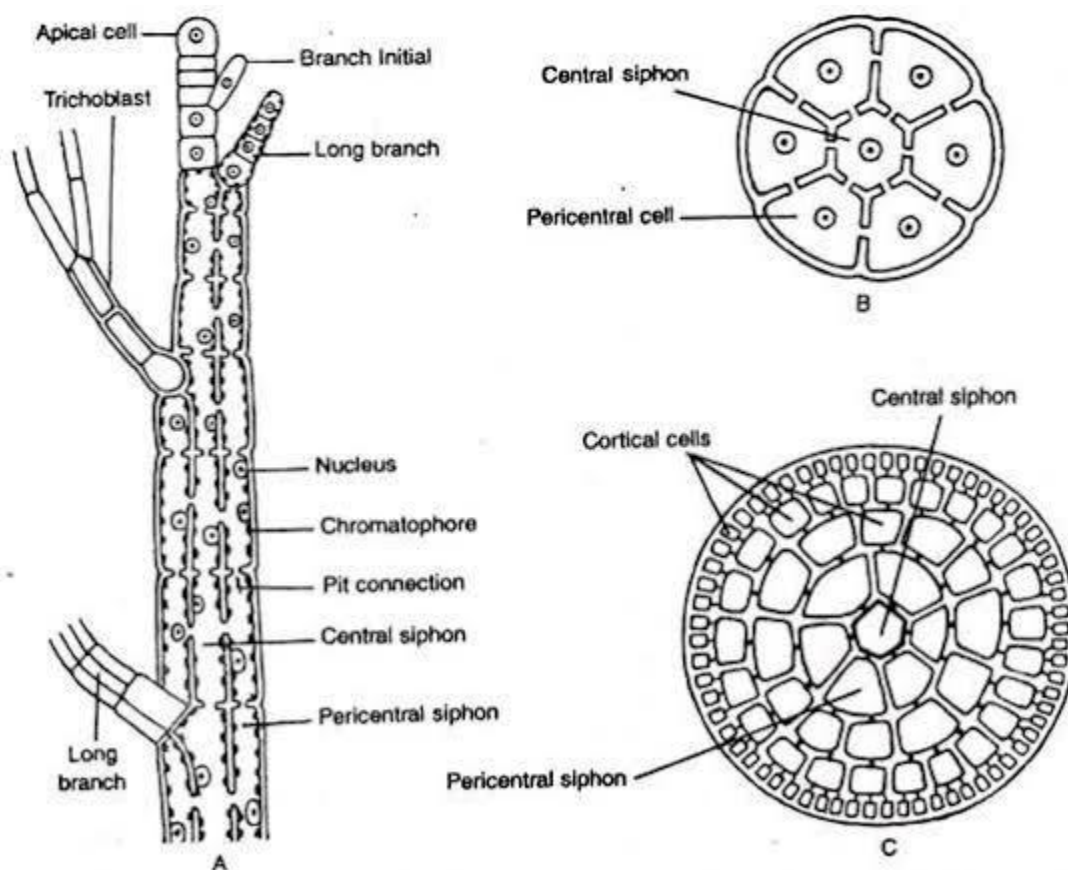
unicells. Pediastrum: Class: Chlorophyceae, Order: Chlorococcales. Coenobium flat, disc-like, star-shaped. 4,8,16,32,64,128 coccoid cells arranged in concentric rings, no spaces between cells. Peripheral cells have two horns/processes. Each cell has single chloroplast with pyrenoid. Reproduction by formation of daughter coenobium inside mother cell.

Q. 28 – Mention an alga which shows multiaxial construction of plant body.

Ans: Multiaxial construction is a type of thallus organization found in Red Algae - Rhodophyceae where the plant body is made up of many / several central axial filaments running parallel to each other, instead of one single axis. It is opposite to Uniaxial construction where only one main central filament is present.

Most important example is: ***Polysiphonia***

Structure of Multiaxial Thallus [Example - *Polysiphonia*]:



Q. 29 – Write note on reserve food in Algae.

Ans: Reserve food in algae is used as Classification character. Different classes store different reserve foods.

1. Chlorophyceae - Green Algae:

Reserve Food: Starch

- True starch - Amylose + Amylopectin - same as higher plants.
- Formed of two components: Amylose (inner) and Amylopectin (outer).
- Storage: Inside chloroplast, around Pyrenoid.
- Pyrenoid produces starch, forms Starch plate.
- Also stores Oils in some algae e.g. *Chlamydomonas*.
- Example: *Spirogyra*, *Volvox*, *Ulothrix* - all have starch.

2. Xanthophyceae - Yellow-Green Algae:

Reserve Food: Oil and Leucosin / Chrysolaminarin

- Starch absent.
- Oil globules present.

3. Phaeophyceae - Brown Algae:

Reserve Food: Laminarin + Mannitol + Oil

- Laminarin: Beta-1,3 glucan, a polysaccharide, stored in vacuoles.
- Mannitol: Sugar alcohol, soluble, 6-carbon.
- Algin also present.
- Starch absent.
- Example: *Laminaria*, *Fucus*, *Sargassum*.

4. Rhodophyceae - Red Algae:

Reserve Food: Floridean Starch

- Special type of starch - Similar to amylopectin + glycogen.
- Not blue with iodine, gives reddish-violet color.
- Stored in cytoplasm outside chloroplast, not inside chloroplast - Important point.
- Also stores Floridoside and Mannoglycerate.
- Example: *Polysiphonia*, *Gracilaria*, *Gelidium*.

5. Bacillariophyceae - Diatoms:

Reserve Food: Oil, Leucosin, Chrysolaminarin (Volutin)

- Large oil drops.
- Starch absent.

6. Cyanophyceae - Blue-Green Algae / Myxophyceae:

Reserve Food: Cyanophycean Starch (Myxophycean Starch) + Cyanophycin

- Myxophycean starch = Alpha-1,4 glucan, glycogen-like, gives reddish brown color with iodine.
- Cyanophycin: Protein granules - reserve of nitrogen.
- Stored in cytoplasm.

7. Euglenophyceae:

Reserve Food: Paramylon (Paramylum Starch)

- Beta-1,3 glucan, stored in cytoplasm as rod-like bodies.
- Example: *Euglena*.

