REPRODUCTION

This is the process by which new generations of offspring are produced in a population.

Reproduction involves the transmission of genetic material from one generation to the next ensuring that the species survive over long periods of time even though individual members of the species die. Some members of the species will die before they reach the reproductive age due to factors like diseases, predation etc so that the species will only survive if each generation produces more offspring than the parental generation. Population size therefore varies according to the balance between rate of reproduction and mortality rate of the individuals.

Types of reproduction

1. **Asexual reproduction.**

This is where new individuals are produced from a single parent without production of gametes.

It usually results in production of genetically identical offspring. However, genetic variation may arise as a result of random mutations among the individuals.

2. **Sexual reproduction**.

This involves the fusion of two gametes to form a zygote which develops into a new organism.

Sexual reproduction forms the basis of genetic variation and provides the raw material for natural selection hence evolution of new species.

ASEXUAL REPRODUCTION

Asexual reproduction allows production of new individuals from a single parent and does not involve formation of any gametes or sex cells. The offspring are produced by mitosis and are identical and are called **clones**. Members of a clone are always identical genetically but differ only when random mutation occurs.

Types of asexual reproduction

1. **Fission.**

This occurs in simple protists e.g. amoeba, bacteria etc. it involves the division of the cell into two or more daughter cells identical to the parent cell.

In a bacterium, the cell divides into two identical daughter cells, a process called **binary fission.**

In plasmodium, the nucleus of the cell divides repeatedly by mitosis and each daughter nucleus breaks away with a small portion of the cytoplasm, a process called **multiple fission**. The splitting process during multiple fission is called **schizogony** and the cells produced are called **schizonts.**

Multiple fission produces as many as 1000 daughter cells from a single schizont during the parasites asexual cycle immediately they enter the liver cell. Each of this then enter the red blood cell and produce a further 24 daughter cells and this increases the infection rate rapidly.

When conditions are favorable fission results into rapid population growth.

Binary fission in a bacterium. (Diagram)Ref BS pg 15

2. **Sporulation.**

This involves the formation of spores. Spores are microscopic reproductive cells produced in large numbers by cell division by the parent organism. They are very light and easily dispersed by air current, water as well animals. They are capable of germinating very fast if conditions are favorable.

Spores are produced by some bacteria, protists, fungi and many lower plants like mosses and ferns.

In fungi, the body structure consists of a mass of threads of fine tubes called **hyphae** and the whole mass of the hyphae is called **a mycelium**. At the tips of the hypha, spores are formed either enclosed in a spherical structure called sporangium or are free. Cytoplasmic streaming causes the nuclei to cluster at the tip. The tip swells as more nuclei and cytoplasm flow in the sporangium. The sporangium burst releasing spores which are later dispersed by wind. The spores germinate when conditions are favorable giving rise to a new hypha.

3. **Budding.**

This is where new individuals are produced as an outgrowth (bud) of the parent plant which increases in size and eventually drops off to live an independent life. This occurs in yeast cells, hydra, certain flat worms as well as lower animals.

4. **Fragmentation.**

This is where an organism may break into one or more pieces which grow into a new individual. Fragmentation depends on the ability of an organism to regenerate itself into a new individual. It occurs in fungi, filamentous algae (spirogyra), sponges etc.

5. **Vegetative propagation.**

This is the most common form of asexual reproduction in plants where part of the plant body grow and develop into a new plant. This may occur naturally or artificially.

Natural vegetative propagation

This is where a new individual develops on the parent plant and later detaches itself from the differentiated part. These plants have specialized parts which store food used for survival during unfavorable conditions called **perennating organs** e.g. bulbs, rhizome, tubers etc.

Food manufactured during photosynthesis in the aerial green leaves are translocated via conducting tissues to the base of the plant where they are changed into starch and stored in the perennating organ. In this state the plant remain dormant but as conditions become favorable, the stored starch is converted to sugar which is supplied to the young buds which grow and sprout while the older aerial shoot begin to die.

Types of perennating organs

1. **Bulb e.g. an onion.**

This is a short swollen stem capable of vegetative propagation. It is covered with brown papery scaly leaves which protect the inside fleshy foliage leaves containing stored food as glucose and vitamin C. in the axil of these leaves are buds which grow and sprout to form a shoot which produces a new bud at the end of the growing season. They have adventitious roots that arise from the reduced stem which anchors the shoot in the soil.

Longitudinal section of an onion bulb (ref diagram BS)

2. **Corm. E.g. yam**

This is a short vertical underground stem. A corm is a more or less spherical body containing heavy deposit of food materials stored in the swollen base of the stem. It has scale leaves but no fleshy foliage leaves like in bulbs. The nodes bear axiliary buds which may develop into new shoots in the next growing season. Food is manufactured by photosynthetic green leaves which are then carried down to the buds which grow into daughter corms. They have adventitious roots which grow from the short swollen stem.

Diagram of a corm (ref diagram BS)

3. **Rhizome e.g. ginger, canalilly, spear grass etc.**

This is a horizontal under ground stem which bears green foliage leaves and scale leaves, buds and adventitious roots. In the axil of the dry scale leaves are buds that sprout to produce new lateral rhizomes or vertical shoots.

Rhizome of canalilly (ref diagram BS)

4. **Tubers.**

These are underground storage organs formed from a stem or root swollen with food and capable of perennation. Tubers survive for only one year and shrivel as their storage contents are used up during the growing season. New tubers are made at the end of the growing season but don't arise from old tubers.

Stem tubers e.g. potato

These are stem structures produced at the tips of thin rhizomes. The stem structure is revealed by the presence of the axillary buds in the axil of the scale leaves. Each bud may grow into new plant during the next growing season.

Root tubers e.g. cassava

These are swollen adventitious roots. Being roots they lack scale leaves and buds although they act as storage organs. New shoots develop from the buds which are on the parent plant.

Tap roots may also become swollen with food storing tissues e.g. in carrots. Together with buds at the base of the old stem just above the tap root, they form organs of perennation.

5. **Stolons and runners.**

A stolon is a creeping horizontally growing stem that grows along the ground surface. It has adventitious roots growing from the nodes. The stem grow diagonally upwards then bends to the ground putting roots out at the tip and producing a bud which grows into a new daughter plant e.g. blackberry, black currant etc.

A runner bear scale leaves with axillary buds which give rise to adventitious roots and new plants. A number of stems usually radiate from the parent plant and new plants develop along the runner where it puts down adventitious roots. The old runner then decays once the new plants are produced e.g. straw berry, creeping buttercup etc.

Artificial vegetative propagation

These involve the separation of a portion from the mother plant and then growing it independently. This is mainly used in agriculture and horticulture. These include;

1. **Cuttings.**

A cutting is a portion of a stem or root which when detached from the parent plant is capable of developing roots under favorable conditions and growing into a new plant e.g. stem cuttings of sugar cane, cassava etc.

2. **Grafting.**

Grafting involves transplanting of a portion of one plant called **scion or donor** onto another plant of the same genus called **stock or recipient**. The advantage of this is that certain beneficial traits of the two plants grafted are combined and also allows rapid multiplication. It mainly used in the propagation of citrus fruits, roses, hibiscus etc.

3. **Layering.**

This is used in plants that produce runners such as straw berries. The runners are pegged out or layered around the parent plant until they produce roots and then cut to detach them from the parent plant so that they can grow independently.

4. **Suckers.**

These are young buds removed from the parent plant and allowed to grow independently e.g. pineapple, banana etc.

Advantages of asexual reproduction

1. It results in maintenance of favorable characters since the offspring are genetically identical.
2. The offspring have greater chances of survival and mature faster since the daughter organisms remain attached to the parent plants which usually have large food reserves.
3. It leads to rapid rate of multiplication and hence rapid increase in population.
4. It does not require much specialization like formation of reproductive organs in sexual reproduction.
5. Only one parent is involved therefore does not require external agents like pollinators etc since every single individual is self sufficient.
6. Enables rapid spread and dispersal of organisms to a wide area e.g. the spores produced is light and easily dispersed by air currents.

Disadvantages of asexual reproduction

1. Does not promote genetic variation hence maintenance of undesirable characters in a population.
2. It results into quick colonization of new areas which may result into over crowding, competition and exhaustion of nutrients since the organisms tend to colonize a limited area.
3. Certain undesirable characteristics carried by the parent organisms are transmitted from parents to the daughter offspring hence the offspring are more prone to pest and diseases.

Differences between asexual and sexual reproduction. Ref BS pgs701-711

SEXUAL REPRODUCTION

This involves the production of offspring by fusion of two gametes to form a diploid zygote which develops into a mature organism.

