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Nutrition in Protozoa

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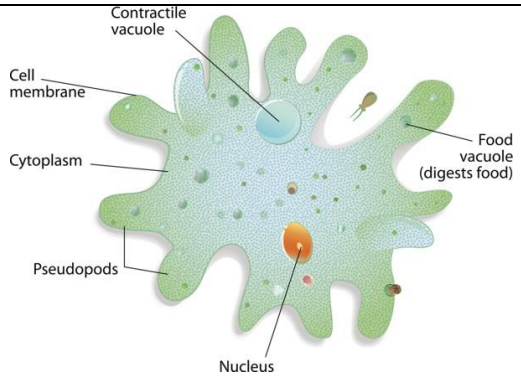
Introduction:

Protozoa (in Greek: *proto*- first, *zoa*- animal) are single celled organisms that have a true nucleus with chromosomes (composed of DNA) enclosed by a membranous envelop. They also have other internal cellular structures known as organelles that perform the many physiological functions needed to maintain the life of the organism. These organelles including mitochondria that breaks down nutrient molecules during respiration to produce energy for the cell. Other organelles are digestive vacuoles that act like small stomachs within the cell to digest food particles and molecules taken in by the cell. Towle (1989) reports that over 56,000 species (40,000 species moving by pseudopodia, 8,000 moving by cilia, 2,500 species by flagella, and 5,500 species in phylum sporozoa with no means of locomotion) of protozoa have been identified the great majority (above more than 60 percent) of which move by pseudopodia, false feet or temporary projections of the cell. Free-living protozoa are and play an important role in their ecology. Protozoa play a role both as herbivores and as consumers in the decomposer link of the food chain. Most protozoa, whether free living or parasitic, lack a protective outer covering. Thus a semi permeable cell membrane serves as the boundary between the environments and the cytoplasm and minerals (calcium, potassium) and gases (O_2 & CO_2) exchange across this membrane (Towle, 1989).

Based on the mode of locomotion, protozoa have been divided into four types-

1. Amoeboids

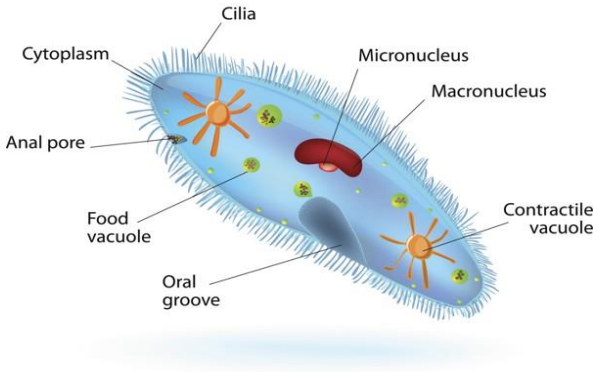
An amoeboid (ameba or amoeba) is a type of cell or organism that is capable of changing its shape, mainly by extending and retracting pseudopods. They are normally found in the soil and in aquatic habitats. They move by using pseudopods. They typically ingest their food by phagocytosis. They extend their pseudopods to engulf a prey. They do not possess a mouth or cytostome. The food sources of amoebae differ.



Amoeba

2. Ciliates

The ciliates are a group of protozoans which possesses hair-like organelles called cilia. Cilia are used in swimming, crawling, attachment, feeding, and sensation. Most ciliates are heterotrophs. They eat organisms such as bacteria and algae. They sweep the food by their modified oral cilia into their oral groove (mouth). The food is moved with the help of cilia through the mouth pore into the gullet, which forms food vacuoles.



