1. (a) Define the following terms (any five):

   - (i) **Gas vacuole:** A gas-filled, protein-bounded vesicle found in some prokaryotes, particularly cyanobacteria and some photosynthetic bacteria. They regulate buoyancy, allowing the organisms to float at optimal depths for light absorption.
   - (ii) **Heterocyst:** A specialized, thick-walled, nitrogen-fixing cell found in some filamentous cyanobacteria (e.g., *Nostoc*, *Anabaena*). They provide an anaerobic environment for the nitrogenase enzyme to fix atmospheric nitrogen into ammonia.
   - (iii) **Akinete:** A thick-walled, dormant, and resistant spore-like cell found in some filamentous cyanobacteria and green algae. They are packed with reserve food materials and help the organism survive unfavorable conditions.
   - (iv) **Cystocarp:** The complex, multicellular sporophyte stage developed after fertilization in red algae. It is typically a sac-like or spherical structure that contains carposporangia, which produce diploid carpospores. The cystocarp is borne on the female gametophyte.
   - (v) **Conceptacles:** Flask-shaped invaginations or cavities within the thallus of certain brown algae (e.g., *Fucus*, *Sargassum*) that contain and protect the reproductive organs (gametangia or sporangia). They open to the outside through an ostiole.
   - (vi) **Eye Spot (Stigma):** A small, reddish-orange, light-sensitive organelle found in the chloroplasts of many motile algae (e.g., *Chlamydomonas*, *Euglena*). It helps in phototaxis, guiding the alga towards optimal light conditions for photosynthesis.
   - (vii) **Amylum stars:** Star-shaped pyrenoids found in the chloroplasts of certain algae, particularly in members of the Zygnematales (e.g., *Spirogyra*). Pyrenoids are centers for starch synthesis and storage, and when the stored starch forms

a star shape around them, they are referred to as amylum stars.

2. (b) Fill in the blanks (any five):
   - (i) Multiflagellate zoospores are found in **Oedogonium** (or *Ectocarpus*, *Fucus*).
   - (ii) Cells in *Polysiphonia* are interconnected by **pit connections**.
   - (iii) Presence of Cap cells is the characteristic feature of **Oedogonium**.
   - (iv) Iodine is extracted from **Laminaria** or **Fucus** or **Sargassum** (Name of algae).
   - (v) **Cephaleuros** causes Rust disease of tea.
   - (vi) **Auxospores** are the characteristic spores of diatoms.
   - (vii) Rhizoids of *Chara* possess **oblique** septa.
3. (c) Name an algal genus for the following (any five):
   - (i) Hormogonium - **Nostoc** or **Oscillatoria** or **Anabaena**
   - (ii) False branching - **Scytonema** or **Tolypothrix**
   - (iii) Trichoblast - **Polysiphonia**
   - (iv) Androspore - **Oedogonium**
   - (v) Spermocarp - **Polysiphonia** (another term for cystocarp in some contexts of red algae)
   - (vi) Rolling alga - **Volvox**
   - (vii) Halophilic alga - **Dunaliella**
4. Differentiate between any three:
   - (i) Gongrosira stage and Plakea stage

- **Gongrosira stage:**
  - Refers to a specific growth form observed in certain green algae, particularly in unfavourable conditions.
  - It is characterized by the formation of an irregular, cushion-like or globose mass of cells that are highly branched and irregularly arranged.
  - These cells may be thick-walled and often appear almost parenchyma-like.
  - It is considered a temporary stage of development, often seen in algae like *Stigeoclonium* or *Trentepohlia*.
- **Plakea stage:**
  - Refers to a plate-like, discoid, or cushion-shaped multicellular thallus formed by some algae.
  - It is a more organized and typically a persistent vegetative growth form, rather than a temporary stage induced by stress.
  - Cells are usually arranged in a compact manner to form a flat, coherent sheet.
  - Commonly seen in some members of the Conjugatophyceae or in certain members of Chlorophyceae, such as *Coleochaete* (where the thallus is truly discoid and forms a compact cushion).

