class-12 Biology
chapter- 2

Sexual reproduction in flowering plants

Flowers is a modified shoot with condensed axis called thalamus and appendages called floral organs.
Definition- Typically flower is a condensed branch in which internodes have become condensed, bringing the nodes close to one another, and the leaves are modified to form floral whorls that directly or indirectly participate in the process of reproduction.
Floriculture- It is the branch of ornamental horticulture concern with growing and marketing of flowers and ornamental plants ,as well as with flower arrangement.

Parts of a typical flower

A flower is generally born on the lateral side of the peduncle at a node in the axil of a leaf like structure called bract.
Flower arising in the axil of a bract is called bracteate and bract is absent, flower is said to be ebracteate.
The stalk of the flower is called pedicel which exposes the flower in favourable position is called pedicellate.
If pedicel is absent the flower is sessile .
If very short pedicel present in the flower Such flower is described as subsessile.
In some flower two small leaf like structure are also present on the flower pedicel called bracteoles and the flower is spoken as bracteolate and bracteoles are absent ebracteolate.
The pedicel has an upper swollen portion called thalamus or Torus also known as receptacle.
Thalamus bears for type of floral leaves arrange in successive whorls the sepals, Petals, stamens and carpels.
In groups the whorls are called calyx, Corolla, androecium and gynoecium.

Sexual reproduction in angiosperms flower

A flower is the branch of the stem specially modified for sexual reproduction.
Stamens represents male and carpels represents female organ.
Smallest flower occurs is Wolffia microscopia.
Largest flower- Rafflesia
National flower of India- Lotus
Complete and perfect flower- a flower containing all the floral part i.e. calyx, corolla,androecium and gyanaecium.
If any whorl is absent in a flower, it is called incomplete.

The flower which possesses both the essential organs is known as perfect or bi sexual or hermaphrodite.
If any of the two reproductive organs is missing the flower is described as im perfect or Unisexual.
In unisexual flower if carpels are absent it is termed as male flower or or staminate flower.
When is stamens are absent the flower is female or pistillate.
Sometimes both the essential whorls are absent in the flower. Such flower is known as neuter.
e.g. sunflower (some are bisexual also)
A plant may have both male and female flowers and termed as monoecious.
e.g. maize, castor, coconut etc.
When male and female flowers are present on the different plants, the plant is spoken as dioecious.
e.g. papaya, mulberry, Date palm etc.

