

Systematic Zoology

Every organism, whether plant or animal, is unique in itself and this uniqueness is the basis of the vast diversity displayed by the organisms in our world. There is a wide diversity in the flora (plants) and fauna (animals) in the world. With such a vast number of organisms, it becomes impossible to study every one of them at individual level. This task of studying the diversity of living organisms can be made easier and more effective if the various organisms are arranged into groups based on their similarities and differences. The branch of science that is involved with the purpose of arranging or grouping animals is called “Systematic Zoology” or “Animal Taxonomy”.

IMPORTANCE OF CLASSIFICATION:

1. It makes the study of such a wide variety of organisms easy.
2. It helps us to understand the interrelationship among different organisms.
3. Various fields of applied biology such as agriculture, public health and environmental biology depend on classification of pests, disease vectors, pathogens and components of an ecosystem.
4. It serves as a base for the development of other biological sciences such as biogeography.

It is necessary at the outset to define basic terms used in taxonomic studies i.e. systematic, taxonomy and classification.

Systematics: According to Blackwedler, Boyden and Simpson “Systematics is the scientific study of the kinds and diversity of organisms and any and all relationships among them according to element/system or part/whole relationships”. The term was used by Linnaeus.

Classification

“It is the ordering of animals into groups or sets on the basis of their relationships”

Taxonomy:

The term taxonomy was coined by De Candolle (1813). It is derived from the Greek words (“taxis” = arrangement and “nomous” = law) “It is the theoretical study of classification including its bases, principles, procedures and rules”.

HOW MANY SPECIES ARE THERE?

This is not an easy question to answer. About 1.8 million animal species have been given scientific names. Nearly 2/3 of these are insects. Estimates of the total number of living species generally range from 10 to 100 million.

It is likely the actual number is on the order of 13 to 14 million, with most being insects and microscopic life forms in tropical regions. However, we may never know how many species are there because many of them will become extinct before being counted and described.

Nomenclature of organisms:

While classifying any animal, its classification is required first. There **are two types** of names for any organisms:

i. Common name:

Organisms are known by different names in different countries and language of the world. This poses a great problem in the study of such organisms.

ii. Scientific names:

The easiest way to solve problems resulting from the variation of common names of the organisms is to use one scientific name for each organism.

Linnaeus puts “**Binomial nomenclature**” system, which still used until now (the binominal system was actually first used by Gaspard Bauhin, 1623 but never caught on).

According to this system, each animal has two-word generic name:

- Genus name: beginning with a capital letter.
- Species name: beginning with a small letter. Both names are always “Latin” and “underlined” or “italic”. For example, the scientific name of man is “*Homo sapiens*”.

The seven level system:

Each kingdom is classified into ► Kingdom ► Phylum ► Class ► Order ► Family ► Genus ► Species.

Six kingdom system:

KINGDOM		No OF SPECIES	CHARACTERS	
Archaeobacteria	Monera	100,000	➤ Most primitive⁴⁵ and often live in extreme environments. ➤ Unicellular and no nucleus (PROKARYOTIC).	
Eubacteria			➤ No organized nucleus or nuclear membrane (PROKARYOTIC). ➤ Include bacteria and blue green algae.	
Protista		250,000	➤ Unicellular organisms (EUOKARYOTIC) with plant or animal-like characteristics. ➤ Include protozoa and all algae except the blue-green.	
Fungi		100,000	➤ Cells are usually organized into branched, multinucleate filaments⁴⁶ which absorb digested food from the external environment. ➤ Include yeasts, molds, and mushrooms.	
Plantae		250,000	➤ Multicellular - possess chloroplasts and cell walls. ➤ Make their own food – PHOTOSYNTHESIS.	
Animalia		1,500,000	➤ Multicellular organisms (Eukaryotes). ➤ Ingest their food – HETEROTROPHS.	

KINGDOM: PROTISTA

Subkingdom: Protozoa

Protista are predominately unicellular organisms with plant or animal-like characteristics. Examples include:

1-Protozoa

2- All algae except the blue-green algae.

They have a true nucleus and nuclear membrane (eukaryotes). Protista is classified into two subkingdoms: Protozoa (Animal-like) and Algae (Plant-like). In animal taxonomy, we are concerned with Protozoa.

GENERAL CHARACTERS OF PROTOZOA:

- 1- They are small microscopic organisms. They are the simplest and most primitive animals.
- 2- They are unicellular (single – celled animals) that perform all the vital activities
- 3- Many species live solitary while few live in colonies.
- 4- Locomotory organelle are present. They are in the form of pseudopodia, flagella or cilia.
- 5- Nutrition may be Holozoic (animal–like), Holophytic (plant–like), Saprozoic (by diffusion) or Parasitic.
- 6- There are no organelles for respiration or excretion which occur by simple diffusion through the general body surface.
- 7- Freshwater forms have an osmoregulatory system in the form of contractile vacuole.
- 8- All protozoa can reproduce asexually by binary fission or by multiple fission. In addition, some protozoa can reproduce sexually by forming male and female gametes as in conjugation.
- 9- Encystement commonly occurs to help in dispersion and to resist unfavorable conditions.