TABLE –

Class	Reserve Food	Place of Storage
Chlorophyceae	True Starch	Around pyrenoid in chloroplast
Phaeophyceae	Laminarin, Mannitol	Vacuole
Rhodophyceae	Floridean Starch	Cytoplasm
Cyanophyceae	Myxophycean Starch, Cyanophycin	Cytoplasm
Bacillariophyceae	Oil, Chrysolaminarin	Cytoplasm
Euglenophyceae	Paramylon	Cytoplasm

Q. 30 – What is algal Biofertilizers?

Ans: Algal biofertilizers are nitrogen fixing algae used to increase soil fertility and crop yield, especially in paddy fields. They fix atmospheric N₂ into soil.

Main Algal Biofertilizers are Cyanobacteria - Blue Green Algae (BGA).

Main Algae Used:

1. Free-living BGA (Most Important for Rice):

- *Anabaena*, *Nostoc*, *Aulosira*, *Tolypothrix*, *Cylindrospermum*, *Scytonema*, *Anabaenopsis*
- Most important: *Aulosira fertilissima* - Best for paddy fields in India.

2. Symbiotic BGA:

- *Anabaena azollae* inside water fern *Azolla pinnata* - Super biofertilizer for rice.
- BGA in symbiosis with *Cycas* coralloid root, *Anthoceros*, *Azolla*.

3. Other Algae:

Green algae like *Chara* and Brown algae as green manure - *Sargassum*, *Laminaria* as potash fertilizer.

Advantages / Importance:

- 1) Increase rice yield by 15-20% - proved by IARI, New Delhi.
 - 2) No pollution: Eco-friendly, chemical fertilizers cause pollution.
 - 3) Add organic matter: After death, algae add organic matter to soil.
 - 4) Reclaim alkaline soils: Blue Green Algae reduces pH of alkaline (Usar) soils by producing organic acids. Can reclaim alkaline soils.
 - 5) Secrete growth hormones: Secrete Vitamin B₁₂, Auxins (IAA), Gibberellins which promote plant growth.
 - 6) Phosphate solubilizing: Some Blue Green Algae solubilize insoluble phosphate.
 - 7) Prevent weed growth: Forms thick mat on water, prevents weed.
 - 8) Low cost: Farmer can produce in small tanks.
-

Q. 31 – Differentiate between saprophytic & parasitic fungi.

Ans: Definition:

1. Saprophytic Fungi (Saprobic / Saprotrophic):

Fungi which grow on dead organic matter, obtain food by decomposition. They are decomposers. Example: *Rhizopus*, *Mucor*, *Agaricus*, *Penicillium*, *Aspergillus*, *Morchella*.

2. Parasitic Fungi:

Fungi which grow on living host (plant, animal or human) and obtain food from host, causing disease.

Example: *Puccinia* (Rust), *Albugo* (White rust), *Phytophthora* (Late blight), *Ustilago* (Smut), *Erysiphe* (Powdery mildew), *Pythium*.

Difference Table-

Character	Saprophytic Fungi	Parasitic Fungi
1. Habitat	Dead organic matter - rotten wood, dung, food, soil humus	Living host - plants, animals, humans
2. Food / Nutrition	Obtain food by decomposition of dead matter	Obtain food from living cells of host
3. Enzymes	Secrete strong extracellular enzymes (cellulase, pectinase) outside to digest matter	Secrete limited enzymes, mainly haustoria to absorb food
4. Special Structure	No haustoria, hyphae ramify on substratum, produce rhizoids	Produce Haustoria - specialized absorbing structure to suck food from host cells
5. Effect on Host / Substratum	Beneficial- Decomposition, recycling of nutrients, humus formation	Harmful - Cause diseases in host
6. Inter-relation	No host-parasite relation. Free living.	Host-parasite relation present. Host specific.
7. Obligate / Facultative	Mostly Obligate saprophytes - <i>Mucor</i> , <i>Rhizopus</i> can live only on dead matter Facultative parasites - Normally saprophytic but can become parasitic if opportunity e.g. <i>Botrytis</i> , <i>Fusarium</i>	Mostly Obligate parasites - e.g. <i>Puccinia</i> can live only on living wheat host Facultative saprophytes - Normally parasitic but can live on dead matter e.g. <i>Phytophthora</i> , <i>Pythium</i>
8. Importance	Industrial importance - Production of alcohol, organic acids, antibiotics, enzymes. Food - <i>Agaricus</i> , <i>Morchella</i> edible	Pathogenic importance - Cause plant diseases - Rust, Smut, Blight, Mildew, Wilt. Cause human diseases - Ringworm, Athlete's foot

Q. 32 – Give Ainsworth’s classification of fungi.

Ans: Ainsworth divided fungi into Myxomycota (slime molds) and Eumycota (true fungi) with 5 sub-divisions Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina based on presence of flagella and type of sexual spores.

Ainsworth's Classification Outline:

KINGDOM: MYCOTA

DIVISION I: MYXOMYCOTA - Slime Molds

Wall-less, plasmodium stage present.

- **Class 1: Acrasiomycetes** - Cellular slime molds
- **Class 2: Hydromycomycetes** - Net slime molds
- **Class 3: Myxomycetes** - True slime molds - e.g. *Physarum*
- **Class 4: Plasmodiophoromycetes** - Parasitic slime molds - e.g. *Plasmodiophora*

DIVISION II: EUMYCOTA - True Fungi

With definite cell wall, mycelium present.