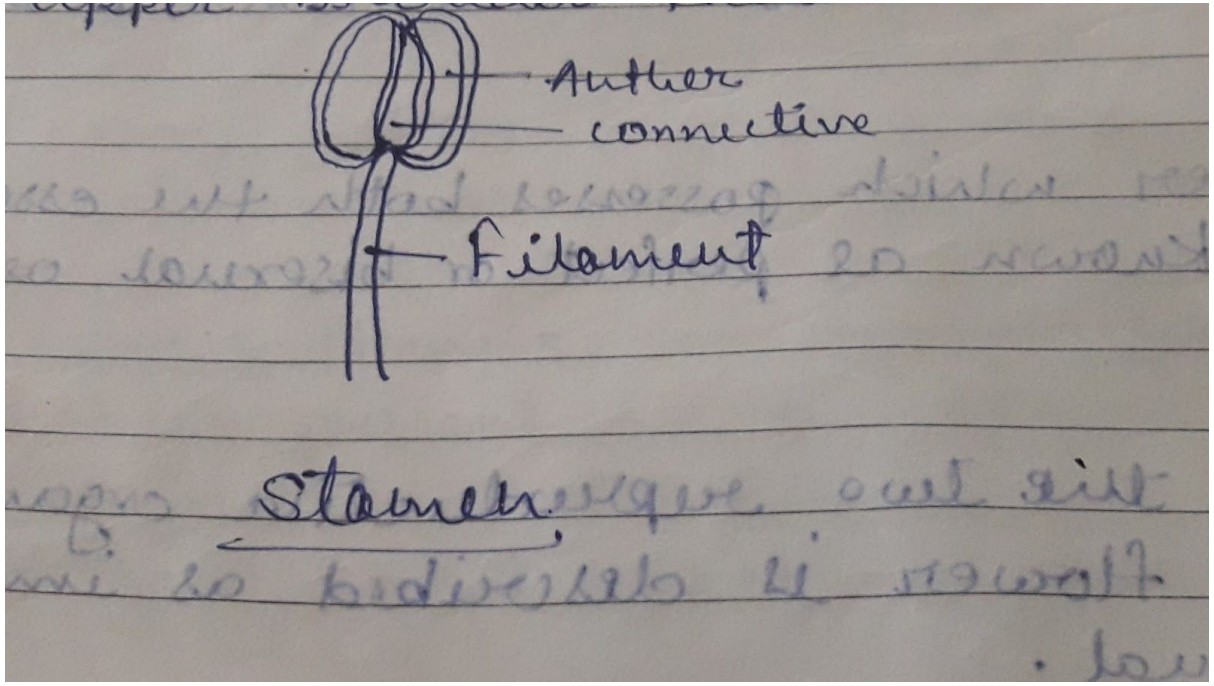
Life cycle of an angiosperm

(sexual reproduction)

pre- fertilization: structure and events

(A) Formation and development of pollen grains

(a)The stamen- Stamen in a flower consists of of two parts, the long narrow Stalk like filament and upper broader knob like bilobed anther.



(b)Structure of anther- a normal bithecous or dithecous anther is made up of two anther lobes, which are connected by a strip of sterile part called connective.

Two anther lobes contain four elongated cavities or Pollen sacs in which pollen grains are produced.

© Structure of microsporangium (Pollen sac)-T.S. of young anther reveals the presence of outermost epidermis. The outermost wall layer lying just below the epidermis is called and endothecium or fibrous layer.

Below the endothecium there are 1-3 middle layer of parenchyma cells. The cells of innermost wall layer are radially elongated and rich in protoplasmic contents.This layer is called tapetum.

The Pollen sac wall encloses a number of of archesporial cells that further forms microspore mother cells.

(d) structure of microspore(pollen grain)- pollen grains develop from the the diploid microspore mother cell in Pollen sacs of anthers.

Typically Pollen Grain is a haploid, unicellular body with a single nucleus.

Pollen grains are generally spherical measuring about 25-50 micrometres in diameter.

The outer surface of microspores may have spines, ridges or furrows which may vary in other ways in different species.
Study of pollen grains is called palynology.

