Paramecium

- Domain- Eukaryota
- Kingdom- Protista
- Phylum- Ciliophora
- Class- Oligohymenophorea
- Order- Peniculida
- Family- Parameciidae
- Genus- *Paramecium*

The common species of *Paramecium* include:
Paramecium aurelia
Paramecium caudatum
Paramecium woodruffi
Paramecium trichium

1. **Habit, Habitat**

- Paramecium caudatum (Gr., paramekes = oblong; L., caudata = tail) is commonly found in freshwater ponds, pools, ditches, streams, lakes, reservoirs and rivers.
- Paramoecium, due to its shape is sometimes called as 'slipper animalcule' or 'Ladies slipper'
- The species name caudatum is derived from the Latin word caudata meaning tail.
- It is specially found in abundance in stagnant ponds rich in decaying matter, in organic infusions, and in the sewage water.
- Paramecium caudatum is a free-living organism and this species is worldwide in distribution.
- In contrast to other protozoans, they have two types of nuclei – one vegetative (the macronucleus), and the other reproductive (the micronucleus).
- Paramoecium, the name given by John Hill (1932), has a number of species of which P. caudatum is the longest and have a single micronucleus and commonly found P.
- Aurelia is less pointed at the rear end and has two micronuclei, while P. multimicronucleatum has many micronuclei. P. bursaria is easily recognised by its green colour due to the presence of symbiotic algae, Zoo chlorella.

Culture of Paramecium

Take submerged weeds from a pond and place in a jar of distilled water, cover the jar and leave it to rot; swarms of Paramecia will appear in a few days. Now boil hay in water, decant the infusion and add a few grains of wheat, and let it stand till turbid with bacteria.

Transfer Paramecia from the first jar into this liquid where they will multiply rapidly. Hay infusions alone will produce Paramecia showing presence of cysts, and cyst resembling sand

grains have been reported, but there is no proof of Paramecia forming cysts, since they have never been confirmed.

Structure of Paramecium Caudatum

(i) Size and Shape of Paramecium Caudatum:

- Paramecium *caudatum* is a microscopic organism and visible to the naked eyes as a minute elongated body.
- It appears light gray or white measuring commonly between 170 to 290 microns in length and may attain a length up to 300-350 microns.
- P. caudatum looks like the sole of a slipper or shoe, hence, the animal is commonly known as slipper animalcule. It is four times as long as broad and somewhat cylindrical with distinctly different ends.
- The forward moving anterior part is slender with a blunt or rounded end, while the posterior end is somewhat pointed or cone-shaped.
- The widest part of the organism is just below the middle.
- The body of the animal is asymmetrical in form showing a well defined oral or ventral surface and an aboral or dorsal one.