Gametes are sex cells that contain a single set of chromosomes (haploid) produced inside the reproductive organs by process of meiosis. During meiosis, crossing over occurs in prophase I and there is random segregation/independent assortment of homologous pairs of chromosomes during metaphase I. Haploid gametes are produced during meiosis and when these haploid gametes fuse at fertilization, the diploid number of chromosomes is restored. Sexual reproduction therefore causes variation among the offspring.

Gametes usually differ from each other in structure, size and behavior but are of two types i.e. male and female gametes. Gametes which are different in structure, size and behavior are called **heterogametes** e.g. sperm and egg cell. This may be produced by separate male and female parents or by a single parent having both male and female reproductive organs. Species that have separate male and female individuals are described as **unisexual** while those capable of producing both male and female gametes within the same organism are described as **hermaphrodite** or **bisexual**.

However, in primitive organisms e.g. green algae and fungi, the gametes produced are of one type only and always identical with each other known as **isogametes** or the gametes may just be slightly different from each other known as **anisogametes.**

At the simplest level, there are no gametes at all but genetic material is transferred directly from one individual to another.

Types of fertilization

1. **Internal fertilization.**

This is where fusion of gametes occurs inside the body of the organism. The evolutionary advantage of this is that it results in the production of offspring at later stages of development capable of resisting changes to environmental conditions.

Types of internal fertilization

i) **Viviparity**. This is where fusion of gametes occurs inside the body of the female and the embryo is protected by embryonic membranes through out gestation period and nourished within the womb and produced at a comparatively advanced stage of development. This takes place in placental mammals e.g. man.

ii) **Oviparity**. This is where fusion of gametes occurs inside the body and thin shelled eggs are laid with little development if any of the embryo e.g. in grasshoppers.

iii) **Ovoviparity**. This is where fusion of gametes occurs inside the body and the eggs are laid after a period of retention in which the embryo is nourished and produced at a later stage of development e.g. in birds.

Advantages of internal fertilization

1. It ensures greater chances of the gametes meeting and there by minimizing wastage of gametes. As a result, production of large numbers of gametes may not be necessary.
2. It occurs in all environments and at any time without the necessity of special environmental conditions e.g. returning to water.
3. The embryos are enclosed in a protective tissue before leaving the body of the female and are born at a later stage of development. This ensures greater chance of survival of the offspring.

2. External fertilization.

This is where fusion of gametes occurs outside the body of the organism e.g. in amphibians, fish etc.

Disadvantages of external fertilization

1. It requires special environmental conditions and when environmental conditions are unfavorable, fertilization is unsuccessful.
2. It requires production of large numbers of gametes since the chances of the gametes meeting is much reduced.
3. There is no protection offered to the developing embryo hence chances of survival of the organism is much reduced.

SEXUAL REPRODUCTION IN PLANTS

1. **Conjugation in algae e.g. spirogyra.**

In algae, there is no differentiation between the sexes; the donor cell is taken to be the male and the recipient cell the female.

Conjugation occurs when conditions are not favorable for binary fission or fragmentation to take place.

Types of conjugation

a) Scalariform conjugation.

During scalariform conjugation;

- Two filaments come close to each other and lie parallel to each other.
- A small protrusion known as **papilla** then develop from opposite cells on the filaments and grow towards each other until they reach a point of contact and force the filaments apart.
- The point of contact between the two papilla is then dissolved by enzyme action resulting into the formation of a **conjugation tube** mean while the cell content change into gametes.
- The gametes from one cell migrate through the conjugation tube to another and fuse to form a zygote.
- The zygote develops a thick resistant wall and becomes known as the **zygospore**. The cell walls of the filaments then breakdown and the zygospore is released and it settles at the bottom of water or is dispersed by wind.
- The zygospore can withstand unfavorable conditions but when conditions become favorable, it germinates into new spirogyra cells which can grow into a long spirogyra filament.

Illustration diagram

b) Lateral conjugation.

This involves only one filament. Fusion of cellular contents occurs between adjacent cells in the same filament and the rest of the process is similar to Scalariform conjugation.

Illustration diagram

2. Sexual reproduction in flowering plants.

A flower is a highly specialized shoot which act as the reproductive organs of the plant. Most plants have both male and female reproductive organs on the same plant and they are termed as **monoecious plants** e.g. hibiscus, maize plant etc while others have a single sex on the plant which can either be s**taminate** (male only) or **pistillate** (female only) and they are termed as **dioecious plants** e.g. pawpaw.

Diagram of a flower

The structure of a flower

A flower has four kinds of floral leaves arranged in rings or whorls attached to the receptacle. The floral leaves are;

1. **Calyx.** This is a collection of **sepals** which form the outermost whorl of the floral leaves. Sepals are usually green in colour and leaf-like in structure and they enclose and protect the floral buds. Occasionally, they may be brightly coloured and petal-like serving to attract insects for pollination. Sepals may be described as **polysepalous** when they are free at the base or **gamosepalous** when they are fused into a tube.

2. **Corolla.** This is a collection of **petals** forming the second whorl of the floral leaves. In insect pollinated flowers, the petals are usually large and brightly coloured and sometimes produce scent to attract insects while in wind pollinated flowers, the petals are usually reduced in size and green or may be entirely absent. Petals may be **polypetalous** when they are free e.g. pea flower or **gamopetalous** when they are fused into a tube e.g. primrose, ipomoea/ potato flower.etc.

   In monocots, the two outer whorls of the flower i.e. calyx and corolla are usually similar and the term **perianth** is used to describe the calyx and corolla while in dicots the two whorls can be differentiated.

3. **Androecium.** This is a collection of **stamens** forming the male reproductive organs of the flower. Each stamen consists of an **anther** and **filament.** The anther contains pollen sacs in which pollen grains are produced. The filament is a slender stalk which supports the anther at the tip and contains vascular bundles which transport water and food to the anther.

   Stamen can be described as;

- **Mono adelphous** if the anthers are free from each other and united by their filaments to form a **staminal tube** e.g. hibiscus
- **Diadelphous** if the anthers are united by the filaments to form two groups or when one is single and the others united e.g. (9)+1 condition in the bean family.
- **Poly adelphous** when the filaments are united to form numerous bundles or several groups.

Stamens can also be freely inserted (**polyandrous**) or inserted into the petals (**epipetalous**) or fused to the gynoecium (**gynandrous**).

Attachment of the anthers to the filament may be;

- **Basifixed** i.e. when the filament is attached to the base of the anther.
- **Dorsifixed** i.e. when the filament is attached to the back of the anther.
- **Versatile** i.e. when the filament is attached to the back of the anther but allowing free swing e.g. in maize.

Illustration diagrams

4. **Gynoecium.** This is a collection of **Carpels** which form the female reproductive organs of a flower. A carpel consists of stigma, style and ovary.

   The stigma receives pollen grains during pollination and the style bears the stigma in a suitable position in the flower to receive pollen grains.

   The ovary is the swollen hollow base of the carpel and contains one or more ovules. Ovules are the structures in which the embryo sac develops and after fertilization becomes the seed. The seed is attached to the ovary wall by a short stalk called **funicle** and the point of attachment is called **placenta.**

   The carpel of a flower may be described as **monocarpous** if it consists of only one carpel e.g. in crotalaria or **apocarpous** if it has more than one carpel which is separate and free or **syncarpous** if it has more than one carpel fused together and usually the ovaries and styles are fused but the stigma remains separate.

Terms used to describe flowers

1. **Complete flower.** This is a flower with all the four floral whorls present i.e. calyx, corolla, androecium and gynoecium.
2. **Incomplete flower.** Is a flower with one or more floral whorls missing.
3. **Perfect flower.** Is a flower with both male and female reproductive organs present.

4. **Imperfect flower.** Is a flower with either the stamen or the carpel present.
5. **Essential parts of the flower.** Are the reproductive parts of the flower i.e. androecium and gynoecium.
6. **Non essential parts of the flower.** Are the non reproductive parts of the flower i.e. calyx and corolla.
7. **Inflorescence.** Is a collection of flowers borne on the same stalk/peduncle.
8. **Bisexual/ hermaphrodite flower.** Is a flower with both the male and female reproductive organs.
9. **Dioecious / unisexual flower.** Is a flower with stamens and carpels borne on separate plants. A flower having only stamen is called **staminate flower** and one with only Carpels/pistil is called **pistillate flower** e.g. pawpaw.
10. **Monoecious flower.** This is a flower with separate male and female organs borne on the same plant e.g. in maize.
11. **Actinomorphic/regular flower.** Is a flower with **radial symmetry** i.e. a flower that can be divided into two similar parts along many planes e.g. hibiscus, morning glory etc.
12. **Zygomorphic/irregular flower.** Is a flower with **bilateral symmetry** i.e. can be divided longitudinally into two similar halves along one line e.g. bean flower, crotalaria flower etc.
13. **Hypogynous/superior ovary.** This is when the ovary lies above the other floral parts on the receptacle e.g. cassia flower, hibiscus flower etc.