Paramecium

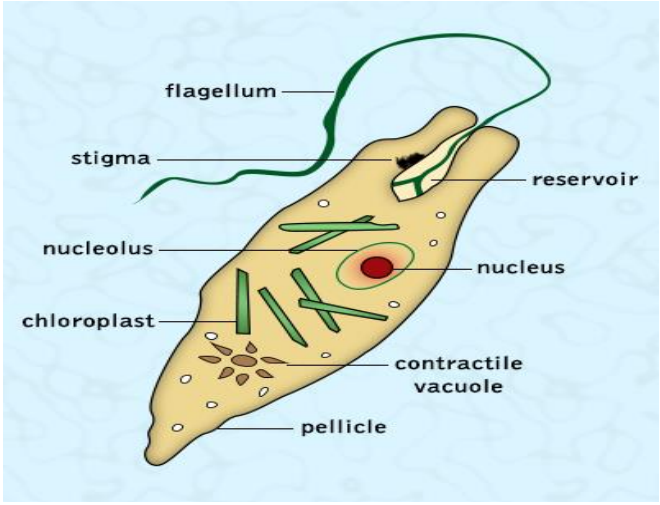
3. Flagellates

Flagellates are organisms which have one or more whip-like organelles called flagella. They may be solitary, colonial, free-living or parasitic. Parasitic forms live in the intestine or bloodstream of the host. An example of a parasitic flagellate is Trypanosoma, which has an interesting life cycle as it uses two hosts; humans and tsetse fly. Many other flagellates like dinoflagellates live as plankton in the oceans and freshwater. Some flagellates are autotrophic while others are heterotrophs.

They are two types-

Phytomastigophorea and

Phytomastigophorea

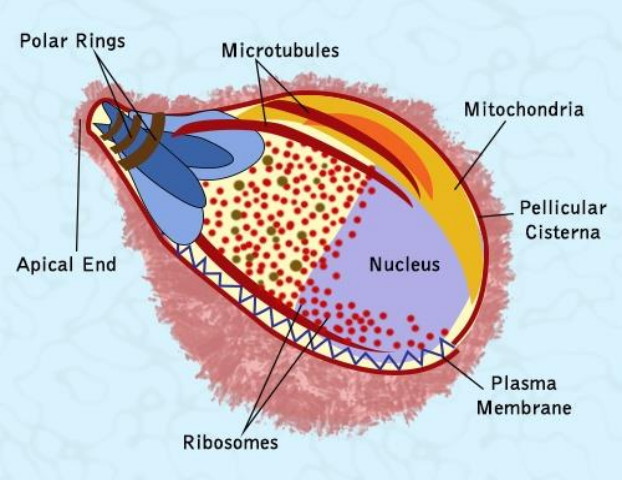


Euglena

4. Saprozoans

Saprozoans are non-motile, unicellular organism usually parasites. These are also called intracellular parasites. *Plasmodium vivax* is a classical example that caused malaria in humans. On the basis of spore they are four types mainly-

1.Apicomplexa
2.Microsporidia
3.Ascetosporea
4.Myxosporidia



Plasmodium

Johnson (1941) reported protozoans obtained nourishment in different ways.

I. Holozoic nutrition-in which the organism ingest solid organic material. This ingestion of particulate matter, in contrast with the diffusive method of obtaining nutrient requirement as found in holophytic and saprozoic, is the characteristic animal way of obtaining food.
II. Holophytic nutrition- in which the organism carry on photosynthesis and are capable of continued growth in a suitable inorganic medium, in the presence of light;
III. Saprozoic or saprophytic nutrition (parasitic mode)- in which organic compounds in solution are required and utilized; and

When the various classes of the protozoa are considered with respect to the mode or modes of obtaining nourishment Johnson noted that

a) The three types of nutrition, holophytic, saprophytic and holozoic, occur in practically all the order of the Mastigophora;
b) Holozoic nutrition is almost universal in the Sarcodina, Saprophytism is rare;
c) With the exception of certain highly modified parasitic forms, all of the Ciliates utilized solid food; and
d) All of the Saprozoa exhibit parasitic nutrition.

Holozoic Nutrition:

Majority of Protozoa nutrition holozoically, i.e., like animals on solid food. The food of protozoa consists of microorganisms like bacteria, diatoms, rotifers, crustacean larvae, other protozoans, algae, small fragments of large animals and plants, etc. These forms of nutrition accomplished by free-living protozoa which directly engulf food, digest it inside their body, and egest unusable remains. The process is phagocytosis to engulf and digest the food.