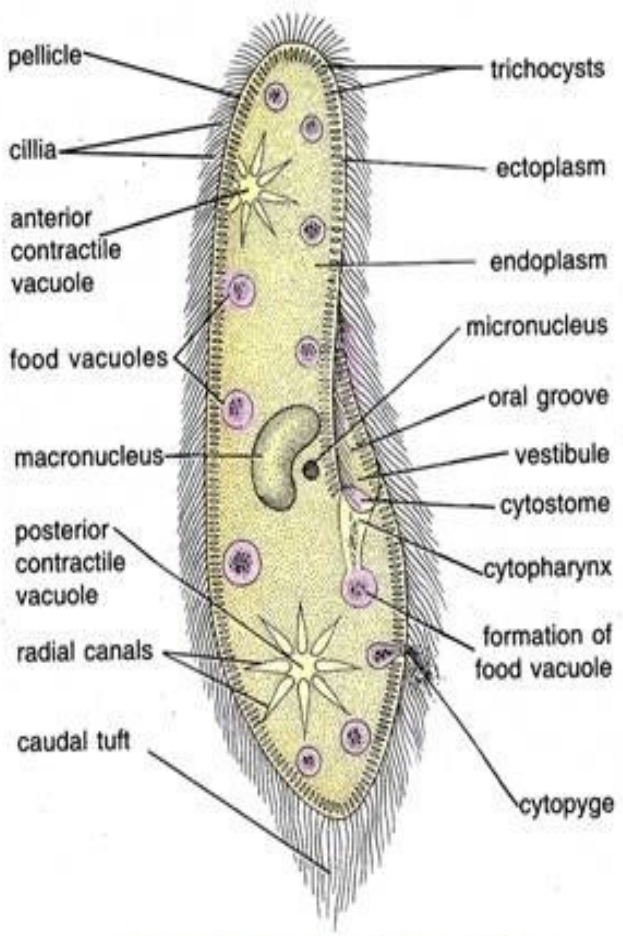


Fig. 20.1. *Paramecium caudatum.*

(ii) Pellicle

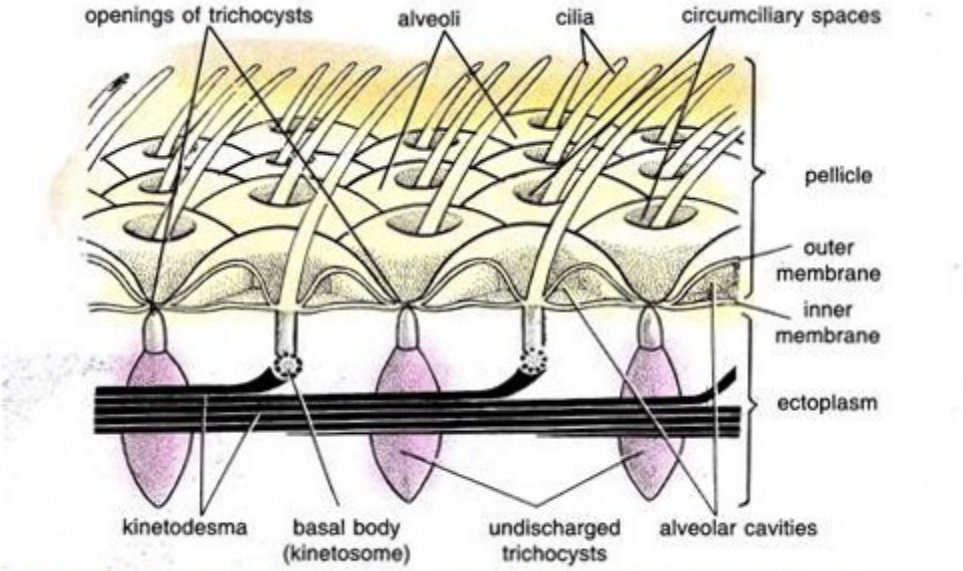


Fig. 20.2. *Paramecium.* Electron structure of pellicle and infraciliary system.

- The body is covered by a thin, double layered, elastic and firm pellicle made of gelatin.
- The pellicle holds the shape of the animal but is elastic enough to permit contractions.
- The pellicle has double membrane, the outer membrane is continuous with the cilia and the inner membrane with the ectoplasm.
- Under the higher magnification of microscope, pellicle shows rectangular or hexagonal depressions on its surface
- This arrangement is preserved on the dorsal surface of Paramecium but on the ventral surface the ridges converge in front and behind towards a preoral and postoral aperture.
- Each hexagonal depression is perforated by a central aperture through which a single cilium emerges out.
- The anterior and posterior margins of hexagonal depressions bear the openings of trichocysts.
- The electron microscopic study of pellicle by Ehret and Powers (1957) has revealed that the hexagonal depressions correspond to regular series of cavities, the alveoli.
- All alveoli collectively form a continuous alveolar layer, which is delimited by an outer alveolar and inner alveolar membranes.
- The outer layer lies in close contact beneath the outer cell membrane. Therefore, pellicle includes outer cell membrane, outer alveolar membrane and inner alveolar membrane.

(iii) Cilia:

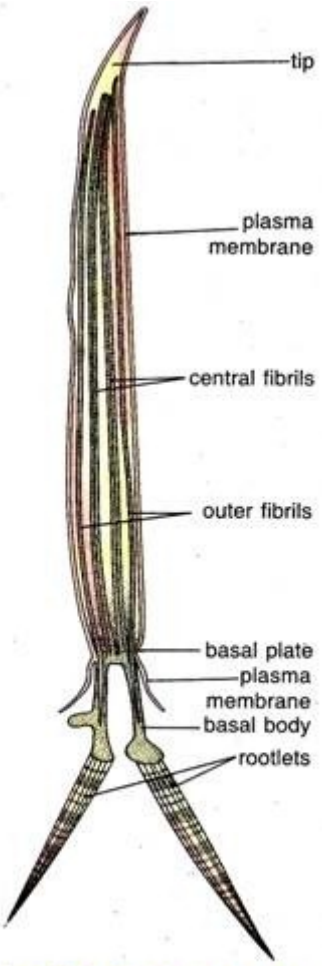
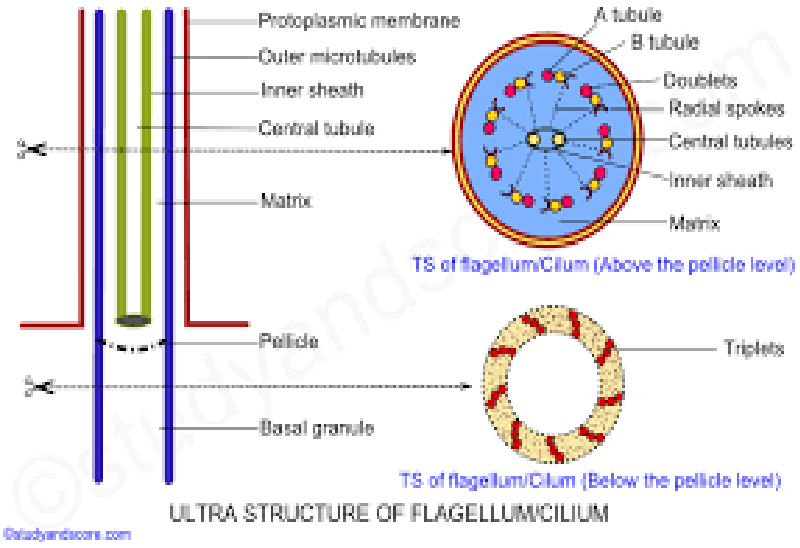


Fig. 20.3. Ultrastructure of a cilium.

- The entire body is covered with numerous, small, hair like projections called cilia. Cilia occur in longitudinal rows all over the body, this condition is known as holotrichous in which the body cilia are equal.
- Cilia have the same structure as flagella, they have an outer protoplasmic sheath or plasma membrane with nine double longitudinal fibrils in a peripheral ring.
- In some cilia the nine outer fibrils are not paired.
- There are two central longitudinal fibrils which are thinner than the outer fibrils.
- Each cilium arises from a basal granule or kinetosome.
- The nine pairs of peripheral fibrils fuse together to form the wall of the kinetosome, thus, kinetosome is a tube which is either open or closed at its lower end, the two central fibrils stop at the level of the pellicle in most ciliates.
- Arising from the kinetosome is a thin rhizoplast which does not join the nucleus. Many Metazoa also have cilia, their structure is the same, except that the basal granule is different and it has fine filaments or rooting fibres extending down into the cytoplasm.
- But cilia differ from flagella in being generally more numerous and shorter in size.
- The ciliature may be conveniently divided into body or somatic cilia which are found on the body surface, and into oral ciliature which is associated with the mouth region.

- The body cilia are equal but they are longer at the posterior end, hence, the name caudatum. The cilia are organelles of locomotion and food collection, they also act as sensory receptors and detect the stimuli of the external environment.

Ultra Structure of Cilia



- The cilia and flagella have a fibrillar composition.
- At the base the cilium has the diameter of about 0.2 micron or 2,000 A^0 which may be up to 10 microns above the cell surface.
- The cilia are bounded by a unit membrane of 90 A^0 thickness which resembles and remains continuous with the plasma membrane.
- The bounded space of the cilium contains a watery substance known as the matrix.
- In the matrix, there remain embedded eleven longitudinal fibrils or microtubules.
- Out of the eleven fibrils, two are located in the centre, while the remaining nine fibrils remain arranged peripherally around the central fibrils.
- Each of the nine outer fibrils is $360A^0$ in diameter and composed of two sub-fibrils of 180 to $250A^0$ diameter.
- These sub-fibrils are designated as the sub-fibril A and sub-fibril B.
- The sub-fibril A is slightly larger than the sub-fibril B.
- The sub-fibril A gives out two thick projections or arms from its one side. The arms of the sub-fibril A of all the outer fibrils remain directed in clockwise direction.
- Further, the sub-fibril A occurs more closely to the centre of the cilium than the sub-fibril B. Both the sub-fibrils have a common wall of $50A^0$ thickness.
- The two central fibrils do not have paired sub-fibrils like the peripheral nine fibrils but each contains only a single tubule.
- Each central fibril has a diameter of about $250A^0$ and is composed of $60A^0$ thick wall.