CLASSIFICATION OF PROTZOA

Subkingdom Protozoa is divided into 3 Phyla according to their locomotory organelles:

PHYLUM: SARCOMASTIGOPHORA

They are the largest protozoan phylum comprising about 18,000 species.

GENERAL CHARACTERS

1. Unicellular solitary or colonial.
2. Locomotion by flagella, pseudopodia, or both.
3. Autotrophic, saprozoic, or heterotrophic nutrition.
4. Single nucleus.
5. Asexual reproduction.

Sarcomastigophoraes are classified
into two subphyla: Mastigophora

and Sarcodina

SUBPHYLUM: MASTIGOPHORA (FLAGELLATES)

General characters

1. Includes protozoa which move by one or more flagella.
2. Nutrition autotrophic (plant- like) or holozoic (animal- like).
3. With one nucleus.
4. Free living or parasitic.
5. Body covered with pellicle.

Matigophora are divided into **two Classes**:

A. Class: Phytomastigophora

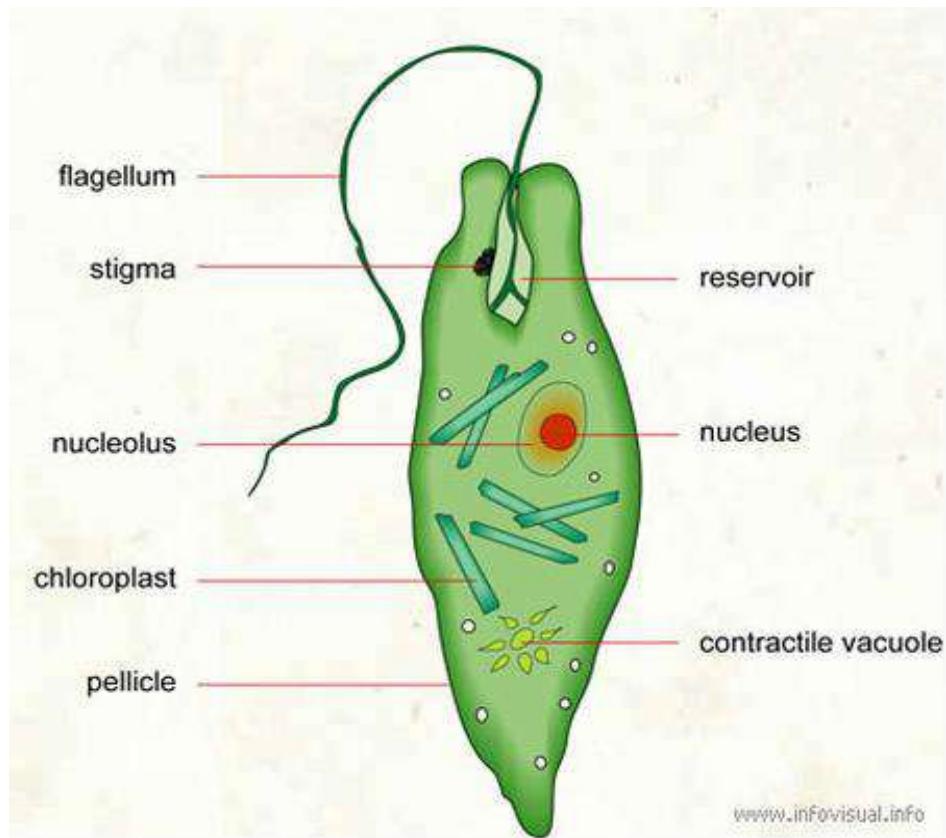
e. g. Euglena

Euglena is a mobile photosynthetic and photosensitive cell.

It is found in aquatic environments, almost freshwater ponds.

They are autotrophs and produce their own energy from chlorophyll in the same manner of plants, a high enough population can make their habitat appear quite green.

