General Protozoology 2

Protozoa-specific organelles in the cytoplasm

- Apical complex
- Kinetoplast
- Basal body
- Flagellum
- Cilium
- Pseudopods
  - Lobopodium
  - Filopodium
  - Retikulopodium
  - Axopodium
- Parabasal body
- Axostyle
- Costa
- Undulating membrane
- Hydrogenosome
- Gylocosome
- Mitosome

Protozoa-specific organelles in the cytoplasm

- **Apical Complex**

- Apicomplexa subphylum
  - Conoid,
  - Polar ring,
  - Rhobtri,
  - Microneme
  - Subpellicular microtubules

Protozoa-specific organelles in the cytoplasm

- **Kinetoplast**

- Kinetoplastida subphylum
  - Kinetoplast is located near to the basal body.
- This organelle is double-membraned (like mitochondria) and is the center of additional energy production.
- Cleavage in protozoa with this organelle usually begins from kinetoplast.
- It also has the ability to split independently from the nucleus.

Protozoa-specific organelles in the cytoplasm

- **Basal body**

- It is an organelle from which the whip and cilium originate. Names such as kinetosome or blepharoplast are also given.
- It is located into the cytoplasm
- It has a centriole structure.
- It consists of 9 triplets microtubes arranged in a circle.

Protozoa-specific organelles in the cytoplasm

- **Flagellum (Whip)**

- Metamonada, Parabasala, Euglenezoa phylum
- The numbers of flagella varies by species.
- It is originated from basal body.
- They do not divide during reproduction.
- They are in charge of movement and feeding.

Protozoa-specific organelles in the cytoplasm

- Flagellum usually comes from the front of the body and extends freely. The numbers can be one or more. In some species, flagellum may contact the body to form a undulating membrane.
- The species of Trypanosomatidae have a single flagellum and this flagellum forms a undulating membrane. At the same time, this flagellum extends forward from the back of the body (trypomastigot form).

Protozoa-specific organelles in the cytoplasm

- **Cilium**

- It is found in protozoan species belonging to Ciliphora phylum.
- The structure and functional characteristics of cilium are similar to flagella.
- However, the numbers are higher, and the structure is thinner and shorter.

Protozoa-specific organelles in the cytoplasm

- **Pseudopods**

- Apart from the whip and cilium that protrude out of the body in protozoa, another organelle that is involved in movement and feeding is also pseudopod.
- These are temporary structures that the protozoon shapes outward.
- This structure is found in the species belonging to Amoebozoa phylum.

Protozoa-specific organelles in the cytoplasm

- **Parabasal body**

- It is a rod-shaped structure in the protozoa belonging to Trichomonadidea order.
- It has been reported that this structure undertakes the task of Golgi apparatus.
- In particular, they have roles in making and transporting polysaccharides.

Protozoa-specific organelles in the cytoplasm

- **Axostyle**

- It is found in species belonging to Trichomonadidea order.
- It is a supporting organelle.

Protozoa-specific organelles in the cytoplasm

- **Costa**

- It is found in species belonging to Trichomonadidea order.
- This structure originates from blefarolast and extends parallel to the back in the cytoplasm.
- It is a structure that supports the undulating membrane.

Protozoa-specific organelles in the cytoplasm

- **Undulating membrane**
- It is a membranous structure between whip and the pellicula.
- It contributes to the movement of the protozoa
- This structure allows the protozoon to turn around and move back-forth.

Protozoa-specific organelles in the cytoplasm

- **Hydrogenosome**

- is a membrane-surrounded organelle in the anaerobic protozoa and plays a role in the energy metabolism.
- It is a production center of hydrogen, CO2 and ATP of the species belonging to Trichomanadidea order.

Protozoa-specific organelles in the cytoplasm

- **Gylocosome**

- It is an organelle surrounded by membranes and has been found to contain glycolytic enzyme.
- It is found in the developmental stages of *Trypanosoma* and *Leishmania* spp. in the blood.
- It is an energy organelle.

Protozoa-specific organelles in the cytoplasm

- **Mitosome**

- It is an energy organelle originating from mitochondria
- It is found in *Entamoeba* and *Giardia* spp.

Nucleus

- Nucleus is the place where genetic materials exist.
- is separated from the cytoplasm with nucleus membrane and has a certain shape.
- The shape of the nucleus is generally round or oval.
- The nucleus consists of membrane in the outer, and chromatins, nucleolus and nucleus fluid in the inner.

