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Classification of Animals

Animalia

- **Protozoa**
  - Unicellular protist (animals) but due to their mode of nutrition. is holozoic so they are considered as primitive type of animals.
  - Phylum Protozoa
- **Metazoa (multicellular animals)**
  - **Parazoa (Porifera)**
    - Grade of organisation is cellular.
    - Phylum Porifera
  - **Eumetazoa**
    - True multi-cellular organism
    - Tissue grade of organisation.

Metazoa - Body is made of more than one cell.
Protozoans have protoplasmic grade of organisation.

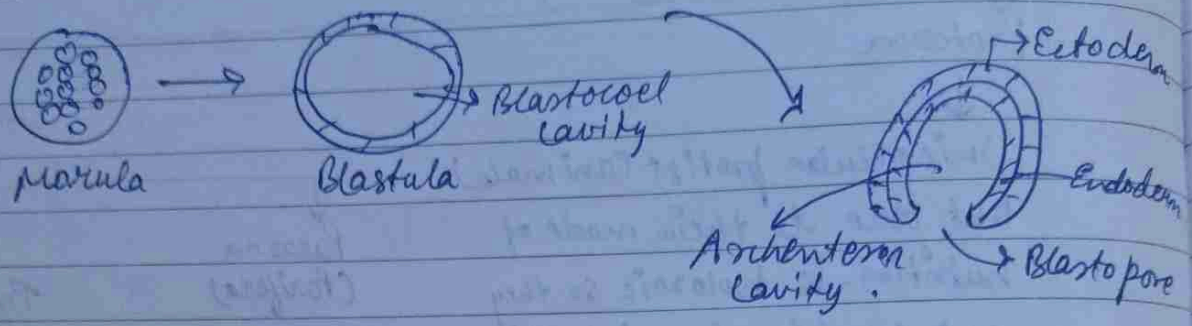
Eumetazoa

on the basis of Symmetry.

- **Radiata**
  - Includes organisms which has radial symmetry.
  - Phylum Coelenterata or Cnideria
- **Bilateria**
  - Bilateral Symmetry.
  - **Protostomia**
    - During embryonic stage mouthpart develop from blastopore.
  - **Deuterostomia**
    - during E.S mouth part develop do not develop from blastopore.
    - they all are Enterocoelomate.

Three developmental stages –

1) Morula 2) Blastula 3) Crastrula.



If mouth part develops by blastopore → Protostomia.

→ Protostomia

Presence of Coelom

Acoelomata	Schizocoelomata	Eucoelomate
Platyhelminthes.	Aschelminthes & Nematoda	Annelida Mollusca Arthropoda.

→ Deuterostomia

All Eucoelomate & there are 2 phylum

1) Echinodermata
2) Chordata.

Lower Invertebrate - Protozoa to Nematoda.

Phylum Protozoa

→ Phylum protozoa includes individuals with protoplasmic grade of organisation

→ These represent the primitive type of animals although their body is not multicellular but their mode of nutrition is very much similar to the multicellular animals that's why we study Protozoan under the head of Animalia.

So Protozoan represents individuals which are unicellular, Eukaryotic and having animal like mode of nutrition.

General characters of Protozoa

Habit and Habitat
They are free living, aquatic / parasitic - (Endoparasite)

Morphology
They are unicellular animal.
Body is covered by plasmalemma, Pellicle or they are shelled.
Body contains cytoplasm, true nucleus and all cellular organelles of Eukaryotes.

Anatomy
→ Cytoplasm is differentiated into two parts - Outer Ectoplasm & Inner Endoplasm / plasma sol & plasma gel.
→ Nucleus single or multiple.

Physiology
→ Locomotion takes place with the help of Pseudopodia, Cilia and flagella. But locomotory organs are absent in certain parasitic forms.
→ Their mode of nutrition is holozoic, heterotrophic, parasitic and saprobiotic.
→ Alimentary Canal is absent, in certain animals such as paramoecium cytostome & Cytopharynx present responsible for formation of food vacuole.
→ Digestion is intracellular, takes place within food vacuoles with the lysosomal enzyme. Medium is 1st acidic then alkaline. So food vacuole of protozoans is analogous to alimentary canal of higher animals.
→ They are ammonotelic, no special excretory organ for excretion, excretion takes place by simple diffusion through general body surface.

In Ciliophora sometimes so more than one nuclei is but

→ Gaseous exchange through general body surface, Parasitic forms perform anaerobic Respiration.

Reproduction
Reproduction by both Sexual and Asexual method.

Development
Protozoans are considered as immortal because there is no natural death and there is no differentiation between somatoplasm & Germplasm.
No laval stage present.

Protozoa
Protozoa is a phylum that includes microscopic animalcules (Tiny animals). They are Eukaryotic, unicellular organisms & protoplasmic grade of organisation. Some Scientist ~~justed~~ suggested that protozoans are acellular organisms because mostly animals are multicellular & specialised tissue to perform a specific activity. (division of labour).

General characters —
→ They are mostly microscopic, primitive & simplest ~~type of~~ among all animals. The body is unicellular containing one or more nuclei & dimorphism in some cases. ('dimorphism' means having 2 nuclei for other functions)
→ The individuals may be solitary or forming loose colonies. In which individuals remain alike & independent
→ The body symmetry is bilateral, radial, spherical or none. Body is naked or bounded & a pellicle & often provided & simple ~~to~~ elaborate cells or exoskeletals.

Body form usually constant but may be varying in some.

→ The single cell body perform all the essential & vital activities which is characterised by the animal body hence only sub-cellular physiological division of labour is met. Locomotory organelles are finger like Pseudopodia or whiplike flagella or hairlike Cilia or may be absent in some individuals.

→ Nutrition is holozoic (i.e animal like), holophytic (plantlike), saprozoic or parasitic.
Digestion occurs intracellularly inside the food vacuoles, Respiration & Excretion through the general surface of the body, Contractile vacuoles are specialised str. that are involved in Excretion as well as in Osmoregulation, Reproduction is asexual in most of the cases but Sexual reproduction is also reported, asexual reproductn occurs by binary fission & budding. while sexual reprodn by conjugation of adults k/a Hologamy. or by the fusion of gametes k/a Syngamy;

→ Life history is often complicated with alternation of Sexual & asexual phases encystment commonly occurs which helps in dispersion as well as to resist unfavourable condition of scarcity of food, high temp and water. The single celled ind. not depend into ~~so cytoplasm~~ somatoplasm & germplasm therefor exempt for natural death.

Mastigophora - Flagella bearing.

Classification of Protozoa

(subphylum)

1. **Sarcomastigophora** — Locomotory organs are and they are either Pseudopodia or flagella. Monomorphism
2. **Sporozoa** — Locomotory organ absent. They produce spores. Simple type of spores.
3. **Cnidospora** — Locomotory organ absent. They produce spores. Cnidoblast cell.
4. **Ciliophora** — Locomotory organs are cilia. Nuclear dimorphism.

1. Sarcomastigophora (divided into 3 superclasses)

- **Mastigophora** (superclass) (class)
  - Phyto-mastigophora (6 orders)
    - → Chrysomonadida (Chryso amoeba)
    - → Cryptomonadida (Cryptomonas)
    - → Euglenida (Euglena) ✓
    - → Volvocida (Volvox)
    - → Chloromonadida (Vacularia)
    - → Dinoflagellida (Noctiluca)
  - Zoo-mastigophora
    - → Rhizomastigida (Mastigo amoeba)
    - → Kinetoplastida (Trypanosoma) ✓
    - → Choanoflagellida (Proterospongia)
    - → Diplomonadida (Giardia) ✓
    - → Hypermastigida (Trichonympha)
    - → Trichomonadida (Trichomonas)
- **Opalinata** — Eg- opalina ✓ — Not further divided. (have more than one nuclei)
- **Sarcodina** — pseudopodia are classified on the basis of pseudopodia

(1) Sarcodina

→ Rhizopodia (class) — (subclass) – 3
- → Lobosia
- → Filosia → (Allogromia)
- → Granulo reticulasia → one order → Foraminiferida (Elphidium)

Lobosia is divided into 2 orders –
- → Amoebida (Amoeba)
- → Arcellinida (Arcella)

→ Actinopodea (class)
- → Heliozoia (Actinophrys)
- → Radiolaria (Collozoum)
- → Acantharia (Acanthometra)
- → Proteomyxidea (Pseudospora)

→ Piroplasmea (Babesia) (class)

(2) Sporozoa (sub phylum)

class Telosporea
- 2 orders
  - → Gregarinia (Gregarina)
  - → Coccidia (Plasmodium)

Toxoplasmea (Toxoplasma)

Haplosporea (Ichthiosporidium)

(3) Cnidospora
- → Myxosporidea (Myxidium)
- → Microsporidea (class) (Nosema)

4) Ciliophora

class - Holotricha (6 orders) | Peritricha | Spirotricha (2 orders) | Suctoria.

Protozoa

Euglena viridis

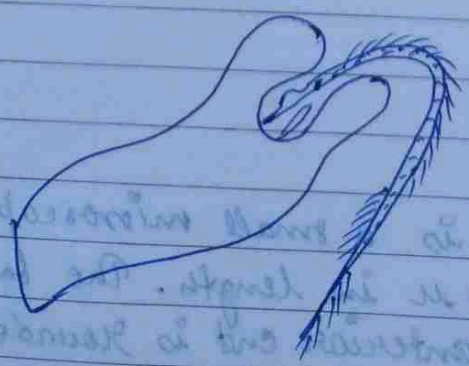
Systematic position

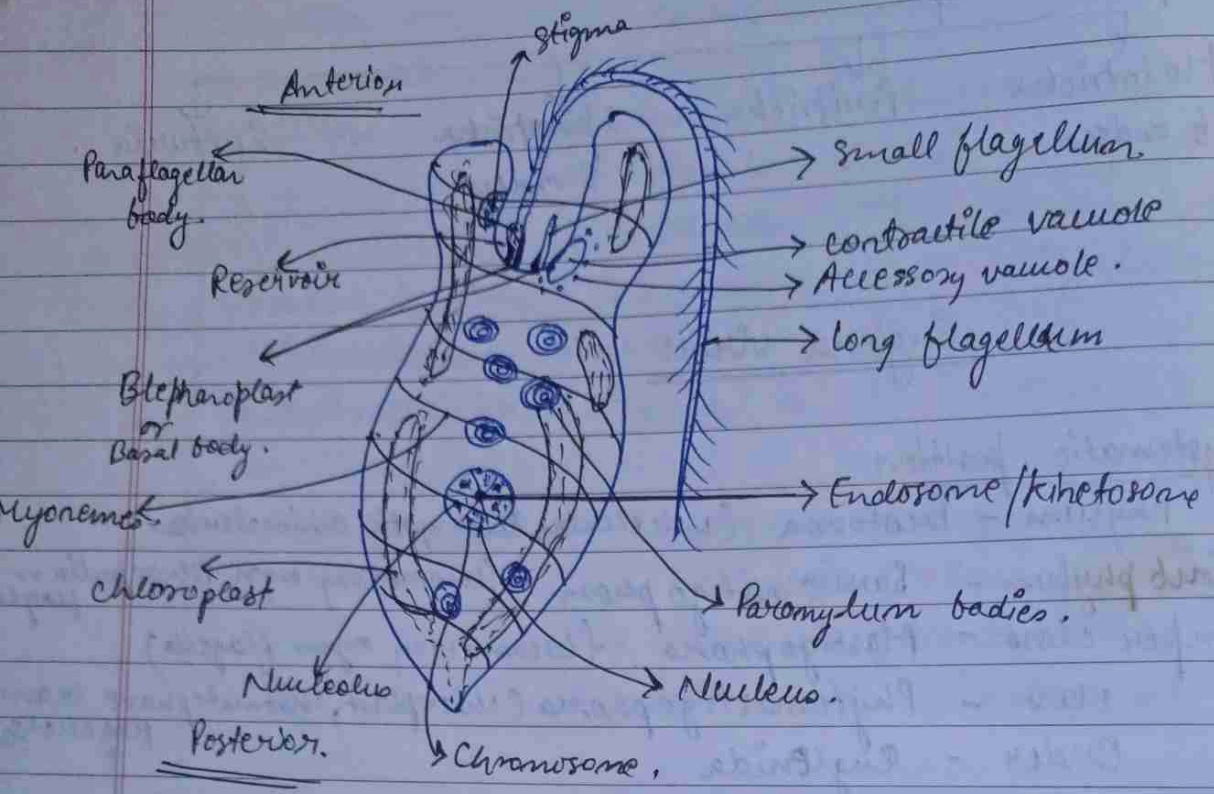
Phylum - Protozoa (unicellular, Eukaryotic animalcules)
Sub phylum - Sarcomastigophora - (locomotory organ Pseudopodia or flagella)
Super class - Mastigophora. (locomotory organ flagella)
class - Phytomastigophora (Chloroplast, chromatophore bearing flagellates)
Order - Euglenida
Genus - Euglena
species - viridis.