Phagocytosis- In these process organism uptake solid objects through small invaginations in the cell membrane that form intracellular vesicle. The protozoans cell that engulfs microorganisms via phagocytosis is called phagocyte. The phagocyte extends small pseudopods around the microbe after the later adheres on its surface. These pseudopods fuse and form a vacuole by means of invagination of the phagocyte plasma membrane engulfing or surrounding the object

(called endocytosis). The vacuole is now called a phagosome. Lysosome granules move towards the phagosome, fuse with it to form a phagolysosome, and discharge their contents (hydrolytic enzymes such as lysozyme, phospholipase, ribonuclease, deoxyribonuclease and several proteases) in to the phagolysosome. The hydrolytic enzyme initiates the killing and digestion of the entrapped microorganism and finally within a few hours, the victim is completely degraded and the contents are absorbed. If the engulfed object is not digestible, it is passed outside by the converse mechanism called exocytosis.

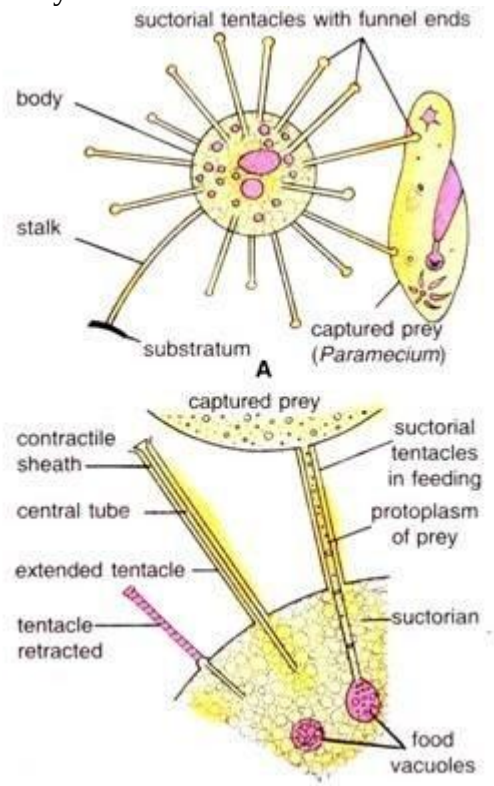


Figure shows mode of feeding in suctoria. A- *Podophrya* sucking paramecium (prey). B- Prey's cytoplasm flowing through tubular tentacle in suctorian body.

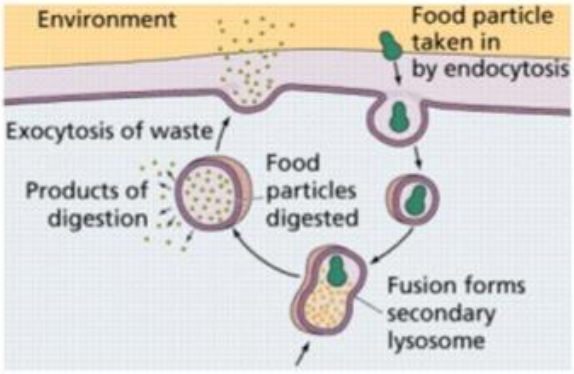
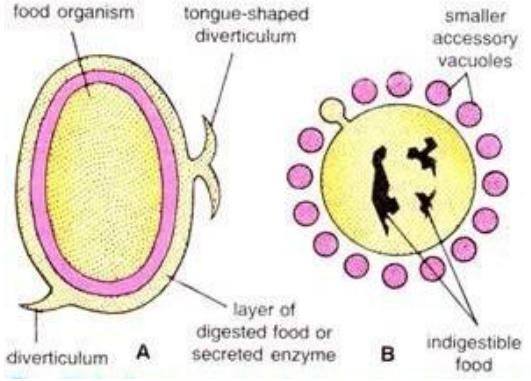


Figure shows- Endocytosis & Exocytosis



Food vacuole A-Recently formed food vacuole B- An older food vacuole.

Rhumbler (1930 has reported that the ingestion of food in *Amoeba* occurs by circumvallation- *Amoeba* engulfs an active prey. In this process sends out pseudopodia around pray and forming a food cup. Food vacuole is formed with the prey in a considerable amount of water. Circumfluence-when amoeba comes in contact with a motionless organism it extends its pseudopodia around the organism and envelops it completely with cytoplasm. Import- it involves the taking food on contact the food passively sinks into body by rupturing the plasmalemma and ectoplasm and Invagination- it has revealed that ingestion of the prey takes place by phagocytosis. Bamigton explain only proteins are digested in *Amoeba*.

