Cilia and their Derivatives

A – Cilia

-These Organelles are characteristic of the opalinate and ciliophora.

-Members of the class suctorea are ciliated only in their younger stages, while their adults are non ciliated and develop special (peculiar) tentacles.

-The cilia are similar to the flagella in their ultrastructure (nine – plus – two) But they are shorter and more restricted in movement.

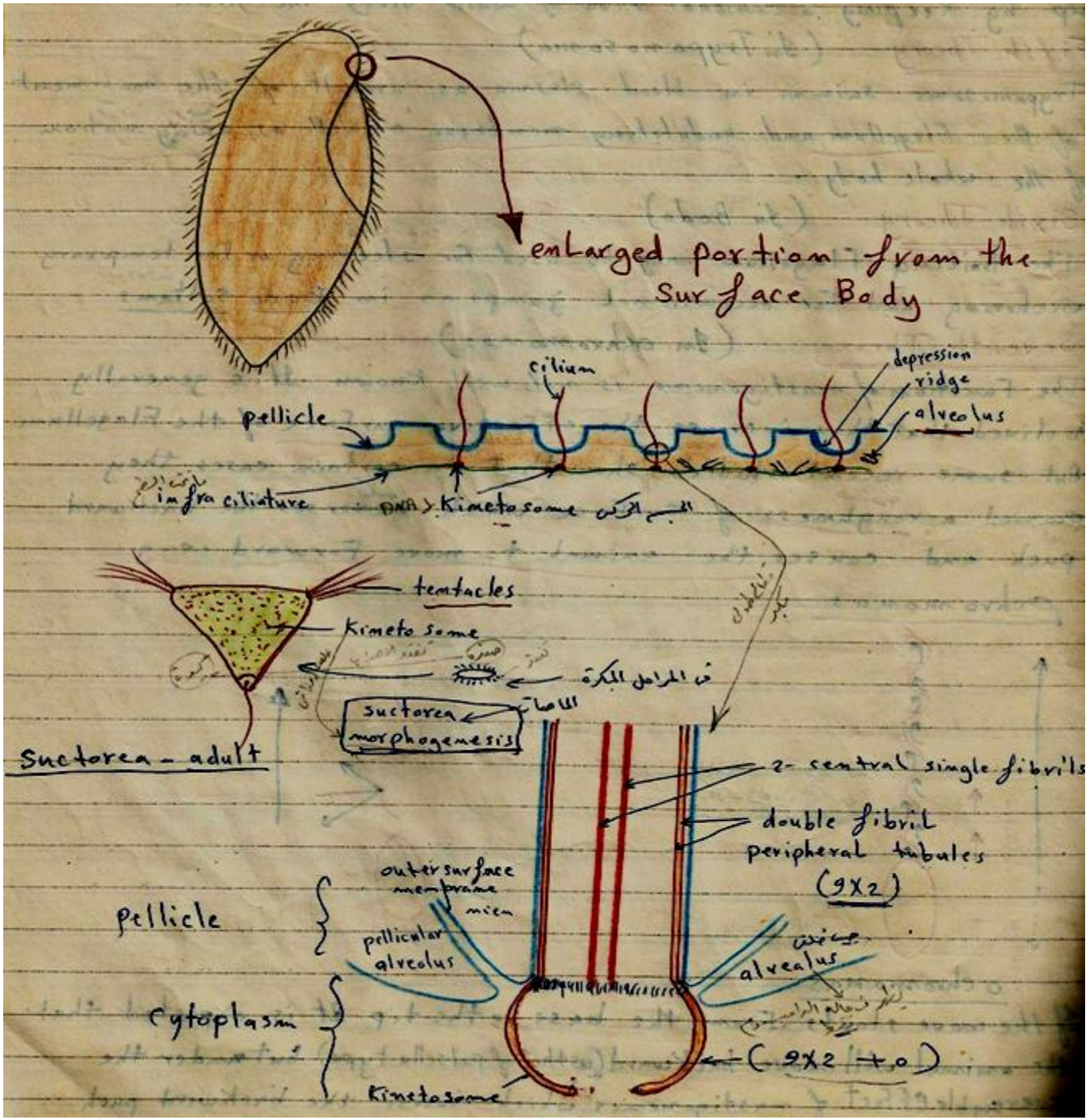
-The arrangement of (9×2 + 2) fibrilis (tubules) is also similar in the ciliated epithelia of metazoan animals.

-The cilium arises from kinetosome while flagellum aries from blepharoplast, but kinetosome doesn't act as a centriole in nuclear division as blepharoplast

-Nevertheless,the kintosomes as like kinetoplast in flagellates is containing DNA, it can self replicated and have genetic continuity from generation to generation, thus they are most important in cytoplasmic heredity and in the morphenogenesis of the ciliates.

-When the cilia are lost the kintosomes are retained it. The kintosomes are connected together by a complicated system of fibrils generally known as the infraciliature.

Flagellum	cilium
Have blepharoplast act as centriole	Have kinetosomes not act as centriole
Few in number	Large in number
long	short
Restricted in some area of the body	Usually covering the whole body


enLarged portion from the Surface Body
cilium
depression
ridge
alveolus
pellicle
infra ciliature
DNA
Kinetosome
tentacles
Kinetosome
suctorea
morphogemesis
Suctorea - adult
2- central single fibrils
double fibril
peripheral tubules
(9X2)
outer surface membrane
pellicular alveolus
pellicle
alveolus
cytoplasm
(9X2 +2)
Kinetosome

Number and distribution of cilia:

-The cilia are usually present in large numbers, in hundreds or few thousands specially in the *opalinata* & most of the two order Holotrichia and Heterotrichida.

-Ordinary cilia covering the whole body from the somatic ciliature and when cilia covered the whole body are nearly alike this condition is called as *Holotrichous*.

The cilia usually lie in longitudinal, diagonal or spiral raws which follow the scalpture of the pellicle if present e.g. *paramecium*.

-In certain cases cilia are limited to special areas (zones) or rows as in *vorticella*, *Busaria*, *Didinium* (2/row). Cilia may fuse to form more powerfull compound known as organelles or ciliary derivatives .

B – Ciliary Derivatives

1-Cirri: These are tufts consisting of 2 or 3 short rows of cilia fused together. Cirri are characteristic of the hypotrichida and limited to the ventral surface in certain groups in *stylonychia* (5- frontal 3 ventral, 3 anal, 3 caudal, and marginal) and in *Euplotes(*7 frontal,2 ventral,4 caudal and 5 anal) . Their number and distribution of cirri are of systematic importance.

2- Membranelles:

These are flat, thin plates formed by the fusion of 2or more transverse short rows of cilia.

-Membranelles are found in all orders of ciliophora, but not common in Holotrichia.

-The membranelles usually form an spiral shape at the margin of the peristome and commonly known as the adoral zone of membranelles (A.Z.M)

buccal ciliature = الأهداب الفمية

membranelles

Enlarged cirrus

Kinetosomes

الوضع البدائي

Holotrichous

adoral zone of membranelles (AZM)

(Anterior cirri)

(5) Frontal cirri

undulating membrane

mouth

[3] ventral cirri

micronucleus

macro nucleus

marginal cirri

(3) anal cirri

(4) caudal cirri

AZM

micro nucleus

frontal cirri

ventral cirri

Anal cirri

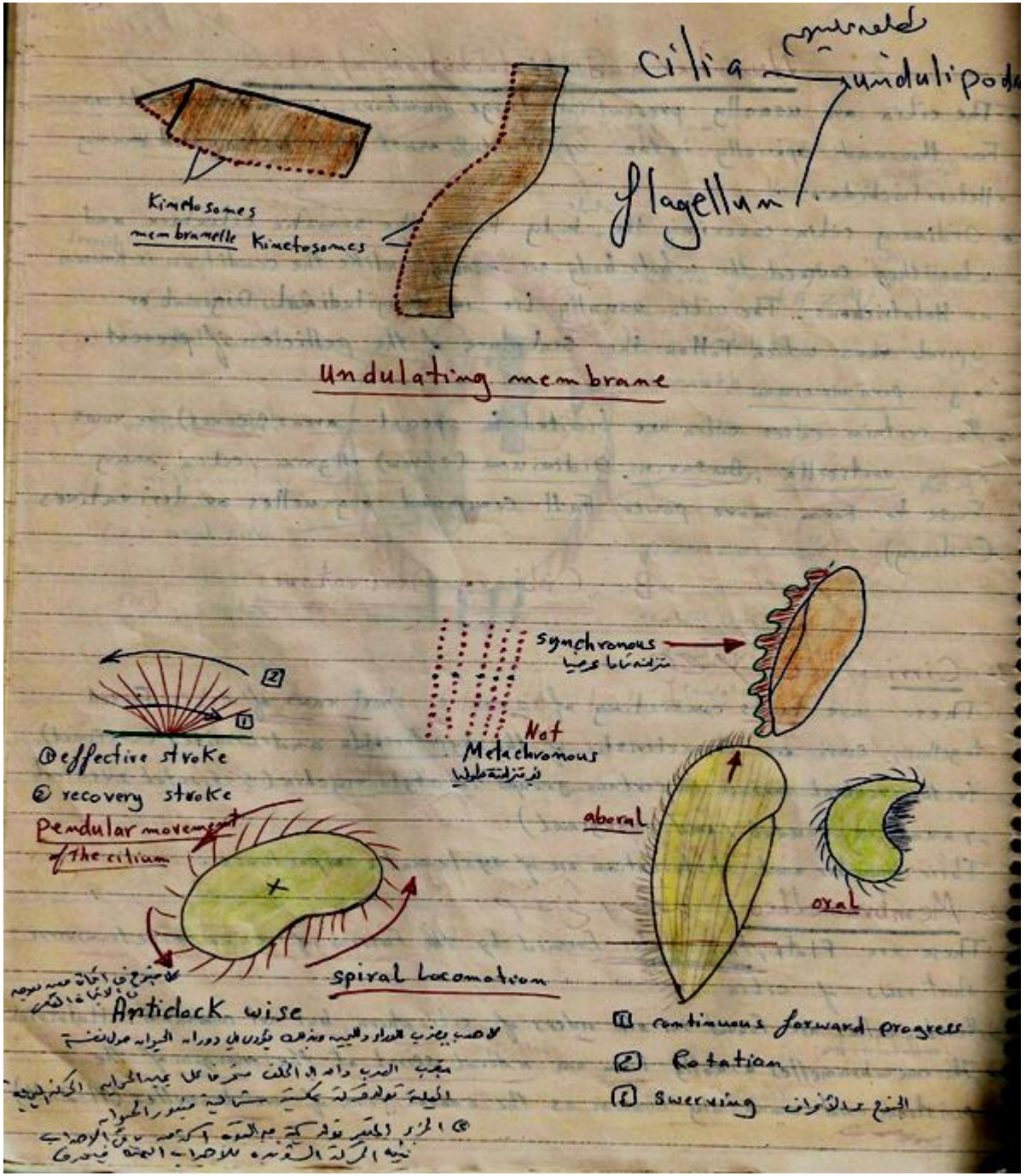
Caudal cirri

order: Stylonychia (Hypotrichida)

Euplotes

3- Undulating Membrane:

One or two longitudinal raws of cilia in a line fused to form a membrane situated usually at the right edge of the peristome or in the cytopharynx. They are found in many species of ciliates .