Habit and Habitat

They are solitary, free living; Aquatic and active type of individual. (freshwater bodies like pond, lake, ditches etc)
Rich in Vegetation or decaying nitrogenous material.

External Morphology





Habit & Habitat

Euglena viridis is a solitary and free living freshwater flagellates. It occurs in freshwater ponds, ditches and slowly running stream where there is considerable amount of vegetation. present, It is also found in freshwater bodies & decaying nitrogeneous decaying material.
It is fairly active and found at various depths below the surface of water.

External feature

1) Shape & Size

Euglena viridis is a small microscopic organism measuring about 60 μ in length. The body is elongated & spindle shape, the anterior end is rounded or blunt. The middle part is somewhat wider and the posterior end is

pointed. From the anterior end a whiplike flagellum arises

The body is covered by a distinct, thin, elastic but tough Pellicle which lies just beneath the plasma membrane, it is flexible enough to permit the movements, it is made up of protein so not homologous to the plant cell wall
Electron microscopy has revealed that a pellicle consist of thin, firm, elastic and helically disposed stripes. these stripes are k/a Myonemes.
In the electron micrograph just beneath the pellicle a row of mucus secreating bodies and bundles of microtubules can be observed.

~~In the~~ Cytoplasm (which is enclosed by Pellicle) is divided into two clear zone - the outer ectoplasm & inner endoplasm.
Ectoplasm is present in the form of a clear, dense, narrow peripheral zone containing microtubules and mucus secreting bodies or musiferous bodies. The Endoplasm is more fluid like granular central zone having nucleus & several other inclusions. These inclusions are as follows -

1) Reservoir.

At the blunt anterior end of the body there is an invagination forming a permanent flask shaped cavity. It consist of a reservoir or flagellar sac.

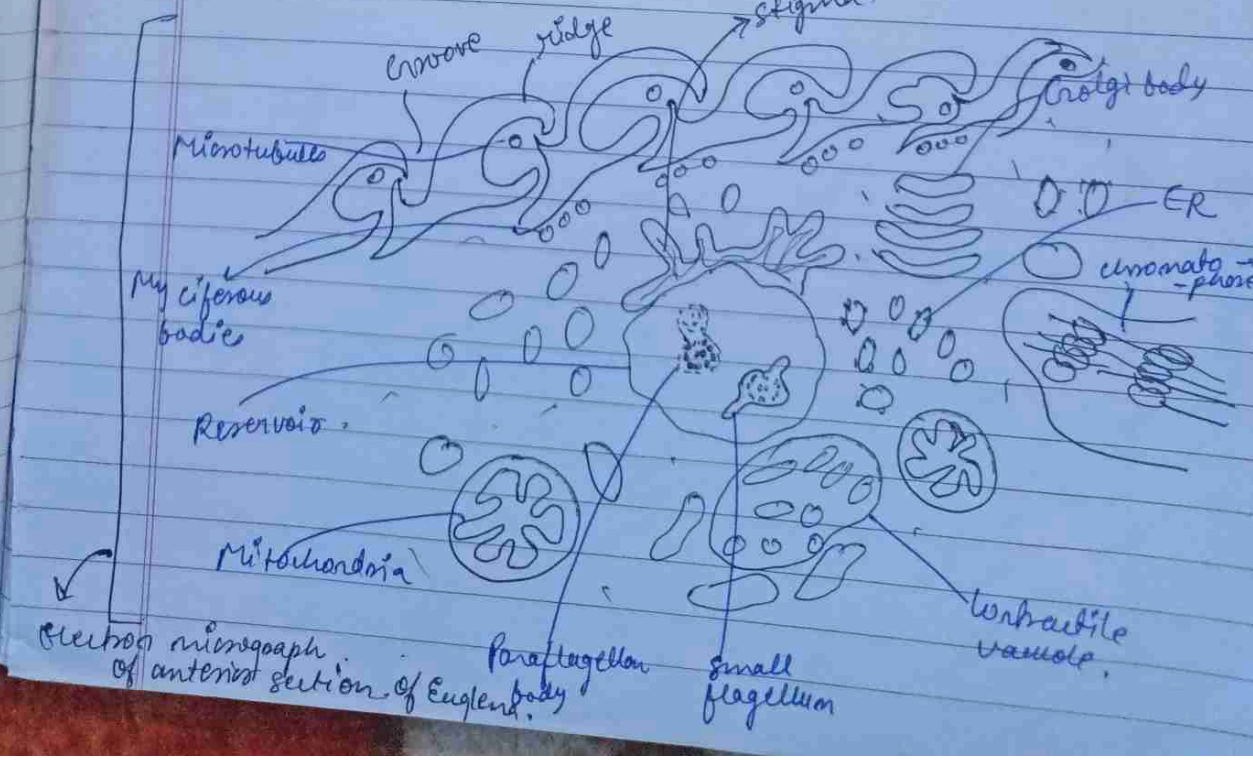
Contractile vacuole

Contractile vacuoles are present near the reservoir. A contractile vacuole consist of a large main vacuole alongwith so many accessory small vacuoles.
Contractile vacuoles are meant for osmoregulation.

Stigma

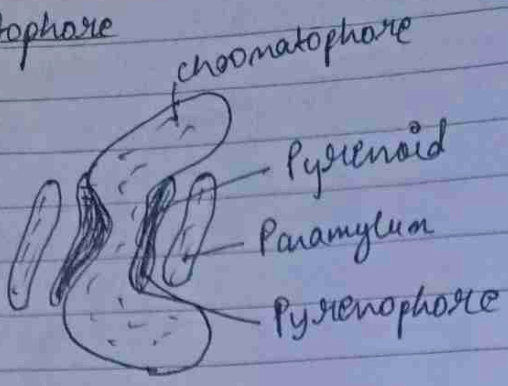
On the opposite side to contractile vacuole a dark coloured body is present which is filled ~~with~~ with carotenoid (red colour pigment) it is also k/a eye spot
Stigma alongwith paraflagellar body regulate the movement of Euglena.

Besides these main structure in cytoplasm so many chromato-phores or chloroplast are also present alongwith paramylin granules.
In the electron micrograph the usual Eukaryotic cell organalles like ER, Golgi body, Mitochondria etc can be observed.



Electron micrograph of anterior section of Euglena.

Chromatophore

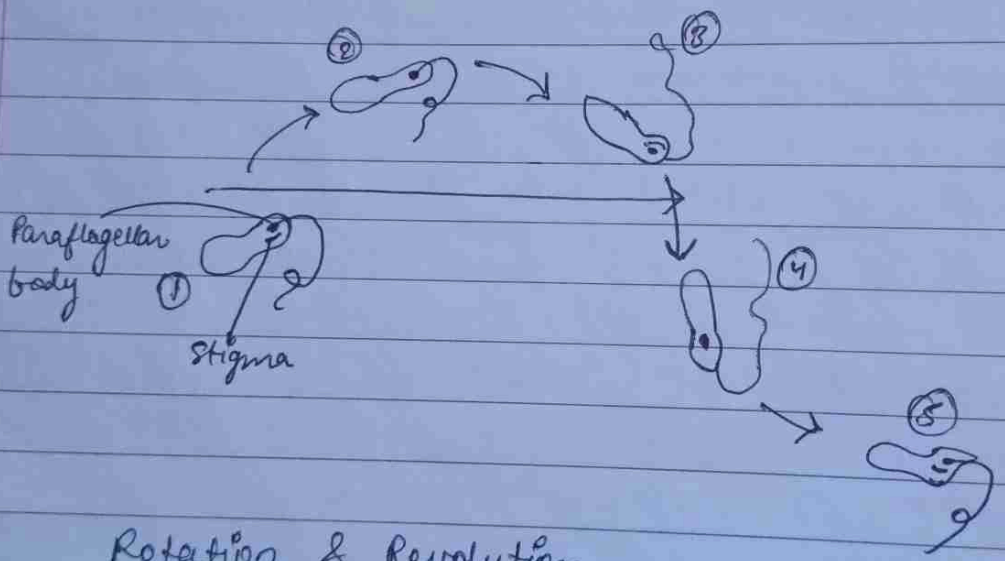


Locomotion

① Free swimming (Flagellar movement)
② Euglenoid movement (Contractile movement)

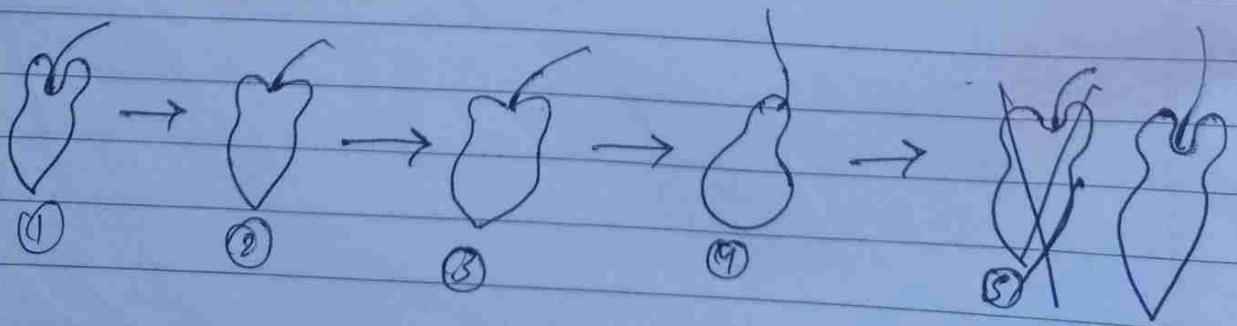
In free su

(1)



Rotation & Revolution

(2)



Successive stage of Euglenoid movement.

Locomotion in Euglena is performed by two mechanisms or there are two types of locomotory movement. these are -

1) Flagellar movement / free swimming — In this type of movement flagella actively take part and ē the beating of flagella the organism move in straight direction. During flagellar movement the flagellum is directed obliquely backward towards the site bearing stigma, it undergoes spiral undulations ē waves that are transmitted from the base to tip causing its beating or sideways lashing. The flagellum beats on an average at a rate of 12 beats per second, the beating of flagellum drives water backward and induces the whole body to move further. Each beat not only force the body forward but also to one side thus when the beats are repeated over and over the Euglena revolves in a circle. As the flagellum is directed obliquely backward to the long axis of the body the organism also rotate on its axis. It has been calculated that Euglena rotate at the rate of 1 turn per second.

2) Euglenoid movement - Due to presence of pellicle which is quite flexible, Euglena can perform peristaltic activity this activity brings about worm like ~~jiggling~~ wriggling or writhing movements while the animal creeps on the bottom. As the peristaltic wave pass the body becomes shorter & wider first at the anterior end then in the middle and later on the posterior end. this characteristic movement is met in Euglena & some other protozoans thats why k/a Euglenoid movement or Metabolic movement.

Nutrition

Mixotrophic

↓

Holophytic (Green)

↓

Plant like

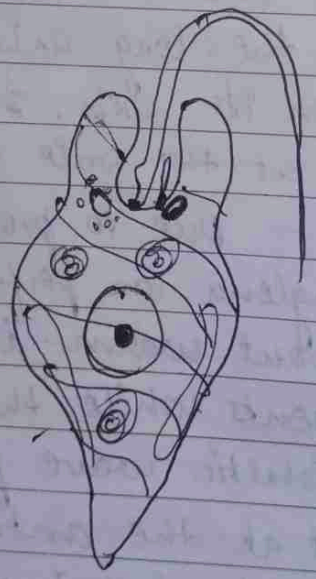
In presence of light
& the help of chloroplast
it can prepare its food.

↓

Saprozoic (Black)

↓

In Dark condition it turns Black due to degeneration of chloroplast and in this condition it gets its nutrition from organic material by saprozoic mode of nutrition



Monocystis

Some of the species of Monocystis are –

M. agilis
M. lumbrici
M. Magna
M. bengalensis
M. beddardi , M. pheretemi

classification

Phylum – Protozoa
Subphylum – Sporozoa
Class – Telosporea
Sub class – Gregarinia
Order – Eugregarinida
Genus – Monocystis
Species – agilis

Habit and Habitat

Endoparasitic in earthworm found in their coelome & seminal vesicle.