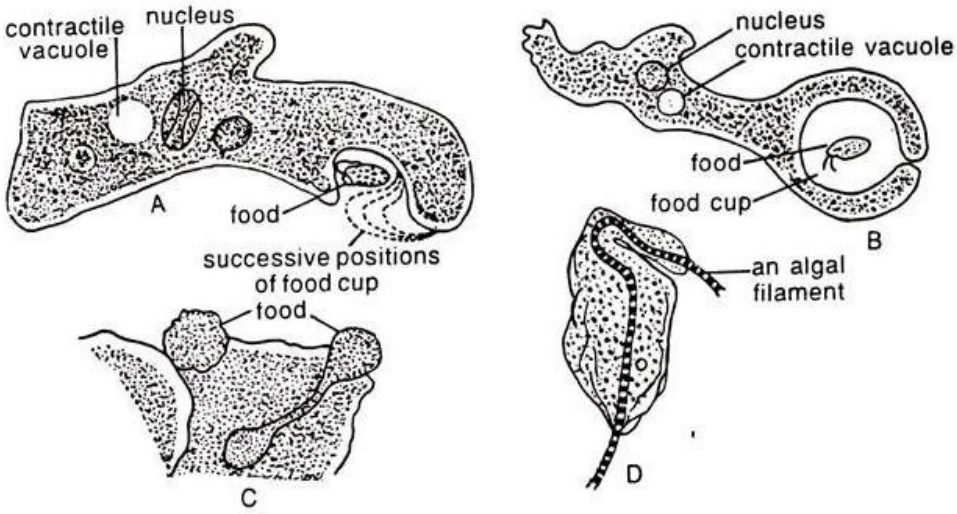
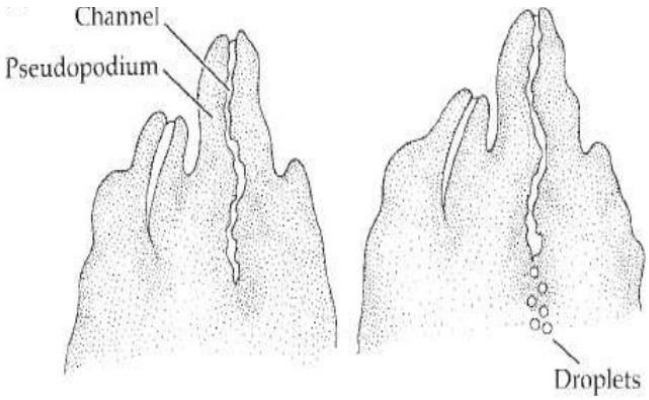


Figure shows feeding in lobose rhizopods (Amoeba sp.). A-Circumvallation B-Invagination (food cup) C-Import D-Circumfluence

Pinocytosis- pinocytosis represents the uptake of the fluids and soluble nutrients through small invagination in the cell membrane that subsequently form intracellular vesicle. This process is also called **cell drinking** and is usually used by amoebae, and some flagellate and ciliate protozoa.the entry of the fluid or soluble nutrient occurs in a similar fashion to that of phagocytosis. Pinocytosis is induced by proteins, inorganic ions and certain dyes. During lab experiment 2 days starved amoeba placed in 1% sodium acetate it becomes star shaped with pseudopodia like projections formed a channel called pinocytosis channel.



Amoeba-Pinocytosis

Holophytic or Autotrophic Nutrition:

Most protozoa are animal-like in their nutritional processes, provision must be made to include the range of flagellates, some of which are pigmented and light-dependent and others which, although pigmented have the capacity to switch reversibly to alternative methods of nutrition in the absence of light. Classifying Nutrition any schemes for classifying living organisms into nutritional types 'depend on the organism's sources of energy, carbon and reducing equivalents' (Hamilton, in Lynch and Poole, 1979). If emphasis is placed on carbon source then grouping organisms as autotrophs which obtain their cell carbon from carbon dioxide. The nature of the energy source divides organisms into phototrophs which utilize energy from the sun and chemotrophs which obtain energy by the oxidation of organic or inorganic compounds. The source of reducing equivalents for cell synthesis labels organisms as lithotrophs when utilizing inorganic and organotrophs when using organic sources.

