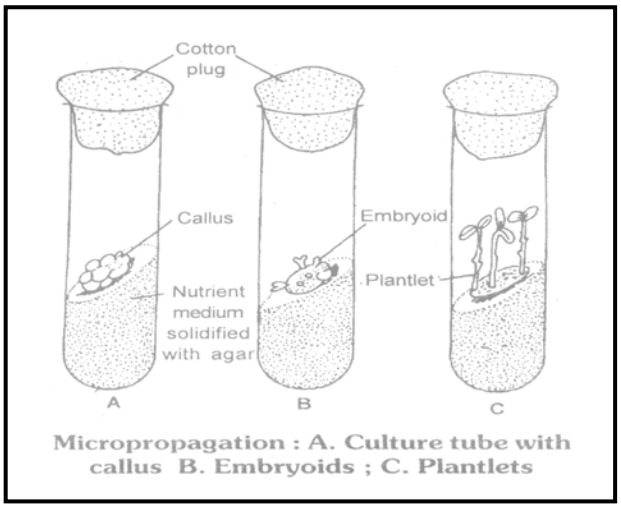
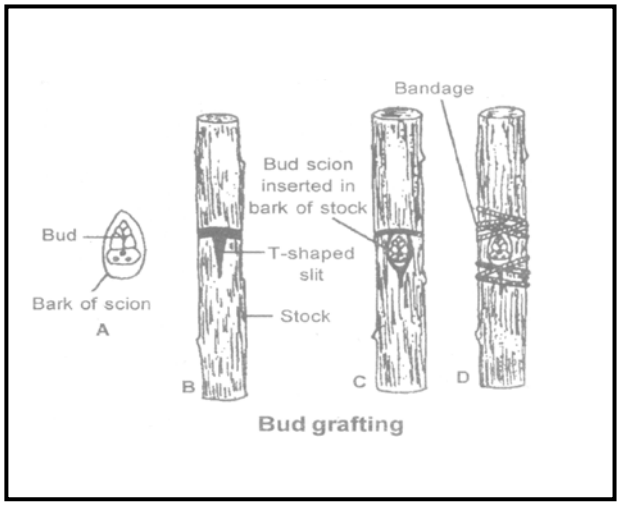
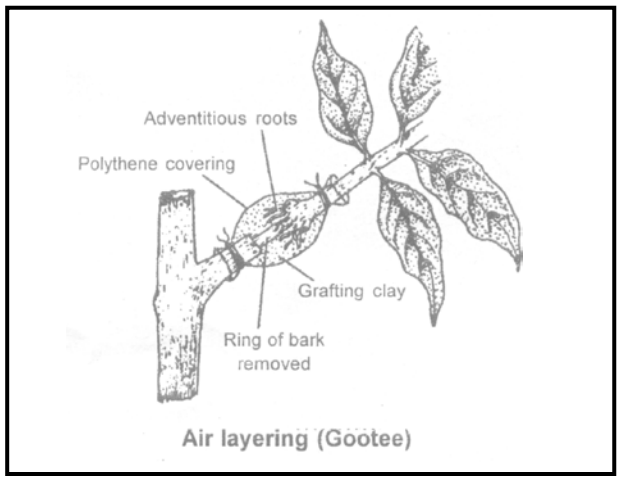


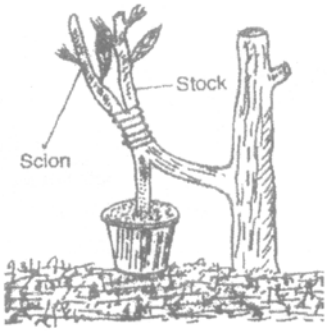
Micropropagation : A. Culture tube with callus B. Embryoids ; C. Plantlets



Bud grafting



Air layering (Gootee)



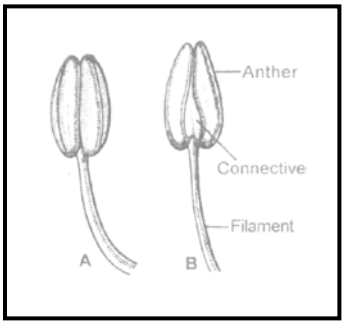
Approach grafting

IV SEXUAL REPRODUCTION

In **Angiosperms male and female gametes** are formed in male and female sex organs by the process of **meiosis.** Both the gametes fuse together to form a **diploid zygote** which gives rise **embryo.** It means **the process in which embryo by meiosis and fertilization is called Amphi mixis.**

1. Male Reproductive Organ – Androecium

Male reproductive organ is called **androecium** and their unit is called **stamen.**Stamen is also known as **microsporophyll.** There are 6 stamens are present in Capsella. A typical stamen is differentiates into three parts –a long, thin structure is called **filament** which joins the stamen to the thalamus. The free end of the filament, a swollen spore bearing structure is called **anther.** Anther and filament are attached together with help of small region, called **connective.**
Connective contains **vascular tissues.** The main parts of the stamen is the **anther.**Each **anther** generally **bilobed structure** i.e. , anther has two **anther lobes** is called **dithecous.**

