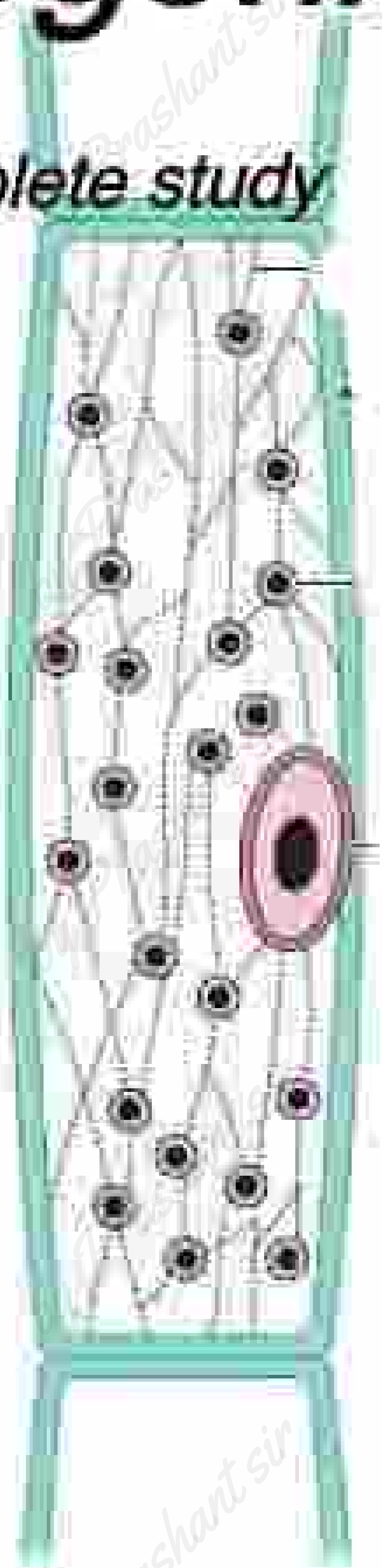
Oedogonium

complete study



Oedogonium is unbranched filamentous alga of Chlorophyceae. In which caps are formed over cells after each cell division. The sexual reproduction is advanced oogamous type. The antheridia can be formed on normal filaments or on special dwarf nannandrous filaments. Depending upon the antheridium types, *Oedogonium* can be nannandrous and macrandrous types.

4. Oedogonium

4.1 Systematic Position

Class : Chlorophyceae
Order : Oedogoniales
Family : Oedogoniaceae
Genus : *Oedogonium*

Order: Oedogoniales

The order oedogoniales is represented by a single family Oedogoniaceae. The member of Oedogoniales are mostly freshwater forms. These are found in permanent water bodies like ponds, tanks and lakes. Oedogoniales, algae have filamentous thallus with distinct polarity. The cell division is characteristic. The reproduction takes place by vegetative, asexual and sexual methods. The motile reproductive structures are multiflagellate.

4.2 Occurrence of Oedogonium

The genus *Oedogonium* (Gr., *Oedos*-swelling, *gonos*- reproductive bodies) comprises about 400 species. Common Indian species are ***O.tenuis***, ***O.elegans***, ***O.oblongellum*** and ***O.cardiacum***. *Oedogonium* is freshwater alga commonly found in stagnant water like in small ditches, ponds, pools and lakes attached to the leaves and stem of other plants *i.e.*, plants are epiphytic. The young filaments may also be found attached on other algae like *Cladophora*, or on mature *Oedogonium*. Some species of *Oedogonium* are terrestrial, found growing on moist soil, *e.g.*, ***O.terrestris*** and ***O.randhawe***. Young filaments are found attached but mature filaments are free floating.

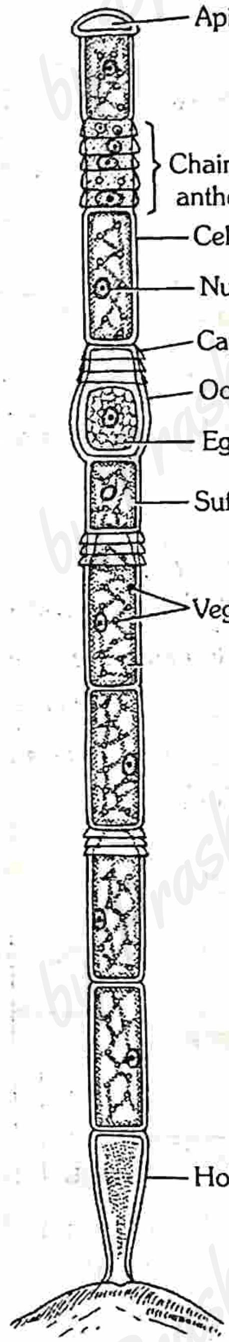


Fig. 8: *Oedogonium:* Thallus Structure– A Filament of a Homothallic Species

4.3 Thallus

The *Oedogonium* thallus is green, multicellular, unbranched filaments made up of cylindrical cells (Fig. 8). The cells are differentiated in following three types:

1. **The lower most basal cells or holdfast**
2. **Intercalary cells**
3. **Apical cell**

1. **Holdfast**: The lower most basal cells or holdfast is club-shaped. The upper part of this cell is generally broad and round and the lower end of the cell is multi-lobed, disc-like or finger-shaped (Fig. 8) which attaches the filament to substratum. It's colourless due to absence of

chloroplast or may possess poorly developed chloroplasts. Hence, it is unable to synthesize food for itself. In flowing waters the holdfast persists and in terrestrial forms it may give out rhizoid like growth.

2. **Intercalary Cells :** The cells between the apical cell and holdfast are called intercalary cells which constitute the major part of the filaments. All intercalary cells are identical and possess chlorophyll. Hence are photosynthetic in nature. Some intercalary cells have cap like structure at their apical end and are called **cap cells** (Fig. 8). The caps are formed at the end of cell division and the number of caps indicate how many time that cell has divided.

3. **Apical Cell:** The apical or terminal cell is round, elongated or acuminate. In some species the apical cell is modified, giving rise to narrow hair like structure, *e.g.*, in ***O.ciliate***. The apical cell possess chlorophyll and is photosynthetic in nature.

4.4 Structure of Cell

The cells are generally long and cylindrical. The cell walls are thick, rigid and rough. Cell walls are differentiated into three layers. The outermost layer is made of **chitin**, the middle layer of pectin and inner most layer is made of **cellulose**. The outermost chitin layer prevents dissolving away of pectin layer.

The protoplast consists of a thin plasma membrane, cytoplasm, central vacuole, reticulate chloroplast with pyrenoids and a single nucleus. The peripheral protoplast is called primordial utricle. The protoplast forms a thin layer between the central vacuole and innermost cellulosic cell wall. The cell contains a central vacuole which possess cell cap. The cell cap contains all type of secretions, excretions and inorganic compounds.

The single **nucleus** present in cell is biscuit shaped or biconvex, it lies in the centre of the cell internal to chloroplast. In some species the nucleus may be eccentric *i.e.*, away from the centre. The nucleus possess 1-2 nucleoli, the chromo- somes are thread like or elongated. (Fig. 9 A-B)

The single chloroplast forms a **reticulum** which extends from pole to pole, parallel to the long axis of the cell. Many pyrenoids are present at the intersection of the chloroplast reticulum. The function of the pyrenoids is to store starch over its surface. However, the excess starch is accumulated between the chloroplast lamellae.