- (ii) Oogamy and Isogamy
  - **Oogamy:**

        - A type of sexual reproduction where the fusing gametes are distinctly different in size, morphology, and motility.
        - The female gamete (egg or ovum) is typically large, non-motile, and rich in stored food.
        - The male gamete (sperm or antherozoid) is small, motile (usually flagellated), and produced in large numbers.
        - Fertilization involves the fusion of a small, motile male gamete with a large, non-motile female gamete.
        - Examples: *Volvox*, *Oedogonium*, *Chara*, *Fucus*, and most higher plants and animals.
    - **Isogamy:**
        - A type of sexual reproduction where the fusing gametes are morphologically and physiologically identical (similar in size, shape, and motility).
        - It is difficult to distinguish male and female gametes based on appearance.
        - Often, both fusing gametes are motile (e.g., flagellated).
        - Examples: *Ulothrix*, some species of *Chlamydomonas*.
- (iii) Unilocular sporangia and Plurilocular sporangia
    - **Unilocular Sporangia:**
        - Single-chambered sporangia found in some brown algae (e.g., *Ectocarpus*, *Fucus*).

- All the nuclei within the single chamber undergo meiosis to produce numerous haploid zoospores (meiospores).
- These zoospores are typically involved in asexual reproduction or can develop into gametophytes in species with alternation of generations.
- They represent the meiotic phase of the life cycle.

- **Plurilocular Sporangia:**
  - Multichambered (multilocular) sporangia found in some brown algae (e.g., *Ectocarpus*).
  - Each chamber (locule) contains a small number of diploid cells that undergo mitosis to produce numerous diploid zoospores (mitospores).
  - These zoospores are involved in asexual reproduction (clonal propagation) or can function as gametes (isogametes) in some species.
  - They represent the mitotic phase of the life cycle or produce gametes in isomorphic alternation of generations.

- (iv) Cyanophyceae and Rhodophyceae
  - **Cyanophyceae (Blue-green algae / Cyanobacteria):**
    - **Cell Type:** Prokaryotic (lack a true nucleus, membrane-bound organelles).
    - **Photosynthetic Pigments:** Chlorophyll a, phycocyanin, phycoerythrin (giving them blue-green to reddish hues), carotenoids.
    - **Reserve Food Material:** Cyanophycean starch and cyanophycin granules (protein).

- **Cell Wall:** Peptidoglycan (murein) layer, similar to Gram-negative bacteria.
- **Motility:** Non-motile, but some exhibit gliding movement. Lack flagella.
- **Reproduction:** Primarily asexual (fragmentation, fission, hormogonia, akinetes, heterocysts). Sexual reproduction is absent.
- **Habitat:** Diverse, found in freshwater, marine, and terrestrial environments; often pioneer organisms.

▪ **Rhodophyceae (Red Algae):**

- **Cell Type:** Eukaryotic (possess a true nucleus and membrane-bound organelles).
- **Photosynthetic Pigments:** Chlorophyll a, phycobilins (phycoerythrin predominates, giving red color), phycocyanin, carotenoids. Chlorophyll b is absent.
- **Reserve Food Material:** Floridean starch (a type of starch similar to glycogen).
- **Cell Wall:** Cellulose and phycocolloids (agar, carrageenan).
- **Motility:** Completely lack flagella in all life stages (unique among eukaryotic algae).
- **Reproduction:** Complex life cycles involving sexual (oogamous) and asexual reproduction; often triphasic (gametophyte, carposporophyte, tetrasporophyte).
- **Habitat:** Predominantly marine, especially in deeper waters where red light penetrates.

- (v) Nannandrous and Macrandrous species of Oedogonium
    - **Nannandrous species of *Oedogonium*:**
        - Characterized by the presence of small, dwarf male filaments called "nannandria" or "dwarf males."
        - These nannandria develop from androspores (specialized asexual spores) and are typically attached to or grow near the oogonia (female gametangia).
        - Each nannandrium produces a few antherozoids.
        - This represents a specialized form of sexual reproduction where the male gametophyte is highly reduced and dependent, resembling a parasitic relationship.
    - **Macrandrous species of *Oedogonium*:**
        - Characterized by the presence of normal-sized male filaments, which are comparable in size to the female filaments or vegetative filaments.
        - These male filaments bear antheridia (male gametangia), which produce antherozoids.
        - There is no specialized dwarf male filament in these species.
        - Sexual reproduction involves fusion of gametes from normal-sized male and female filaments.

