Unit 22 · Protista

STUDY NOTES

WHAT NEB'S GRADE 11 EXAM ASKS

- **CDC's grid (2077):** Faunal Diversity (Units 22–26 together): 19 of 75 marks, 1 MCQ, 2 short and 1 long; in one group with Evolutionary Biology, Units 18–21 (28 marks)
- **The paper:** 11 MCQs × 1 · 8 short × 5 · 3 long × 8; 3 hours; 1 mark per expected point
- **CDC's model paper:**
  - MCQ: what trichocysts of *Paramecium* do (defense, offense, adhesion)
  - short (1 + 2 + 2): what transverse binary fission is; its process in *Paramecium*
- **MCQ (1 mark)**
  - bioluminescent protist; mixotrophic protist; fungus-like protist
  - cell anus; osmoregulation; a flagellate
  - what moves food vacuoles (cyclosis)
  - macronucleus removed; radial canals (6–10)
  - daughters after conjugation (8); no conjugation (weaker)
  - digestion; pellicle; cilia; oral groove
- **Short and long (in parts)**
  - *Euglena* vs *Amoeba*: their groups, four differences
  - slime molds and their characters
  - *Paramecium*: name parts A–D; functions of micronucleus, cilia, caudal tuft
  - **draw** *Paramecium*, labeled; why "slipper animalcule"; external features
  - trichocysts and how they discharge
  - contractile vacuole and osmoregulation
  - macronucleus vs micronucleus
  - binary fission (with diagram); conjugation and its significance

Key terms

Protists: eukaryotes that are not plants, animals or fungi; mostly single-celled.

Protoplasmic (acellular) level: one cell does everything a whole animal does.

Mixotrophic: photosynthesizes in light, takes in food in the dark (*Euglena*).

Holophytic: photosynthetic; **holozoic**: eats solid food; **saprozoic**: absorbs dissolved food from dead matter.

Intracellular digestion: food digested inside the cell, in food vacuoles.

Plankton (*planktos*, drifting): small organisms that **drift** with the water; **phytoplankton** (diatoms, dinoflagellates), **zooplankton** (foraminiferans, radiolarians, ciliates).

Osmoregulation: keeping water and salts in the cell steady (contractile vacuole).

Nuclear dimorphism: two kinds of nucleus (*Paramecium*).

Cyclosis: streaming of cytoplasm that carries food vacuoles along a fixed path.

Encystment: forming a cyst in bad conditions.

Conjugation: temporary union of two Paramecia of different mating types to exchange micronuclei.

Amphimixis: complete fusion of two nuclei from different individuals.

Kingdom Protista

- **Haeckel**, **1866** (*protistos*, the very first); **Whittaker**, five kingdoms, **1969** (cell type, organization, nutrition, relationships)
- examples:
  - *Euglena*: flagellum, fresh water, **mixotrophic**
  - *Paramecium*: ciliate, heterotrophic, eats bacteria
  - *Fuligo*: slime mold on decaying wood
  - *Plasmodium*: intracellular blood parasite, malaria
- plant-like (golden algae, diatoms) · animal-like (*Paramecium*, *Amoeba*) · both (*Euglena*; *Astasia* only feeds) · fungus-like (*Fuligo*, *Protostelium*)

Characteristic features

1. **aquatic** (fresh water, sea); some moist soil; many inside other organisms
2. microscopic **unicellular eukaryotes**; a few **colonial** (*Volvox*)
3. **protoplasmic** (acellular) organization
4. covered by cell membrane, **pellicle**, cell wall or shell
5. **one nucleus**; **two kinds** (*Paramecium*); **many** (*Opalina*: multinucleate, coenocytic)
6. move by **pseudopodia**, **flagella**, **cilia**; none in *Plasmodium*
7. nutrition: holophytic, holozoic, mixotrophic, saprozoic, parasitic

8. **intracellular digestion**
9. respiration, excretion: diffusion through **body surface**
10. asexual: binary fission, multiple fission, cysts, spores; sexual: **conjugation**, **syngamy**

Classification of Protista

Group A: Photosynthetic protists (plant-like)