Structure of trophozoides – adult and feeding stage of Parasite

Shape & size

Microscopic, unicellular.
Shape & size differ in different stages.
In young stage it is 5μ long rounded & oval.
In full grown stage it is elongated, spindle shaped

Myo - movement
volutin - protein rich in phosphorous & nucleic acid.

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flattened, worm like, tapering end. 500μ long and 40μ broad.

Pellicle

Pellicle may be striated or thrown into ridges & furrows, contain long arranged contractile microtubule & it is outermost covering of body.

Cytoplasm

Cytoplasm is divided into outer Ecto and inner granular ectoplasm.

→ Outer ectoplasm is again divided into outer epi, Middle Sarcocyte & inner myosite.
Inner myosite layer contain.

→ Endoplasm is granular and contains abundance of paraglycogen granules, fat globules and sometimes volutin.

→ Mitochondria & Golgi body is also found as in other protozoans and mitochondria is present in more number at periphery.

Nucleus

Single and basicular & spherical or ellipsoidal form Nucleolus is one or many. and 4 chromosomes are present in haploid number.

Gregarine
It may secrete a digestive enzyme.

Physiology

1 - Locomotion

Locomotion is wriggling or gliding ——— brought by rhythmic contraction & relaxation of myonemes.
characteristic of monocystis in Gregarine or Gregarine movement which is similar to Euglenoid movement.

2 - Nutrition

Sporozoic absorb seminal vesicle fluid by osmotrophy through general surface of body.
It secrete enzyme upon the outer fluid and rendering protoplasmic particle soluble for their absorption and reserved food material in the form of paraglycogen granules.

3 - Respiration

It takes oxygen through diffusion from pellicle, from the cell content of host sperm or fluid of seminal vesicle.

4- Excretion

Carbon dioxide and nitrogenous waste product is eliminated by diffusion.

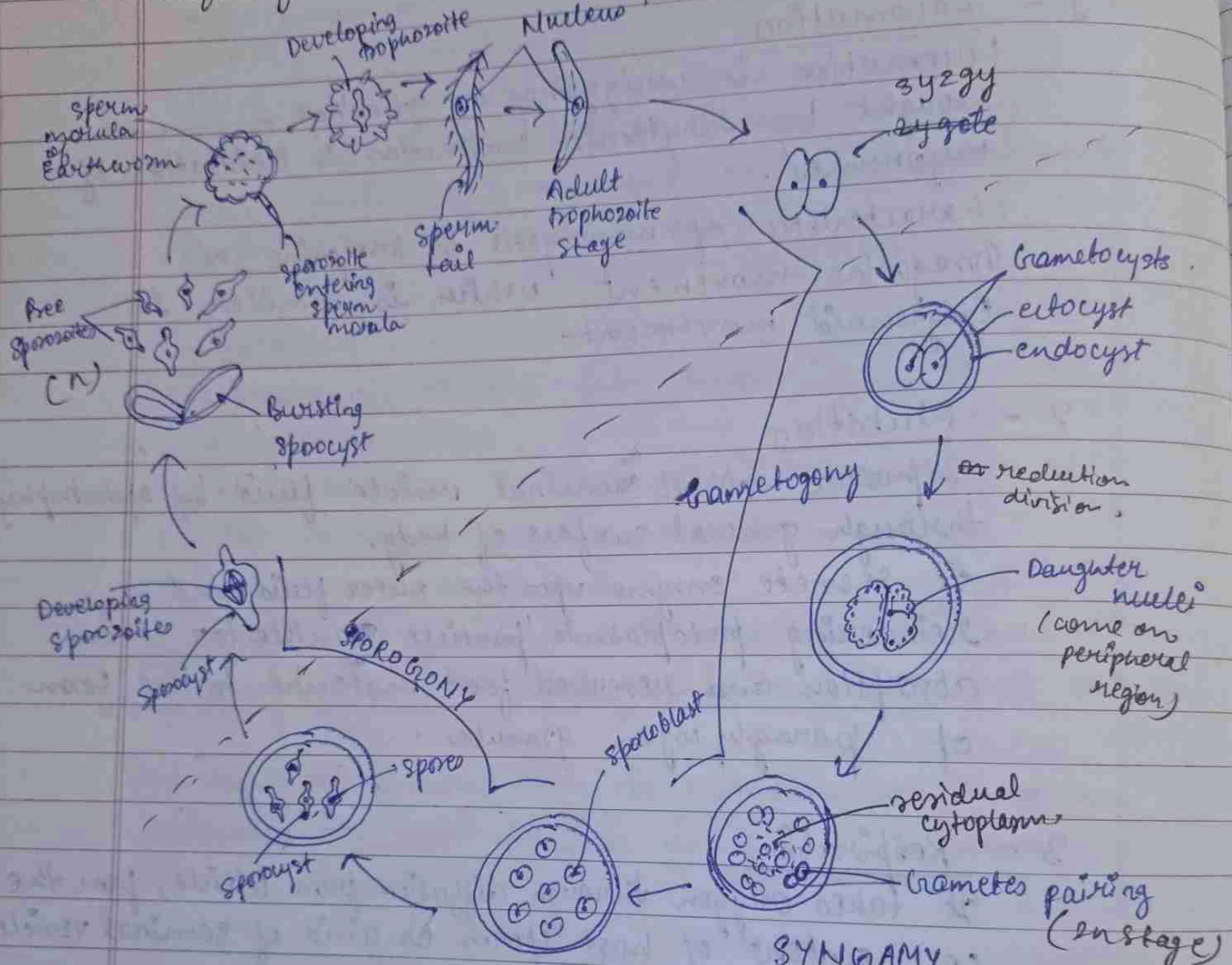
Mironemes help in locomotion.

Syzgy - connecting or making a pair.

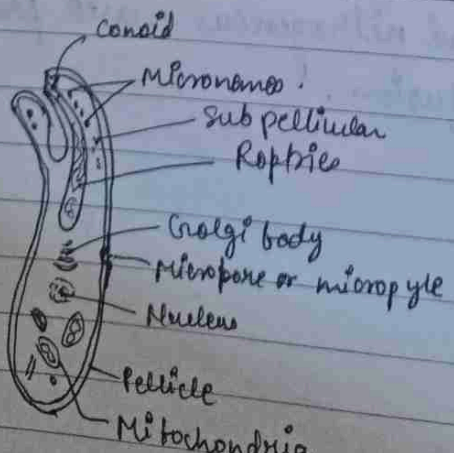
Anisogametes -

Sperm morula - sperm mother cell.

5- Life cycle and Reproduction



[Life cycle of Monocystis]



[Sporozoite of Monocystis]

Gamontogony - similar to gametogamy.

→ Difference b/w male & female ascaris.

Reproduction

Monogenetic, only zygote is diploid and all other stages are haploid.

Gamontogony / Gametogony - pairing of gametes, formation of gametes & fertilisation takes place, it has different stages —

(i) Syzgy

After a period of feeding, growing and wandering each trophozoites becomes an oval reproductive body i.e gamon/gametocyte, these are short, spherical and associate in pairs.

Two of them secrete common resistant & protective cyst wall that is k/a gametocytes/gamontocyst.

Cyst wall has two layer - outer thick & rigid, while the thin ~~and~~ endocyte, within the cyst wall they never fuse or conjugate and this type of pairing is called Syzgy.

ii) Gametogony

Each gametocyte undergo nuclear division by mitosis. Nucleus formed move to periphery and each get surrounded by small amount of cytoplasm.

These uninucleate cytoplasmic bodies become free as gametes leaving a certain amount of residual cytoplasm in the center of gametocyst.

these gametes are anisogametes and contain 4 haploid chromosomes.

All gametes form one gametocyte and are of the same sex. Small & pointed are males and larger & rounded are ♀

Pseudonavicella. Autotomy -

iii) Syngamy
The gametes mingle c the gametocyst & fused in pairs to form diploid zygote.
Numerous diploid zygote are formed within the single gametocyst

iv) Sporogamy
Each zygote is transformed into unicellular oval body be/a sporoblast which secrete a thick cyst wall & /a. spore cyst & becomes a spore. It posses a mucoid plug on each side, it undergo successive nuclear divisions producing 8 daughter nuclei & it is surrounded c cytoplasmic mass & form 8 minute sporozoites or zoïdes.

Pseudonavicella

All these changes occur in cyst wall, at this stage cyst wall ruptures and spores are liberated into cavity of seminal vesicle of earthworm and wait for transmission to a new earthworm host.

v) Transferance
Exactly the process of transferance is not known but the spores of monocystis are transferred from one host to other by these processes -
(a) During copulation
(b) Death of Host
(c) By birds.
(d) Auto tomization

(vi) Sporozoites

Minute spindle shaped, single nucleus, one or more mitochondria, golgi complex & granules of reserve food material chiefly carbohydrate.

At the anterior region a pair of secretory organelle or roptries & their secretion help in penetration of tissue. Anterior end also bears conoids and micronemes whose function is not known.

(vii) Invasion of seminal vesicle

With the help of microtubules, microcystis sporozoites moves into epithelial cells of gut mucosa, one sporozoite enter in one cell. Here they grow in size and escape into seminal vesicle. & then they enter in the cell of sperm morule (SPM)

Development of ~~trophozoid~~ sporozoid

In the sperm morula sporozoides feeds & grow into young trophozoites.

It exhibits hair like sperm tails around its body which are the remenants of degenerating sperm & the degenartion of sperm cell the trophozoide becomes free in the cavity of seminal vesicle as an adult trophozoid, thus the trophozoid are 1st intracellular & then extracellular.

retrogression - absence of mouth, gullet

Effect on Parasitism

(a) On the Host

Almost every worm infected but its fertility is not greater impaired since most of the seminal vesicle are not involved. the worm is able to recover some of the parasites by forming a resistant envelop around the trophozoid or by phagocytising & killing the resistant spores.

(b) On the parasite

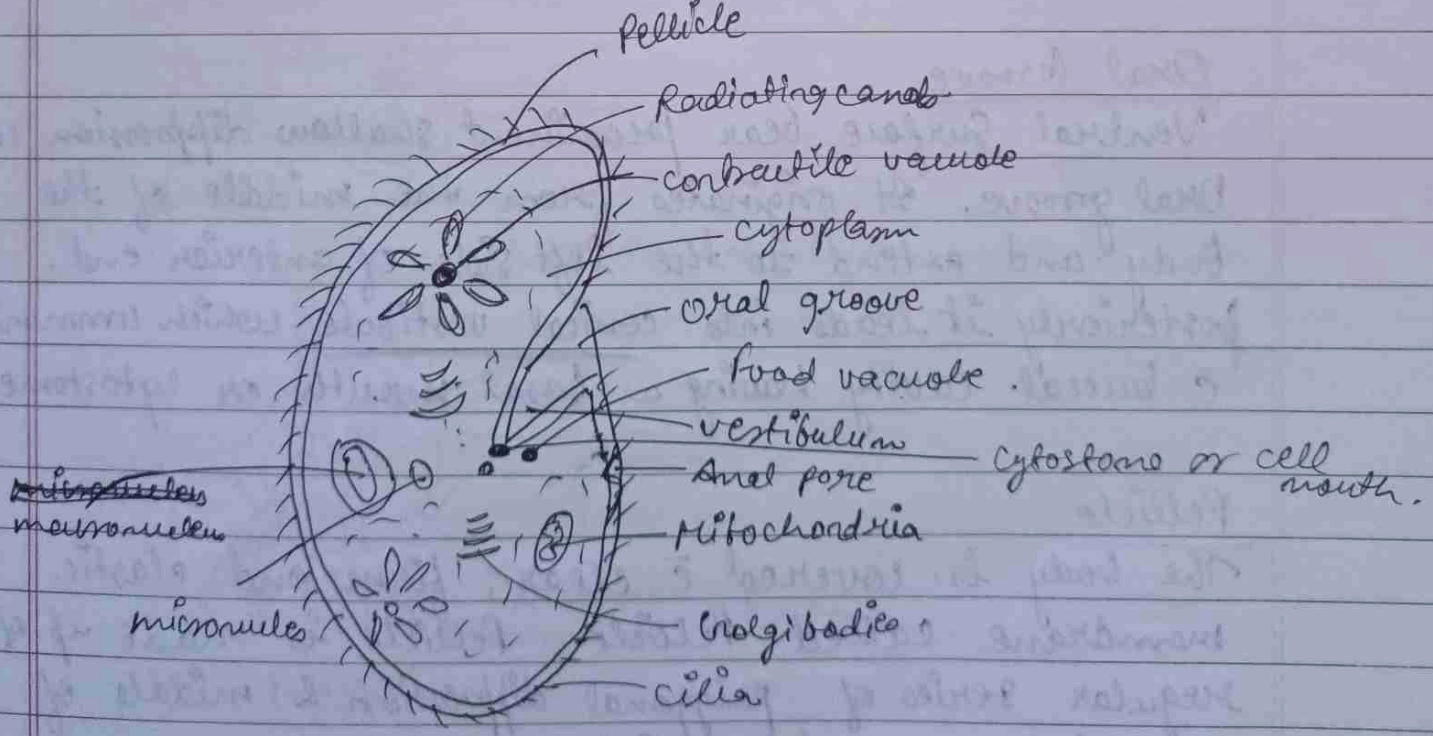
With the abundance of food & no competition, trophozoite undergo extreme retrogression

Another host worm is essential so the sporozoite has resistance covering to compensate high mortality huge no. of individuals are produced to ensure the survival.

