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ZOOLOGY	**PAPER No.: IX (NON-CHORDATES)**
	MODULE No. 2 (REPRODUCTION IN PROTOZOA)

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1. Learning Outcomes:

In this module,

- You shall learn about the information regarding the concept of reproduction in protozoa.
- You shall learn about Various types of reproductions like Sexual and Asexual, parthenogenesis etc.
- You get knowledge about habit and habitats of the protozoans.

2. INTRODUCTION:

Protozoans reproduce in a variety of ways and the process of reproduction is variable amongst different groups. But in all essence and purpose protozoan reproduction is nothing more than the division of the cell. It reproduces both asexually and sexually.

I. Asexual Reproduction: When the continuity of species is main-tained without the participation of the gam-etes and the asexual reproduction takes place by the division of the body of individual into two or more parts, these parts give rise to the new individuals.

The asexual reproduction is of the follow-ing types:

A. Binary fission,

B. Multiple fission or Sporulation,

1. Schizogony or Agamogony
2. Gamogony
3. Sporogony

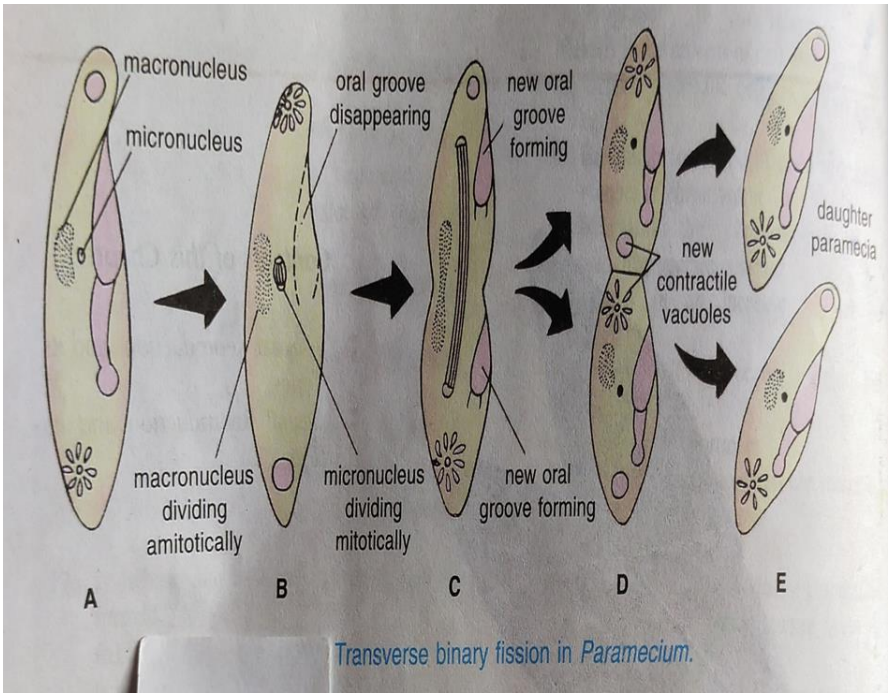
C. Plasmotomy

D. Budding

E. Repeated fission.

A. Binary fission:

It is the usual method in which the body of the individual divides into two equal halves and the furrow ex-tends along the long and the extended axis of the body.



Transverse binary fission in *Paramecium*.