    Diagram

14. **Epigynous/inferior ovary.** This is when the other floral parts arise above the ovary on the receptacle or when the ovary is below the origin of the other floral parts e.g. in sunflower, canalilly etc.

Diagram

INFLORESCENCE

This refers to the arrangement of flowers on a plant or is a collection of flowers borne on the same stalk/peduncle.

Each flower is called **a floret**. When the flowers are grouped, the main axis on which they are borne is called the **peduncle**. The small out growths often found on the pedicel are called **bracteoles** and may also be regarded as reduced leaves.

Types of inflorescence

1. **Racemose /indefinite inflorescence.** This is a type of inflorescence where the tip of the flower axis/stalk continues to produce new flower buds during growth. As a result, the youngest flowers are at the top and the oldest flowers are at the base of the stalk. In a flattened inflorescence e.g. Capitulum, the youngest flowers are in the centre and the oldest flowers are on the outside.

   Types

- Capitulum e.g. inflorescence of *Biden pilosa*, daisy, dandelion, sunflower
- Spike e.g. plantain, maize male inflorescence, grasses and cereals.
- Raceme e.g. cassia, jacaranda, hyacinth etc.
- Corymb e.g. lantana inflorescence.
- Umbel e.g. hogweed inflorescence.

2. **Cymose /definite inflorescence**. This is where the first formed flower develops from the growing region at the top of the flower stalk and the tip of the flower axis loses the ability to produce new flower buds during growth. Thus no new flower buds can be produced at the tip and other flowers are produced from lateral buds beneath.

   Types

- Monochasial cyme e.g. buttercup, forget-me-not (myosotis) etc. Here, development of the flower at the tip is followed by a new flower axis growing from a single lateral bud.
- Dichasial cyme e.g. bougainvillea. Here, the development of the flower at the apex is followed by two new flower axes developing from buds opposite one another.

Read more on inflorescence.

POLLINATION

This is the transfer of pollen grains with the help of pollinating agents from the anther to the stigma of a flower.

After formation of pollen grains in the pollen sacs, the cells in the wall of the anther begin to dry and shrink setting tension that eventually results in the splitting of the anther down the side along two lines of weakness. This result into the release of pollen grains which are then transferred by pollinators to the stigma of the flower.

Types of pollination

1. **Cross pollination.**

This is the transfer of pollen grains from the anther to the stigma of another flower on a different plant but of the same species.

This leads to cross fertilization/ outbreeding hence increased amount of genetic variation. When male gamete of one plant fertilizes the egg of a flower on another plant, the zygote contains a new mixture of chromosomes from both parents. The hybrid resulting from cross pollination shows increased resistance to diseases, high yield and early maturity. It therefore provides greater evolutionary potential.

Mechanisms that promote cross pollination/ cross fertilization/ outbreeding in flowering plants

i) **Self sterility or self incompatibility of the pollen grains on the stigma of its own flower**. In this case the pollen grains fail to germinate on the stigma of is own flower even if self pollination occurs. This may be as a result of specific inhibition of pollen penetration of the stigma or of pollen tube down the style determined by self incompatibility genes of some flowers.

ii) **Dichogamy**. This is a condition in which the male and female reproductive organs of the flower mature at different times there by ensuring that self fertilization does not occur. When the stamen matures/ripens first before the Carpel, it's described as **protandry** and when the Carpel matures first before the stamen, it's described as **protogyny.** This ensures that pollen from one plant can only fertilize the stigma of another plant of the same species if they mature at the same time.

iii) **Dioecious plant/unisexual plant** i.e. a plant having separate male and female reproductive parts on different plants e.g. pawpaw plant. This promotes cross pollination and selfing is prevented.

iv) **Monoecious plant** i.e. plant having separate male and female reproductive parts located at different position on the same hermaphrodite plant. This promotes cross pollination though selfing may also occur e.g. maize plant.

v) **Special floral structures**. In most hermaphrodite plants, there are special structural features that favor cross pollination;

- In insect pollinated flowers, the stigma is usually borne above the anthers thus preventing the possibility of pollens falling on the stigma of the same flower. A visiting insect carrying pollen from another plant will touch the stigma first as it enters the flower.

- In wind pollinated flowers, the stamen or the whole flower or inflorescence may hung down so that falling pollen may drop on the plant before being blown by wind to another flower.

Morphological and physiological adaptations to cross pollination

Morphological	Physiological
-brightly coloured corolla, often grouped in large clusters especially in insect pollinated flowers.	-stamens ripen before carpel (protandry) or carpel ripens earlier (protogyny).
-dioecious flowers have either stamens (staminate) or pistil (pistillate).	-incompatibility due to chemicals prevents germination of pollen on the stigma of same flower (self-sterility).
-Production of nectar which acts as a bait for insects.	
-stamens situated below the stigma (heterostyle). Stamens remain covered by corolla while the style continues to be exposed outside.	

2. **Self pollination/self fertilization/inbreeding.**

This is the transfer of pollen grains from the anther to the stigma of the same flower.

Self pollination leads to self fertilization/inbreeding and this promotes **homozygosity** i.e. transmission of the same genotype within the population from generation to generation hence no genetic variation within the population. Prolonged selfing leads to decreased fertility, decreased resistance to diseases and therefore decreased evolutionary potential of the species.

Mechanisms that promote self pollination/self fertilization/inbreeding in plants

i) **Self compatibility** of the stamen and the carpel such that the pollen can germinate on the stigma of its own flower.

ii) **Homogamy** i.e. when the male (stamens) and female (Carpels) reproductive organs of the flower mature at the same time there by allowing self fertilization to occur.

iii) **Bisexual flower** i.e. flower with both male and female reproductive organs on the same plant thus promoting self pollination.

iv) Flowers being borne underground or fail to open allowing self pollination to occur.

v) Stamens being situated above the stigma or anther is close to the stigma such that pollen from the anther easily fall on the stigma e.g. in maize plant.

vi) In some flowers the style and filament coil on one another so that the stigma touches on the ripe anther thus promoting self pollination.

vii) Cleistogamy i.e. a condition where some flowers releases pollen on to the ripe stigma surface before the flower bud opens thus favoring self pollination.

Morphological and physiological adaptations of self pollination

Morphological	**Physiological**
-flowers reduced and inconspicuous.	-stamens and carpels mature at the same time
-stamens situated above the stigma or the anther is close to the stigma.	-bisexual flowers may not open or remain under ground.
-stigma often coiled to touch ripe anthers.	-pollen released by matured anthers on the stigma before the flower opens
-style and filament coil on one another	-pollen is compatible with the tissues of style, thus allowing for their germination on the stigma.

POLLINATING AGENTS

The original agent of pollination earlier in the evolutionary history of plants was wind, but this is inefficient because it relies on chance interception of pollen grains by the flower. Many flowering plants (cereals) still rely on wind but they have to produce large quantities of pollen grains which is a drain on the plant materials and energy.

However, insects are much more precise agents of pollination than wind. This is because they can carry a small amount of pollen from the anther of one flower and deposit it precisely on the stigma of another flower; therefore there is no wastage of pollen grains. As a result of this, there is a special relationship between the insects and the flower in that, the insects receive food from the flower inform of nectar while the flower is pollinated.

Characteristics/adaptations of insect pollinated flowers/ entomophilous flowers

i) The flowers are conspicuous with large and brightly coloured petals which help to attract insects. If the flowers are tiny and inconspicuous, they are often held in inflorescence.

ii) They have small and sticky/glandular stigmas enclosed within the flower to hold the pollen grains.

iii) They produce large, rough and sticky pollen grains in small quantities for easy carriage by the insects so that they do not fall.

iv) The anthers are firmly fixed at their bases (basifixed) or fused along their backs (dorsifixed) so that they are immovable.

v) They produce nectar which acts as a bait and the flowers are usually scented to attract insects.

vi) The flowers are often in dense groups covering large areas to attract insects.