Divided into 5 Sub-divisions:

Sub-division 1: Mastigomycotina - Flagellated fungi, zoospores present

- **Class: Chytridiomycetes** - Posterior whiplash flagellum - e.g. *Synchytrium*
- **Class: Hyphochytridiomycetes** - Anterior tinsel flagellum
- **Class: Oomycetes** - Biflagellate zoospore, Oogamous, wall of cellulose - e.g. *Pythium*, *Phytophthora*, *Albugo*, *Saprolegnia*

Sub-division 2: Zygomycotina - No flagella, zygospore present

- **Class: Zygomycetes** - Coenocytic mycelium, sexual spore zygospore - e.g. *Mucor*, *Rhizopus*, *Pilobolus*
- **Class: Trichomycetes** - Insect gut fungi

Sub-division 3: Ascomycotina - Sac fungi, ascospores in ascus

- **Class: Hemiascomycetes** - No ascocarp, naked ascus - e.g. Yeast (*Saccharomyces*)
- **Class: Loculoascomycetes** - Asci in locule, bitunicate - e.g. *Venturia*
- **Class: Plectomycetes** - Cleistothecium - e.g. *Penicillium*, *Aspergillus*, *Erysiphe*
- **Class: Laboulbeniomycetes** - Ectoparasites on insects
- **Class: Pyrenomycetes** - Perithecium - e.g. *Neurospora*, *Claviceps*
- **Class: Discomycetes** - Apothecium - e.g. *Peziza*, *Morchella*

Sub-division 4: Basidiomycotina - Club fungi, basidiospores on basidium

- **Class: Teliomycetes** - Rusts and Smuts
 - Order: Ustilaginales - Smut - e.g. *Ustilago*
 - Order: Uredinales - Rust - e.g. *Puccinia*
- **Class: Hymenomycetes** - Mushrooms, brackets
 - Order: Agaricales - e.g. *Agaricus*
 - Order: Polyporales - e.g. *Polyporus*
- **Class: Gasteromycetes** - Puff balls - e.g. *Lycoperdon*

Sub-division 5: Deuteromycotina - Imperfect fungi / Fungi imperfecti

- No sexual reproduction known.
- **Class: Blastomycetes** - Budding yeasts
- **Class: Hyphomycetes** - Mycelial molds - e.g. *Alternaria*, *Fusarium*, *Cercospora*
- **Class: Coelomycetes** - Pycnidia / Acervuli - e.g. *Colletotrichum*

Merits of Ainsworth's Classification:

- 1) Based on modern characters - septation, flagellation, spore type.
 - 2) Separates slime molds in Myxomycota.
 - 3) Most widely accepted till now in Indian Universities.
-

Q. 33 – What is a holocarpic fungus? Give an example.

Ans: The term Holocarpic and Eucarpic was given by De Bary. Holocarpic Fungus is a fungus in which whole thallus (entire vegetative body) is converted into reproductive structure at the time of reproduction.

Holo = Whole + Carpic = Fruit

No separation between vegetative and reproductive parts. After reproduction, vegetative body is completely finished / disappears.

Opposite is Eucarpic: Only a part of thallus converts into reproductive structure, rest remains vegetative. Example - *Mucor*, *Agaricus* - most higher fungi are eucarpic.

Characteristics of Holocarpic Fungi:

- 1) Thallus is simple, very small, without mycelium - mostly unicellular.
- 2) During reproduction, entire cell acts as sporangium or gametangium.
- 3) After reproduction, no vegetative part remains.
- 4) Mostly primitive, lower fungi - e.g. *Chytrids*, Yeasts, Slime molds.
- 5) Endobiotic - live inside host cells.

Examples of Holocarpic Fungi:

Synchytrium endobioticum

- Class: Chytridiomycetes. Causes Wart disease of Potato (Black wart).
 - Thallus is unicellular, endobiotic inside potato tuber cell.
 - At maturity, whole thallus converts into sporangium producing zoospores.
 - Vegetative body completely disappears.
-

Q. 34 – What is Protorus?

Ans: • A **protorus** is the **initial cell or early thallus stage** formed during the asexual life cycle of certain primitive fungi, most notably in the order *Chytridiales* (such as the plant pathogen *Synchytrium endobioticum*, which causes potato wart disease).

□ It acts as a **precursor structure** that germinates to give rise to a cluster of reproductive structures (sporangia).

Development and Formation:

- **Infection:** A motile, haploid **zoospore** attacks the host plant's epidermal cell and sheds its flagellum.
- **Entry:** The naked protoplast enters the host cell and sinks to the bottom of the cell.
- **Growth:** It absorbs nutrients from the host, grows rapidly in size, and develops a thick, smooth, golden-yellow double wall.
- **Final Form:** This enlarged, nutrient-rich, resting structure occupying the host cell is called the **prosorus**.

Mechanism of Germination:

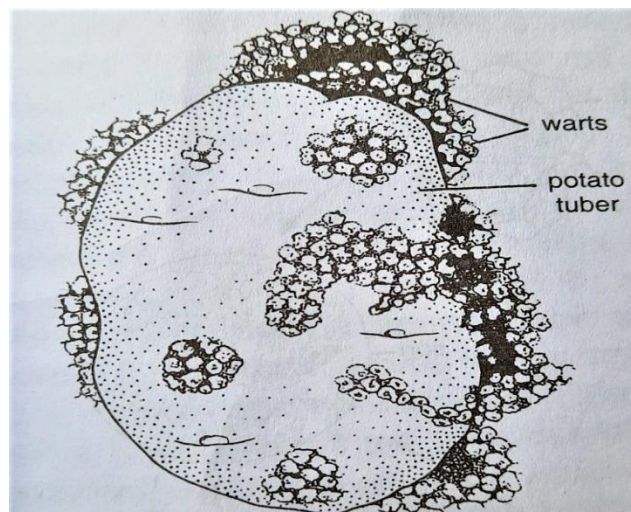
- Upon maturity and in the presence of water, the prosorus functions as a single macro-cell.
- The thick outer wall (exospore) ruptures.
- The thin inner wall (endospore) protrudes out like a vesicle or balloon into the upper part of the host cell.
- The entire protoplasm and all the nuclei of the prosorus stream up into this newly formed vesicle.

Division and Sorus Formation:

- Inside the vesicle, the protoplasm undergoes repeated synchronous nuclear divisions.
- The multinucleated protoplasm is then cleaved by cell walls into **4 to 9 distinct segments**.
- Each segmented compartment transitions into a **zoosporangium** (summer sporangium).
- A collective cluster of these sporangia is called a **sorus**. Thus, the prefix "*pro-*" signifies that it is the structure that comes *before* the sorus.

Q. 35 – What is wart disease of Potato?

Ans: Potato wart disease is a severe, soil-borne fungal infection that deforms potato plants and reduces crop yields.