The protoplasm also contains, mitochondria, Golgi bodies, endoplasmic reticulum and other cell organelle.

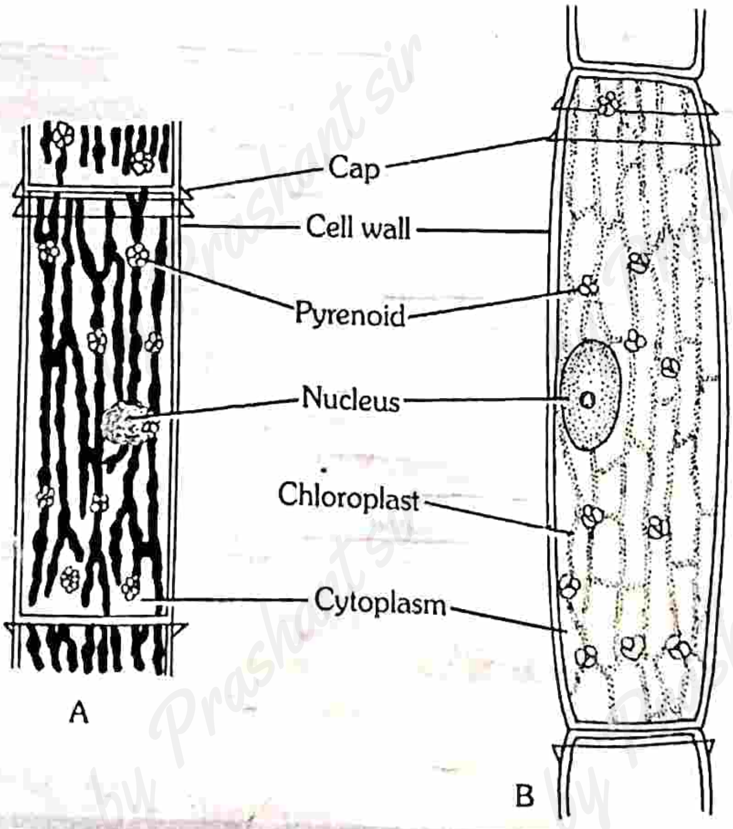


Fig. 9 (A-B): *Oedogonium:* Cell Structure; (A) Young Cell, (B) Mature Cell

Growth

Growth in *Oedogonium* takes place by the division of intercalary cells. However, in some cases the apical cell may also divide to increase the length of filament.

4.5 Reproduction

In *Oedogonium* reproduction takes place by vegetative, asexual and sexual methods.

4.5.1 Vegetative Reproduction

The vegetative multiplication takes place by fragmentation and akinete formation.

1. **Fragmentation :** When a filament of *Oedogonium* breaks into fragments, each fragment is capable of forming new thallus. The fragmentation may occur due to any of the following reasons:
   (i) Mechanical injury
   (ii) Drying up of some intercalary cells.
   (iii) Disintegration of intercalary cells after the formation of sporangia
   (iv) Accidental breaking of the filaments under favourable conditions, these fragments develop into new thalli.
2. **Akinete Formation :** Akinetes are the modified vegetative cells which become round or oval, reddish-brown and thick walled. These cells contain starch as the reserve food material and reddish-orange oil. The akinetes are formed in unfavourable season and are formed in chains. After liberation the akinetes germinate into new filaments in favourable season. (Fig. 10)

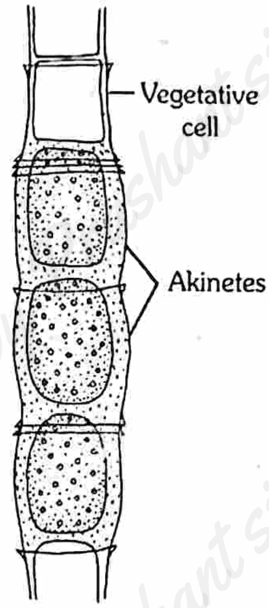


Fig. 10: *Oedogonium* : A Row of Akinetes

4.5.2 Asexual Reproduction

The asexual reproduction takes place by means of zoospores. (Fig. 11)

1. Formation of Zoospore (Fig. 11 A-C) : Generally, the newly formed cap cell *i.e.*, a recently divided cell functions as zoosporangium. The zoosporangia are not formed in series, one sterile cell is always present between two nearby zoosporangia. Each zoosporangium contains only one zoospore. The cell which is going to function as zoosporangium gets filled with abundant food reserves. The contents of the cell contract slightly from the cell wall.

   The central vacuole disappears, chloroplast frees itself from one end of the cell and become conical. A small hyaline area develops on one side of the protoplast which eventually becomes the anterior end of the zoospore. At the base of this hyaline area, a ring of basal granules appears and from each granule a single flagellum arises. The basal granules remain connected with each other by fibrous strands. Thus, a ring of flagella (About 30 flagella) appear at sub apical end below the hyaline area of zoospore.
2. **Structure of Zoospore:** The mature zoospore is an oval, spherical or pear-shaped structure. The apical part of zoospore is hyaline and the rest is green due to presence of chlorophyll. The chloroplast is ring-shaped with few pyrenoids embedded in it. The zoospore also contains eye-spot at one end and a few contractile vacuoles. At maturity of the zoospore the wall of zooporangium splits near the cap region, the adjacent cell moves apart and a passage is formed for the liberation of zoospore (Fig. 11 D). The zoospore come out in a delicate mucilaginous vesicle, which soon gets dissolved and zoospores become free. A ring of flagella about 30 and 120 in ***O. cardiacum*** is found at the base of hyaline region, this kind of flagellation is called stephanokontic type.