Characteristics /adaptations of wind pollinated flowers/ anemophilous flowers.

i) The flowers are inconspicuous with small dull coloured petals or no petals at all.

ii) They have large branched and feathery stigmas hanging outside the flower to trap the pollen grains.

iii) They produce small, light and smooth pollen grains in large quantities for easy carriage by wind.

iv) The anthers are loosely attached at mid point to the tip of the long filament (versatile) so that they can swing freely in air current and release pollen grains.

v) The stamen is usually pendulous i.e. dangle or hung outside the flower to release pollen grains.

vi) The flowers do not produce nectar or scent.

vii) The flowers are often single or in small groups.

Questions

1. **Discuss the genetic consequences of inbreeding and out-breeding in plants.**

2. a) Describe the mechanisms which promote out-breeding in monoecious plants. (12 marks)

b) Explain how sexual reproduction may cause variation. (8 marks) ref 2003 p2

3. Outline the differences between asexual and sexual reproduction.

4. Dioecious plants are rare, despite the advantages of cross pollination. Suggest the reasons for this.

b) Suggest why dioecism is more successful in animals than in flowering plants.

c) Give four differences between the stamens of insect pollinated and wind pollinated flowers.

5. Explain the reproductive strategies of flowering plants that have led to their;

(a) Diversity. (08 marks)

(b) Survival. (12 marks)

GAMETOGENESIS IN FLOWERING PLANTS

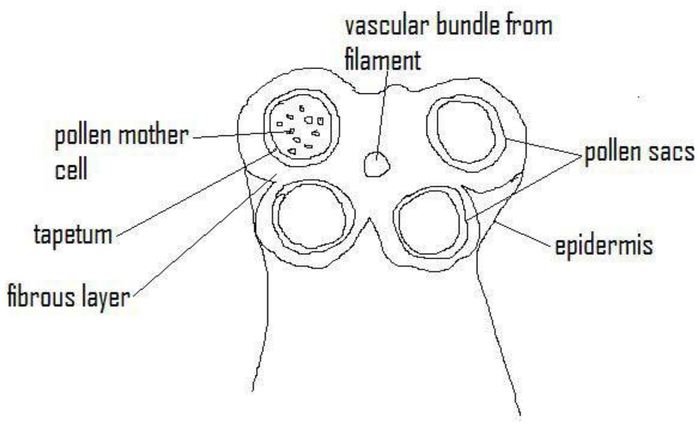
1. Development of the pollen grains

The pollen grain represents the male gamete of the flowering plant formed within an anther.

Structure of an anther

Each stamen consists of an anther and a filament. An anther consists of four pollen sacs in which pollen grains are produced. Each pollen sac contains many diploid pollen mother cells/microspore mother cells. The pollen sacs are derived from sporogenous tissues whose wall later differentiate into outer epidermis, fibrous layer and tapetum which provides food for the developing microspore cells. At the centre of the pollen sacs, there is a vascular bundle which supplies water and nutrients.

Transverse section of mature anther



During development of the pollen grains;

- ✓ The diploid pollen mother cell /microspore mother cell produced by mitosis undergo meiotic cell division to form four haploid pollen cells called **tetrads**. The tetrad secretes walls and each becomes separate pollen cell.
- ✓ The nucleus of each tetrad/ pollen cell then divides by mitosis to produce the **generative nucleus** and the **tube nucleus.**
- ✓ The wall of each pollen cell then differentiate into a thick outer wall called **exine** which is made up of a water proof substance called **sporopollenin** and adheres firmly to the sticky surface of the stigma and an inner smooth wall called **intine** which protects the content of the cytoplasm.
- ✓ When the mature pollen grain lands on the stigma, the generative nucleus divides by mitosis to produce two male gametes.

Summary diagram (ref BS)

2. Development of the embryo sac.

Each carpel consists of a stigma, style and ovary. Within the ovary one or more ovules develop each attached to the ovary wall at a point called placenta by a short stalk called funicle through which water and food pass to the developing ovules. The main body of the ovule is called the **nucellus** and is enclosed and protected by integuments, leaving a small pore at the lower end of the ovule called micropyle.

LS of a mature carpel (ref BS)

During development of the embryo sac;

- ✓ Inside the nucellus at the end nearest to the micropyle, there is a single megaspore mother cell/embryo sac mother cell (2n) which undergoes meiotic cell division to form a row of four haploid megaspore cells/embryo sac cells. Three of these cells degenerates and only one survive to form the embryo sac.
- ✓ The remaining embryo sac cell grows being nourished by the nucellus and its nucleus undergoes three successive mitotic cell divisions to form eight nuclei, four at each end of the embryo sac.
- ✓ One nucleus from each end migrate to the centre of the embryo sac forming **polar nuclei**, three nuclei at the upper end of the embryo sac become separated by thin cell walls forming **antipodal cells** which are non functional during fertilization while the remaining cells at the micropyle end develop cell walls and become separate cells; one is the **egg cell** and the other two are **Synergid cells**.

NB: In some plants, the two polar nuclei fused to form a diploid nucleus and the embryo sac contains 7 nuclei.

The embryo sac represents the female gametophyte and is an equivalent of the pollen grain.

Summary diagram

Qn. Explain why the megaspores are larger and microspores are small.

Megaspore is large because it must contain sufficient food reserves to support the female gametophyte and subsequent development of the embryo sporophyte until the sporophyte becomes self supporting.

Microspores by being small, can be produced economically in large quantities and are light enough to be carried by air currents or insects, thus increasing the chances of the male gametes that they contain reaching the female parts of the plants.

FERTILIZATION IN FLOWERING PLANTS

This involves the fusion of the male and female gametes to form a diploid zygote from which the embryo later develops.

In flowering plants, the male gamete is got from the generative nucleus found in the pollen grain and the egg cell from the embryo sac.

- When the pollen grain lands on the stigma of a compatible species, it germinates to form a pollen tube which emerges from one of the pits or aperture of the inner wall of the pollen grain and grows quickly down the style towards the ovary. Its growth is controlled by the tube nucleus of the pollen grain found at the tip of the growing pollen tube. The growth of the pollen tube is stimulated by sucrose secreted by the epidermal cells of the stigma and Auxins produced by the gynoecium. The pollen tube is directed towards the ovary by certain chemicals secreted by the Synergid cells in the embryo sac.
- As the pollen tube grow down the style, the haploid generative nucleus of the pollen grain divides by mitosis to form two male nuclei (male gametes). The pollen

tube then enters the ovule through the micropyle, the tube nucleus disintegrates and the tip of the pollen tube bursts, releasing the two male nuclei/gametes which enter the embryo sac.

- One male gamete fuse with the egg cell/female gamete to form a diploid zygote which develops into an embryo and the other male nucleus fuse with the diploid polar nuclei forming a triploid nucleus which develops into the primary endosperm nucleus. The endosperm provides food and nourishment to the embryo at later stages of development.

This type of fertilization is called **double fertilization** which is a unique feature to all flowering plants.

Definition:

Double fertilization is where two male gamete nuclei fuses separately with different female nuclei in the embryo sac; one male nucleus fuses with the egg cell to form a diploid zygote (2n) and the second male nucleus fuses with the diploid polar nucleus/two haploid polar nuclei at the centre of the embryo sac to form a triploid nucleus (3n) which develops into a primary endosperm nucleus.

Diagram showing germination of pollen grain and the growth of pollen tube

Diagram showing the process of fertilization (ref BS)

Events after fertilization (development of fruits and seeds)

Immediately after fertilization, a number of changes take place in the floral parts of the plant which include;

i) The zygote grows by mitotic cell divisions to become a multicellular embryo. The embryo becomes attached to the walls of the embryo sac by a row of cells called **suspensor** through which it can derive nourishment. The embryo becomes differentiated into plumule (first shoot), radical (first root) and either one or two seed leaves called cotyledons. The cotyledons are simpler in structure than the first true foliage leaves and may become swollen with food to act as a storage tissue

ii) The triploid primary endosperm nucleus undergoes repeated mitotic cell divisions forming a mass of nuclei which become separated from one another by thin cell walls forming a semi fluid storage tissue called the endosperm. This surrounds the developing embryo and provides it with nourishment. In some seeds the endosperm remains as food store e.g. in cereals. However, if the cotyledons act as the food store it grows at the expense of the endosperm, which may disappear all together. Some seeds store food in both the endosperm and the cotyledons.

iii) As the growth of the embryo and food store continues, the surrounding nucellus breaks down supplying nutrients for growth and more nutrients are supplied by the vascular bundle in the stalk/funicle of the ovule.

iv) The integuments develops into the seed coat, the outer integument becomes the **testa** and the inner one the **tegmen**. Both layers are tough and provide protection to the embryo.