- **Pyrrophyta** (**dinoflagellates**; *pyrrhos*, fire-colored)
  - mostly **sea**; unicellular, motile (two flagella), photosynthetic
  - some **bioluminescent**: luciferase on luciferin, when water is disturbed (*Noctiluca*)
  - **theca** (lorica): cellulose plates; "naked" *Gymnodinium* without
  - mostly asexual, binary fission
  - *Noctiluca*, *Gymnodinium*; **red tides**, poisons in shellfish
- **Chrysophyta** (**diatoms**, **golden-brown algae**; *chrysos*, gold)
  - unicellular, some colonial; sea and fresh water
  - silica shell, the **frustule**, two halves like a box and lid
  - sexual and asexual; binary fission commonest
  - start of food chains in the sea
  - *Navicula*, *Triceratium*
- **Euglenophyta** (**euglenoids**)
  - free-living flagellates; **fresh water**, damp soil
  - **no cell wall**; flexible **pellicle**
  - **flagella**; red **eyespot** (stigma) near its base
  - chlorophyll in some; reserve food **paramylon**
  - **mixotrophic**
  - **longitudinal binary fission**
  - *Euglena*, *Peranema*, *Trachelomonas*

Group B: Consumer–decomposer protists (slime molds, **protistan fungi**)

- amoeboid when feeding; fungus-like when making spores
- **no chlorophyll**; feed on decaying matter
- sexual and asexual (spores)
- **plasmodial** (true, acellular) slime molds
  - decaying leaves, logs
  - only a plasma membrane
  - feeding stage, the **plasmodium**: one **multinucleate** mass
  - *Physarum*, *Tubifera*, *Fuligo*
- **cellular** slime molds
  - upper layer of moist soil
  - feeding stage: **single amoeboid cells**
  - food short → **aggregate**, each keeps its membrane → spores
  - *Dictyostelium*, *Acytostelium*

Group C: Protozoan protists (animal-like)

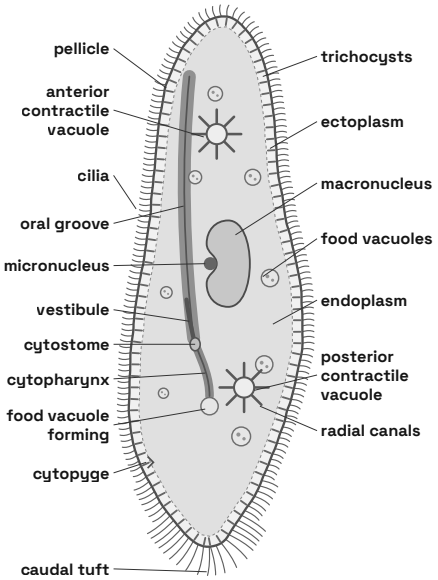
- many **parasitic**; others free-living, commensal, saprozoic
- simplest acellular **animalcules**; solitary or colonial
- membrane, pellicle or shell; varied shapes
- **ectoplasm** (clear outer) and **endoplasm** (granular inner)
- **holozoic**; intracellular digestion
- respiration by diffusion
- excretion: body surface or contractile vacuole; waste out by **cytopyge**
- **contractile vacuole**: osmoregulation (fresh water)
- asexual (fission, budding, sporulation); sexual (gametes, conjugation)
- **encystment** in bad conditions

Class	Moves by	Examples
Flagellata (Mastigophora)	flagella	*Leishmania* (kala-azar), *Trypanosoma*, *Giardia*
Rhizopoda (Sarcodina)	pseudopodia	*Amoeba*, *Entamoeba histolytica*
Sporozoa	none	*Plasmodium*, *Babesia*, *Monocystis*
Ciliata	cilia	*Paramecium*, *Balantidium coli*, *Vorticella*

- covering: flagellates, sporozoans **pellicle**; rhizopods only **plasma membrane**, no fixed shape; ciliates firm pellicle, **fixed shape**
- sporozoans: all **endoparasites**
- flagellates: one nucleus (*Giardia* two); rhizopods: binary fission; sporozoans, ciliates: asexual and sexual
- **kala-azar**: *Leishmania donovani*, sandfly *Phlebotomus argentipes*; Nepal's Terai; 2,200+ cases a year (2000s) → 218 (2018)
- Protista: not a natural group; learn the five-kingdom grouping

Paramecium caudatum (slipper animalcule)

- Protista · Protozoa · Ciliata · *Paramecium* · *caudatum*
- fresh water rich in **decaying organic matter**: ponds, ditches, stagnant water, slow streams (bacteria as food)
- **infusorian**: appears in infusions of decaying matter



Paramecium caudatum: oral groove on the ventral side.