5. Write short notes on the following (any three):
    - (i) **Evolutionary significance of Prochloron**
        - *Prochloron* is a genus of unicellular cyanobacteria that holds significant evolutionary interest due to its unique

pigment composition. Unlike typical cyanobacteria that contain chlorophyll *a* and phycobilins, *Prochloron* contains both chlorophyll *a* and chlorophyll *b*, but lacks phycobilins. This pigment combination is characteristic of green algae and higher plants.

- **Evolutionary Significance:**
  - **Endosymbiotic Theory:** *Prochloron*'s pigment composition strongly supports the endosymbiotic theory, which proposes that chloroplasts in green algae and plants originated from an ancient cyanobacterium living symbiotically within a eukaryotic host cell. The presence of chlorophyll *a* and *b* in *Prochloron* suggests it (or a close ancestor) could be a direct descendant or a close relative of the prokaryotic ancestor that gave rise to plant chloroplasts.
  - **Phylogenetic Link:** It serves as a living example of a potential evolutionary link between simple prokaryotic photosynthetic organisms and the more complex eukaryotic photosynthetic organisms.
  - **Alternative Photosynthetic Pathway:** It demonstrates an alternative photosynthetic strategy within the cyanobacteria, highlighting the diversity of early photosynthetic life.
  - **Loss of Phycobilins:** The absence of phycobilins in *Prochloron*, which are common accessory pigments in most cyanobacteria, suggests a loss or reduction of these pigments during its evolution, possibly adapting to specific light environments (e.g., high light conditions where phycobilins might be photoprotective but not essential for light harvesting).

    - While not directly the ancestor, *Prochloron* provides crucial insights into the evolutionary pathway of photosynthesis and the origin of plant life.

- (ii) **Sexual reproduction in Chara**
    - *Chara* is a highly evolved freshwater green alga belonging to the Charophyceae, a group considered to be the closest living relatives to land plants. Its sexual reproduction is highly advanced and oogamous, showing distinct male and female reproductive structures.
    - **Reproductive Structures:**
        - *Chara* is monoecious (both male and female organs on the same plant) or dioecious (separate male and female plants).
        - **Male sex organ (Antheridium / Globule):** A spherical, red-orange colored structure found at the nodes of the short lateral branches. It has a complex organization with an outer layer of 8 shield cells, which enclose the manubria (stalks) that bear filaments. These filaments produce numerous biflagellate antherozoids (sperms).
        - **Female sex organ (Oogonium / Nucule):** An oval-shaped structure located above the antheridium (in monoecious species) or at the nodes of female plants. It is covered by 5 spirally twisted tube cells that terminate in 5 crown cells (coronula). Inside, it contains a single large egg cell.
    - **Process of Fertilization:**
        - **Water Requirement:** Like bryophytes, *Chara* requires water for fertilization.

- **Antherozoid Release:** When mature, the shield cells of the globule separate, allowing the antherozoids to be released into the surrounding water.
- **Egg Protection:** The spiral tube cells of the nucule slightly untwist and separate at the apex, forming a small opening through which the antherozoids can enter to reach the egg.
- **Syngamy:** A single biflagellate antherozoid fuses with the egg cell, forming a diploid zygote.
- **Oospore Formation:** The zygote develops a thick, resistant wall, forming an oospore. This oospore is a resting spore that can survive unfavorable conditions.
- **Germination:** Upon favorable conditions, the oospore germinates by meiosis, producing a haploid protonema that develops into a new *Chara* plant.

- The complex, multicellular sex organs and oogamous reproduction in *Chara* are considered homologous to those in land plants, highlighting its evolutionary importance as a link to higher plant evolution.