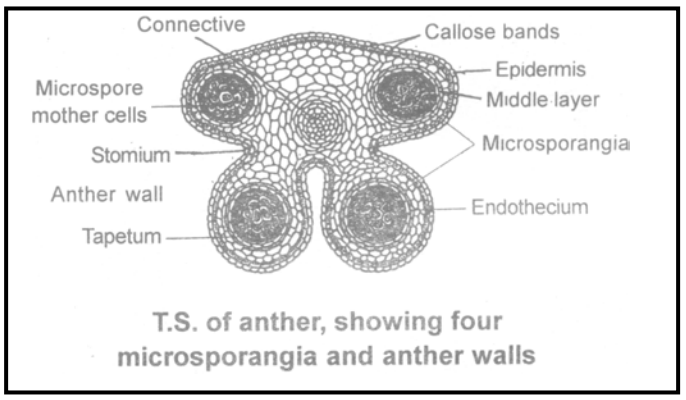


Each **lobe** of anther has two **chambers** which are called **pollen sacs** or **pollen chambers.**

☞ Therefore, a typical anther has four pollen sacs iscalled **terasporangiate.**

☞ Pollen grains are formed inside the pollen sthrough the meiotic division of pollen mother cells.

☞ At the maturity of the pollen grains, sterile tissuedegenerate which are present in between the pollen sace. Both the pollen sac fused together. Because of this reason, only one chamber appears in each anther lobe at maturity. So **two chambers** are seen in the **mature anther** at the time of dehiscence.



T.S. of anther, showing four microsporangia and anther walls

☞ In **Capsella,** which is member of the **Cruciferae** or **Brassicaceae, anther are dithecous** and **terasporangiate** type.

☞ But in **Malvaceae,** the anther of stamen has only **one anther lobe.** This is called **monothecous** and it contains only **two pollen sacs** called **Bisporangiate.**

☞ **Monothecous anther** are also found in **Moringa, Wolffia** plants.

☞ In **Arceuthobium** where there is only **one microsporangium** per anther. This condition is called **Monosporangiate.**

[A] STRUCTURE OF ANTHER:

The development of **anther** in origin is **Eusporangiate** type i.e. it is developed from more then one archesporial cells.]

☞ In the transverse section of anther, it is seen almost spherical.

☞ The following structures are present in the anther:-

(i) Epidermis: - It is the outermost layer of anther. It is single celled thick and continuous layer but not archesporial in origin . It forms the outermost **protective layer.**

☞ In **Arceuthobium** (Smallest Parasitic Angiosperm) fibrous thickening present in epidermis so it is called **exothecium.**

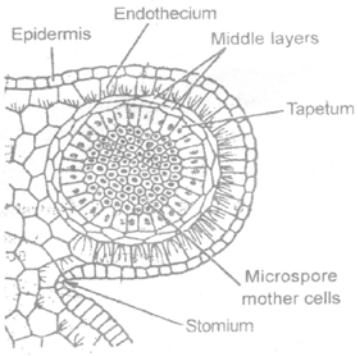
(ii) Endothelium: - This layer is present below the epidermis. It is single called thick layer. During the maturation of anther, various changes take place in different walls of cell of endothecium. The outer wall of these cells remains thin walled, but inner walls and radial walls become think due to thickening of **α- cellulose fibers. Callose bands** are also present along the radial walls. At some places callose bands and fibrous thickening are absent. These place are called **stomium.** The dehiscence of anther takes place only from these places. **Endothecium** becomes **hygroscopic nature** due to presence of fibrous thickening. So it helps in dehiscence of anther.

Note: Hydrocharitaceae family – fibrous thickening is absent in endothecium.

(iii) Middle layer :- Middle layer is consist of parenchymatous cells. This layer is **one to three celled think structure.** Food is stored by **parenchymatous**cell in this layer. Middle layer is **ephemeral** in nature and absent in a mature anther.

Note: (1) In **Holoptelia** plant 3 to 4 celled think middle layer is present. (2) In **Najadaceae** & **Lemnaceae** families middle layer is absent. (3) In Wolffia middle layer is absent.

(iv) Tapetum: - It is the inner most layer which acts as **nutritive layer.** It is known as **tapetum.** Pollen sacs surrounded by tapetum. This is also single celled thick layer. The cells of the tapetum initially **diploid** but they become **polyploidy** due to **endomitosis.** It means these cells contain many chromosomes.



