Protozoa

By- Dr. Ekta Khare

Department of Microbiology,

Chhatrapati Shahu Ji Maharaj University, Kanpur

Introduction

- A protozoan can be defined as a usually motile eukaryotic unicellular protest.
- Protozoa grow in a wide variety of moist habitats.
- Most protozoa are free living and inhabit freshwater or marine environments.
- Many terrestrial protozoa can be found in decaying organic matter, in soil, and even in beach sand; some are parasitic in plants or animals.
- They make up a large part of **plankton**—small, free floating organisms that are an important link in the many aquaticfood chains and food webs of aquatic environments.
- A **food chain** is a series of organisms, each feeding on the preceding one.
- A **food web** is a complex interlocking series of food chains.
- Protozoa are also useful in biochemical and molecular biological studies.
- Many biochemical pathways used by protozoa are present in all eukaryotic cells.
- Some of the most important diseases of humans and animals are caused by protozoa.

Table 27.1 Pathogenic Protozoa That Cause Major Diseases of Domestic Animals

Protozoan Group[a]	Genus	Host	Preferred Site of Infection	Disease
Amoebae	*Entamoeba*	Mammals	Intestine	Amebiasis
	Iodamoeba	Swine	Intestine	Enteritis
Sporozoa	*Babesia*	Cattle	Blood cells	Babesiosis
	Theileria	Cattle, sheep, goats	Blood cells	Theileriasis
	Sarcocystis	Mammals, birds	Muscles	Sarcosporidiosis
	Toxoplasma	Cats	Intestine	Toxoplasmosis
	Isospora	Dogs	Intestine	Coccidiosis
	Eimeria	Cattle, cats, chickens, swine	Intestine	Coccidiosis
	Plasmodium	Many animals	Bloodstream, liver	Malaria
	Leucocytozoon	Birds	Spleen, lungs, blood	Leucocytozoonosis
	Cryptosporidium	Mammals	Intestine	Cryptosporidiosis
Ciliates	*Balantidium*	Swine	Large intestine	Balantidiasis
Flagellates	*Leishmania*	Dogs, cats, horses, sheep, cattle	Spleen, bone marrow, mucous membranes	Leishmaniasis
	Trypanosoma	Most animals	Blood	Trypanosomiasis
	Trichomonas	Horses, cattle	Genital tract	Trichomoniasis (abortion)
	Histomonas	Birds	Intestine	Blackhead disease
	Giardia	Mammals	Intestine	Giardiasis

Morphology

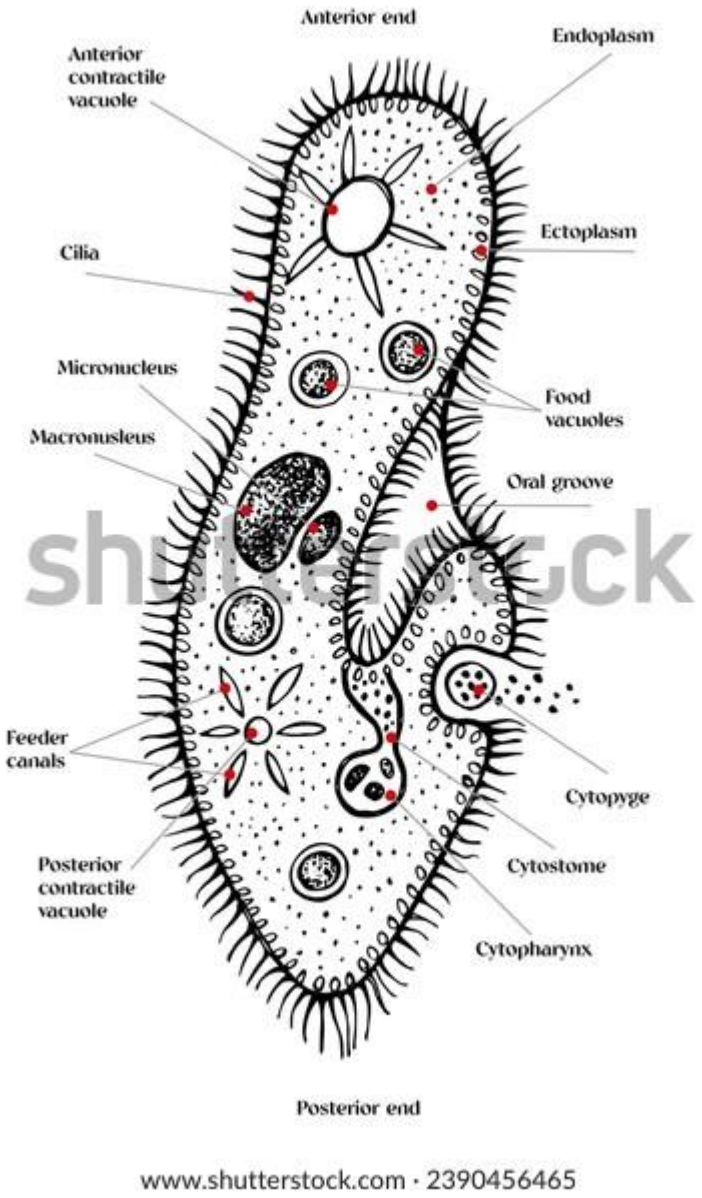
- In some species the cytoplasm immediately under the plasma membrane is semisolid or gelatinous, giving some rigidity to the cell body. It is termed the **ectoplasm.**
- The bases of the flagella or cilia and their associated fibrillar structures are embedded in the ectoplasm.
- The plasma membrane and structures immediately beneath it are called the **pellicle.**
- Inside the ectoplasm is the area referred to as the **endoplasm,** which is more fluid and granular in composition and contains most of the organelles.
- Some protozoa have one nucleus, others have two or more identical nuclei.
- Still other protozoa have two distinct types of nuclei—a macronucleus and one or more micronuclei.
- The **macronucleus,** when present, is typically larger and associated with trophic activities and regeneration processes.
- **The micronucleus** is diploid and involved in both genetic recombination during reproduction and the regeneration of the macronucleus.