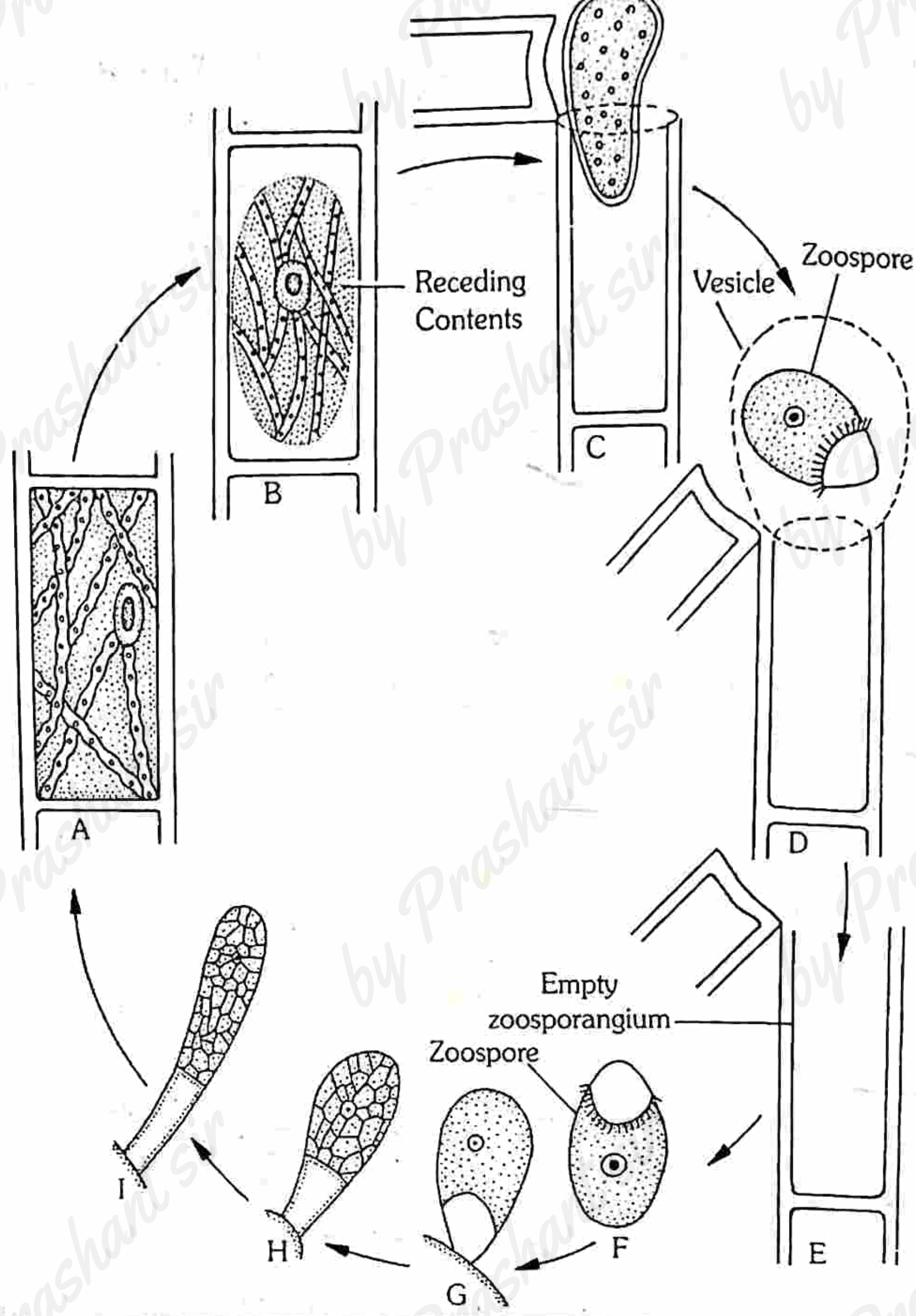


Fig. 11: Stages in Asexual Reproduction in *Oedogonium*, (A-C), Formation of Zoospore, (D) Liberation of Zoospore, (F-I), Zoospore and its Germination

3. **Germination of Zoospore (Fig. 11 F-I) :** After liberation the zoospores swims for an hour or more. Then it settles and attaches to a solid substratum with its hyaline flagellated end, soon it becomes deflagellated and elongates considerably. A transverse septum separates the basal hyaline part and the lower part. The lower part elongates to develop holdfast. The upper part divides repeatedly to make new filament. The terminal cell forms the apical cell.

4.5.3 Sexual Reproduction

The sexual reproduction in *Oedogonium* is of **advanced oogam- ous** type (Fig 12). Sexual reproduction sets in when the water is alkaline and deficient in nitrogen, in presence of sufficient light and CO_2. It is more common in forms growing in stagnant water than those growing in running water..

It takes place with the help of male and female gametes. The male gametes known as antherozoids are formed in **antheridium.** The female gametes called eggs are formed in **oogonium.** The genus *Oedo- gonium* exhibits sexual dimorphism because the male and female gametes differ morphologically as well as physiologically.

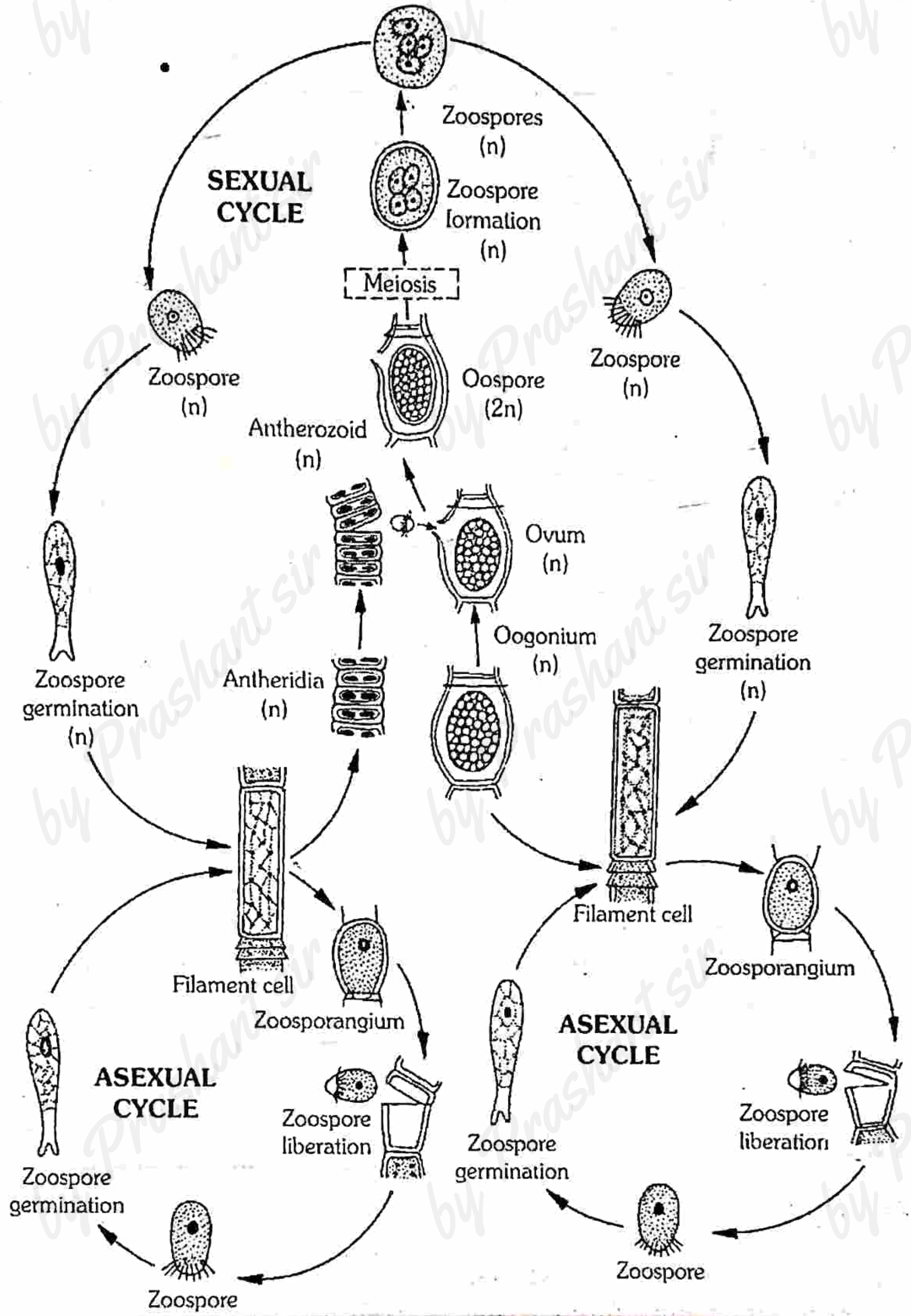


Fig. 12: Reproduction in a Macrandrous Dioecious Species of *Oedogonium*

Distribution of Sex Organs

On the basis of distribution of sex organs, *Oedogonium* species can be **macrandrous** type and **nannandrous** types.

