

CHARACTER AND CLASSIFICATION OF PHYLUM PROTOZOA

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Definition:

Unicellular or acellular, eukaryotic and commonly motile heterotrophic organisms are called Protozoa.

It is a loose assemblage of different groups of unicellular organisms and they do not belong to a monophyletic lineage, probably shares a member of polyphyletic lineages. Dobell (1911) first introduced the term 'acellular' or non-cellular, instead of unicellular and Hyman (1940) extensively used the term acellular or non-cellular.

General Characteristic Features:

1. Protozoans are usually microscopic and unicellular individuals.
2. They exhibit all types of symmetry.
3. Most species occur as single but many are colonial.
4. Body is bounded by a cell membrane or plasmalemma.
5. Body may be naked or is covered by a pellicle or a test, made of silica or calcium carbonate.
6. A filamentous network of the cytoskeleton may form a dense supportive structure, called the epiplasm.
7. Usually uninucleate, but may be more than single nucleus in some forms.
8. Locomotor organelles may be flagella (e.g., Euglena), cilia (e.g., Paramecium), pseudopodium (e.g., Amoeba) or absent in parasitic forms (contractile myonemes are present in the body).
9. Nutrition may be holozoic, e.g., Amoeba (animal-like), holophytic (e.g., Euglena), saprophytic, mixotrophic or parasitic.
10. Intracellular type of digestion occurs within the food vacuoles.
11. Respiration performs generally through the outer surface of the body, but may be few obligatory or facultative anaerobes.

12. Excretion performs generally through the body surface, and water regulation of the body is accomplished by contractile vacuole.
13. Asexual reproduction occurs by fission (mitosis), plasmotomy or budding. In certain forms sexual reproduction may occur either by conjugation or fusion by gametes (syngamy).
14. They never develop from blastula stage during development.
15. Mainly aquatic but many are parasitic, commensal or mutualistic.

Classification

A. Subphylum Sarcomastigophora:

Features:

1. Locomotory structures are present either in the form of flagella, pseudopodia or both.
2. Nucleus is usually of single type (excepting the developmental stages of certain Foraminiferida).
3. No spore formation.
4. Sexual reproduction when present is through syngamy.

It includes three super-classes—Mastigophora, Opalinata and Sarcodina.

Superclass Mastigophora:

Features:

1. Either solitary or colonial.
2. Presence of one or more flagella in trophozoite stage.
3. Sexual reproduction is uncommon.
4. Nutrition may be either phototrophic or heterotrophic or both.

It is subdivided into two classes—Phytomastigophorea and Zoomastigophorea.

I. Class Phytomastigophorea:

Features:

1. Usually possess chromatophores which may be secondarily lost.
2. Presence of one or two emergent flagella.
3. In some groups amoeboid forms occur.
4. Most members are free-living and certain forms exhibit sexual reproduction.

There are ten orders in this class.

Order 1. Chrysomonadida:

Features:

1. Presence of one to three flagella.

2. One or two yellow or yellow green or brown coloured chromatophores are usually present.
 3. Amoeboid stages are frequent.
 4. Food reserves are present as leucosin and lipids.
 5. Cyst wall is always siliceous.
- Examples. Ochromonas, Chromulina.

Order 2. Silicoflagellida:

Features:

1. Flagellum is either absent or only one.
2. Chromatophores are brown coloured.
3. Inner skeleton is made up of silica.

Examples. Dictyocha, Clathropyxidella.

Order 3. Coccolithophorida

Features:

1. Flagella and chromatophores are always two in number.
2. Presence of calcareous plates as external covering.
3. Usually marine.

Examples. Discoaster, Coccolithus.

Order 4. Heterochlorida:

Features:

1. Two flagella are of unequal length.
2. Yellow green coloured chromatophores vary from two to several.
3. Usually amoeboid forms are present.
4. Lipids are common food reserves.
5. Walls of cysts are made up of silica

Examples. Heterochloris, Rhizochloris.

Order 5. Cryptomonadida:

Features:

1. Body is compressed.
2. Two flagella usually originate from a depression.
3. Chromatophores are two and usually brown but may be red, olive green or blue green in colour.
4. Amoeboid stages are absent.
5. Starch and amyloid bodies are the usual food reserves.