…Morphology

- One or more vacuoles are usually present in the cytoplasm of protozoa.
- These are differentiated into contractile, secretory, and food vacuoles.
- **Contractile vacuoles** function as osmoregulatory organelles in those protozoa that live in a hypotonic environment, such as a freshwater lake.
- Osmotic balance is maintained by continuous water expulsion.
- Most marine protozoa and parasitic species are isotonic to their environment and lack such vacuoles.
- **Phagocytic vacuoles** are conspicuous in holozoic and parasitic species and are the sites of food digestion (*see figure 4.10*).
- **Secretory vacuoles** usually contain specific enzymes that perform various functions (such as excystation).

…Morphology

- Most anaerobic protozoa (such as *Trichonympha,* which lives in the gut of termites; *see figure 28.26*) have no mitochondria, no cytochromes, and an incomplete tricarboxylic acid cycle.
- However, some do have small, membrane-delimited organelles termed **hydrogenosomes.**
- These structures contain a unique electron transfer pathway in which hydrogenase transfers electrons to protons (which act as the terminal electron acceptors), and molecular hydrogen is formed.
- Other protozoa have mitochondria with discoid cristae (trypanosomes), tubular mitochondrial cristae (ciliates, sporozoa), and lamellar cristae (foraminiferans).



Nutrition

- Most protozoa are chemoheterotrophic.
- Two types of heterotrophic nutrition are found in the protozoa:
  - holozoic
  - saprozoic
- In **holozoic nutrition,** solid nutrients such as bacteria are acquired by phagocytosis and the subsequent formation of phagocytic vacuoles.
- Some ciliates have a specialized structure for phagocytosis called the **cytostome** (cell mouth).
- In **saprozoic nutrition,** soluble nutrients such as amino acids and sugars cross the plasma membrane by pinocytosis, diffusion, or carrier mediated transport (facilitated diffusion or active transport).

Encystment and Excystment

- Many protozoa are capable of **encystation.**
- They develop into a resting stage called a **cyst,** which is a dormant form marked by the presence of a wall and by very low metabolic activity.
- Cyst formation is particularly common among aquatic, free-living protozoa and parasitic forms.
- Cysts serve three major functions:
- (1) they protect against adverse changes in the environment, such as nutrient deficiency, desiccation, adverse pH, and low partial pressure of O_2;
- (2) they are sites for nuclear reorganization and cell division (reproductive cysts); and
- (3) they serve as a means of transfer between hosts in parasitic species.
- Although the exact stimulus for **excystation** (escape from the cysts) is unknown, excystation generally is triggered by a return to favorable environmental conditions.
- For example, cysts of parasitic species excyst after ingestion by the host and form the vegetative form called the **trophozoite.**

Locomotory Organelles

- A few protozoa are nonmotile.
- Most, however, can move by one of three major types of locomotory organelles: pseudopodia, flagella, or cilia.
- **Pseudopodia** are cytoplasmic extensions found in the amoebae that are responsible for the movement and food capture.
- There are many types of pseudopodia.
- Flagellates and ciliates move by flagella and cilia.
- Electron microscopy has shown that protozoan flagella and cilia are structurally the same and identical in function to those of other eucaryotic cells.