Paramecium

P. multimicronucleatum – It has many nucleus.
P. bursaria – Show symbiotic association ē the algae Zoochlorella.
P. caudatum – It has single large micronucleus.

Systematic
Phylum – Protozoa
Subphylum – Ciliophora
Class – Ciliata
Subclass – Holotricha
Order – Hymenostomatida
Genus – Paramecium
Species – Caudatum



[P. Caudatum : Structure]

Habit and Habitat
Freshwater ponds, lakes, reservoir, river etc.

Gr - Paramekes - Oblong
Caudatum - tail

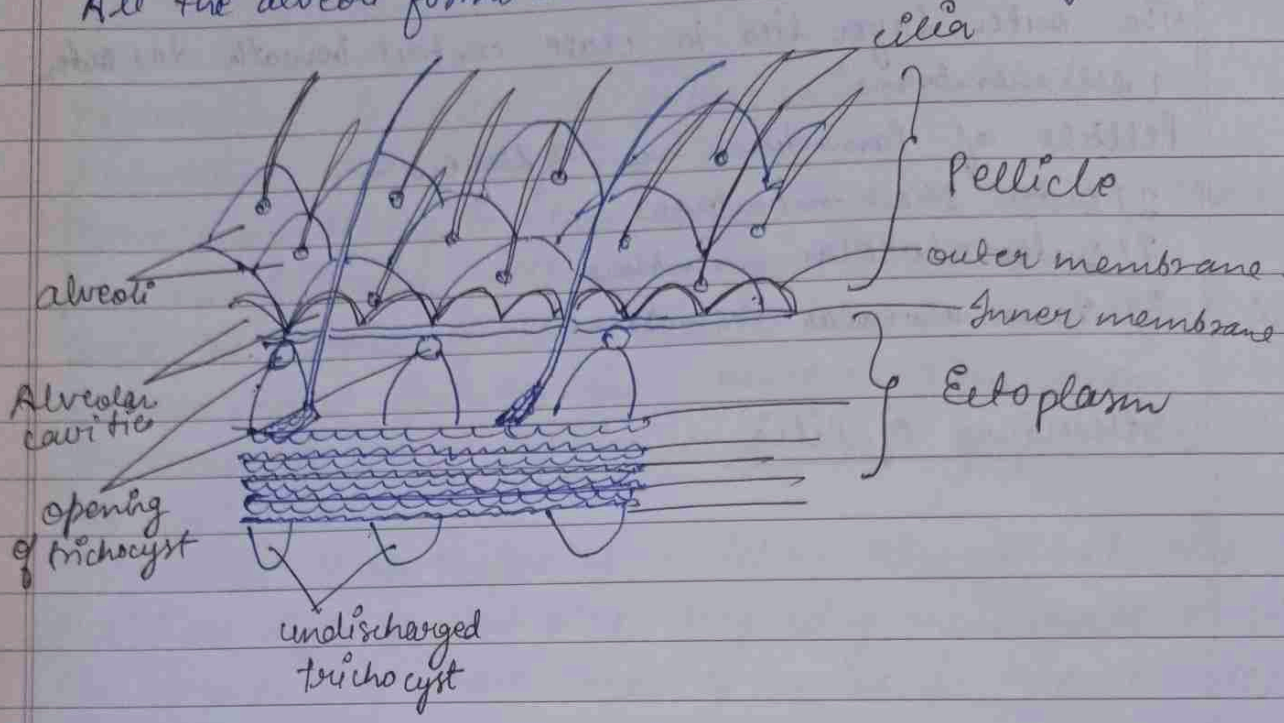
External structure
These are microscopic in size, size varies from 80-350μ in length

Shape
Slipper shaped, Cigar shaped or spindle shaped
Circular with greatest diameter behind the center of body.
Body is divided into oral or ventral and aboral or dorsal surface.

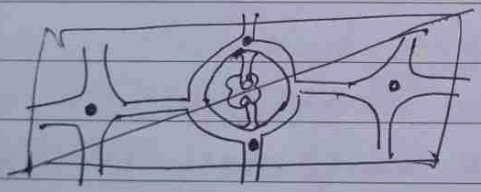
Oral Groove
Ventral surface bear prominent shallow dippression called Oral groove. It originates from the middle of the body and extend to the left side of anterior end. posteriorly it leads into conical vestibule which communicate c buccal cavity having a basal mouth or cytostome.

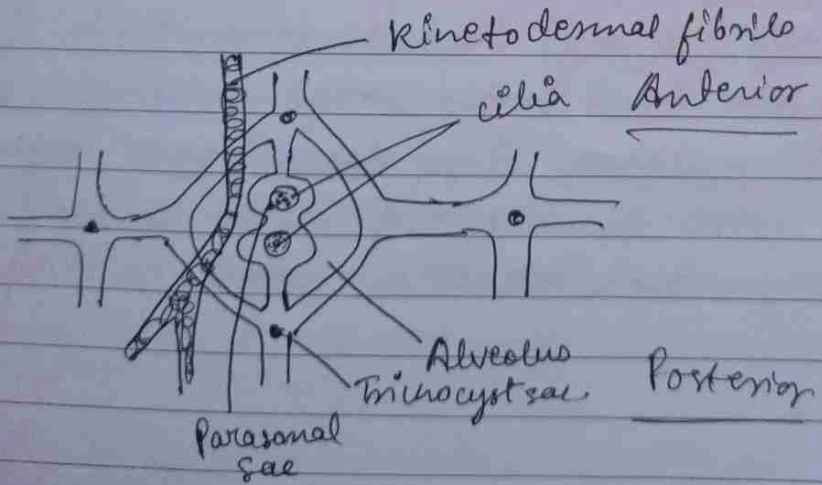
Pellicle
The body is covered c clear, firm and elastic membrane called Pellicle. Pellicle is made up of regular series of polygonal dippression & middle of each polygon a single cilium emerges.
These polygons are defined by regular series of cavities known as alveoli.

All the alveoli forms a continuous alveolar layer.



Pellicle and Infraciliary System



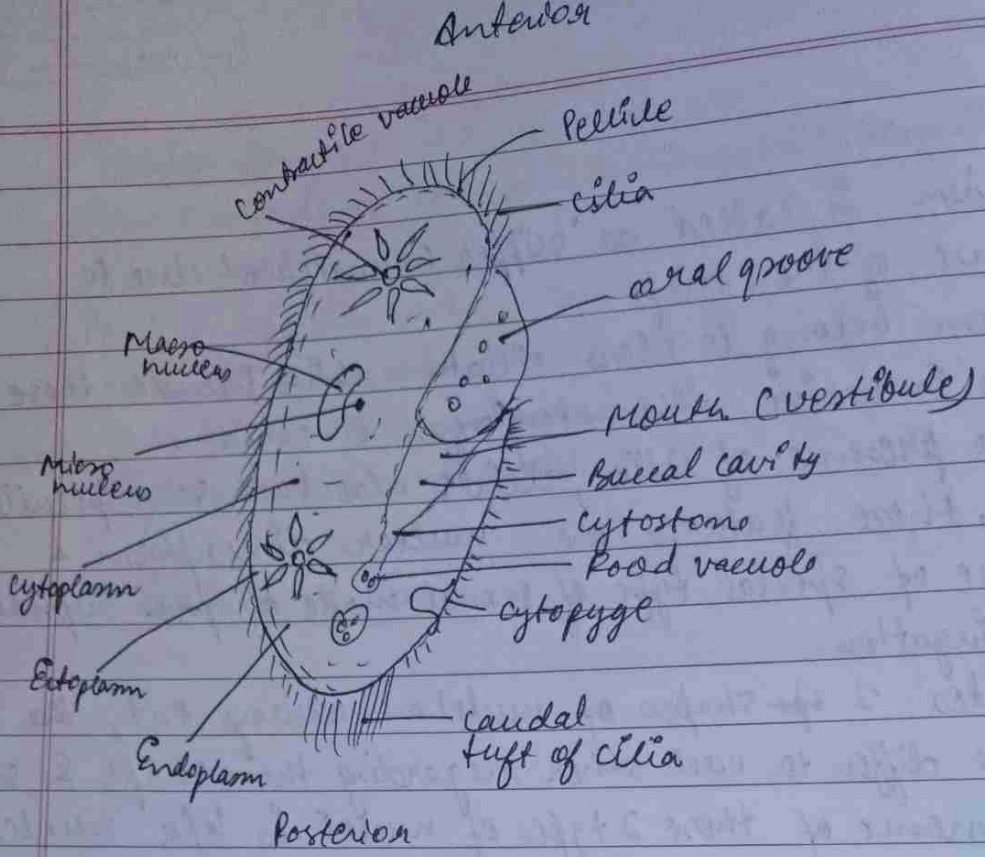


Small area of pellicle

which is
The outer layer lies in close contact beneath the outer cell membrane.
Pellicle of Paramecium has 3 layers -
1) Outer shell membrane
2) Outer alveolar membrane
3) Inner alveolar membrane.

Structure of Cilia

Paramoecium is called as 'slipper animalcule' due to resemblence of the shape.
Paramecium belong to class ciliata which includes those protozoans in which locomotory organ is cilia.
Beside the presence of cilia, ciliates also have some peculiar features, these features are - nuclear dimorphism & occurence of special type of sexual mode of ~~pro~~ reproduction k/a conjugation.
In ciliates 2 ~~sp~~ shapes of nuclei are always ~~but~~, the nuclei are differ to each other regarding their shape & size. the occurence of these 2 types of nuclei is k/a nuclear dimorphism.
Out of these 2 types of nuclei, the ~~1~~st nuclei (micronuclei) which is smaller in size regulate the genetic features of individual while another nucleus which is macronucleus is larger in size and regulate the metabolic process.
There are some species ~~not~~ in which more than one nuclei are reported. these species are P. aurelia (~~true~~ 2 nucleus), P. multimicronucleatum (more than 2 micronucleus), P. bursaria (green colour due to the presence of a symbiotic algae Zoochlorella), P. caudatum (largest in size) name given due to the presence of group of longer cilia in posterior region i.e caudal tuft.



General str. of Paramecium caudatum

I External Morphology

Shape & Size

The shape of body is elongated & very much similar to slipper that's why known as slipper animalcule. It is often described as slipper, cigar & spindle shaped. The anterior end of the body is broad in the comparison of posterior end. The posterior end is sharp & tapering & can be identified by presence of longer cilia i/a caudal tuft.