Cause and Spread

- **Pathogen:** It is caused by the fungus *Synchytrium endobioticum*.
- **Survival:** The fungus produces hardy resting spores that can survive in the soil for up to 20 to 40 years without a host.
- **Spread:** It moves through contaminated soil, infected seed tubers, farm machinery, footwear, and manure from animals that ate infected potatoes.
- **Safety:** The disease does not affect humans or animals.

Symptoms

- **Growths:** It forms abnormal, spongy, cauliflower-like lumps called galls or warts on underground stems, stolons, and tuber eyes.
- **Color changes:** Warts start white or green, turn brown, and decay into a dark black mass.
- **Hidden impact:** Roots are not attacked, and aboveground growth usually looks healthy, meaning the disease is often only discovered during harvest.

Management

- **Resistant varieties:** Planting immune or resistant potato cultivars is the most effective defense.
 - **Quarantine:** Many regions enforce strict quarantine rules to stop the transport of infected soil or tubers into clean areas.
-

Q. 36 – What is resting sporangium?

Ans: The resting sporangium (or winter sporangium) of *Synchytrium*, most notably in the potato wart pathogen [*Synchytrium endobioticum*]. Resting sporangium of *Synchytrium endobioticum* is a thick-walled, dormant reproductive structure adapted to survive harsh winter conditions and long periods in the soil.

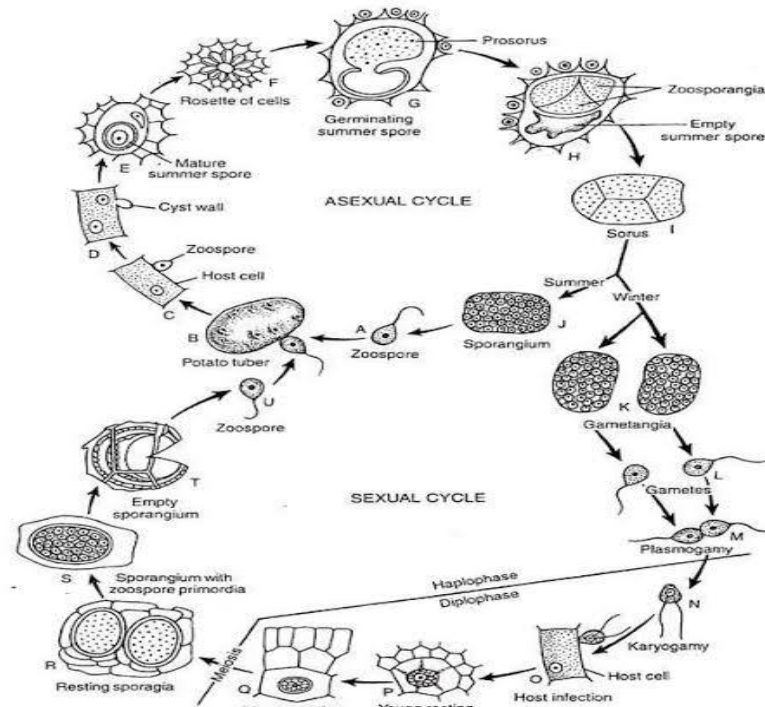
Structure and Formation

- **Origin:** Formed sexually when pairs of motile zoospores (gametes) fuse into a zygote under unfavorable environmental conditions like cold or drought, which then infects the host plant tissue.
- **Wall Composition:** Features a thick, multilayered outer wall containing resistant compounds, waxes, and lipids that help it remain viable in soil for up to 20 to 30 years.
- **Internal Features:** Contains lipid droplets, storage bodies, and a large central nucleus during its developmental stages.

Function and Germination

- **Survival:** Acts as the primary over-wintering and long-term survival structure inside decaying plant warts left in the soil.

- **Germination:** When spring warmth and moisture return, the resting sporangium germinates, undergoing nuclear divisions to release numerous mobile zoospores that seek out new host epidermal cells to start the infection cycle anew.



Q. 37 – What is Fairy ring, name the fungus in which ‘fairy ring’ are formed?

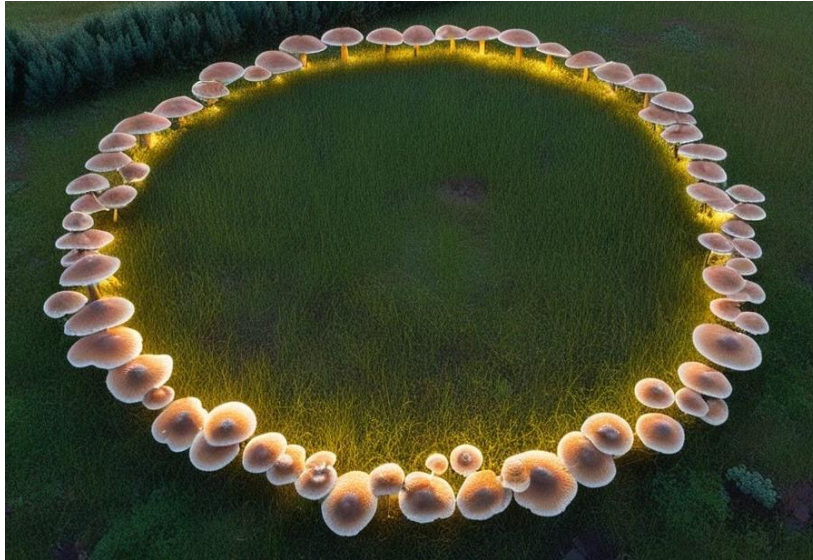
Ans: Definition: A ring or arc formed on the ground by mushroom fruiting bodies.

- **Underground Growth:** The main fungus grows underground as a network of thread-like structures called mycelium.
- **Expansion:** The mycelium spreads outward evenly in all directions from a central point as it searches for food. Mushrooms sprout at the active outer edges.
- **Grass Effects:** The fungus breaks down organic matter, releasing nitrogen that turns the grass dark green, or it creates a water-repellent soil layer that causes a dead (necrotic) ring of grass.

Fungi That Form Fairy Rings

About 100 species of fungi can form fairy rings, primarily belonging to the group Basidiomycetes. Notable examples include:

- **Agaricus campestris:** The common **field mushroom**, which frequently forms smaller fairy rings.