Asexual Reproduction

- Most protozoa reproduce asexually, and some also carry out sexual reproduction.
- The most common method of asexual reproduction is **binary fission.**
- During this process the nucleus first undergoes mitosis, then the cytoplasm divides by cytokinesis to form two identical individuals

Sexual Reproduction

- The most common method of sexual reproduction is **conjugation.**
- In this process there is an exchange of gametes between paired protozoa of complementary mating types (**conjugants**).
- Conjugation is most prevalent among ciliate protozoa. A well-studied example is *Paramecium caudatum*.
- At the beginning of conjugation, two ciliates unite, fusing their pellicles at the contact point.
- The macronucleus in each is degraded.
- The individual micronuclei divide twice by meiosis to form four haploid pronuclei, three of which disintegrate.
- The remaining pronucleus divides again mitotically to form two gametic nuclei, a stationary one and a migratory one.
- The migratory nuclei pass into the respective conjugates.
- Then the ciliates separate, the gametic nuclei fuse, and the resulting diploid zygote nucleus undergoes three rounds of mitosis.
- The eight resulting nuclei have different fates: one nucleus is retained as a micronucleus; three others are destroyed; and the four remaining nuclei develop into macronuclei.
- Each separated conjugant now undergoes cell division.
- Eventually progeny with one macronucleus and one micronucleus are formed.

