UNIT 4 REPRODUCTION IN ALGAE

Structure

4.1 INTRODUCTION

In unit 3 you have learnt that algae vary in size from small microscopic unicellular forms like *Chlamydomonas* to large macroscopic multicellular forms like *Laminaria*. The multicellular forms show great diversity in their organisation and include filamentous, heterotrichous, thalloid and polysiphonoid forms. In this unit we will discuss the types of reproduction and life cycle in algae taking suitable representative examples from various groups. Algae show all the three types of reproduction vegetative, asexual and sexual. Vegetative method solely depend on the capacity of bits of algae accidentally broken to produce a new one by simple cell division. Asexual methods on the other hand involve production of new type of cells, zoospores.

In sexual reproduction gametes are formed. They fuse in pairs to form zygote. Zygote may divide and produce a new thallus or it may secrete a thick wall to form a zygospore.

What controls sexual differentiation, attraction of gametes towards each other and determination of maleness or femaleness of gametes? We will discuss this aspect also.

You will see that sexual reproduction in algae has many interesting features which also throw light on the origin and evolution of sex in plants. This will be discussed in the last section of this unit.

Objectives

After studying this unit you should be able to:

- describe with suitable examples the three types of reproduction vegetative, asexual and sexual in algae,
- distinguish the three types of union of gametes - isogamy, anisogamy and oogamy in algae,
- illustrate diagrammatically reproduction and life cycle in *Chlamydomonas, Ulothrix, Ulva, Laminaria* and *Fucus* and describe their special features,
- describe the four basic types of life cycle found in algae and
- discuss the origin and evolution of sex in algae.

4.2 TYPES OF REPRODUCTION

Reproductive processes found in various groups of algae can be broadly divided into three types: vegetative, asexual and sexual methods.

4.2.1 Vegetative Reproduction

The most common type of reproduction in algae is by binary fission. In unicellular prokaryotic algae like *Anacystis* it is the only method of reproduction found in nature. In filamentous and multicellular forms, the algae may get broken accidently into small pieces, - each developing into a new one. The above methods of propagation are known as vegetative reproduction.

4.2.2 Asexual Reproduction

When vegetative reproduction takes place through specialised cells (other than sex cells), it is described as asexual reproduction.

Anabaena and *Nostoc*

The cells accumulate food materials, develop thick walls to become spores or **akinetes** (Fig. 4.1). Akinetes can withstand dryness (lack of water) and high temperature for a long time, but when conditions are suitable they germinate to form new filaments.

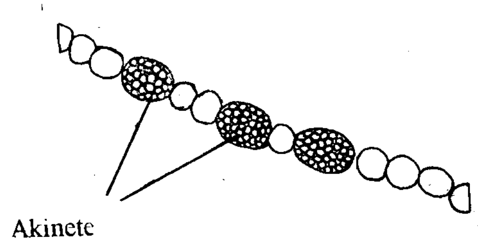

Fig. 4.1: *Anabaena* showing akinetes.

Ulothrix

Filamentous algae (like *Ulothrix*) may reproduce by producing motile cells called **zoospores** (Fig. 4.2). The protoplast of a single cell divides many times by mitosis to produce several zoospores. Each zoospore has 2-4 flagella with which it swims for sometime and then settles by its anterior end. It subsequently divides into a lower cell which becomes the **holdfast** and the upper cell which by further divisions becomes the vegetative filament. Zoospores are produced in other algae also.

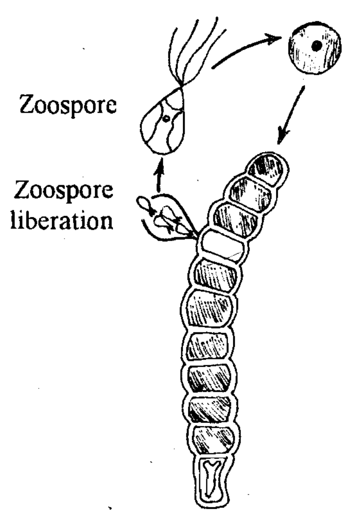

Fig. 4.2 : Formation of zoospores in *Ulothrix*.

Asexual reproduction in other algae is described below.

Chlamydomonas

Although this is a unicellular motile algae but it produces zoospores. The parent cell divides inside the cell-envelop and each daughter cell develops two flagella each. These zoospores look exactly like the parent cell except they are smaller in size. When the zoospores are fully developed the parent cell wall disolves, releasing them free into the surrounding water (Fig. 4.3).

Sometimes when there is less water outside, zoospores may lose flagella and round up. These non-motile spores are called **aplanospores** which develop into thick walled **hypnospores.**

On moist soil when zoospores can not be released due to lack of free water, they get embedded within a gelatinous material formed from parent cell wall. Such cells do not have flagella but whenever they become flooded with water they develop flagella and swim away in the water. These gelatinous masses containing thousands of non-motile cells are known as **palmella stage** of *Chlamydomonas*.

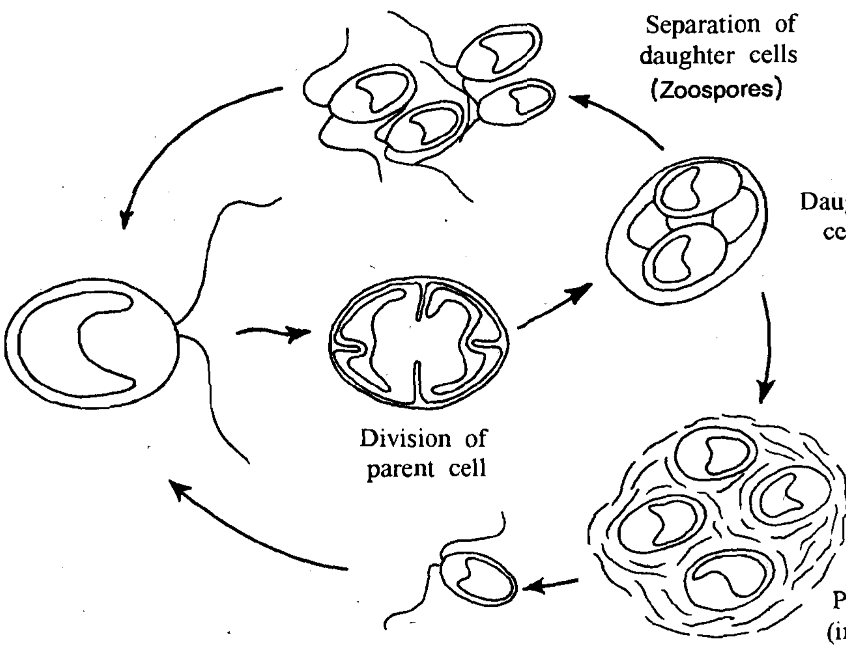

Fig. 4.3: Formation of zoospores and palmella stage in *Chlamydomonas*.

Oedogonium

Zoospore are produced singly in a cell. Each has one nucleus and a crown of flagella at the apex.

Draparnaldiopsis* and *Ulva

Many zoospores are produced from a single cell, as in *Ulothrix*. They have single nucleus and 2-4 flagella.

Ectocarpus

Zoospores are produced in sporangia which are of following two types:

i) **Plurilocular Sporangia**: The sporangium is made up of many cells and several biflagellate zoospores are produced (Fig.4.4).

ii) **Unilocular Sporangia**: The sporangium is made up of one cell which produces single biflagellate zoospore (Fig.4.4).

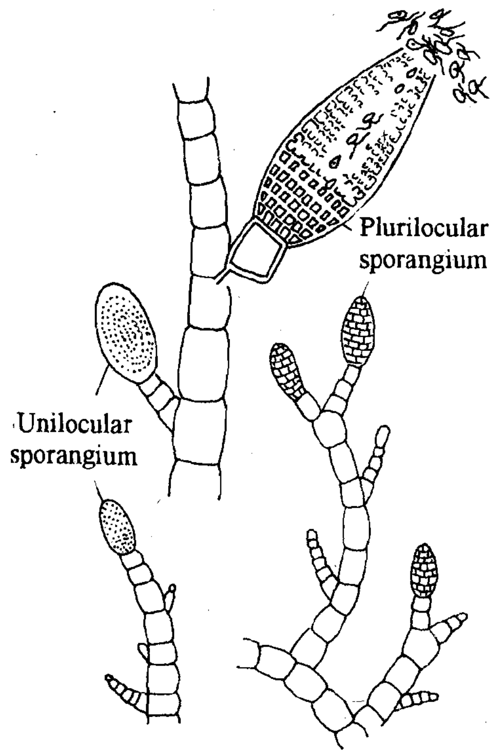

Fig.4.4: Unilocular and Plurilocular sporangia of *Ectocarpus*.