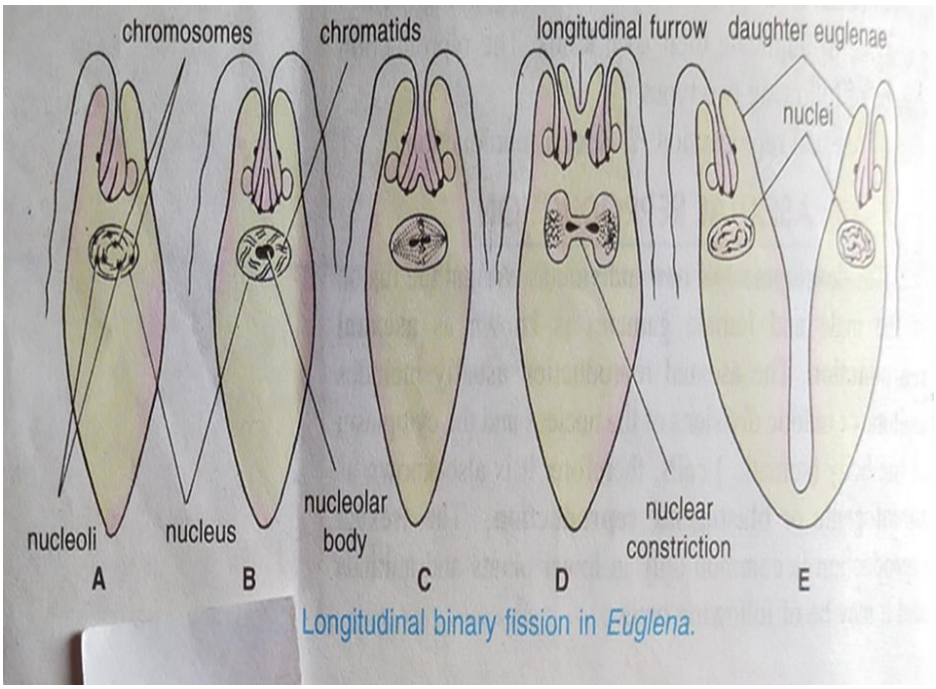
Depending upon the plane of division, the binary fissions are of the following cat-egories:

(i) Transverse binary fission:

The plane of division of the body constricts transversely, e.g., Paramoecium.

(ii) Longitudinal binary fission:

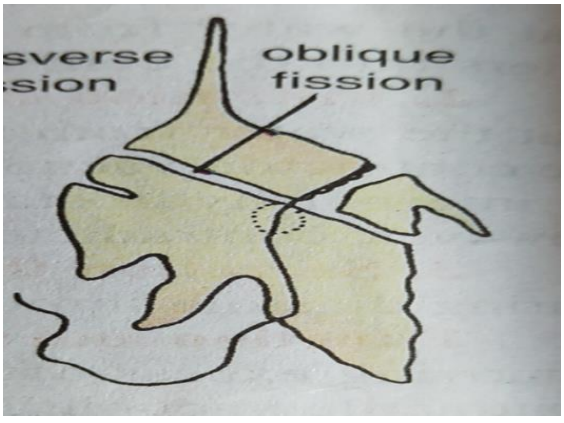
The plane of constriction is along the long axis of the animal, e.g., Euglena, Vorticella, Trypanosoma etc.



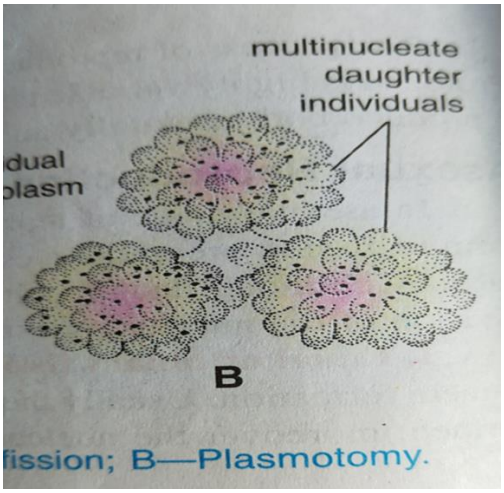
Longitudinal binary fission in *Euglena*.

(iii) Oblique binary fission:

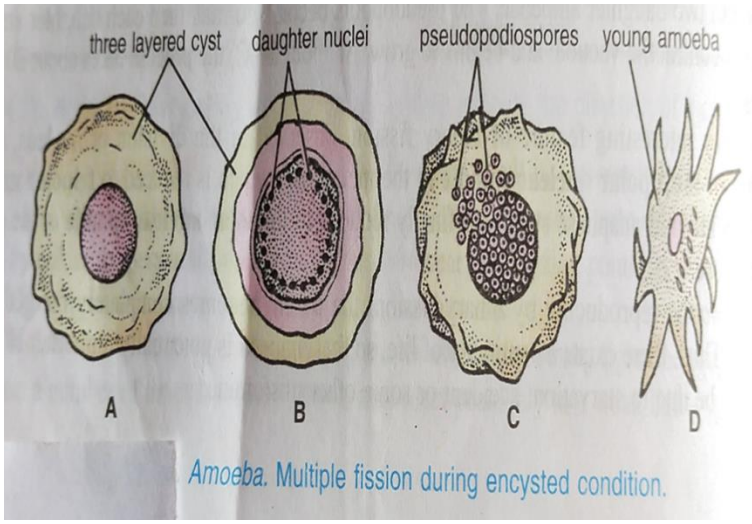
The plane of division is somewhat oblique, e.g., Ceratium. The different organelles present in the body may divide or they may be retained by one of the daughter cells; while in the other cell regenerates the lost organelles. In extreme cases organelles disappear altogether and are regenerated by both the offspring.



