



### General Features

- Single-celled eukaryotic microorganisms belonging to kingdom protista are classified as **Protozoa**
- The single protozoal cell performs all functions.
- Most of the protozoa are completely nonpathogenic but few may cause major diseases such as malaria, leishmaniasis, and sleeping sickness.
- Protozoa like *Cryptosporidium parvum* and *Toxoplasma gondii* are being recognized as opportunistic pathogens in patients affected with human immunodeficiency virus (HIV) and in those undergoing immunosuppressive therapy.
- Protozoa exhibit wide range of size (1–150  $\mu\text{m}$ ), shape, and structure; yet all possess essential common features.

### Differences Between Protozoa and Metazoa

	Protozoa	Metazoa
Morphology	Unicellular; a single 'cell-like unit'	Multicellular; a number of cells, making up a complex individual
Physiology	A single cell performs all the functions: reproduction, digestion, respiration, excretion, etc.	Each special cell performs a particular function
Example	Amoeba	Tapeworm

### Structure

The typical protozoan cell is bounded by a trilaminar unit membrane, supported by a sheet of contractile fibrils enabling the cell to move and change in shape.

#### Cytoplasm

It has 2 portions:

**Ectoplasm:** Outer homogeneous part that serves as the organ for locomotion and for engulfment of food by producing **pseudopodia** is called as the ectoplasm. It also helps in respiration, discharging waste material, and in providing a protective covering of cell.

**Endoplasm:** The inner granular portion of cytoplasm that contains nucleus is called endoplasm. The endoplasm shows number of structures—the golgi bodies, endoplasmic reticulum, food vacuoles, and contractile vacuoles.

Contractile vacuoles serve to regulate the osmotic pressure.

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## Nucleus

The nucleus is usually single but may be double or multiple; some species having as many as hundred nuclei in a single cell.

The nucleus contains one or more nucleoli or a central karyosome.

### Terminologies used In Protozoology

- **Chromatoid Body**

Extranuclear chromatin material is called chromatoid body (e.g., as found in *Entamoeba histolytica* cyst).

- **Karyosome**

It is a DNA containing body, situated peripherally or centrally within the nucleus and found in intestinal amoeba, e.g. *E. histolytica*, *E. coli*.

- **Kinetoplast**

Non-nuclear DNA present in addition to nucleus is called kinetoplast. It is seen in trypanosomes. Flagellum originates near the kinetoplast. Point of origin of flagellum is called as **basal body**.

- **Cilia**

These are fine, needle-like filaments, covering the entire surface of the body and are found in ciliates, e.g. *Balantidium coli*.

- **Trophozoite (Trophos: nourishment)**

Active feeding and growing stage of the protozoa is called the trophozoites. It derives nutrition from the environment by diffusion, pinocytosis, and phagocytosis.

- The chromatin may be distributed along periphery (peripheral chromatin) or as condensed mass around the karyosome.

### Reproduction

Reproduction can be:

- Asexual reproduction
- Sexual reproduction.