Cilia
undulipodia
flagellum
Kinetosomes
membranelle
Kinetosomes
Undulating membrane
synchronous
Not
Metachronous
① effective stroke
② recovery stroke
Pendular movement
of the citium
aboral
oral
spiral Locomotion
Anticlock wise
① continuous forward progress
② Rotation
③ Swerving

Locomotion by cilia and their Derivatives

Locomotion by cilia:

-Locomotion by cilia is very efficient up to 200M.or more / second in some cases.

-Cilia like flagella move as a result of various contractions in their peripheral double fibrils.

-A.T.P as an energy source and various ions are involved.

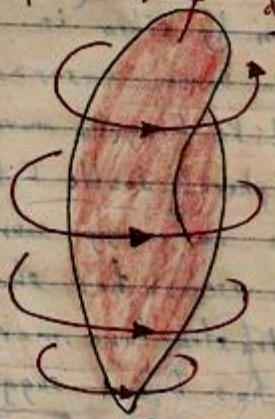
-Recent research has shown that cilia and Flagella are so similar in ultrastructure movement and biochemical features that is has been suggested two groups them under one type of organelles called undulipodia.

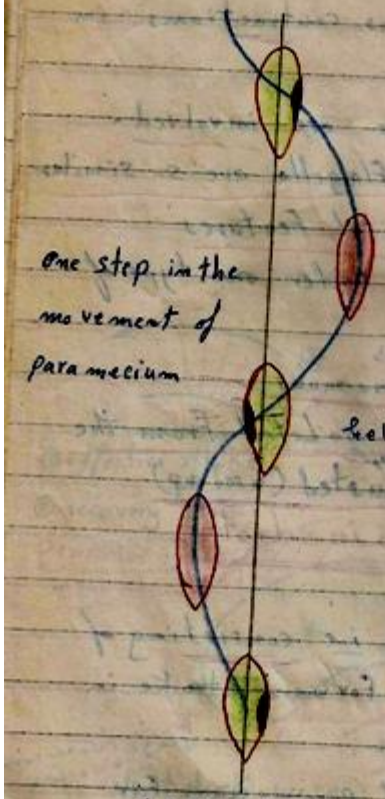
-Both cilia and flagella are autonomous.

i.e. They can more even if they are isolated from the organisms till the energy reserves is exhausted (consumed) .

- pregress forward

T.s showing the swerving & compensation of it in different directions





One step in the movement of paramecium

helical movement

The classical view of locomotion in ciliates:

It has been as follows:

-The movement of the cilium is "pendular“. i.e. It consisting of an effective backward stroke and recovery forward stroke in one plane.

-The anticlockwise spiral locomotion of *paramecium* for example has been explained to result from 3 types:

1-Continuous forward progress:

Due to a metachronous(longitudinal) waves of ciliary movements.

2-Rotation :

Due to diagonal backward direction of cilia to the right during their backward stroke.

3-Swerving :

Due to stronger action of long cilia in the oral groove (gullet). When the animal rotates swerving occur in any direction, this compensated by equal swerving in the opposite direction.

More Recent studies suggest another picture

1-In a swimming *paramecium* the cilium beat directed backward,a helical (spiral)wave traveling from its base to tip of each cilium.

2-A metachronous (longitudinal)ciliary waves extend from posterior end to forwards.

3-The moving cilia produce a system of whirly streams(دوامـة) of water which caused the animal to rotate and move forward. Rotation and spiraling therefore do not depend on body shape but on the direction of these whirly streams.

Locomotion by ciliary derivatives :

- **Locomotion by cirri:**

Cirri can be move together or independently in all direction acting like legs in crawling (creeping)

- **Locomotion by Membranelles *:***

Membranelles serve for swimming and for deriving food into the mouth.

- **Locomotion by undulating membrane *:***

Undulating membranes are organelles for food capture and collection.

Contractile Fibrils "Myonemes"

In many protozoa contractility is a general function of protoplasm but in certain cases there are special contractile fibrils commonly known as Myonemes.

1– In Mastigophora :

Contractile fibrils are rare in Flagellates. The tentacle of *Noctiluca* is contractile and cross, striated (transversed). The so called myonemes of some trypanosomes are sub – pelicular tubules and some times (not used) mere strations.

2- In Sarcodina:

The myonemes are found only in certain Radiolarida in *Acanthometron* for example:

each axial spine is connected with a number of myonemes originating in the outer protoplasmic layer when the myonemes contract, the body volume increases and thus they help in floating the animal and act as hydrostatic organelles.

3- In Sporozoa:

The myonemes are particularly developed in the order Gregarinida their contraction produces the gliding and worm–like "gergarine movement" .In some monocystids, myonemes are arranged in an outer circular and in inner longitudinal layers.

4- In Ciliophora:

Myonemes reach the best development in many ciliates for example:

- In *stentor* and *spirostomum*: (Heterotrichida)

Myonemes are ribbon like and extend longitudinally in 2 layers.

- In *vorticella* and *carchesium* :

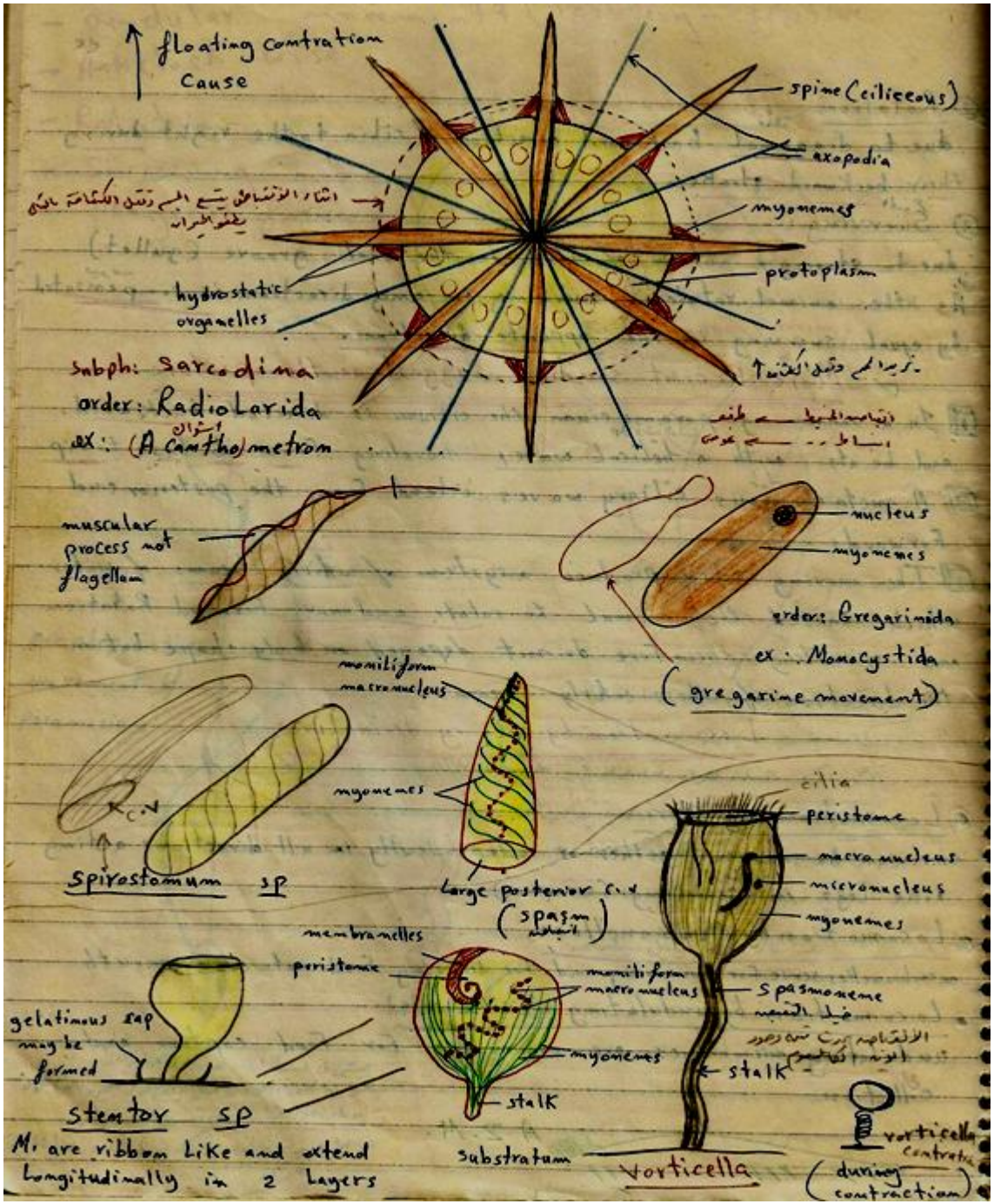
Myonemes of the body converge at the base of the bell to form the spiral myonemes of the stalk, known together (collectively) spasmoneme.

- In the complicated *Entodinomorphina* :

Entodinomorphina are the highest ciliophora and in turn they the highest protozoa .Myonemes are highly specialized and may form powerfull retractor and sphincters muscle.