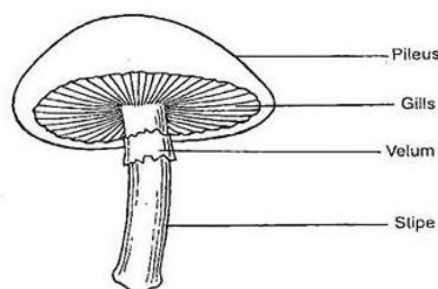
Q. 38 – What is Mushrooms? Give an example.

Ans: A mushroom is the spore-bearing, fleshy reproductive structure of a fungus that typically grows above ground.

- Mushrooms are not plants or animals; they belong to the separate kingdom of **fungi**. (Fungi are organisms that get food by absorbing nutrients from organic matter rather than making it via sunlight like plants).
- **Structure:** A typical mushroom has a stem, a rounded cap, and gills or pores underneath where tiny reproductive cells called **spores** are made.
- **Function:** They act as nature's recyclers by breaking down dead leaves, wood, and other organic material in the environment.

Example:

- **White Button Mushroom (*Agaricus bisporus*):** This is the most common edible mushroom found in grocery stores. It has a smooth white cap, a short stem, and mild flavor, and people often use it in salads, soups, and stir-fries.



Q. 39 – What is rhizomorph?

Ans: A **rhizomorph** is a threadlike or cordlike strand formed by fungi when thousands of microscopic fungal filaments (called hyphae) bundle and cement together.

The word literally means "root form" because these structures look very much like plant roots. You can often find them underground, wrapping around rotting wood, or hiding beneath the bark of dying trees.

Structure and Function

- **Complex Design:** Unlike random tangles of mold, rhizomorphs have specialized tissue layers. An outer protective rind surrounds an inner core (medulla) that helps transport resources.
 - **Nutrient and Water Transport:** They act like plumbing systems for the fungus, moving water, minerals, and organic nutrients across long distances from established food sources to growing areas.
 - **Oxygen Movement:** They can carry oxygen from the base of the structure to the growing tips exploring new territory.
 - **Exploration and Survival:** Rhizomorphs let fungi cross nutrient-poor areas—like bare soil or rock—to find new wood or living trees to infect. A famous example is the honey fungus (*Armillaria*), which uses rhizomorphs to spread destructively through forests.
-

Q. 40 – Short notes on role of Lichens as indicator of air pollution?

Ans: Lichens act as natural **bioindicators** that help determine air quality and pollution levels because they absorb water and nutrients directly from the atmosphere rather than from the soil.

Lichens are Sensitive to Air Pollution

- **No Roots or Cuticle:** Lichens lack a protective outer cuticle and true roots, meaning gases and airborne particles pass directly into their tissues.
- **Year-Round Exposure:** As perennial (long-lived) organisms, they are exposed to environmental toxins in all seasons and cannot shed leaves to avoid damage.
- **Direct Accumulation:** They trap heavy metals, sulfur, and nitrogen compounds, which quickly reach toxic levels and disrupt their metabolism.

Major Pollutants Affecting Lichens

- **Sulfur Dioxide (SO₂):** Even low concentrations of sulfur dioxide damage the chlorophyll in the algal partner, stopping photosynthesis and killing the organism.
- **Nitrogen Oxides and Excess Nitrogen:** High levels of atmospheric nitrogen over-fertilize lichens, altering the symbiotic balance and harming growth.

Sensitivity Scale

Different types of lichens show varying degrees of tolerance to polluted air:

1. **Fruticose (Shrubby):** Most sensitive; found only in very clean, unpolluted air.
 2. **Foliose (Leafy):** Moderately sensitive to intermediate pollution levels.
 3. **Crustose (Crust-like):** Most tolerant; can survive in moderately urban or polluted environments.
-

Q. 41 – Sexual reproduction in Lichens.

Ans: Sexual reproduction in lichens involves only the fungal partner (the mycobiont), which produces spores that must later find and re-associate with a compatible algal or cyanobacterial partner (the photobiont) to form a new lichen.

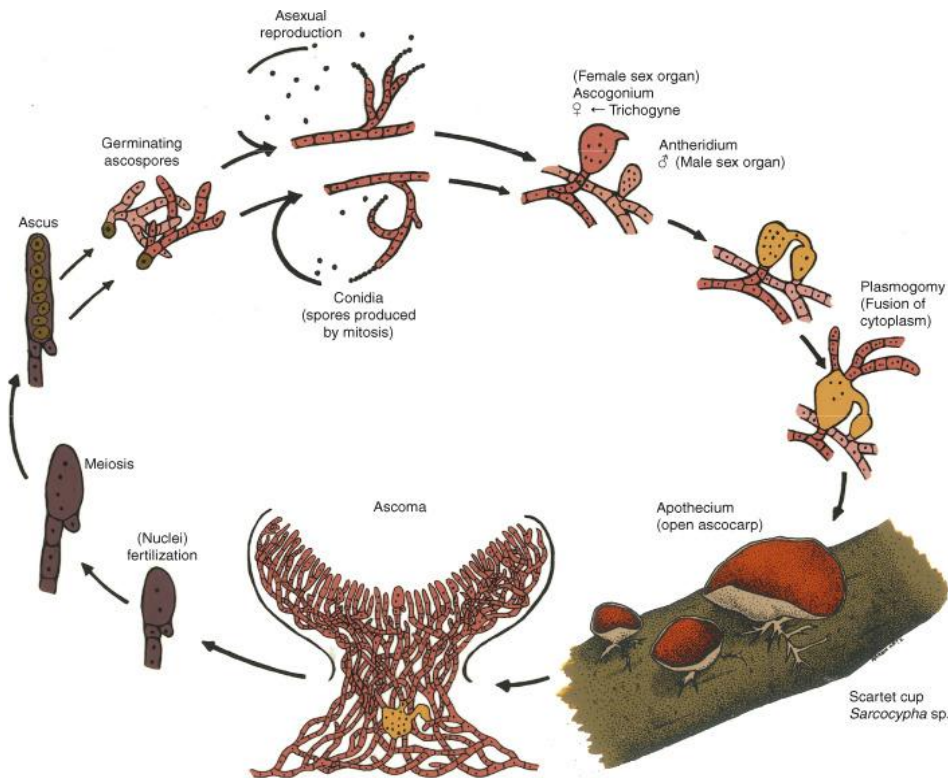
- **Mycobiont:** The fungal partner that undergoes sexual reproduction, typically belonging to the *Ascomycota* (forming ascolichens) or *Basidiomycota* (forming basidiolichens).
- **Photobiont:** The algal or cyanobacterial partner, which does not participate in sexual reproduction.