4.2.3 Sexual Reproduction

Sexual reproduction in algae like in other organisms involves the fusion of two cells from opposite sex called gametes, resulting in the formation of a zygote. Some basic features of this method of reproduction are as follows:

Gametes are always haploid and may or may not be different in morphology. If both the sex cells look alike, they could be male called **plus (+) or female called minus (-) mating types or strains**. Gametes can fuse only when one is plus and the other is minus.

Both of them + and - may be produced by a single parent. This is called **monoecious** or **homothallic** condition. When they come from different plus or minus thallus types it is called **dioecious or heterothallic** condition.

There are three types of gametic fusion (Fig. 4.5):

a) **Isogamy**: When both the gametes are of the same size and morphology.
b) **Anisogamy**: The two gametes are distinctly different in size or shape, the larger of the two is minus (female) type.
c) **Oogamy**: The female gamete, egg or ovum is big in size and has no flagella hence it is non-motile. Male gametes are flagellated and highly motile. They are also known as **antherozoids**, **spermatozoids** or sperms.

The male gametes are attracted by the female cells because of special hormones called gamones (a volatile hydrocarbon) produced by them. Fusion of the gametes leads to the formation of a zygote. If the conditions are unsuitable for growth, the zygote may develop a thick wall and become a resting zygospore. Gametes being haploid, are produced by mitosis in a haploid thallus. If the thallus is diploid as in *Fucus* the reproductive cells undergo meiosis or reduction division to form haploid gametes.

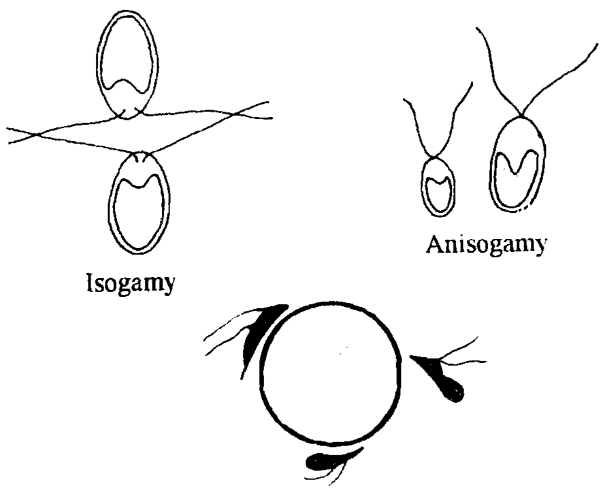

Fig. 4.5: Three types of gametic fusion.-isogamy, anisogamy and oogamy.

In haploid thallus, after the fusion of gametes, the diploid zygote undergoes meiosis during germination. However, in diploid algae a zygote may divide mitotically and give rise to a diploid thallus (*Fucus*). Both haploid and diploid thallus are found in *Ulva*. They look very similar in size and shape.

SAQ 4.1

a) Which of the following algae reproduce **only** by binary fission?
   i) *Volvox*
   ii) *Chlamydomonas*
   iii) *Anacystis*
   iv) *Microcystis*

b) In the following statements fill in the blank spaces with appropriate words:
   i) .... is an enlarged cell in blue- green algae which accumulates food reserve, develops a thick wall and functions as a resting spore.
   ii) Under unfavourable conditions the zoospores lose their flagella and round up, they are called ....
   iii) When a filamentous alga is accidently broken it develops into a ....
   iv) The stage when thousands of zoospores of *Chlamydomonas* cluster together in a gelatinous mass is called ....
   v) When both plus (+) and minus (–) strains are produced by the same parent the condition is called ....
   vi) When two gametes (plus and minus) arise from different parent algae the condition is called ....
   vii) Fusion of gametes of same size and morphology is called ....
   viii) In anisogamy the two gametes are of ....

c) In the following statements choose appropriate alternative word given in the parenthesis:
   i) In algae gametes are always (haploid/diploid).
   ii) The chemical substance produced by (female/male) gamete that attracts the (female/male) gamete is called (gamones/chemone).
   iii) In algae the product of fusion of male and female gametes is called (zoospore/zygospore/zygote).

4.3 REPRODUCTION AND LIFE CYCLE

We have given above the basic modes of reproduction in algae. Now we take up some specific algal types to illustrate their life cycle in nature. It is to be noted that the life cycle of an alga is very much controlled by environmental factors like temperature, light, seasons, and availability of nutrients, and also salinity, wave action and periodicity of tides in the case of marine forms. Observations made by people during different times from various geographical locations and sometimes experimentally studied under controlled conditions, give us fairly comprehensive if not a complete picture of the life cycle of an alga.

4.3.1 *Chlamydomonas*

Sexual reproduction in this alga shows all the three different types depending on the species (Fig. 4.6). Isogamy is found in *C.moewusii, C.reinhardii, C.gynogama* and *C.media*

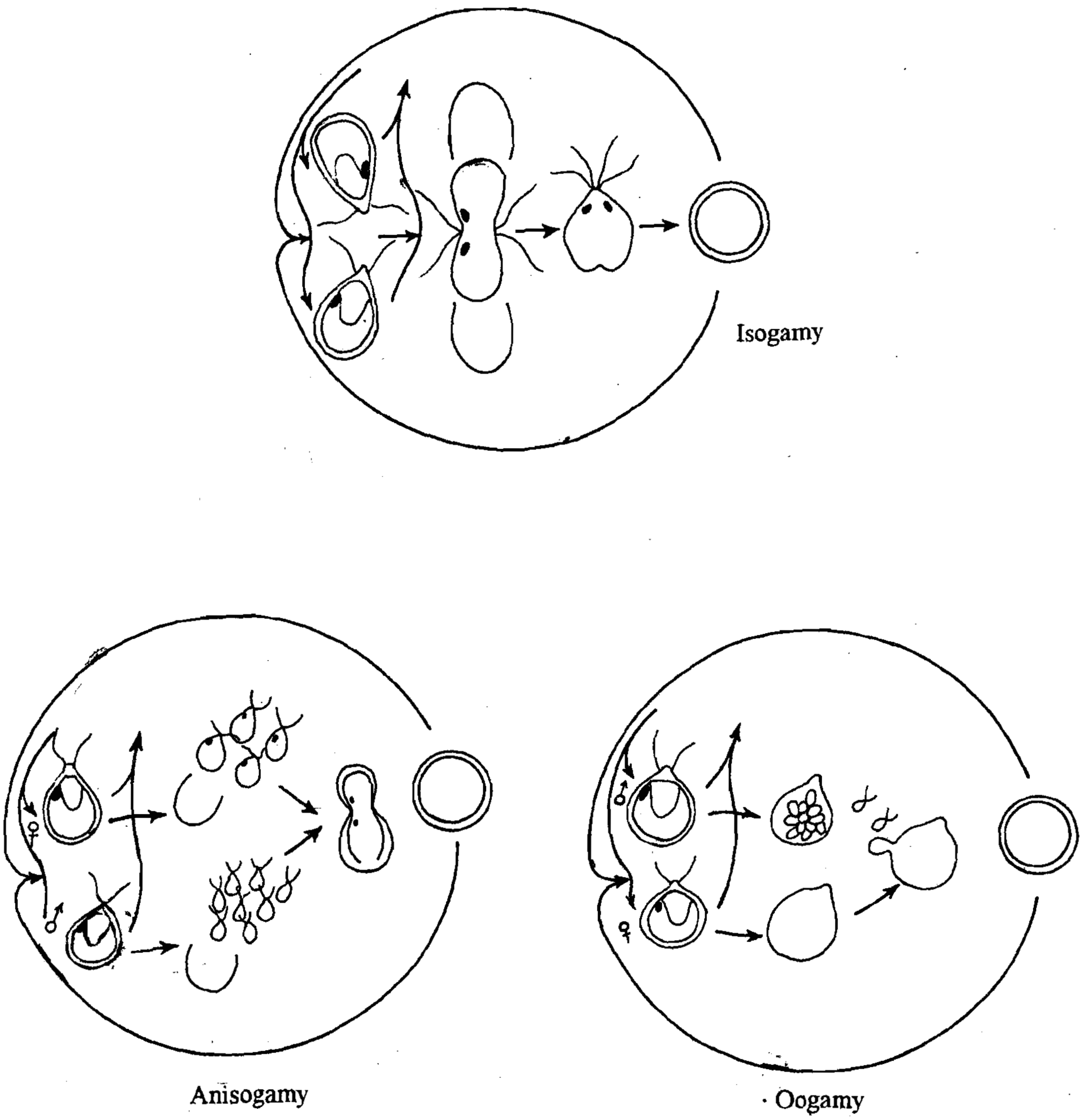

Fig. 4.6 : Sexual reproduction in *Chlamydomonas:* Isogamy ,anisogamy and oogamy.