Examples. Chilomonas, Cryptomonas.

Order 6. Dinoflagellida:

Features:

1. Body is divided into cingulum and sulcus by transverse and longitudinal grooves.
2. Each part contains a flagellum.
3. Of these two flagella, one is transverse and causes both rotation and forward movement, and the other longitudinal one drives water posteriorly and helps in forward movement.
4. Chromatophores are either yellow or dark brown, but may be green or blue green.
5. A theca, a thickened pellicle is present in many forms.
6. Reserve foods are starch and lipids.

Examples. Noctiluca, Gymnodinium, Glenodinium, Amphidinium, Ceratium, Dinophysis, Zooanthella.

Order 7. Ebrida:

Features:

1. Chromatophores are absent and usually with two flagella.
2. Internal skeleton is siliceous.

Example. Ebria.

Order 8. Euglenida:

Features:

1. One or two flagella arise from an anterior reservoir.
2. Chromatophores are green and their shapes may vary.
3. Though body form may change yet no amoeboid movement occurs.
4. Food reserves are present as paramylum.

Examples. Euglena, Peranema.

Order 9. Chloromonadida:

Features:

1. Two flagella originate from the side of a superficial apical cleft or furrow.
2. Body is dorsoventrally flattened.
3. Chromatophores green and numerous.
4. Food reserves present as lipids and glycogen.

Example. Gonyostomum.

Order 10. Volvocida (Phytomonadida):

Features:

1. Either solitary or colonial.

2. Flagella are two to four and apical.
 3. Chromatophores, when present, are leaf green.
 4. Appearance more or less like a shell or cup.
 5. Amoeboid forms usually absent.
 6. Food reserves in the form of starch.
- Examples. *Pandorina*, *Volvox*.

II. Class Zoomastigophorea:

Features:

1. Usually live in association.
2. Chromatophores are absent.
3. Presence of one to many flagella.
4. Amoeboid forms, when present, may not have flagella.

It includes nine orders.

Order 1. Choanoflagellida:

Features:

1. Free-living and may be solitary or colonial.
2. A peduncle for attachment may be present in some forms.
3. Flagellum is single, anteriorly placed and enclosed posteriorly by a thin collar.

Examples. *Proterospongia*, *Codosiga*.

Order 2. Bicosoecida:

Features:

1. Free-living, with two flagella—one is free and the other is attached to the posterior end.

Examples. *Bicosoeca*, *Poteriodendron*.

Order 3. Rhizomastigida:

Features:

1. Usually free-living.
2. Flagella and pseudopodia occur either at the same time or at different times.

Examples. *Dimorpha*, *Histomonas*.

Order 4. Kinetoplastida:

Features:

1. Most members live in association.
2. Number of flagella varies from one to four.
3. A self-replicating (DNA), Feulgen positive organella, called Kinetoplast, is located within a single large mitochondrion.

Examples. Trypanosoma, Leishmania, Herpetomonas, Bodo.

Order 5. Retortamonadida:

Features:

1. Usually live in association.
2. Presence of a ventral cytostome with fibrillar border.
3. Number of flagella ranges from two to four, and one of them is turned posteriorly to remain attached with cytostomal region.

Examples. Retortamonas, Chilomastix.

Order 6. Diplomonadida:

Features:

1. Most members live in association.
2. Body is bilaterally symmetrical and possesses two karyomastigonts each having four flagella and set of accessory organelles.

Example. Giardia.

Order 7. Oxymonadida:

Features:

1. Presence of one or more karyomastigonts, each having two pairs of flagella.
2. A few flagella are turned posteriorly and attach for some distances to the body surface.
3. Axostyles vary one to many.

Examples. Oxymonas, Pyrsonympha.

Order 8. Trichomonadida:

Features:

1. Presence of four to six flagella.
2. Undulating membrane, when present, is associated with recurrent flagellum.
3. Axostyle and parabasal apparatus are present.
4. Spindle during division is extra-nuclear.
5. Sexual reproduction and cyst formation are absent.
6. Usually live in association.

Examples. Trichomonas, Tritrichomonas.

Order 9. Hypermastigida:

Features:

1. Presence of six multiple flagella and numerous parabasal apparatus.
2. Golgi apparatus and filament associated with basal body constitutes the parabasal body.