- (iii) **Significant contribution of F.E. Fritsch and M.O.P. Iyengar**

  - **F.E. Fritsch (Felix Eugen Fritsch, 1879-1954):**
    - A prominent British phycologist renowned for his monumental work "The Structure and Reproduction of the Algae," published in two volumes (1935, 1945).
    - **Contribution:**

- **Comprehensive Classification:** Fritsch provided a highly detailed and influential classification system for algae, based primarily on their morphological, anatomical, and reproductive features. His system became the standard for many decades and profoundly influenced phycological studies worldwide.
- **Morphological Diversity:** He thoroughly documented the vast range of thallus organization in algae, from unicellular forms to complex parenchymatous structures.
- **Reproductive Biology:** His work extensively covered the diverse modes of reproduction (asexual and sexual) across different algal groups.
- **Textbook Standard:** His book served as the definitive textbook for phycology, synthesizing a vast amount of existing knowledge and providing a framework for future research. It is still considered a foundational text.
- **Physiological Insights:** While focused on morphology, he also integrated physiological aspects, such as the roles of pigments and storage products, into his understanding of algal biology.

- Fritsch's work provided the most comprehensive and authoritative account of algal form and function of his time, shaping the discipline of phycology.

- **M.O.P. Iyengar (Mandayam Osuri Parthasarathy Iyengar, 1886-1963):**

- Often hailed as the "Father of Indian Phycology," Iyengar was a pioneering Indian botanist and phycologist who made immense contributions to the study of algae in India.
- **Contribution:**
  - **Discovery of New Algal Forms:** He extensively explored diverse algal habitats across India, leading to the discovery and description of numerous new genera and species, particularly from freshwater environments. His findings significantly expanded the knowledge of Indian algal flora.
  - **Detailed Morphological Studies:** He was known for his meticulous and precise studies of algal morphology, reproduction, and life cycles, often publishing detailed illustrations.
  - **Emphasis on South Indian Algae:** He focused particularly on the rich algal diversity of South India, including forms from rice fields, stagnant waters, and specialized habitats.
  - **Mentorship and School of Phycology:** Iyengar established a thriving school of phycology at the University of Madras, guiding many students who later became prominent phycologists themselves. His influence helped build a strong foundation for phycological research in India.
  - **Pioneering Research:** His work on the life cycles of unusual and endemic algal species (e.g., members of the Zygnematales, such as

Oedogonium and *Coleochaete*) was particularly insightful.

- Iyengar's dedication to field collection, rigorous taxonomic description, and his role as a mentor were instrumental in establishing phycology as a significant botanical discipline in India.

- (iv) **Bioluminescence in algae**
  - Bioluminescence is the production and emission of light by a living organism as a result of a chemical reaction. In algae, this phenomenon is primarily observed in certain marine **dinoflagellates** (e.g., *Noctiluca scintillans*, *Gonyaulax polyedra*, *Pyrocystis*).
  - **Mechanism:**
    - The light is typically produced by an enzyme-catalyzed reaction involving a luciferin (light-emitting pigment) and luciferase (enzyme). In dinoflagellates, the luciferin is a chlorophyll-derived compound, and the luciferase is activated by a sudden change in pH when stimulated.
    - The reaction is triggered by mechanical disturbance (e.g., waves, ship movement, fish swimming) or stress.
    - The light emission is a brief flash, not a continuous glow.
  - **Ecological Significance:**
    - **Defense Mechanism:** The most widely accepted hypothesis for dinoflagellate bioluminescence is as a "burglar alarm" defense. When a predator (e.g., copepod) grazes on bioluminescent dinoflagellates, the flashes attract a secondary predator (e.g., fish)

that preys on the primary grazer. This deters the initial grazer from consuming the dinoflagellates.

- **Predator Avoidance:** The sudden flash may startle or distract a predator, allowing the dinoflagellate to escape.
- **Communication/Aggregation:** While less clear, some theories suggest it might play a role in communication or promoting aggregation in certain species.