5- In Opalinata :

Myonemes not present.


floating contraction
Cause
spine (ciliceous)
axopodia
myonemes
protoplasm
hydrostatic
organelles
Subph: Sarcodina
order: Radiolarida
ex: (A Cantho) metron
muscular
process not
flagellum
nucleus
myonemes
order: Gregarinida
ex: Monocystida
(gregarine movement)
moniliform
macronucleus
myonemes
C.V
Spirostamum sp
Large posterior C.V
(spasm)
cilia
peristome
macronucleus
micronucleus
myonemes
membranelles
peristome
moniliform
macronucleus
myonemes
stalk
Spasmoneme
stalk
gelatinous sap
may be
formed
Stentor sp
M. are ribbon like and extend
Longitudinally in 2 layers
substratum
Vorticella
vorticella
(during
contraction)

Function of Myonemes:

-In such cases the myonemes serve to contract the body and close up the peristome as a protective measure (method).

-Recent E.M. studies have shown that myonemes of *vorticella* are made of closely packed bundles microfibrils.

-A system of tubules connect these bundles with the endoplasmic reticulum and can accumulate calcium.

-Contraction of isolated stalks can be induced by raising the ca^{++} ions concentration above a certain threshold.

Respiration

-In protozoa respiratory exchange takes place by simple diffusion through the body surface this is quite efficient in suck small animals with a relatively wide exposed surface.

-Most of the free living forms are obligate or facultative aerobes requiring (needing) free molecular Oxygen where they live. The same is for parasites living in the blood or tissues of other animals where there is an adequate(eneugh) supply of Oxygen.

-In all such cases respiration follows the same general biochemical pattern as in metazoan cells.

-On the other hand intestinal parasites and protozoa living in the bottom mud of stagnant poles (water). In sewage and similar habitants are obligate and facultative anaerobes.

-Such forms obtain energy by means of reactions others than union with free Oxygen, for example by the break down of glycogen into lactic acid or various anaerobic pathways of respiratory metabolism.

-Obligate anaerobes protozoa may even be killed in presence of $O_{2,}$ for example the intestinal Flagellates termites.

Circulation/coelom

a There is nothing corresponding to a circulatory system as in metazoans.

b Internal transport of materials is probably due to diffusion but may be aided by endoplasmic streaming in some species.

Co-ordination

Irritability and Related Organelles:

In many protozoan such as amoebae irritability is apparently performed by undifferentiated protoplasm, but in certain cases differentiated organelles for reception, response, conduction, co-ordination are recognizable.

1-Organelles of receptions or sensory organelles:-

-The cilia and Flagella seem to be in part sensory and in many ciliates, there are certain stiff motionless cilia specialized for this function.

-Well developed sensory organelles are rare in the protozoa and the photoreceptors are the most important ones.

-The stigma or (eyes spot) is characteristic of the colored phyto flagellates it is usually believed to be sensitive to light although in *Euglena* for example, it only serves to shade the true photoreceptor which is found near to the base of Flagellum one.

-This shading serves to detect the direction of light rays while the animal is rotating, that the photoreceptor seems to transfer the light energy to the Flagellum.

-In certain Dinoflagellates as *Erythropsis* the “eye spot” there is a peculiar structure known as the ocellus, this is composed of a hyaline(glass) lens and a dark mass of pigment which may capable of changing its form.

③ Conduction & coordination

Response ② (effecter organelles)

① Reception (sensory organelles)

(shock reaction)

A

B

true photoreceptor

stigma (eye spot)

(not sensitive to light)

lens hyaline

pigment (dark mass)

(ocellus)

Erythropsis

from Dino flagellates

pellicle

discharged trichocyst

indischarged Trichocyst

discharged Trichocyst

2-Organelles of responses or Effector organelles:-

(Explosive organelles = extrusomes)

- The locomotory organelles are the most prominent effecter organs.

- However there are certain other complicated structure which are always located below the pellicle and respond rapidly to external stimuli by strong extrusion to outside and therefore they are known as the explosive organelles or extrusomes.

-The most important of these explosive organelles are the following:-

1-Trichocyst:

-The trichocysts are characteristic of Holotrichia (*Paramecium*) they are regularly distributed in the ectoplasm as vesicles or rods attached to the pellicle perpendicular to the body surface. The trichocyst is surrounded by a thin membrane and consists of body, tip and cap.

-Under mechanical, chemical or electric stimuli, the trichocysts are discharged in few milliseconds into long striated threads or shafts with charged tip.

-The striations are due to a regular arrangement of a fibrous protein called Trychinin.

-The method of discharge is not exactly known it was explained by a sudden absorption of water causing great increase in volume and explosion.

-Recently shaft formation has been explained to results from process of highly ordered molecular re-orientation or by sudden extension of a pre existing para–crystalline lattice.

-It was thought that trichocysts originate from kinetosomes but recent studies have shown that they develop from certain vesicles in the cytoplasm, but how they orient and fix themselves in the correct position it is still mystery.

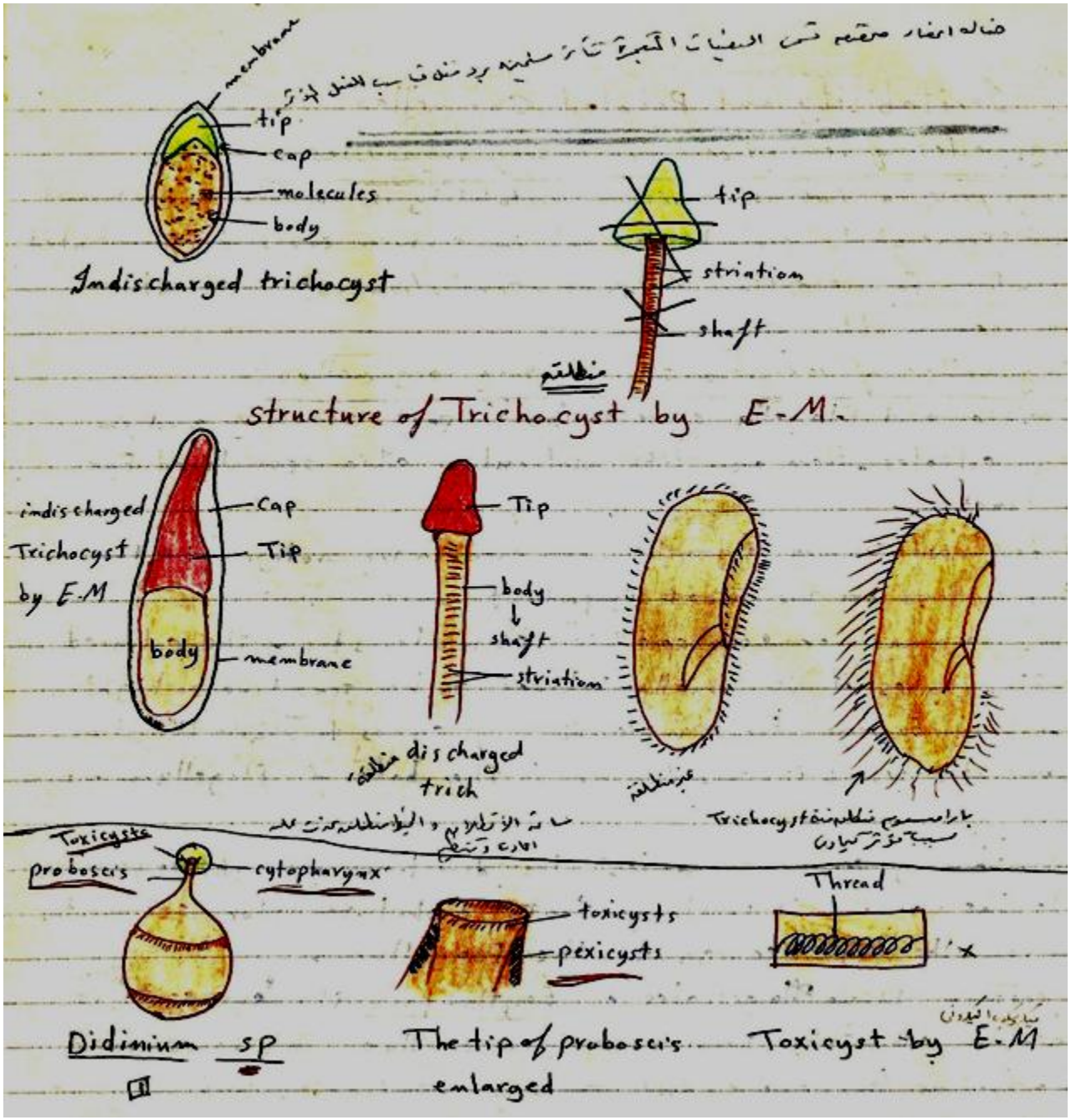
-The function, of trichocyst is not exactly known in *paramecium* they fail to protect the animal from *Didinium* so they are not defensive as it is usually said. They may be used in *paramecium* for temporary anchoring (ancharge) while the animals feeding on bacteria (in richly media).

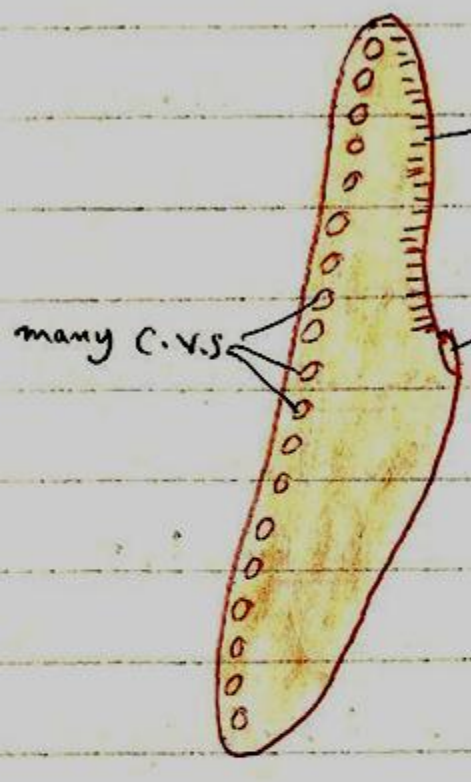
2-Toxicysts :-

-Toxicysts are found in the *raptorial Gymnostomatida*.