MORPHOLOGY

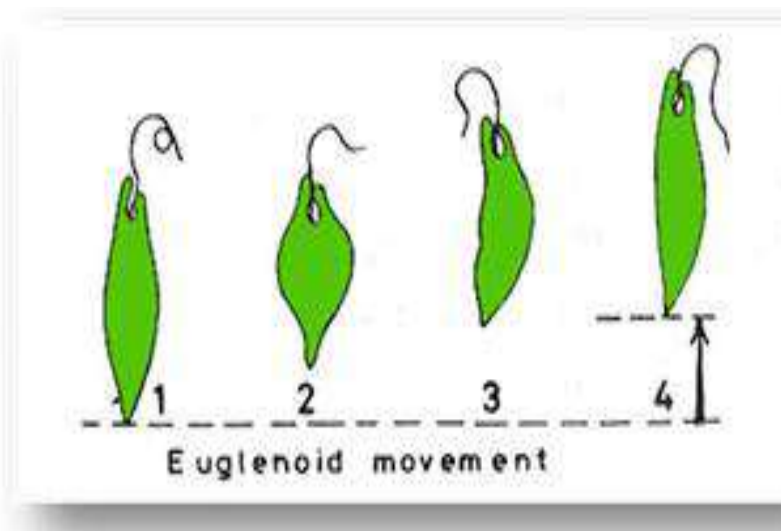


LOCOMOTION

Euglena moves in its environment by **Two methods**:

A-Euglenoid movement: This is a slow worm-like movement.

It is carried out by contraction and relaxation of the different parts of the body by the aid of muscles.



B- Flagellar movement:

= Faster and enable the animal to swim rapidly in water.

= It is carried about by the active vibrations of its highly contractile flagellum.

= The flagellum lashes obliquely backwards with waves passing along the flagellum from base to tip in a spiral manner. As a result, the whole body move forward through the water with a spiral rotation.

= The flagellum beats at a rate of 12 times / second.



Fig. (2-3): Flagellar movement

NUTRITION:

A- Holophytic (autotrophic) nutrition:

In the presence of sunlight, *Euglena* can synthesize carbohydrates from CO₂ and water by the aid of its chlorophyll - bearing chloroplast.

This method of nutrition is identical to the process of photosynthesis in plants.

B- Holozoic (animal – like) nutrition:

In the absence of light, *Euglena* can absorb soluble food materials from the surrounding medium through the body surface by “**pinocytosis**”

OSMOREGULATION:

The outer covering of *Euglena* is semi-permeable and the concentration of salts is higher in its cytoplasm than in the surrounding fresh water, water tends to flow into its body by osmosis.

Osmoregulation is carried out by the “**contractile vacuole system**” as following:

a- Excess water collects as minute droplets in the small vacuoles.

b- The small vacuoles empty in the large central vacuole.

c- The large vacuole bursts into the reservoir which evacuates water into the exterior.

RESPIRATION & EXCRETION:

= Exchange of O₂ and CO₂ takes place by simple diffusion.

= Soluble excretory products pass also from the cytoplasm to the surrounding environment by simple diffusion.

REPRODUCTION

Euglena reproduces asexually by one of the following methods

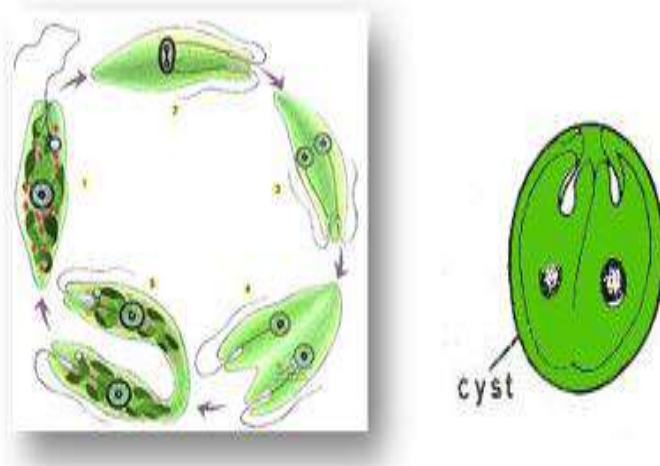
- 1- **Longitudinal binary fission** in suitable conditions, *Euglena* multiplies by a simple longitudinal binary fission into two daughter individuals.

2- Encystement:

In **unsuitable** condition, Euglena rounds up and secretes a thick gelatinous cyst around itself.

The encysted animal can withstand the adverse conditions of life.

Encystement is normally followed by a longitudinal binary fission with the formation of two daughter Euglena. When the conditions become suitable, the daughter individuals become liberated from the cyst.



B- Class: Zoomastigophora

e.g1. Trypanosoma

Trypanosoma is the causative agent of disease known as sleeping sickness, which in many parts of Africa considers as the first problem in economic and social progress. *Trypanosoma* lives as a parasite in the blood of many vertebrates (definite host). The life cycle also involves blood-sucking invertebrate host (intermediate host) mainly *TSE TSE* fly.

Man hosts 3 species of *Trypanosoma* namely *Trypanosoma gambiense*, *Trypanosoma rhodesiense* and *Trypanosoma cruzi*. It transmitted to man by *Tse Tse* fly.