- Both the central fibrils remain separated by a space of $350A^0$ and remain enveloped in a common sheath.
- Gibbnos (1967) has reported that the sheath of the central fibrils gives out nine radially oriented links or spokes to each sub-fibril A.
- The high resolution electron microscopy has revealed that each of the peripheral and central fibrils of the cilia and flagella is composed of ten to twelve filaments of $40A^0$ thickness.
- Each filament is beaded.
- Each bead remains arranged in the lattices of 40 by $50A^0$ in the plane of the wall of the tubule. These beads are considered as the basic subunit of the tubule structure.

(iv) Infra-Ciliary System

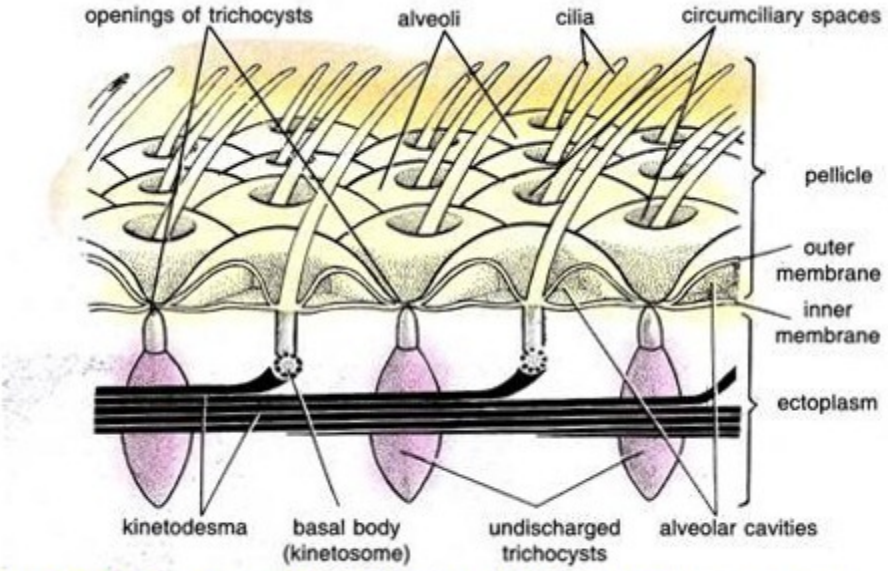


Fig. 20.2. *Paramecium.* Electron structure of pellicle and infraciliary system.

- The infra-ciliary system is located just below the pellicular alveoli.
- It consists of the kinetosome or basal body and kinetodesma.
- The cilia arise from kinetosomes and from each kinetosome arises a delicate cytoplasmic fibril called kinetodesma.
- Lying below the pellicle slightly to the right, but joined to all kinetosomes of one longitudinal row, is a longitudinal bundle of several kinetodesmata, a kinetodesmata of each kinetosome extends for a distance anteriorly into its own bundle of kinetodesmata.
- A longitudinal row of kinetosomes with their kinetodesmata forms a longitudinal unit called a kinety. All the kineties or kinetia make the infra-ciliary system of a ciliate. The kinetia lie in the cortex below the pellicle, their number is fairly constant for each ciliate.
- The infra-ciliary system controls and coordinates the movements of the cilia, and it brings about formation of organelles in cell division, e.g., some kinetia form the mouth. In binary fission of ciliates the kinetia are cut transversely into two, each going to one daughter cell, this is called perikinetal fission.

(v) Oral Groove and Cytopyge:

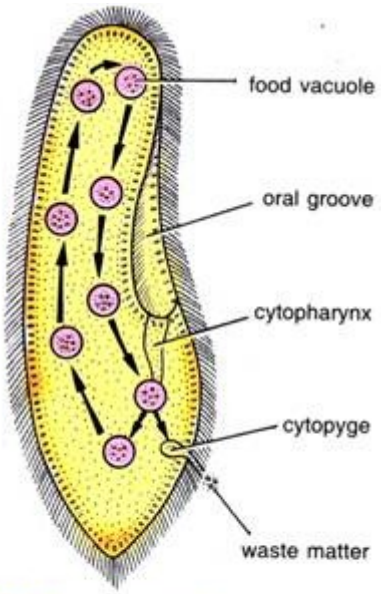


Fig. 20.17. *Paramecium.* Showing cyclosis and the course of food vacuoles in the endoplasm.