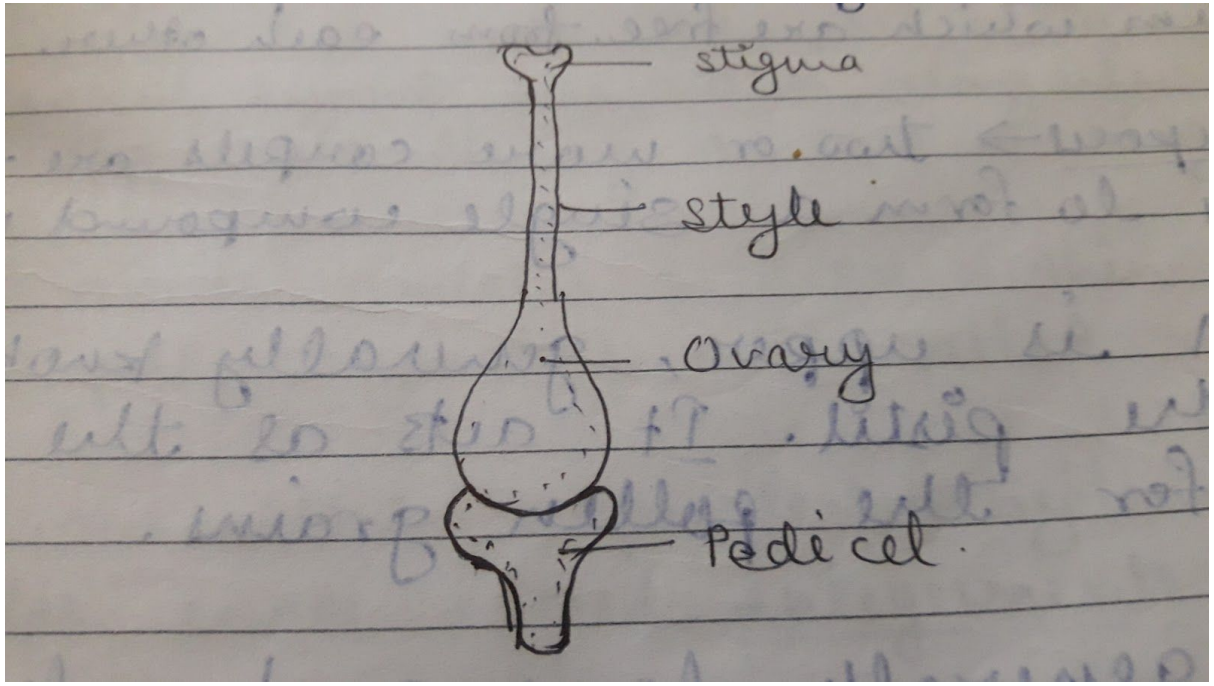
Development of male gametophyte

Development of male gametophyte starts in pollen grains while still present in the microsporangium or Pollen sac.
Microspores undergoes mitotic division and leads to the formation of of larger vegetative cell and smaller generative cell.
These cells do not possess any cell wall Hence a temporary callose wall is laid down between the two cells.
Soon this callose wall dissolves and generative cell lie freely in the cytoplasm of vegetative cell.
The cytoplasmic contents of generative cell are almost hyaline and do not possess much of stored food material.
It is usually at this two celled stage that pollen grains are liberated from Pollen sacs of anther lobes.
Other stages for the development of pollen tube etc. Occur on the stigma after pollination.
All these stages for the development of male gametophyte are grouped under pre pollination stages.
After falling of pollen grains on the stigma post pollination changes occur.
Pollen Grain absorb water and nutrients of the stigmatic secretion through its Germ pores.
The generative nucleus divides to form two male nuclei, which become surrounded by cytoplasmic masses and appear as distinct male gametes.
Usually generative cell comes down into Pollen tubes and then divide to form the male gametes.
The pollen grains on male gametophyte in angiosperms is highly reduced.

Pistil

The gynoecium or pistil is composed of one or more carpels.

A carpel has three distinct part , namely the ovary, style and stigma and is a highly modified leaf folded along the midrib.



The margin of the leaf fuse to form the ventral suture of the carpel and the midrib side represents the dorsal suture.
A cushion like parenchymatous outgrowth develops on the ventral suture called placenta on which the ovules are born.
The ovary is a basal swollen portion of the pistil containing one or more Chambers or loculi and accordingly the ovary is known as and and unilocular, bilocular, trilocular, Tetralocular, pentalocular and multilocular.
On the basis of number of carpels thegynoecium is of following types:
Single carpel- monocarpellary
Two carpel- bicarpellary
Three carpel- tricarpellary
Four carpel- Tetracarpellary
Five carpel- Pentacarpellary
More than 5- polycarpellary

On the basis of free and fused carpels the gynoecium is of following nature:

1.Apocarpous- two or more carpels in a gynoecium which are free from each other.

2.Syncarpous- two or more carpels are fused together to form a single compound ovary.