1. **Macrandrous Species:** In these species the antheridia are formed on the filaments of normal size. Macrandrous *Oedogonium* species can be **monoecious** or **dioecious** (Fig. 12).

   In **macrandrous monoecious** species the antheridia and oogonia are formed on the same filament, e.g., ***O. fragile*** and ***O. hirnii, O. nodulosum, O. kurzii***. In macrandrous dioecious species the antheridia and oogonia are formed on different filaments, e.g., ***O. aquaticum, O. gracilius, O. boscii, O. crassum***. The filaments bearing antheridia and oogonia are morphologically similar but physiologically different.

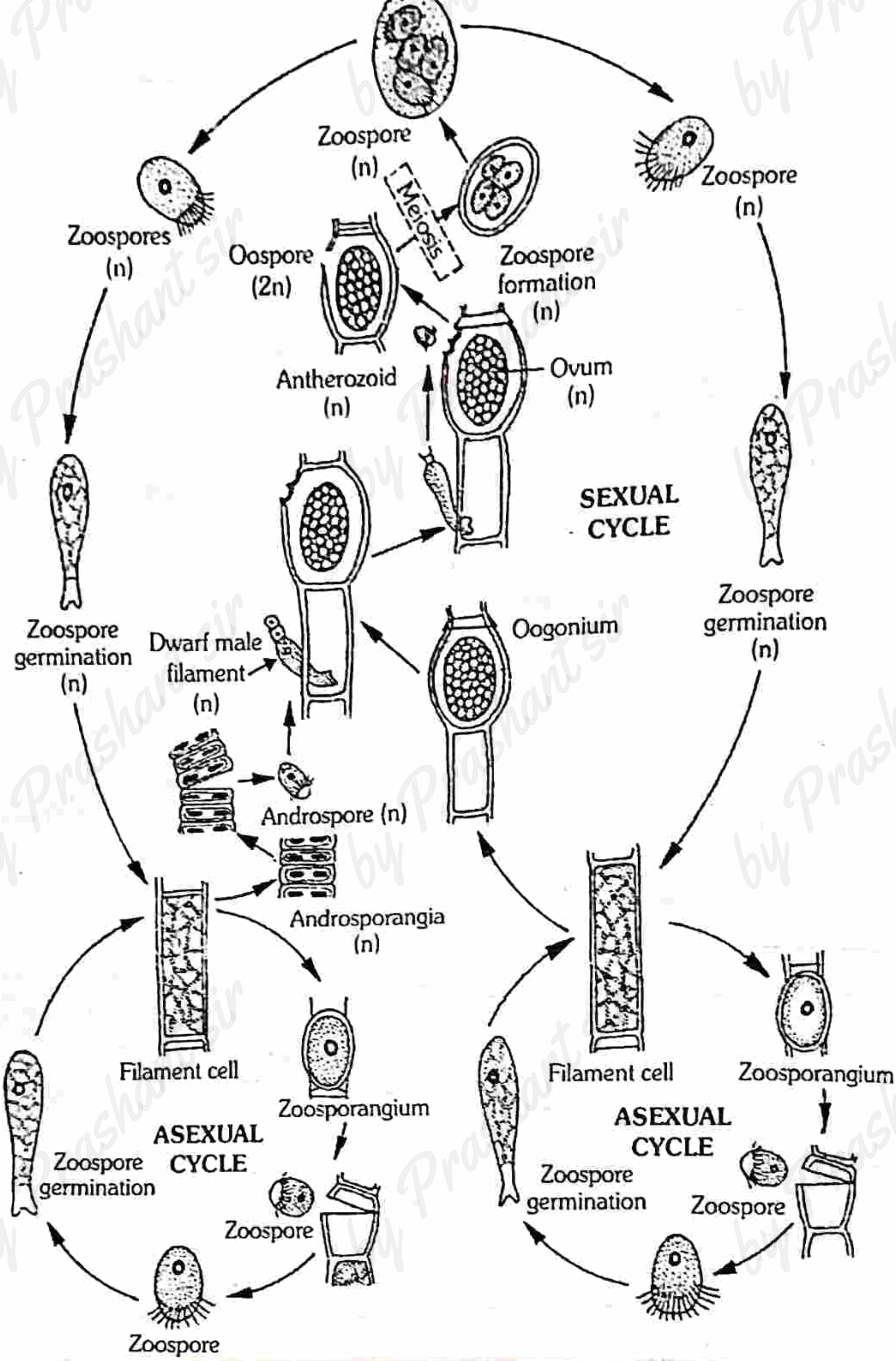


Fig. 13: Reproduction in a Nannandrous Species of *Oedogonium*

2. **Nannandrous Species (Fig. 13 and 15):** In nannandrous species, the male filaments bearing antheridia are much smaller than female filaments and are called **dwarf male** or **nannandrium.** Nannandrous species are always dioeious as antheridia and oogonia are formed on different filaments, e.g., ***O. concatenatum.*** The dwarf male filaments grow epiphytically attached to the female filament. The filaments bearing antheridia and oogonia are morphologically as well as physiologically different.

Antheridia

1. **In Macrandrous Species:** In macrandrous species the antheridia are formed or filaments of normal size. The initial cells that give rise to antheridia are called antheridial mother cell, these cells can be

terminal or intercalary and are cap cells generally. The antheridial mother cell divides by transverse division to make upper smaller cell called antheridium and a lower larger sister cell. The sister cell divides repeatedly to form a series of antheridia 2-40 in number. The antheridia are flat, short, cylindrical, uninucleate disc like cells. (Fig. 14 A-D)