Reproductive Organs

- **Spermogonium (Male):** A small, flask-shaped structure embedded in the upper surface of the lichen thallus that releases tiny male cells called **spermatia** (or microconidia).
- **Carpogonium (Female):** The female organ divided into a lower, coiled multicellular **ascogonium** (hidden in the inner tissue) and an upper, thread-like **trichogyne** (protruding outside to catch spermatia).

The Process of Sexual Reproduction

1. **Fertilization:** Wind, rain, or water splashes carry male spermatia to the sticky thread-like trichogyne of the female carpogonium.
2. **Fruiting Body Formation:** After the male and female nuclei fuse, the fertilized ascogonium develops specialized reproductive cells (asci) inside visible fruiting bodies, most commonly cup-like **apothecia** or flask-like **perithecia**.
3. **Spore Dispersal:** The fruiting bodies release fungal spores (**ascospores** or **basidiospores**) into the air or via vectors like mites.
4. **Relichenization:** If an ejected spore lands in a suitable microhabitat and successfully encounters and captures a compatible free-living photobiont, it germinates and grows into a new lichen thallus.



Q. 42 – Describe asexual reproductive bodies in Lichens.

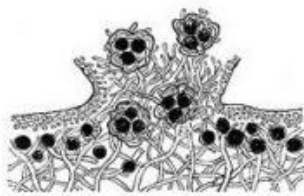
Ans: Lichens reproduce asexually using specialized vegetative propagules that contain both the fungal partner (mycobiont) and the photosynthetic partner (photobiont/alga or cyanobacterium), or through fungal-only asexual spores.

Specialized Vegetative Structures (Containing Both Partners)

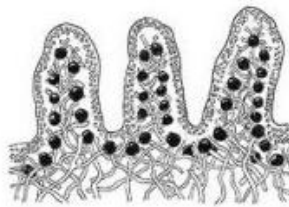
- **Soredia:** Tiny, powdery, spherical clusters of algal cells wrapped in fungal hyphae. They form inside the lichen and burst through the surface via ruptures or specialized areas called soralia. Wind, rain, or insects easily disperse them to grow into a new, identical lichen.
- **Isidia:** Small, fragile, finger-like or coral-like outgrowths on the surface of the lichen thallus (the main body). They are covered by an outer protective layer (cortex) and contain both symbionts. When they break off, they grow into new lichens. While attached, they also help increase the surface area for gas exchange.
- **Fragmentation:** A simple mechanical process where a piece of the mature lichen thallus breaks off due to wind, animals, or drying. Each broken fragment can regenerate into a complete new thallus if conditions are right.

Fungal-Only Asexual Structures

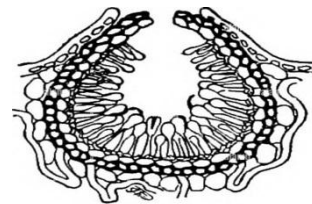
- **Pycnidia:** Small, flask-shaped cavities embedded in the upper surface of the lichen thallus. They produce asexual fungal spores called **pycniospores** (or conidia).
- **Dispersal Challenge:** Pycniospores release only the fungal partner. For a new lichen to form, the germinating spore must independently find and capture a compatible free-living algal partner in the environment.
- **Oidia:** Small, single-celled fungal spores formed when fungal hyphae break apart into segments. Like pycniospores, they germinate to recreate the fungal part of the symbiosis.



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Pycnidia

Q. 43 – What is mycorrhiza?

Ans: A **mycorrhiza** is a mutually beneficial symbiotic relationship between a fungus and the roots of a vascular plant.

- **The Fungus:** Forms a network of fine filaments (**hyphae**) that reach deep into the soil. This vastly increases the surface area for absorbing water, phosphorus, nitrogen, and other minerals.
- **The Plant:** Provides the fungus with sugars and organic food produced during photosynthesis.

Types of Mycorrhiza

- **Ectomycorrhiza:** The fungal hyphae form a dense outer sheath or mantle around the root tip without penetrating individual root cells. This is common in trees like pine and oak.
- **Endomycorrhiza (including Arbuscular Mycorrhiza):** The fungal hyphae penetrate directly into the cells of the plant root. This type is common in the majority of herbaceous plants and crops.

Ecological Importance

- Enhances plant resistance to drought and root diseases.
 - Plays a major role in global nutrient cycles, especially for phosphorus.
 - Connects different plants underground to share nutrients and water signals.
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Q. 44 – Transmission of viral diseases.

Ans: Plant viruses spread from an infected plant to a healthy one through various natural and artificial vectors, broadly classified into horizontal (external) and vertical (parent-to-offspring) transmission.

1. Insect Vector Transmission

Insects with piercing and sucking mouthparts are the most common and important agents of virus spread in the field.

- **Aphids:** Transmit non-persistent or persistent viruses like Potato Virus Y and Cucumber Mosaic Virus.
- **Whiteflies & Leafhoppers:** Carry specialized viruses through their salivary glands or circulatory systems.
- **Thrips:** Act as vectors for diseases such as Tomato Spotted Wilt Virus.

2. Mechanical Transmission (Sap Transmission)

- Viruses pass physically from a diseased plant to a healthy one via sap contact.
- Abrasion of leaves, handling during farm practices, or tools contaminated with plant sap can spread robust viruses like Tobacco Mosaic Virus (TMV).

3. Vegetative Propagation and Grafting

- Using infected plant parts—such as tubers, bulbs, corms, rhizomes, or cuttings—perpetuates and spreads viral infections to new crops (e.g., Potato Virus X in potatoes).
- **Grafting:** Joining an infected scion to a healthy rootstock allows the virus to move systemically through the phloem (e.g., Citrus Tristeza Virus).

4. Seed and Pollen Transmission

- Some viruses infect the reproductive tissues, passing vertically to seeds or pollen grains.
- Seedlings grown from these infected seeds often show systemic symptoms early in development.