(iv) Encysted condition: In Colpoda, Tellina and in testaceans, binary fission takes place in encysted condition. One of the daughter individuals remains within the old test while the other moves away to form a new one.

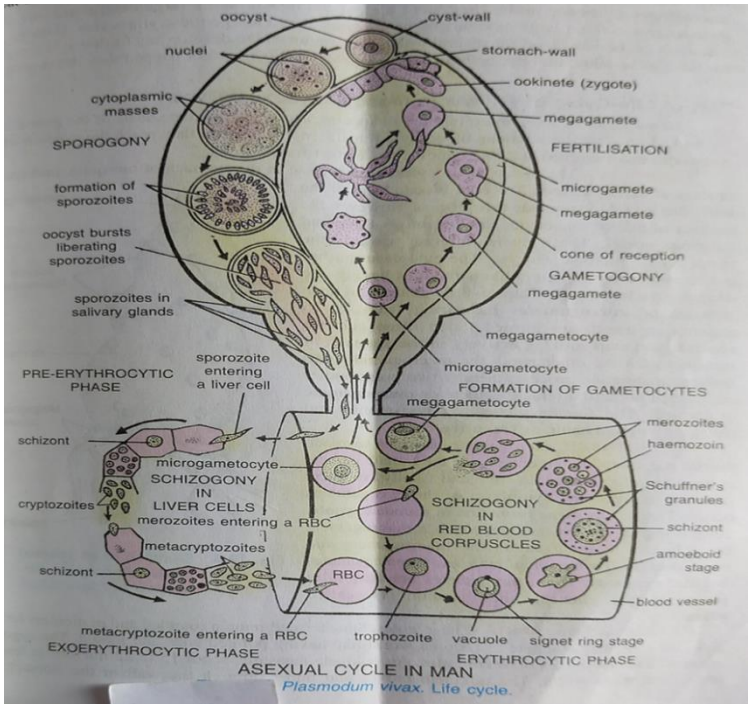


B. Multiple fission or Sporulation: In multiple fission the body divides and a number of daughter individuals are formed. The nucleus divides a number of times and a multinucleate state result. The nuclei come to the periphery and gather some amount of cytoplasm round them. The cell-membrane breaks and daughter individuals correspond-ing to the number of nuclei are produced.



The number of individuals produced by multiple fission varies and sometimes as many as 1000 individuals are formed. Mul-tiple fission occurs in Foraminifera, Radiolarians and Sporozoans. Multiple fission is also known by the following names:

1. **Schizogony or Agamogony:** When the products of the fission directly develop into individuals as in Plasmodium in the red blood cells or hepatic cells of man.



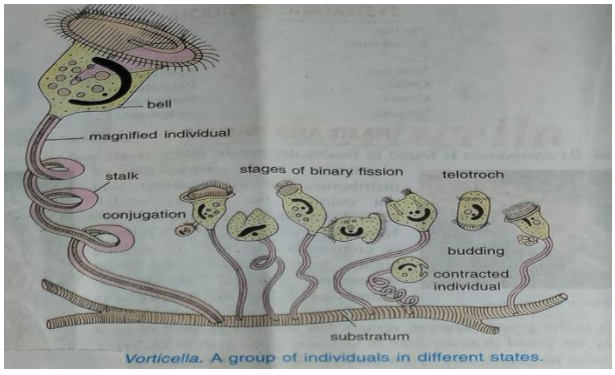
Plasmodum vivax. Life cycle.