1) Photoautotroph. Many flagellates are autotrophs which obtain their energy from the sun (phototrophy), and thus can be called photoautotrophs. This process of trapping light energy for the synthesis of glucose units and other cell carbon compounds from carbon dioxide is photosynthesis. It may be considered by many biologists to be of only peripheral interest in protozoan nutrition and yet a large section of the Mastigophora relies on light as a primary source of energy. The Process of Photosynthesis In simple terms photosynthesis, as found in photo autotrophic organisms such as Euglena, can be expressed by the equation-
2) Photoheterotroph. A number of flagellates, although phototrophic in energy requirements, cannot use carbon dioxide for cell synthesis and must have organic carbon compounds. These may be appropriately thought of as photoheterotrophs.
3) Chemoheterotroph. Organisms which require chemical energy and organic carbon sources are the chemoheterotrophs. The nutritional versatility of euglenoid flagellates particularly, which has already been mentioned, allows these flagellates to change from photoautotrophy to chemoheterotrophy in the dark if suitable organic compounds are available. It is important to point out at this stage that although many euglenoid flagellates are essentially photoautotrophic in light, they are incapable of growing without at least an inorganic nitrogen source and certain vitamins. The kind of facultative switch found in euglenoids and many other pigmented flagellates makes the allocation of protozoa to nutritional categories a far from simple exercise.

Osmotrophic or Saprozoic Nutrition-

Some protozoa absorb complex organic substances in solution through the body surface by the process of osmosis called osmotrophy. Such protozoa are called saprozoic. Saprozoic forms need ammonium salt, amino acids or peptones for their nutritional requirements. Decaying of animals or plants in water forms protein and carbohydrates. The saprozoic protozoa are usually parasites like *Monocystis*. But some parasites, like *Entamoeba histolytica* and *Balantidium coli* feeding holozoically also absorb dissolved organic substances through their general body surface. However, some colourless flagellets like *Chilomonas, Astasia, Polytoma*

and species of *Euglena* absorb nutrients from their surrounding environment through their general body surface. The saprophytic organisms release digestive enzymes in their surrounding medium to convert the complex organic molecules in simple forms such as glucose.

Parasitic Nutrition-

In this type of nutrition, the organisms (called parasites) depend on the body of other living organisms (called their host) for getting their food. The parasitic forms feed either holozoic or saprozoic. So, they are grouped into two categories on the nature of food and their mode of nutrition. First Food Robbers-The parasites feeding upon the undigested or digested food stuffs of their hosts are known as food robbers. Some ciliates like *Nyctotherus, Balantidium*. These parasites feed holozoically on solid food particles, while others like *Opalina* feed upon the liquid food by the process of osmosis through their general body surface. The food robbers are generally non pathogenic to the hosts. The second types of organism are Pathogenic Parasites causing harm to their hosts. They feed upon the living tissue of the host. They absorb liquid food through their general body surface for example *Trypanosoma, plasmodium* etc.

Mixotrophic Nutrition-

Euglena is a mixotrophic organism (it is a holophytic organism because it produces her own food through photosynthesis in chloroplasts, and it is also a heterotrophic organism because it absorbs elaborated food, i.e. biotic products). *Euglena gracilis*, is single cells are biflagellate, with the flagella originating in a small reservoir at the anterior of the cell. *Euglena* has several chloroplasts surrounded by three membranes and with pyrenoids. These chloroplasts are of green algal origin. The main storage product is paramylon, a β-1,3 polymer of glucose stored in the form of granules in the cytoplasm (Monfils et al., 2011). A red eyespot (stigma) is located near the base of the reservoir and this filters the light and focuses it on the paraflagellar body, and is involved in the phototaxis of this alga (Häder and Iseki, 2017). Euglena's stigma is composed by thirty to fifty granules of beta-carotene. *Euglena* lacks a cell wall.

Coprozoic Nutrition-

Many cost-free residing Protozoans feed on the faecal matter of other animals and are termed as coprozoic. Eg., Cercomonas and so on.

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