Size - The size of paramecium varies from species to species (80 to 300 µm)

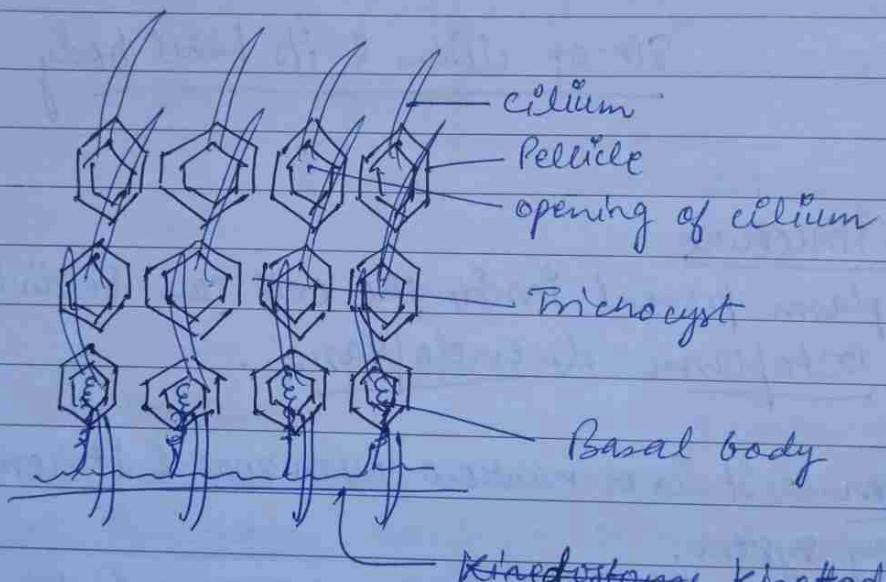
The longest species of Paramecium is P. caudatum is 170 µm to 290 µm

Oral groove

At the ventral surface a narrow depression is present k/a oral groove. It is meant for ingestion of food particle, oral groove is extended in the form of a cavity k/a vestibule. which finally opens into a wide buccal cavity which open into narrow gullet cytopharynx and at the end of buccal cavity cytostome is present.

Food particle passing through these structures finally drop into food vacuole.

Pellicle



~~Kinetostome~~ Kinetodesmata.

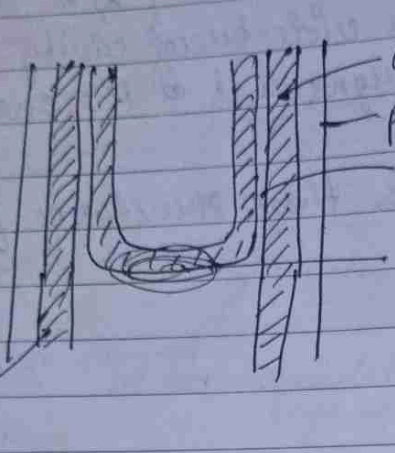
Str. of Pellicle

Cilia

On the body surface so many small thread like structure appear k/a cilia. Their no. is 10,000 to 40,000 depend upon the species. Their size also varies from 10 to 12 um

Cilias length is uniform throughout except for a few longer cilia at the extreme posteriorend of the body forming a caudal tuft hence the species named.

Caudatum. It consist of fluid matrix surrounded by outer membr. sheath which is continuous ē the outer cell membr. of the body.



str. of cilium & its basal body

Internal structure

The cytoplasm present inside the cell can be divided into 2 zone ectoplasm & endoplasm.

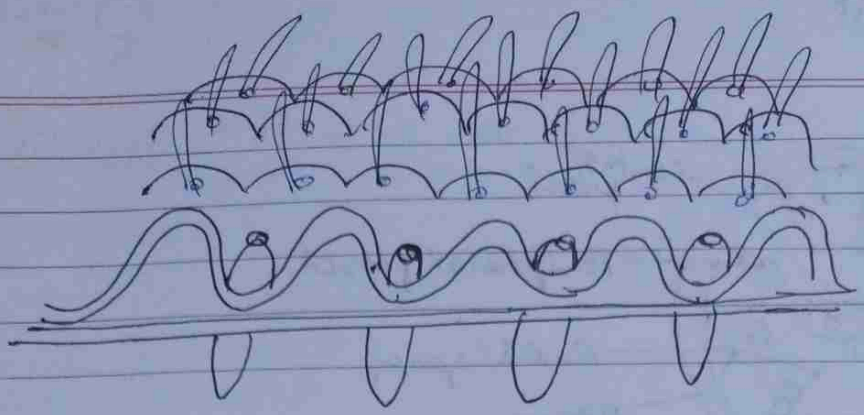
Ectoplasm - It is a narrow clear zone & it comprises infraciliary system.

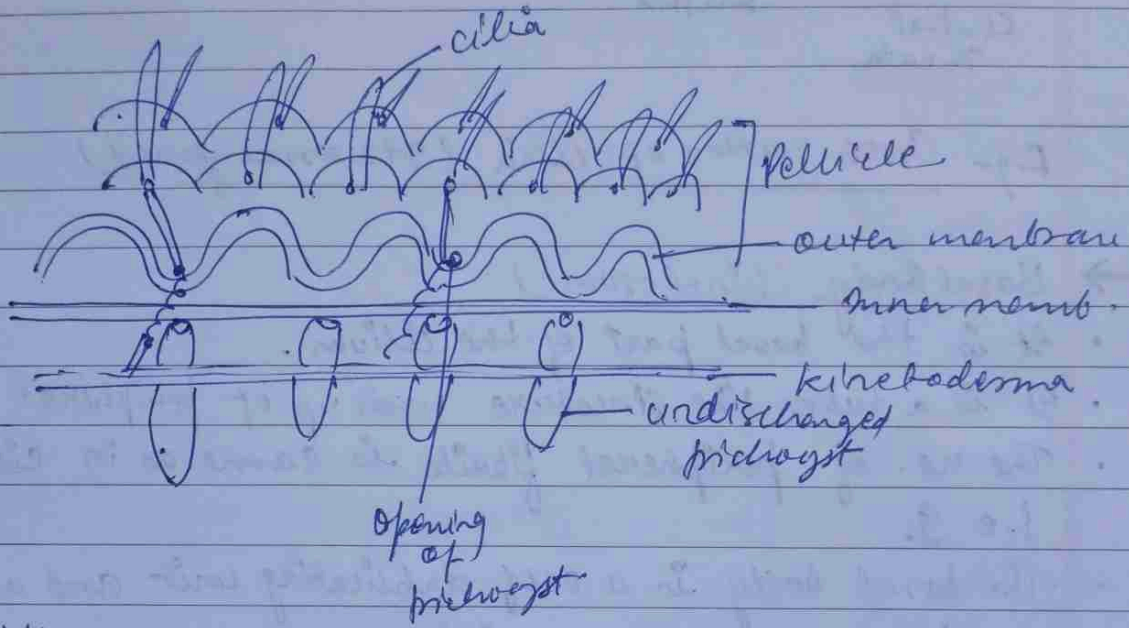
Endoplasm - It is a central granular zone & comprises different cell organelles for various type of activities. In electron microscope golgi body, lysosome, endoplasmic reticulum are clearly seen in this zone.

Infraciliary System -

It is made up of 3 type of str. & a basal body ie Kinetosome & Trichocyst.

10,000 to 40,000





Infraciliary System

Pellicle is external living clear, elastic circular membrane, the pellicle of Paramecium comprises so many polygonal or hexagonal str. when it is seen under light microscope.

In observation of same of under electron microscope the polygonal str. appear as a cavity pom which cilium arises, these structure are k/a alveolus.

These str. are present in series & form an alveolar layer. In the Ectoplasm the 3 str. are present these structures are basal body, kinetodesmata & trichocyst.

The 1st 2 str. i.e basal body & kinetodesmata help in coordination & movement of cilia & form a system present just below of cilia thats very k/a Infraciliary System.

28/11

1/9/18 - Book

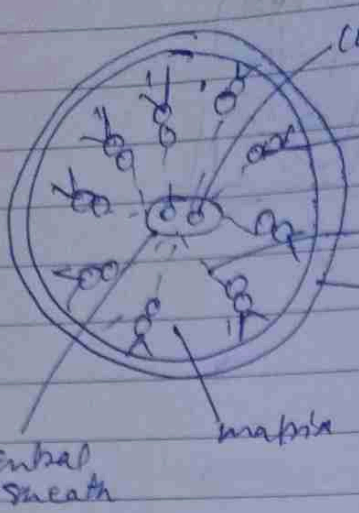


Fig- Cross section of cilia (9+2 arrangement)

→ Basal Body (kinetosome)

- It is the basal part of the cilium.
- It is a tube like structure made up of peripheral fibrils only.
- The no. of peripheral fibrils is same as in cilium i.e 9.
- The basal body is a self duplicating unit and acts as a progenator of new cilia.
- Basal body is actually a centriole or its derivative.

→ Kinetodesmata

Kinetodesmata represents the group of fibrils (5), which is closely associated with kinetosome or Basal body.

- Actually, a single fibril comes out of from each Kinetosome, known as "Kinetodesmata" and join to another Kinetosome present at opposite end.
- In this way a bundle of fibril is formed, known as "Kinetodesmata".
- The fibrils of kinetodesmata are striated type. They co-ordinate the ciliary beats & movement.

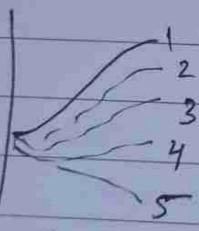
Paramoecium

Paramoecium is also k/a slipper animal cell due to resemblance of its shape. It has streamlined body which enables it to swim in water and the locomotary organ in paramoecium is cilia.

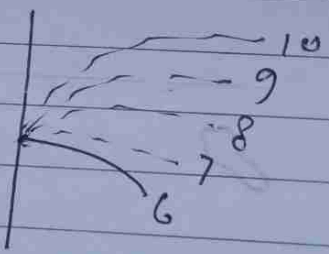
Cilia are hair like organelles & it helps in rapid swimming by bitting of itself. It is present all over the paramoecium body and paramoecium moves ē a speed of 1500 μ/sec. so it show ciliary movement. It occurs by 2 means Effective stroke & Recovery stroke.

Effective stroke is fast and cilium becomes slightly curved. It is also k/a backward dash.

Recovery stroke is slow and ~~it~~ it brings the cilium again into the position for the next effective stroke.



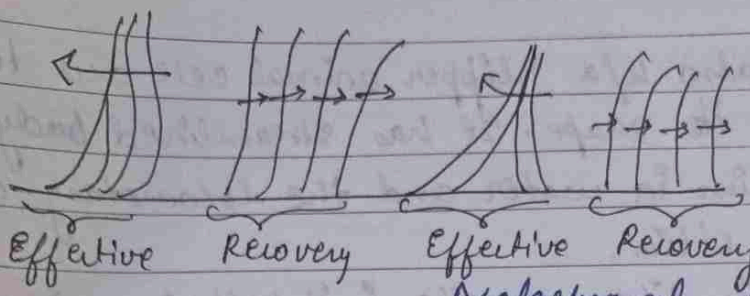
Effective stroke



Recovery stroke

1. All the cilia do not move simultaneously & independently but progressively in a characteristic wave like manner called metaclon metachronal rhythm.

During forward mov. the metachronal ~~rhy~~ ~~rhythm~~ ~~duewaves~~ pass from the posterior end forward.



Metachronal Rhythm

Mode of Swimming

Animal does not follow a straight path but rotate spirally like a riffle bullet along a left handed helix ∧ In the spiral mov. The cilia do not beat directly backward but somewhat obliquely toward right. So that animal rotates over to the left on its long axis but the cilia of oral groove strike obliquely & more vigorously so as to turn the anterior end continuously away from the oral side & moving in circle.

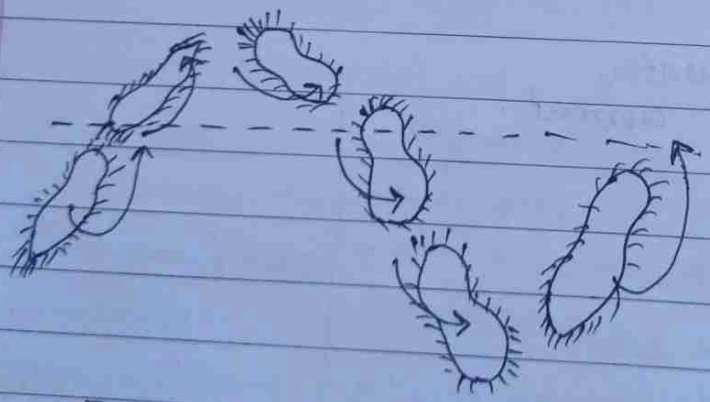
The combined effect causes the movement of paramecium around a fairly str. path rotating about its axis in anticlockwise direction. In the backward mov. the paramecium follow the str. coarse due to the metachronal wave passes from anterior and backward but the exact mechanism of ciliary mov. is little study.

During the effective stroke the cillum become slightly curved & rigid and strokes the water like oar so that body is propelled forward in opposite direction of stroke.

Recovery stroke - follows immediately. Bring the cillum again into position for effective stroke.