3. Kinetosomes are distributed in various ways and meet anteriorly in a central structure.
4. Uninucleated and extra-nuclear spindle formation occurs during division.
5. Occurrence of sexual reproduction is observed in some forms.

Examples. Lophomonas, Trichonympha.

Superclass Opalinata:

It includes a single order Opalinida.

Order Opalinida:

Features:

1. Presence of cilium-like organelles in oblique rows over entire body surface.
2. Cytostome is absent, more than one nucleus of same type.
3. Sexual reproduction happens through the production of anisogamous flagellated gametes.
4. Always live in association.

Examples. Opalina, Zelleriella.

Superclass Sarcodina:

Features:

1. Usually free-living locomotor organella in the form of pseudopodia.
2. Flagella appear in some forms during development.
3. Cortical cytoplasm is undifferentiated.
4. Body may or may have various types or exo or endo-skeleton.
5. Asexual reproduction occurs by fission.
6. Sometimes sexual reproduction with flagellate or amoeboid gametes is noted.

The members of this superclass are again subdivided into three classes— Rhizopodea, Piroplasmae and Actinopodea.

III. Class Rhizopodea:

Features:

1. Nutrition is phagotrophic.
2. Pseudopodia may be lobopodia, filo- podia or reticulopodia.

There are five subclasses—Lobosia, Filosia, Granuloreticulosia, Mycetozoa and Labyrinthulia.

Subclass 1. Lobosia:

Features:

1. Locomotion by characteristic lobose type of pseudopodia, occasionally becoming filiform or anastomosing.

It consists of the orders, Amoebida Arcellinida.

Order 1. Amoebida:

Features:

1. Uninucleate and without any covering.
2. Majority, are free-living.

Examples. Amoeba, Pelomyxa, Entamoeba, Chaos.

Order 2. Arcellinida:

Features:

1. Free-living forms having a test or rigid membranes.
2. Pseudopodia protrude through definite aperture.

Examples. Arcella, Diffugia.

Subclass 2. Filosia:

Features:

1. Filopods are tapering and branching but the branches rarely anastomose.
- Two orders, Aconchulinida and Gromiida are included within this subclass.

Order 1. Aconchulinida:

Features:

1. Filosia with naked body.

Example. Penardia.

Order 2. Gromiida:

Features:

1. Presence of test with definite aperture.
2. Certain members possess uniflagellate gametes.

Examples. Gromia, Euglypha.

Subclass 3. Granuloreticulosia:

Features:

1. Pseudopods are thin, reticular and granular.

Three orders, Athalamida, Foraminiferida and Xenophyophorida are present within this subclass.

Order 1. Athalamida:

Features:

1. Without any test and pseudopodia may originate from any part of the body.

Example. Biomyxa.

Order 2. Foraminiferida:

Features:

1. Presence of a test having one or more chambers.
2. Pseudopodia appear from aperture or perforations or both.
3. Life cycle involves definite alteration of sexual and asexual forms.
4. Gametes are with flagella and sometimes they may be amoeboid.
5. Presence of sexual dimorphism in some.

Examples. Elphidium, Rosalina, Globigerina.

Order 3. Xenophyophorida:

Features:

1. Body is multinucleated Plasmodium i.e. the amoeboid syncytial mass, and network of pseudopodia passes through a hollow organic tube.
2. Many foreign particles are present in the interstices of pseudopodial network.

Example. Stannoma.

Subclass 4. Mycetozoia:

Features:

1. Trophic amoeboid forms either form an aggregate or a multinucleate Plasmodium.
2. Complicated life cycle involves sexual reproduction and ends in sporangia form.
3. Spore gives rise to amoeboid form.
4. Nutrition may be heterotrophic or osmotrophic.

This subclass includes three orders— Acrasida, Eumycetozoida and Plasmodiophorida.

Order 1. Acrasida:

Features:

1. Never forms true plasmodium.
2. Flagellated stage absent.
3. Free-living.
4. No sexual reproduction.

Example. Dictyostelium.

Order 2. Eumycetozoida:

Features:

1. Free-living.
2. Flagellated stage present.

3. Presence of true plasmodium and typical sporangia with peridia (pi.), i.e., the covering of the spore-bearing organ and capillitia (pi.), i.e., a net-work of filaments in which spores are embedded within sporangia.