- On the ventrolateral side is a large oblique, shallow depression called oral groove or peristome which gives the animal an asymmetrical appearance.
- It runs obliquely backwards from one side (usually left to right but in some cases right to left) and ending a little behind the middle body. The oral groove leads into a short conical funnel-shaped depression called vestibule.
- The vestibule leads directly into the fixed, oval-shaped opening called cytostome (mouth). Extending directly from the cytostome toward the centre of the body is the wide cytopharynx. The cytopharynx then turns sharply towards the posterior side to become the slender tapering oesophagus.
- Thus, the oesophagus is roughly parallel to the body surface of Paramecium except at its posterior extremity. Here the oesophagus turns again toward the centre of the animal to lead into the forming food vacuole.
- The cytopyge (also termed cell anus or anal spot or cytoproct) lies on the ventral surface of the body almost vertically behind the cytostome or mouth.
- Undigested food particles are eliminated through the cytopyge. The ciliation of cytopharynx is very complicated.
- Gelei (1934) reported the presence of four rows and Lund (1941) observed at least four rows. A structure called penniculus is found on the left wall of the cytopharynx and spirals through approximately 90 degrees so that its posterior extremity is on the oral (ventral) surface of the oesophagus.
- According to Lund, the penniculus consists of eight rows of cilia arranged in two closely set blocks of each. A similar band composed of four rows of long cilia which are less compact than in the penniculus is termed as quadrulus. It spirals down the dorsal wall of buccal cavity and ends close to the penniculus.

- The penniculus and quadrulus have been wrongly called an undulating membrane by some workers. The quadrulus and penniculus control the passage of food. It is not known how cilia work, probably their fibrils contract in rhythmic way which causes bending. Gelei (1925) pointed out that the function of penniculus is the forcing of food elements into the body.

(vi) Cytoplasm

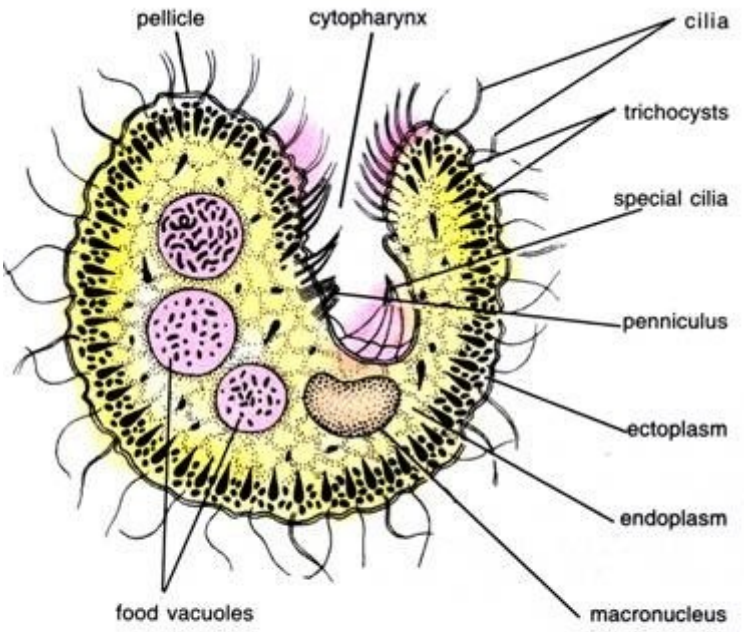


Fig. 20.5. *P. caudatum*. Diagrammatic tranverse section through the region of cytopharynx showing ciliation of pharynx (After **Gelei**).

The cytoplasm is differentiated into a narrow, external or cortical zone called the ectoplasm and a larger, internal or medullary region called the endoplasm.

(vii) Ectoplasm

- The ectoplasm (ectosarc or cortex) is a permanent part of the body, strikingly delimited from the endoplasm.
- Ectoplasm forms a firm, clear, thin and dense outer layer.
- It contains the trichocysts, cilia and fibrillar structures and is bounded externally by a covering called pellicle.

