

CHAPTER 11 PROTOZOANS

Protozoa are a diverse assemblage with mixed affinities.

- a. They lack a cell wall.
- b. They have at least one motile stage in the life cycle.
- c. Most ingest their food.

Biological Contributions

- 1. Protozoa have intracellular specialization or organization of organelles in cells.
- 2. Cells may have distinct functions; some colonial protozoa have separate somatic and reproductive zooids.
- 3. Asexual reproduction occurs by mitotic division.
- 4. Some have true sexual reproduction with zygote formation.
- 5. Responses to stimuli represent the simplest reflexes and inborn behaviors known.
- 6. Shelled protozoa have the simplest exoskeletons.
- 7. Basic enzymes systems support all types of nutrition: autotrophic, saprozoic and holozoic.
- 8. Many have developed means of locomotion

General Features

- 1. A protozoan is a complete organism in which all life activities are carried on within the limits of a single plasma membrane.
- 2. Phylogenetic studies show that protozoa do not form a monophyletic group.
- 3. Over 64,000 species are named; half are fossils.
- 4. Although they are unicellular organisms, protozoan cell organelles are highly specialized.
- 5. They are ecological diverse, widely dispersed, but many are limited to narrow environmental ranges.
- 6. They can be fantastically numerous, forming gigantic ocean soil deposits.
- 7. About 10,000 are symbiotic in or on animals or plants; some are human disease agents.
- 8. Some are colonial with multicellular stages but have noncolonial forms.
- 9. Protozoa have only one non-reproductive cell type and lack embryonic development; embryonic development is one of the criteria for metazoa.

Characteristics of Protozoan Phyla

- 1. They are unicellular with some colonial and multicellular stages.
- 2. Most are microscopic.
- 3. All symmetries are present within members of the group.
- 4. No germ layers are present.
- 5. No organs or tissues are formed, but specialized organelles serve many of these functions
- 6. They include free-living, mutualistic, commensal and parasitic forms.
- 7. They move by pseudopodia, flagella, cilia and they can direct cell movements.
- 8. Most are naked, but some have a simple endoskeleton or exoskeleton.
- 9. All types of nutrition are present: autotrophic, heterotrophic and saprozoic.
- 10. They can be aquatic or terrestrial.
- 11. Reproduction is asexual by fission, budding or cysts; or sexual by conjugation or syngamy of gametes.
- **Classification:** Follows Hausmann and Hulsmann (1996) and represents a major departure from the Eleventh Edition:
 - Phylum Chlorophyta
 - Phylum Retortamonada

- Class Diplomonadea
- Order Diplomonadida
- Phylum Axostylata
- Class Parabasalea
- Order Trichomonadida
- Phylum Euglenozoa
- Subphylum Euglenida
- Class Euglenoidea
- Subphylum Kinetoplasta
- Class Trypanosomatida
- Members of Axostylata have a stiffening rod composed of microtubules, the **Axostyle**. (Figure 11.11)
- Members of the Class Parabasalea have a **parabasal body**, which is a Golgi apparatus connected by a fiber to one of the kinetosomes.
- Although mitochondria are absent, members of Order Trichomonadida possess **hydrogenosomes** which are organelles analogous to mitochondria but which produce molecular hydrogen when oxygen is absent.
- *Trichomonas vaginalis* infects the urogenital tract of humans and is sexually transmitted.

Representative Types

Phyla Retortamonada and Axostylata

- Small groups but of importance to humans.
- May represent groups derived very early from an ancestral eukaryote before mitochondria and plastids were acquired by symbiogenesis.
- Mitochondrial enzymes have been reported in both groups so their absence of mitochondria may be a secondary derivation.

Retortamonads lack both mitochondria and Golgi bodies (e.g., *Giardia lamblia*)

Phylum Sarcodina

1. This includes two subgroups of protozoa that move by either pseudopodia or flagella; however, some in each group use the method found predominantly in the other group.
2. **Subphylum Mastigophora:** the Flagellated Protozoa

This is divided into class Phytomastigophorea with chlorophyll and animal-like Zoomastigophorea without chlorophyll.

- Phylum Sarcodina (the amoeba and relatives)
- Some are naked and some have shells
- A. Radiolaria
- B. Foraminifera
- In some classifications these are placed in a subphylum Actinopoda.
- The other members of sarcodines are put in Rhizopoda

Subphylum Kinetoplasta

- a. Zooflagellates lack chromoplasts and have holozoic or saprozoic nutrition; most are symbiotic.
- b. Trypanosoma is an important genus of protozoan parasites; some are not pathogenic.
- 1) *Trypanosoma brucei gambiense* and *T. b. rhodesiense* cause African sleeping sickness in humans.
- 2) *T. brucei brucei* causes a related disease in domestic animals.
- 3) These trypanosomas are transmitted by tsetse flies; natural reservoirs include antelope and other wild mammals.