Examples. Physarum, Ceratiomyxa.

Order 3. Plasmodiophorida:

Features:

1. Live in association with plants.
2. Occurrence of large plasmodium with host tissue.
3. Presence of flagellated stages.
4. Sporangia without peridia and capillitia.

Example. Plasmodiophora.

Subclass 5. Labyrinthulia:

Only one order Labyrinthulida represents the subclass.

Order Labyrinthulida:

Features:

1. Individuals are spindle-shaped and form a net along filamentous tracks.
2. Either live on marine plants or in soil.
3. True amoeboid stage lacking.

Example. Labyrinthula.

IV. Class Piroplasma:

It includes a single order piroplasmida.

Order Piroplasmida:

Features:

1. Small forms of various shapes.
2. Spores, flagellal and cilia absent.
3. Locomotion by gliding.
4. Binary fission takes place.
5. Lives as parasite in vertebrate blood and are carried by ticks.

Examples. Theileria, Babesia.

V. Class Actinopodea:

Features:

1. Usually floating with spherical body and delicate pseudopodia.
2. Pseudopodia may be axopodia, filose or reticulate.
3. Usually naked, when test present it is either membranous or chitinous or silicious or strontium.

4. Both asexual and sexual reproduction occur.
5. Gametes are flagellated.

There are four subclasses, **Radiolaria**, **Acanthacia**, **Heliozoia** and **Proteomyxida**.

Subclass 1. Radiolaria:

Features:

1. Marine forms having one to many pores in the central capsule.
2. Presence of siliceous spicules or skeleton.
3. Locomotor organelles are either filopod or reticulopod or axopod.

Two orders, Porulosida and Oculosida are included within this subclass.

Order 1. Porulosida:

Features:

1. The round central capsule bears pores all around.

Examples. Pipetta, Thalassicolla.

Order 2. Oculosida:

Features:

1. The central capsule has pores only at one pole.

Examples. Cystidium, Eucyrtidium.

Subclass 2. Acantharia:

Features:

1. Thin central capsule with membranous poreless covering.
2. Strontium sulphate forms regularly oriented radial spines.
3. Pseudopodia as axopod.
4. All are marine.

Two orders included are—Acanthometrida and Acanthophractida.

Order 1. Acanthometrida:

Features:

1. Rod-like skeleton without lattice shell.

Example. Acanthometron.

Order 2. Acanthophractida:

Features:

1. Skeleton completely latticed.
- Example. Challengeron.

Subclass 3. Heliozoia:

Features:

1. Central capsule is absent.
2. Sometimes skeletons are present as siliceous scales or spines, but usually naked.
3. Locomotion through axopods or filopods.
4. Most of the members are freshwater.

It has three orders—Actinophryida, Centrohelida and Desmothoracida.

Order 1. Actinophryida:

Features:

1. Skeleton and centroplast are absent.

Examples. Actinophrys, Actino-sphaerium.

Order 2. Centrohelida

Features:

1. Centroplast is present.
2. Plate or spine-like skeletons are siliceous.

Example. Acanthocystis.

Order 3. Desmothoracida:

Features:

1. Centroplast is absent.
2. Chitinous skeleton has siliceous impregnation.

Example. Clathrulina.

Subclass 4. Proteomyxidia:

Features:

1. Filopodia and reticulopodia are present in some species.
2. Marine and freshwater parasites of algae and higher plants.

Order Proteomyxida:

Features:

1. Only a few forms are free-living.
2. No test, filopodia, reticulopodia and flagellated forms
3. Cysts are seen in some cases.

Examples. Pseudospora, Leptomyxa.

B. Subphylum Sporozoa:

Features:

1. Simple spores without polar filaments carry one to many sporozoites.
2. Cilia absent but flagellated gametes may occur.
3. Sexual reproduction, when occurs, is syngamous.
4. All the forms live in association.

It is subdivided into three classes— Telosporea, Toxoplasmea and Hoplosporea.

VI. Class Telosporea:

Features:

1. Spores are seen.
2. Both asexual and sexual reproduction take place.
3. Locomotion by gliding or body flexion.
4. Pseudopodia are usually absent but sometimes used only for food capture.
5. Microgametes are flagellated in some. Two subclasses Gregarina and Coccidia are included in this class.