- **Impact on Humans:**
    - **Red Tides/Harmful Algal Blooms:** During blooms (high concentrations) of bioluminescent dinoflagellates, the ocean surface can appear to glow at night, particularly when disturbed. These "red tides" or "sea sparkle" events, while often visually spectacular, can also be harmful algal blooms if the dinoflagellates produce toxins.
    - **Navigational Hazard (Historically):** Intense bioluminescence could sometimes obscure visibility for sailors in historical contexts.
- Bioluminescence in algae is a fascinating example of how organisms have evolved complex chemical processes for survival and interaction within their marine ecosystems.

- (v) **Palmella stage in Chlamydomonas**
    - The Palmella stage is a temporary, asexual, and non-motile colonial aggregation of cells observed in certain green algae, most notably *Chlamydomonas* (a typically unicellular, biflagellate alga), under unfavorable environmental conditions.

- **Conditions for Formation:** This stage is induced by environmental stress factors such as:
  - Scarcity of water (drought conditions)
  - High salt concentration
  - Lack of nutrients
  - Accumulation of metabolic waste products
  - Unsuitable pH or temperature.
- **Characteristics of the Palmella Stage:**
  - **Loss of Flagella:** The motile *Chlamydomonas* cells lose their flagella.
  - **Repeated Cell Divisions:** The cells undergo repeated mitotic divisions.
  - **Mucilaginous Envelope:** The daughter cells, instead of separating and developing flagella, remain embedded within the gelatinous matrix of the mother cell wall, which swells and becomes mucilaginous. This forms an amorphous, irregular colony.
  - **Non-motile:** The entire colony is non-motile, as individual cells do not develop flagella.
  - **Survival Strategy:** This stage acts as a survival mechanism, protecting the cells from harsh conditions. The mucilaginous sheath helps retain moisture and provides a protective barrier.
- **Reversion:** When favorable conditions return (e.g., water becomes available), the individual cells within the Palmella matrix develop flagella, become motile

zoospores, and are released from the mucilaginous mass, reverting to their normal motile unicellular form.

- **Significance:** The Palmella stage illustrates the phenotypic plasticity of *Chlamydomonas* in response to environmental cues and highlights a simple colonial organization that might represent an evolutionary precursor to more complex colonial and filamentous forms in algae.

6. Draw well-labelled diagrams of the following (any three):
    - (i) V.S. bisexual conceptacle of Sargassum
        - (The diagram would show a longitudinal section of a conceptacle embedded in the receptacle. It would be a flask-shaped cavity opening via an ostiole. Inside, it would show branched paraphyses and both antheridia (male gametangia) and oogonia (female gametangia). The antheridia would be smaller, borne on branched filaments, while the oogonia would be larger, typically stalked, each containing a single egg.)
    - (ii) Discoid thallus of Coleochaete
        - (The diagram would show a circular or irregularly rounded, flattened, disc-shaped thallus, typically one cell thick. It would be composed of radiating filaments of cells. In some species, setae (hair-like projections with a basal sheath) might be visible.)
    - (iii) E.M. of Heterocyst
        - (The diagram would show a thick-walled, larger cell embedded in a filament of vegetative cells. Key features would include: thickened cell wall (especially at the poles), absence of photosynthetic thylakoids (or highly reduced ones) in the central region, presence of polar

nodules (connection to vegetative cells), and granular cytoplasm containing nitrogenase enzyme.)

- (iv) W.M. of cystocarp of Polysiphonia / Gracillaria
  - (The diagram would show the cystocarp as a spherical or urn-shaped structure developed on the female gametophyte thallus. It would be surrounded by a protective pericarp. Inside the pericarp, a central gonimoblast filament would be visible, bearing numerous club-shaped carposporangia, each containing a single carpospore.)
- (v) E.M. of Chlamydomonas / Chlorella
  - (The diagram for *Chlamydomonas* would show a pear-shaped cell with two anterior flagella, an eye spot, a large cup-shaped chloroplast containing a pyrenoid, a nucleus, contractile vacuoles, and mitochondria. The cell wall would also be shown. For *Chlorella*, it would be a spherical or ovoid cell with a prominent cup-shaped or parietal chloroplast, a central nucleus, and storage granules, but no flagella or eye spot.)