MORPHOLOGY:

It has fusiform body covered with hard pellicle.

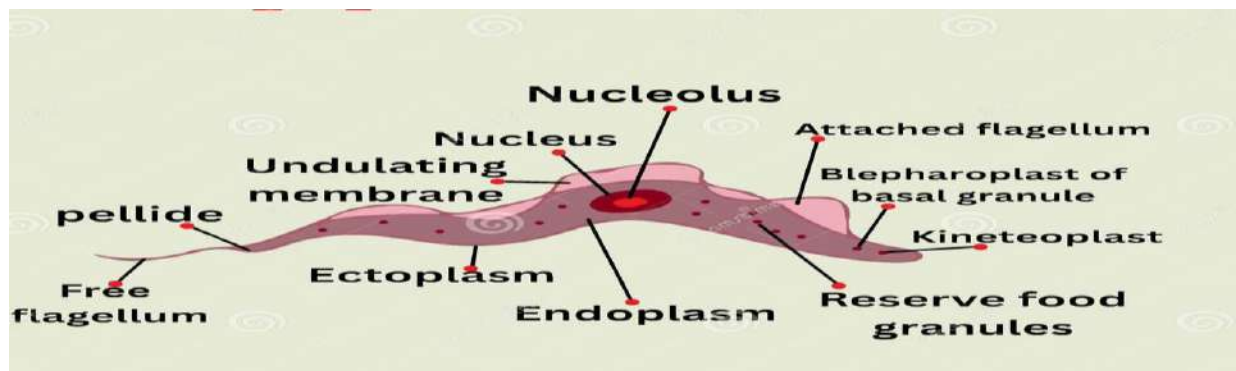
There is a large oval nucleus with a large central endosome.

A long flagellum joined to the body by a thin undulating membrane.

The flagellum extends freely in front of the body.

At the base of the flagellum, there is a granule known as basal granule or blepharoplast.

Very close to the blepharoplast is a larger granule known as parabasal granule



LOCOMOTION

Trypanosoma swim in the blood plasma of the host by the vibratile movements of the flagellum and undulating membrane.

LIFE CYCLE

T. gambiense & *T. rhodesiense*. Life cycle is completed within **two hosts**:

A-Primary host: Man and other vertebrates.

B-Secondary host: *TSE TSE* fly.

In Man:

A-Infection:

If an infected *Tse Tse* fly bits a healthy person, the parasite enters his blood with the fly's saliva.

B-Multiplication:

Inside the blood plasma of human host, the parasite multiplies rapidly by longitudinal binary fission for about two weeks (a period known as incubation period) before the symptoms of the disease start to appear.