Subclass 1. Gregarina:

Features:

1. Live as extracellular parasites in the digestive tract and body cavity of invertebrates.

It consists of three orders— Archigregarinida, Eugregarinida and Neogregarinida.

Order 1. Archigregarinida

Features:

1. Presence of three schizogony.
2. Live as parasites of ascidians, enteropneusids, sipunculids and annelids.

Example. Selenidium.

Order 2. Eugregarinida:

Features:

1. Live as parasites of annelids and arthropods and have no schizogony.

Examples. Monocystis, Gregarina, Nina.

Order 3. Neogregarinida:

Features:

1. Presence of secondary, schizogony.
2. Lives as parasite of insects.

Example. Ophryocystis.

Subclass 2. Coccidia:

Features:

1. Always live as intracellular parasite and have small trophozoites.
- Two orders, Protococcida and Eucoccida are present in this subclass.

Order 1. Protococcida:

Features:

1. Parasites of marine annelids and do not have schizogony.

Example. Eucoccidium.

Order 2. Eucoccida:

Features:

1. Live as parasite in epithelial and blood cells of invertebrates and vertebrates.
2. Presence of schizogony.
3. Alternation of asexual and sexual phases in life cycle.

Examples. Eimeria, Plasmodium.

VII. Class Toxoplasmea:

It includes single order Toxoplasmoda under this class.

Order Toxoplasmoda:

Features:

1. No spore formation.
2. Asexual reproduction by binary fission.
3. Locomotion is effected by gliding or body flexion.
4. Structures like pseudopodia and flagella are absent.
5. Cysts include naked trophozoites.

Examples. Toxoplasma, Sarcocystis.

VIII. Class Haplosporea:

It includes a single order Haplosporida.

Order Haplosporida:

Features:

1. Presence of spores, only asexual reproduction takes place.
2. Schizogony is present.
3. Though pseudopodia may appear in some cases, yet flagella are absent.

Examples. Haplosporidium, Coelosporidium.

C. Subphylum Cnidospora:

Features:

1. Presence of spores having one or more spore filaments and sporoplasms.
 2. All the members live as parasite.
- Two classes—Myxosporidea and Microsporidea are present.

IX. Class Myxosporidea:

Features:

1. Multicellular state gives rise to spore.
2. Presence of one or more sporoplasms and more than one valve.

It comprises of three orders— Myxosporida, Actinomyxida and Helicosporida.

Order 1. Myxosporida:

Features:

1. Presence of one or two sporoplasms and one to six polar capsules.
2. Each capsule having a coiled polar filament for anchoring.
3. Spore membrane may have up to six valves.
4. Live as parasite in poikilothermal vertebrates.

Examples. Leptotheca, Myxidium.

Order 2. Actinomyxida:

Features:

1. Presence of three polar capsules in a spore.
2. Each capsule with a polar filament.
3. Three valves are present in the membrane.
4. Many sporoplasms occur.
6. Live in annelids and other invertebrates.

Example. Triactinomyxon.

Order 3. Helicosporida:

Features:

1. Three sporoplasms in a spore are enclosed by coiled thick filament.
2. Spore membrane possesses one valve.
3. Parasites in insects.

Example. Helicosporidium.

X. Class Microsporidea:

Order Microsporida:

Features:

1. Spores originate from a single cell.
2. Presence of single sporoplasm, valve and an elongated tubular polar filament.
3. Parasites in invertebrates.

Examples. Caudospora, Nosema.

D. Subphylum Ciliophora:

A single class Ciliata, constitutes the subphylum.

XI. Class Ciliata:

Features:

1. Free living forms with cilia or ciliated organelle at least in some part of the life cycle.
2. Sub-pellicular infra-ciliature always present, even during the absence of cilia.
3. Usually two types of nuclei are seen.
4. Both asexual and sexual reproductions occur.
5. Sexual reproduction involves either conjugation or autogamy or cytogamy.
6. Nutrition is heterotrophic.

It is divided into four subclasses— Holotrichia, Peritrichia, Suctoria and Spirotrichia.