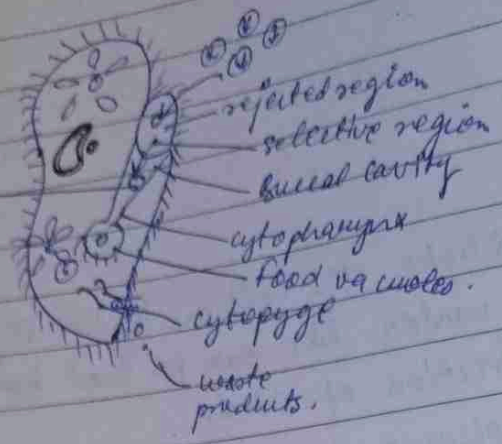
Modes of swimming -

The animal does not follow a straight & part but rotate spirally like anticlockwise.



[Anticlockwise movement of Paramecium]

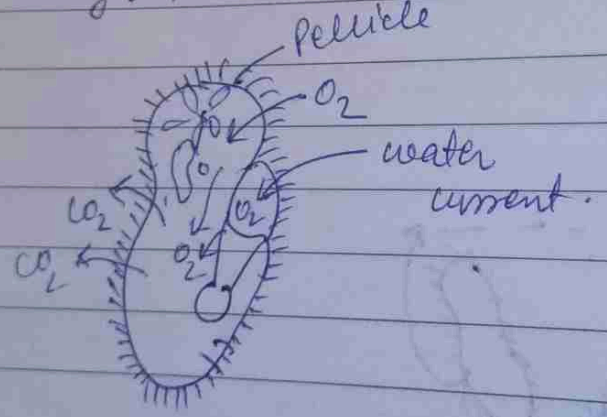
Nutrition in Paramecium



1) Ingestion
2) Digestion
3) Egestion.

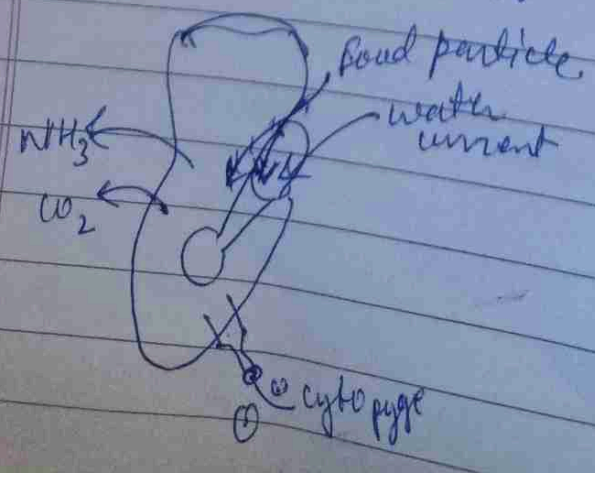
Respiration.

Through Pellicle.



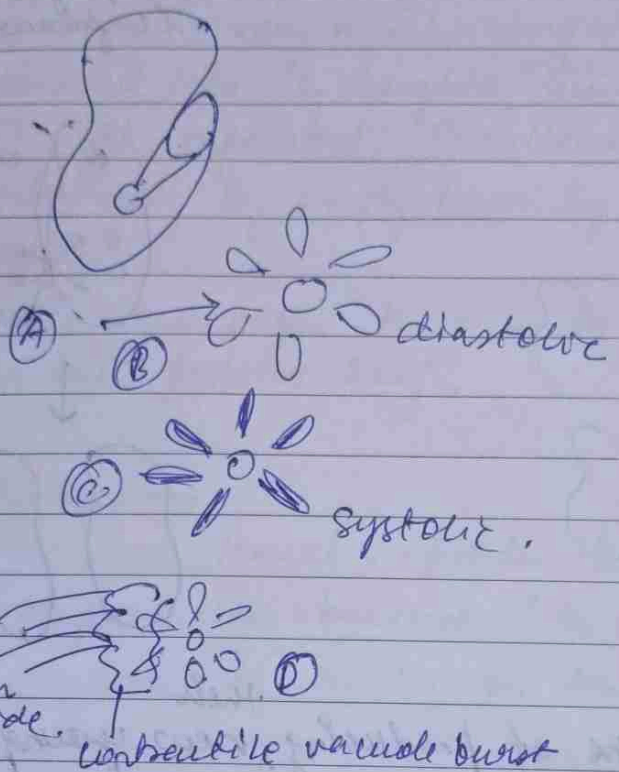
Excretion.

Through cytopharynx cytopyge



Osmoregulation

Cytostolic & diastolic contractile vacuole,
Endosmosis occurs.

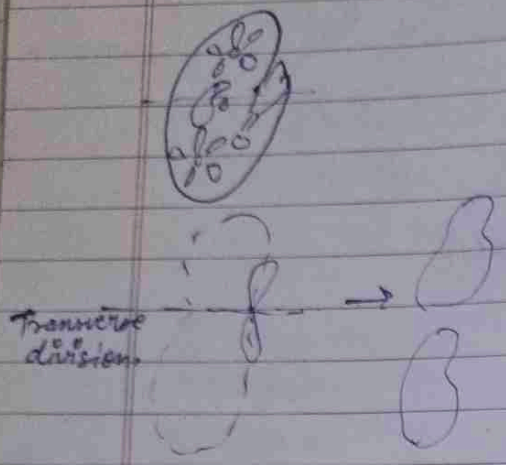


Diagramatic representation of

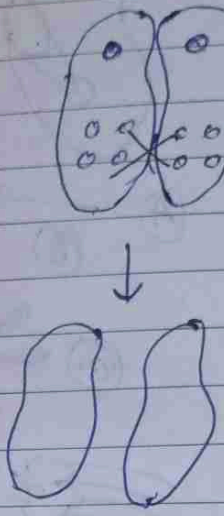
Behaviour	Reproduction
→ Thermotaxis -25°C	→ conjugation (sexual)
→ Phototaxis	→ Transverse division.
→ Oreonegative	→ Favourable condition - asexual repr.
→ Chemotaxis	→ oral groove disappear.
→ Neotaxis	conjugation during unfavourable condition.
→ Thigmo ~~Thigmotaxis~~	
→ Avoid rxn	

Reproduction in Paramecium

Binary fission



Conjugation (unfavourable condition)



It is the process of producing their new young ones for continuity of species.

Paramecium reproduces by asexual method by transverse binary fission (furrow appears on transverse axis)

During favourable condition Paramecium commonly reproduces by transverse binary fission (asexual mode) which is at right angles to the longitudinal axis of the body. Paramecium stop feeding and its oral groove basal structure begins to disappear. While this is happening, the micronucleus start dividing by the complecated process.

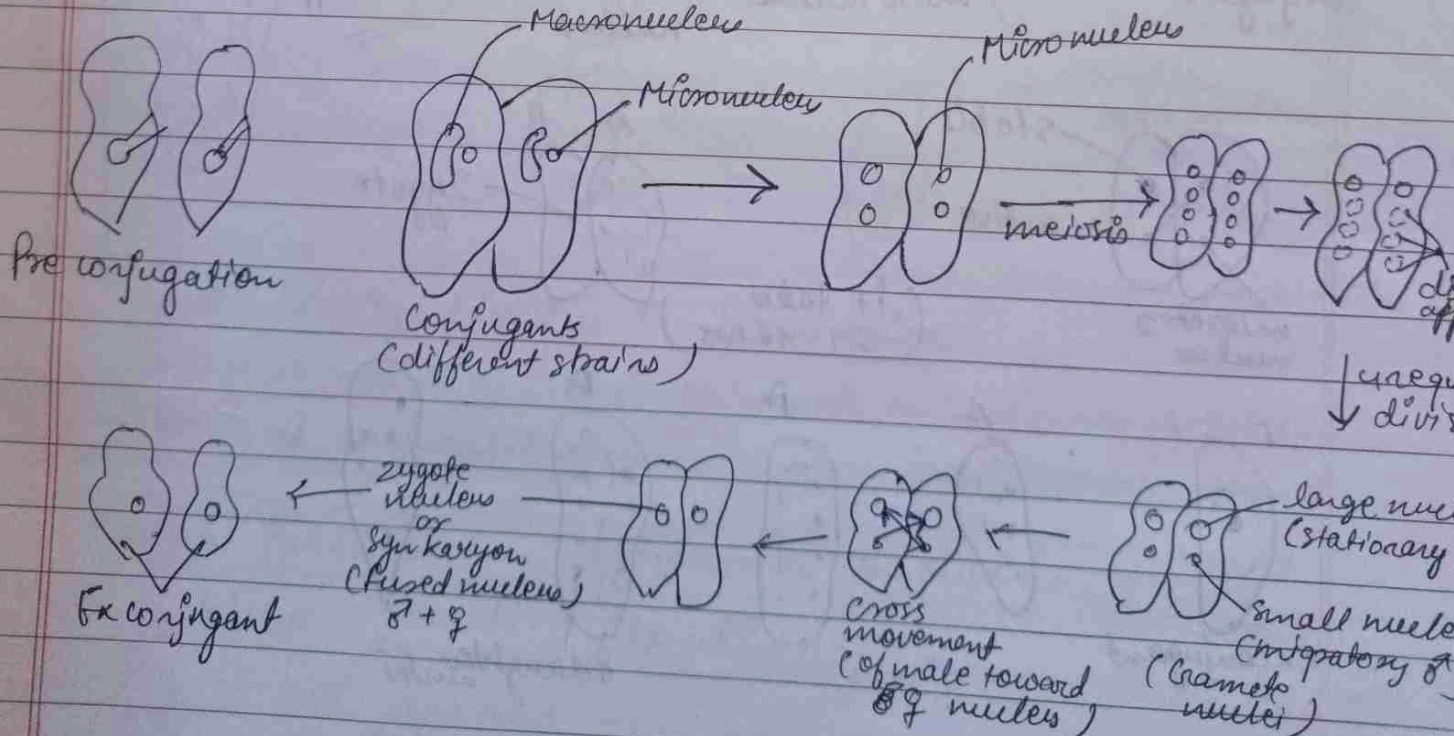
Micronucleus 1st increases in size & then chromosomes numbering from 36 to 150 depending upon the race, begin to appear

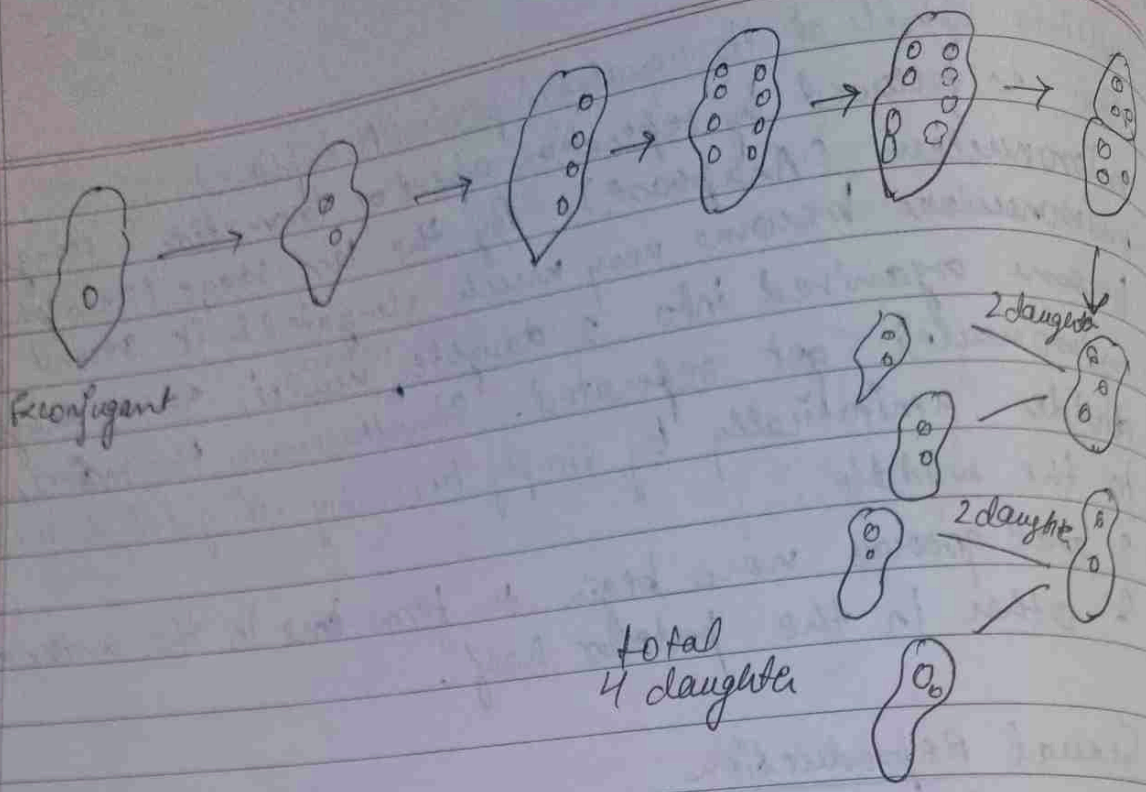
Each chromosome split longitudinally to form chromatids (Prophase stage). Paired chromatids now get arranged on the