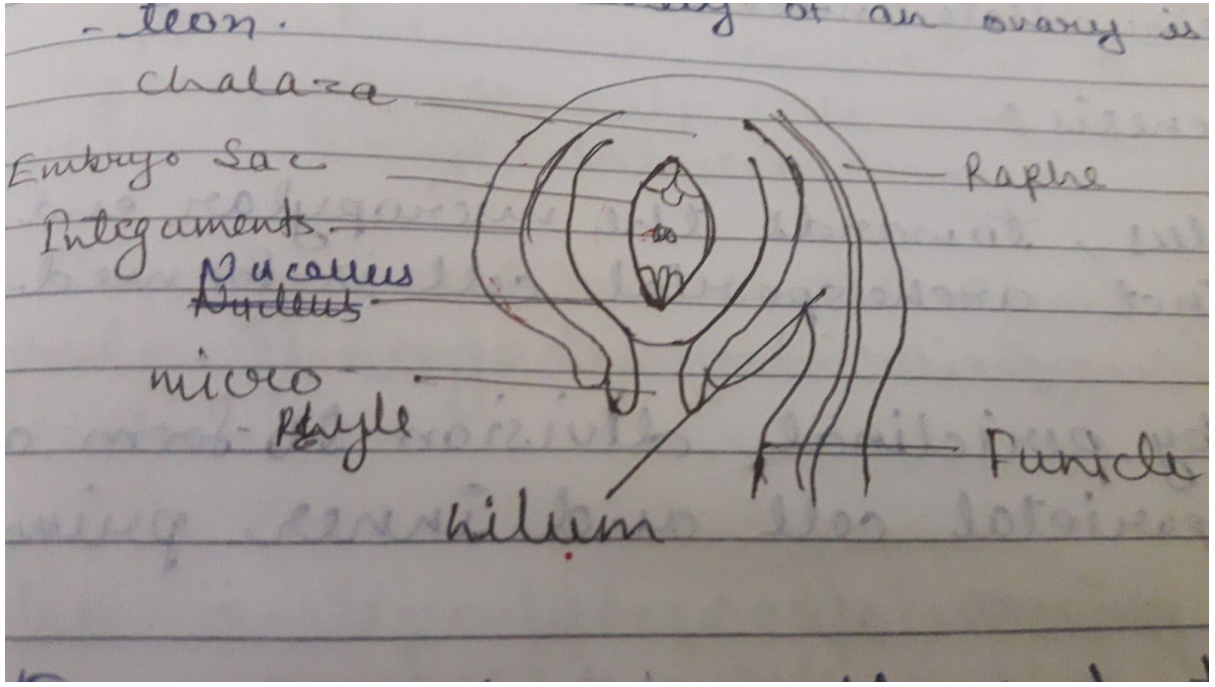
Stigma is upper, generally knobbed part of the pistil. It acts as the landing platform for the pollen grains.

style is generally long and slender part of pistil which raises stigma to increase the chances of pollination.

Development of ovule and the female gametophyte

(a) The ovule(megasporangium)- the placenta is a ridge of tissue a parenchymatous mass in the inner wall of the ovary to which ovule are attached.

The manner in which Placenta are distributed in the cavity of an ovary is called placentation.



Each ovule is attached to placenta by a selender stalk called funicle.

The point of attachment of the body of the ovule to its stalk or funicle is known as hilum.

In inverted ovule the part of funicle remain attached beyond the the hilum along side of the body of the ovule forming a a sort of ridge called raphe.

The ovule contains a mass of thin walled nutritive parenchymatous cells called nucellus.

The nucellus is protected by one or two multicellular coates called integuments.

The basal portion of the nucellus from where the integuments arise is called chalaza.

The ovules with one integument are called Unitegmic and with two are called bitegmic.

depending upon the thickness of the nucellus ovule are called tenuinucellate(nucellus thin) & Gassinucellate(nucellus massive).

(b) Megasporogenesis:

In the nucellus towards the micropylar hypodermal distinct archesporial cell is formed.

This divides by periclinal division to form an outer primary parietal cell and inner primary sporogenous cell.

Primary sporogenous cell forms megaspore mother cell(MMC).

The megaspore mother cell undergoes meosis to form four haploid megaspores. The step is call megasporogenesis.

© Development of female gametophyte

The functional megaspore forms female gametophyte or or embryo sac.

The nucleus of megaspore divides into two ,four and finally eight daughter nuclei.

Four of which are located at each pole.

One nucleus from each pole migrates to the centre to form to polar nuclei which further close to form a diploid fusion or secondary nucleus.

Thus, Central cell bears two polar nuclei.

Three nuclei at the chalazal end of embryo sac from antipodal cells.