External structure

- **shape**: slipper (sole); **asymmetrical** (oblique oral groove); blunt front, widest behind the middle, pointed back
- **ventral** (oral) and **dorsal** (aboral) surfaces
- **170–300 μm**; whitish speck to the eye
- **pellicle**: thin, firm, **elastic** (squeezes through gaps); **hexagonal** depressions, a **cilium** from the center of each, trichocyst openings at their front and back margins (on the ridges)
- **cilia**: same length, **longitudinal rows**; each from a **basal body** (kinetosome); 9 + 2 microtubules
  - longer cilia at the back: **caudal tuft** → **changes direction**
  - jobs: **locomotion**, **feeding** (oral groove), **sensing**
  - **metachronal rhythm**: beat one after another in waves; spiral path, ~1 mm a second
  - **avoiding reaction** (Jennings, 1906): bump → cilia reverse → back, turn, go

Internal structure

- **ectoplasm**: thin, clear, firm; trichocysts, basal bodies, fibrils
- **endoplasm**: granular, fluid; nuclei, vacuoles, mitochondria, Golgi, ribosomes
- **trichocysts**
  - rod-shaped or oval, in **ectoplasm**, **alternating with basal bodies**, at **right angles** to the surface; pores on the hexagons' ridges
  - undischarged: sac (**shaft**) of refractive protein, pointed **tip** (spike), **cap**
  - stimulus (touch, chemical, heat, electric current, predator) → Ca^{2+} in → cap opens → protein swells, unfolds, takes in water → **~8×** its length in milliseconds
  - discharged: long **striated thread** with the spike: like an upside-down nail with a cap
  - jobs: **anchoring** while feeding; **defense** (pushes away *Dileptus*; not *Didinium*); **offense** in some ciliates
- **nuclei**: **nuclear dimorphism**

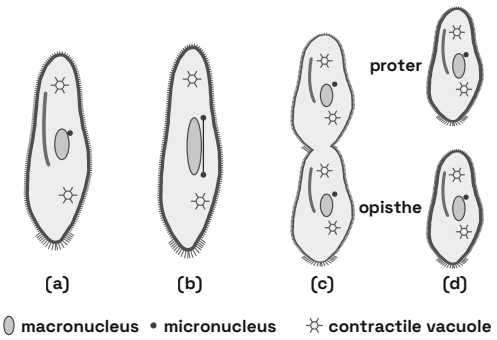
Macronucleus	Micronucleus
large, **bean-shaped**	small, **spherical**, in its hollow
hundreds of copies of genes	**diploid**
controls **metabolism**: somatic, vegetative	controls **reproduction**: generative
amitosis in fission	**mitosis** in fission; **meiosis** in conjugation
breaks up in conjugation; new one made	survives; its products exchanged
removed → cell **dies soon**	removed → lives, can't conjugate; line dies out

- **contractile vacuoles**: **two**, anterior and posterior; fixed places near the **dorsal** surface; permanent pores
  - each with **6–10 radial canals**, like a star
  - canals collect water → vacuole swells → contracts → out through pore
  - **posterior** contracts **more often**: near the **cytopharynx**, water comes in with food
  - job: **osmoregulation** (water enters by osmosis: cytoplasm more concentrated than pond water); some waste
  - sea protozoa: small or none
- **food vacuoles** (gastrioles): non-contractile; bacteria, water, **enzymes**; moved by **cyclosis**; digest → absorb → assimilate
- **oral apparatus**: **oral groove** (oblique, ventro-lateral) → **vestibule** (funnel) → **cytostome** (cell mouth) → **cytopharynx** (gullet) → new food vacuole; cilia sweep food in
- **cytopyge** (anal spot, cytoproct): ventral, **behind the cytostome**; seen only during **egestion**

Reproduction

Transverse binary fission (asexual)

- in **favorable** conditions (food, temperature); **2–3 times a day**, **1–2 hours** each
- plane **across**, at right angles to the long axis; karyokinesis, then cytokinesis
- steps:
  1. stops feeding; oral (buccal) structures disappear
  2. **micronucleus** → **mitosis**; daughters to the two ends
  3. **macronucleus** lengthens → **amitosis**
  4. two **oral grooves** form, one in each half
  5. each half: a **new contractile vacuole** (two each)
  6. **transverse furrow** deepens → cuts cell in two
  7. front daughter **proter**; back **opisthe**
- daughters identical (a **clone**); after many generations, slows → needs **conjugation**