-They are found around the cytostome in *Didinium* or on a proboscis anterior to the cytostome as in *Dileptus* or on certain extensible papillae as in *legendrea*.

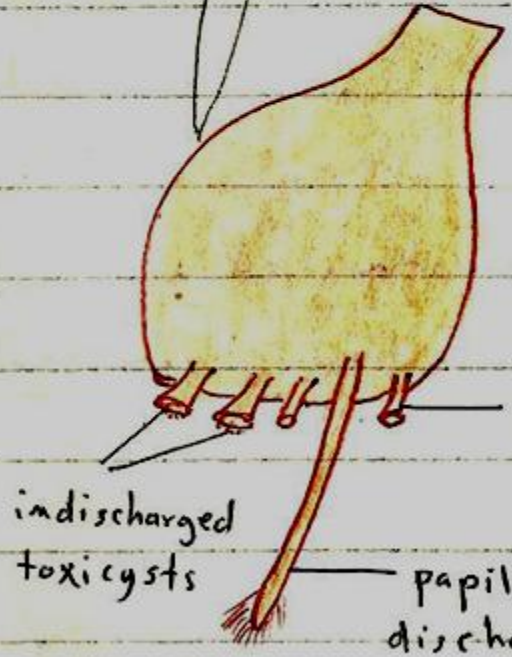
-They were simmlar trichocysts but they are different in structure. They are in the form of thread inside a tubular capsule and contain toxin which paralysis the prey and thus they are offensive weapons used for food capture.


membrane
tip
cap
molecules
body
Indischarged trichocyst
tip
striation
shaft
منطقة
structure of Tricho.cyst by E.M.
indischarged
Trichocyst
by E.M
Cap
Tip
body
membrane
Tip
body
shaft
striation
منطقة
discharged
trich
منطقة
Trichocyst
Toxicysts
proboscis
cytopharynx
Didinium sp
toxicysts
pexicysts
The tip of proboscis
enlarged
Thread
x
Toxicyst by E.M

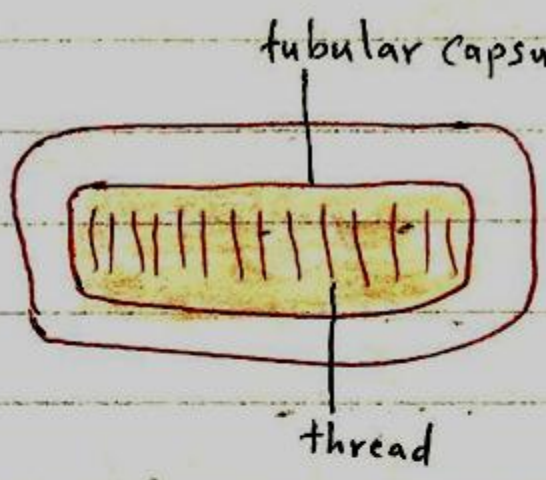


Dileptus sp

[2]



[1] Legendrea sp



Toxicyst by E.M.

3-Pexicysts:

These are short rods (attachment rods) lying below the surface of the oral cone in *Didinium* and are used for establishing contact with *paramecium* before the toxicyst are discharged.

4-Mucocysts:

These are found in some ciliates as in *tetrahymena* and *Didinium*. They are sacs below the pellicle from which mucoid contents can be expelled on stimulation forming a protective covering as like in frog.

5-Haptocysts:

They are small and complicated structures, recently discovered at the end of the tentacles of suctorea and can penetrate the pellicle of the prey.

6-Ejectisomes:

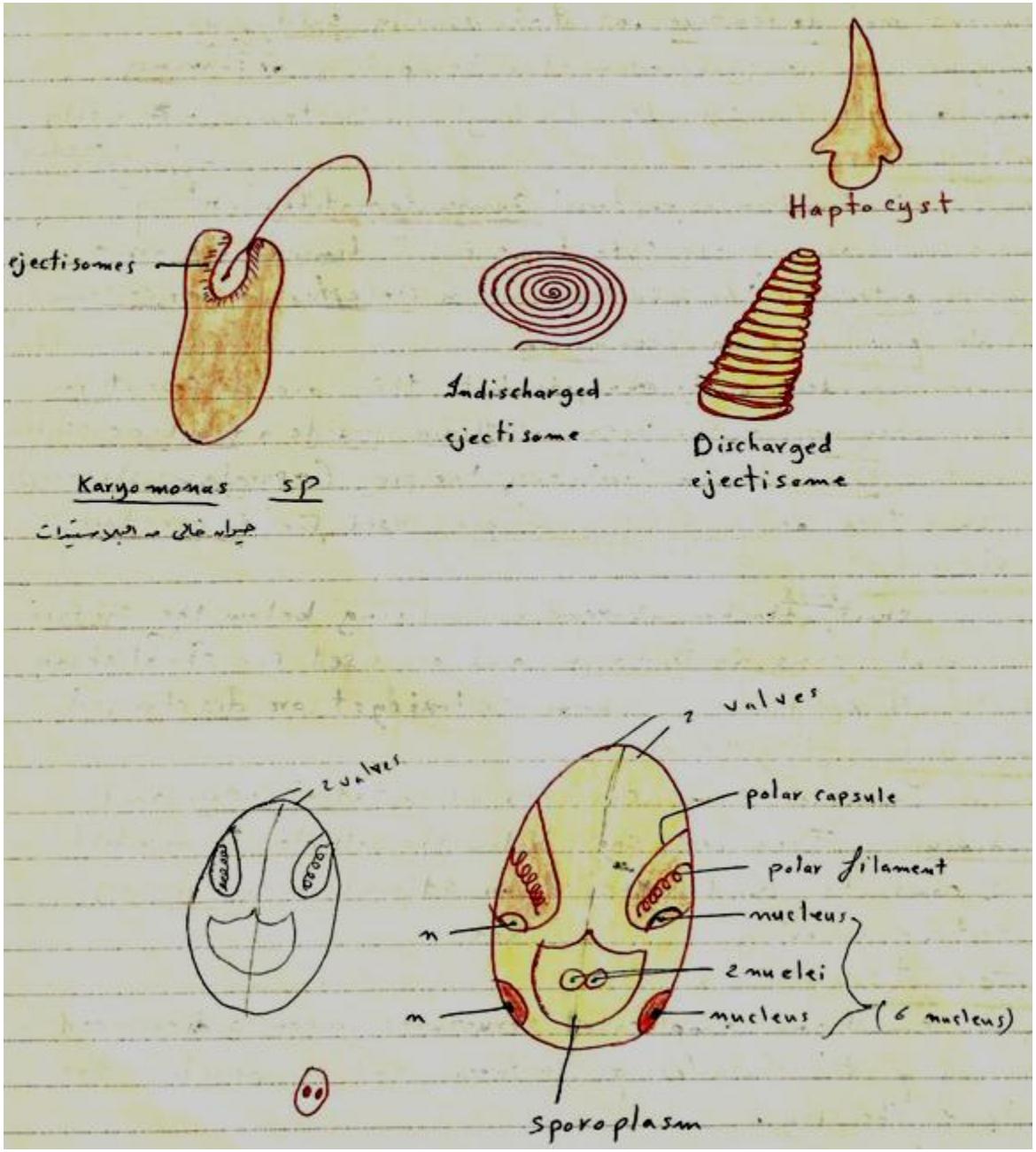
The ejectisomes are found below the pellicle especially in the invagination of cryptomonds, they contain a continuous coild tap and the explosion is similar to pulling a part or a roll of paper into long pointed tube with the outer coils at the base and the inner one at the tip.

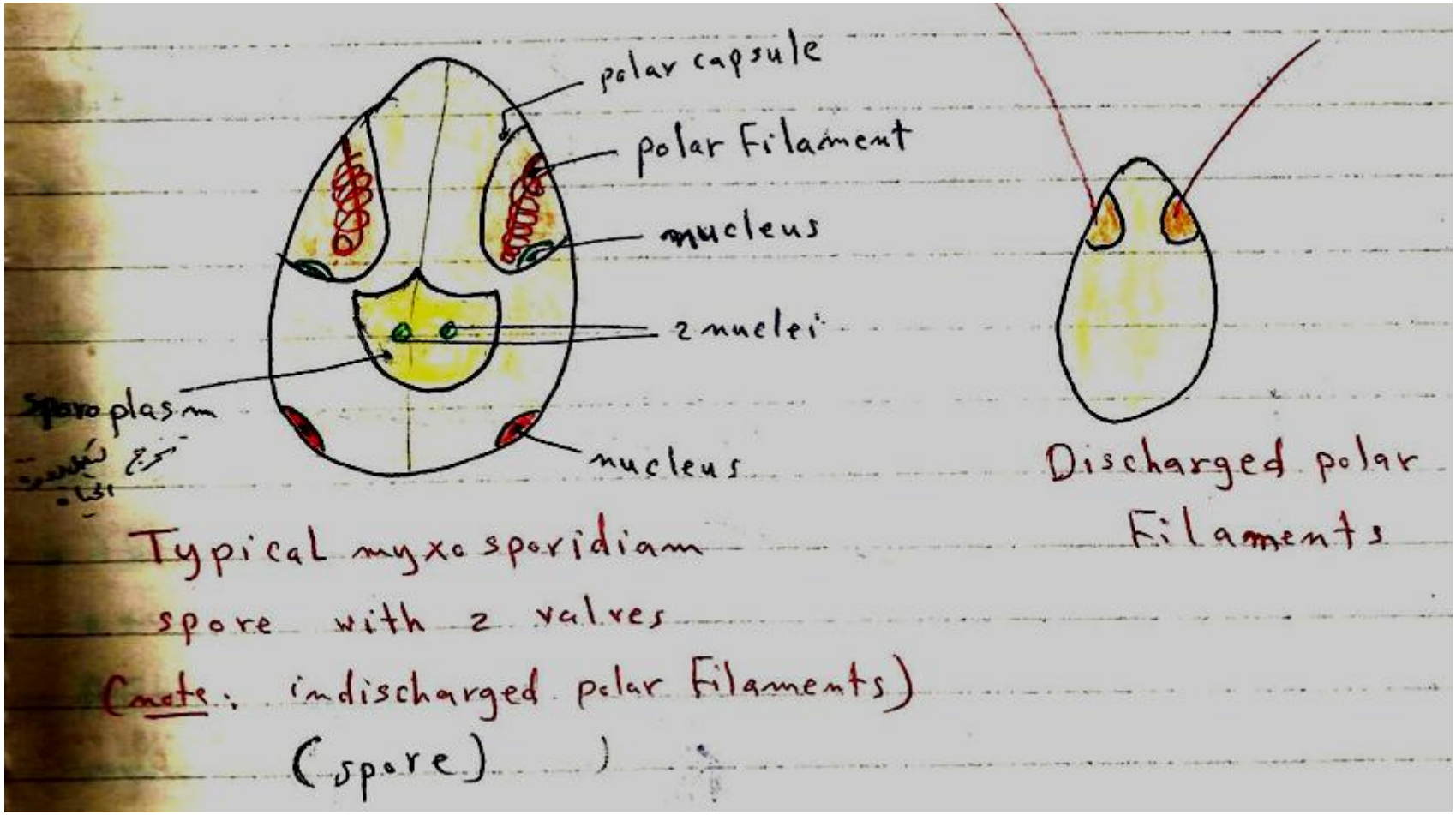
7-Polar Capsules:

-The polar capsules are characteristic of most class cnidosporea.