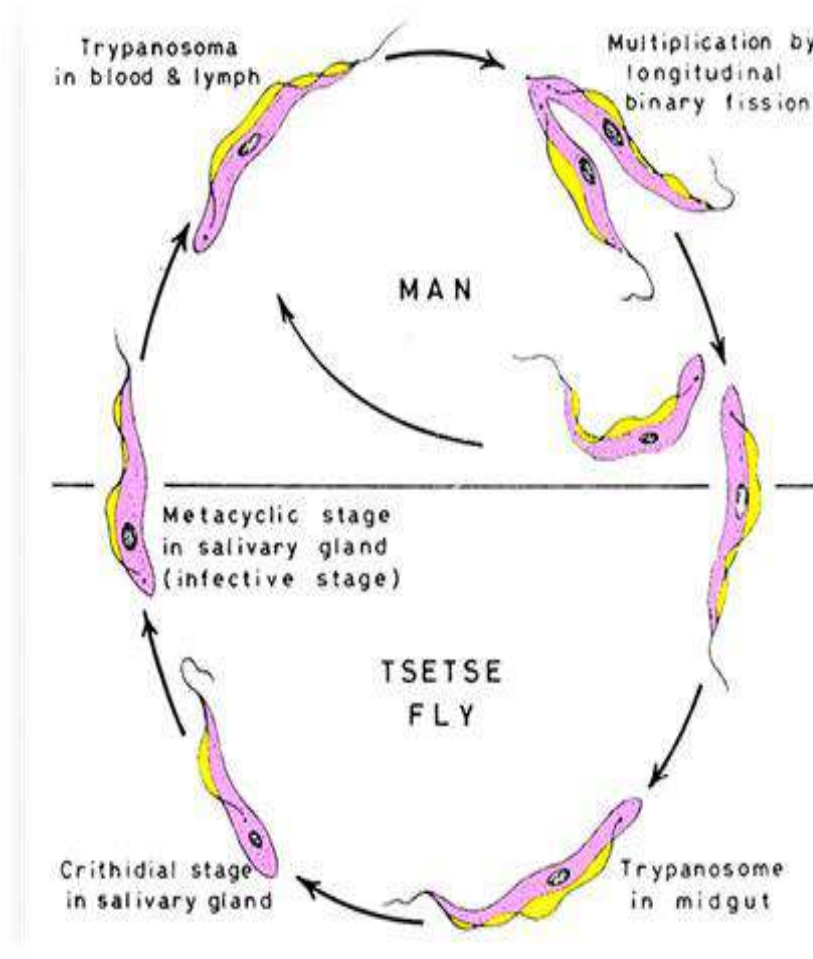
3- Life cycle in *Tse Tse* fly

A-Transfer to *Tse Tse* fly: when *Tse Tse* fly bits an infected person the trypanosomes are taken with sucked blood into the midgut of the fly.

B-Development in midgut: in the midgut, the parasites divide by longitudinal binary fission producing a large number of immature stages.

Development in salivary glands:

1. After 10 –12 days, the immature forms migrate to the salivary glands.
2. The parasite continues to multiply in the salivary glands by binary fission producing a stage known as crithidial stage. It has a narrow undulating membrane. The basal and parabasal granules lie in front of the nucleus.
3. Multiplication by binary fission continues for few more days when another stage known as the metacyclic stage (its basal and parabasal granules lie behind the nucleus).
4. Metacyclic stage is the infective stage, which may infect another human host.



C- HOST-PARASITE RELATIONSHIP:

Trypanosoma lives in the blood plasma and affect the human host in the following ways:

1. It consumes a large amount of blood glucose.
2. The excretory products of the parasite are toxic to the human host.
3. When the parasites invade the tissues of the brain, they produce a great damage and cause coma (hence the name sleeping disease) and finally death of the host.

e.g2 Leishmania donovani

Leishmania is an endoparasite lives inside the macrophage cells of several vertebrates

There are two stages:

A- Leishmania stage

- Round with central large nucleus.
- With parabasal body and blepharoblast
- With short flagellum which does not extend outside the body.
- Found in phagocytes of final host.

B- Leptomonad stage

- Spindle shape with large nucleus.
- With free flagellum arising from the blepharoblast.
- Found in the gut of sand fly (intermediate host).

LIFE CYCLE

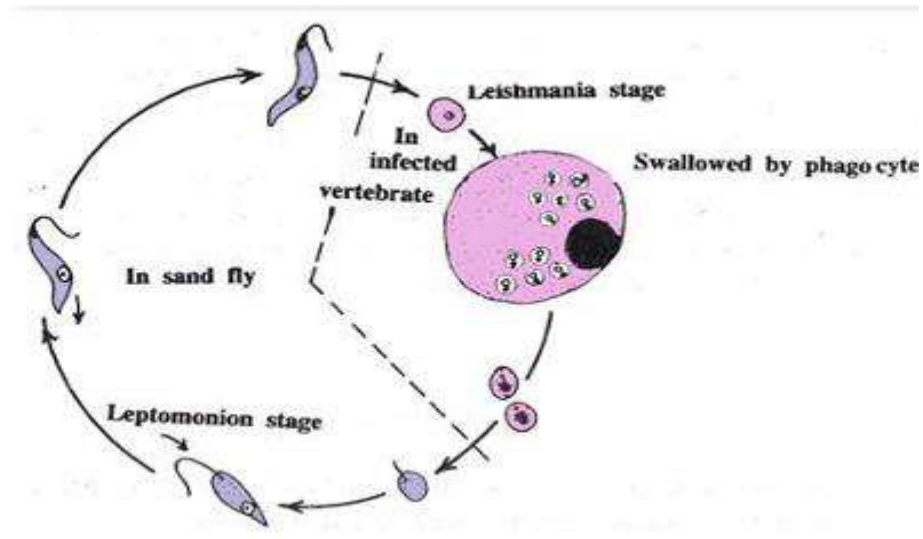
Leishmania completes its life cycle in **Two hosts**:
man and sand fly (Phlebotomus sp).

a- In Man

1. The parasites are introduced into the human blood with the bite of an infected sand fly.
2. They find their way into macrophages and assume Leishmanial form.
3. They undergo binary fission to produce large number of leishmanial stages.
4. The macrophage ruptures and the parasites are released into the blood.

b- In sand fly

1. While feeding, the sand fly ingests the leishmanial forms.
2. In the gut, the parasite developed into Leptomonad stage that multiplies by longitudinal binary fission.
3. Leptomonads migrate into the buccal cavity and become ready to infect another host.



HOST PARASITE RELATIONSHIP

Leishmaniasis currently infects 350 million men, women, and children in 88 countries around the world and there are **three kinds** :

Cutaneous, Mucocutaneous and Visceral Leishmaniasis.