(viii) Trichocysts

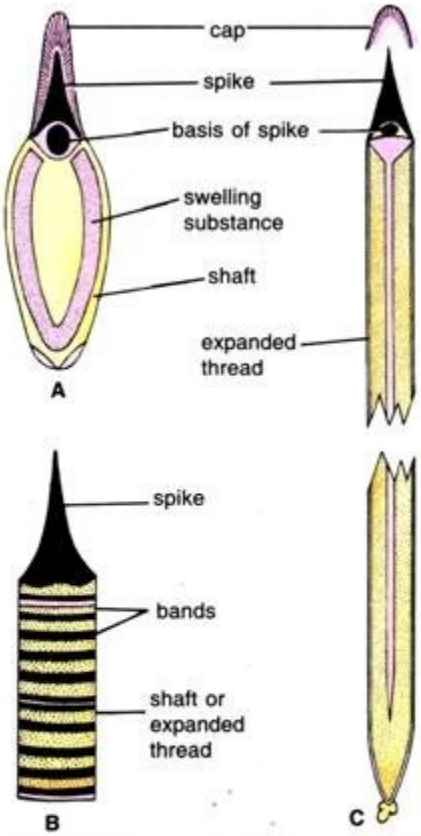


Fig. 20.6. *Paramecium.* Trichocyst. A—L.S. of hypothetical undischarged trichocyst; B—Tip of trichocyst as seen in electron microscope; C—Discharged trichocyst.

- Embedded in the ectoplasm at right angles to the surface are small spindle-shaped bags called trichocysts.
- A small spot on each anterior and posterior margin of the hexagon marks the position of a trichocyst. They are filled with a refractive, dense fluid having a swelling substance, at the outer end is a conical head or spike.
- The trichocysts lie perpendicular in the ectoplasm, they open by small pores on the ridges of the hexagonal areas of the pellicle.
- They arise from kinetosomes of cilia, then migrate and locate themselves at equal distance in the endoplasm. When the animal is irritated, the trichocysts are discharged as long sticky threads. A discharged trichocyst has an opaque spike-like an inverted nail, and a long striated shaft, but the shaft is not seen in the un-discharged state and is probably formed during discharge.
- The function of trichocysts is uncertain, but they are discharged as a reaction to local contacts and injury, they may serve as organelles of defence.

- But this is uncertain because the trichocysts are ineffective against Didinium, the chief predator on Paramecium, they may be for fixing the animal to a spot during feeding. In some ciliates, the trichocysts act as organelles of offence. After trichocysts are discharged, regenerated from kinetosomes.

(ix) Neuromotorium and Associated Fibrils

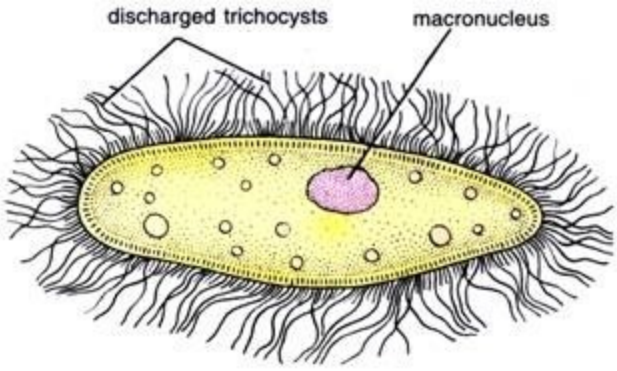


Fig. 20.7. *Paramecium* with discharged trichocysts as a result of the application of picric acid.

- According to Lund (1933) on the left dorsal wall of the cytopharynx at about the level of the posterior margin of the cytostome is a very small, bilobed mass, the neuromotorium. From the neuromotorium, fibrils radiate into the endoplasm.
- Of these four or more usually pass almost to the dorsal body wall but the rest are shorter and not definite in position. All are termed endoplasmic fibrils. Their function is unknown, but they may coordinate the feeding movements of the oral cilia.
- The fibrils may also give mechanical support, elasticity, contractility, conductivity and metabolic influence.

(x) Endoplasm:

- The endoplasm or medulla is the more fluid and voluminous part of the cytoplasm which contains many cytoplasmic granules as well as other inclusions and structures of a specialised nature.
- The cytoplasmic inclusions are mitochondria, Golgi apparatuses, vacuole, crystals, granules and chromidia, etc. Other structures, viz., nuclei, contractile vacuoles and food vacuoles are also found in the endoplasm.