-In typical cases the spore contains from 1 – 4 polar capsules each containing a polar filament which can be shot out.

-They explode when the spore comes into contact with the tissues of its host. They serve as temporary anchoring organelles of the spores while they are germinating in the alimentary canal of the host.


Hapto cyst
ejectisomes
Indischarged ejectisome
Discharged ejectisome
Karyomonas sp
2 valves
2 valves
polar capsule
polar filament
nucleus
2 nuclei
nucleus
(6 nucleus)
n
n
sporoplasm



Typical myxosporidiam spore with 2 valves

(Note: indischarged polar Filaments)

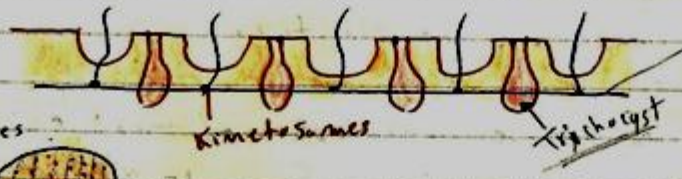
(spore)

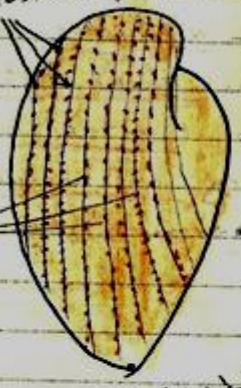
3-Organelles of Conduction, Coordination:

-Conduction and coordination seem to be ectoplasmic but in most protozoa no specialized organelles can be demonstrated however in ciliates, the infraciliature is thought by some to perform these function.

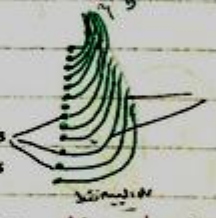
-E.M has shown that from the right hand side of each kinetosome comes out a cross striated fibril which runs for some distance (about 5 – ciliary spaces in *paramecium*). Tapring to a point and over labing other similar fibrils.

① By Light microscopy



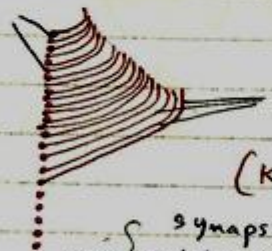


silver impergnation
silver line system
neuro-motor system



one Kinety by E.M

② By electron microscopy



(Kinety) desmodexy

synapse
acetyl choline
cholinestrase

Kinety No 1

Last Kinety

Tetrahymena sp

silver-line rule
role

-this fibril from kinetosomes laying in a longitudinal row form together a composite fiber known as kineto desma. The unit composed of the kinetosomes and their kinetodesmata is known as a kinety.

-The rule that kinetodesmata are always on the right side of their rows of kinetosomes is known as desmodexy. These kineties are very important in the morphogenesis of ciliates. They are giving certain numbers starting from the right margin of the cytostome.

-.

-This system of kineties has been frequently consider as a neuromotor system. After using silver impregnation this system as well as other granules and fibrils appear the whole forming the so called silver-line system.

-However, the nervous function of kineties has not been definitely proved, but substances of the acetylcholine – cholinesterase system have been recently detected in the ectoplasm of some ciliates.

This is of special interest because these substances play an important in role in the biochemistry of synapse and nerve endings in higher animals.

On the other hand some recent work suggests that the ciliary control is mediated by hydrodynamic effects and certain electrochemical phenomena

Reproduction

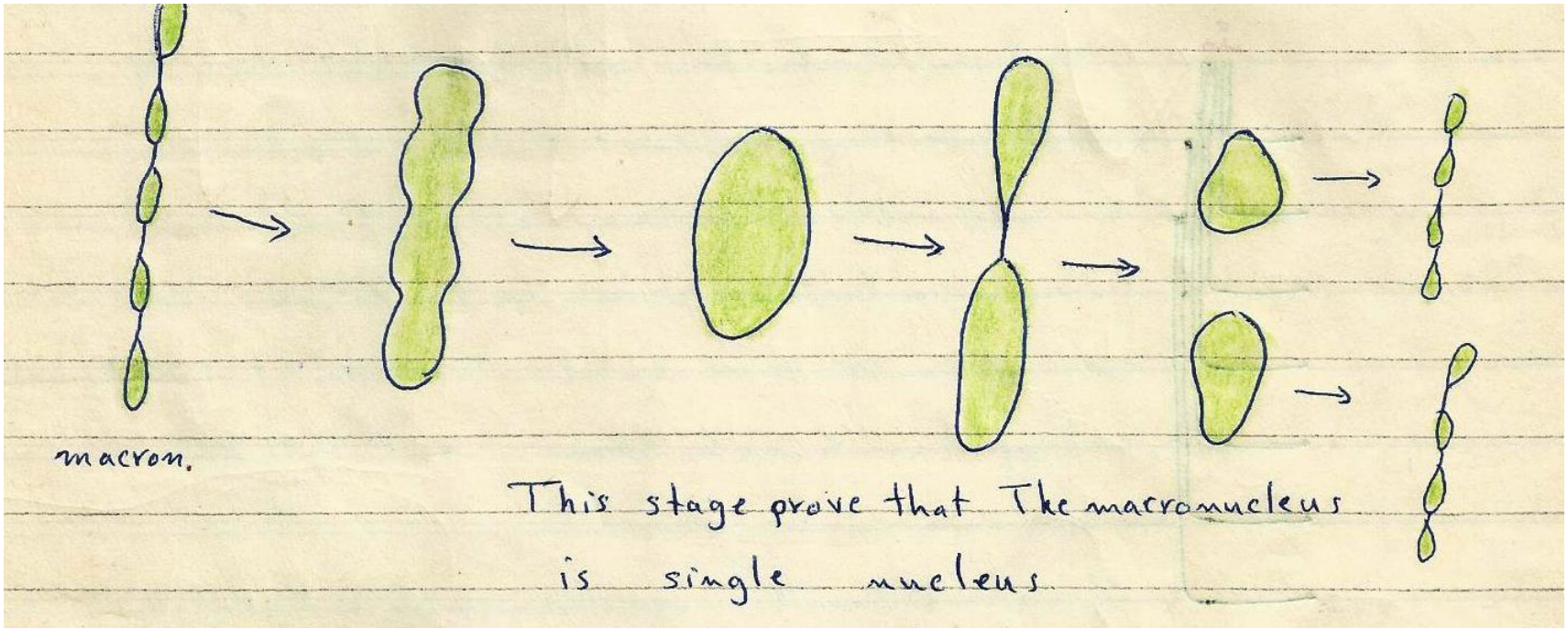
Reproduction in protozoa is in many cases analogous to division of metazoan cells. It is initiated by nuclear division followed by cytoplasmic fission. the letter takes various forms in different protozoa. This asexual reproduction is the main and may or may not accompanied by sexual phenomena.

1- Nuclear Division or Karyokinesis :

-The micronucleus of ciliated and nuclei of all other protozoa seem to divide always by some sort of mitosis. This may be eumitosis similar to that of metazoan nuclei or paramitosis showing various modifications and usually take place inside the nuclear membrane which persists.

-The macronucleus of ciliates appears and has been usually regarded to divide directly by amitosis however, recent studies have shown that its chromosomes are duplicated internally before the nucleus divides into 2 parts and the process is therefore known as endomitosis.

-Long branched lobed or on moniliform macronuclei undergo shorting and condensation before division.



macron.