L. Donovanii causes a disease known as visceral leishmaniasis (Kala- Azar) or black fever characterized by:

- Enlargement of the liver and spleen.
- Anaemia, weakness and fever.
- Darkening of the skin.

L. tropica causes a disease known as cutaneous leishmaniasis (also called oriental sore or Baghdad sore).

It infects the skin of hands, legs and face causing a sore at the bite site, which heals in a few months to a year, leaving an unpleasant looking scar.

SUBPHYLUM: SARCODINA

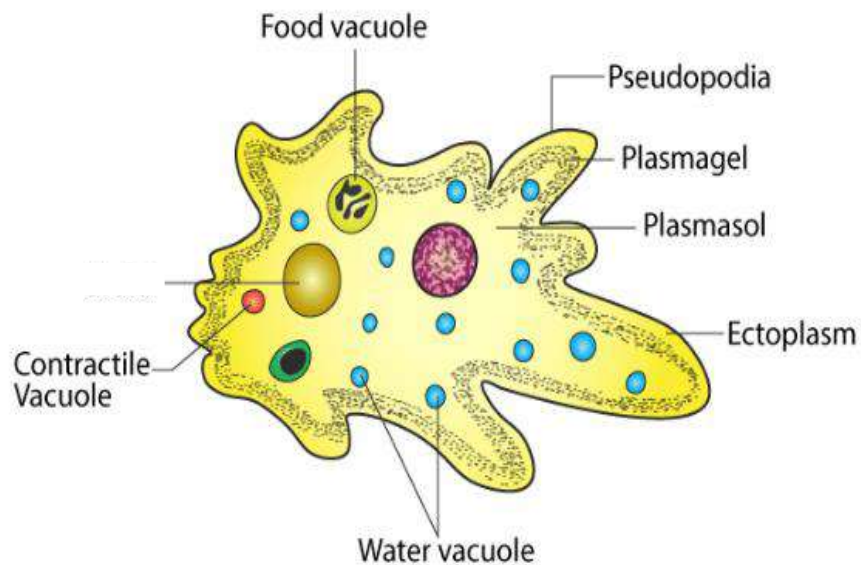
GENERAL CHARACTERS

- Mostly free living.
- Locomotory organoids in the form of pseudopodia.
- Holozoic nutrition.
- Asexual reproduction.

e.g. Amoeba

MORPHOLOGY

- The living Amoeba appears under the microscope as an irregular jelly-like mass which is constantly changing its shape due to the formation of finger-like protoplasmic projection known as pseudopodia.
- The body is covered with thin plasma membrane.
- The cytoplasm is differentiated into an outer clear ectoplasm and an inner granular endoplasm.
- The cytoplasm contains: oval nucleus with centrosome, contractile vacuole and many food vacuoles.



LOCOMOTION:

(Amoeboid movement):

Amoeba move and capture food by means of protoplasmic protrusions known as pseudopodia.

The pseudopodium is produced **as following:**

1. The colloidal state of the ectoplasm is changed from plasmagel to plasmasol.
2. The internal pressure causes the plasmasol from the endoplasm to flow out at this weak point forming the pseudopodium.
3. Then plasmasol is changed again into plasmogel.
4. A similar process takes place at the other end of the body where a pseudopodium is drawn

NUTRITION:

Nutrition in Amoeba is **holozoic** (animal – like) and takes place **as following:**

Feeding:

1. when an amoeba comes in contact with food particles (e.g. small protozoa, bacteria, microscopic plants.... etc.), it flows around it by a number of pseudopodia, forming a food cup.
2. Formation of food vacuole. The food cup gradually encloses the food together with a drop of water and thus a food vacuole is formed inside the cytoplasm.

Digestion:

food vacuole acts as a temporary stomach where food is digested by the action of enzymes secreted from the cytoplasm.

Assimilation the digested food materials are absorbed by diffusion into the cytoplasm and distributed in the cell.

Egestion: The remaining undigested materials are egested by bursting of food vacuole at any point of the surface

Steps of phagocytosis in Amoeba:

1. Encirclement:

The amoeba extends its pseudopods to surround the food particle.

2. Engulfment:

The pseudopods meet and fuse, fully enclosing the food within the amoeba's cell membrane.

3. Vacuole formation:

A food vacuole is formed around the engulfed particle, a small sac that holds the food inside the cell.