The remaining three nuclei at the micropylar end get surrounded by cytoplasm to form pyriform cells. These cells together constitute egg apparatus, which consists of two cells known as synergids or help cells and an egg or oosphere which hangs between them.

The egg cell on fertilization give rise to zygote while synergids get disorganised soon after fertilization.

The antipodal cells sooner or later also get disorganised.

A typical angiospermic embryo sac egg maturity though eight nucleate is seven celled. so development of embryo sac is generally monosporic i.e. from one megaspore.

Pollination

Transfer of pollen from anther anther to stigma is called pollination. Pollination end when the Pollen has reached the stigma.

It is of two types:

1**. Self pollination-** plants are said to be selfpollinated when Pollen is transferred from an anther to a stigma of same flower or to the stigma of another flower on the same plant.

Self pollination can be further classified into:

(a) Autogamy- it is the transference of pollen grains from anther of a flower to the stigma of the same flower evidently bisexual.
e.g. pea, wheat, rice etc.

(b) Geitonogamy- When pollen from one flower are deposited on the stigma of another flower borne on the same plant.

Devices favouring self pollination

(1)Homogamy- it is the condition in which anthers & stigmas in bisexual flower attain maturity at the same time.

(2)Cleistogamy-In this, flowers never open to expose their sex organs and the pollens fall on the stigma of same flower. cleistogamy is followed by geocarpy. e.g. groundnut(fruits are formed in the soil)

2.cross pollination or xenogamy or allogamy

Cross pollination can also be defined as the Migration of pollen grains from one flower to stigma of genetically different flower.
This causes genetic recombination.
Different Agencies helping in cross pollination are:
(a)Anemophily- Anemophilous are wind pollinated plants.
e.g. coconut, palm, rice, wheat etc.
(b)Hydrophily- pollination brought about through the agency of water in plants especially submerged plants is termed hydrophily.
e.g. algae, bryophytes, pteridophytes.
Hydrophily is further of two types:
1.Hypohydrogamous type- pollination takes place below the surface of water.
2.Epihydrogamous type- pollination occurs over the surface of water.
©Zoophily- many animals act as pollination agents.
e.g. Bees, flies, Birds, ants etc.
Larged sized animals like arboreal (tree dwelling), rodents, reptiles (Garden lizard) can also go for pollination.
It is of following types:
1.Entomophily- Insect pollinated flowers

e.g Jasmine, Rafflesia, yucca

2.Ornithophily- Birds pollinated flowers.

These flowers are generally scentless, large in size and also beautifully coloured.

e.g. Coral tree, bottle brush, silk cotton tree.

3.Chiropterophily- bat pollinated flower.

e.g. Kigella pinnata, Durio, Anthocephalus(Kadam) etc.

The bats hold onto the freely exposed large and relatively tough flower which open in the evening or night.

Adaptation/ outbreeding devices promoting cross pollination

(1) Dicliny (unisexuality)- These unisexual flowers are present it on different plants Thus promoting the cross pollination. example- papaya, Mulberry.
(2) Dichogamy- In bisexual flowers anthers and stigma mature at different times. example- sunflower, cotton, mirabilis jalapa.
(3) Suppression of one sex- In certain bisexual flowers one sex organ either stamen or carpel is completely suppressed and becomes sterile.
    Anther does not form pollen grains and carpel does not produce ovule. Thus facilitating cross pollination.
(4) prepotency- In many plants the pollen grains from a flower when present on the stigma of another genetically different flower germinate more quickly as compare to the pollen grains the same flower. example- grapes, Pear, Apple etc.
(5) Self sterility or self incompatibility- pollen grains of a flower are in capable of effecting fertilization even if they are placed on the stigma of the same flower due to mutual inhibition. example- potato, tobacco.
(6) Hetrostyly- The occurrence of two or more types of flowers having different length of Styles and stamens. Example- Prime rose and Jasmine these are two types of flowers based on the length of Style and stamens.
(7) Herkogamy- In some flowers there may be some physical barriers between the anther and the stigma. So that pollination between them becomes difficult or even impossible and cross pollination is performed with the help of external agencies. Example- calotropis

Significance of pollination

As both male and female gametes in angiosperms are non motile, they have to be brought together for fertilization to take place. This aim is achieved by process of pollination.