This stage prove that The macronucleus is single nucleus

2-Cytoplasmic Fission or Cytokinesis

There are 7 methods of Cytokinesis :-

- Binary Fission or Monotomy (simple – B. F)
- Repeated Binary Fission or Planitomy
- Multiple Fission or Syntomy
- Budding
- Schizogony
- Endodyogeny
- Plasmotomy

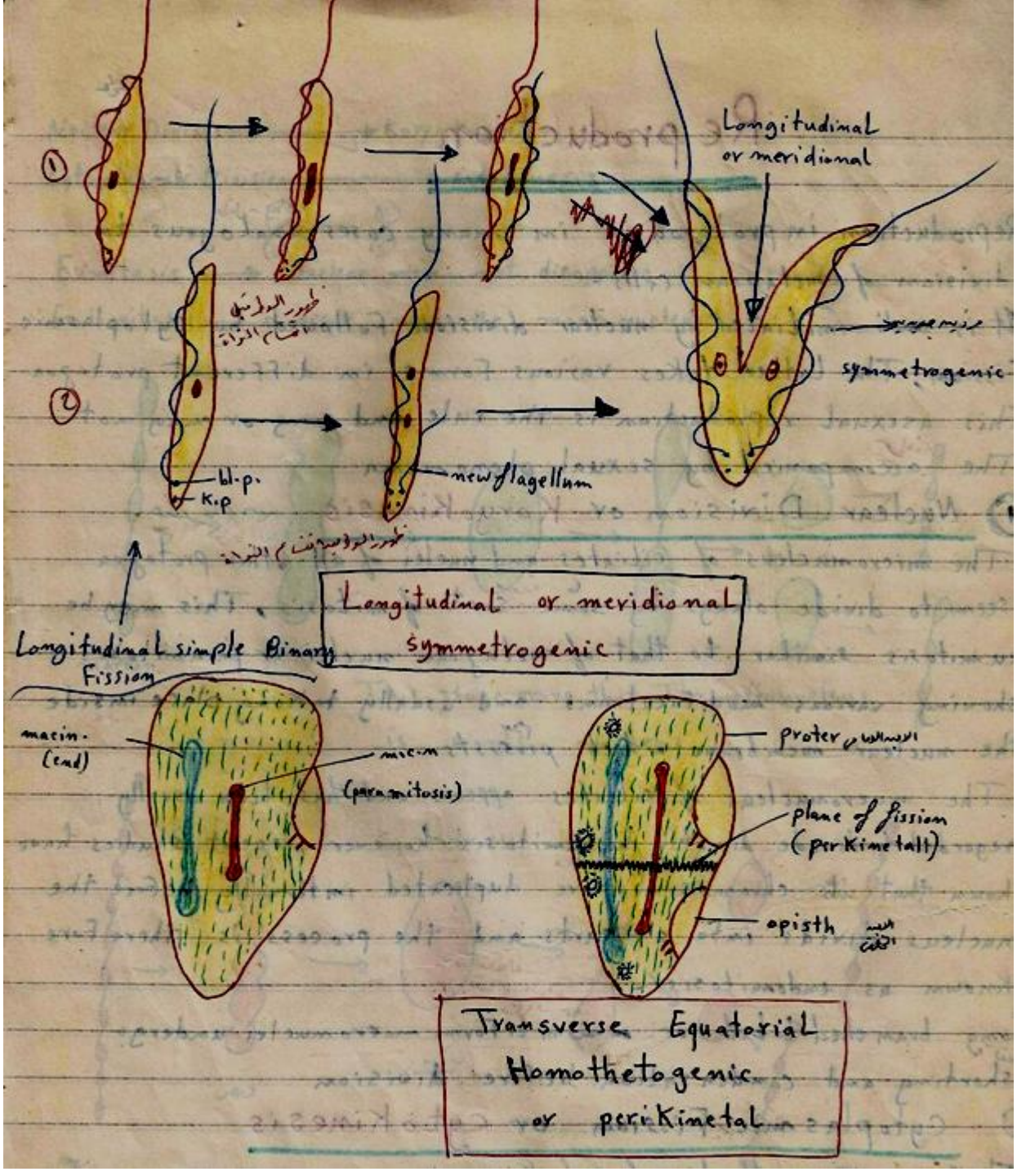
1- Binary Fission or Montomy (simple .B.F)

-This is the most common, the 2 resulting organisms are more or less equal in size. The plan of Fission varies:

a-In Mastigophora: it is meridional or longitudinal and starts at the anterior and separating two daughter forms which are mirror images of one another and fission is therefore described as symmetrogenic.

b-In Ciliophora: the plan is equatorial or transverse producing an anterior porter and a posterior opisth which become by morphogenesis duplicated of each other and fission is them described as *Homothetogenic*. As Fission plane usually passes across all the kineties it is called *perkinetal*.

In *Peritrichida*: Fission is only apparently longitudinal which is an adaptation to sessile life, resulting in the change of the longitudinal axis of the body in these ciliates.

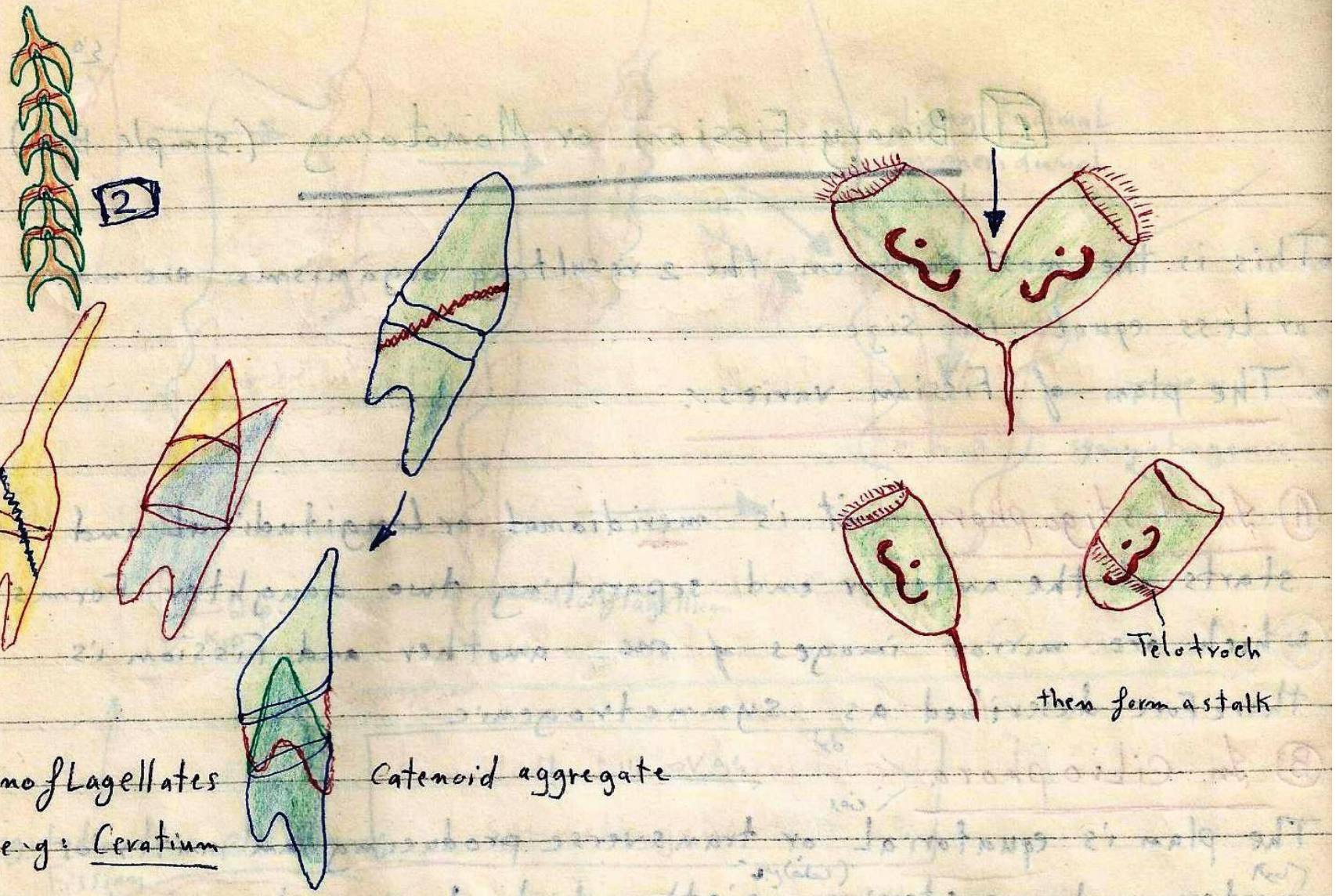

Longitudinal or meridional
symmetrogenic
bl.p.
K.p
new flagellum
Longitudinal simple Binary Fission
Longitudinal or meridional symmetrogenic
macin. (end)
mic.m (paramitosis)
plane of fission (perikinetal)
apisth
Transverse Equatorial Homothetogenic or perikinetal

c-In some DinoFlagellates: like *ceratium,* the plan is oblique.

d-In Shapeless and spherical Forms (sarcodina): (as most sarcodina) no such planes can be recognized or determined.

2-Repeated Binary Fission (or planitomy)

This is B.F. successively repeated without complete separation of daughters it lead to formation of colonies, aggregates e.g. *Ceratium*.

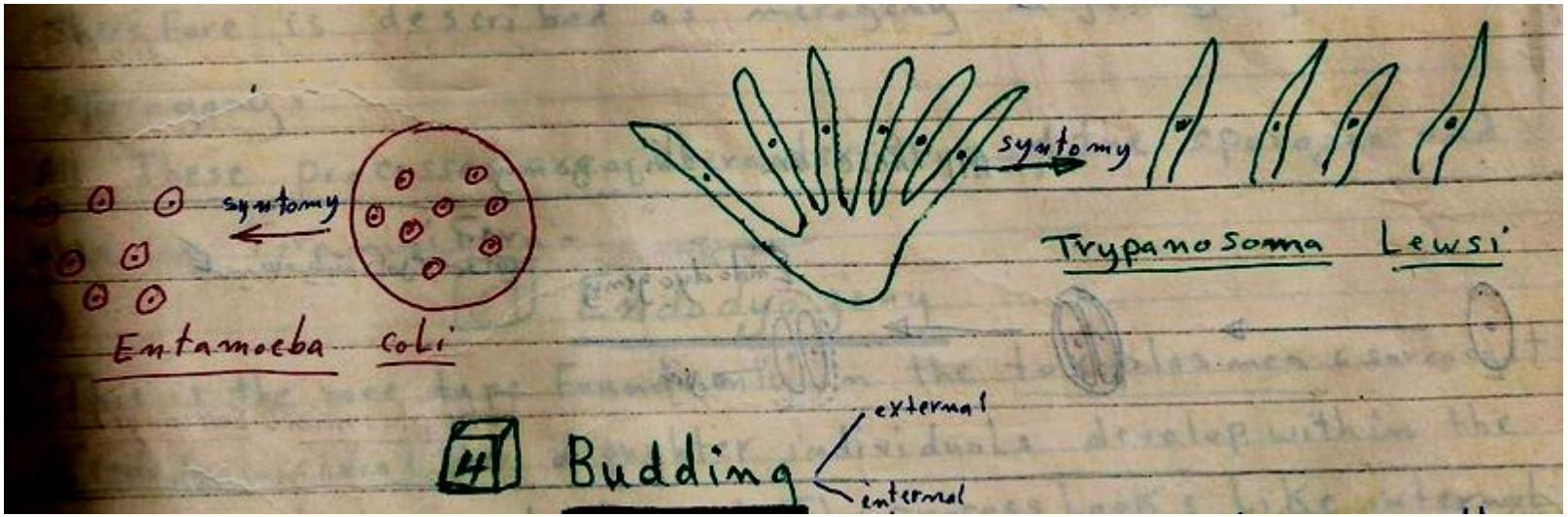

2
Telotroch
then form a stalk
Dinoflagellates
e.g: Ceratium
Catenoid aggregate

3-Multiple Fission (or syntomy)

Here successive nuclear division in more rapid than for precedes cytoplasmic fission and as a result a temporary multinucleate body formed as cyst of *Entamoeba coli* or *histolytica* or several individuals remain attached to each other before complete separation as in *Trypanosoma Lewsi*.

