Chapter 2: Biological Classification

Comprehensive Study Notes

Class 11 Biology - NCERT Based

EXAM SPRINT - Complete Coverage for Board Examinations

Introduction

Biological classification is the systematic arrangement of living organisms into groups based on their similarities and differences. This fundamental process in biology helps us understand the diversity of life and evolutionary relationships between different organisms.

Historical Development of Classification

Early Classification Systems:

- **Instinctive Classification**: Based on utility (food, shelter, clothing)
- **Practical purposes**: Agriculture, medicine, hunting
- **Limited scientific basis**: Morphological observations only

Aristotle's Contribution (384-322 BCE):

- **First scientific approach** to biological classification
- **Plant classification**: Trees, shrubs, and herbs
- **Animal classification**:
  - Animals with red blood (vertebrates)
  - Animals without red blood (invertebrates)

- **Limitations**: Based only on gross morphological features

Linnaeus System (1707-1778):

- **Two Kingdom System**: Plantae and Animalia
- **Binomial nomenclature**: Scientific naming system
- **Hierarchical classification**: Kingdom, Class, Order, Genus, Species
- **Limitations**:
  - No distinction between prokaryotes and eukaryotes
  - No separation of unicellular and multicellular organisms
  - Grouped photosynthetic and non-photosynthetic organisms together

Need for Modern Classification

Problems with Two Kingdom System:

1. **Prokaryotic-Eukaryotic confusion**: Bacteria grouped with plants
2. **Unicellular-Multicellular mixing**: Single cells with complex organisms
3. **Nutritional mode ignored**: Fungi (heterotrophic) with plants (autotrophic)
4. **Cell wall composition**: Chitin (fungi) vs cellulose (plants) not considered
5. **Many organisms**: Didn't fit either category properly

Modern Classification Criteria:

- **Cell structure**: Prokaryotic vs eukaryotic
- **Body organization**: Cellular, tissue, organ system levels
- **Mode of nutrition**: Autotrophic vs heterotrophic
- **Reproduction methods**: Asexual, sexual, alternation of generations
- **Phylogenetic relationships**: Evolutionary connections

- **Biochemical characteristics**: Molecular evidence
- **Ecological roles**: Environmental functions

Whittaker's Five Kingdom Classification (1969)

R.H. Whittaker proposed the most widely accepted classification system dividing all life into five kingdoms based on:

- **Cell structure** (prokaryotic/eukaryotic)
- **Body organization** (cellular/tissue/organ system)
- **Mode of nutrition** (autotrophic/heterotrophic)
- **Reproduction** (asexual/sexual)
- **Phylogenetic relationships** (evolutionary history)

Comparative Analysis of Five Kingdoms

Character	Monera	Protista	Fungi	Plantae	Animalia
Cell Type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell Wall	Non-cellulosic (polysaccharide + amino acid)	Present in some	Present (chitin)	Present (cellulose)	Absent
Nuclear Membrane	Absent	Present	Present	Present	Present
Body Organization	Cellular	Cellular	Multicellular/loose tissue	Tissue/organ	Tissue/organ/organ system
Mode of Nutrition	Autotrophic & Heterotrophic	Autotrophic & Heterotrophic	Heterotrophic	Autotrophic	Heterotrophic

Character	Monera	Protista	Fungi	Plantae	Animalia
Examples	Bacteria, Cyanobacteria	Protozoans, Algae	Mushrooms, Yeasts	Trees, Herbs	Mammals, Insects

Modern Developments

Three-Domain System:

- **Domain Bacteria**: True bacteria (eubacteria)
- **Domain Archaea**: Archaebacteria
- **Domain Eukarya**: All eukaryotic organisms
- Results in **six-kingdom classification**
- Based on molecular and biochemical evidence

2.1 Kingdom Monera

General Characteristics

Defining Features:

- **Most abundant microorganisms** on Earth
- **Prokaryotic cells**: No membrane-bound nucleus
- **Cosmopolitan distribution**: Present everywhere
- **Extreme habitat colonizers**: Hot springs, deserts, deep oceans
- **Metabolic diversity**: Greatest among all life forms
- **Parasitic forms**: Many live in/on other organisms

Cell Structure:

- **Genetic material**: Freely floating in cytoplasm (nucleoid)

- **Cell wall**: Non-cellulosic (peptidoglycan)
- **Ribosomes**: 70S type
- **Membrane-bound organelles**: Absent
- **Plasmids**: Extra-chromosomal DNA

Morphological Classification

Based on Shape:

1. Coccus (Spherical):

- **Single**: Monococcus
- **Pairs**: Diplococcus (e.g., Streptococcus pneumoniae)
- **Chains**: Streptococcus
- **Clusters**: Staphylococcus
- **Packets**: Sarcina

2. Bacillus (Rod-shaped):

- **Single**: Single bacillus
- **Chains**: Streptobacillus
- **Examples**: E. coli, Salmonella, Bacillus subtilis

3. Vibrio (Comma-shaped):

- **Curved rods**: Slightly bent
- **Example**: Vibrio cholerae (cholera)
- **Marine environments**: Often found in water

4. Spirillum (Spiral):

- **Rigid spirals**: Spirillum
- **Flexible spirals**: Spirochaete
- **Examples**: Treponema pallidum (syphilis)

Nutritional Classification

1. Autotrophic Bacteria:

a) Photosynthetic Autotrophs:

- **Mechanism**: Use light energy to synthesize food
- **Pigments**: Chlorophyll a (cyanobacteria)
- **Examples**: Cyanobacteria (Nostoc, Anabaena)
- **Ecological importance**: Primary producers

b) Chemosynthetic Autotrophs:

- **Mechanism**: Oxidize inorganic substances for energy
- **Substrates**: Nitrates, nitrites, ammonia, sulfur compounds
- **Examples**: Nitrosomonas, Nitrobacter, Thiobacillus
- **Ecological role**: Nutrient cycling (N, P, S cycles)

2. Heterotrophic Bacteria:

- **Most abundant** in nature
- **Decomposers**: Break down organic matter
- **Parasites**: Cause diseases
- **Symbionts**: Beneficial relationships
- **Saprotrophs**: Feed on dead organic matter

2.1.1 Archaebacteria (Ancient Bacteria)

Unique Characteristics:

- **Ancient origin**: Possibly the earliest life forms
- **Extreme environments**: Survive harsh conditions
- **Cell wall composition**: Different from eubacteria
- **Membrane lipids**: Unique branched-chain lipids
- **RNA polymerase**: Different from other bacteria

Types Based on Habitat:

1. Halophiles (Salt-loving):

- **Environment**: Extremely salty areas (>15% salt)
- **Examples**: Dead Sea, Great Salt Lake
- **Species**: Halobacterium, Halococcus
- **Adaptations**: Special proteins and osmotic balance

2. Thermoacidophiles (Heat and acid-loving):

- **Environment**: Hot springs, volcanic areas
- **Temperature range**: 60-80°C
- **pH range**: 1-3 (highly acidic)
- **Examples**: Thermus aquaticus, Sulfolobus
- **Applications**: Heat-stable enzymes for PCR

3. Methanogens (Methane producers):

- **Environment**: Marshy areas, anaerobic conditions

- **Metabolism**: Produce methane from organic matter
- **Location**: Ruminant guts, sewage treatment plants
- **Examples**: Methanobrevibacter, Methanosarcina
- **Economic importance**: Biogas production

2.1.2 Eubacteria (True Bacteria)

General Features:

- **Rigid cell wall**: Peptidoglycan layer
- **Motility**: Flagella when motile
- **Reproduction**: Binary fission, budding, fragmentation
- **Genetic material**: Single circular chromosome
- **Wide distribution**: Almost everywhere on Earth

Major Groups:

1. Cyanobacteria (Blue-green Algae):

- **Photosynthetic capability**: Chlorophyll a + accessory pigments
- **Oxygen production**: Oxygenic photosynthesis
- **Morphology**: Unicellular, colonial, filamentous
- **Habitat**: Freshwater, marine, terrestrial
- **Special features**:
  - **Heterocysts**: Specialized nitrogen-fixing cells
  - **Gelatinous sheath**: Protective covering in colonies
  - **Bloom formation**: Rapid multiplication in polluted waters

Important Examples:

- **Nostoc**: Filamentous, nitrogen-fixing
- **Anabaena**: Heterocyst-containing, aquatic
- **Oscillatoria**: Filamentous, oscillating movement
- **Spirulina**: Spiral-shaped, protein-rich food source

Ecological Importance:

- **Primary productivity**: Major oxygen producers
- **Nitrogen fixation**: Convert atmospheric N_2 to ammonia
- **Evolutionary significance**: Responsible for Earth's oxygenation
- **Food chain base**: Primary producers in aquatic ecosystems

2. Chemosynthetic Bacteria:

- **Energy source**: Chemical oxidation of inorganic compounds
- **Ecological role**: Nutrient cycling
- **Examples**:
  - **Nitrosomonas**: Ammonia → Nitrites
  - **Nitrobacter**: Nitrites → Nitrates
  - **Thiobacillus**: Sulfur oxidation
  - **Ferrobacillus**: Iron oxidation

3. Heterotrophic Bacteria:

a) Decomposers (Saprotrophs):

- **Function**: Break down dead organic matter
- **Importance**: Nutrient recycling in ecosystems

- **Habitat**: Soil, water, decaying matter
- **Examples**: Many soil bacteria

b) Beneficial Bacteria:

- **Nitrogen fixation**: Rhizobium in legume roots
- **Food production**:
  - Lactobacillus (curd, yogurt)
  - Streptococcus thermophilus (cheese)
- **Antibiotic production**: Streptomyces (streptomycin)
- **Industrial applications**: Fermentation processes

c) Pathogenic Bacteria:

- **Disease-causing**: Various human, animal, plant diseases
- **Examples**:
  - **Vibrio cholerae**: Cholera
  - **Salmonella typhi**: Typhoid
  - **Clostridium tetani**: Tetanus
  - **Xanthomonas citri**: Citrus canker

Reproduction in Bacteria

1. Asexual Reproduction:

- **Binary fission**: Most common method
- **Budding**: Unequal division
- **Fragmentation**: Breaking into parts
- **Spore formation**: Under unfavorable conditions

2. Sexual Reproduction (Genetic Recombination):

- **Conjugation**: Direct transfer of genetic material
- **Transformation**: Uptake of external DNA
- **Transduction**: Gene transfer via viruses

Special Group: Mycoplasma

Unique Characteristics:

- **No cell wall**: Completely lacking
- **Smallest living cells**: 0.1-0.3 μm diameter
- **Pleomorphic**: Variable shape
- **Oxygen requirement**: Can survive without oxygen
- **Pathogenic**: Many cause diseases in animals and plants
- **Examples**: Mycoplasma pneumoniae (atypical pneumonia)

Significance:

- **Medical importance**: Cause respiratory diseases
- **Research applications**: Cell biology studies
- **Evolutionary interest**: Minimal genome studies

2.2 Kingdom Protista

General Characteristics

Defining Features:

- **Single-celled eukaryotes**: True nucleus and organelles
- **Boundary issues**: Classification boundaries not well-defined

- **Primarily aquatic**: Marine and freshwater environments
- **Link kingdom**: Connects plants, animals, and fungi
- **Diverse nutrition**: Both autotrophic and heterotrophic forms
- **Reproduction**: Both asexual and sexual methods

Cell Structure:

- **Membrane-bound nucleus**: Well-defined
- **Organelles**: Mitochondria, endoplasmic reticulum, Golgi body
- **Locomotory structures**: Flagella, cilia, pseudopodia
- **Cell covering**: Cell wall (some), pellicle, or plasma membrane

Major Groups of Protista

2.2.1 Chrysophytes

Golden Algae and Diatoms:

- **Habitat**: Both freshwater and marine
- **Lifestyle**: Planktonic (float passively)
- **Nutrition**: Mostly photosynthetic
- **Pigments**: Golden-brown (fucoxanthin + chlorophyll)

Diatoms - The Jewels of Plant Kingdom:

Structure:

- **Cell wall**: Two overlapping shells (like soap box)
- **Silica content**: Walls embedded with silica (SiO_2)
- **Symmetry**: Bilateral or radial symmetry

- **Indestructible walls**: Resist decay after death

Ecological and Economic Importance:

- **Primary producers**: Chief producers in oceans
- **Diatomaceous earth**: Fossilized diatom deposits
- **Commercial uses**:
  - **Polishing**: Toothpaste, metal polish
  - **Filtration**: Oil and syrup filtering
  - **Insulation**: Heat and sound insulation
  - **Construction**: Lightweight concrete

Examples:

- **Navicula**: Boat-shaped
- **Pinnularia**: Elongated with markings
- **Coscinodiscus**: Circular with pores

2.2.2 Dinoflagellates

Fire Algae or Whirling Whips:

- **Habitat**: Mostly marine
- **Nutrition**: Photosynthetic (some heterotrophic)
- **Pigmentation**: Yellow, green, brown, blue, or red
- **Cell wall**: Stiff cellulose plates

Locomotion:

- **Two flagella**: Different orientations

- **Longitudinal flagellum**: Propels forward
- **Transverse flagellum**: Causes spinning motion
- **Furrow**: Transverse flagellum in groove between plates

Ecological Phenomena:

Red Tides:

- **Cause**: Rapid multiplication of red dinoflagellates
- **Example**: Gonyaulax species
- **Effects**:
  - Sea appears red in color
  - Toxin release kills marine animals
  - Economic loss to fisheries
  - Human health hazards

Bioluminescence:

- **Mechanism**: Light production in darkness
- **Function**: Defense mechanism
- **Examples**: Noctiluca, Pyrodinium

Examples:

- **Gymnodinium**: Naked dinoflagellate
- **Ceratium**: Horned appearance
- **Alexandrium**: Toxic species

2.2.3 Euglenoids

Plant-Animal Border Organisms:

- **Habitat**: Freshwater, especially stagnant water
- **Dual nutrition**: Both autotrophic and heterotrophic
- **No cell wall**: Flexible pellicle instead
- **Locomotion**: Two flagella (one long, one short)

Unique Characteristics:

- **Flexible body**: Pellicle allows shape changes
- **Nutritional flexibility**:
  - Photosynthetic in light
  - Heterotrophic in darkness (predation)
- **Pigments**: Identical to higher plants
- **Eyespot**: Light-sensitive structure for phototaxis

Structure:

- **Pellicle**: Protein-rich, flexible covering
- **Contractile vacuole**: Osmoregulation
- **Nucleus**: Single, well-defined
- **Chloroplasts**: When present, similar to plants

Examples:

- **Euglena**: Most common example
- **Phacus**: Flattened body

- **Trachelomonas**: With lorica (shell)

2.2.4 Slime Moulds

Fungus-like Protists:

- **Nutrition**: Saprophytic
- **Habitat**: Decaying organic matter
- **Body**: Creeping plasmodium
- **Unique lifecycle**: Complex with multiple stages

Life Cycle Stages:

1. Vegetative Phase:

- **Plasmodium**: Multinucleated, acellular mass
- **Movement**: Streaming cytoplasm
- **Feeding**: Engulfs organic material
- **Size**: Can spread over several feet

2. Reproductive Phase:

- **Trigger**: Unfavorable conditions
- **Fruiting bodies**: Differentiated structures
- **Spore production**: At tips of fruiting bodies
- **Spore characteristics**: True walls, extremely resistant
- **Dispersal**: By air currents
- **Survival**: Many years under adverse conditions

Types:

- **Plasmodial slime moulds**: True slime moulds
- **Cellular slime moulds**: Individual cells aggregate

Examples:

- **Physarum**: Yellow plasmodium
- **Fuligo**: Large, conspicuous
- **Dictyostelium**: Cellular slime mould

2.2.5 Protozoans (Animal-like Protists)

General Characteristics:

- **Nutrition**: All heterotrophic
- **Lifestyle**: Predators or parasites
- **Evolutionary position**: Primitive relatives of animals
- **Habitat**: Aquatic, terrestrial, parasitic
- **Reproduction**: Both asexual and sexual

Classification Based on Locomotion:

1. Amoeboid Protozoans:

- **Movement**: Pseudopodia (false feet)
- **Feeding**: Engulfment of food particles
- **Habitat**: Fresh water, sea water, moist soil
- **Shell**: Marine forms have silica shells

Examples:

- **Amoeba proteus**: Free-living, freshwater

- **Entamoeba histolytica**: Parasitic, causes dysentery
- **Radiolaria**: Marine, silica shells
- **Foraminifera**: Marine, calcareous shells

2. Flagellated Protozoans:

- **Movement**: One or more flagella
- **Lifestyle**: Free-living or parasitic
- **Parasitic diseases**: Several important human diseases

Examples:

- **Trypanosoma**: Sleeping sickness, Chagas disease
- **Leishmania**: Kala-azar, oriental sore
- **Trichomonas**: Urogenital infections
- **Giardia**: Intestinal infections

3. Ciliated Protozoans:

- **Movement**: Thousands of cilia
- **Habitat**: Aquatic environments
- **Activity**: Actively swimming
- **Feeding**: Gullet opens to cell surface
- **Coordination**: Rows of cilia beat in rhythm

Structure:

- **Macronucleus**: Vegetative functions
- **Micronucleus**: Reproductive functions

- **Contractile vacuoles**: Water balance
- **Food vacuoles**: Digestion

Examples:

- **Paramecium**: Slipper-shaped
- **Stentor**: Trumpet-shaped
- **Vorticella**: Bell-shaped, stalked

4. Sporozoans:

- **Spore stage**: Infectious in life cycle
- **Parasitic**: All members are parasites
- **No locomotory structures**: In adult stage
- **Complex life cycles**: Multiple hosts

Most Important Example - Plasmodium:

- **Disease**: Malaria
- **Species**: P. vivax, P. falciparum, P. malariae, P. ovale
- **Vector**: Anopheles mosquito
- **Life cycle**: Alternates between human and mosquito
- **Global impact**: Major cause of morbidity and mortality

Life Cycle Stages:

- **Sporozoites**: Infective stage in mosquito saliva
- **Merozoites**: Multiply in liver and blood cells
- **Gametocytes**: Sexual stages in blood

- **Gametes**: Formed in mosquito gut

2.3 Kingdom Fungi

General Characteristics

Defining Features:

- **Heterotrophic eukaryotes**: Cannot synthesize their own food
- **Morphological diversity**: Unicellular to complex multicellular
- **Habitat diversity**: Cosmopolitan distribution
- **Cell wall composition**: Chitin and polysaccharides
- **Body structure**: Filamentous (except yeasts)
- **Nutrition modes**: Saprophytic, parasitic, symbiotic

Economic Importance:

- **Beneficial**: Food (mushrooms), fermentation (bread, beer)
- **Harmful**: Plant diseases (rusts, smuts), human infections
- **Medical**: Antibiotics (Penicillin), immunosuppressants
- **Industrial**: Enzymes, organic acids, vitamins

Body Organization:

1. Hyphae:

- **Structure**: Long, slender, thread-like filaments
- **Growth**: Tip growth (apical growth)
- **Types**:
  - **Coenocytic**: Continuous tubes, multinucleated

- **Septate**: Cross walls (septa) present

2. Mycelium:

- **Definition**: Network of hyphae
- **Types**:
  - **Vegetative**: Absorbs nutrients
  - **Aerial**: Reproductive structures
- **Function**: Absorption and reproduction

Nutrition in Fungi

1. Saprophytic Fungi:

- **Substrate**: Dead organic matter
- **Function**: Decomposers in ecosystems
- **Examples**: Most soil fungi, wood rotting fungi
- **Ecological role**: Nutrient recycling

2. Parasitic Fungi:

- **Host**: Living organisms (plants, animals, humans)
- **Effects**: Disease-causing
- **Examples**: Puccinia (wheat rust), Candida (human infections)
- **Economic impact**: Crop losses, medical costs

3. Symbiotic Fungi:

- **Mutualistic relationships**: Both partners benefit

a) Lichens:

- **Partners**: Fungus + algae/cyanobacteria
- **Fungal partner**: Mycobiont (provides shelter)
- **Algal partner**: Phycobiont (provides food)

b) Mycorrhiza:

- **Partners**: Fungus + plant roots
- **Benefits**:
  - Fungus gets carbohydrates
  - Plant gets minerals and water
- **Types**: Ectomycorrhiza, Endomycorrhiza

Reproduction in Fungi

1. Vegetative Reproduction:

- **Fragmentation**: Hyphae break into fragments
- **Fission**: Cell division (yeasts)
- **Budding**: Outgrowth formation (yeasts)

2. Asexual Reproduction:

- **Spore types**:
  - **Conidia**: External spores on conidiophores
  - **Sporangiospores**: Internal spores in sporangia
  - **Zoospores**: Motile spores (aquatic fungi)

3. Sexual Reproduction:

- **Three distinct phases**:

1. **Plasmogamy**: Fusion of protoplasms
2. **Karyogamy**: Fusion of nuclei
3. **Meiosis**: Reduction division in zygote

Special Condition - Dikaryophase:

- **Definition**: Two nuclei per cell (n + n)
- **Duration**: Variable period before karyogamy
- **Occurrence**: Ascomycetes and Basidiomycetes
- **Significance**: Genetic variability

Classification of Fungi

2.3.1 Phycomycetes (Lower Fungi)

General Characteristics:

- **Habitat**: Aquatic or moist terrestrial environments
- **Mycelium**: Aseptate and coenocytic
- **Cell wall**: Cellulose or chitin
- **Reproduction**: Both asexual and sexual

Asexual Reproduction:

- **Zoospores**: Motile, flagellated (aquatic species)
- **Aplanospores**: Non-motile (terrestrial species)
- **Sporangium**: Contains spores endogenously

Sexual Reproduction:

- **Zygospore formation**: Fusion of gametes

- **Gamete types**:
  - **Isogamous**: Similar gametes
  - **Anisogamous**: Dissimilar size gametes
  - **Oogamous**: Egg and sperm type

Important Examples:

Mucor (Black Bread Mould):

- **Habitat**: Bread, organic matter
- **Structure**: Stolons, rhizoids, sporangiophores
- **Reproduction**: Sporangiospores, zygospores
- **Economic importance**: Food spoilage

Rhizopus (Bread Mould):

- **Structure**: Stolon with rhizoids and sporangiophores
- **Reproduction**: Abundant sporangiospore production
- **Industrial use**: Alcohol production

Albugo (White Rust):

- **Host**: Mustard plants
- **Symptoms**: White spots on leaves
- **Economic impact**: Crop disease

2.3.2 Ascomycetes (Sac Fungi)

General Characteristics:

- **Mycelium**: Branched and septate

- **Habitat**: Terrestrial, some aquatic
- **Nutrition**: Saprophytic, parasitic, or coprophilous
- **Size**: Mostly multicellular, some unicellular (yeasts)

Asexual Reproduction:

- **Conidia**: Produced exogenously
- **Conidiophores**: Specialized hyphae bearing conidia
- **Chain formation**: Conidia often in chains

Sexual Reproduction:

- **Ascospores**: Sexual spores
- **Ascus**: Sac-like structure containing ascospores
- **Ascocarp**: Fruiting body containing asci
- **Types of ascocarps**:
  - **Cleistothecium**: Closed
  - **Perithecium**: Flask-shaped opening
  - **Apothecium**: Cup-shaped, open

Important Examples:

Saccharomyces (Baker's/Brewer's Yeast):

- **Structure**: Unicellular, oval cells
- **Reproduction**: Budding, ascospore formation
- **Economic importance**:
  - Bread making (CO_2 production)
  - Alcohol fermentation

    - Single-cell protein
- **Research**: Model organism for genetics

Penicillium:

- **Structure**: Brush-like conidiophores
- **Habitat**: Soil, organic matter
- **Economic importance**:
    - Penicillin antibiotic production
    - Food spoilage
    - Cheese production (P. roqueforti)

Aspergillus:

- **Structure**: Radiating conidiophores
- **Species diversity**: Over 200 species
- **Economic importance**:
    - Enzyme production (amylase)
    - Food fermentation (soy sauce)
    - Some species pathogenic

Neurospora (Pink Bread Mould):

- **Research significance**:
    - Biochemical genetics studies
    - One gene-one enzyme hypothesis
    - Nobel Prize research organism
- **Life cycle**: Well-studied sexual reproduction

Edible Forms:

- **Morels**: Morchella species, highly prized
- **Truffles**: Underground fungi, expensive delicacies

2.3.3 Basidiomycetes (Club Fungi)

General Characteristics:

- **Common forms**: Mushrooms, bracket fungi, puffballs
- **Habitat**: Soil, decaying wood, living plants
- **Mycelium**: Branched and septate
- **Economic importance**: Edible, parasitic diseases

Unique Features:

- **No sexual organs**: Plasmogamy by somatic cell fusion
- **Dikaryotic stage**: Prominent phase
- **Basidium**: Club-shaped reproductive structure
- **Clamp connections**: Maintain dikaryotic condition

Reproduction:

- **Asexual**: Rare, mostly fragmentation
- **Sexual**: Complex process involving dikaryophase
- **Basidiospores**: Produced externally on basidia
- **Basidiocarp**: Fruiting body (mushroom)

Life Cycle Stages:

1. **Primary mycelium**: Monokaryotic (n)

2. **Secondary mycelium**: Dikaryotic (n + n)
3. **Basidium formation**: In fruiting body
4. **Karyogamy**: Nuclear fusion (2n)
5. **Meiosis**: Four basidiospores (n)

Important Examples:

Agaricus (Common Mushroom):

- **Structure**: Stipe, pileus with gills
- **Spore production**: On gill surfaces
- **Economic importance**:
  - Edible mushroom cultivation
  - High protein content
  - Commercial production

Plant Pathogenic Forms:

Puccinia (Wheat Rust):

- **Host**: Wheat plants
- **Symptoms**: Orange-red rust spots
- **Economic impact**: Significant crop losses
- **Life cycle**: Complex with alternate hosts

Ustilago (Corn Smut):

- **Host**: Corn/maize plants
- **Symptoms**: Black sooty masses

- **Spore masses**: Replace kernels
- **Economic impact**: Crop damage

2.3.4 Deuteromycetes (Imperfect Fungi)

Defining Characteristic:

- **Sexual stage unknown**: Only asexual reproduction observed
- **Artificial group**: Not a natural taxonomic group
- **Reclassification**: Moved when sexual stage discovered
- **Connection**: Often linked to Ascomycetes or Basidiomycetes

General Features:

- **Mycelium**: Septate and branched
- **Reproduction**: Only asexual (conidia)
- **Habitat**: Terrestrial environments
- **Nutrition**: Saprophytic or parasitic

Ecological Importance:

- **Decomposers**: Major role in litter decomposition
- **Mineral cycling**: Release nutrients
- **Soil formation**: Contribute to soil development

Important Examples:

Alternaria:

- **Plant pathogen**: Early blight of potatoes
- **Conidiospores**: Large, multicellular

- **Economic importance**: Crop diseases

Colletotrichum:

- **Disease**: Anthracnose in various plants
- **Symptoms**: Circular spots on leaves/fruits
- **Economic impact**: Post-harvest losses

Trichoderma:

- **Biocontrol agent**: Against plant pathogens
- **Soil inhabitant**: Common in agricultural soils
- **Commercial use**: Biological pesticide

2.4 Kingdom Plantae

General Characteristics

Defining Features:

- **Eukaryotic organization**: True nucleus and organelles
- **Chlorophyll presence**: Primary photosynthetic pigment
- **Autotrophic nutrition**: Synthesize own food through photosynthesis
- **Cell wall**: Primarily cellulose
- **Specialized exceptions**: Some partially heterotrophic forms

Exceptional Members:

Insectivorous Plants:

- **Examples**: Venus flytrap, Bladderwort, Pitcher plants
- **Adaptation**: Supplement nutrition in nutrient-poor soils

- **Mechanism**: Trap and digest insects
- **Photosynthesis**: Still perform photosynthesis

Parasitic Plants:

- **Example**: Cuscuta (Dodder)
- **Adaptation**: Derive nutrients from host plants
- **Chlorophyll**: Reduced or absent
- **Connection**: Haustoria penetrate host tissues

Plant Groups Included:

1. **Algae**: Simple aquatic plants
2. **Bryophytes**: Mosses and liverworts
3. **Pteridophytes**: Ferns and their allies
4. **Gymnosperms**: Cone-bearing plants
5. **Angiosperms**: Flowering plants

Alternation of Generations:

- **Two distinct phases**: Diploid sporophyte and haploid gametophyte
- **Variation**: Relative dominance varies among plant groups
- **Free-living vs dependent**: Some phases independent, others dependent
- **Evolutionary trend**: Sporophyte dominance increases in higher plants

2.5 Kingdom Animalia

General Characteristics

Defining Features:

- **Heterotrophic eukaryotes**: Cannot synthesize own food
- **Multicellular organization**: Complex tissue and organ systems
- **No cell wall**: Flexible cell membrane only
- **Holozoic nutrition**: Ingestion of food particles
- **Internal digestion**: Specialized digestive cavity
- **Storage forms**: Glycogen and fat reserves

Advanced Characteristics:

- **Definite growth pattern**: Determinate growth to adult size
- **Sensory systems**: Elaborate sensory mechanisms
- **Neuromotor coordination**: Nervous system control
- **Locomotion capability**: Most can move actively
- **Sexual reproduction**: Copulation and embryological development

Dependency on Plants:

- **Direct**: Herbivores feed on plants
- **Indirect**: Carnivores feed on herbivores
- **Energy flow**: All animal energy ultimately from plants

2.6 Viruses, Viroids, Prions and Lichens

Acellular Organisms

These entities are not included in Whittaker's five-kingdom system because they lack cellular organization, representing a unique category of biological entities.

2.6.1 Viruses

Historical Discovery:

- **Dmitri Ivanovsky (1892)**: First discovered virus causing tobacco mosaic disease
- **M.W. Beijerinck (1898)**: Named "virus" (meaning poisonous fluid)
- **Term**: Contagium vivum fluidum (infectious living fluid)
- **W.M. Stanley (1935)**: Crystallized viruses, showed protein composition

Fundamental Characteristics:

- **Non-cellular**: No cell membrane, nucleus, or organelles
- **Obligate parasites**: Cannot reproduce outside host cells
- **Crystalline structure**: Inert outside host
- **Host dependency**: Take over host cell machinery
- **Size**: Smaller than bacteria (20-300 nm)

Chemical Composition:

- **Nucleoprotein structure**: Nucleic acid + protein coat
- **Genetic material**: Either DNA or RNA (never both)
- **Protein coat**: Capsid made of capsomeres
- **No metabolism**: No enzymes for independent metabolism

Genetic Material Variations:

- **Plant viruses**: Usually single-stranded RNA
- **Animal viruses**: Single/double-stranded RNA or double-stranded DNA
- **Bacteriophages**: Usually double-stranded DNA

Capsid Structure:

- **Capsomeres**: Protein subunits
- **Geometric forms**: Helical or polyhedral
- **Function**: Protects genetic material
- **Specificity**: Determines host range

Major Types:

1. Plant Viruses:

- **Genetic material**: Mostly single-stranded RNA
- **Examples**:
  - **Tobacco Mosaic Virus (TMV)**: Rod-shaped, RNA virus
  - **Cauliflower Mosaic Virus**: DNA virus in plants
- **Symptoms**: Mosaic patterns, leaf curling, yellowing, stunting
- **Transmission**: Insects, mechanical injury, grafting