Post pollination events double fertilization

After pollination the intine of pollen grains form Pollen tube through weak areas on exine.

The length of pollen tubes depends on the length of Styles.

Depending on the internal structure, the styles are of two types:

1. Hollow style- It has a wide Canal which is lined by Canal cells.
2. solid style- It bears conductive tissue instead of canal. The cells of the tissue have thick pectin wall.

In solid style, entry of pollen tubes is intercellular through conductive tissue.
When Pollen tube enters through the micropylar end of the ovule for fertilization it is called Porogamy (most common type).
When Pollen tube enter the embryo sac through the base(chalaza) of the ovule is called chalazogamy.
When Pollen tube pierces through the integuments it is called mesogamy.
On piercing the nucellus, the Pollen tube penetrates the embryo sac. Its tip penetrates in the embryo sac and reaches the egg apparatus passing either between the egg and synergids or between one synergid and wall of the embryo.
Ultimately, the tip of the Pollen tube burst and two male gametes are discharged.
One of these male gametes fuses with the the egg cell or oosphere causing fertilization as a result of which diploid oospore or zygote is formed.
The Other gamate fuses with the secondary nucleus forming the triploid primary endosperm nucleus(PEN) which later on gives rise to endosperm.
Thus the process of fertilization which occurs twice in the same embryo sac at a time by the two male gametes is called double fertilization.

significance of double fertilization

1. Double fertilization is found in angiosperms only.
2. There will be no wastage of energy in the development of endosperm.
3. There is no such provision in gymnosperm.

Post fertilization

A)**Endosperm formation**

The formation of endosperm occurs usually prior to the zygotic division.
Endosperm accumulates food Reserves and functions as the nutritive tissue for the developing embryo.
Three main types of endosperm can be classified:
1.Nuclear type- In nuclear type of endosperm the first division of primary endosperm nucleus and few subsequent nuclear divisions are not accompanied by wall formation.
2.Cellular type- In this case, there is cytokinesis after each nuclear division of endosperm nucleus. The endosperm, thus, has a cellular form, from the very beginning because first and subsequent divisions are all accompanied by wall formation.
3.Helobial type- it is an intermediate type between nuclear and cellular types.

The first division is accompanied by cytokinesis but the subsequent ones are free nuclear.

B) Embryo development

After fertilization, the fertilized egg is called zygote or oosphere.
Following a predetermined mode of development it gives rise to an embryo, which has the potentiality to form a complete plant.
There are no fundamental differences in the early stages of development in dicotyledonous and monocotyledonous embryos.
First division of the zygote is usually transverse in most of the angiosperms. However in some cases first division may be longitudinal or oblique.
From this two celled stage till the differentiation of organs ,embryo is called proembryo.

Polyembryony

Polyembryony may be defined as occurrence of two or more embryos in one ovule.
This was first noticed for the first time by Leeuwenhoek (1719) in the seeds of orange.
According to Ernest (1918) & Schnarf (1929) . Polyembryony may be true or false. Depending upon whether the embryo arise in the same embryo sac or in different embryo sac in the same ovule.
Various types of true polyembryony are:

1. Cleavage polyembryony- It results from the cleavage of the zygote or earlier stages of its development into two or more units.
   It is common in gymnosperms, but it is of rare occurrence in angiosperms.
2. Embryos from cells of embryo sac other than egg- The embryo may appear from synergids and antipodal cells in the embryo sac.
3. Embryos arising from the cells outside embryo sac- cells of the nucellus and integuments have also been observed to develop into embryo.
   Such embryos subsequently come to lie in the embryo sac and are nourished by the endosperm.
4. Embryos from endosperm- Ernest (1913)found that such embryos develop from egg, got embedded in Cellular endosperm.

Spontaneous polyembryony- which includes instances of naturally occurring polyembryony.
It is of two types:

(a) Gametophytic- Arising from gametic cell of embryo sac.
(b) Sporophytic- Arising from zygote, proembryo or initial sporophytic cells of the ovule.