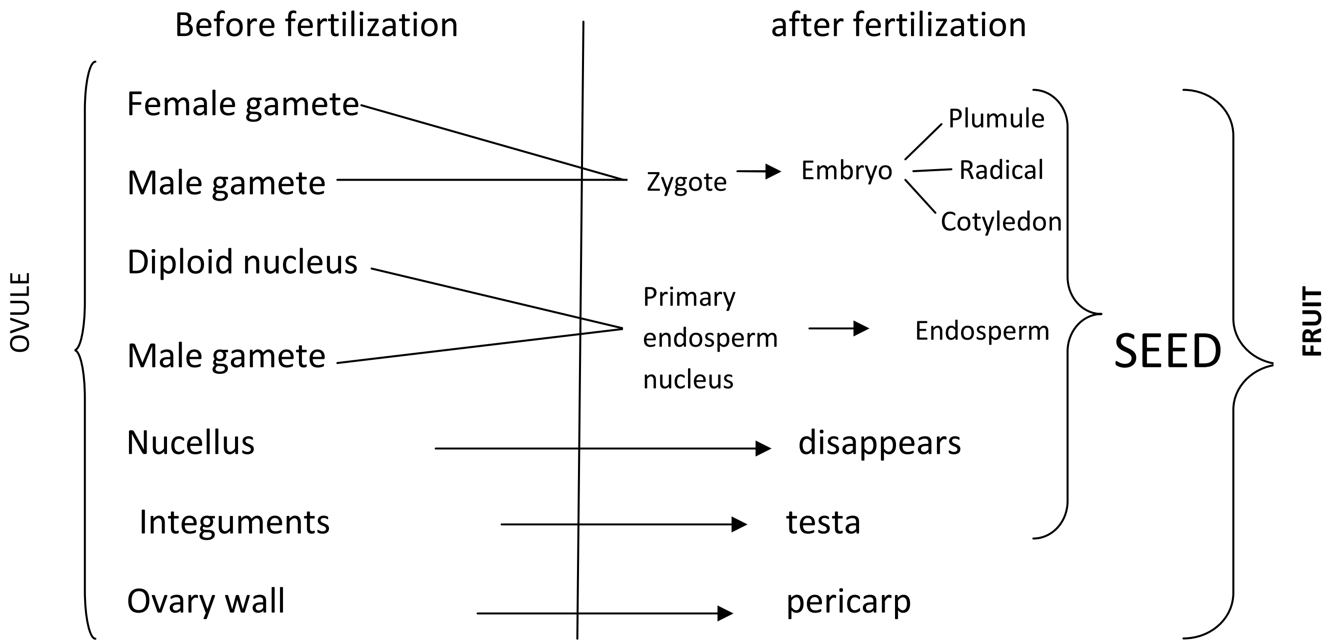
v) The micropyle remains as a small pore in the testa through which oxygen and water will enter during germination.

vi) The ovule becomes the seed and the ovary becomes a mature fruit, the ovary wall develops into a fruit wall known as pericarp.

vii) The remaining floral parts withers and falls off but the flower stalk remains and become the fruit stalk.

viii) In the final stages in the development of a seed, there is a great reduction in the water content of the seed from the normal level of 90% by mass to about 10-15% by mass. This greatly decreases the potential for metabolic activity hence seed dormancy.

Summary of changes that occur after fertilization in flowering plants



Qn;

1. **a) Describe the process of fertilization in flowering plants.**

   b) Outline the events which take place after fertilization in a flowering plant. (20 marks)

Advantages of reproduction by seeds/ sexual reproduction

i) The plant is independent of water for sexual reproduction since gametes are non motile and therefore better adapted for land environment.

ii) Seeds protect the embryo.

iii) Seeds contain food for the embryo either in the cotyledons or in the endosperm.

iv) Seed is usually adapted for dispersal.

v) Seed can remain dormant and survive adverse conditions.

Disadvantages of reproduction by seeds

i) Seeds are relatively large structures because of large food stores. This makes dispersal more difficult than the spores.

ii) Seeds are often eaten by animals for their food reserves.

iii) There is a great reliance on external agents such as wind, insects and water for pollination. This makes pollination and hence fertilization more dependent on chance, particularly wind pollination.

iv) There is large wastage of seeds because the chances of survival of a given seed are limited. The parent must therefore invest large quantities of material and energy in seed production to ensure success.

v) The food supply in the seed is limited where as in vegetative reproduction; food is available from parent plant until the daughter plant is fully established.

vi) Two individuals are required in dioecious species, making the process more dependent on chance than reproduction in which only one parent is involved.

Questions

1. **Discuss the relative merits and demerits of sexual reproduction and vegetative propagation in plants.**

2. **The use of seeds and other planting materials are common methods in plant propagation. Using named examples, give the advantages and disadvantages of each method. (20 marks- qn bank 2000)**

PARTHENOGENESIS

This refers to the development of new individuals from an unfertilized egg.

Types of parthenogenesis

a) Diploid parthenogenesis.

This is where the eggs are formed by mitosis instead of meiosis with the result that they are diploid. The resulting adult will therefore have the normal diploid number of chromosomes e.g. in aphids. In summer months, wingless females produce further generations of mainly wingless females by diploid parthenogenesis which is a rapid and efficient way of increasing their number without the necessity of the presence of males.

b) Haploid parthenogenesis.

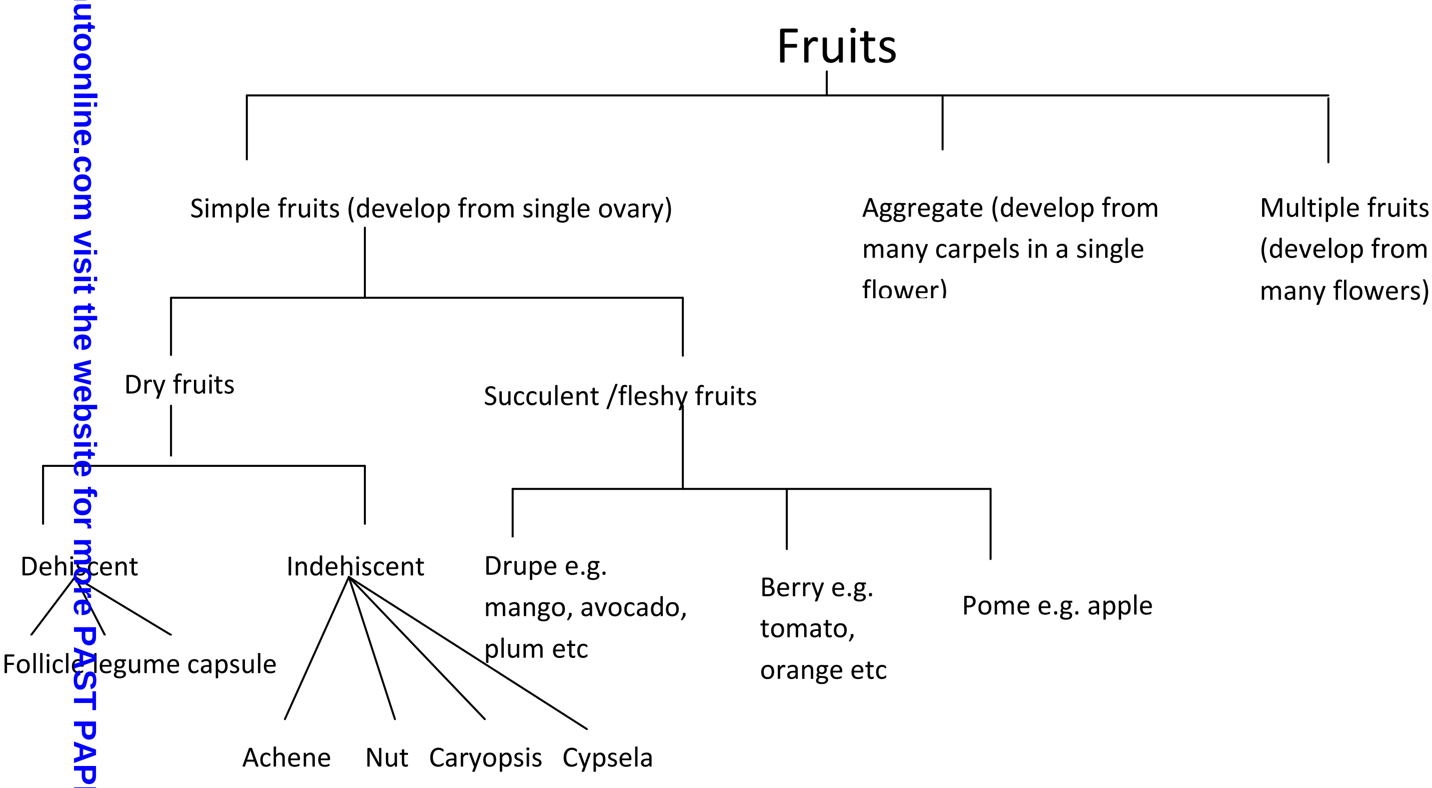
This is where eggs are produced by meiosis in the usual way and are therefore haploid. The eggs develop without fertilization into a new individual whose cells are haploid e.g. in the life cycle of honey bees, the drones (fertile males) develop from haploid unfertilized eggs laid by the queen.