5. Soil-Borne Pathogenic Vectors

- **Fungi:** Soil-inhabiting fungi like *Olpidium* species can harbor and introduce viruses (such as Tobacco Necrosis Virus) into plant roots through zoospores.
- **Nematodes:** Plant-parasitic nematodes (such as *Xiphinema* species) feed on roots and transmit soil-borne polyhedral viruses like Grapevine Fanleaf Virus.

6. Transmission by Parasitic Plants

- Parasitic angiosperms like **Dodder (*Cuscuta*)** bridge two separate host plants via haustoria, passively drawing and transferring viruses from an infected host to a healthy one through shared vascular connections.
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Q. 45 – Explain pathogenicity and pathogenesis.

Ans: Pathogenicity is the qualitative ability of a pathogen to cause disease in a plant, while pathogenesis is the sequential chain of biological events and processes involved in how that disease develops.

Pathogenicity : The qualitative trait or genetic capacity of an organism (like a fungus, bacterium, virus, or nematode) to infect a host and induce disease.

- **Concept:** It is a "yes or no" or categorical attribute—an organism is either pathogenic to a specific host or it is not.
- **Virulence vs. Pathogenicity:** Virulence measures the *degree* or severity of the disease caused by a specific pathogenic strain, acting as a quantitative scale under pathogenicity.
- **Mechanisms:** Driven by specific genes encoding toxins, hormones, and cell-wall-degrading enzymes (such as cutinases and pectinases) that break down plant defenses.

Pathogenesis : The step-by-step process or progression of disease development, starting from initial contact between the plant and pathogen to the final appearance of symptoms.

- **Stages of the Disease Cycle:**
 - **Inoculation:** The pathogen (the inoculum) lands or arrives on the host plant surface.
 - **Penetration:** The pathogen enters the plant tissue directly through the cuticle, via natural openings (stomata, hydathodes), or through wounds.
 - **Infection:** The pathogen establishes active contact inside the host cells or tissues and begins absorbing nutrients.
 - **Colonization (Invasion):** The pathogen grows, multiplies, and spreads throughout the plant tissue, leading to visible structural abnormalities or symptoms.
 - **Dissemination & Survival:** The pathogen reproduces and spreads secondary propagules to new hosts or forms resting structures to overwinter.
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Q. 46 – What are primary and secondary inoculum?

Ans: Primary inoculum is the pathogen stage that survives harsh conditions to start the first plant disease of the season, while secondary inoculum is produced by those initial infections to spread the disease further during the same growing season.

An **inoculum** is any part of a pathogen (like fungal spores, bacterial cells, or viral particles) that can land on a host plant and cause an infection.

Primary Inoculum

The overwintering or oversummering dormant form of a pathogen that causes the very first infection (primary infection) in a crop.

- **Timing:** Operates at the start of a growing season, typically in spring or autumn.
- **Survival:** Survives unfavorable, dormant conditions in plant debris, soil, seeds, or perennial weeds.
- **Examples:** Fungal structures like *sclerotia*, *mycelium*, or *oospores*.
- **Impact:** More abundant primary inoculum close to crops generally leads to more severe early disease and larger crop losses.

Secondary Inoculum

New infectious material produced by the active plant tissues that became diseased during the primary infection.

- **Timing:** Produced later, spreading and perpetuating the disease repeatedly during the same growing season.
- **Spread:** Dispersed rapidly by wind, water, or insects to neighboring healthy plants, causing secondary infections.
- **Examples:** Spores like *conidia*, *uredospores*, or *zoospores*.
- **Impact:** Drives polycyclic diseases (diseases with multiple cycles per season), making outbreaks harder to control once they start.

Differences

Feature	Primary Inoculum	Secondary Inoculum
Timing	Survives off-seasons (winter/summer) and acts at the start of a crop season.	Produced actively during the current growing season after the first infection.
Type of Infection	Causes primary infection (the original outbreak).	Causes secondary infection (subsequent spreading waves).
Origin/Source	Overwinters in crop debris, soil, seeds, or alternate hosts.	Arises directly from tissue or spores created by active primary infections.
Disease Spread	Initiates the disease cycle or epidemic.	Perpetuates and multiplies the epidemic rapidly in polycyclic diseases.
Management Goal	Reducing it prevents or delays the initial outbreak.	Controlling it stops the ongoing spread within the field.

Q. 47 – Write short notes on Chlorosis, Hypertrophy and wilt.

Ans: 1. Chlorosis: It is a plant condition where leaves turn pale green, yellow, or nearly white because they do not make enough chlorophyll. **Chlorophyll** is the natural green pigment that plants use to capture sunlight and make food. Without it, the plant cannot produce energy properly.

Symptoms

- **Fading color:** Leaves lose their bright green look and turn pale yellow or yellow-white.
- **Green veins:** In many cases, the main veins of the leaf stay green while the tissue between them turns yellow.
- **Stunted growth:** Leaves may become smaller, dry out at the edges, or drop off early.

Common Causes

- **Nutrient deficiencies:** A shortage of [Iron](#), magnesium, or nitrogen stops the plant from building chlorophyll.
- **High soil pH:** Alkaline or lime-rich soils lock up vital nutrients like iron so roots cannot absorb them, even if the nutrients are present in the dirt.
- **Root damage:** Overwatering, compacted dirt, or root rot prevents roots from doing their job.
- **Pests and diseases:** Viruses, fungi, or tiny bugs like spider mites can trigger yellowing.

2. Hypertrophy: Hypertrophy in plants is the abnormal or excessive enlargement of plant tissues caused by an increase in the size of individual cells rather than an increase in the number of cells.

Characteristics

- **Cell Enlargement:** Existing plant cells expand significantly by accumulating water, vacuolar contents, or synthesizing more cytoplasm and cell wall materials, without undergoing cell division (mitosis).
- **Abnormal Growths:** It frequently results in visible structural malformations, swelling, or distortions on leaves, stems, or roots.
- **Pathological Trigger:** In plant pathology, hypertrophy is usually provoked by external irritants, stress, or pests rather than normal physiological development.