2. Gamogony: When the products are sex cells as the microgametocytes of Plasmodium.

3. Sporogony: When it occurs following sexual fusion as in Monocystis and Plasmo-dium.

C. Plasmotomy: It is the division of the cell-body without nuclear division and oc-curs in many multinucleate ciliates like Opalina.

D. Budding: It is a process in which one or more individuals are produced on the body of the parent and are budded off. The indi-viduals generally do not resemble the mother and undergo further development before or after being free. Budding occurs only in Suctoria. The site of bud formation may be inside or outer side of the body.



Vorticella. A group of individuals in different states.

1. Exogenous bud: When the buds are constricted off to the exterior as in Noctiluca and some Myxosporidia.

2. Endogenous bud: When the buds are formed in the brood chamber or internal spaces of the mother body and come out later as in Testaceans, Arcella, Suctorians and many Myxosporidia.

E. Repeated fission: In which equal division of the nucleus occurs twice or thrice forming four or eight nuclei which do not separate till the process for which the nu-cleus divides is complete as in the micronucleus of Paramoecium and Volvox.

II. Sexual Reproduction:

Sexual reproduction is one when it takes place by the union of two entire individuals or it involves merely the nuclear exchange and their subsequent fusion. In Protozoa the sexual reproduction occurs by the following processes:

A. Syngamy or Copulation: In which union of two sexual cells, called gametes, occur. On the basis of structure and behav-iour of the sexual units the following types of syngamy can be recognised:

(a) Hologamy: In which no true gamete formation takes place but two mature trophic individuals unite with each other and fusion of both nucleus and cytoplasm takes place. It occurs in few flagellates and rhizopods.

(b) Isogamy: The copulating sex units are similar in size and form and cannot be mor-phologically distinguished from each other though there exist physiological differences. The units are generally produced by multi-ple fission. Isogamy is common in Formaminifera, Gregarines and Phytomonadina like Copromonas.

(c) Anisogamy: It is fusion of dissimilar gametes. The copulating sex units are dis-similar in size, form and behaviour. The large and non-motile unit is called female or macrogamete and the small mobile one is termed male or microgamete in such fusion. They widely occur in Phytomonadina and Sporozoa, e.g., Plasmodium.

(d) Oogamy: In this case the gametes are quite dissimilar. The female gamete is non- motile egg and the male is a flagellate and motile sperm. It is found in Volvex.

(e) Paedogamy: When the fusing pronu-clei are present in two different cells derived from a single parent cell, the process is called paedogamy. The process has been observed in Actinophrys sold by Blar (1922) and in some Myxosporidia.

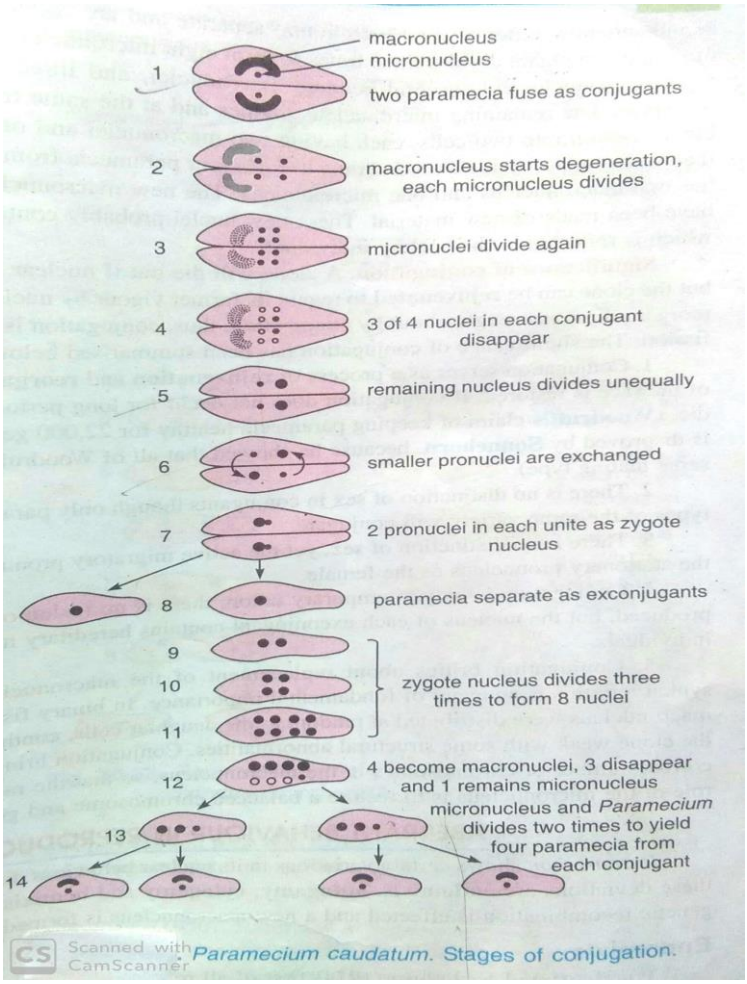
Significance of syngamy:

(i) Syngamy brings about a nuclear re-organization, and physiologically it has distinct effects.

(ii) It brings two previously separated lines of heredity in close association.

(iii) It increases diversity among the off-spring.

B. Conjugation: Conjugation may be defined as a temporary union of two indi-viduals belonging to same species for the purpose of exchange of nuclear material. Conjugation is a complex process in which several nuclear divisions occur both in the preparatory and post-conjugation phases and one of these divisions is meiotic in nature. Conjugation occurs in Euciliates and Suctorians.



Paramecium caudatum. Stages of conjugation.

Significance of conjugation:

(i) Conjugation helps in rejuvenescence to gain vigour and vitality.

(ii) It brings about the genetic recombi-nation, and the origin of genetic vari-ations takes place.

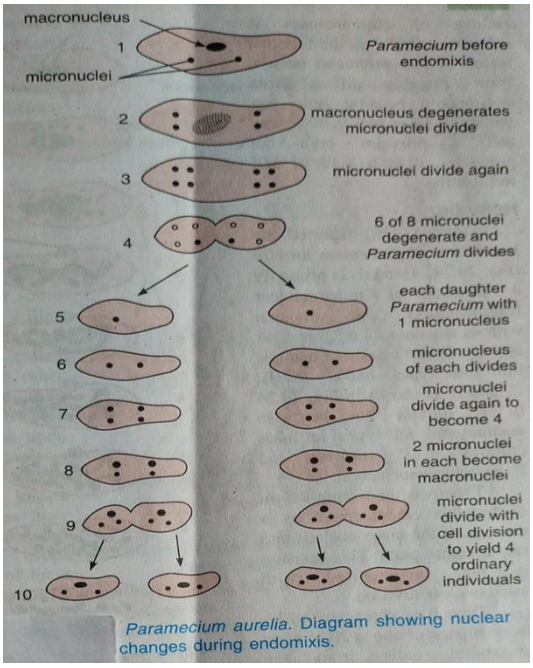
(iii) Reorganesation of nuclear apparatus takes place between the individuals.

Aberrant reproduction in Paramoecium: Peculiar variation in behaviour of Paramoecium in nuclear division during conjugation is encountered.

These variations in behaviour have been classified in the following ways:

(a) Autogamy: Very similar to conjuga-tion but all the changes occur in a single individual. It is accompanied by fusion of pronuclei and meiosis and provides an op-portunity for the reshuffling of genes. Auto-gamy occurs in Paramoecium aurelia.

(b) Endomixis: Woodruff and Erdmann (1914) first described the process in Paramoecium aurelia. This is very similar to conjugation but nuclear changes are restricted to a single individual. Fusion of pronuclei and meiosis does not occur, though a new meganucleus is formed out of the micro- nuclear material as in conjugation.



Paramecium aurelia. Diagram showing nuclear changes during endomixis.

(c) Hemimixis: The process was observed by Diller (1936) in Paramoecium aurelia and P. multimicronucleatum. In this case the meganucleus behaves in a strange fashion. It divides into two or a part of it may be pro-truded into the cell mass. The meganuclear activity is independent of cell division or syngamy.

Parthenogenesis: In case the syn-gamy is missed, gametes develop parthenogenetically. The examples are Actinophrys, Polytoma and Chlamydomonas.