Isogamy is of two types:

In **clonal populations** (cells obtai .ed by the repeated divisions of a single parent cell) fusion may take place betw' en gametes which are homothallic or in self compatible strains. For exampl', fusion occurs between any two cells of *C.gynogama* and *C.media.*

In *C.moewusii* and *C.reinhai lii* fusion of gametes can take place only when they come from two different unrelated (heterothallic, self incompatible) strains.

In many isogamous species the parent cell may divide to produce 16 to 64 biflagellate gametes while in some the adult cells themselves may directly behave as gametes and fuse.

Anisogamous form of gametic fusion is found in *C.braunii.* A female cell divides and produces four large cells. Each of these cells have two flagella but are less active. The male cells are about 8 in number but smaller in size.

Oogamy is the advanced type of sexual reproduction found in *C. coccifera.* A parent cell discards its flagella and directly becomes a non-motile egg or ovum. While male parent cell by repeated divisions produces sixteen male gametes. These are biflagellate and highly motile.

The process of gametic attraction, fusion and related phenomena have been studied in some detail in the laboratory. Under proper light condition and carbon dioxide concentration, production of gametes can be initiated by nitrogen starvation. The formation of male or female gametes (even in the case of isogamy) is attributed to the varying concentration of gamones produced by them. The attraction between gametes was found due to the presence of glycosidic mannose at the tips of the flagella of one strain which in a complementary way binds with the substance present in the flagella of the gamete of the opposite strain. Once this sticking of the flagella of plus and minus gametes takes place, flagella twist about each other bringing the anterior ends of the gametes close. This is followed by cellular and nuclear fusion.

The zygote secretes a thick wall and accumulates large amount of food materials like starch, lipids and orange- red pigments. It is now known as **zygospore** which remains dormant till the environmental conditions are favourable for its germination.

It has been shown that during germination of zygospore meiosis takes place followed by mitosis resulting in haploid *Chlamydomonas* cells.

Life Cycle

Chlamydomonas is unicellular, haploid and reproduces asexually many times by forming zoospores. Under unfavourable environmental conditions it produces gametes which fuse to form diploid zygospores. During germination reduction division takes place and haploid cells are formed (Fig. 4.7).

Chlamydomonas is of great interest to biologists. Its study has brought to light several interesting features of biological importance, some of which are listed below:

i) Presence of DNA in the chloroplasts of the alga.
ii) Presence of cytoplasmic genes.
iii) Production of genetic mutations- affecting nutrition, photosynthesis and production of mutants without flagella or cell wall.
iv) Discovery of gamones and their role in sexual reproduction.
v) Presence of isogamy, anisogamy and oogamy in a single genus.
vi) Control of reproduction by environmental conditions.

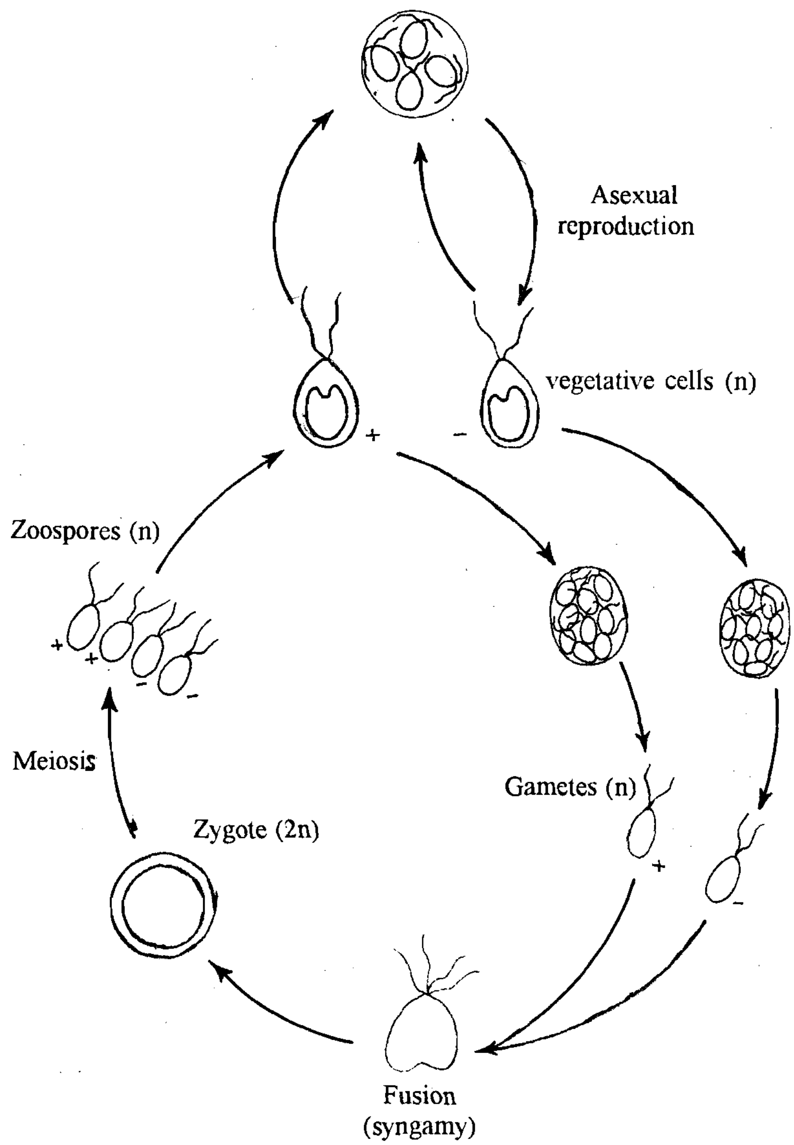

Fig. 4.7: Life cycle of *Chlamydomonas*.

4.3.2 *Ulothrix*

Sexual reproduction takes place by means of isogamous, biflagellate gametes. Fusion takes place only between plus and minus mating types. The gametes are from different filaments (heterothallic). The zygote develops a thick wall and remains dormant till the conditions are favourable for germination. When conditions become favourable meiosis takes place and 4-16 haploid zoospores are produced which settle down and give rise to vegetative filaments (Fig. 4.8).

It has been found that *Ulothrix* produces gametes when grown under long day conditions while short day conditions initiate the formation of zoospores.

Life Cycle

Look at Fig. 4.8 showing the life cycle of *Ulothrix*.

Which is the diploid stage of the algae?
The thallus of *Ulothrix* is haploid and the diploid stage is represented by the zygote only.

We would like to draw your attention to the fact that in some species (*U.speciosa, U.flcca* and in *U.implexa*) the zygote develops into an independent, unicellular thallus which is diploid in nature. It produces zoospores asexually by meiosis. The zoospores develop into haploid filaments.

Thus in *Ulothrix* two types of life cycles can be distinguished:

Haplobiontic:

The thallus is haploid and only the zygote is diploid e.g. ***U.zonata***?

Diplobiontic:

In diplobiontic cycle, the alga consists of a haploid thallus that produces gametes and a diploid unicellular stalked thallus which produces zoospores after meiotic division. The two generations - haploid and diploid, alternate with each other. (alternation of generations). Because the two thalli are very different in size and morphology it is known as **heteromorphic, diplobiontic** life cycle.