➤ **Subphylum Sarcodina**

- a. *Amoeba proteus* in the superclass Rhizopoda is most commonly studied.
- b. They are freshwater but require a substratum on which to crawl.
- c. The cell membrane encloses the ectoplasm and endoplasm.
- d. The nucleus, contractile vacuole and vesicles can be seen by microscope.
- e. Ameba feed on algae, protozoa, rotifers, etc. by phagocytosis; food vacuoles exist 15-30 hours.
- f. Reproduction is by binary fission using mitosis.
- g. Other rhizopoda include the huge *Chaos carolinense*, *Amoeba radiosa* with slender pseudopodia and entozoic ameba.
- h. *Entamoeba histolytica* lives in the human large intestine and attacks the intestinal wall with enzymes, causing severe and often fatal diarrhea.
- i. *Entamoeba coli* in the intestine and *E. gingivalis* in the mouth are not disease agents.
- j. Some rhizopods have a siliceous or chitinous test for protection; pseudopodia project from openings.
- k. Foraminiferans are shelled rhizopods found mainly in oceans; some have complex haploid and diploid cycles.
- l. Slime molds in class Eumycetozoa live on forest detritus; they stream together to form a pseudoplasmodium with discrete cells or a multinucleate plasmodium producing a fruiting body.
- m. Radiolarians reproduce by binary fission, budding and sporulation.
- **Role of Sarcodina in Building Earth Deposits**
- a. Hard shells of foraminiferans and radiolarians have been preserved since Precambrian times.
- b. Abundant in the Cretaceous and Tertiary periods, some measured up to 100 mm in diameter!
- c. One-third of the sea bottom ooze in the Atlantic consists of *Globigerina* shells.
- d. Radiolarians have less soluble siliceous shells and form the ooze in Pacific and Indian oceans and fossil in Tertiary rocks of California.
- e. The White Cliffs of Dover are sedimentary sarcodine deposits that were uplifted.
- f. Their use as indicators of rock ages is important to oil geologists.
- **Pseudopodia (Figures 11.4, 11.5)**
- a. This is chief means of locomotion in Sarcodina, many flagellates and ameboid cells of many invertebrates and vertebrates.
- b. **Lobopodia** are large blunt extensions of the cell body containing both endoplasm and ectoplasm.
- c. In the **limax** form, the whole body moves rather than sending out arms.
- d. **Filopodia** are thin extensions containing only ectoplasm; these are seen in class Filosea.
- e. **Reticulopodia** repeatedly rejoin to form a netlike mesh.
- f. **Axopodia** occur in Actinopoda. (**Figure 11.6**)
 - 1) Axial rods of microtubules support these long thin pseudopodia.
 - 2) They form a geometrical array, which is the axonome of the axopod.
 - 3) Addition and removal of microtubular material extends and retracts the axopod.

- 4) Cytoplasm flows away from the body on one side and toward the body on the other.
- 4. **Superclass Actinopoda (Figure 11.17)**
- a. Actinopoda consist of the freshwater class Heliozoa and three marine classes of radiolarians.
- b. All have axopodia; and all, except Heliozoa, have tests.
- c. Radiolarians are the oldest known protozoa; they are pelagic and live in shallow water.
- d. A central perforated capsule separates the inner and outer cytoplasm.
- e. The shell surface is fused with spines; cytoplasm around the capsule extends axopodia to catch prey.
- **Phylum Apicomplexa (Superphylum Alveolata)**
- 1. All are endoparasites; hosts are in many animal phyla.
- 2. An apical complex is a feature of this phylum; it is present only in certain stages.
- 3. Rhoptries and micronemes help it penetrate the host's cells.
- 4. Pseudopodia occur in some stages; gametes may be flagellated and contractile fibrils may form waves to propel it through liquid.
- 5. The life cycle usually includes both sexual and asexual stages; an invertebrate may be an intermediate host.
- 6. At some point, they form a spore (oocyst) that is infective in the next host and protects the sporozoan.
- Class Sporozoa
- a. Sporozoa is the most important class; it contains three subclasses.
- 1) *Gregarinia*, or gregarines, are common parasites of invertebrates but are of little economic import.
- 2) *Piroplasmia* includes some veterinary parasites: *Babesia bigemina* causes Texas red-water fever in cattle.
- 3) *Coccidia* are important intracellular parasites in both invertebrate and vertebrates.
- b. *Eimeria* is a genus (along with *Isospora*) that causes coccidiosis.
- 1) *Isospora* infections are mild unless the immune system is weak, as in AIDS patients.
- 2) *Eimeria tenela* is often fatal to young fowl.
- 3) Organisms undergo schizogony in intestinal cells; the zygote forms an oocyst that passes in the feces and releases eight sporozoites when ingested by the next host.
- c. *Toxoplasma gondii* is a parasite of cats.
- 1) Rodents, cattle, sheep, birds and humans can ingest sporozoites.
- 2) They cross the intestine and asexually reproduce in tissues.
- 3) As the host builds immunity, the zoites enclose in tough tissue cysts called bradyzoites.
- 4) Up to half of the U.S. population carries tissue cysts from eating undercooked meat.
- 5) Toxoplasmosis is a serious threat during pregnancy; 2% of the cases of mental retardation may be due to congenital toxoplasmosis.
- **Plasmodium: The Malarial Organism**
- 1) Malaria is the most important infectious disease of humans.
- 2) Four species infect humans; each produces different clinical symptoms.

- 3) *Anopheles* mosquitoes carry all forms; the female injects the *Plasmodium* in her saliva.
- 4) **Sporozoites** penetrate liver cells and initiate schizogony.