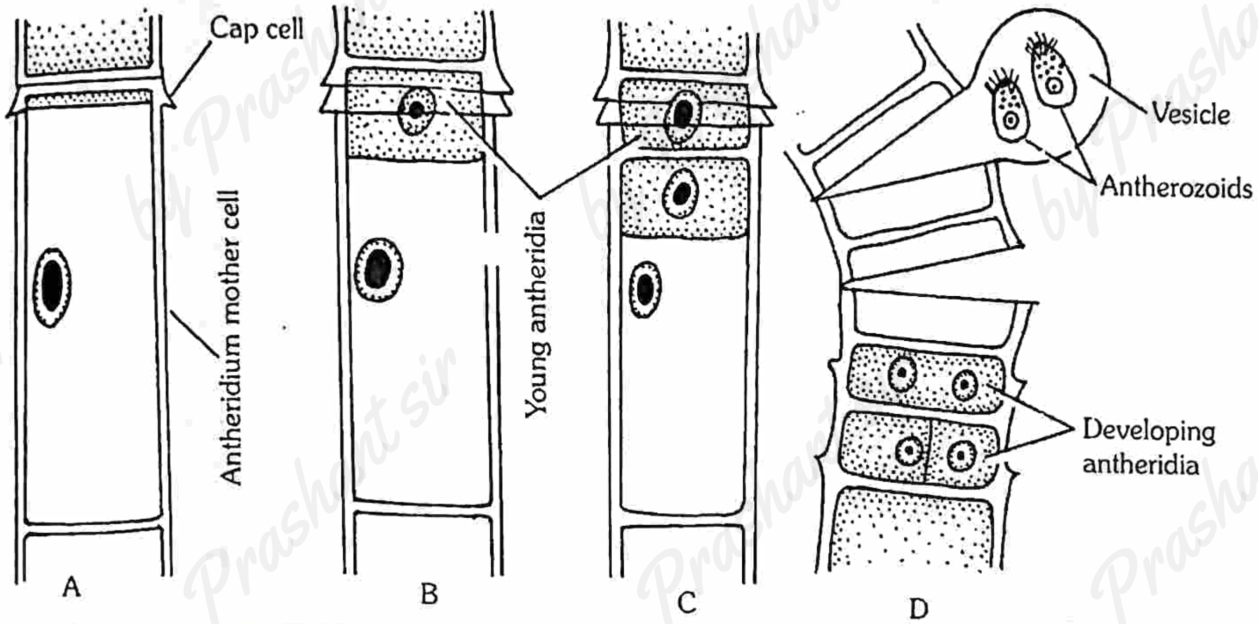


Fig. 14. (A-D): *Oedogonium* : Development of Antheridium (Macrandrous Type)

The protoplasm of antheridial cell may undergo vertical or transverse division to form **antherozoids** or **spermatozoids**. In case of vertical division the antherozoids lie side by side and in case of transverse division they lie superposed in antheridium. Rarely one antherozoid is formed in an antheridium.

The liberated **antherozoids** or **sperms** are pale green or yellowish green, motile oval or pear-shaped structures. The antherozoids are similar to zoospores in appearance but smaller in size and with fewer flagella. The antherozoids possess sub-apical ring of flagella, stephanokontic, at the base of hyaline number. In some species the flagella are longer than the body of antherozoid, *e.g.* , in *O.crassum* and *O.kurzii*. The antherozoids swim freely and finally reach the oogonia.

2. **In Nannandrous Species:** In nannandrous species the antheridia are formed on short or **dwarf male** filaments called **nannandria.** The cells which form dwarf male are called **androsporangia.** The androsporangia may develop on the female filament possessing oogonium (Fig.15A), these *Oedogonium* species are called **gynandrosporus.** If androsporangia develop on a separate filament (Fig. 15B) other than female filament such *Oedogonium* species are called **idioandrosporus,** *e.g.*, ***O.confertum, O.iyengari, O.setigerum***.

The androsporangia are flat, discoid cells slightly larger than **antheridia**. Single **androspore** develops in each androsporangium. The androspores possess sub-apical stephanokontic ring of flagella. The motile androspores are liberated in a manner similar to liberation of zoospore. The androspores swim in all directions (Fig. 15C), after reaching the female filaments, they get attached on the wall of the oogonium, *e.g.*, ***O.ciliatum*** (Fig. 15D) or on the supporting cell, *e.g.*, ***O. concatenatum*** (Fig. 15E).

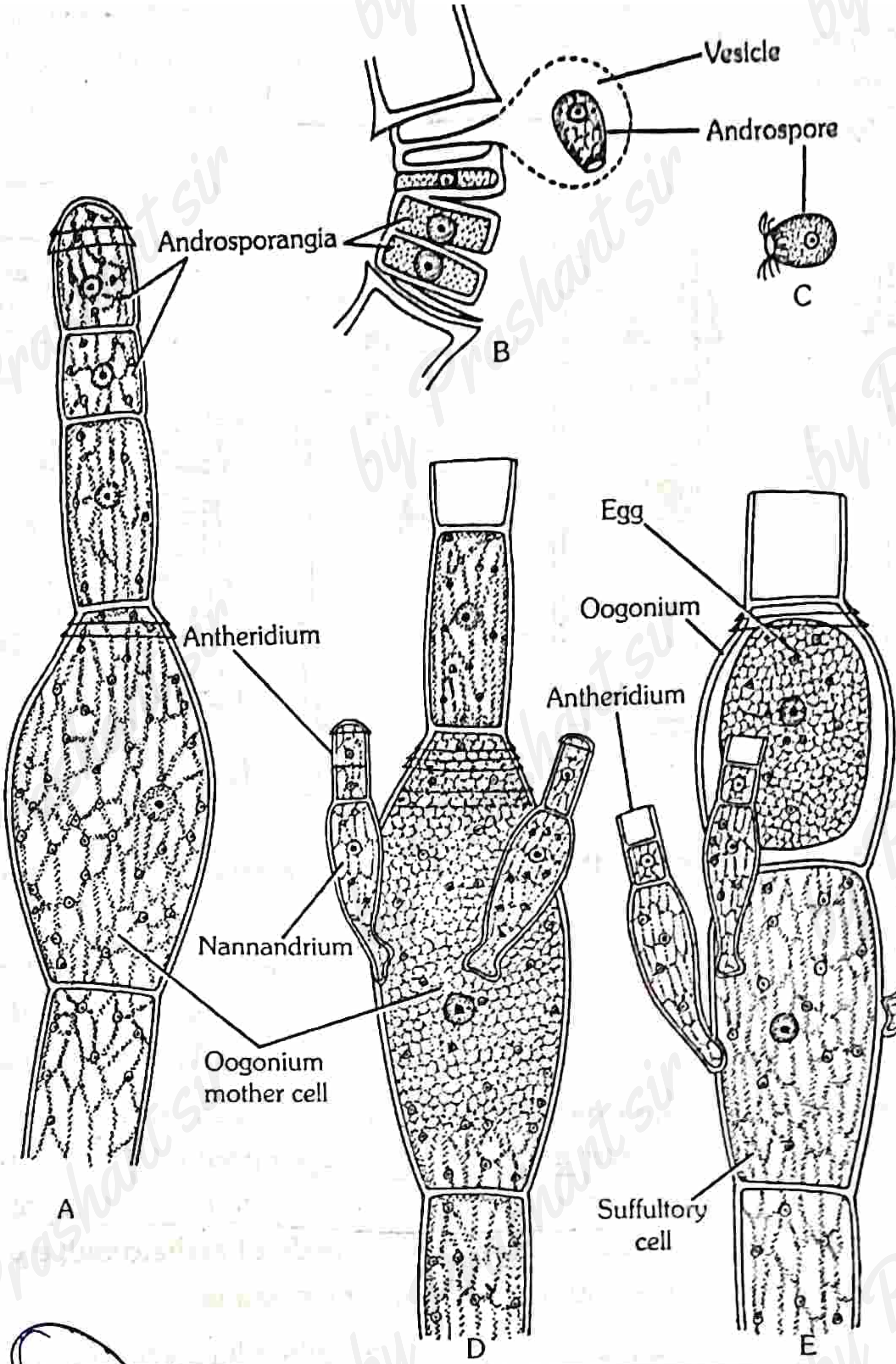


Fig. 15 (A-E): *Oedogonium* : Sexual Reproduction in a Nannandrous Species, (A) Androgporangia and Oogonium on the Same Filament, (B) Androsporangia on a Separate Filament Showing Liberation of Androspore into a Vesicle, (C) Free Swimming Androspore, (D) Drawf Male Attached to Oogonium, (E) Dwarf Male Attached to Suffultory Cell

The androspores germinate on female filament to produce a narrow filament called **nannandrium** or dwarf male. Nannandrium may be unicellular, *e.g.*, ***O. diplandrum, O. perspiccum***, or few celled long. The cells of nannandrium form one or more discoid antheridia and the lower cell functions as stalk cell or rhizoidal cell or attaching cell.