2. Animal Viruses:

- **Genetic material**: RNA or DNA
- **Examples**:
  - **Influenza**: RNA virus causing flu
  - **Herpes**: DNA virus causing cold sores
  - **HIV**: Retrovirus causing AIDS
- **Diseases**: Mumps, smallpox, herpes, influenza, AIDS
- **Transmission**: Airborne, contact, vectors, sexual

3. Bacteriophages:

- **Genetic material**: Usually double-stranded DNA
- **Structure**: Head, tail, tail fibers
- **Host**: Bacterial cells
- **Reproduction**: Lytic and lysogenic cycles
- **Research importance**: Genetic studies, gene therapy

Viral Diseases:

Human Diseases:

- **Respiratory**: Influenza, common cold, COVID-19
- **Skin**: Herpes, chickenpox, warts
- **Systemic**: HIV/AIDS, hepatitis, measles
- **Neurological**: Rabies, polio, encephalitis

Plant Diseases:

- **Mosaic diseases**: TMV, cucumber mosaic
- **Yellowing**: Beet yellows, barley yellow dwarf
- **Stunting**: Tomato bushy stunt
- **Economic impact**: Billions of dollars in crop losses

Living vs Non-Living Debate:

Non-Living Characteristics:

- Cannot reproduce independently
- No cellular structure
- No metabolism outside host

- Can be crystallized
- Inert outside host

Living Characteristics:

- Contain genetic material
- Can reproduce (with host help)
- Show genetic variation
- Evolve and adapt
- Respond to environment

Conclusion: Viruses exist at the boundary between living and non-living matter.

2.6.2 Viroids

Discovery: T.O. Diener (1971) discovered while studying potato spindle tuber disease.

Characteristics:

- **Composition**: Free RNA only
- **No protein coat**: Unlike viruses
- **Size**: Smaller than viruses
- **Low molecular weight**: Single-stranded RNA
- **Host**: Mainly plants
- **Pathogenic**: Cause plant diseases

Diseases Caused:

- **Potato spindle tuber disease**: Stunted, spindle-shaped tubers
- **Chrysanthemum stunt**: Reduced plant growth

- **Citrus exocortis**: Bark scaling in citrus
- **Economic impact**: Significant crop losses

Mechanism of Action:

- **RNA interference**: Disrupts host gene expression
- **Replication**: Uses host RNA polymerase
- **Transmission**: Mechanical injury, grafting, insects

2.6.3 Prions

Discovery: Stanley Prusiner (1982) identified prions as infectious protein particles.

Characteristics:

- **Composition**: Abnormally folded proteins only
- **No nucleic acid**: No DNA or RNA
- **Size**: Similar to small viruses
- **Infectivity**: Protein conformation changes cause disease
- **Resistance**: Highly resistant to standard sterilization

Diseases Caused:

Animal Diseases:

- **Bovine Spongiform Encephalopathy (BSE)**: Mad cow disease
- **Scrapie**: In sheep and goats
- **Chronic Wasting Disease**: In deer and elk

Human Diseases:

- **Creutzfeldt-Jakob Disease (CJD)**: Human equivalent of BSE

- **Kuru**: Historically found in Papua New Guinea
- **Fatal Familial Insomnia**: Genetic prion disease

Mechanism:

- **Protein misfolding**: Normal protein adopts abnormal shape
- **Template effect**: Abnormal protein induces others to misfold
- **Accumulation**: Misfolded proteins accumulate in brain
- **Neurodegeneration**: Brain tissue develops sponge-like holes

2.6.4 Lichens

Definition: Symbiotic association between fungi and algae/cyanobacteria.

Components:

- **Mycobiont**: Fungal partner (usually ascomycete)
- **Phycobiont**: Algal partner or cyanobacterial partner
- **Relationship**: Mutualistic symbiosis

Symbiotic Benefits:

Fungal Partner Provides:

- **Shelter**: Physical protection
- **Water absorption**: From atmosphere
- **Mineral uptake**: From substrate
- **Structural support**: Framework for algae

Algal Partner Provides:

- **Photosynthesis**: Organic compounds (glucose)

- **Oxygen**: Byproduct of photosynthesis
- **Primary productivity**: Energy source

Structure:

- **Cortex**: Outer fungal layer
- **Algal layer**: Photosynthetic zone
- **Medulla**: Inner fungal layer
- **Lower cortex**: Attachment structures

Types Based on Morphology:

1. Crustose Lichens:

- **Growth form**: Crusty, firmly attached
- **Substrate**: Rocks, tree bark
- **Examples**: Many rock lichens
- **Characteristics**: Cannot be removed without damage

2. Foliose Lichens:

- **Growth form**: Leaf-like, loosely attached
- **Examples**: Parmelia species
- **Characteristics**: Can be peeled off substrate

3. Fruticose Lichens:

- **Growth form**: Shrub-like, branching
- **Examples**: Reindeer moss, Old man's beard
- **Characteristics**: Three-dimensional growth

Ecological Importance:

Pioneer Species:

- **Primary succession**: First organisms on bare rock
- **Soil formation**: Break down rocks mechanically and chemically
- **Habitat creation**: Prepare ground for other organisms

Environmental Indicators:

- **Pollution sensitivity**: Cannot tolerate air pollution
- **Bio-indicators**: Used to assess air quality
- **Clean air requirement**: Absent in polluted areas
- **Monitoring**: Environmental health assessment

Economic Uses:

- **Food**: Some species edible (Iceland moss)
- **Dyes**: Natural coloring agents
- **Medicines**: Traditional remedies
- **Perfumes**: Source of fixatives

Reproduction:

- **Vegetative**: Fragmentation, soredia, isidia
- **Sexual**: Through fungal partner only
- **Dispersal**: Wind, water, animals

Examples:

- **Graphis**: Crustose on tree bark

- **Parmelia**: Foliose, common on rocks
- **Usnea**: Fruticose, beard-like
- **Cladonia**: Cup lichens, reindeer moss

Modern Classification Trends

Molecular Phylogeny

DNA Sequencing: Modern classification increasingly based on genetic evidence rather than just morphology.