Parthenocarpy in plants

This refers to the development of a fruit from the ovary without fertilization e.g. banana and pineapple. Since fertilization does not occur, parthenocarpic fruits normally lack seeds i.e. they are seedless.

Read and make notes on;

1. **Classification of fruits**



2. **Placentation**

- Axile placentation e.g. orange, tomato etc
- Marginal placentation e.g. bean pod
- Parietal placentation e.g. pawpaw
- Free central placentation e.g. avocado, mango

3. Adaptations of fruits and seeds for the different dispersal mechanisms

4. Importance of fruits and seeds dispersal

LIFE CYCLE OF PLANTS

An organism's life cycle begins from the time an egg inside the body or outside the body of the female is fertilized by the sperm.

Defn;

Life cycle refers to the progressive sequence of changes an organism goes through from the time of fertilization until death of the organism.

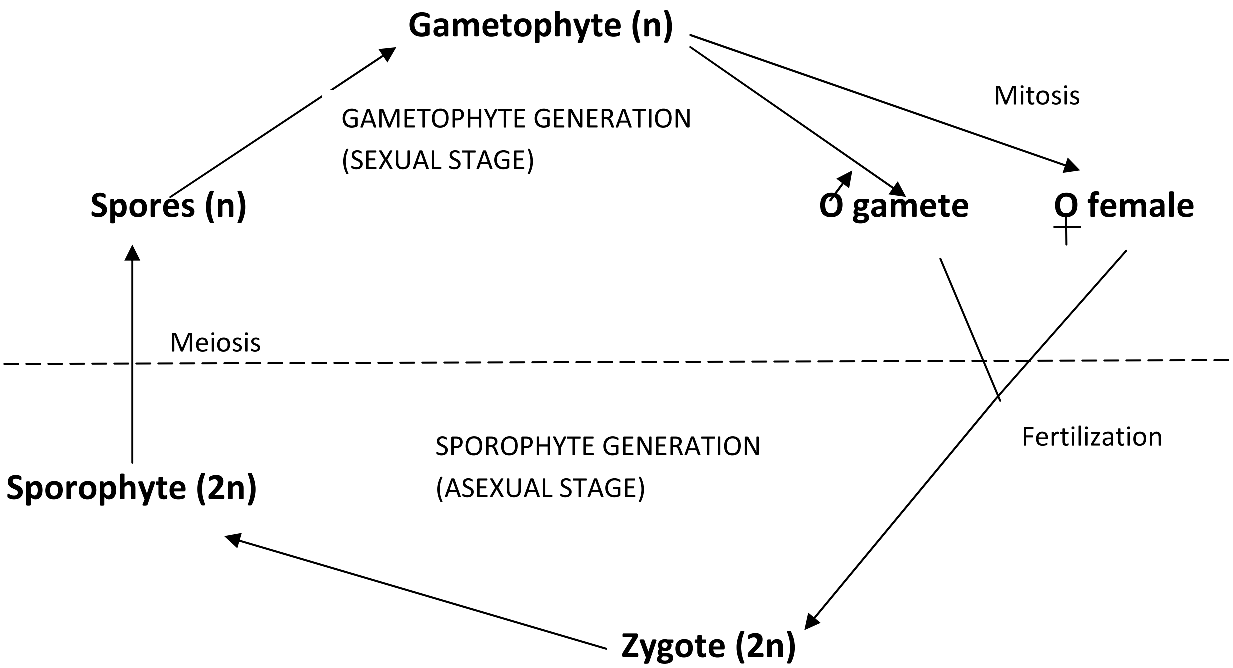
In the course of the life cycle, the organism normally produces new generation of individuals which repeat the process.

In lower plants such as mosses and ferns, they have two distinct stages in their life cycle i.e. sporophyte generation which is concerned with spore production by process of meiosis and gametophyte generation concerned with gametes production by process of mitosis. The two generations differ in terms of morphological features, the way they reproduce as well as their genetic constitution. The haploid gametophyte generation alternates with the diploid sporophyte generation within the life cycle and this phenomenon is called **alternation of generations.**

Defn:

Alternation of generations is the occurrence within the life cycle of an organism of two distinct forms or generations' i.e. Haploid gametophyte and diploid sporophyte alternating with each other in the same life cycle and each differ from each other in their morphological features, method of reproduction as well as their genetic constitution.

Generalized scheme showing alternation of generations



In flowering plants, the gametophyte generation is extremely reduced and virtually considered non existent and there is no free living gametophyte stage. The male gametophyte is represented by the protoplasmic content of pollen grains and the female gametophyte by the protoplasmic contents of the embryo sac. The entire plant represents the sporophyte and the gametophyte is contained within the sporophyte plant.

However, flowering plants owe much of their success to the ways in which their sexual reproduction has been adapted to dry land in the following ways;

i) The gametophyte generation is very reduced and always protected within the sporophyte plant which is well adapted for life on land.

ii) They produce non motile male gametes carried within the pollen grains to the female parts of the plant by process of pollination hence fertilization is independent of water.

iii) The fertilized ovule (seed) is retained for some time on the parent sporophyte plant from which it obtains protection and food before dispersal and can remain dormant until conditions are favorable for germination.

Qn. How are flowering plants adapted to reproduce on land?

Other adaptations of seed bearing plants (higher plants) to life on land include;

i) They have well developed true roots which absorb water in the soil.

ii) The plant is protected from desiccation by an epidermis with water proof cuticle.

iii) The epidermis of aerial parts, particularly leaves has many small pores called stomata which allow gaseous exchange between the plant and the atmosphere.

iv) Many seed plants show secondary growth with production of large amount of wood which provides support. Such plants become trees and shrubs and are able to compete effectively for light and other resources.

v) They have well developed vascular system through which materials are transported.

vi) They have adaptations that enable them to survive in hot, dry environments e.g. shading off leaves, opening of stomata at night etc.

NB: The main problems/challenges associated with terrestrial life include;

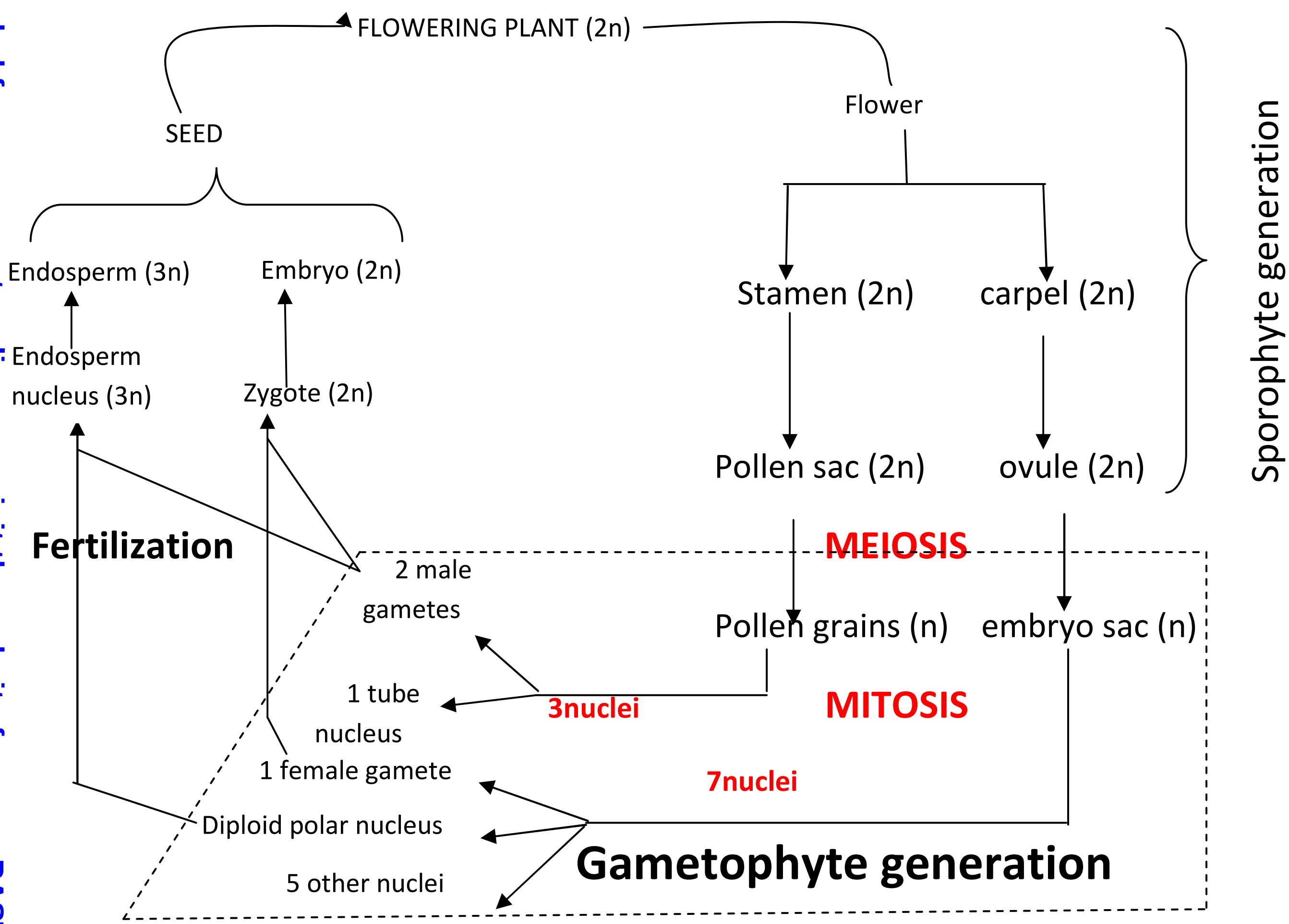
- Desiccation.
- Reproduction.
- Nutrition.
- Support.
- Gaseous exchange.
- Environmental variables.