The protoplast of each antheridium divides to form two spermatozoids or sperms. In unicellular nannandrium the attaching cell directly functions as antheridium and forms sperms. According to Iyengar (1951) the antheridium of dwarf male produces a single sperm. The antheridial cell disorganizes or a lid separates it from tip for liberation of sperms.

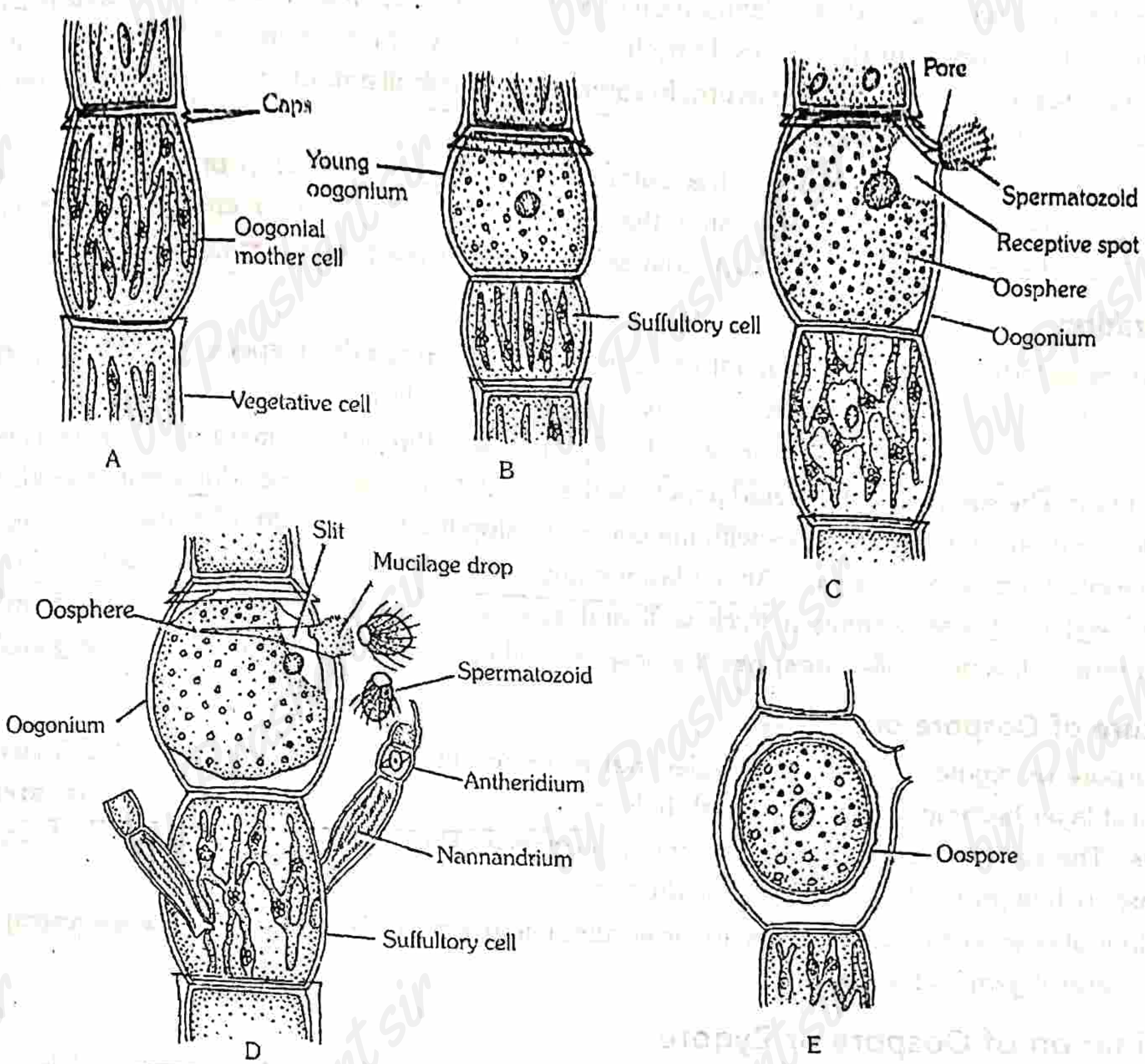


Fig. 16: *Oedogonium*: Oogonium and Fertilization; (A) Oogonial Mother Cell, (B) Formation of Oogonium, (C-D) Oospheres of Macrandrous Poriferous Species and Operculate Nannandrous Species respectively ready for Fertilization, (E) An Oospore

Oogonia

In monoecious species antheridia and oogonia are formed on the same filament, but in dioecious species they are formed on different plants. The development of oogonium is similar in both macrandrous and nannandrous species. Oogonia are highly differentiated female gametangia. The oogonia are usually intercalary but may be terminal, *e.g.*, ***O. palaiense***. A newly formed actively growing cap cell functions as **oogonial mother cell** (Fig.16A). It undergoes an unequal transverse division to form an upper larger **oogonium** and a lower smaller **supporting** or **suffulatory cell** (Fig.16B). If one of the two cells again become oogonial mother cell then oogonia are formed in chains. In some species, oogonia develop directly from the oogonial mother cells. Suffulatory cell is absent in ***O.americanum***. The oogonium enlarges in size, swells up due to the accumulation of food reserves and secretes a hormone which induces suffulatory cell to grow in size. In monoecious species the suffulatory cell may divide to form antheridia, *e.g.*. ***O. nodulosum***.

The protoplast of oogonium contracts to form a single ovum or egg. The egg or **oosphere** is non -motile, with centrally placed nucleus and green due to presence of chlorophyll. As egg matures it swells up and nucleus moves to the periphery. A prominent colourless or hyaline receptive spot appears near wall of oogonium just external to the nucleus. The receptive spot is formed to receive sperms.

This spot may be pore formed by gelatinization of a tiny papilla on oogonial wall in **poriferous** species, or a transverse slit as in **operculate** species. In both cases a thin membrane exists on the innerside of the exit. It forms a passage leading down to the ovum. In some species a small amount of mucilage is extruded through the opening to attract sperms.

In macrandrous monoecious species, the antheridia and oogonia develop on the same filament. The antheridia usually develop one day after the oogonia (Protogynous) to ensure cross fertilization. In macrandrous dioecious species, the antheridia and oogonia develop on separate filaments.

Fertilization

The process of fertilization is similar in both macrandrous and nannandrous species. The mature egg secretes a chemical substance to attract antherozoids (Chemotactic attraction).

The sperms are motile and egg is non-motile. The sperms swim through a pore or transverse slit into the wall of oogonium. The sperm or antherozoid penetrate the egg at its receptive spot. Many antherozoids may enter oogonium but one antherozoid fuses with the ovum. To stop the further entry of antherozoids the nature of protoplasmic membrane changes. After plasmogamy and karyogamy a diploid zygote is formed. The fertilized egg or zygote secretes a thick wall and around itself and changes its colour from green to reddish-brown. It is now called **oospore** the oospore is liberated by the disintegration of oogonial wall.