Nuclei

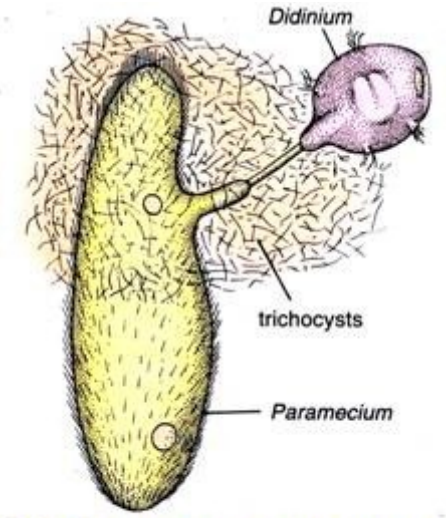
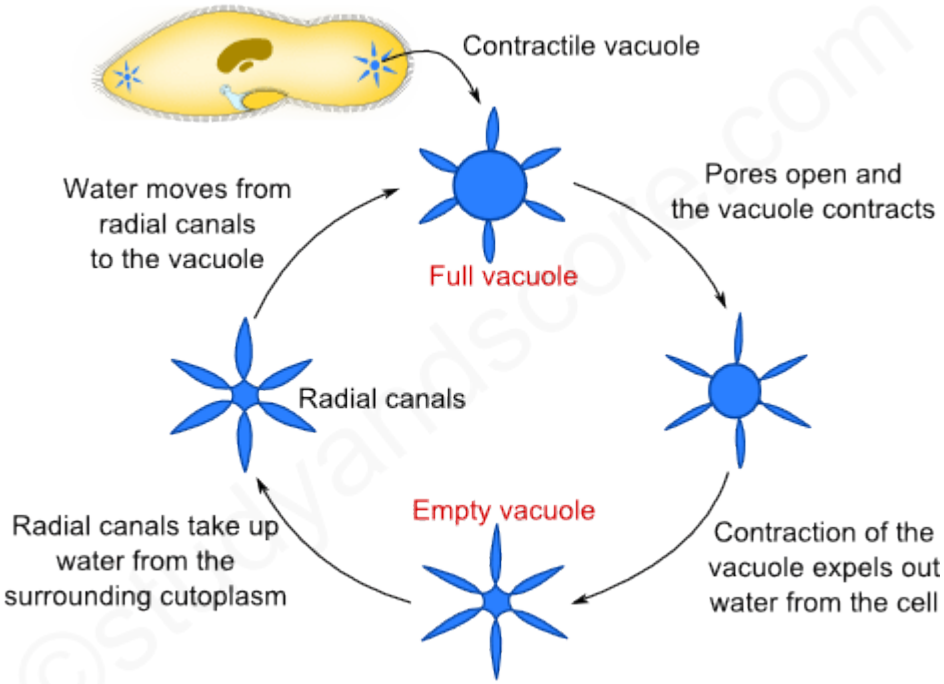


Fig. 20.8. *Paramecium.* Throwing out trichocysts when attacked by a small *Didinium.*

- In the endoplasm near the cytostome are two nuclei, i.e., Paramecium is heterokaryotic, a large ellipsoidal and granular macronucleus and other small compact micronucleus.
- Macronucleus is a conspicuous, ellipsoidal or kidney-shaped body. It is of a compact type containing fine threads and tightly packed discrete chromatin granules of variable size and embedded in an achromatic matrix. It possesses many nucleoli and much more chromatin material (DNA).
- It is somatic or vegetative nucleus. It divides amitotically and controls the vegetative functions (metabolic activities) of the animal. It does undergo mitosis
- Micronucleus is small, compact and spherical. It is generally found close to the macronucleus often in a concavity. Fine chromatin granules and threads are uniformly distributed throughout the structure. The micronucleus divides mitotically and controls the reproduction.
- The number of micronucleus varies with the species; it is one in P. caudatum, two in P. aurelia and many in P. multimicronucleatum. The micronucleus contains a distinct nucleolus in P. aurelia but it is not found in P. caudatum. Moses (1949; 1950) has reported that the macronucleus and micronucleus are identical in chemical composition**.**

(xi) Contractile vacuoles



STEPS IN THE PROCESS OF OSMOREGULATION IN PARAMECIUM

- There are two large, liquid-filled contractile vacuoles, each situated near one end of the body close to the dorsal surface.
- Their position is fixed (unlike Amoeba), they lie between the ectoplasm and endoplasm, but they are temporary organelles disappearing periodically.
- In some species, they appear to have a lining membrane, in which case they do not disappear entirely during systole.
- Connected to each contractile vacuole are five to twelve tubular radiating canals, each consisting of a terminal part, long ampulla which collapses when empty, and a short injector canal which opens into the vacuole.