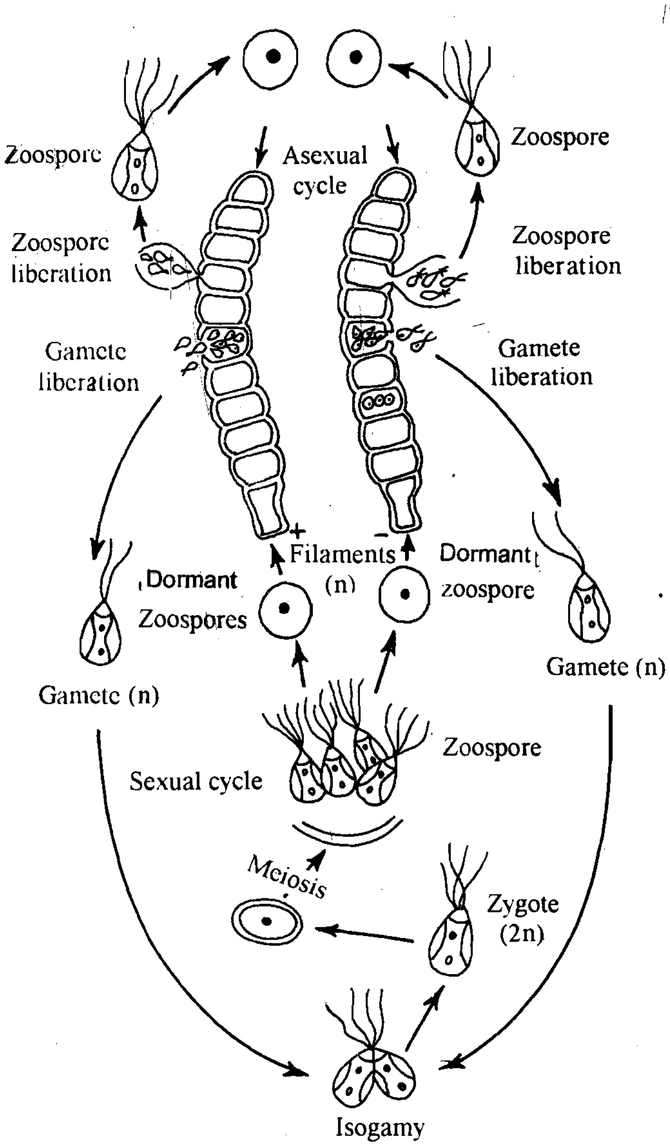

Fig. 4.8 : Life cycle of *Ulothrix.*

Box Item 1

Alternation of Generations

The type of life cycle of an organism in which reproduction alternates with each generation between sexual reproduction and asexual reproduction is called alternation of generations. The two generations are termed as **gametophytic** and **sporophytic** generations. The gametophytic generation is haploid(n) and the sporophytic generation is diploid (2n).

The fusion of two gametes(n) results in zygote(2n) which on germination forms the plant / thallus called sporophyte. The sporophyte in turn produces haploid spores by meiosis. When a spore germinates it develops into gametophyte which bears male or female gametes or both on the same plant / thallus.

In some bryophytes the gametophytic generation is more conspicuous. While in ferns the sporophytic generation is more prominent. In angiosperms main plant body is sporophyte and the gametophytic generation is reduced to a few cells. You will see that all type of situations prevail in algae. In some algae gametophyte is prominent while in others sporophyte is prominent

4.3.3 *Ulva*

The life cycle of *Ulva* is shown in Fig. 4.9. Note the thalli of sporophyte and gametophyte. Both are morphologically alike. However, the gametophyte is haploid (n) whereas the sporophyte is diploid (2n). The haploid gametophyte produces gametes and the diploid sporophyte produces after meiosis zoospores that germinate to form haploid gametophytes.

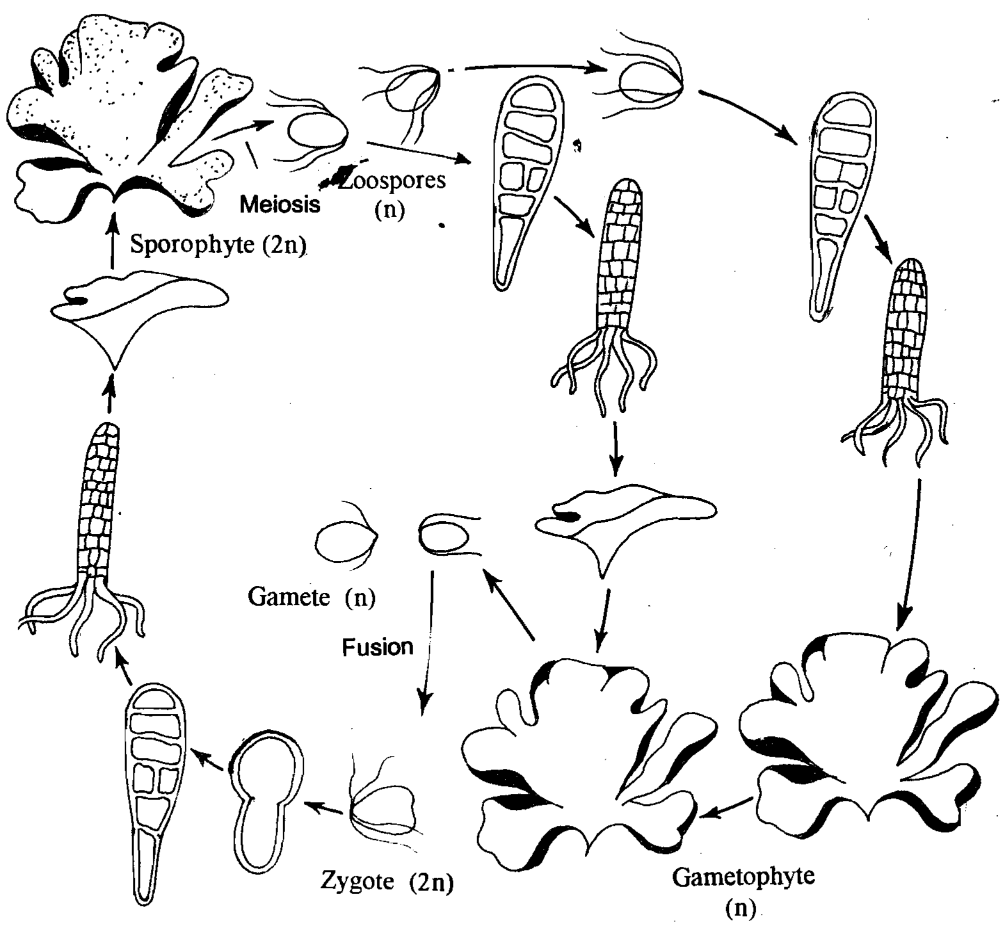

Fig. 4.9: Life cycle of *Ulva*. Note the isomorphic alternation of generations.

The gametophytes of *Ulva* produce gametes which are isogamous or anisogamous. After fusion the zygote is formed which develops into a diploid sporophyte.

The life cycle of *Ulva* is described as **isomorphic, diplobiontic** type.

4.3.4 *Laminaria*

Sexual reproduction in *Laminaria* is oogamous type.

The mature diploid thalli of sporophytes produce sori or unilocular sporangia on the surface of the lamina. Each sporangium divides by meiosis to give rise to 32 biflagellate zoospores which germinate to form male and female gametophytes (Fig. 4.10).