Regeneration: Protozoa possess a remarkable power to regenerate lost parts, provided nuclear material is included. When an amoeba is cut into two parts and the parts are kept in proper environment—the part without nucleus degenerates while the nu-clear part regenerates. Shell of Foraminifera regenerates if broken. Besides these restora-tive regenerations in protozoa there occur regenerations of lost parts like cilia, flagella, cytostome and vacuoles after asexual and sexual reproduction. The process of morpho-genesis in regeneration and reorganisation has been a subject of research.

Nuclear Division:

A. Mitosis: The modes of nuclear divi-sion during reproduction are worthy of con-sideration. Earlier the existence of mitotic phenomenon in protozoa used to be disre-garded and it was advocated that in proto-zoa there occurs 'amitoses or an unusual type of mitosis. Now it has been made evident that the nuclear division in protozoa passes through all the steps of mitosis and is iden-tical with those of metazoan cells in most cases and in the rest they are abbreviated.

The mitotic phenomenon in protozoa is de-scribed in the following ways:

(1) Eumitosis: When there is distinct chromosome formation and chromosomes on the whole behave like those of the metazoan. Eumitosis is a common feature of free-living forms.

(2) Paramitosis: The chromosomes dur-ing paramitotic division do not shorten at metaphase and remain asymmetrically arranged on the equator of the spindle. The sister chromatids do not lie side by side but hang together at one end. As a result, during separation, they present a picture of false transverse division of chromosomes. Paramitosis occurs in Coccidians, Dinoflagellates, etc.

(3) Cryptomitosis: In cryptomitosis trans-lation of the chromatin material into chro-mosomes is lacking and the whole chroma-tin material is lodged as a mass on the equa-tor of the spindle. The chromatin mass be-comes divided into two halve which go to the two poles. Cryptomitosis occurs in parasitic and coprozoic forms like Hoylosyoridium and Naegleria.

B. Meiosis: The Protozoan nuclei undergo divisions prior to sexual reproduction. And it is expected that one of these divisions should be meiotic in nature so that the con-stancy of the number of chromosomes could be maintained.Information about meiosis in protozoa is scanty or fragmentary. Meiotic division in protozoa may occur before the formation of gametes (pre-gametic) or after the fusion of gametes (post-zygotic). Pregametic meiosis occurs in Paramoecium and post-zygotic in Telosporidia.

Cytoplasmic Division: The division of nucleus is followed by division of cytoplasm and extra-nuclear organelles, such as chromatophores and pyrenoid, blepharoplast and kinetosome. But nuclear division in encysted condition results accumulation of cytoplasm round each nu-cleus and there is no cytoplasmic division in true sense.

Encystment: Many protozoa exhibit a phase reversal. At one phase of life cycle, they remain active and carry-on vital life processes and in an-other phase they become inactive and dis-card most of the life processes. The active phase is called trophic or trophozoite stage and the inactive phase is called cyst and cystic stage. That means many protozoa are capa-ble of existing alternately as trophic and cystic forms.

Summery:

In Stentor coeruleus, a process called physiological regenera-tion takes place occasionally and its biological significance is not known. During the transformation from trophic to cystic the trophozoites cease to ingest, extrude remains of food particle and become round in appearance. This phase is called the pre-cystic phase. De-differentiation of the whole organism now occurs and cell organellae like cilia, peristome, axostyle, contractile vacuole, etc., are absorbed. Finally, they secrete substances which solidify and form resistant walls round the organism.

Thus, a cyst is formed. The number of walls in a cyst varies from 1-3. The cysts are capable of remaining viable for a long time. The wall of the cysts contains silliceous plates in Euglypha, cellulose in Phytomonadina and chitinous elements in most cases.

Video:
https://drive.google.com/file/d/1kVSnvSwnVMixVd_27Bk2Moq834Y0q2i-/view?usp=sharing

Assignment: https://docs.google.com/forms/d/e/1FAIpQLSf-BiLH33jUBgYxuQCCgKharGqaE7lxIgimcNyyZRQqyLmwog/viewform?usp=sf_link

Know more:

Suggested readings, web links:

1. Text book of Invertebrates Dhami Dhami
2. Invertebrates by R.L.Kotpal
3. Text book of Non chordates by S.N.Prasad
4. https://www.biologydiscussion.com/invertebrate-zoology/protozoa/protozoa-nutrition-respiration-and-excretion/32547

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