Three-Domain System:

- **Domain Bacteria**: Eubacteria
- **Domain Archaea**: Archaebacteria
- **Domain Eukarya**: All eukaryotes

Advantages:

- **Evolutionary relationships**: More accurate phylogeny
- **Molecular evidence**: Genetic similarities/differences
- **Objective criteria**: Less subjective than morphological classification

Limitations of Five Kingdom System

Boundary Issues:

- **Kingdom Protista**: Most problematic, artificial grouping
- **Algae placement**: Some in Protista, others in Plantae
- **Fungal relationships**: Closer to animals than plants
- **Prokaryotic diversity**: Archaea very different from bacteria

Future Directions:

- **Six or more kingdoms**: Further subdivision likely
- **Phylogenetic classification**: Based on evolutionary history
- **Molecular markers**: DNA/RNA sequence comparisons
- **Computer analysis**: Sophisticated statistical methods

Practical Applications and Significance

Medical Applications

Disease Understanding:

- **Pathogen identification**: Proper classification aids treatment
- **Antibiotic selection**: Different drugs for different pathogens
- **Vaccine development**: Understanding viral/bacterial structure
- **Drug discovery**: Natural products from fungi, bacteria

Agricultural Importance

Crop Protection:

- **Disease identification**: Proper classification for treatment
- **Biological control**: Using beneficial organisms
- **Breeding programs**: Understanding genetic relationships
- **Soil health**: Role of microorganisms

Biotechnological Applications

Industrial Microbiology:

- **Fermentation**: Bacteria and yeasts

- **Enzyme production**: Fungal sources
- **Antibiotic synthesis**: Microbial products
- **Waste treatment**: Microbial decomposition

Environmental Applications

Ecosystem Services:

- **Decomposition**: Recycling nutrients
- **Nitrogen fixation**: Bacterial processes
- **Pollution indicators**: Lichen monitoring
- **Bioremediation**: Cleaning up pollutants

Study Strategies for Board Exams

Important Topics Priority

High Priority:

- Five kingdom classification criteria
- Characteristics of each kingdom
- Major groups in each kingdom
- Economic importance of organisms
- Disease-causing organisms

Medium Priority:

- Detailed life cycles
- Morphological structures
- Reproduction methods

- Ecological roles

Low Priority:

- Scientific names (unless specifically asked)
- Minor classification details
- Advanced molecular concepts

Exam-Focused Questions

Short Answer Questions (2-3 marks):

- Define classification terms
- List characteristics of kingdoms
- Give examples of organisms
- State economic importance

Long Answer Questions (5 marks):

- Compare different kingdoms
- Describe life cycles
- Explain symbiotic relationships
- Discuss ecological significance

Diagram-Based Questions:

- Structure of bacteria
- Viral structure
- Fungal reproductive structures
- Life cycles

Memory Techniques

Acronyms:

- **Five Kingdoms**: My Pets Frequently Play Around (Monera, Protista, Fungi, Plantae, Animalia)
- **Bacterial shapes**: Can't Believe Very Small (Coccus, Bacillus, Vibrio, Spirillum)

Comparisons:

- Make comparison tables
- Contrast similar groups
- Identify key differences
- Use flowcharts

Visual Learning:

- Draw diagrams
- Use color coding
- Create concept maps
- Make flowcharts

Summary and Key Points

Historical Development:

- Classification evolved from practical needs to scientific systems
- Aristotle → Linnaeus → Whittaker represents increasing sophistication
- Modern classification incorporates molecular data

Five Kingdom System:

- **Monera**: Prokaryotic, diverse metabolism
- **Protista**: Unicellular eukaryotes, link between kingdoms
- **Fungi**: Heterotrophic eukaryotes with chitin walls
- **Plantae**: Autotrophic eukaryotes with cellulose walls
- **Animalia**: Heterotrophic multicellular eukaryotes without walls

Acellular Forms:

- **Viruses**: Obligate parasites at life's boundary
- **Viroids**: RNA-only pathogens of plants
- **Prions**: Protein-only infectious agents
- **Lichens**: Successful symbiotic partnerships

Modern Trends:

- Molecular phylogeny replacing morphological classification
- Three-domain system gaining acceptance
- Continued refinement as knowledge increases

Practical Importance:

- Medical diagnosis and treatment
- Agricultural pest management
- Industrial applications
- Environmental monitoring

EXAM SPRINT - Master biological classification with focused study, regular practice, and conceptual understanding rather than rote memorization. Success comes from connecting

concepts across kingdoms and understanding evolutionary relationships.

Source: NCERT Biology Textbook Class 11 - Chapter 2

Complete coverage for comprehensive board exam preparation