7. (i) Explain the alternation of generation and its significance in *Ectocarpus*.
   - **Alternation of Generation:**
     - Alternation of generation is a type of life cycle that involves the alternation between two distinct multicellular forms: a haploid **gametophyte** generation and a diploid **sporophyte** generation. Each generation produces the other.
     - **Gametophyte:** This is the haploid (n) generation that produces gametes (sex cells) by mitosis. When two

gametes fuse (fertilization), they form a diploid zygote, which develops into the sporophyte.

- **Sporophyte:** This is the diploid (2n) generation that produces spores by meiosis. These haploid spores germinate to produce the gametophyte.
- This life cycle ensures both sexual reproduction (leading to genetic variation through meiosis and fertilization) and asexual propagation (through spores), allowing for both adaptability and efficient multiplication.

- **Alternation of Generation in *Ectocarpus* (Isomorphic Alternation):**
  - *Ectocarpus* (a brown alga) typically exhibits **isomorphic alternation of generations**, meaning that both the sporophyte and gametophyte generations are morphologically similar (look alike) but differ in their ploidy level and reproductive structures.
  - **1. Sporophytic Generation (Diploid, 2n):**
    - The diploid sporophyte is a branched, filamentous thallus.
    - It bears two types of sporangia:
      - **Unilocular Sporangia:** These are single-chambered, oval structures. Inside, the diploid cells undergo **meiosis** to produce numerous haploid (n) zoospores (meiospores). These zoospores are motile and biflagellate. When they settle, they germinate directly to form the haploid gametophytes.
      - **Plurilocular Sporangia:** These are multicellular, elongated structures divided into many small compartments (locules). The

diploid cells within these locules undergo **mitosis** to produce diploid (2n) zoospores (mitospores). These mitospores can germinate directly to form new diploid sporophytes (asexual reproduction), or they can develop into gametophytes under certain conditions.

- **2. Gametophytic Generation (Haploid, n):**
  - The haploid gametophyte is also a branched, filamentous thallus, morphologically identical to the sporophyte.
  - It bears **plurilocular gametangia**, which are multicellular structures similar to plurilocular sporangia.
  - Inside these gametangia, haploid cells undergo **mitosis** to produce numerous haploid (n) isogametes (gametes that are morphologically similar, though physiological differences might exist, leading to male and female classification).
  - **Fertilization:** Two isogametes from different gametophytes (or sometimes from the same) fuse to form a diploid (2n) zygote.
  - The zygote then germinates and develops into a new diploid sporophyte, completing the cycle.

- **Significance in *Ectocarpus*:**
  - **Genetic Diversity:** The meiotic process in unilocular sporangia generates haploid zoospores, which develop into gametophytes. The subsequent fusion of gametes (fertilization) during sexual reproduction ensures genetic

recombination and introduces variation in the population. This is crucial for adaptation to changing environments.

- **Efficient Propagation:** The presence of plurilocular sporangia allows the sporophyte to produce diploid mitospores mitotically. These can directly develop into new sporophytes, enabling rapid asexual propagation and colonization of new areas under favorable conditions without the need for gamete fusion. This allows for quick population increase.
- **Adaptation to Environment:** The alternation between genetically variable (sexual) and clonally reproducing (asexual) phases provides flexibility. Sexual reproduction helps in long-term adaptation and survival in unstable environments, while asexual reproduction facilitates rapid expansion in stable, favourable conditions.
- **Maintenance of Ploidy Levels:** The cycle meticulously balances the haploid and diploid phases through meiosis and fertilization, ensuring the stability of the chromosome number across generations.
- **Isomorphism:** The isomorphic nature (sporophyte and gametophyte look alike) suggests an evolutionary strategy where both generations are equally adapted to their environment, maximizing survival and reproductive potential in both haploid and diploid states. This is considered a primitive form of alternation of generations among brown algae.

8. (ii) Discuss the range of thallus organization in algae.

   - Algae exhibit an astonishing diversity in their thallus (body) organization, ranging from simple microscopic unicells to large, complex macroscopic forms. This wide range reflects their evolutionary history and adaptation to various aquatic and terrestrial environments.