Nucleus

- Each protozoa has at least one nucleus
- There are two nucleus in some species, for example; *Giardia* spp.
- There are two type nucleus in some species such as Ciliophora (macronucleus and micronucleus).
  - Macronucleus performs metabolic activities.
  - Micronucleus performs division activities.

- It is seen that some protozoa change the nucleus numbers according to the developmental stages.
  - 4 nucleuses in *Entamoeba histolytica* and *Giardia* spp. cysts
  - 8 nucleuses in *E. coli* cyst.
- It is seen that many protozoa have multi-nucleus structure during different developmental stages.
  - Multi-nucleus meronts are derived from single-nucleus trophozoite during asexual meragony stage of Sporozoa species.

Nucleus membrane

- It separates the genetic material from the cytoplasm as in all eukaryotes
- has lipoprotein structure and is double-layered.
- There are dents on the lipid layer where the specific proteins are located. They control the passage from the membrane into the cytoplasm or from the cytoplasm into the nucleus.
- They have a selective permeability as in the cell membrane.

Nuclear plasma

- It is also called nucleus fluid.
- Its composition contains DNA, RNA, minerals, various enzymes, proteins and water.

Nucleolus

- It is a unmembraneous structure that can be found as one or more in the cell nuclei.
- plays an active role in ribosome synthesis.
- It contains DNA, RNA and proteins.
- RNA in the nucleolus is more rRNA, and these rRNAs constitute the ribosome subunits by combining with proteins.

Chromatin

- It coexists with DNA and proteins in the nucleus, and called as complex chromatin.
- If the cell is not in the cleavage state, these structures appear as a thread-shaped in the nucleus fluid. The structure formed by these threads is called the chromatin network.
- Chromatin strands constitute chromosomes when the cell begins to divide.
- The shaped and condensed chromatin material is called as chromosome.

- There are two types of nuclei in the protozoa depending on the presence of the chromatin material and the nucleus fluid.
- **Vesicular nucleus**
- **Compact nucleus**

Locomotion in protozoa

- There are mainly two type movements in protozoa
  - Active movement
  - Passive movement

- Active movement
  - 1- Pseudopodial movement
  - 2- Flagellate movement
  - 3- Ciliary movement
  - 4- Peristaltic movement
- Passive movement

Pseudopodial movement

- Some protozoa move with the help of pseudopodia. Pseudopodia are blunt, finger-like temporary protrusions of the cytoplasm. These may be variously shaped. It is also called amoeboid movement.
- The numbers and shapes of these structures vary according to species and developmental stages.
- The pseudopodium is fixed on the support by some adhesive secretion and the protoplasm of the body gradually flows into it.
- The ectoplasm-where a pseudopodium is formed-is dissolved by the formation of an acid and the endoplasm flows. New pseudopodia appear and , by the repetition of the process, the animal slowly creeps forward.

Entamoeba histolytica

Flagellate movement

- Certain protozoa move with the help of flagella. Flagella are whip-like structures in the formation of which cytoplasm takes part.
- Flagella is a constant permanent ectoplasm extension. It originates from the basal body.
- The number of flagellum varies by species.
- These structure allow the protozoon to move both forward and around itself.
- It also plays a role in catching food.
- The undulating membrane found in some protozoans consists of the parts of the flagellum that touch the body

Trypanosoma cruzi

Ciliary movement

- Some protozoa move with the help of cilia. Cilia are small hair-like structures, present usually in large numbers on the body surface. Cilia are usually arranged in definite rows.
- It originates from basal body.
- These structures allow the protozoon to move both forward and around itself.
- Cilium can cover the entire body of the protozoa or are found in the piles in different regions. Such as, provide food catching near the mouth.

Paramecium

Presitaltic movement

- Some protozoa move with the help of micronems. Micronems are small thread-like contractile fibrils usually located in the inner layer of ectoplasm.
- These protozoa have not any additional movement organelle such as flagella, cilia etc.
- Sporozoa (*Toxoplasma*, *Sarcocystis*, *Eimeria* merozoites).