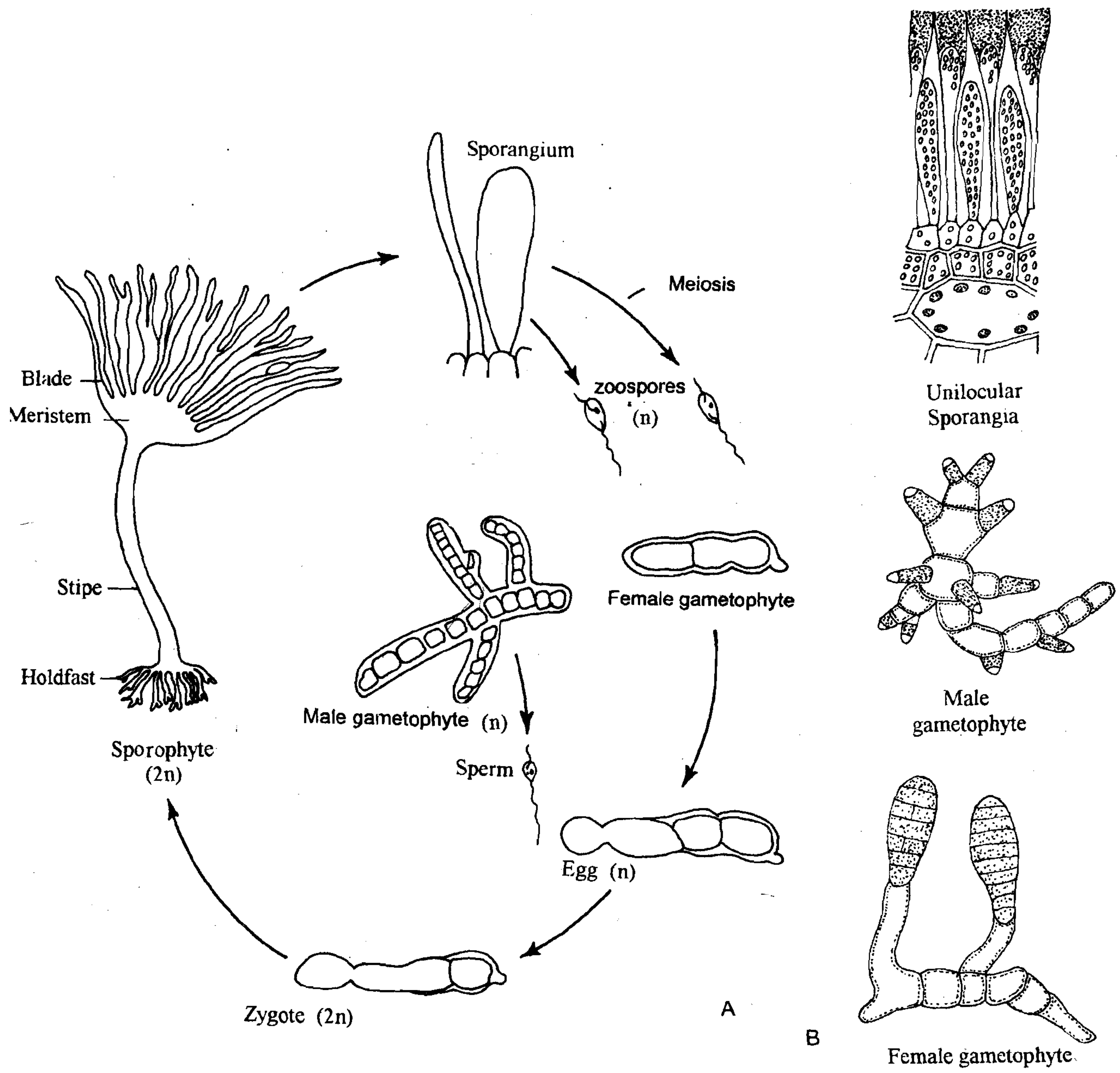

Fig. 4.10: A) Life cycle of *Laminaria*. B) The sporophyte is macroscopic and the male and female gametophytes are microsopic.

The gametophytes of both sexes are microscopic with a few branches and their fertility is controlled by environmental conditions.

Any cell of the female gametophyte can develop into an oogonium, the contents of which form a single egg. The egg protrudes out when mature but remains attached to the mouth of the empty oogonial cell.

Antheridia are produced singly as lateral outgrowths of the male gametophyte. Only one sperm is produced from each antheridium, which is pear shaped and has two flagella of unequal length.

After fertilization the zygote immediately divides mitotically without any resting period and develops into a sporophyte (Fig, 4.10).

Life Cycle

In *Laminaria* there is a distinct alteration of haploid gametophyte and a dominant diploid sporophyte.

Reduction division takes place in the sporangia of sporophyte before the formation of zoospores, which germinate to form the male and female gametophytes.

The two dissimilar generations - one simple filamentous gametophyte and the other highly differentiated, complex multicellular thallus - alternate with each other - hence the life cycle is termed **heteromorphic alternation of generations.**

4.3.5 *Fucus*

Fucus has advanced type of reproductive structures, termed as **receptacles**, which are swollen at the tips of branches (Fig. 4.11 A).

Distributed over the surface of each receptacle are small pores, known as **ostioles** which lead into the cavities, called **conceptacles** (Fig. 4.11B). Each conceptacle may produce only eggs, only sperms or as in some cases both. A thallus may be unisexual - either having male receptacle or only female ones.

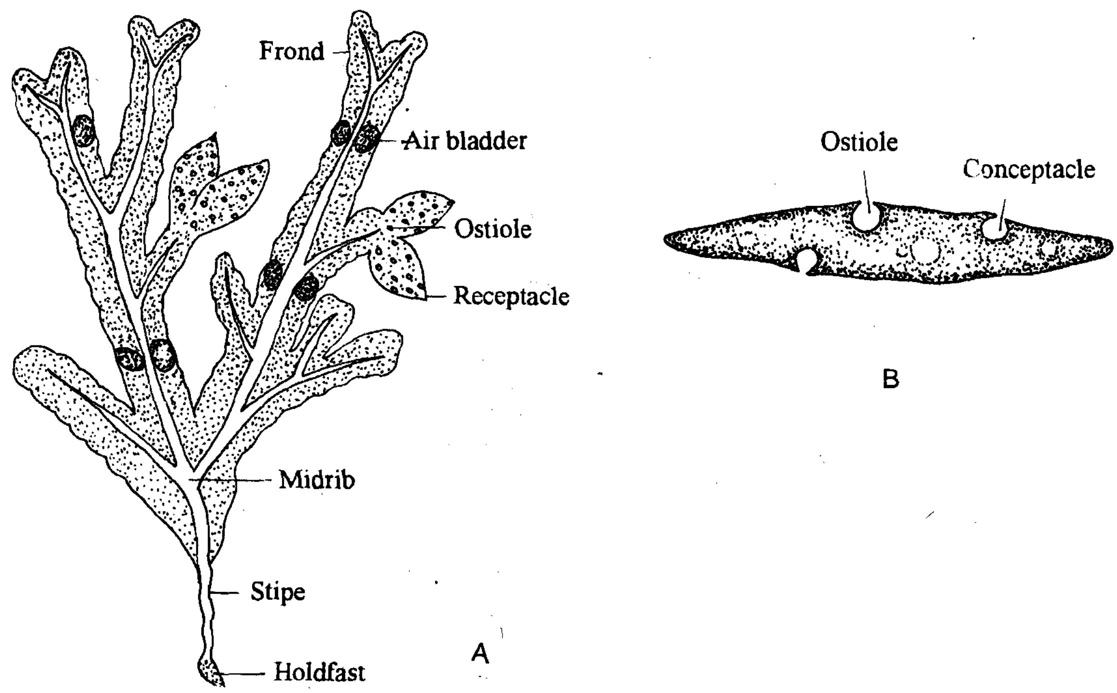

Fig. 4.11 : *Fucus*: A) Structure of thallus, B) Enlarged receptacle.

At the base, inside the conceptacle is a fertile layer of cells which develops into oogonia (Fig. 4.12A and 4.14A). Each oogonium has a basal stalk cell and an upper cell which undergoes reduction division and produces eight haploid eggs (4.12 C and D). These are liberated in the conceptacle (Fig. 4.12E). Some of the cells inside the conceptacle produce unbranched multicellular hairs called **paraphyses** which emerge out of the ostiole as tufts.

