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PLANT KINGDOM

Short Note for UG NEET Examination

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- Whittaker's classification system proposed the Five Kingdom classification: Monera, Protista, Fungi, Animalia, and Plantae.
- Fungi, Monera, and Protista with cell walls were initially classified under Plantae but are now excluded from the plant kingdom.
- Cyanobacteria, previously known as blue-green algae, are no longer considered algae.
- Classification within the plant kingdom includes Algae, Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.
- Early classification systems relied on superficial morphological characters, such as habit, color, and leaf characteristics.
- Artificial systems based on a few characteristics often separated closely related species.
- Natural classification systems consider natural affinities among organisms and include external and internal features such as ultrastructure, anatomy, embryology, and phytochemistry.
- George Bentham and Joseph Dalton Hooker developed a natural classification system for flowering plants.
- Phylogenetic classification systems based on evolutionary relationships between organisms are currently accepted.

- These systems assume that organisms within the same taxa share a common ancestor.
- Additional sources of information are used to aid classification when fossil evidence is lacking.
- Numerical Taxonomy, facilitated by computers, involves assigning numbers and codes to observable characteristics and processing the data.
- This approach ensures equal importance is given to each character and allows for the consideration of hundreds of characters.
- Cytotaxonomy utilizes cytological information such as chromosome number, structure, behavior to aid in classification.
- Chemotaxonomy employs chemical constituents of plants to resolve classification uncertainties.
- These approaches are used by taxonomists to enhance classification accuracy and understanding.

ALGAE

- Algae are chlorophyll-bearing, simple, thalloid, autotrophic, and mostly aquatic organisms.
- They can be found in various habitats including water (freshwater and marine), moist stones, soils, and wood.
- Some algae have associations with fungi (lichen) and animals (e.g., on sloth bears).

- Algae exhibit a wide range of forms and sizes, from colonial forms like Volvox to filamentous forms like Ulothrix and Spirogyra. Some marine algae, such as kelps, form massive plant bodies.
- Algae reproduce through vegetative, asexual, and sexual methods.
- Vegetative reproduction occurs through fragmentation, where each fragment develops into a thallus.
- Asexual reproduction involves the production of different types of spores, with zoospores being the most common. Zoospores are flagellated and give rise to new plants upon germination.
- Sexual reproduction involves the fusion of two gametes. Gametes can be flagellated and similar in size (isogamous) or non-flagellated but similar in size (as in Spirogyra). In some cases, fusion occurs between dissimilar-sized gametes (anisogamous), and in others, fusion happens between a large, non-motile female gamete and a smaller, motile male gamete (oogamous).
- Algae play a crucial role in the ecosystem and are beneficial to humans in various ways.
- They contribute significantly to carbon dioxide fixation and the production of oxygen through photosynthesis.

- Algae serve as primary producers of energy-rich compounds, forming the basis of food cycles in aquatic ecosystems.
- Several species of marine algae, including Porphyra, Laminaria, and Sargassum, are used as food.
- Certain algae produce hydrocolloids like algin (from brown algae) and carrageenan (from red algae), which have commercial applications as water holding substances.
- Agar, obtained from Gelidium and Gracilaria algae, is used in microbiology, ice-creams, and jellies.
- Chlorella, a protein-rich unicellular alga, is used as a food supplement, even by space travelers.
- Algae are classified into three main classes: Chlorophyceae (green algae), Phaeophyceae (brown algae), and Rhodophyceae (red algae).

CHLOROPHYCEAE

- Chlorophyceae are commonly known as green algae.
- Plant body can be unicellular, colonial, or filamentous.
- Green algae are typically grass green due to the dominance of chlorophyll a and b pigments.
- Chloroplasts in green algae can have various shapes, such as discoid, plate-like, reticulate, cup-shaped, spiral, or ribbon-shaped.