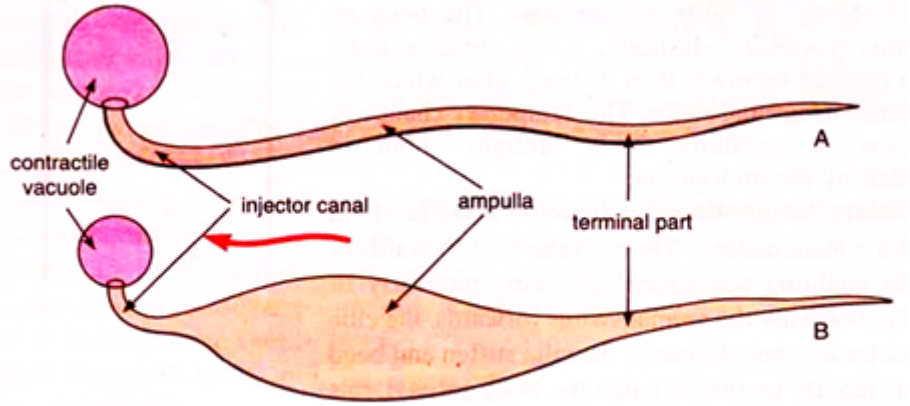


Fig. 20.10. *Paramecium*. Radial canal. A—Empty; B—Full.

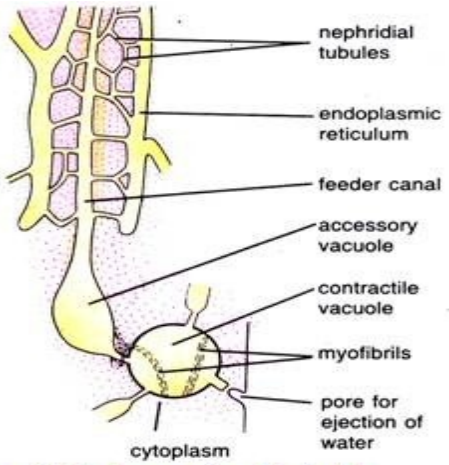


Fig. 20.11. *Paramecium.* Contractile apparatus.

- The canals communicate with a large part of the body from where they take up liquids and pour them into the vacuole which is, thus, reconstituted and grows in size, when the contractile vacuole reaches its maximum size it contracts suddenly (systole) and discharges its contents through a permanent pore in the pellicle, then the canals again form the contractile vacuoles, the canals do not disappear entirely since they are permanent structures.
- The two contractile vacuoles discharge irregularly, the posterior one contracts more rapidly because it is near the cytopharynx and more water comes into it.
- The main function of the canals and the contractile vacuoles is hydrostatic, they remove excess of water from the protoplasm, the water is partly absorbed and partly taken in while feeding.
- The nitrogenous waste substance has ammonia compounds and some urates which are expelled from the contractile vacuoles along with CO_2 but there is no evidence of the excretory matter being secreted by the protoplasm into the canals or contractile vacuoles.
- There is a fixed permanent cytopyge or anus below the peristome to one side of the cytopharynx, through which undigested remains of food and urates are expelled.
- The electron microscopic study of contractile vacuoles has revealed that each contractile apparatus consists of some of the tubules of endoplasmic reticulum, nephridial tubules, feeder canals, accessory vacuoles (radial canals) and main contractile vacuole. The accessory vacuoles are supposed to be the ampullae of feeder canals

(xii) Food vacuoles:

- These are roughly spherical, non-contractile bodies varying in size and number lying in the endoplasm.
- They contain ingested food particles, principally bacteria and a small amount of fluid bounded by a thin definite membrane.
- Volkonsky (1934) proposed the name gastrioles for these vacuoles. Associated with the food vacuoles are the digestive granules.