4. Digestion:

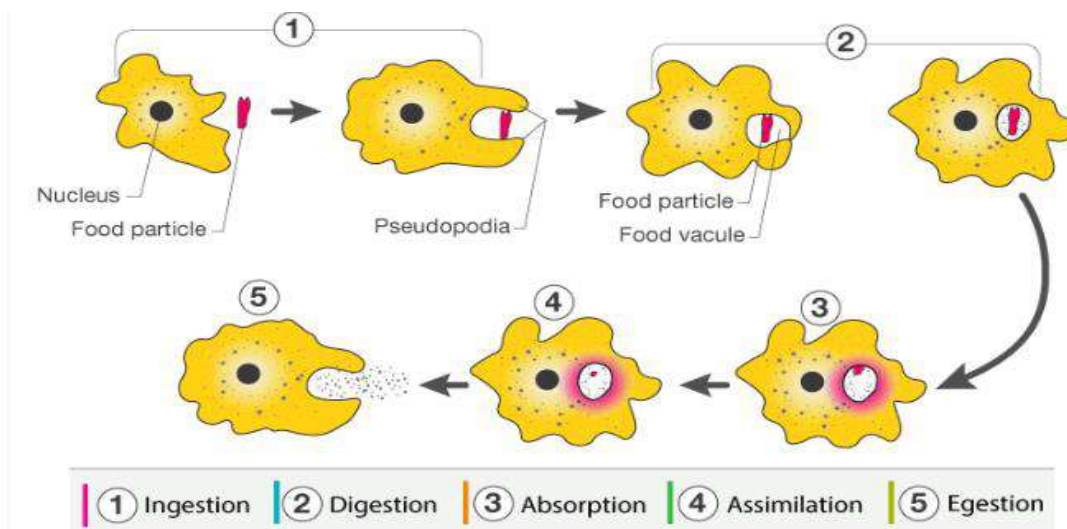
Digestive enzymes from the cytoplasm are secreted into the food vacuole to break down the insoluble food into soluble nutrients.

5. Absorption:

The soluble nutrients are absorbed into the cytoplasm, while the undigested waste remains in the vacuole.

6. Egestion:

The food vacuole moves to the edge of the cell, and the cell membrane ruptures to expel the undigested waste.



OSMOREGULATION

- The protoplasm of Amoeba is more concentrated than the surrounding medium.
- Water diffuses into it by osmosis and may lead to bursting of Amoeba.
- The regulation of water content or osmoregulation is carried out by the contractile vacuole which collect excess water, enlarges and then bursts at any point of the surface where its water content is expelled to outside.

RESPIRATION

- Gaseous exchange takes place by simple diffusion through the permeable plasma membrane.
- O₂ diffuses from outside (high concentration) to the cytoplasm (low concentration).
- CO₂ diffuses from cytoplasm (high concentration) to the surrounding water (low concentration).

EXCRETION

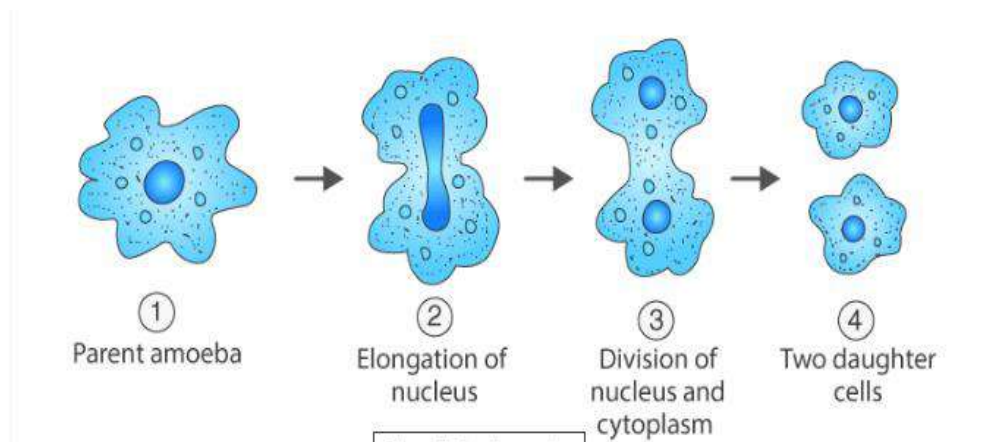
- Amoeba has no special excretory organs.
- The harmful excretory substances diffuse to the surrounding medium through the plasma membrane by simple diffusion.

REPRODUCTION

Amoeba asexually reproduces **by one of the following methods:**

A-Binary fission: It takes place during suitable conditions of food and temperature as following.

1. Amoeba grows in size and withdraw its pseudopodia.
2. It then divided into two parts.
3. Each part feeds and grows into new individual.