Structure of Oospore or Zygote

The oospore or zygote is round or globular, red or brown in colour. The wall is thick 2-3 layered. The outermost layer becomes ornamented with help of smooth or reticulate **pits, spines, ribs, areolae** and **flanges.** The ornamentation is of taxonomic importance. The oospore contains a diploid nucleus and cytoplasm rich in proteins and coloured oil droplets.

The colour of oospore becomes red due to the accumulation of reddish oil. The oospore is a resting spore but in some cases it germinates directly.

Germination of Oospore or Zygote

The oospore is liberated by decay of the oogonial wall and settles down at the bottom of pond. It undergoes a period of rest, the zygote is believed to require chilling treatment for germination. The dormant state helps in tiding over unfavourable period. In favourable conditions the diploid zygote nucleus undergoes **zygotic meiosis** to form four haploid nuclei. The colour of the protoplast turns from red to green and divides to form four uninucleate daughter protoplasts. Each haploid daughter protoplast and nucleus form a meiozoospore with crown of flagella at sub-apical end. The meiozoospores resemble the zoospores formed in asexual reproduction. The liberated zoomeiospores remain enclosed in a vesicle for sometime but soon the vesicle vanishes.

In some species the oospore wall ruptures and the naked protoplast is released in vesicle where it divides meiotically to form four haploid daughter protoplast which metamorph into haploid meiozoospores. Under certain conditions the daughter protoplast do not develop flagella and secrete a wall around itself. These **meioaplanospores** are liberated by gelatinization of vesicle. Each meioaplanospore later on liberates a swarmer which gives rise to new plant.

The liberated meiozoospores swim freely in water for sometime. Soon they settle on some substratum. Each meiozoospore germinates to give rise to a haploid plant just like a zoospore. In dioecious species out of four meiozoospores, two give rise to male filaments and two develop in female filaments. Some *Oedogonium* species exhibit the phenomenon of **parthenogenesis.**

4.5.4 Life-cycle

The thallus of ***Oedogonium*** in all species is haploid. The life-cycle in *Oedogonium* is **haplontic type**. The haploid gametes or haploid thalli are formed and after fusion of male and female gametes a **diploid zygote** is formed. Zygote is the only diploid stage in life-cycle. The zygote undergoes meiotic division to form **zoomeiospores.** Each haploid zoomeiospore develops into a haploid thallus.

The stages in life-cycle differ slightly among different species of *Oedogonium*:

4.5.4.1 Macrandrous Species

1. **In Macrandrous Monoecious Species:** The antheridia of normal size and oogonium develop on same filament. This filament forms both antherozoid and egg. The two gametes fuse to form diploid zygote which undergoes meiosis to make zoomeiospores. Each zoomeiospore germinates to form macrandrous type of *Oedogonium* filament.

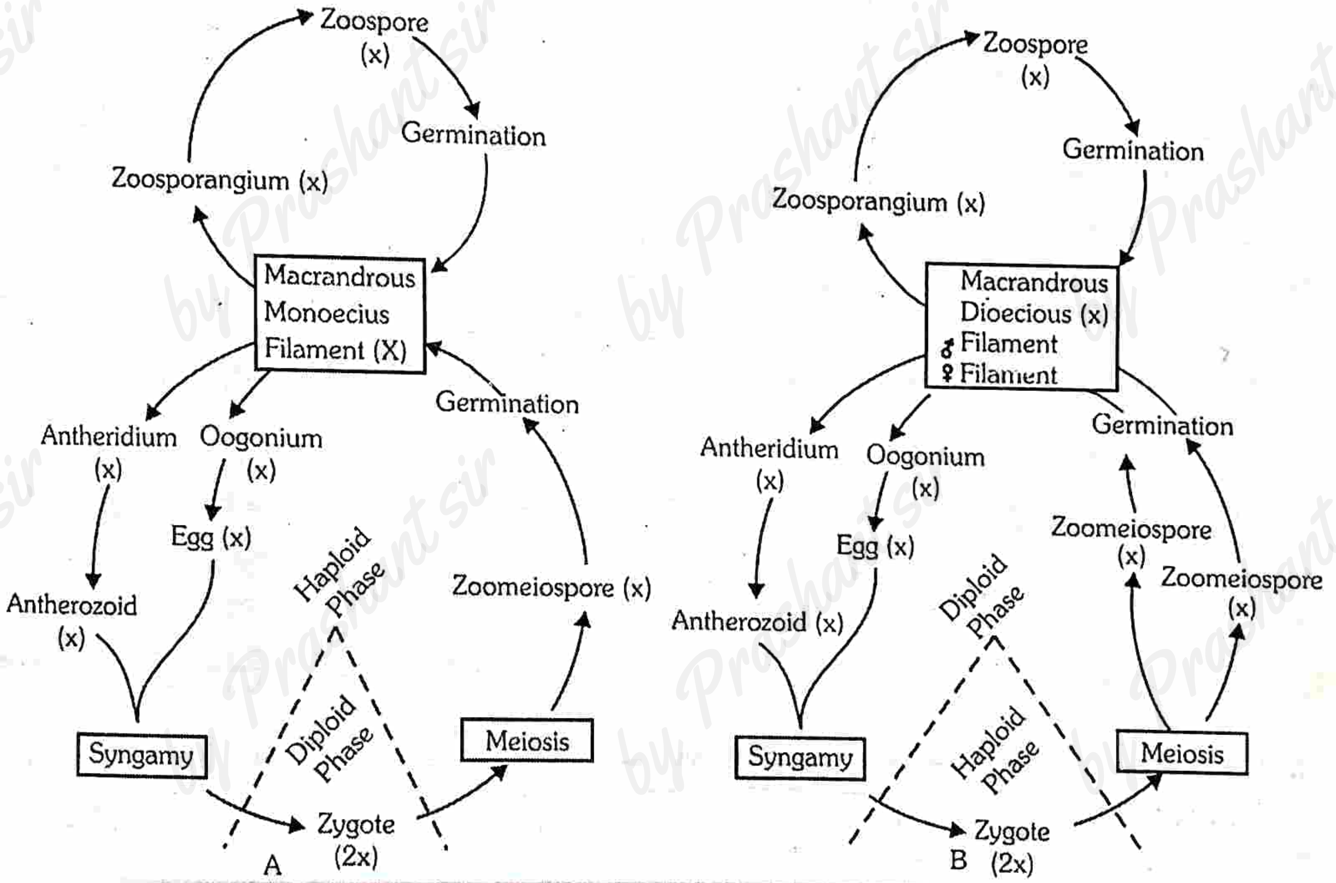


Fig. 17 (A-B): *Oedogonium*: Life-cycle of Macrandrous Species; (A) Monoecious Species, (B) Dioecious Species

2. **In Macrandrous Dioecious Species :** The antheridia and oogonia are formed on separate haploid filament. The antheridia form antherozoid and oogonium forms egg. After fertilization a diploid zygote is formed. The zygote divides by meiosis to make four meiozoospores. Two zoomeiospores make haploid male *Oedogonium* and the other two make haploid female oogonium.