Passive movement

- No organ or organelle is needed for this movement.
- The protozoa move with the movement of the environment.
- Some free living protozoans reach the upper part of the fluid when they accumulate CO_2 in vacuoles or spaces in their cytoplasm.
- On the contrary, they become heavy and descended into the lower parts when vacuoles are filled with water.
- Such as, Ciliophora

Nutrition in protozoa

- Nutrition is a necessary physiological basis for the survival of living beings and for the continuation of the next generation.
- The basic necessities of life are nutrients and nutrition.
- Parasite protozoans feed as heterotrophic.

- Protozoon takes suitable nutrients into the cell by way of passive (diffusional, osmosis) or active transport, or endocytosis (pinocytosis, phagocytosis) by the selective feature of the cell membrane.
  - The bullwhip in *Trypanosoma* species which is specialized in protozoa.
  - Micropores in sporozoe species.
  - Cytostom in Ciliophora species.
  - The movement organelles (flagella, cilium, pseudopod) are also involved capturing and ingesting food.

Heterotrophic nutrition

- **Holozoic nutrition:** Digestion is performed in the body after the ingestion of food.
- Foods are taken into the food vacuole, then digestion is carried out by means of lysosomal enzymes.
  - Most of the parasitic protozoa are fed this way.

Heterotrophic nutrition

- **Saprozoic nutrition:** Digestive enzymes are secreted onto the food in the outdoor environment and digestion takes place outside.
- The digested food is then absorbed into the body.
  - This situation is usually observed in bacteria and some protozoan species.

- **Autotrophic nutrition:** In this nutritional form, needed organic materials are synthesized from inorganic materials.
- Energy resources are needed for this.
- It usually observed in protozoa (especially in Ciliophora) that live freely or live on fish.

- Protozoa preserve their vitality and even reproduce thanks to the nutrients they store in the cystic periods when they are not particularly active.
- They use carbohydrates that can be easily converted into energy as nutrients.
  - Glycogen in cysts of *Giardia, Entamoeba* species
  - *Eimeria* species store amylopectin in their oocysts.

Respiration and energy gain

- Protozoa have developed metabolic organelles such as mitochondria, hydrogenosomes, glycosomes and mitosomes, and respiratory centers, which are necessary to gain energy from nutrients.

- The relationship with oxygen of parasitic protozoa varies with the location of the infection.
  - Oocysts of *Eimeria* species can not be sporulated under anaerobic conditions.
  - The intestinal protozoa of the vertebrates are anaerobes.
  - Ciliata species that live in the rumen are obligate anaerobes.
  - *Trichomonas vaginalis* develops best in the full anaerobic environment.

Encystation in protozoa

- The form of parasitic protozoa that can move, grow and multiply in the organism is called trophozoite or vegetative form.
- These forms have no chance of survival for a long time in environments that are outside from the organism.
- Their life usually end within 1-2 hours.
- Protozoa, which have to live outside from the living organism, have to transform a form that is resistant to adverse external conditions before going out.

- Parasitic protozoa may need to leave due to the deterioration of living conditions, reduction of nutrients, environmental contamination, change of environmental chemistry etc.
- In this case, the protozoa decide to transform a more stable form and encysted.

- This durable structure is formed as a result of encysting is called as
  - **Cyst** in species belonging to Metamonada, Amoebozoa, and Ciliophora
  - **Oocyst** in Apicomplexa**,**
  - **Spore** in Microspora
- These forms do not move, not feed, but they can reproduce, and provide a transition of the protozoa from one host to another host at the same time.

Reproduction in protozoa

- Asexual reproduction
- Sexual reproduction

Asexual reproduction

- Protozoa usually reproduce asexually by binary fission and multiple fission.
- The cytoplasm fission follows the nucleus fission.
- The kinetoplast can be divided before the nucleus in protozoa that have kinetoplast.
- The divided cell is called as mother cell, the obtained offspring is called daughter cell.
- The fusion may be mitosis or amitosis.

Binary fission

- Binary fission is the most common method of asexual reproduction where parent divides into two daughter individuals.
- It involves division of nucleus formed by the division of the cytoplasm.
- The plane of fission differs in different protozoans.
  - Irregular binary fission (*Amobea*)
  - Longitudinal binary fission (*Euglena*)
  - Transverse binary fission (*Paramecium*)
  - Oblique binary fission (*Ceratium*)

Multiple fission

- Multiple fission is the division of the parent into numerous daughter individuals.
- Nucleus divides into many nuclei followed by the cytoplasmic division.
- It is prominent in Sporozoans and Sarcodines.
- Schizogony (merogony) is the asexual kind of multiple fission and its end products of schizogony grow into trophozoites.
- The obtained multinuclear cell is called the schizont or meront

- The obtained multinuclear cell is called the schizont or meront.
- Following the nuclear fusion, the cytoplasm participates in the division and as many nuclei as there are daughter cell. These are called merozoides or schizozoites.
  - These are seen in protozoa belonging to Sporozoea class.