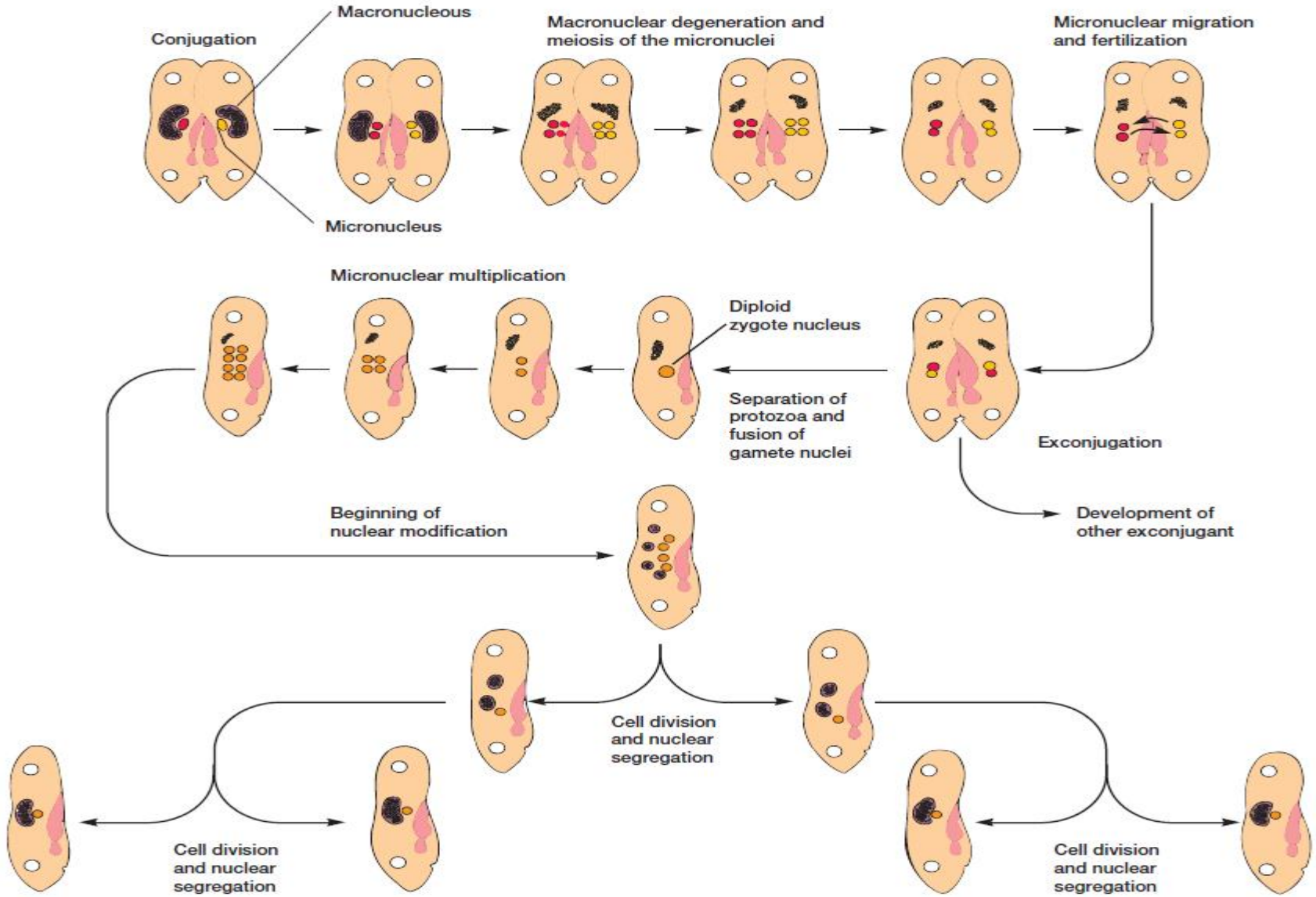


Figure 27.2 Conjugation in *Paramecium caudatum*, Schematic Drawing. Follow the arrows. After the conjugants separate, only one of the exconjugants is followed; however, a total of eight new protozoa result from the conjugation.

Classification

- Many protozoan taxonomists regard the *Protozoa* as a subkingdom, which contains seven of the 14 phyla found within the kingdom *Protista.*

Table 27.2 Abbreviated Classification of the Subkingdom *Protozoa*[a]

Taxonomic Group	Characteristics	Examples
Phylum: *Sarcomastigophora*	Locomotion by flagella, pseudopodia, or both; when present, sexual reproduction is essentially syngamy (union of gametes external to the parents); single type of nucleus	
Subphylum: *Mastigophora*	One or more flagella; division by longitudinal binary fission; sexual reproduction in some groups	
Class: *Zoomastigophorea*	Chromatophores absent; one to many flagella; amoeboid forms, with or without flagella; sexuality known in some groups; mainly parasitic	*Trypanosoma* *Giardia* *Trichomonas* *Leishmania* *Trichonympha*
Subphylum: *Sarcodina*	Locomotion primarily by pseudopodia; shells (tests) often present; flagella restricted to reproductive stages when present; asexual reproduction by fission; mostly free living	
Superclass: *Rhizopoda*	Locomotion by pseudopodia or by protoplasmic flow with discrete pseudopodia; some contain tests	*Amoeba* *Elphidium* *Coccodiscus*
Phylum: *Labyrinthomorpha*	Spindle-shaped cells capable of producing mucous tracks; trophic stage as ectoplasmic network; nonamoeboid cells; saprozoic and parasitic on algae and seagrass	*Labyrinthula*
Phylum: *Apicomplexa*	All members have a spore-forming stage in their life cycle; contain an apical complex; sexuality by syngamy; all species parasitic; cysts often present; cilia absent; often called the Sporozoa	*Plasmodium* *Toxoplasma* *Eimeria* *Cryptosporidium*
Phylum: *Microspora*	Unicellular spores with spiroplasm containing polar filaments; obligatory intracellular parasites	*Nosema*
Phylum: *Ascetospora*	Spore with one or more spiroplasms; no polar capsules or polar filaments; all parasitic in invertebrates	*Haplosporidium*
Phylum: *Myxozoa*	Spores of multicellular origin; one or more polar capsules; all parasitic, especially in fish	*Myxosoma*
Phylum: *Ciliophora*	Simple cilia or compound ciliary organelles in at least one stage in the life cycle; two types of nuclei; contractile vacuole present; binary fission transverse; sexuality involving conjugation; most species free living, but many commensal, some parasitic	*Didinium* *Stentor* *Vorticella* *Tetrahymena* *Paramecium* *Tokophrya* *Entodinium* *Nyctotherus* *Balantidium* *Ichthyophthirius*

[a]Based on the 1980 Committee on Systematics and Evolution of the Society of Protozoologists.