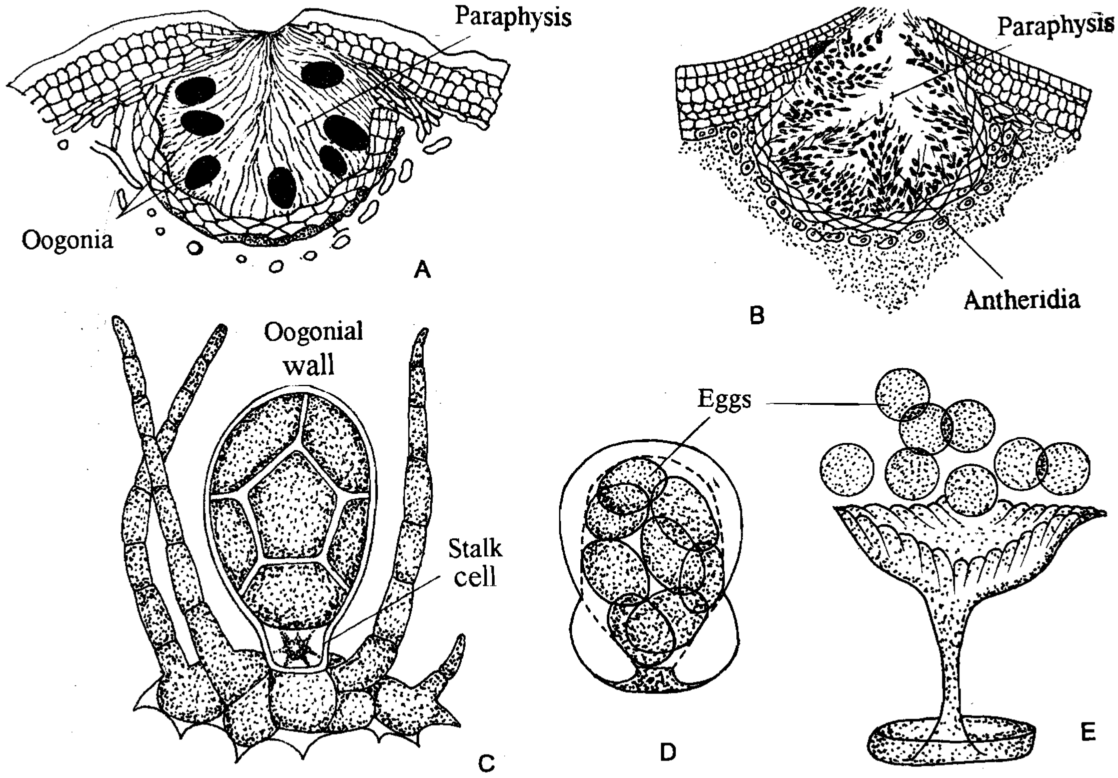

Fig. 4.12: *Fucus* **A) T.S. through female conceptacle showing oogonia, B) T. S. through male conceptacles showing antheridia, C) structure of an oogonium, D and E) formation and liberation of eggs.**

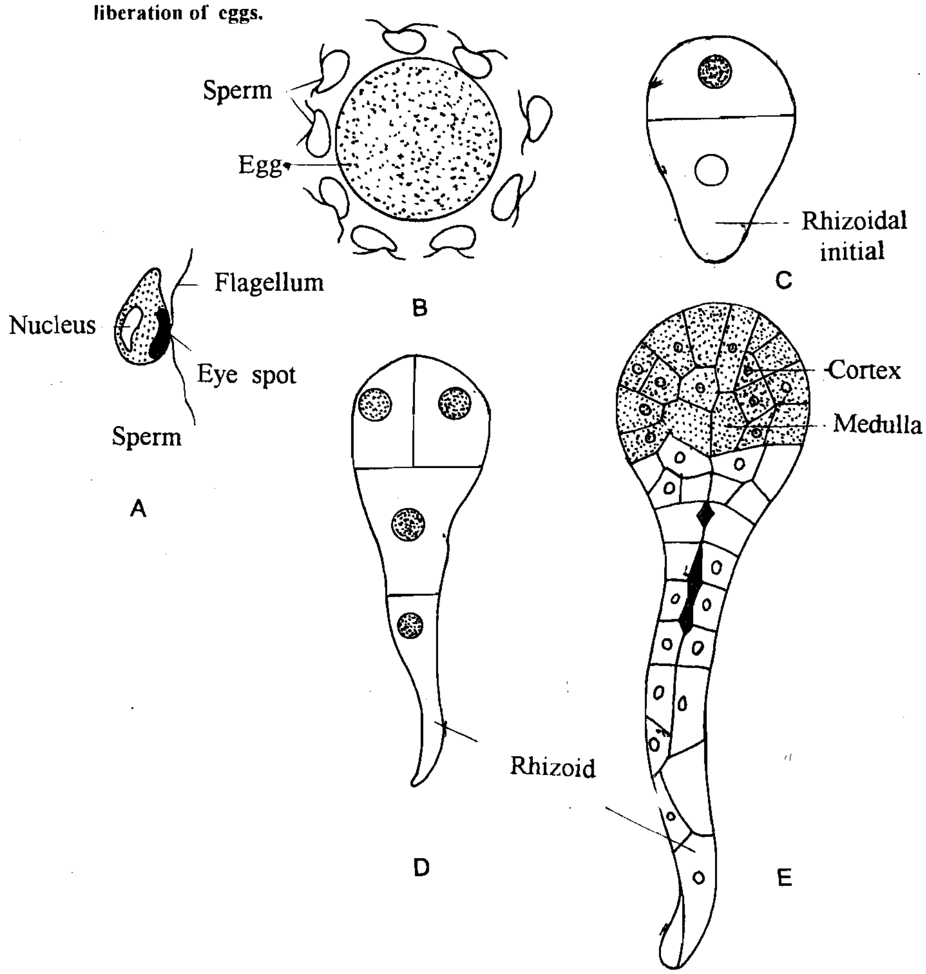

Fig. 4.13: Formation and developmental stages of a zygote.

Antheridia are produced on branched paraphyses inside the conceptacle (Fig 4.12B and 4.14B). Each antheridium is like a unilocular sporangium which divides meiotically and then by further divisions produces 64 haploid sperms. The biflagellate sperm has a longer flagellum pointing backwards and a shorter one projecting towards the front. It has a single chloroplast and a prominent orange eye spot (Fig. 4.14A).

The release of the gametes is connected with the sea tides. At low tide, *Fucus* fronds shrink due to loss of water, and when such fronds are exposed to an on coming tide, the eggs and sperms are released into the surrounding sea water.

The eggs of *Fucus* are known to attract sperms (Fig.4.13 A and B) by secreting a gamone . Immediately after fertilization a wall is secreted around the zygote. It has been shown that unfertilized eggs can develop into germlings parthenogenetically if treated with dilute acetic acid.

The diploid zygote germinates by producing a rhizoidal outgrowth on one side. It is later cut by wall formation to form a lower rhizoidal cell and apical cell (Fig. 4.13C) which by further divisions (Fig. 4.13 D and E) gives rise to the *Fucus* fronds.

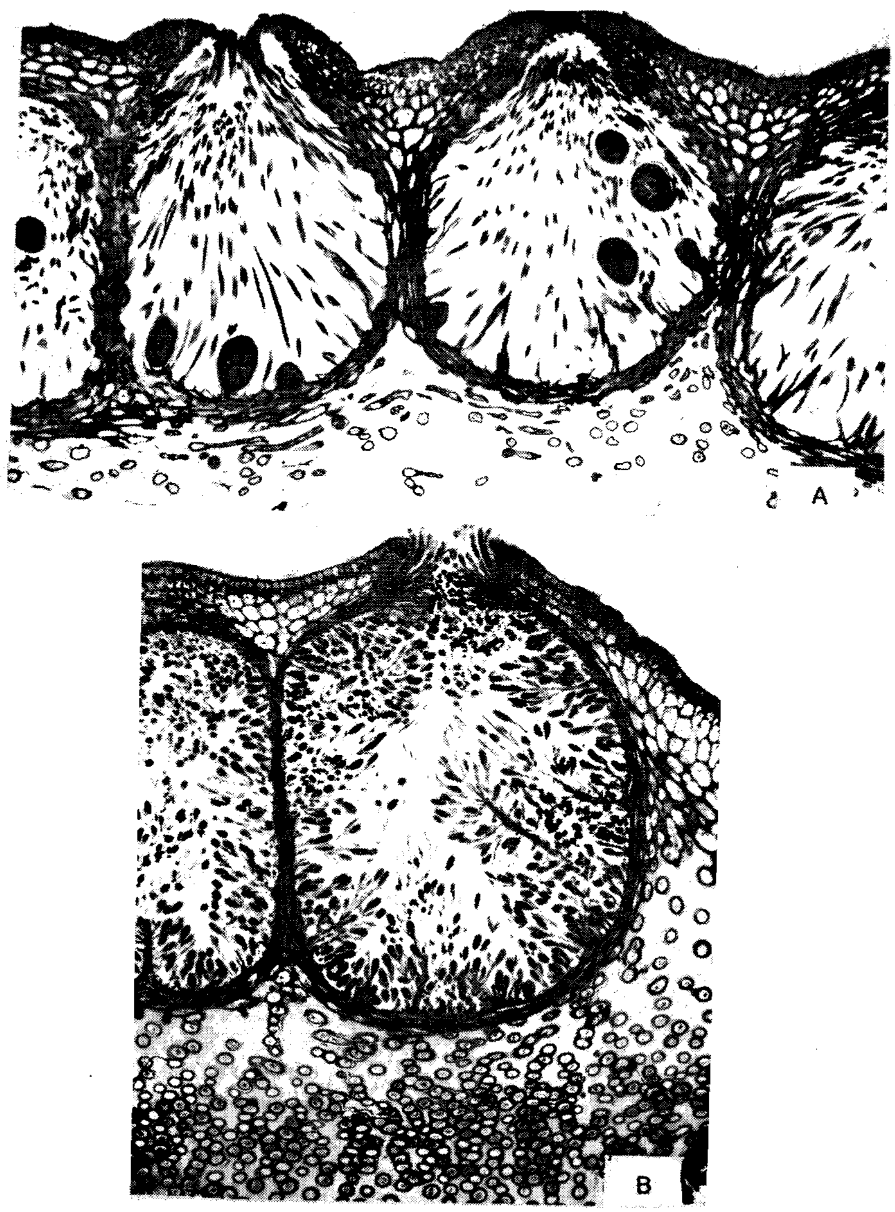

Fig. 4.14: *Fucus*: A) C.S. of a female conceptacle and B) C. S. of male conceptacle.