Sexual reproduction

Sexual reproduction in protozoans is by syngamy or conjugation.

- Syngamy
- Conjugation

Syngamy

- **Syngamy** is seen in protozoa belonging to Sporozoa class of Apicomplexa
- Syngamy is the complete and permanent union or fusion of two specialized protozoan individuals or gametes resulting in the formation of a fertilized cell or zygote.
  - Male cell is called microgamont (microgametocyte)
  - Female cell is called macrogamont (macrogametocyte)

Syngamy

- Gametogony is the sexual kind of multiple fission by which gametes are formed.
- Microgametes are small, the nucleus is bigger than the cytoplasm, active and some of these have flagella.
- In macrogametes, the nucleus is smaller than the cytoplasm and the cytoplasm has granules.

- Macrogamets and microgamets that occur in gametogony are often not alike (such as *Theileria* and *Eimeria* species). This is called anisogamy.
- In some protozoans (e.g., *Babesia* spp.), the gamets are similar to each other. This is called isogamy.

- Syngamy is also called fertilization.
- Each of the microgamets that have a whip and are quite active fertilize only one macrogamet. (e.g., in *Eimeria* spp.)
- Diploid chromosomal **zygote** is formed by fertilization of the haploid chromosomal sex cells.
- This is also called syngamy.

- The zygote is thrown out in some species. The zygote must become resistant to external environment. Therefore, it stores the materials that can easily turn into energy (amylopectin) and the outer wall is surrounded by a second shell. It transforms a cyst-like structure. This is called **oocyst**.
- A number of offspring (1-4-8- or even hundreds) depending on the species occur by sexual means and these offspring are called **sporozoite**.

- Especially in indirectly growing species, the zygotes are formed in intermediate hosts.
- The gametocytes or gametes in definitive host are taken by invertebrate (arthropod species) and the zygote is formed in the vector.
- This zygote does not need to be surrounded by a thick shell since it will not go outdoors.
- It is active and can feed from outside. This is called **ookinete**.

Sporogony

- Sporogony is a kind of asexual reproduction and occurs following sexual fusion.
- Sporogony is a complex reproduction including meiosis, mitosis and amitosis.

Sporogony

- Sporoblasts, sporocyst and finally sporozoites, respectively, form from the mass of protoplasm in the oocyst or ookinete.
- Oocysts and ookinetes complete the sporogony phase and become infective after sporozoites occur.

Sporogony

- Suitable conditions (such as humidity, heat, and oxygen) are required for the completion of the sporogonic development.
- The infection is occurred by taking oocysts that are sporulated in the outdoors with food and water or by giving these sporozoites via vectors during blood feeding.
- Sporozoites enter the target organ and tissue cells and start the merogony.

- In species belonging to the Sporozoea class of Apicomplexa
  - start with asexual schizogony
  - continue with sexual syngamy
  - are completed with sporogony
- These biological processes are called **metagenesis**.

Conjugation

- It is the temporary union of two mating types of individuals of the same species to facilitate exchange of nuclear materials.
- These reproduction type are generally seen in the protozoa belonging to Ciliophora phylum.
- The pellicle and ectoplasm fuse at the point of contact and a protoplasmic bridge is formed between the individuals.

Conjugation

- Macronuclei breaks up and disappears.
- The diploid micronucleus of each individual undergo meiotic division and 4 haploid daughter micronuclei are produced of which 3 degenerate and disappear in each individual.
- The remaining one micronucleus divides by mitosis forming 2 unequal pronuclei or gametic nuclei.

- The smaller one is the active migratory gamete nucleus or male pronucleus and the bigger one is the passive stationary gamete nucleus or female pronucleus.
- Male pronucleus of one individual passes through the protoplasmic bridge into the other individual and fuses with its female pronucleus, forming a single diploid zygote nucleus or synkaryon.

- The complete fusion of two nuclei from two different individuals forming a zygote nucleus.
- After a union of about 12 to 48 hours, two individuals separate.
- Each individuals undergoes further nuclear and cytoplasmic divisions forming four daughter individuals.