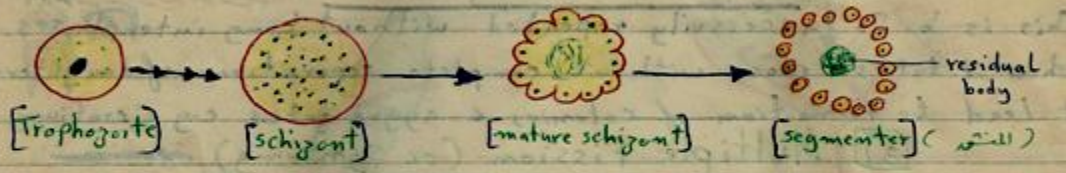
4-Budding

The bud or buds are usually much smaller and frequently differ from the parent, undergo differentiation before or after being separated. Budding may be monotomic (binary) or syntomic (multiple). It is external (exogenous) as in *vorticella* and *Arcella* or internal endogenous as *Tokophyra* both of types are found in suctorea, where budding is the regular method of reproduction.


syntomy
Entamoeba coli
syntomy
Trypanosoma Lewsi
4
Budding
external
internal

5-Schizogony : Successive mitosis gives rise to a number of daughter nuclei (from four to thousands) which arrange themselves on the periphery of the cytoplasm. Then each daughter nucleus becomes surrounded with a small piece bud of cytoplasm and eventually the daughter forms break off (separate).

The schizont itself is destroyed leaving a residual body of unused cytoplasm. The daughter forms may be merozoites or gemetes or sporozoites and the process is therefore is described as merogeny or gamegony or sporogony. All these processes are characteristic of the sporozoa and also in foraminifera



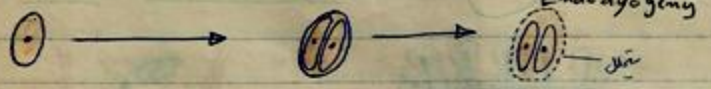
في الإنسان ← merogony — Produce → merozoites (عشائر تتكاثر)

" " ← merogony — Produce → merozoites (عشائر تتكاثر الجم)

في الإنسان والبعوضة ← gamogony — Produce → gametes (Human & mosquitoes)

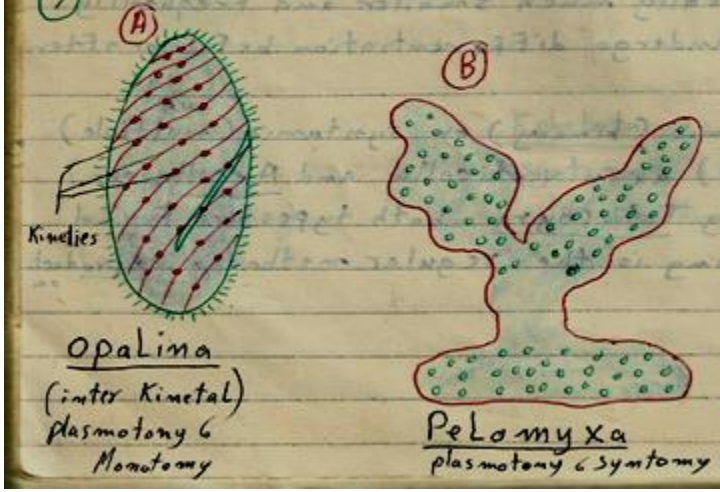
في البعوضة ← Sporogony — Produce → sporozoites (mosquitoes)

All these are schizogony



Toxoplasmin & Sarcocyst

(7)



Opalina
(inter Kinetal)
plasmotomy & Monotomy

Pelomyxa
plasmotomy & syntomy

Myxidium
Myxosporida
plasmotomy & external budding

6-Endodyogeny:

This is the rare type. Found only in the *toxoplasmea*, sarcocyst (endodyococcidia) two daughter individuals develop within the parent which is undestroyed. The process looks like internal budding but it may be regarded as a special kind of schizogony.

7-Plasmotomy

This means fission of multinucleate protozoa dividing into 2 or more organism each receiving some of the parental nuclei. Plasmotomy may be or may not be synchronised(simultenous) with nuclear division.

It may be binary i.e. monotomic as *opalina* multiple i.e. syntomic as in *pelomyxa* or by budding as in myxospordia, *Myxidium.* It should be noted that in *opalina* fission looks as if it were oblique but in fact it is meridional or longitudinal and interkinetal i.e. it is more similar to the case in mastigophora, than to that in ciliophora.

Morphogenesis:

-During fission parental organelles are often shared equally or unequally by the daughter organisms or retained by one of them.

-Other complex organelles as cirri and membranelles of the Hypotrichida are often destroyed or resorbed.

-In all cases the daughter individuals undergo free organization or difinitiation to produce missing organelles and complete their normal structure.

-In this way a renewal of organelles is regularly obtained reorganization reaches its maximum capacity in ciliates and the morphogenesis of the cytoplasm and its related organelles. i.e. stomatogenesis is of special interest .

Stomatogensis in ciliates:

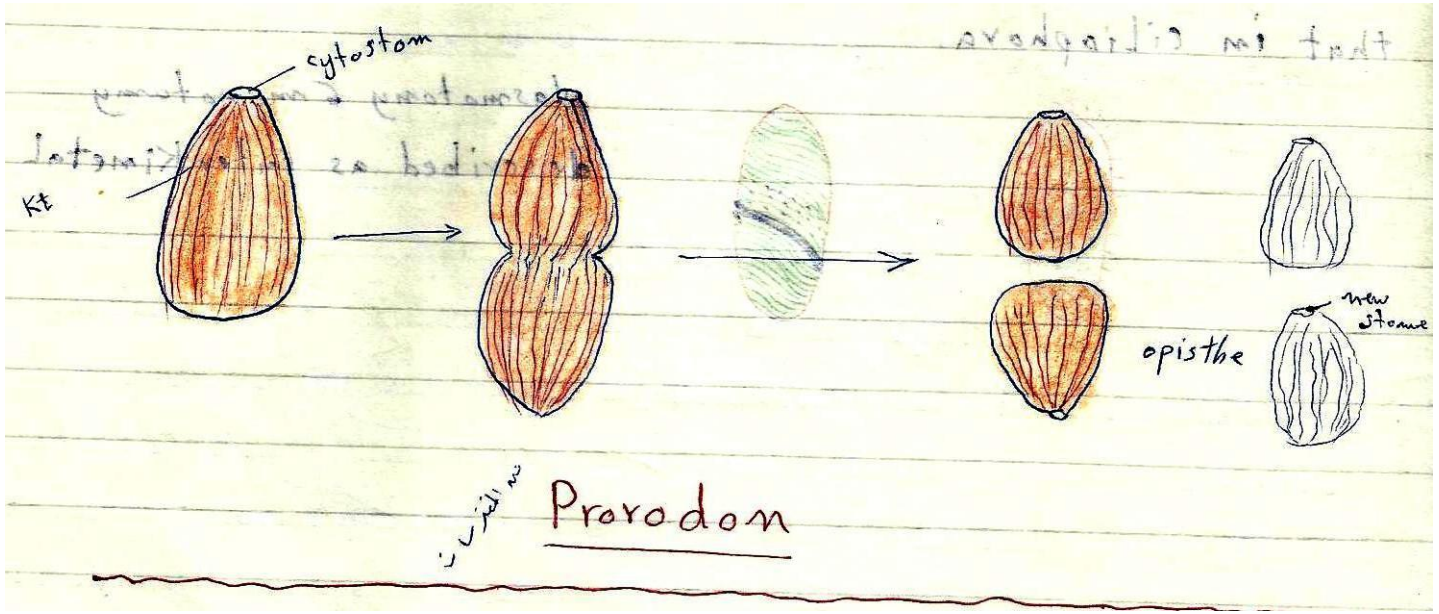
Structures for the cytoplasm is found in the infraciliature, there are various patterns and this may help to understand phylogenetic relationshp between the different groups.