Life Cycle

Fucus plants are diploid and the haploid stage is represented by gametes only. The life cycle of *Fucus* is described as diplontic life cycle.

The four basic types of life cycles described above are summerised in Fig. 4.15.

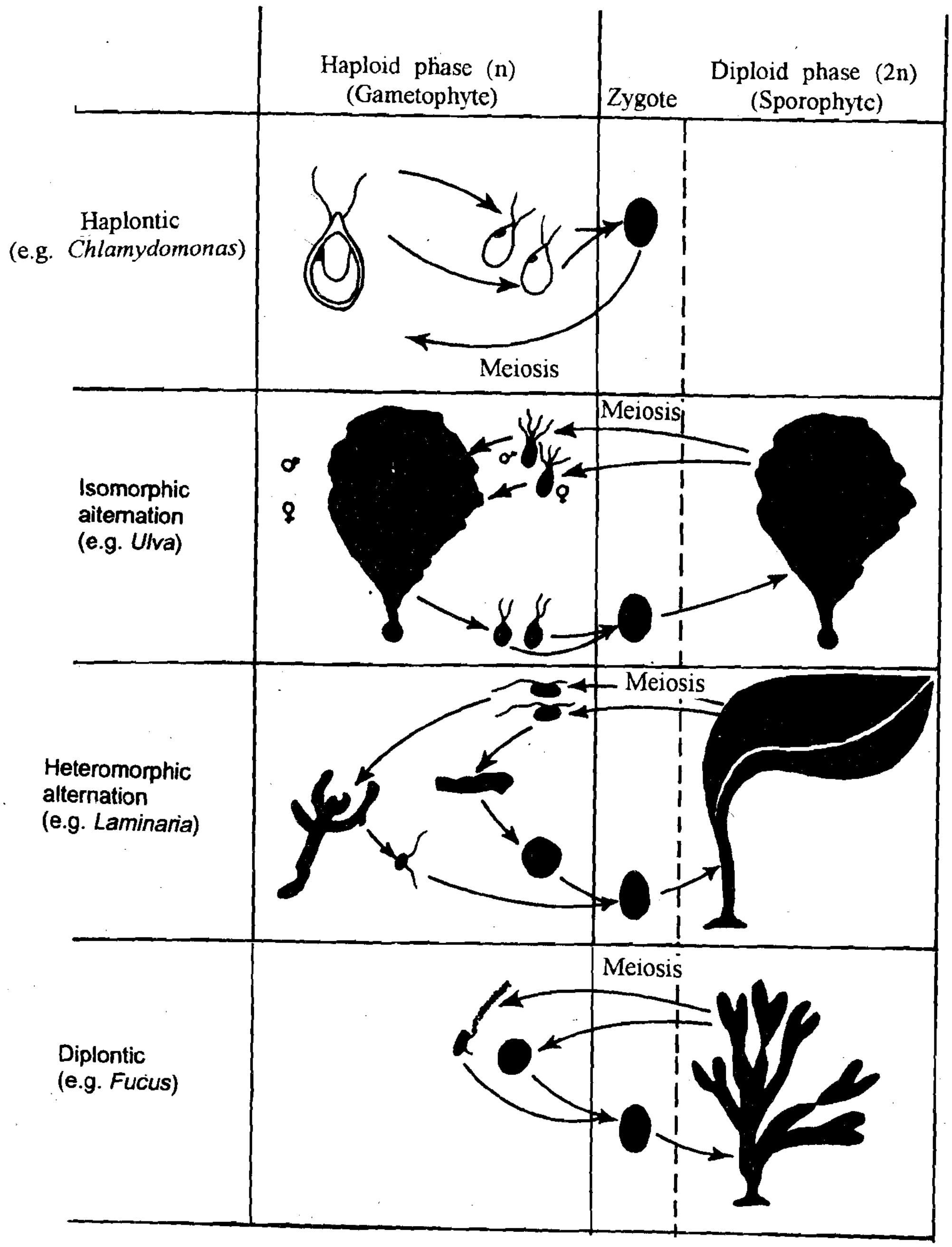

Fig.4.15 : Four basic types of life cycles in algae.

When the dominant phase is the haploid gametophyte, the life cycle is termed as haplontic life cycle. In this cycle diploid state or sporophyte is represented by zygote which produces spores by meiosis that develop into gametophytes.

In diplontic cycle the main or dominant phase is the diploid sporophyte. The zygote directly germinates into a sporophyte. Later meiosis takes place producing haploid gametes that fuse to form the zygote. In the diplontic algae it is to be noted that no free living haploid thalli are found.

When both the gametophyte and the sporophyte are equally developed and look morpholoigically similar, we have isomorphic alternation of generations. However, if gametophyte is underdeveloped compared to the sporophyte the life cycle is known as heteromorphic alternation.

SAQ 4.2

a) In the following statements choose the correct alternative word given in the parentheses.

i) Zygote of *Chlamydomonas* undergoes (meiosis/mitosis) during germination.

ii) Short-day condition initiates the formation of (zoospores/gametes) in *Ulothrix*.

iii) In haplontic life cycle, the alga is (haploid/diploid), only the zygote is (haploid/diploid).

iv) In (haplontic/diplontic) type of life cycle the alga producing gametes is haploid and the alga producing zoospores is diploid.

v) The reproductive structures present at the swollen tips of branches in *Fucus* are called (receptacles/conceptacles).

vi) The small pore present on the (receptacle/conceptacle) leads to a cavity called (receptacle/conceptacle).

b) In the following statements fill in the blank spaces with appropriate word(s):

i) The alternation of generations where gametophyte and sporophyte of a given species are morphologically distinct from each other; the gametophyte generally microscopic is called ....

ii) In .... the thallus of gametophyte and sporophyte are morphologically alike. Such type of alternation of generations is called ....

iii) Ostioles are the .... on the surface of receptacles that lead into the cavity called ....

iv) In *Fucus* sperms are ....

v) In *Fucus* the eggs secrete .... to attract sperms.

vi) The life cycle of *Fucus* is of .... type of alternation of generations.

4.4 ORIGIN AND EVOLUTION OF SEX

4.4.1 Origin of Sex

The basic feature of sex is the fusion of two cells – gametes which are of two types, male (plus) and female (minus).

What factors lead to the fusion of cells as such is not clear but fusion brings about mixing of two different (but related) genomes together, one probably compensating for the deficiencies of the other. This particular feature is a biological advantage for the survival of the species. It is no wonder that almost all organisms developed sexual method of reproduction.