Induced polyembryony- includes instances of experimentally used case.

The embryos developed in culture medium are known as adventitious embryos, somatic embryos, supernumerary embryos or embryoids.

Practical value of polyembryony

1. Nucellar adventive polyembryo is of great significance in horticulture.
2. The adventive embryos provide uniform Seedling of parental type.
3. Nucellar embryos are free from diseases.

Outbreeding devices

In bisexual flowers, to discourage self pollination and to encourage cross pollination several methods have developed.
In some flowers, anther and stigma are present at such positions that pollen fail to come in contact with stigma of some flower.
Production of unisexual flowers is another device.

Pollen pistil interaction

A special character of sexual reproduction in angiosperms is the interaction of pollen grain, male gametophyte with massive sporophytic tissue of pistil (stigma and style) before discharging the male gametes near the egg.
Sexually reproducing organisms have the ability to recognise and select suitable gametes for fertilization.
The function of recognition and acceptance of mating partners is at the choice of gametes themselves.
Female gametes produce chemicals to attract male gametes.
In flowering plants, female gamete is present in embryo sac and thus seated deep inside the ovule in nucellus which inturn is covered by the pistil to form ovary, style and stigma.
In flowering plants, massive Pollen- pistil interaction followed by the transfer of the function of recognition and rejection from egg to the sporophytic tissue of pistil has led to the successful establishment of self incompatibility.
Pollen pistil interaction is of much importance in the biology of sexual reproduction and of seed formation.

Incompatibility

Incompatibility is the inability of functional male and female gametes to effect fertilization in particular combinations.
Incompatibility operates between inter specific species as well as intraspecific species.
In interspecific, fertilization between gametes which originate from unrelated plants is prevented.
However in the intraspecific incompatibility fertilization is prevented between gametes which originate from same individual and some other individuals of the same species.
Intraspecific incompatibility or self incompatibility is a pre- fertilization barrier.

Self incompatibility may follow:

(a) Heteromorphic system- In this type of incompatibility same species produce more than one morphological type of flowers.
e.g. relative length of styles and stamens in a flower of same species.
Such type of system has been reported in plants like sweet potato and buckwheat.

(b) Homomorphic system- In this type, incompatibility is not connected with morphological differences of flowers and may be due to the genotype of the plant on which it is produced or by its own genotype.

Biological significance relevance of self incompatibility

Self incompatibility may be used in hybrid seed production.

In nature inbreeding and outbreeding of plants is regulated by intraspecific incompatibility.

Interspecific incompatibility brings out reproductive isolation and is thus responsible for the emergence of new races and species through the process of mutation and open hybridization.

Parthenogenesis

Parthenogenesis is the formation of embryo directly from egg cell for a male gamete.

Apogamy means development of a sporophyte(i.e. embryo) out of any gametophytic cell without fusion of gametes.

- Apospory represents the formation of gametophyte(i.e. Pollen or embryo sac) from sporophyte without undergoing meiosis.

Parthenogenesis thus is a type of apogamy.

In solanum nigrum development of haploid egg into embryo has been observed. It leads to formation of haploid embryo and plant. This type of parthenogenesis is called haploid parthenogenesis.

Haploid plants are usually sterile.

In diploid parthenogenesis embryo sac is formed from any sporophytic cell of ovule without undergoing meiosis(i.e. by apospory).

All cells of embryo sac are diploid.

Parthenocarpy

The fruits is normally formed by stimulus of fertilization.

Sometime fruits may be formed without the act of fertilization. This is called parthenocarpy.

It may be due to two reasons:

1. Stimulus of pollination (without fertilization) may be sufficient to cause fruit formation.
2. Parthenocarpy may be induced by hormones.
   Parthenocarpic fruits are seedless. Because seedless fruits are in great demand, the process is of practical value also.

seeds

Asee is a ripened fertilized ovule and the final product of sexual reproduction.