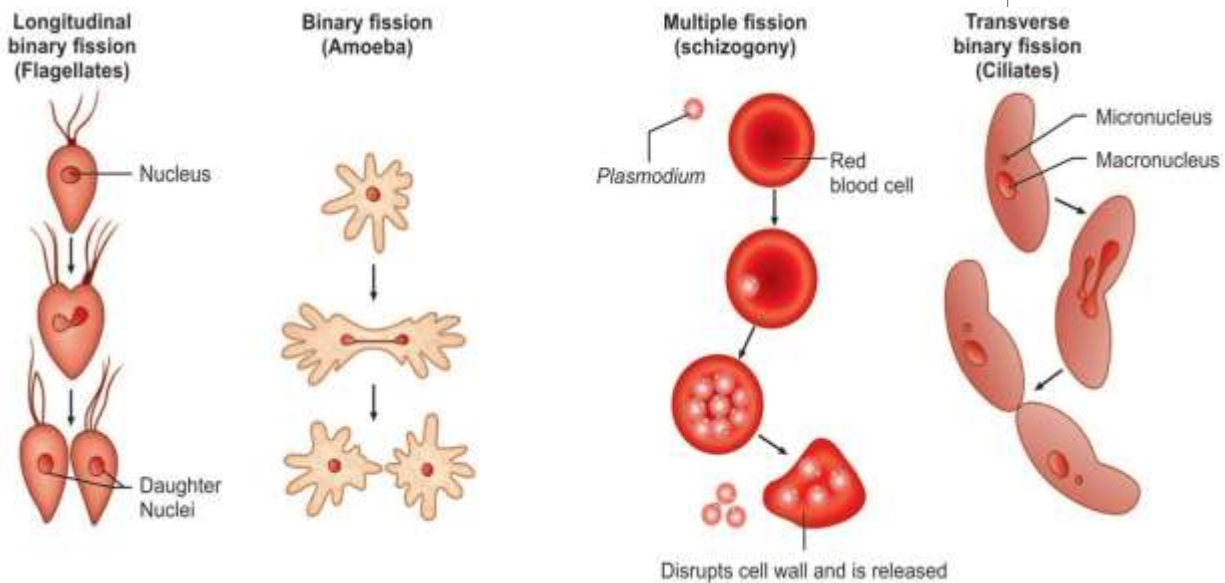
Reproduction usually occurs asexually in protozoans; however, sexual reproduction occurs in ciliates and sporozoans.

#### Asexual Reproduction

- **Binary fission:** It is a method of asexual reproduction, by which a single parasite divides either longitudinally or transversally into two or more equal number of parasites. Mitotic division of nucleus is followed by division of the cytoplasm. In amoebae, division occurs along any plane, but in flagellates, division is along longitudinal axis and in ciliates, in the transverse plane.
- **Multiple fission or schizogony:** *Plasmodium* exhibits schizogony, in which nucleus undergoes several successive divisions within the **schizont** to produce large number of **merozoites**
- **Endodyogeny:** Some protozoa like *Toxoplasma*, multiply by internal budding, resulting in the formation of two daughter cells.

#### Sexual Reproduction

- **Conjugation:** In ciliates, the sexual process is conjugation, in which two organisms join together and reciprocally exchange nuclear material (e.g. *Balantidium coli*).



## Asexual reproduction in protozoans

- **Gametogony or syngamy:** In sporozoa, male and female gametocytes are produced, which after fertilization form the zygote, which gives rise to numerous sporozoites by sporogony (e.g. *Plasmodium*).

## Life Cycle

- **Single Host:** Protozoa like intestinal flagellates and ciliates require only 1 host, within which they multiply asexually in trophic stage and transfer from one host to another by the **cystic form**.
- **Second host:** In some protozoa like *Plasmodium*, asexual method of reproduction occurs in one host (man) and sexual method of reproduction in another host (mosquito).

## Classification of Protozoa

Protozoan parasites of medical importance have been classified into **kingdom** Protista, **subkingdom** Protozoa which is further divided into the following four phyla

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- Sarcomastigophora
- Apicomplexa
  - Microspora
  - Ciliophora

The important protozoan pathogens of human are summarized in Table 2.3.

### **Phylum Sarcomastigophora**

Phylum Sarcomastigophora has been subdivided into 2 subphyla based on their modes of locomotion.

- **Sarcodina** (*Sarcos meaning flesh or body*): It includes those parasites, which have no permanent locomotory organs, but move about with the aid of temporary prolongations of the body called **pseudopodia** (e.g. Amoebae).
- **Mastigophora** (*Mastix, meaning whip or flagellum*): It includes those protozoa which possess whip-like flagella (e.g. *Trypanosoma* and *Trichomonas*).