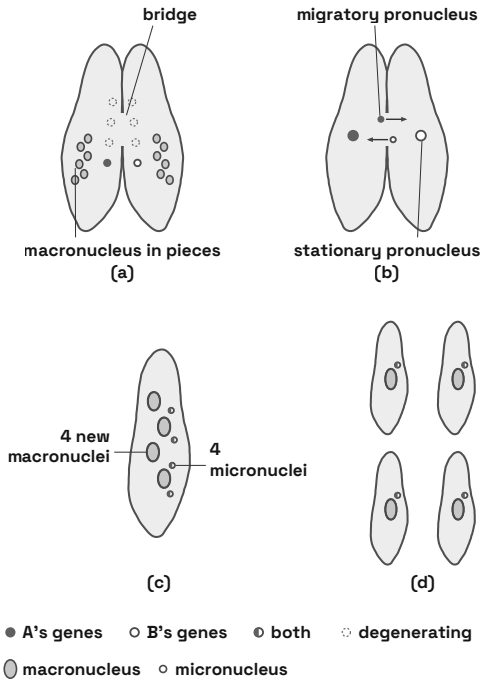


Transverse binary fission: (a) grown cell; (b) nuclei divide; (c) furrow; (d) proter and opisthe.

Conjugation (sexual: exchange of nuclei)

- two of the **same species**, **different mating types** (Sonneborn, 1937): **pre-conjugants**
- brought on by:
  - starvation
  - weak, small after long fission
  - darkness, fall in temperature
  - **mating-type substances** on cilia
- events:
  1. join by **ventral** surfaces (oral grooves)

2. oral structures go; stop feeding
3. pellicle, ectoplasm dissolve → **protoplasmic bridge**: **conjugants**
4. **macronucleus breaks up**; micronucleus → **meiosis** → **4 haploid**
5. **3 degenerate**; 1 → **mitosis** → two **pronuclei**
6. smaller **migratory** (male); larger **stationary** (female)
7. migratory pronuclei **cross the bridge** → fuse with stationary
8. **zygote nucleus** (synkaryon), diploid: **amphimixis**
9. separate after **12–48 hours**: **exconjugants**
10. synkaryon → **3 mitoses** → **8 nuclei**: **4 macronuclei**, **4 micronuclei**
11. **3 micronuclei degenerate**
12. micronucleus divides; cell divides → 2 cells, each 2 macro + 1 micro
13. again → **4 cells**, each 1 macro + 1 micro
14. each exconjugant **4**; the pair **8** daughters, genetically new



Conjugation: (a) conjugants, bridge, macronucleus in pieces, meiosis; (b) migratory pronuclei cross; (c) exconjugant, 8 nuclei; (d) 4 daughters.

- **significance**:
  - reorganizes nuclei: needed for fission to go on
  - **rejuvenates** the line
  - **new macronucleus** from the synkaryon
  - **variation** (meiosis, exchange)
  - **8** offspring from a pair
- **autogamy** (self-conjugation, *P. aurelia*): two pronuclei of one cell fuse; no outside genes
- **endomixis** (1914): reorganization without fusion; now thought misread autogamy (Diller, 1936)

Binary fission	Conjugation
asexual	sexual (exchange of nuclei)
one parent	two, different mating types
favorable conditions	unfavorable (starvation, weakness, cold, dark)
micronucleus: mitosis	micronucleus: meiosis, then mitosis
macronucleus: amitosis	macronucleus breaks up, replaced
no fusion	pronuclei fuse (amphimixis)
clone	variation
2 daughters	8 from a pair
1–2 hours	union 12–48 hours

Euglena vs Amoeba

Euglena (Group A, Euglenophyta)	Amoeba (Group C, Rhizopoda)
chlorophyll	none
holophytic (mixotrophic)	holozoic
stores paramylon	glycogen, fat
spindle shape, pellicle	no fixed shape, plasma membrane
flagellum	pseudopodia
eyespot	no eyespot
longitudinal binary fission	simple binary fission

COMMON MISTAKES

✗ Plankton swim freely on the surface
✓ they **drift** with the water, all through the sunlit layers.

✗ Dinoflagellates reproduce only asexually
✓ mostly asexual; a few sexually.

✗ Trichocysts lie in the endoplasm
✓ in the **ectoplasm**, alternating with basal bodies.

✗ Macronucleus controls reproduction
✓ **micronucleus**; macronucleus: metabolism.

✗ Both nuclei divide by mitosis in fission
✓ micronucleus **mitosis**, macronucleus **amitosis**.

✗ Anterior vacuole contracts more often
✓ **posterior** (near the cytopharynx).

✗ Conjugation gives two daughters
✓ **eight** from a pair (four per exconjugant).

✗ Migratory pronucleus is the larger
✓ the **smaller** is migratory.