It contains an embryonic plant, reserve food & protective coat.
The embryo in the Seed is made up of embryonal axis.
It contains radical (embryonic root)and plumule (embryonic shoot).
On the side, one or two embryonic leaves or are cotyledons are present.
In some seeds food is stored in the endosperm. The seeds which store their food in endosperm are called endospermic seed for albuminous seed.
e.g. castor, bean, rubber, wheat, rice, maize etc.
The seeds which store their food in cotyledons (endosperm absent) are called non endospermic are exalbuminous.
e.g. pea, gram, groundnut etc.

Structure of Bean seed(dicot non endospermic seed)
The seeds of Bean like those of other legumes are formed within the pod, which is a ripened ovary.
The seed is attached to the inside of the pod by the funiculus or seed stalk.
When the seeds are shed, the funiculus break off, leaving a prominent scar, the hilum.
Just below the hilum can be seen the micropyle and above the hilum is the Ridge formed by the Raphe.
The seed coat have characteristic colour like brown, black and white.

Structure of Castor seed (dicot endospermic seed)
It is broader at one end and pointed at the other end with elliptical outline.
The colour is dark brown with hard smooth and shining testa.
Tegmen is thin, white and membranous.
A soft, white spongy structure called car- -uncle is present at one end of the seed.
There are two cotyledons which are thin, oval, papery & veined.
Endosperm is fleshy in which food is stored.

Structure of maize grain (monocot endospermic grain)
It is one seeded fruit called caryopsis or grain because pericarp (fruit wall) is fused with testa.
Each grain is made up of following parts:

1. seed coat- it is the outer brownish layer of the grain.
2. Endosperm- it is composed of region:

(a) outer single layered alurone layer, mainly made up of alurone proteins.
(b) Inner starchy endosperm & separated from embryo by a layer called epithelium.

3. Embryo- It contains a single lateral cotyledons called scutellum and embryo axis with plumule and radicle are at its two ends. Radicle is surrounded by a protective sheath called coleorhiza. Plumule is also protected by a covered sheath known as coleoptile.

Seeds as physiological enigma

Seeds have been considered as physiological enigma of living world. They contain a miniature plant, a protective seed coat, reserve food for future growth & little long lived RNA to guide future metabolism and growth.

Fruit

Fruit may be defined as a mature and ripened ovary.
A true fruit is one which develops from a single ovary of a single flower with no other parts outside the ovary.
e.g. Mango, tomato etc.
A fruit is false or spurious (pseudocarp) when other floral parts also take part in the formation of fruit.
e.g. Lichi, Apple, pear etc.
All aggregate and multiple fruits are false.

Dormancy

Sometimes a particular set of conditions needs to be satisfied before the seeds began growth this period of inactivity is called dormancy.
Examples include:

1. A period of sustained cold.
2. A set period of time to allow certain very slow chemical process to occur.
3. A certain amount of light above a given intensity.
4. A partial break down of the seed coat.
5. The heat of a flash fire.

Apomixis

The apomixis is the formation of new individuals through asexual reproduction without involving the formation fusion of gametes.
Amphimixis is the formation of new individuals through the normal process of sexual reproduction by meiotic formation of gametes and their subsequent fusion during fertilization.
Apomixis is a form of a sexual reproduction that mimics sexual reproduction.

Agamospermy is the formation of new individuals by sexual reproduction without involving fusion and formation of gametes.

It is of following types:

(a) Adventive embryony- In this case one or few extra embryos are formed from a diploid cell of nucellus are integuments but never from egg.
(b) Non recurrent agamospermy-It is the development of the embryo from haploid female gamete without fertilization.
(c) Recurrent apomixis-A diploid embryo sac is formed which has a diploid egg or oosphere.
(d) Parthenogenesis- It is the development of seed from a female gamete without fertilization.
(e) Parthenogamy- It is the union of two incompatible gametes i.e. fusion of two female gametes.
(f) Apospory- It involve the development of gametophyte from sporophyte directly.
(g) Apogamy- It is the development of sporophyte from gametophyte without the the fusion of gametes.
(h) Diplospory- in this case diploid embryo sac can develop directly from diploid megaspore mother cell.