Qns. **Discuss the various ways by which plants are adapted to terrestrial life. (20marks). OR**

How have plants overcome the challenges of terrestrial environment?

How are vertebrates adapted to terrestrial life? (20 marks).

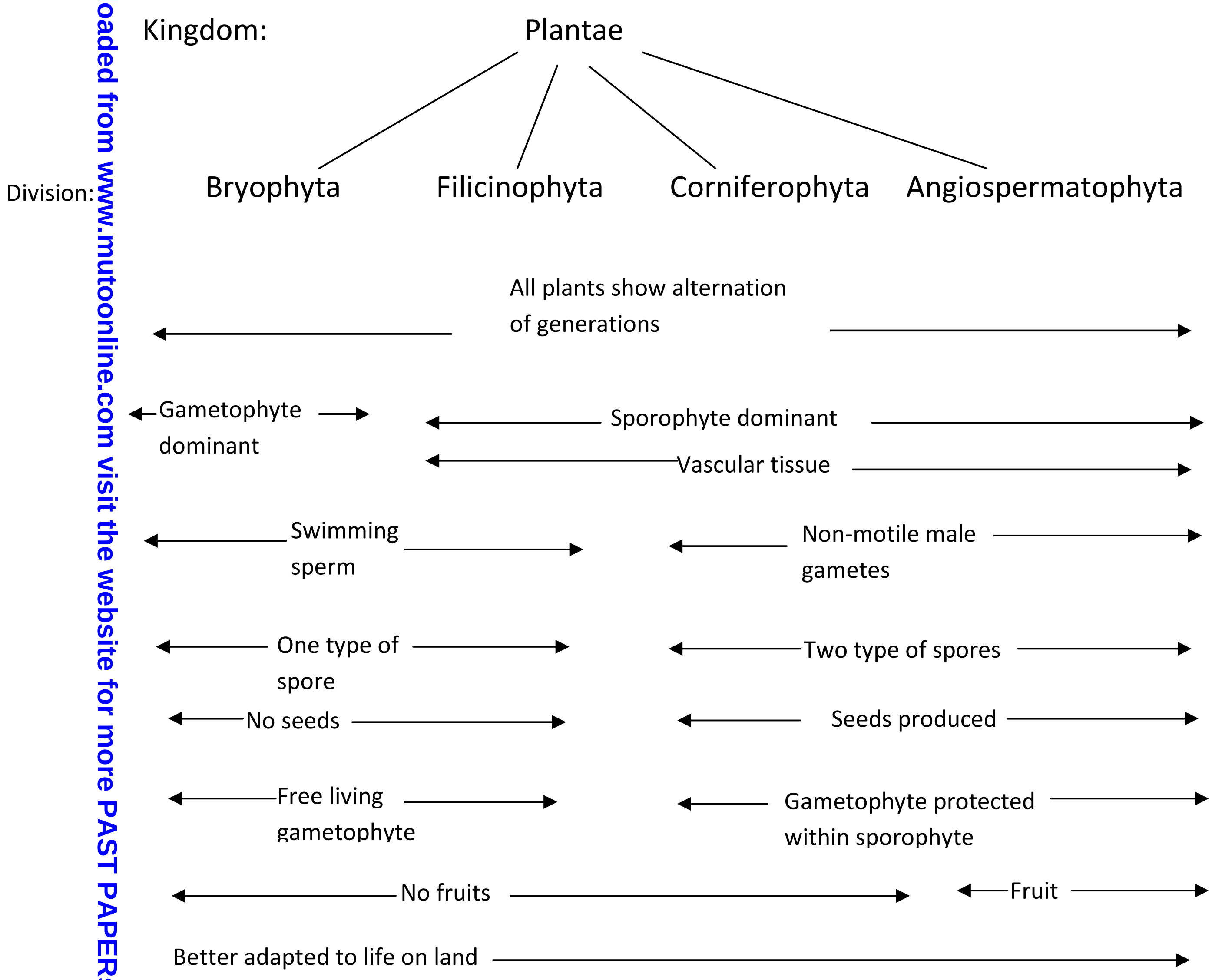
Life cycle of flowering plants showing alternation of generation



LIFE CYCLE OF LOWER PLANTS

Plants are thought to have evolved from multicellular green algae that lived in damp conditions. During the course of their evolution, plants have become increasingly adapted to life on land. The first groups of plants evolved in water and there has been gradual transition from water to dry land. However, lower plants still rely on water for their sexual reproduction because they produce motile male gametes.

Evolutionary trend of plants



1. Division bryophyta e.g. mosses and liverworts

Among all plants living today, bryophytes are anatomically least well adapted to life on land. Many species are confined to damp or moist places for most of their active lives. During dry season; they have adaptations that enable them to tolerate desiccation and produce resistant spores. During sexual reproduction, they need water because they produce motile male gametes that can reach the female gametes only by swimming in water therefore they still rely on water for sexual reproduction.

Characteristics of bryophytes

i) They show alternation of generations in which the gametophyte generation is the most dominant/conspicuous and last longer than the sporophyte generation.

ii) They lack vascular tissues i.e. xylem and phloem.

iii) They lack true roots, stems or leaves and the gametophyte is anchored by thin filaments called rhizoids.

iv) The plant surface lacks cuticle and there is no barrier against water loss or entry.

v) The sporophyte is attached to and dependent upon the gametophyte for its nutrition.

vi) They produce spores inside a highly specialized structure called spore capsule on the end of a slender stalk above the gametophyte.

vii) Their body is a thallus or differentiated into simple leaves and stems.

viii) They live mainly in damp, shady places.

NB: A thallus is a relatively undifferentiated vegetative body with no true roots, stems, leaves or vascular system. It found in the algae, fungi, mosses and liverworts and in the gametophyte generation of clubmosses, horsetails and ferns.

Division bryophyta contain two main classes;

Class Hepaticae e.g. liverworts

They are simpler in structure than mosses and more confined to damp and shady habitats. They are found on the banks of streams, on damp rocks and in wet vegetations. Most liverworts show regular lobes or definite ‘stem’ with small simple ‘leaves’.

Characteristics of liverworts

i) Gametophyte is a flattened structure that varies from being a thallus to ‘leafy’ with a ‘stem’, with intermediate lobed type.

ii) Their ‘leaves’ are in three ranks along the stem.

iii) They have unicellular rhizoids.

iv) Capsule of the sporophyte splits into four valves for spore dispersal aided by dispersal agent/elaters.

v) The archegonia (female) and antheridia (male) are enclosed within the thallus.

External features of a liverwort

Class Musci e.g. mosses.