- **1. Unicellular Forms:**
  - These are the simplest forms, consisting of a single cell that performs all life functions.
  - **Motile:** Possess flagella for movement. (e.g., *Chlamydomonas*, *Euglena*, *Chlorella* (non-motile but unicellular)).
  - **Non-motile:** Lack flagella. (e.g., Diatoms, some *Chlorella* species).
  - **Amoeboid:** Some unicells can change shape and move by pseudopodia (e.g., some Chrysophyceae).
- **2. Colonial Forms:**
  - Consist of aggregates of cells living together in a loose association. Cells may or may not be permanently attached or organized.
  - **Motile Colonies:** Cells are flagellated and arranged in a definite shape, moving as a coordinated unit. (e.g., *Volvox* - a highly organized coenobium where cells are interconnected by cytoplasmic strands and show division of labor; *Pandorina*, *Eudorina* - simpler motile colonies).
  - **Non-motile Colonies:** Cells are embedded in a mucilaginous matrix, forming an irregular mass. Individual cells may retain their flagella or lose them. (e.g., *Tetraspora*, **Palmella stage** of *Chlamydomonas*).
  - **Dendroid Colonies:** Cells are arranged in a tree-like branching pattern. (e.g., *Ecballocystis*).
- **3. Filamentous Forms:**

- Cells are arranged end-to-end to form a thread-like structure (filament).
- **Unbranched Filaments:** Simple chains of cells. (e.g., *Ulothrix*, *Spirogyra*, *Oscillatoria*).
- **Branched Filaments:** Filaments that show branching patterns.
    - **True Branching:** Due to cell division in more than one plane from a single cell. (e.g., *Cladophora*, *Stigeoclonium*, *Chara* - complex branching with nodes and internodes; *Scytonema* - true branching in cyanobacteria).
    - **False Branching:** Occurs when a filament breaks and the ends grow out through the sheath, giving the appearance of branching. (e.g., *Nostoc*, *Tolypothrix* in cyanobacteria).
- **Heterotrichous Filaments:** Show both prostrate (creeping) and erect (upright) systems of filaments. This represents an advanced filamentous organization. (e.g., *Ectocarpus*, *Coleochaete*, *Stigeoclonium*).

- **4. Siphonaceous (Coenocytic) Forms:**
    - The thallus is an aseptate, multinucleate tube or sac, lacking cross walls (coenocytic). The entire thallus is essentially a single giant cell.
    - **Branched:** (e.g., *Vaucheria*, *Codium*).
    - **Unbranched:** (e.g., *Botrydium*).
- **5. Parenchymatous Forms:**
    - The thallus is composed of cells that divide in multiple planes, forming a compact, three-dimensional tissue-like structure. These are the most complex algal forms.

        - **Sheet-like/Blade-like:** (e.g., *Ulva* (sea lettuce) - two cells thick; *Porphyra* - one cell thick).
        - **Complex Body:** Large, differentiated thalli resembling higher plants, with holdfasts, stipes, and blades. (e.g., *Laminaria*, *Fucus*, *Sargassum* - brown algae with complex differentiation).
        - **Branched Multiaxial/Uniaxial:** Red algae like *Polysiphonia* have a central filament surrounded by pericentral cells, giving a pseudoparenchymatous appearance, though their development is filamentous.
    - This wide range of thallus organization reflects the adaptive radiation of algae in diverse aquatic environments, enabling them to occupy various niches from microscopic plankton to macroscopic, kelp forest-forming organisms.

9. **OR**
    - Explain the reproduction in *Nostoc*? Highlight its ecological and economic importance.
    - **Reproduction in *Nostoc*:**
        - *Nostoc* is a genus of filamentous cyanobacteria, characterized by bead-like cells forming unbranched or falsely branched filaments embedded in a mucilaginous sheath, often forming macroscopic colonies (balls or sheets). Its reproduction is primarily asexual. Sexual reproduction is absent in cyanobacteria.
        - **1. Fragmentation:**
            - The most common method of vegetative reproduction. The main filament breaks into smaller fragments, each of which can grow into a new *Nostoc* colony. This fragmentation can be

accidental or facilitated by the death of intercalary cells.