- Many green algae have pyrenoids, storage bodies within chloroplasts containing protein and starch.
- Some green algae store food in the form of oil droplets.
- Green algae have a rigid cell wall consisting of an inner layer of cellulose and an outer layer of pectose.
- Vegetative reproduction occurs through fragmentation or the formation of different types of spores.
- Asexual reproduction involves flagellated zoospores produced in zoosporangia.
- Sexual reproduction in green algae can be isogamous, anisogamous, or oogamous.
- Commonly found green algae include Chlamydomonas, Volvox, Ulothrix, Spirogyra, and Chara.

PHAEOPHYCEAE

- Phaeophyceae or brown algae are primarily found in marine habitats.
- Brown algae exhibit a wide range of sizes and forms, from simple branched, filamentous forms to large kelps that can reach heights of 100 meters.
- They contain chlorophyll a, c, carotenoids, and xanthophylls.

- Brown algae vary in color from olive green to various shades of brown, depending on the amount of the xanthophyll pigment, fucoxanthin.
- Food is stored as complex carbohydrates, such as laminarin or mannitol.
- Vegetative cells have a cellulosic wall covered by a gelatinous coating of algin.
- Protoplasts contain plastids, a centrally located vacuole, and a nucleus.
- The plant body of brown algae is usually attached to the substratum by a holdfast and consists of a stalk (stipe) and leaf-like photosynthetic organ (frond).
- Vegetative reproduction occurs through fragmentation.
- Asexual reproduction in most brown algae involves biflagellate zoospores with two unequal laterally attached flagella.
- Sexual reproduction in brown algae can be isogamous, anisogamous, or oogamous.
- Gamete union may occur in water or within the oogonium in oogamous species.
- Gametes in brown algae are pyriform (pear-shaped) and bear two laterally attached flagella.
- Common examples of brown algae include Ectocarpus, Dictyota, Laminaria, Sargassum, and Fucus.

RHODOPHYCEAE

- Rhodophyceae or red algae are named so due to the predominance of the red pigment, r-phycoerythrin, in their body.
- Most red algae are found in marine environments, with higher concentrations in warmer areas.
- They inhabit well-lit regions close to the water surface as well as deep ocean areas with limited light penetration.
- Red algae generally have multicellular thalli, and some exhibit complex body organization.
- Food is stored as floridean starch, which is structurally similar to amylopectin and glycogen.
- Vegetative reproduction in red algae occurs through fragmentation.
- Asexual reproduction involves non-motile spores.
- Sexual reproduction in red algae is oogamous and accompanied by complex post-fertilization developments.
- Common examples of red algae include Polysiphonia, Porphyra, Gracilaria, and Gelidium.
- Chlorophyceae (Green Algae):
    - Chlorophyll pigments: a, b
    - Major stored food: Starch

- Cell wall: Cellulose
- Flagella: 2-8, equal, apical insertions
- Habitat: Fresh water, brackish water, saltwater

- Phaeophyceae (Brown Algae):
  - Chlorophyll pigments: a, c, fucoxanthin
  - Major stored food: Mannitol, laminarin, and algin
  - Cell wall: Cellulose
  - Flagella: 2, unequal, lateral (rare)
  - Habitat: Freshwater, brackish water, saltwater

- Rhodophyceae (Red Algae):
  - Chlorophyll pigments: a, d, phycoerythrin
  - Major stored food: Floridean starch
  - Cell wall: Cellulose, pectin, and poly sulfate esters (some)
  - Flagella: Absent
  - Habitat: Freshwater, brackish water, saltwater (most)

BRYOPHYTES

- Bryophytes include mosses and liverworts commonly found in moist shaded areas.
- Bryophytes are called amphibians of the plant kingdom because they can live in soil but depend on water for sexual reproduction.
- They thrive in damp, humid, and shaded environments and play a crucial role in plant succession on bare rocks/soil.
- The plant body of bryophytes is more differentiated than that of algae, with a thallus-like and prostrate or erect structure.
- Bryophytes lack true roots, stems, or leaves but may have root-like, leaf-like, or stem-like structures.
- The main plant body of bryophytes is haploid and called a gametophyte, which produces gametes.
- Bryophytes have multicellular sex organs, with an antheridium being the male sex organ that produces biflagellate antherozoids, and an archegonium being the female sex organ that produces a single egg.
- Fertilization occurs when an antherozoid fuses with the egg in water, forming a zygote.
- The zygote develops into a sporophyte, which remains attached to the gametophyte and derives nourishment from it.