Mosses have more differentiated structure than liverworts. The gametophyte generation is a small leafy body that grows in damp/moist and shady places. The gametophyte plant is large and more conspicuous bearing male sex organs called antheridia which produce sperms/antherozoids and female sex organs called archegonia which produce the egg. Both antheridium and archegonium have a cluster of leaves at the tip which enclose and protect the reproductive organs.

Characteristics of mosses

i) Gametophyte is 'leafy' with a stem.

ii) Their leaves are arranged spirally along the stem.

iii) They have multicellular rhizoids.

iv) Capsule of sporophyte has an elaborate mechanism of spore dispersal, dependent on dry conditions and involving teeth or pores.

External structure of a moss plant

Qn; why are bryophytes restricted to growing in damp environment?

- They have no vascular tissues i.e. xylem and phloem for transport and support.
- They lack true roots, stems or leaves and the gametophyte is anchored by thin filaments called rhizoids.
- The plant surface lacks water proof cuticle and there is no barrier against water loss or entry.
- They depend on water for fertilization since they produce motile male gametes.

Suggests why bryophytes are able to grow successfully on land.

- Lacks a water proof cuticle so can take up water over the entire body surface.
- Inhabit moist places where water is readily available.
- Their gametes develop in protective structures i.e. antheridia and archegonia.
- Their mode of dispersal depends on drying out of the capsule.
- They are able to tolerate desiccation.
- They are short therefore do not need supporting tissue

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ALTERNATION OF GENERATION IN A MOSS PLANT

- ✓ A moss plant consists of two alternate forms/generations in its life cycle i.e. the haploid gametophyte and the diploid sporophyte.
- ✓ The gametophyte is the dominant stage and undergoes sexual reproduction and produces gametes by the process of mitosis while the sporophyte undergoes asexual reproduction and produces spores by process of meiosis.
- ✓ The gametophyte bears both the male and female reproductive organs called antheridia (male) and archegonia (female) respectively where gametes are produced.
- ✓ When the antheridium matures, it releases sperms/antherozoids /spermatozoids which swim in a film of water towards the open neck of the archegonium being attracted by sucrose secreted by the archegonium and fuses with the ovum to form a diploid zygote.
- ✓ The zygote develops into a diploid sporophyte plant which remain attached to and surviving on the gametophyte.

- ✓ As growth continues, the sporophyte produce haploid spores within the spore sac of the sporangium by process of meiosis.
- ✓ In dry weather condition, the operculum falls off and the flexible teeth bends upwards releasing the spores which are dispersed by wind or air currents.
- ✓ On landing on favorable environment, the spores germinate into a green **filamentous protonema** which develops bud and later develop into a fully mature gametophyte and the cycle is repeated.

Summary diagram showing alternation of generation in a bryophyte

2. **Division filicinophyta/pteridophyta e.g. ferns.**

Ferns are the first primitive group of plants to develop vascular system. They are the first groups of plants to have adapted to life on dry land and they are much more adapted to life on dry land than bryophytes. This is due to;

i. Presence of vascular tissue made up of xylem and phloem. These tissues are concerned with translocation of water and nutrients round the plant body and also provide mechanical support to the plant.

Development of vascular tissue is a major evolutionary advance in the evolutionary history of plants compared with simple conducting cells in bryophytes and algae. This is found only in sporophyte generation and is one reason why sporophyte generation is conspicuous in all vascular plants. Hence ferns have developed large, more complex bodies, grow taller and live in drier habitats than bryophytes.

ii. Presence of waxy cuticle on the fronds which reduce water loss from the plant.

iii. Sporophyte generation possesses true roots, stems and leaves. Roots penetrate into the soil with the result that water and dissolved nutrients can be obtained more easily and xylem conducts it to other parts of the plant.

iv. The mature sporophyte in a fern is not dependent on the gametophyte which requires water for reproduction.

Despite these advances in adapting to dry land environment in the sporophyte generation, the gametophyte still remains dependent on wet conditions because it lacks a waxy cuticle, no true vascular system and produces flagellated male gametes which need water for swimming in order to reach the female gamete.

Qn; **how are ferns better adapted to live on land than mosses? (03 marks)**

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OR Why are ferns poorly adapted on land?

Characteristics of ferns

i) They show alternation of generation in which the sporophyte generation is dominant/conspicuous and live longer.

ii) Gametophyte generation is small and inconspicuous reduced to a small structure called prothallus.

iii) Has vascular tissues i.e. xylem and phloem in the sporophyte.

iv) Sporophyte has true roots, stems and leaves.

v) Leaves are relatively large and are called fronds.

vi) Have structures on the underside of the fronds called sporangia in which asexual non motile spores are produced and they usually occur in clusters called sori.

ALTERNATION OF GENERATION IN FERNS

- ✓ Ferns consist of two alternate forms/generations in its life cycle i.e. haploid gametophyte and diploid sporophyte. The gametophyte is much reduced and produces gametes by process of mitosis and sporophyte is the dominant form that produces spores by process of meiosis.
- ✓ A mature sporophyte plant starts to develop spores within the spore sac of the sporangium by process of meiosis.
- ✓ When the spores matures, the indusium (protective covering of sorus) shrivels and drops off, exposing the sporangium walls which begin to dry out. Eventually the wall of sporangium ruptures releasing the spores which are dispersed by wind or air current.

- ✓ On landing on favorable environment, the spores germinate into a thin- heart shaped haploid structure called **prothallus** which is the gametophyte.
- ✓ The gametophyte/prothallus produces simple antheridia and archegonia on its lower surface. Gametes are produced by mitosis of gamete mother cells, the antheridia producing sperms and archegonium producing ovum.
- ✓ In wet condition, antheridium releases the sperm which swim in a film of water to the archegonium and fuses with the ovum to form a diploid zygote which grows into the sporophyte plant.
- ✓ The young embryo absorbs nutrients from the gametophyte until its own roots and leaves can take over the role of nutrition. The gametophyte/prothallus then withers and dies mean while the sporophyte continues to develop thus completing the life cycle.

Summary diagram showing alternation of generation in a pteridophyte

Differences between bryophytes and pteridophytes

Bryophytes e.g. moss	Pteridophytes e.g. ferns
1. Gametophyte is dominant/conspicuous and long lived.	Sporophyte is dominant /conspicuous.
2.Sporophyte is attached to and depend on the gametophyte	Sporophyte is a self supporting plant
3. Do not have true roots, stems and leaves, only has filamentous rhizoids	Have true roots, stems and leaves.
4. Have no vascular tissue i.e. xylem and phloem.	Have lignified vascular tissue.
5.lacks waxy cuticle on the 'leaves', 'roots' and 'stems'	Have waxy cuticle which prevent water loss from the plant.
6. Spores germinate and grow into protonema.	Spores germinate and grow into prothallus.
7. Generally they are small land plants found in moist habitats only.	They may be found in slightly drier places.
8. Sperms/antherozoids are biflagellate.	Sperms /antherozoids are multiflagellate.

Similarities

i) Both show alternation of generations.

ii) Both need water for fertilization to occur. This is because the flagellated male gamete has to swim in a film of water in order to reach the female gamete and fertilize it.

iii) In both cycles, the gametophyte bears antheridia and archegonia

iv) Both produce motile male gametes.

v) In both, female gametes are non motile.

vi) In both, the diploid zygote grows into a sporophyte and the haploid spores germinate into a gametophyte.

vii) In both gametes are produce by mitosis.

viii) In both spores are produced by meiosis.

ix) In both spores are formed in sporangia.

Significance of alternation of generations

i) Increases chances of survival in adverse environmental conditions.

ii) Rapid multiplication since spores are produced in large quantities.

iii) Sexual stage in the life cycle brings about genetic variation since it involves fusion of male and female gametes.

iv) Leads to colonization of new habitats hence minimizing competition.

v) There is interdependence where each stage depends on another hence survival of both stages.

Questions:

1. **What is meant by the term alternation of generations? Give a detailed account of alternation of generations in a named bryophyte or pteridophyte. (20 marks)**

2. **a) State the differences and similarities between bryophytes and pteridophytes. OR compare the life cycle of a moss and a fern.**

   b) Discuss the significance of alternation of generations to the life histories of plants. (20 marks) 2010

3 a) What problems do plants face on land and how have they solved these problems? (10 marks)

b) Why do mosses and liverworts show great reliance on water? (5marks)

c) Liverworts and mosses are described as amphibians of plant world. Briefly explain this statement. (5marks)

4a) why are ferns better adapted to life on land than liverworts and mosses?

b) In what main aspects are liverworts, mosses and ferns poorly adapted to live on land?

END.