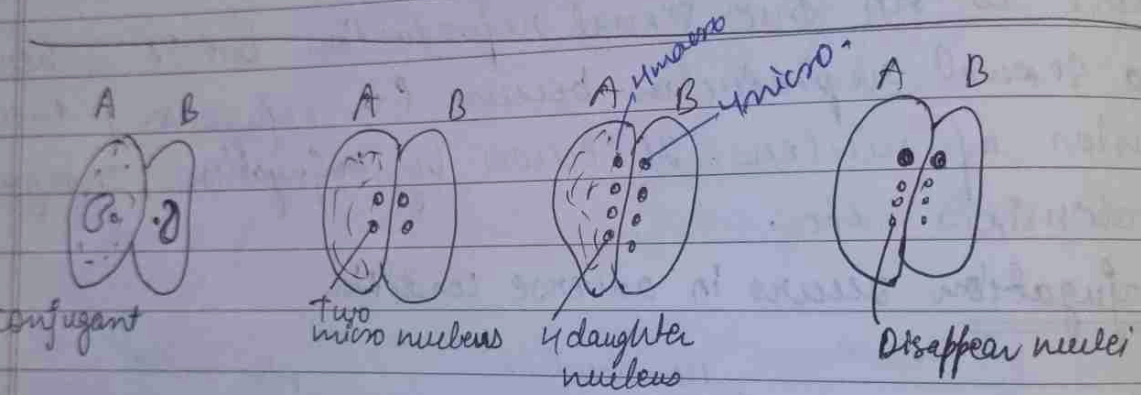
nuclear spindle at its equatorial plate (Metaphase).
This is followed by seperation apart of chromatids & elongation of micronucleus (Anaphase). By the last stage (Telophase) micronucleus become very much elongated & its second end become organised into 2 daughter micronuclei. The 2 daughter micronuclei get seperated. Simultaneously the macronucleus divides amitotically by simply becoming elongated & constricted in the middle.
2 oral grooves now begin to form one in the anterior half & other in the posterior half.

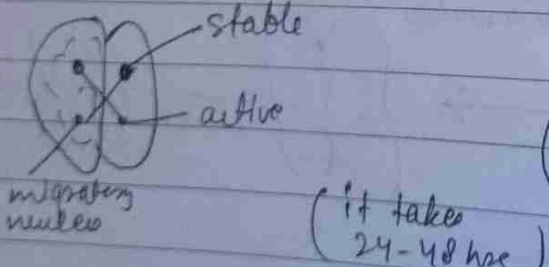
Sexual Reproduction

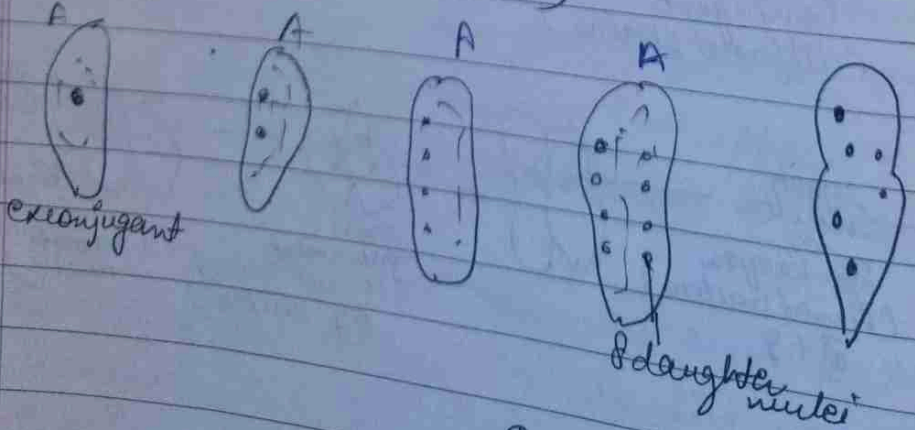
There is no true sexual reproduction but it is here k/a sexual reproduction because (in conjugation) there is fusion of nucleus. It occurs by conjugation, autogamy, endomixis etc.
Conjugation occurs in adverse condition







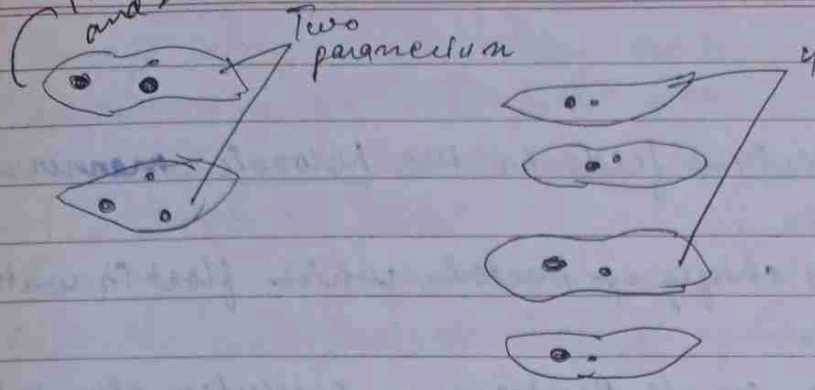




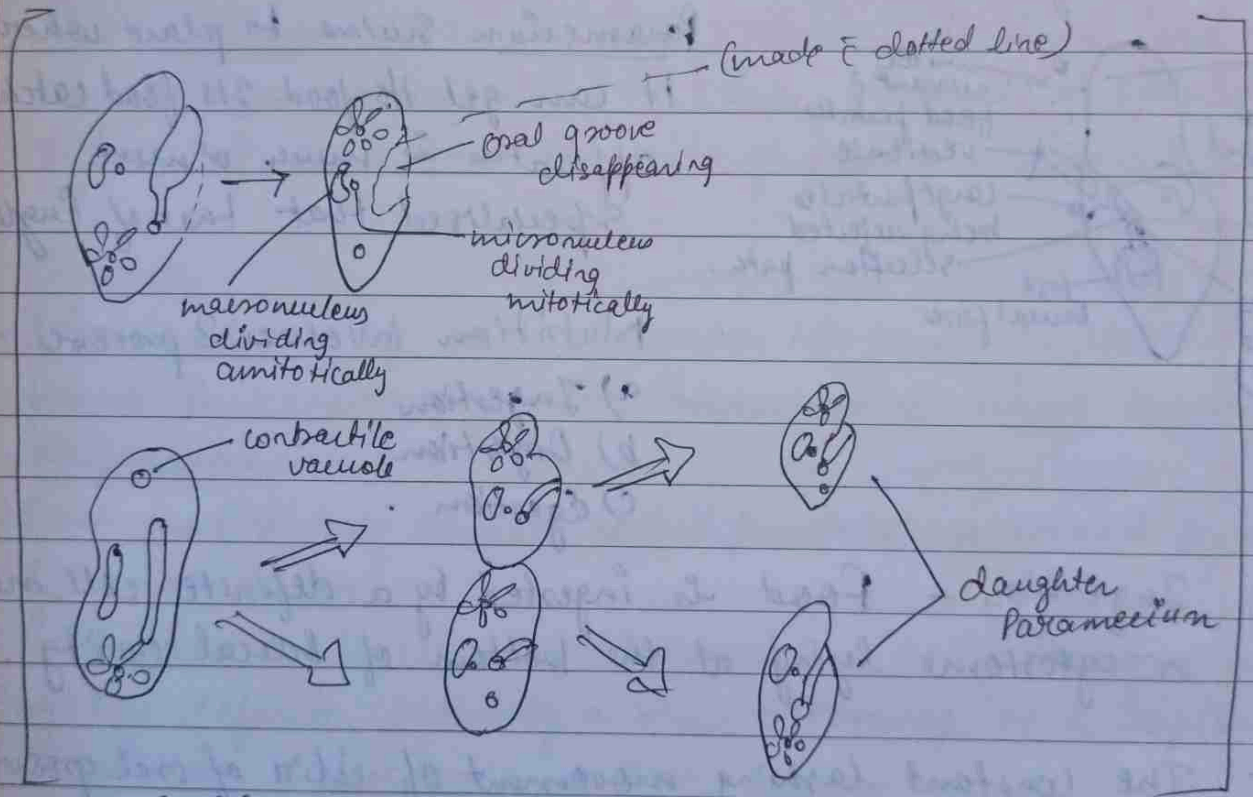
Endomixis - diffusion.

Kappa particle —
Paramecium is secreted which destroy other Paramecium that do not contain kappa.

1 micro and 2 macronucleus.



[Conjugation in Paramecium caudatum]

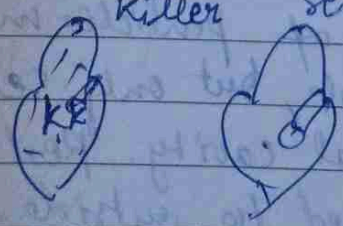


* Binary fission in Paramecium

Merits of conjugation —

Kappa Particles — Cytoplasmic Inheritance,

Killer Sensitive (~~kk or Kk~~) (K_k kk)

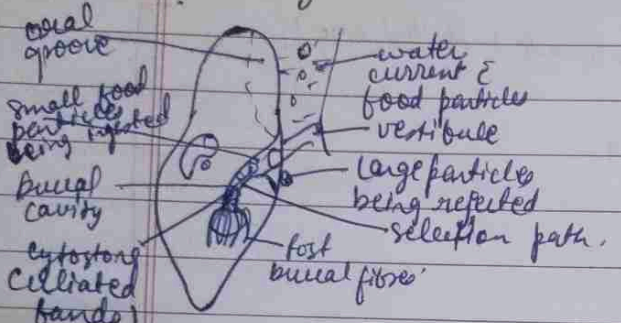


Nutrition

(I) Food – Paramecium feeds in the holozoic manner like amoeba.

- The food consists chiefly of bacteria which float in water in which it lives.
- It also feeds upon small Protozoa, unicellular plants (algae, diatom, yeasts etc) and small bits of animal & vegetables.

(II) Feeding Mechanism.



Paramecium swims to place where it can get its food. Its food catching apparatus is much more specialised that that of Euglena.

Nutrition involves 3 processes –

a) Ingestion
b) Digestion
c) Egestion.

a) Ingestion – Food is ingested by a definite cell mouth or cytostome lying at the bottom of buccal cavity.

- The constant lashing movement of cilia of oral grooves drive a current of water with food particles towards vestibule. Ciliary bands of vestibule direct the food particles into buccal cavity.
- Paramecium is a selective feeder (feed small & organic matter)
- A/c to mast (1947), many kinds of particles may be carried c water current into vestibule, but only selected ones are passed on inside the buccal cavity. Rest of particles are rejected i.e discharged to outside.

- Passage along which ciliary action drives selected food particles, is termed as "selective path" whereas passage along which unwanted food particles are driven outside vestibule, is the "rejection path".
- Beating of cilia of membranelles of buccal cavity drives the selected food particles through cytostome into cell gullet or cytopharynx.
- The food now gradually collects at the bottom of the cytopharynx into a membranous ~~vestibule~~ vesicle which is later nipped off as a food vacuole. Another food vacuole may be formed within 1 to 5 min. depending upon the supply of food and the rate of feeding.

b) Digestion.

Breaking down of large molecules into small particles. This process is required for the production of energy through Respiration.

- Each food vacuole consists of food particles surrounded by a thin film of water.
- Food vacuole is circulated around the body along a more or less definite path by a slow streaming of endoplasm, known as cyclosis.
- Several vacuoles may be seen thus circulating in a well fed Paramecium. The vacuoles are carried first posteriorly, then forward and aboral and again posteriorly and orally upto cytopyge.
- Digestion and assimilation of food occurs during this journey.