- Some cells of the sporophyte undergo meiosis, producing haploid spores.
- The spores germinate and give rise to a new gametophyte.
- Bryophytes have limited economic importance, but some mosses provide food for animals and species like Sphagnum moss are used as fuel and packing material due to their water-holding capacity.
- Mosses and lichens are the first organisms to colonize rocks and play a crucial ecological role in decomposing rocks and preventing soil erosion.
- Bryophytes are divided into liverworts and mosses.

LIVERWORTS

- Liverworts typically grow in moist, shady habitats such as stream banks, marshy ground, damp soil, bark of trees, and deep in the woods.
- The plant body of a liverwort is thalloid, as seen in species like Marchantia.
- The thallus of liverworts is dorsiventral and closely pressed against the substrate.
- Leafy liverworts have small leaf-like appendages arranged in two rows on stem-like structures.
- Asexual reproduction in liverworts occurs through thallus fragmentation or the formation of specialized structures called gemmae.

- Gemmae are multicellular, asexual buds that develop in gemma cups on the thalli. They detach from the parent body and germinate to give rise to new individuals.
- Liverworts exhibit sexual reproduction, with male and female sex organs produced on the same or different thalli.
- The sporophyte generation of liverworts is differentiated into a foot, seta, and capsule.
- Meiosis takes place within the capsule, producing spores.
- These spores germinate to form free-living gametophytes, completing the life cycle of liverworts.

MOSSES

- The gametophyte stage is the predominant stage in the life cycle of mosses.
- The first stage of the gametophyte is the protonema, which develops directly from a spore.
- The protonema is a creeping, green, branched, and filamentous stage.
- The second stage of the gametophyte is the leafy stage, which develops from the secondary protonema as a lateral bud.
- The leafy stage consists of upright, slender axes with spirally arranged leaves.

- Mosses are attached to the soil through multicellular and branched rhizoids.
- The leafy stage of the gametophyte bears the sex organs, namely antheridia and archegonia.
- Vegetative reproduction in mosses occurs through fragmentation and budding in the secondary protonema.
- Sexual reproduction in mosses involves the production of antheridia and archegonia at the apex of the leafy shoots.
- After fertilization, the zygote develops into a sporophyte, consisting of a foot, seta, and capsule.
- The sporophyte of mosses is more elaborate than that of liverworts.
- The capsule of the sporophyte contains spores, which are formed after meiosis.
- Mosses have an elaborate mechanism for spore dispersal.
- Common examples of mosses include Funaria, Polytrichum, and Sphagnum.

PTERIDOPHYTES

- Pteridophytes include horsetails and ferns.
- They are used for medicinal purposes and as soil-binders, and are commonly grown as ornamentals.

- Pteridophytes are the first terrestrial plants to possess vascular tissues, namely xylem and phloem.
- They are primarily found in cool, damp, shady places, although some species can thrive in sandy soil conditions.
- The main plant body in pteridophytes is the sporophyte, which has differentiated root, stem, and leaves.
- The organs of pteridophytes, including the leaves, possess well-differentiated vascular tissues.
- Leaves in pteridophytes can be small (microphylls) or large (macrophylls).
- The sporophytes of pteridophytes bear sporangia, which are subtended by leaf-like appendages called sporophylls.
- In some cases, sporophylls may form distinct compact structures known as strobili or cones (e.g., Selaginella, Equisetum).
- The sporangia produce spores through meiosis in spore mother cells.
- The spores germinate and give rise to inconspicuous, small, multicellular, free-living, mostly photosynthetic thalloid gametophytes called prothallus.
- Gametophytes of pteridophytes require cool, damp, shady places to grow.