- **2. Hormogonia Formation:**
  - Hormogonia are short, motile fragments of the vegetative filament, typically consisting of a few cells.
  - They are formed when the filament breaks at specific points (e.g., near heterocysts or dead cells).
  - Hormogonia are capable of gliding motility and can move away from the parent colony to establish new colonies when they find suitable conditions. This is an important dispersal mechanism.
- **3. Akinete Formation:**
  - Akinetes are specialized, thick-walled, dormant resting spores.
  - They are larger than vegetative cells and packed with reserve food materials (e.g., cyanophycin, glycogen).
  - Akinetes are formed under unfavorable conditions (e.g., nutrient depletion, desiccation, temperature extremes) and can survive for long periods.
  - When conditions become favorable again, akinetes germinate to produce new vegetative filaments.
- **4. Heterocyst Formation (Indirectly for Reproduction):**
  - Heterocysts are specialized, thick-walled cells involved in nitrogen fixation, not directly in reproduction, but they are crucial for the survival and growth of the colony.

- They can serve as points of fragmentation for hormogonia.
- Their ability to fix nitrogen supports the growth of the entire colony, thereby contributing to the perpetuation of the species.

- **Ecological and Economic Importance of *Nostoc*:**
  - **Ecological Importance:**
    - **Nitrogen Fixation:** This is the most significant ecological role. *Nostoc* possesses heterocysts, which are specialized cells capable of fixing atmospheric nitrogen (N_2) into ammonia (NH_3), a form usable by plants. This process enriches the nitrogen content of the soil and water, making *Nostoc* a vital component of nutrient cycling in various ecosystems, particularly in rice paddies and barren lands.
    - **Soil Fertility:** By fixing nitrogen, *Nostoc* contributes significantly to soil fertility, especially in nitrogen-poor soils. This reduces the need for synthetic nitrogen fertilizers in agriculture.
    - **Pioneer Organisms:** *Nostoc* species can colonize harsh environments, such as newly exposed rock surfaces, deserts, or volcanic ash. Their ability to fix nitrogen and form mucilaginous sheaths allows them to establish and contribute to soil formation and primary succession.
    - **Biofertilizer:** Used as a natural biofertilizer in paddy fields in many parts of the world, providing a sustainable and eco-friendly alternative to chemical fertilizers.

- **Food Source in Ecosystems:** They can serve as a food source for aquatic invertebrates and other organisms.
- **Moisture Retention:** The mucilaginous sheath of *Nostoc* colonies helps in retaining moisture in soil, particularly in dry conditions.

▪ **Economic Importance:**

- **Food Source:** In some cultures, particularly in East Asia (e.g., China, Japan) and South America, certain *Nostoc* species (e.g., *Nostoc commune* or "fat choy") are consumed as food, providing protein, vitamins, and minerals.
- **Biofertilizer:** As mentioned, *Nostoc* is widely used as a natural biofertilizer in agriculture, especially for rice cultivation. This is economically beneficial as it reduces the cost of synthetic fertilizers and promotes sustainable farming practices.
- **Medicinal Potential:** Research is ongoing into the potential pharmaceutical applications of *Nostoc* extracts. They have been found to contain various bioactive compounds with antioxidant, anti-inflammatory, antiviral, and even anticancer properties.
- **Bioremediation:** Some *Nostoc* species show potential in bioremediation efforts, such as removing heavy metals or other pollutants from contaminated water bodies due to their ability to absorb or bind these substances.
- **Research Model:** *Nostoc* serves as a model organism for studying nitrogen fixation,

photosynthetic processes, and cellular differentiation in prokaryotes.

- **Biodiesel Production (Potential):** Like other algae, some *Nostoc* species contain lipids and could potentially be used for biodiesel production, though this is still largely in research stages.

- In summary, *Nostoc* plays a crucial role in global nitrogen cycling and offers various benefits, particularly in sustainable agriculture and potential biotechnological applications, despite being a simple cyanobacterium.