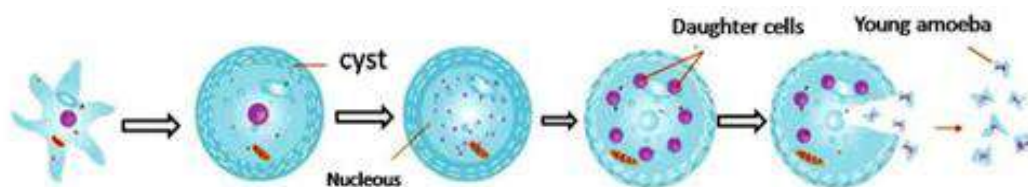
B-Regeneration:

- It takes place also in suitable condition.
- When an Amoeba is cut into two or more pieces, each piece, containing part of the nucleus, will grow into a complete Amoeba.

C-Encystment:

-It takes place during unsuitable condition, such as the drying up of the water, as following.

1. Amoeba withdraws its pseudopodia, become spherical and forms a resistant cyst around itself.
2. The nucleus divides repeatedly to form a large number of daughter nuclei.
3. Each daughter nucleus becomes surrounded by portion of the cytoplasm forming a small Amoeba.
4. When the environmental conditions improved the wall of the cyst rupture and the daughter Amoeba become liberated.



e.g2. *Entamoeba histolytica*

This is an intestinal parasite of man.

MORPHOLOGY

Three forms are recognized in the life cycle:

Trophozoite, Precystic stage and cyst.

1-Trophozoite (trophic stage)

- It is spherical but at one end there is a single ectoplasmic pseudopodium.
- The cytoplasm is differentiated into outer clear ectoplasm and an inner granular endoplasm containing food vacuoles (Fig., 2-16).
- It has single nucleus with central endosome.
- The surface is bounded by thin plasmalemma.

Two types of trophozoites are recognised:

- a. **Minute trophozoite:** 10-20 μm in diameter.
It lives in the lumen of the intestine and feed on bacteria.
- b. **Large trophozoite:** when minute trophozoite invades the mucosal layer of intestine, it feeds on cellular elements and blood cells and develops into large trophozoite.

2-Precystic stage

- a. It is also found in the lumen of intestine.
- b. It is small in size.
- c. The cytoplasm is free from food vacuoles

3-Encysted stage (Infective stage):

The precystic stage is transformed into the mature cyst **as following:**

- a. It rounds up and secretes a thin protective cyst around itself.
- b. The nucleus divides twice by mitosis to produce 4 nuclei.

c. It stores 2 chromatin bodies (protein reserve).

REPRODUCTION AND LIFE CYCLE.

A- Binary fission: The trophozoite multiplies asexually by binary fission in the lumen of the large intestine.

B- Encystment:

- is the transformation of trophozoites into cyst.
- The trophozoite rounds up and secretes a thin protective cyst around itself.
- The nucleus divides into 4 daughter nuclei and chromatoid material are stored in the cytoplasm.

C- Infection of new host:

- The mature cysts are the **infective stage**.
 1. It passes out with the faeces and can survive outside for sometimes.
 2. A new host acquires the infection by ingestion of the encysted stage of the parasite in contaminated food or drinking water.
 3. This stage passes into the intestine without any change in the stomach.

D. Excystation:

It is process of transformation of cysts **into trophozoites:**

1. In the small intestine, the cyst dissolved by the action of trypsin enzyme and four nucleated individuals are liberated.
2. The four nuclei divide once more producing eight – nucleated individual.

3. This is followed by cytoplasmic division.

Thus 8 small uni - nucleated trophozoites are produced.

HOST PARASITE RELATIONSHIP (effect of parasite on the host):

There are **two types** of infection in man:

- 1- **Harmless infection:** the small trophozoites live in the lumen of the intestine, feed on bacteria and are harmless.

- 2- **Pathological infection:** the large trophozoites which invade the mucosal wall of the intestine, penetrate into the deeper tissue causing bleeding and ulcers and developing a disease known as Amoebic dysentery. Moreover, some of trophozoites may penetrate to the blood streams and reach liver, lungs, brain.... etc. producing some ill effects.

E.g3 *Entamoeba coli* It differs from *E. histolytica* in the following (table, 3):

Table (2-3): Comparison between *E. histolytica* and *E. coli*.

<i>E. histolytica</i>	<i>E. coli</i>
➤ It may attack the wall of intestine. <u>Trophozoite</u> ➤ small 10 – 20 μ. ➤ with single pseudopodium. ➤ with small central endosome. <u>Cyst (infective stage)</u> ➤ small (12 μ). ➤ with two chromatin bodies with four nuclei. ➤ harmful causing diseases.	➤ It never attacks the wall of intestine. ➤ large 20 – 30 μ. ➤ with two pseudopodia. ➤ with large accentric acroosome. ➤ large (17 μ). ➤ two chromatin bodies and eight nuclei . ➤ harmless.

ENTAMOEBA HISTOLYTICA	ENTAMOEBA COLI
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Fig. (2-18): Life cycle of *Entamoeba histolytica* and *E. coli*