- The spread of living pteridophytes is limited due to their specific requirements and the need for water for fertilization.
- Pteridophyte gametophytes have male and female sex organs called antheridia and archegonia, respectively.
- Water is necessary for the transfer of antherozoids (male gametes) to the archegonium for fertilization.
- Fusion of the male gamete with the egg in the archegonium results in the formation of a zygote.
- The zygote develops into a multicellular, well-differentiated sporophyte, which is the dominant phase of pteridophytes.
- Most pteridophytes are homosporous, producing spores of similar kinds.
- Some pteridophyte genera, like Selaginella and Salvinia, are heterosporous, producing two kinds of spores: macrospores and microspores.
- Megaspores and microspores germinate to give rise to female and male gametophytes, respectively.
- Female gametophytes in heterosporous plants are retained on the parent sporophytes for varying periods.
- The development of zygotes into young embryos within the female gametophytes is a precursor to the seed habit, an important step in evolution.

- Pteridophytes are classified into four classes: Psilopsida (e.g., Psilotum), Lycopsida (e.g., Selaginella, Lycopodium), Sphenopsida (e.g., Equisetum), and Pteropsida (e.g., Dryopteris, Pteris, Adiantum).

GYMNOSPERMS

- Gymnosperms have naked seeds, meaning the ovules are not enclosed by an ovary wall and remain exposed before and after fertilization.
- Gymnosperms include medium-sized trees or tall trees and shrubs.
- The roots of gymnosperms are generally tap roots.
- Some gymnosperm genera have fungal associations through mycorrhiza (e.g., Pinus), while others have small specialized roots called coralloid roots associated with N2-fixing cyanobacteria (e.g., Cycas).
- The stems of gymnosperms can be unbranched (e.g., Cycas) or branched (e.g., Pinus, Cedrus).
- The leaves of gymnosperms may be simple or compound.
- In Cycas, the pinnate leaves persist for a few years.
- Gymnosperm leaves are well-adapted to withstand extremes of temperature, humidity, and wind.
- Conifers have needle-like leaves that reduce surface area.

- The thick cuticle and sunken stomata of gymnosperm leaves help reduce water loss.
- Gymnosperms are heterosporous, producing haploid microspores and megaspores.
- Microspores and megaspores are produced within sporangia borne on sporophylls, arranged spirally along an axis to form strobili or cones.
- Strobili bearing microsporophylls and microsporangia are called microsporangiate or male strobili.
- Microspores develop into a highly reduced male gametophyte called a pollen grain, which is confined to a limited number of cells.
- Pollen grains develop within the microsporangia.
- Cones bearing megasporophylls with ovules or megasporangia are called macrosporangiate or female strobili.
- Male and female cones or strobili may be borne on the same tree (e.g., Pinus), while in cycas, male cones and megasporophylls are borne on different trees.
- The megaspore mother cell is differentiated from one of the cells of the nucellus, and the composite structure protected by envelopes is called an ovule.
- Ovules are borne on megasporophylls, which may cluster to form female cones.

- The megaspore mother cell undergoes meiosis to form four megaspores.
- One of the megaspores enclosed within the megasporangium develops into a multicellular female gametophyte that bears archegonia, the female sex organs.
- The multicellular female gametophyte is retained within the megasporangium.
- Unlike bryophytes and pteridophytes, the male and female gametophytes in gymnosperms do not have an independent free-living existence and remain within the sporangia on the sporophytes.
- Pollen grains are released from the microsporangium and are carried by air currents to reach the opening of the ovules.
- The pollen tube grows towards the archegonia in the ovules and releases male gametes near the mouth of the archegonia.
- Following fertilization, the zygote develops into an embryo and the ovules develop into seeds, which remain uncovered.