4.5.4.2 Nannandrous Species

1. **In nannandrous gynandrosporous** species the oogonial cells bearing haploid filaments form a chain of androsporangia. The oogonium forms egg *n*. A single androspores develops in each androsporangium. The androspore after liberation comes in contact with the oogonium or with the supporting cell of the filament. Soon, androspore develops into a short filament called **dwarf male** or

nannandrium. The terminal cells of **dwarf male** develop into **antheridia**. Each **antheridium**, develops two antherozoids (*n*) which are liberated shortly. After liberation, they fuse with the egg and develop into zygote (2*n*). The zygote undergoes meiotic division to form zoomeiospores (*n*) each of which give rise to a new thallus.

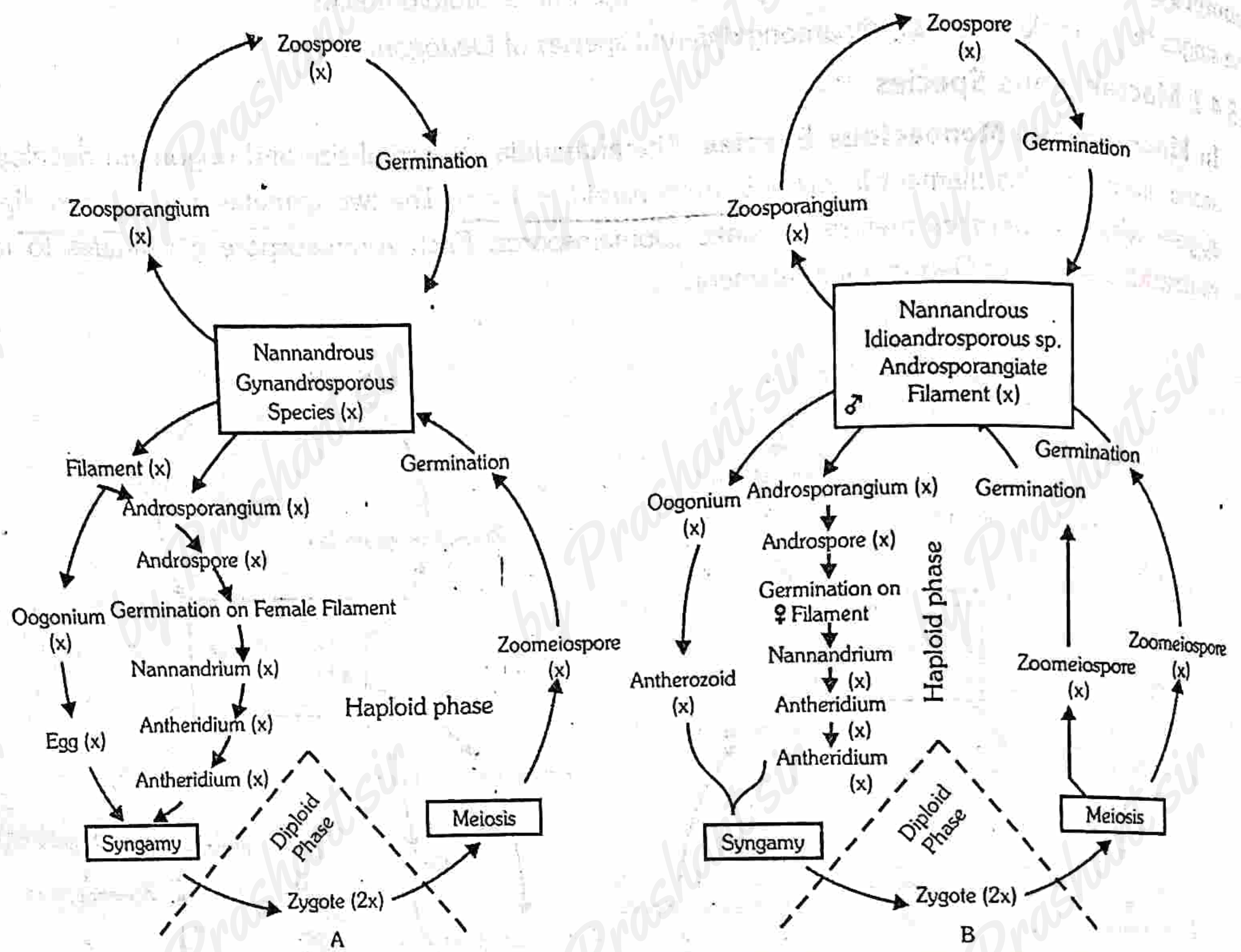


Fig. 13 (A-B): *Oedogonium*: Life-cycle of Nannandrous Species— (A) Gynandrosporous, (B) Idioandrosporous

2. **In the Nannandrous (Idioandrosporous)** species, development of oogonia (*n*) and andros- porangia (*n*) takes place on separate haploid filaments. Oogonium forms a female gamete called **egg** and each androsporangium produces an androspore. On being liberated, each androspore settles either on the oogonium or on supporting cells of the female filament and develops into a dwarf male filament. Terminal cells of the dwarf male filament develop into antheridia. Each antheridium produces two antherozoids. An antherozoid (*n*) and an egg (*n*) fuse to form a zygote (2*n*). The zygote undergoes meiotic division to form four zoomeiospores (*n*). Out of these four, two develop to form male *i.e.*, androsporangiate filament and two develop into female filaments which produce oogonia.

4.5.5 Salient Features in the Life-cycle of Oedogonium

The life-cycle of *Oedogonium* shows a number of interesting features. Some of these are described as follows:

1. **Specialization of Cells in Thallus :** Though the thallus of *Oedogonium* is an unbranched filament, it shows marked specialization among the cells of the filament :
   (i) A majority of cells are **green vegetative** cells which are basically concerned with **nutrition**.
   (ii) A **non-green basal cell** is specialized to serve as an organ or attachment to the substratum.

(iii) **Cap cells** at various intervals are concerned with the cell division. These may also function as **zoosporangia**.

(iv) The **gametangia** are also highly specialized cells which arise by the transformation of vegetative cells.

2. **Reproduction :** The **haploid** filament reproduces :
   (i) Vegetatively by **fragmentation.**
   (ii) Asexually by forming **zoospores.**
   (iii) Sexually by **oogamy.**

3. One zoospore is produced per zoosporangium. The zoospores have a **crown of flagella** at the **anterior** end at the base of a colourless **beak**.

4. **Sexual reproduction** is of **advanced oogamous** type.

5. Male sex organs **(Antheridia)** are short, cylindrical, disc-shaped cells formed in a row of 2-40.

6. The female sex organs **(Oogonia)** are large, round/oval and occur either singly or in chains of 2-3 in the filament.

7. The **oospheres** (Female gametes) are produce singly within the oogonia. These are retained within the oogonia and have a receptive spot (The point for the entry of the male gamete).

8. The **antherozoid** is motile, **multiflagellate** resembling the zoospore; but is smaller in size.

9. The zygote is **tick-walled** and undergoes a **resting phase** to tide over unfavourable conditions.

10. Meiosis in zygote leads to the production of **four** haploid, motile **meiospores**. Each meiospore gives rise to a haploid filament.

11. Distribution of antheridia and the size of male filament differs in different species of Oedogonium:
    (i) **In macrandrous monoecious** species, the antheridia and oogonia are produced on the same filament and are of normal size.
    (ii) **In macrandrous dioecious** species, the antheridia and oogonia are formed on different filaments and are of normal size.
    (iii) **In nannandrous** species, the antheridia are produced on the male filament which is highly reduced.