Subclass 1. Holotrichia:

Features:

1. Ciliature on the surface is uniform and simple.
2. Buccal ciliature present in a few cases.

It includes seven orders:

Order 1. Gymnostomatida:

Features:

1. Larger-sized forms with no oral ciliature.
2. Cytostome communicates directly to the outside.
3. Presence of rods in the cytopharyngeal wall.

Examples. Didinium, Urotricha.

Order 2. Trichostomatida:

Features:

1. Generally body ciliation is uniform but may be asymmetrical in some cases.
2. No buccal ciliation in oral area.

Examples. Balantidium, Colpoda.

Order 3. Chonotrichida:

Features:

1. Body ciliature absent in mature forms which are vase-shaped and cling to the crustacean body by means of non- contractile stalk.
 2. Reproduction is asexual and by budding.
- Examples. Spirochona, Chilodochona.

Order 4. Apostomatida:

Features:

1. Body ciliature in mature forms is spiral.
2. Cytostome is inconspicuous.
3. Life cycle exhibits polymorphous.

Examples. Foettingaria, Polyspira.

Order 5. Astomatida:

Features:

1. Body ciliature is uniform.
2. Cytostome is absent.
3. Usually of large size, some have endoskeletons or structures as holdfast.
4. Usually parasites in oligochaetes.

Examples. Anoplophrya, Haptophrya.

Order 6. Hymenostomatida:

Features:

1. Small-sized forms.
2. Uniform body ciliature.
3. Buccal cavity is ventral and presence of one undulating membrane on the right.
4. Three membranelles on the left.

Examples. Tetrahymena, Paramoecium.

Order 7. Thigmotrichida:

Features:

1. Tuft of cilia is present near the anterior end.
2. Buccal ciliature either ventral or posteriorly placed.
3. Usually live in association with bivalve molluscs.

Examples. Ancistrocoma, Concho- phthirus.

Subclass 2. Peritrichia:

The only order belonging to this subclass is Peritrichida.

Order Peritrichida:

Features:

1. Body ciliature is usually absent in matured forms.

2. Presence of either contractile stalk or adhesive disc for attachment to the substrate.
3. Ciliary arrangement in the oral region is conspicuous.
4. It coils here around apical pole counter-clockwise to cytostome.

Examples. Vorticella, Epistylis.

Subclass 3. Suctoria:

It includes a single order Suctorida.

Order Suctorida:

Features:

1. Absence of external ciliature in mature forms.
2. Usually sessile with non-contractile stalk for attachment.
3. Presence of suctorial tentacles for nutrition.
4. Reproduction by budding.
5. Larva is free-swimming and with external ciliation.

Examples. Podophyra, Acineta.

Subclass 4. Spirotrichia:

Features:

1. External ciliature is sparse in most.
2. Presence of cirri in some.
3. Elaborate buccal ciliature.
4. Presence of adoral zone with many membranelles.
5. Oral cilia coil around apical pole in clockwise to cytostome.

It includes six orders under this subclass:

Order 1. Heterotrichida

Features:

1. External ciliature is uniform.
2. Large sized body in some cases bears pigments.

Examples. Stentor, Spirostomum.

Order 2. Oligotrichida:

Features:

1. External ciliature is absent.
2. Prominent buccal membranelles are present.
3. Small size.
4. Usually marine.

Examples. Halteria, Tontonia.

Order 3. Tintinnida:

Features:

All with varied coverings, called lorica, from where prominent oral membranelles extend.

2. Marine.

Examples. Tintinnus, Codonella.

Order 4. Entodiniomorphida:

Features:

1. External ciliature is absent.

2. Oral membranelles are restricted.

3. Presence of membranelar tufts or zones.

4. Pellicle stiff and extended posteriorly in some forms as spine.

Examples. Entodinium, Diplodinium.

Order 5. Odontostomatida:

Features:

1. Eight membranelles represent oral ciliature.

2. Laterally compressed miniature body sometimes possesses spines on the pellicle.

Example. Saprodinium.

Order 6. Hypotrichida:

Features:

1. Various types of cirri are ventrally placed.

2. Dorso-ventrally flattened body.

3. Membranelles are prominent in anterior zone.

Examples. Aspodisca, Gastrostyla, Euplotes.