### **Amoebae**

These protean animalcules can assume any shape and crawl along surfaces by means of foot-like projections called **pseudopodia** (literally meaning **false feet**). They are structurally very simple and are believed to have evolved from the flagellates by the loss of the flagella. Two groups of amoebae are of medical importance.

- **Amoebae of the alimentary canal:** The most important of these is *E. histolytica*, which causes intestinal and extraintestinal amoebiasis. Amoebae are also present in the mouth.
- **Potentially pathogenic free-living amoebae:** Several species of saprophytic amoebae are found in soil and water. Two of these, *Naegleria* and *Acanthamoeba* are of clinical interest because they can cause eye infections and fatal meningoencephalitis.

### **Flagellates**

These protozoa have whip-like appendages called **flagella** as the

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organs of locomotion. The fibrillar structure of flagella is identical with that of **spirochetes** and it has been suggested that they may have been derived from symbiotic spirochetes, which have become endoparasites. In some species, the flagellum runs parallel to the body surface, to which it is connected by a membrane called the **undulating membrane**. Flagellates parasitic for man are divided into 2 groups:

- **Kinetoplastida:** These possess a kinetoplast from which a single flagellum arises. They are the **hemoflagellates** comprising the trypanosomes and *Leishmania*, which are transmitted by blood-sucking insects and causes systemic or local infections.
- **Flagellates without kinetoplast:** These bear multiple flagella. *Giardia*, *Trichomonas*, and other luminal flagellates belong to this group. Because most of them live in the intestine, they are generally called intestinal flagellates

### Phylum Apicomplexa

Phylum Apicomplexa was formerly known as **sporozoa**.

Members of this group possess, at some stage in their lifecycle, a structure called the **apical complex** serving as the organ of attachment to host cells.

- They are tissue parasites.
- They have a complex life cycle with alternating sexual and asexual generations.
- To this group, belongs the malarial parasites (suborder: Haemosporina, Family: Plasmodiidae), *Toxoplasma*, *Sarcocystis*, *Isospora*, and *Cryptosporidium* (under the Suborder: Eimeriina), *Babesia* (under the subclass: Piroplasma), and the unclassified *Pneumocystis jirovecii*.

### Phylum Ciliophora

These protozoa are motile by means of cilia, which cover their entire body surface. The only human parasite in this group is *Balantidium coli*, which rarely causes dysentery.

### Phylum Microspora

Phylum Microspora contains many minute intracellular protozoan parasites, which frequently cause disease in immunodeficient subjects. They may also cause illness in the immunocompetent, rarely.

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Species	Habitat	Disease
<i>Entameba histolytica</i>	Large intestine	Amoebic dysentery, amoebic liver abcess
<i>Naegleria fowleri</i>	CNS	Amoebic meningoencephalitis
<i>Acanthamoeba</i>	CNS, eye	Encephalitis, keratitis
<i>Giardia lamblia</i>	Small intestine	Malabsorption, diarrhea
<i>Trichomonas vaginalis</i>	Vagina, urethra	Vaginitis, urethritis
<i>Trypanosoma brucei</i>	Blood, lymphnode, CNS	Sleeping sickness
<i>Trypanosoma cruzi</i>	Macrophage of bone marrow, nerves, heart, colon etc.	Chagas' disease
<i>Leishmania donovani</i>	Reticuloendothelial system	Kala-azar, Post kala azar dermal leishmaniasis
<i>Leishmania tropica</i>	Skin	Cutaneous leishmaniasis (oriental sore)
<i>Leishmania braziliensis</i>	Naso-oral mucosa	Mucocutaneous leishmaniasis (Espundia, Chiclero's ulcer)
<i>Plasmodium spp.</i>	RBC	Malaria
<i>Babesia microti</i>	RBC	Babesiosis
<i>Isospora belli</i>	Intestine	Diarrhea in AIDS
<i>Cryptosporidium parvum</i>	Intestine	Diarrhea in AIDS
<i>Balantidium coli</i>	Large intestine	Dysentery