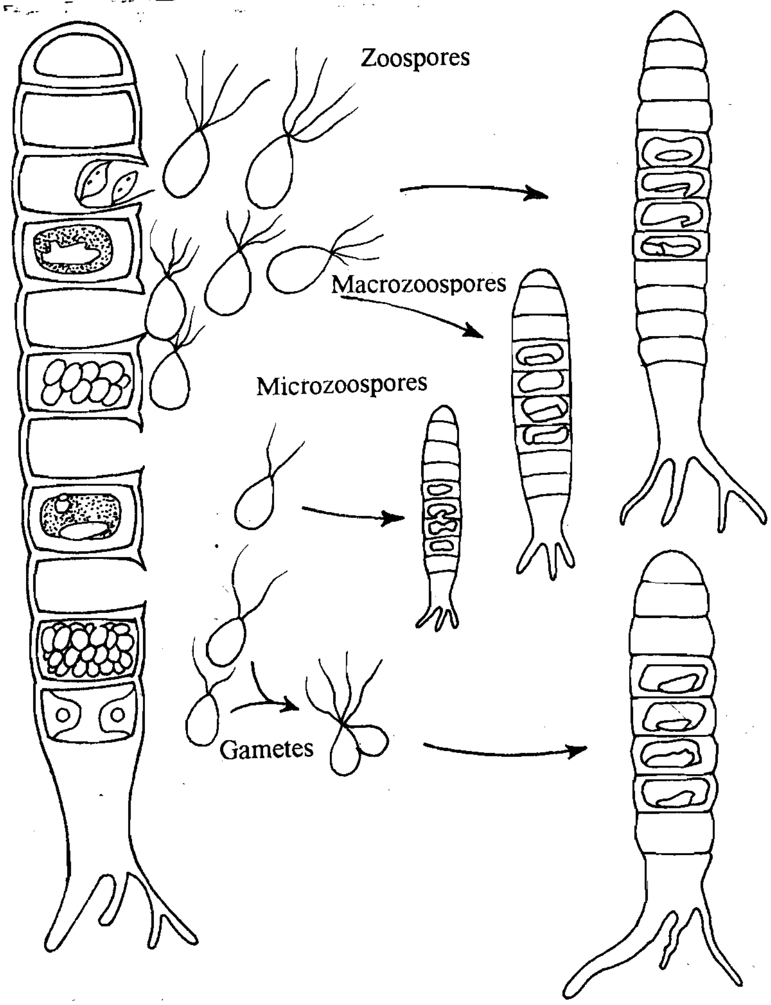

Fig. 4.16 : Hypothetical diagram illustrating the origin of sex in *Ulothrix* (Adapted from Kumar and Singh, 1990).

Even in the case of prokaryotic cyanobacteria, and also in other bacteria different mechanisms were discovered (para-sexual mechanisms) whose essential feature is exchange or mixing of genes or complete genomes between a donor and a recipient.

In all eukaryotic algae as in all plants and animals, fusion of cells is the method by which sexual reproduction takes place. The question is how this fusion of cells originated and further how this phenomenon was preserved and refined during evolution. The study of the sexual processes found in the present day algae provide some answers to the above questions.

In lower algae like *Chlamydomonas*, *Ulothrix* and others asexual reproduction takes place through motile swarmers called zoospores. In *Ulothrix* depending on the number of divisions that a cell undergoes, at least two types of zoospores are produced, small **microzoospores** and large **macrozoospores**. The microzoospores often fail to germinate to produce new plants, probably due to deficiency or low level of some vital substances needed for cell division and growth. However, such swarmers are found to fuse in pairs occasionally and then develop into *Ulothrix* filaments. It appears that macrozoospores are self sufficient and do not require any such fusion.

In many algae one can not make out any difference in structure between a zoospore and a gamete, except for their behaviour - a zoospore directly develops into a filament whereas a gamete needs fusion with another gamete for further development. If certain type of zoospores - small microzoospores can behave like gametes, at times gametes which fail to fuse may behave like zoospores and develop directly into thallus - a phenomenon called **parthenogenesis** reported to be present in diverse organisms. Such observations indicate that gametes are modified zoospores and gametic fusion originated through accidental fusion of small and weak zoospores. As such fusions in general help by genetic mixing, to acquire characters useful for biological survival, the essential features of sex were retained and improved further during evolution.

4.4.2 Evolution of Sex

Isogamy, fusion of identical gametes seems to be the earliest state of sex. However, the morphologically similar gametes may be different in origin, arising from two different gametic mating types, plus and minus strains (heterothallic).

The simplest early state appears to be the fusion (not any more accidental but regularised) of morphologically similar gametes, perhaps arising from the same thallus - homothallic isogamy. This is improved further by heterothallic isogamous fusion, in which though gametes looked morphologically similar but with genetical and biochemical differences to encourage fusion of opposite mating types, plus and minus only.

Anisogamy constitutes an intermediary state as it may involve fusion of gametes with distinct size difference. Although both gametes are flagellated, the bigger one may be less active than the smaller male gamete. Further refinement ultimately led to oogamy - which is the most common and the only form of sexual reproduction in higher thalloid algae.

Oogamy is characterised by big non-motile egg and a small motile spermatozoid. The gametes may be produced in oogonia and antheridia. The oogonia may produce only a few eggs (eight) or as in some algae a single egg, while the number of sperms formed is always very large.

Generally, the eggs are liberated into the surrounding water but there is a tendency to retain the egg inside the oogonium itself, where fertilization also takes place. The zygote or oospore may develop further inside the empty oogonium.

It is to be noted that the above account of the origin and evolution of sex is entirely based on the study of reproductive process of various algae. Biologists in recent years discovered that in algae, sex has genetic and biochemical basis. In *Chlamydomonas* gametes produce a volatile substance that attracts the gametes of the opposite sex. The eggs of *Fucus, Laminaria, Oedogonium* and many other algae have been shown to produce species-specific chemicals to attract the spermatozoids. Such chemicals are known by a collective name 'gamones or pheromones' or sex hormones.

In algae, several other processes connected with reproduction like gametogenesis, chemotaxis of gametes, adhesion and fusion of gametes of opposite sex - are known to be controlled by pheromones.

SAQ 4.3

a) Indicate which of the following statements are true or false. Write **T** for true and **F** for false in the given boxes.

i) In many algae zoospores and gametes cannot be distinguished from their morphology. ☐

ii) In algae at times zoospores behave like gametes and gametes behave like zoospores. ☐

iii) Plus and minus gametes are genetically alike. ☐

4.5 SUMMARY

In this unit you have learnt that:

- Algae reproduce by vegetative, asexual and sexual methods,
- Asexual reproduction involves the formation of various types of spores formed in any vegetative cell or in specially differentiated cells,
- Sexual reproduction in algae involves fusion of two gametes.
- The gametes may not have clear morphological differences to be called male or female, hence designated as plus and minus mating types. The fusion product is known as zygote.
- In isogamy both the gametes are equal in size and flagallated, in anisogamy both are flagellated but one gamete is bigger in shape and size called female or minus type. In Oogamy the bigger one, is without flagella, non-motile egg and male gametes, spermatozoids are small and motile.
- Haploid gametes are produced by mitosis in a haploid thallus or by meiosis in a diploid thallus. A complete life cycle of an alga involves two phases - haploid phase and a diploid phase.
- In different algae the haploid and diploid phases show a variety of morphology and the two phases alternate with each other known as alternation of generations, even though both phases occur within a single life cycle.
- Algae show haplontic, diplontic, isomorphic and heteromorphic alternation of generations.

4.6 TERMINAL QUESTIONS

1. List the factors that control the life cycle of an algae.

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2. With the help of a labelled diagram describe the three types of gametic fusion in sexual modes of reproduction.

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3. What is the special advantage of sexual reproduction to a particular species?

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4. "Gametes are modified zoospores" Comment.

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4.7 ANSWERS

Self-assessment Question

4.1 a) *Anacystics,* and *Microcystis*

b) i) Akinete, ii) aplanospores, iii) new filament, iv) palmella stage, v) homothallic or monoecious, vi) heterothallic or dioecious, vii) isogamy, viii) distinctly different in size.

c) i) haploid, ii) female, male, gamone, iii) zygote

4.2 a) i) meiosis, ii) zoospore, iii) haploid, diploid, iv) diplontic, v) receptacles, vi) receptacle, conceptacle

b) i) dimorphic
ii) *Ulva*, isomorphic,
iii) small pores, conceptacle
iv) biflagellate
v) gamone
vi) diplontic

4.3 i) T, ii) T, iii) F

Terminal Questions

1. Temperature
Light
Availability of nutrients
Seasons
Wave action
Periodicity of tides
2. Isogamy
Anisogamy
Oogamy
3. There is mixing of two different but related genomes, one compensating for the deficiency of the other. This is particularly advantageous for the survival of species.
4. In many algae one can not make out any difference in structure between a zoospore and a gamete, except for their behaviour - a zoospore directly develops into a filament whereas a gamete needs fusion with another gamete for further development. If certain type of zoospores - small microzoospores can behave like gametes, at times gametes which fail to fuse may behave like zoospores and develop directly into thallus - a phenomenon called **parthenogenesis** reported to be present in diverse organisms. Such observations indicate that gametes are modified zoospores and gametic fusion originated through accidental fusion of small and weak zoospores.