Causes of Plant Hypertrophy

- **Pathogen Infection:** Attacks by fungi, bacteria, or viruses can disrupt normal hormonal balance in plant tissues.
- **Insect and Nematode Activity:** Feeding or egg-laying by insects, mites, and root-knot nematodes injects saliva or biochemicals that trigger localized cell swelling.
- **Galls and Tumors:** Pests or pathogens often force infected areas to develop abnormal spherical swellings known as plant galls, where individual cells expand to shelter or feed the organism.

3. Wilt: Wilt disease is a destructive plant condition that blocks the water-carrying vessels inside a plant.

Causes:

- **Pathogens:** It is caused by soil-borne fungi (like [Fusarium](#) and [*Verticillium*]), bacteria, or nematodes.
- **Vascular Blockage:** The microscopic organisms enter through the roots and multiply inside the xylem (water pipes), stopping moisture from reaching the leaves.

Common Symptoms

- **Drooping:** Leaves droop during the hottest part of the day and may seem to recover at night before wilting permanently.
- **Yellowing:** Lower leaves turn yellow or brown, often starting on just one side of the plant or branch.
- **Stem Discoloration:** Cutting open an infected stem reveals a dark brown or reddish streak inside the tissue.

Prevention and Control

- **No Cure:** Infected plants cannot be cured and should be pulled up and thrown away immediately.
 - **Resistant Varieties:** Planting disease-resistant seeds or plant types is the best defense.
 - **Sanitation:** Keep garden tools clean and rotate crops to reduce soil contamination.
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Q. 48 – What are facultative parasites?

Ans: A **facultative parasite** is an organism that can live and complete its life cycle independently of a host, but can also act as a parasite when a suitable host is available.

Characteristics

- **Independent Survival:** They do not rely on a host to survive or reproduce. They can live freely as saprophytes—feeding on dead or decaying organic matter in the soil or environment.
- **Opportunistic Infection:** If they encounter a living host, they can switch lifestyles to infect it and draw nutrients from it.
- **Flexibility:** Unlike obligate parasites (which die without a host), facultative parasites have a flexible mode of nutrition.

Examples in Plant Science

- **Fungi and Bacteria:** Many plant-pathogenic fungi (such as species of *Fusarium*) and bacteria are primarily saprophytic. They live off dead plant debris in the soil, but can opportunistically infect living plants when conditions favor disease.
 - **Parasitic Flowering Plants:** Some green plants, like [*Rhinanthus* \(yellow rattle\)](#), can grow and photosynthesize completely on their own, but they also act opportunistically as root parasites on neighboring green plants to boost their nutrient intake.
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Q. 49 – Define systemic disease.

Ans: Systemic diseases in plants are infections where pathogens spread throughout the entire plant system rather than staying in one local spot.

Common Causes

- **Viruses:** Pathogens like the [Tobacco Mosaic Virus](#) move cell-to-cell and travel via the vascular system.
- **Fungi:** Vascular-colonizing fungi like *Fusarium* and *Verticillium* plug water-carrying tissues.
- **Bacteria:** Certain systemic bacteria invade the xylem and phloem, causing widespread wilting.

Typical Symptoms

- **Wilting:** Loss of water pressure causes the whole plant or large branches to droop.
- **Yellowing (Chlorosis):** Leaves turn pale or yellow due to blocked nutrients or failing chloroplasts.
- **Dwarfing/Stunting:** Growth stops or slows down significantly across the entire plant.
- **Mosaic Patterns:** Mottled, uneven color appears across the foliage.

Prevention and Management

- **Use Resistant Varieties:** Choose seeds or plants bred to resist specific systemic pathogens.
 - **Sanitation:** Remove and destroy infected plant debris to stop pathogens from spreading.
 - **Control Vectors:** Manage insects like aphids that carry viruses into plant tissues.
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Q. 50 – Describe cultural, chemical and biological methods of disease control.

Ans: Cultural, chemical, and biological methods are the core approaches used in agriculture to manage plant diseases and protect crop yields.

Cultural Methods

Cultural methods involve changing standard farming practices to make the environment unfavorable for pathogens and prevent disease outbreaks.

- **Crop Rotation:** Alternating susceptible crops with non-host plants starves soil-borne pathogens and breaks their life cycles.
- **Sanitation:** Removing and destroying infected plant debris, weeds, and fallen leaves eliminates the primary sources of overwintering inoculum.
- **Deep Summer Ploughing:** Exposing the deep soil to high summer sun and heat kills resting spores, larvae, and pathogen propagules.
- **Adjusting Planting Times:** Shifting sowing or planting dates helps plants bypass the peak environmental windows when specific pathogens are most active.
- **Proper Spacing and Drainage:** Maintaining adequate plant spacing and good water drainage reduces high humidity and moisture levels that favor fungal and bacterial growth.

Chemical Methods

Chemical methods use synthetic or natural chemical compounds to directly kill, inhibit, or stop the spread of pathogens on or inside plants.

- **Fungicides and Bactericides:** Protective or systemic chemicals (such as Mancozeb or copper-based compounds) are sprayed on foliage to stop fungal spores and bacterial spots from infecting the plant tissue.
- **Seed Treatments:** Applying chemical dusts or liquid dips to seeds before planting prevents seed-borne fungal and bacterial infections during germination.
- **Soil Drenching:** Pouring chemical solutions into the soil controls root-rotting pathogens and oomycetes before they attack the root system.
- *Drawbacks:* Overusing chemicals can lead to environmental pollution, pesticide resistance in pathogens, and harm to non-target beneficial organisms.

Biological Methods

Biological methods use living beneficial organisms—such as bacteria, fungi, or nematodes—to suppress or compete against harmful pathogens.

- **Antagonistic Microorganisms:** Beneficial bacteria (like *Bacillus* species) or fungi (like *Trichoderma*) are introduced to the soil or seed coat to outcompete harmful pathogens for food and space.
 - **Hyperparasitism:** Certain beneficial fungi directly parasitize and destroy the structures of harmful disease-causing fungi.
 - **Induced Systemic Resistance (ISR):** Beneficial microbes stimulate the host plant's natural defense mechanisms, making it tougher and more resistant to subsequent infections.
 - *Advantages:* Biological controls are eco-friendly, target specific pests or diseases, and leave minimal toxic residues in the environment.
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