The following is some examples :-

-In simple cases where the mouth is simple and apical, the symmetrically arranged kineties elongate by means of multiplication of kinetosomes, fission takes place across all the kineties and thus the pattern of somatic infraciliature is

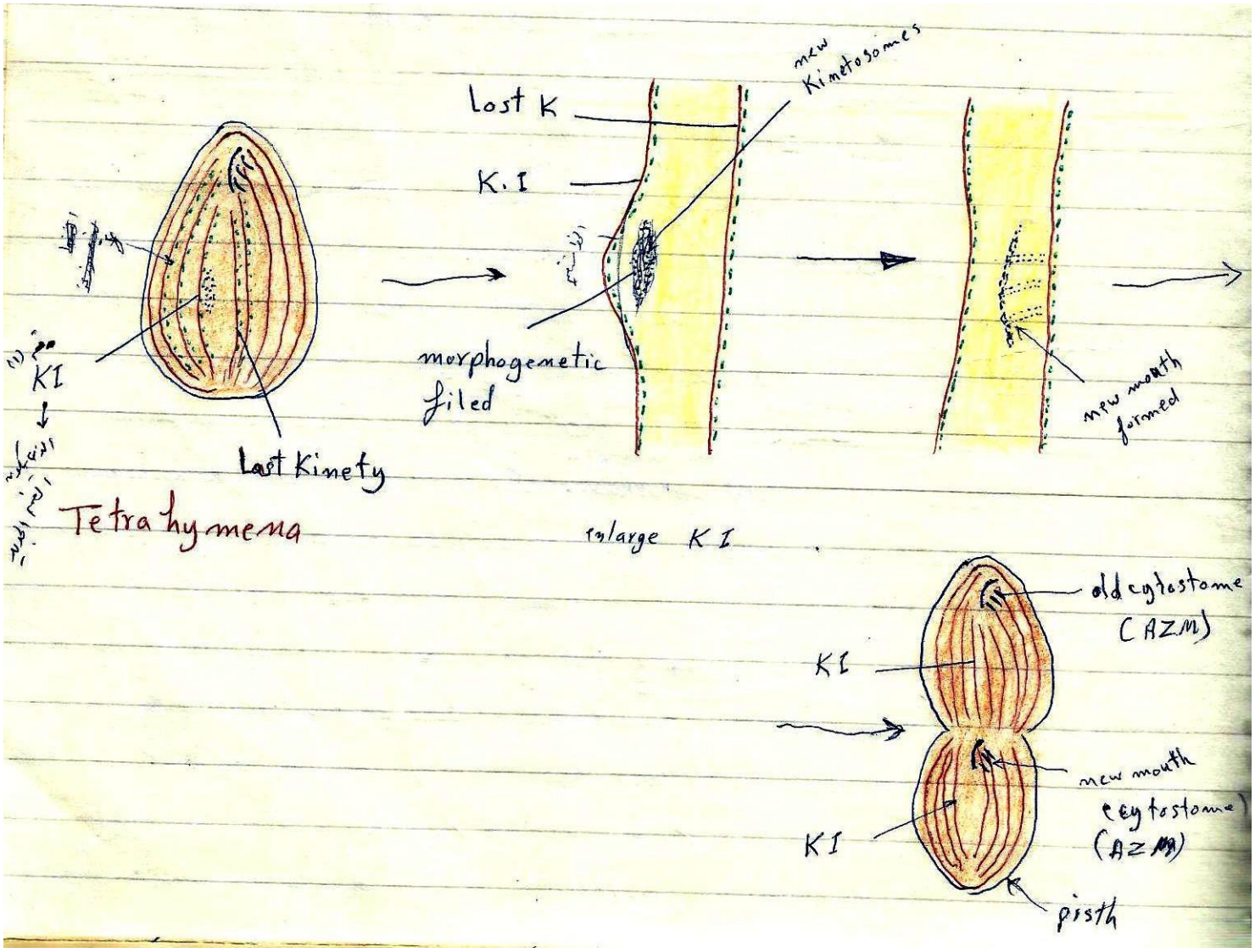
transmitted by equal division to both daughters. In new mouth develop to the opisth, this is found in primitive gymnostomes as in *prorodon*.

-The kineties elongate as in pervious case but a new posterior buccal apparatus is formed from a morphogenetic for example:



Prorodon

In *tetrahymena* some kinetosomes of kinety 1 multiply formed a group of kinetosomes to their left latter the new kinetosomes in the filed arrange themselves and produce cilia which transform into an undualating membrane on the right and free membranelles on the left which is characteristic for the genus.


KI
Last Kinety
Tetrahymena
Lost K
K.I
new Kinetosomes
morphogenetic filed
new mouth formed
enlarge KI
old cytostome (AZM)
KI
new mouth (cytostome) (AZM)
KI
pisth

In some heterotrichida as *stentor* the process is very similar to the pervious case, but several kineties share the formation of morphogenetic filed instead one. This primordium develops into the complex buccal structure of the opisth.

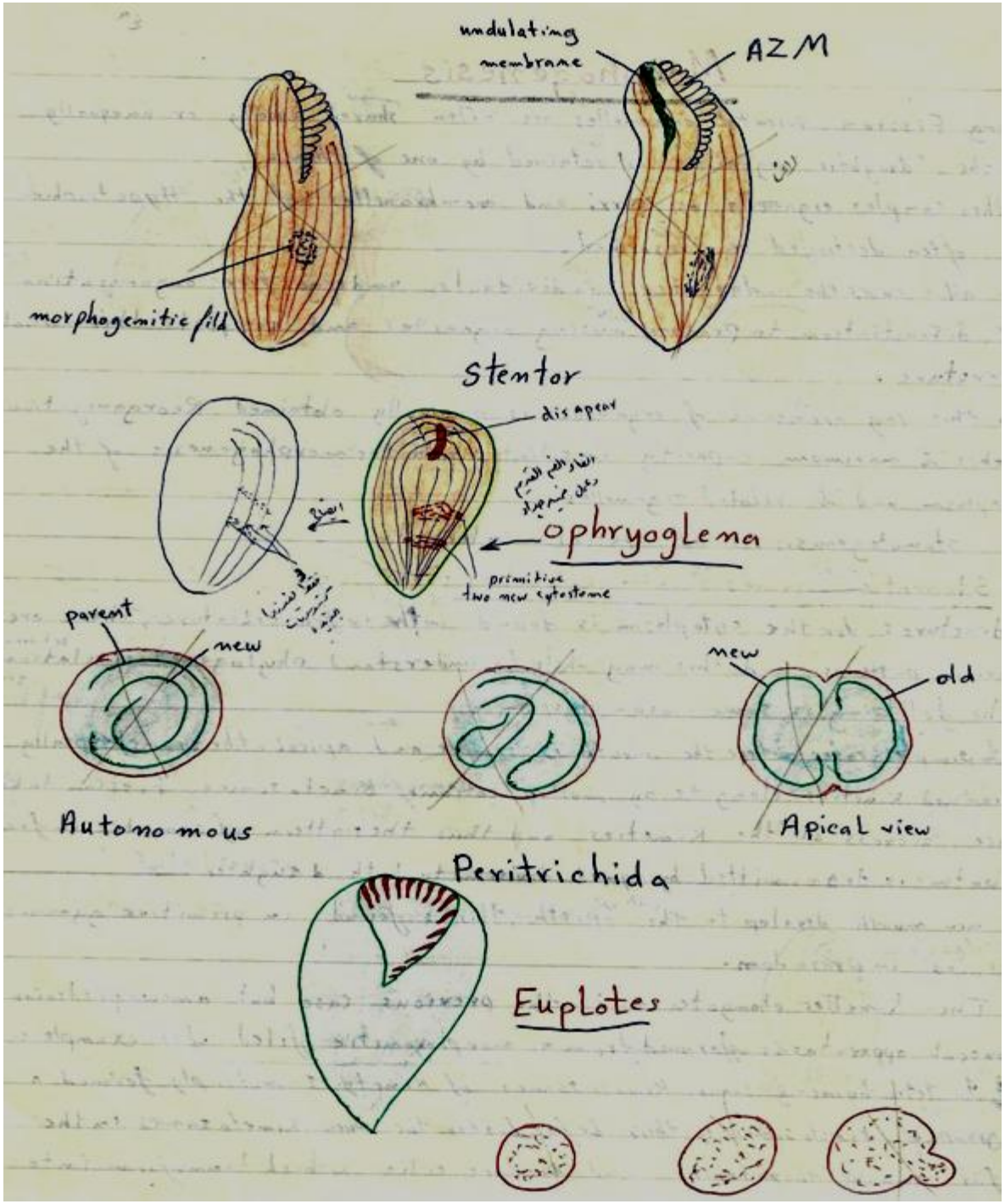
-Free the old oral apparatus is resorbed 2 morphogenetic fileds are forward across a number of kineties, each forming a new oral apparatus for example *ophryoglena*.

-Stomatogenesis is autonomous. i.e. the new buccal structures are derived from kinetosoms directly provided from parent buccal structures. This takes place in peritrichida where ciliature is only oral and in some spirotrichia.

In *paramecium* is another example in which the new mouth develop in continuity with the old structure. Old kinetosomes of the original buccal structure migrate forward into the anterior half of the body, while the newly forward kinetosomes move backward to form the buccal apparatus of opisth.

-A very specialized case or state from the pervious case is formed in Hypotrichida. (*Euplotes*) where the morphogenetic filed for all the new complex oral structure is derived from a single kinetosome arising from the border of the parental AZM.

-In case where the ciliature is suppressed in the adult as in suctorea free kinetosomes always persist scatter at random below the pellicle before budding the kinetosomes form local concentration and arranged themselves to supply the cilia of the buds.


undulating membrane
AZM
morphogemitic fild
Stentor
disapear
ophryoglena
primitive two new cytostome
parent
new
Autonomous
new
old
Apical view
Peritrichida
Euplotes

Fossil record

Fossil representatives are known for the Ciliophora (Order Tintinnida), Mastigophora (Orders Silicoflagellida, Dinoflagellida and Coccolithophorida), and Sarcodina (Order Foraminiferida and Subclass Radiolaria). The Superclass Sarcodina has the most extensive fossil record; of the approximately 20,000 described species, the majority are foraminiferans.

Fossil protozoans are found in a variety of sedimentary rocks and in some instances, e.g. foraminiferans in limestone and chalk deposits, they are important rock formers. In some horizons protozoan fossils are important zonal indices and in the identification of strata in rock drillings, e.g. in the oil industry.

Economic importance

i Free-living species. Photosynthetic flagellates are important primary producers of organic matter in aquatic habitats. Many Protozoa, particularly ciliates and amoebae, and a few flagellates, play a part in the decomposition of organic matter; others feed on bacteria. These two roles are of importance in soil and polluted waters, and in the treatment of wastes in sewage plants (where ciliates are the most abundant of the protozoans present).

ii Parasitic species. Of the approximately 5000 parasitic species of Protozoa, animal parasites predominate. All subphyla have parasitic representatives and the Sporozoaand Cnidospora are entirely parasitic. The parasites of greatest economic importance are found in the Superclass Mastigophora and Subphylum Sporozoa.

In the Mastigophora these are the haemoflagellates of the Suborder Trypanosomatina, Trypanosoma spp. and Leishmania spp. They are blood and tissue parasites of vertebrates, transmitted by intermediate hosts or vectors which are usually blood-sucking insects. They exhibit polymorphism.

Habitat

All Protozoa require adequate moisture in their environment and are therefore restricted to watery or damp habitats. Other factors which may influence the distribution and abundance of individual species include temperature, availability of oxygen and food, pH, salinity, light and degree of predation.