ANGIOSPERMS

- In angiosperms or flowering plants, pollen grains and ovules are developed in specialized structures called flowers.
- Angiosperms have seeds enclosed in fruits.

- Angiosperms are a large group of plants found in a wide range of habitats and provide various commercial products.
- They are divided into two classes: dicotyledons and monocotyledons.
- Dicotyledons have seeds with two cotyledons, reticulate venation in leaves, and tetramerous or pentamerous flowers (four or five members in each floral whorl).
- Monocotyledons have seeds with a single cotyledon, parallel venation in leaves, and trimerous flowers (three members in each floral whorl).
- The male sex organ in a flower is the stamen, consisting of a filament and an anther where pollen grains develop.
- The female sex organ in a flower is the pistil, consisting of an ovary, style, and stigma. Ovules are present inside the ovary.
- Each ovule contains a megaspore mother cell that undergoes meiosis to form four megaspores, of which only one survives and develops into the embryo sac.
- The embryo sac consists of the egg apparatus (egg cell and two synergids), antipodal cells, and polar nuclei.

- Pollen grains are dispersed from the anthers and carried to the stigma of a pistil, a process known as pollination.
- Pollen grains germinate on the stigma and form pollen tubes, which grow through the tissues of the stigma and style to reach the ovule.
- The pollen tubes enter the embryo sac and discharge two male gametes.
- One male gamete fuses with the egg cell (syngamy) to form a zygote, while the other fuses with the polar nuclei to produce the triploid primary endosperm nucleus (PEN).
- Double fertilization occurs, involving both syngamy and triple fusion, a unique event to angiosperms.
- The zygote develops into an embryo (with one or two cotyledons), and the PEN develops into endosperm, providing nourishment to the developing embryo.
- The synergids and antipodals degenerate after fertilization.
- Ovules develop into seeds, and ovaries develop into fruits.
- The life cycle of an angiosperm involves the formation of flowers, pollination, fertilization, seed development, and fruit formation.

PLANT LIFE CYCLES AND ALTERNATION OF GENERATIONS

- In plants, both haploid and diploid cells can undergo mitosis.
- Mitosis in haploid cells leads to the formation of a haploid plant body called the gametophyte.
- The haploid gametophyte produces gametes through mitosis.
- After fertilization, the zygote resulting from the fusion of gametes divides by mitosis to form a diploid sporophytic plant body.
- The diploid sporophyte produces haploid spores through meiosis.
- The haploid spores, in turn, divide by mitosis to develop into a haploid plant body (gametophyte) once again.
- This alternation of generations between the gametophyte and sporophyte represents the life cycle of sexually reproducing plants.

Different Plant Life Cycle Patterns:

- Haplontic Life Cycle:
    - Sporophytic generation represented by the one-celled zygote.

    - No free-living sporophytes; meiosis in the zygote forms haploid spores.
    - Haploid spores divide by mitosis to form the dominant, free-living gametophyte.
    - Examples: Volvox, Spirogyra, some species of Chlamydomonas.
- Diplontic Life Cycle:
    - Diploid sporophyte is the dominant, independent, photosynthetic phase.
    - Gametophytic phase represented by single to few-celled haploid gametophyte.
    - Examples: Fucus (algae), gymnosperms, and angiosperms (seed-bearing plants).
- Haplo-diplontic (Intermediate) Life Cycle:
    - Bryophytes and pteridophytes exhibit this pattern.
    - Both phases are multicellular.
    - Dominant, independent, photosynthetic thalloid or erect phase is represented by haploid gametophyte.

- Short-lived multicellular sporophyte alternates, partially or totally dependent on the gametophyte for anchorage and nutrition.
- Examples: All bryophytes and pteridophytes.

Additional Notes:

- Some algal genera, typically haplontic, exhibit the haplo-diplontic pattern, such as Ectocarpus, Polysiphonia, and kelps.
- Fucus, an alga, follows the diplontic pattern.
- Most algae are haplontic, except for these exceptions.