- Digestive enzymes / protease, Carbohydrate, Lipase. are secreted by the lysosome into the food vacuole - As in amoeba the contractile vacuole first become increasingly acidic, but later gradually become alkaline. (can be demonstrated with the help of Congo Red like indicator dye).
- The alkaline phase results from the secretion of enzymes within an alkaline medium into the vacuole.

Products of digestion (glucose & fat globules) are diffused into the surrounding cytoplasm and either stored or used for vital activity and growth.

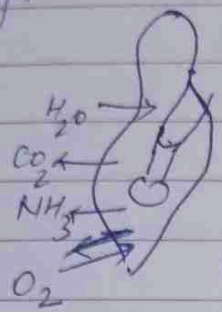
(c) Egestion — The vacuole generally becomes smaller as digestion and absorption proceed. Finally, the undigested reduced matter ~~or~~ is eliminated from the body through a definite anal spot or cytopyge on ventral surface posterior to cytostome.

Respiration and Excretion —

- Respiration is process in which exchange of gases occur.
- There is no any specialised organ in Paramecium for respiration. It takes place by diffusion through the semi-permeable pellicle. Oxygen dissolved in water is diffused in & used for oxidation of protoplasmic molecule.

- Excretion is the process of removal of waste / toxic material (like NH_3) or nitrogenous substances.

Catabolic waste products such as CO_2 & nitrogenous matter (NH_3) ~~as nitrogenous substances~~ simply diffuse out into external water because their concentration is always higher in body.

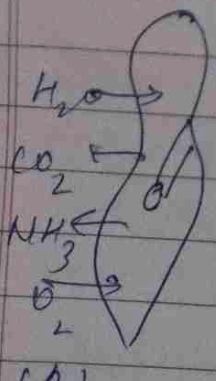


Diagrammatic representation of Excretion & osmoregulation.

→ Osmoregulation,

The function of contractile vacuoles in Paramecium is Osmoregulation.

- An excess of water accumulates in body bcz of continuous endosmosis, the conc. of body cytoplasm being higher than that of external medium.
- Small quantities of water are also taken in along the ingested food.
- This excess of water is get rid off by means of contractile vacuoles which contract (Systole) & expand (diastole) at regular intervals, assisted by the contractility of myofibrils.



(A)

(B)

Physical significance of conjugation —

Conjugation is important for variation (genetic variation).

- The conjugation is a process of temporary union of 2 individuals for the exchange of genetic material. It is also k/a Amphimixis bcz of fusion of 2 gamete nuclei to form a zygote nucleus or "synkaryon".

The process of conjugation resulted into 3 very important processes named as —

1) Rejuvenation
2) Nuclear reorganisation
3) Hereditary variation.

1) Rejuvenation.

If binary fission continues repeatedly for several generations, the Paramecium loses its vigour. The individual ceases to multiply, reduce in size, degenerates in organisation and eventually dies off.

The process of conjugation seems to rejuvinate and revive the lost vigour for asexual reproduction.

2) Nuclear Reorganisation —

During conjugation, the nuclear Apparatus is reorganised and readjustment occurs btw it and the cytoplasm.

- The replacement of macronucleus brings renewed vigour and vitality to accelerate the metabolic activities.

3) Hereditary Variation - During asexual reproduction by fission, the hereditary material of the parent passes unchanged on to the progeny, so that all the descendents of one Paramecium have the same inheritance. The periodic occurence of conjugation, however ensures inherited variation
- It brings about the blending of 2 lines of ancestor just as bisexual reproduction does.

* Genetic consequences of Conjugation.
If conjugation takes place btw 2 Paramecium one homozygous for a dominant gene (AA) and the other homozygous for its recessive gene (aa), the first generation would be heterozygous (Aa).
- If the 2 conjugants are already heterozygous (Aa) then the resulting progeny would be either homozygous or heterozygous depending upon which gene gets eliminated at the stage of disintegration of 3 micronuclei in each conjugation.

(b) Autogamy - W.F Diller (1936) described a process of nulear re-organisation in P. aurelia resembling conjugation, but taking place within a single individual He called it "Autogamy or Self conjugation"
- During Autogamy in P. aurelia, the 2 diploid micronuclei divide by meiosis to form 8 haploid daughter nuclei.
- 7 of them degenerate and the remaining micronucleus undergoes a mitotic division forming 2 gamete nuclei.
- Meanwhile the macronucleus grows into an irregular, skein like mass which breaks into pieces and later absorbed in cytoplasm.

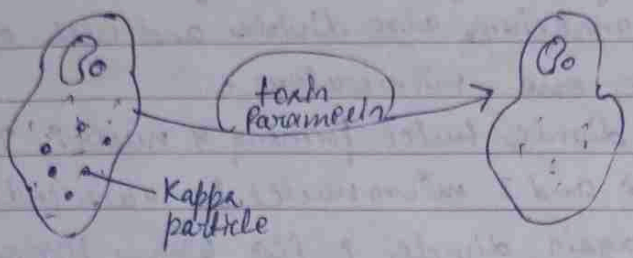
- The 2 gamete nuclei enter a protoplasmic tube temporarily formed near cell mouth and then fuse together to form a completely homozygous diploid zygote nucleus or 'Synkaryon'. This Synkaryon divide twice to yield 4 nuclei, 2 of which become macronuclei and 2 micronuclei.
- The cell body and micronuclei then divide to form 2 daughter individuals, each with a new macronucleus and 2 micronuclei. Autogamy rejuvenates Paramecium.

* Cytogamy — In 1940, R. Wichterman reported in P. caudatum. Cytogamy - a process that resembles conjugation in 2 small Paramecia (200 μ long) temporarily fuse by their oral surface. The nuclear divisions are also similar to those of conjugation, but there is no nuclear exchange bw the individuals (cytogamonts). But 2 haploid gamete nuclei in each individual are said to fuse to form a synkaryon as in autogamy.

* Endomixis — It is a phenomenon involving a total internal nuclear reorganisation within a single individual in a culture of a pedigreed race of Paramecium, taking place in the absence of conjugation. It was first reported by Woodruff

(continued after to next page)

* Lambda Particles — are borne by killer Paramecia and cause the sensitive Paramecia to lyse or disintegrate.



Killer Paramecium (with kappa particle)

Sensitive Paramecium (no kappa particle) when Paramecin enter into it, it gets dead.

→ Cytoplasmic Particle —

Paramecium has 2 races

↙ Killer or Survivor
- Kappa particles (k)
- Pi particles (π)
- Mu particle (μ)
- Lambda particles (λ)

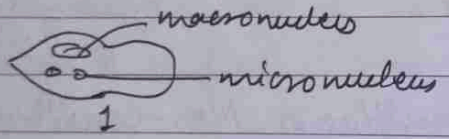
↘ Sensitive or Non-sensitive cytoplasmic particles are absent.

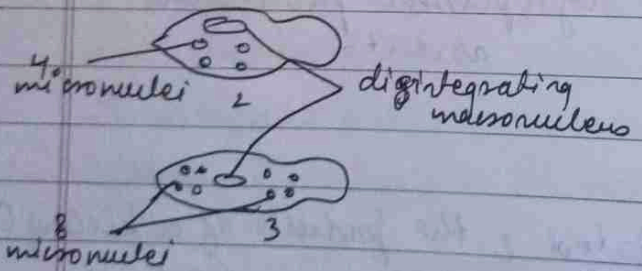
* Kappa particles are associated ε the products of a killing (toxic) substance Paramecin. This substance diffuses out into the surrounding water and causes death of the sensitive (kappa free) Paramecium.
— They are transmitted directly by cytoplasmic genes (Plasmogenes) from cytoplasm of parent cell to daughter cells and not by nuclear genes as in ordinary heredity.
* Pi particles are mutant form of kappa particles. They don't produce killer substance (Paramecin)
* μ particles - are also killers and kill the mate without such particles, during conjugation.

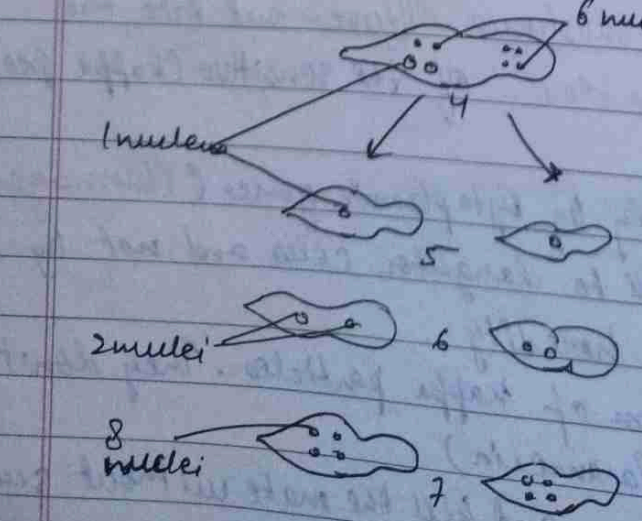
Endomixis —

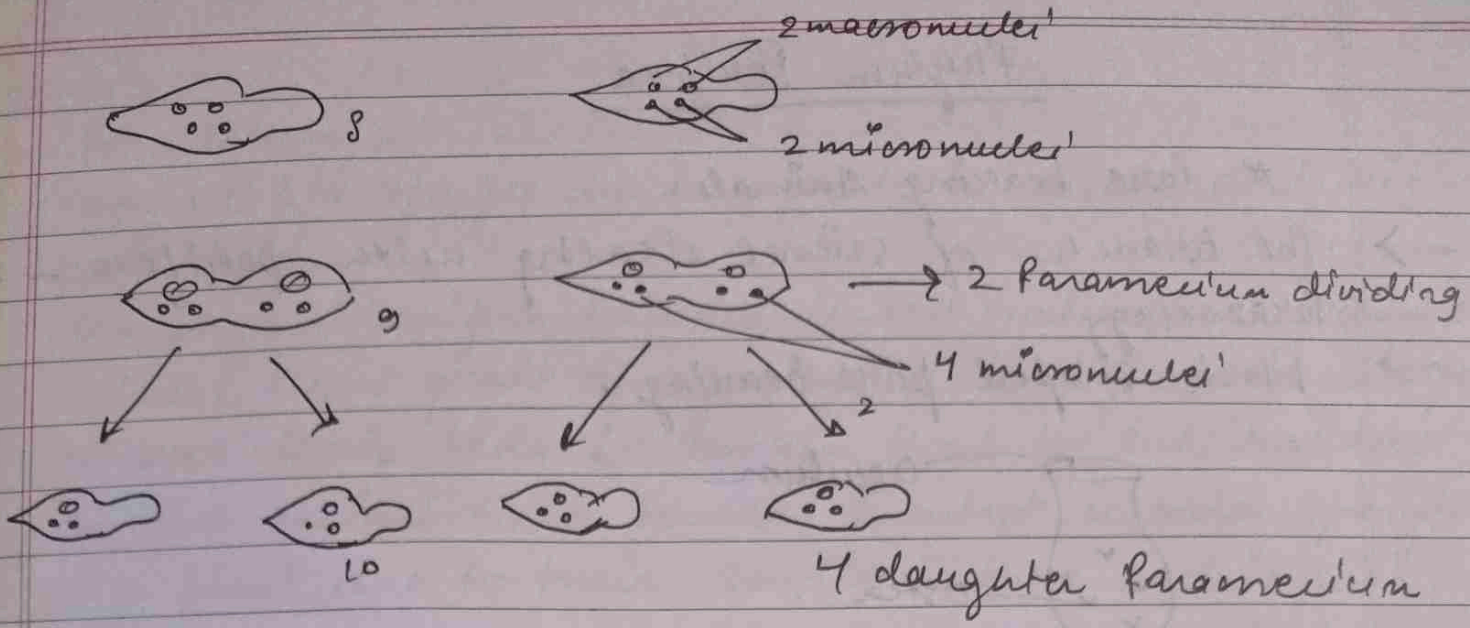
→ In this process, the vegetative macronucleus degenerates and disappears while the micronuclei divide twice by mitosis followed by forming 8 daughter nuclei of which 6 degenerates. At this stage, Paramecium also divides and each daughter Paramecia receive one micronucleus.

- The micronucleus divides twice forming 4 nuclei, 2 of which become macronuclei and 2 micronuclei in each individual.
- The micronuclei again divides & free binary fission of Paramecium into 2 daughters, each getting 1 macronucleus and 2 micronuclei.
- Therefore, 4 daughters are produced from a single parent & there is an intracellular nuclear reorganisation and readjustment btw the cytoplasm & the nuclear apparatus in each individual.









[Fig → Paramecium stages in Endomixis.]