T. S. of young anther showing four microsporangia and vascular bundle.

Tapetum **absorbs food** from the **middle layer** and provide nutrition to the microspore mother cells or microspores. The cells of tapetum secrete **hormones** and **enzymes.** The tapetum layer disappears in the mature anther.

Note: In **Nicodia** and Costum **plants, tapetum is multilayered.**

Pollen sace: Four Pollen sacs are present in the anther. Pollen sacs are also known as **microsporangia.** Inside the pollen sacs, **microspores** are formed by the **meiotic division** of **microspore mother cells.**

TAPETUM IS OF TWOTYPES:-

(i) AMOEBOIDTAPETUM/INVASIVETAPETUM/PERIPLASMODIAL TAPETUM:-

It is found in **primitive Angiosperm.** Such type of tapetum **absorb all foods** from the middle layer. So middle layer immediately degenerates. In the beginning , all food materials stored by tapetum. Tapetal cells convert absorbed food into **special food granules** called **protoplast bodies.** The innermost layer of tapetum dissolve and release its protoplast into the cavity of the microsporangium. Now inside the pollen sace protoplast bodies are known as **periplasmodium.** Microspore mother cells are surrounded by periplasmodium and provides nourishment to the developing microspores. This type of tapetum provide nutrition to the microspores after degeneration .

Example : Typha, Alisma and Tradescantia.

(ii) GLANDULAR OR SECRETORY TAPETUM:-

It is **developed type** of tapetum. It is not degenerates quickly. It absorbs nutrients from the middle layer and secreted into the cavity of the micro sporangia (Pollen sacs) and does not store it e.g. Usually it is found in most of **Flowering plants (Capsella).**

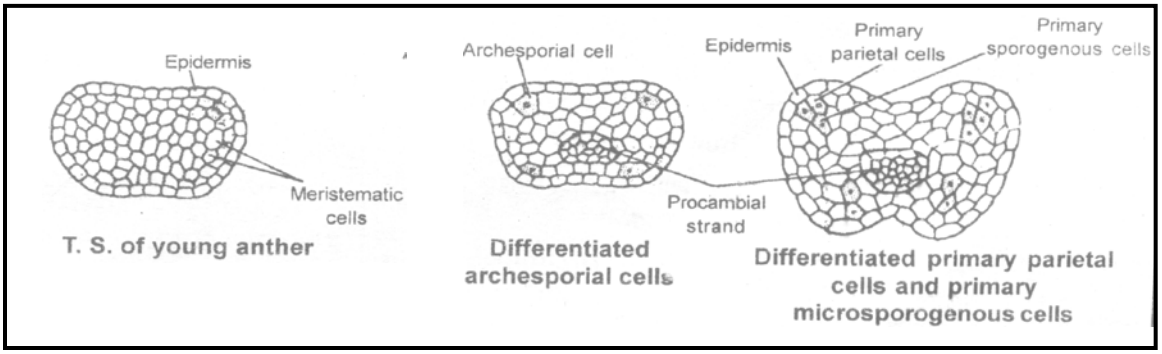
Before degeneration of cells of tapetum, they form special granules called **Proubisch bodies** in cytoplasm. Proubisch bodies transfer between cell wall and cell membrane of Tapetal cells. Here they are surrounded by **sporopollenin.** Now they are called **Ubisch bodies** or **orbicules.** At last tapetum degenerates and ubisch bodies released into pollen sacs.

Generally , sporopollenin participates in the formation of **other covering** (Exine) of Pollen grains.

Note – Tapetum helps in transfer of food, storage of food, formation of sporopollenin and pollenkitt materials.

[B] MICROSPOROGENESIS:

- The anther appears as outgrowth like structure in the initial stage which shows spherical or oval shaped structure.
- At this stage , it is a mass of **undifferentiated** and **homologous meristematic cells** which is surrounded by a single cells thick outer layer . This layer is known as **epidermis.** First of all vascular tissue are formed in middle region simultaneously four cells located just below the epidermis in vertical rows in the region of hypodermis at the four corners are become large has visible nucleus with dense cytoplasm. Due to this reason they are different from the rest of the cells. These cells are called **archesporial cells.**
- These cells divide **periclinally** to form **primary parietal** cells below the epidermis and **primary sporogenous cells** towards the centre. Both of the cells usually undergo further division to form complete structure of anther except epidermis.



- **Primary parietal cells** undergo further **periclinal** and **anticlinal division** to form a series of **3-5** layers making the walls of the anther.
- Out of them **outer most layer** of anther is formed just below the epidermis by primary parietal cells is called **endothecium** or **fibrous layer.** The endothecium is followed by 1-3 celled thick layer is termed **middle layer.** The **innermost layer** of the anther which surrounds pollen sacs, is called **tapetum.** Later the Tapetal cells play a significant role during the meiotic cell division in microsporogenous cells and in pollen development.
- **The primary sporogenous cells divide twice or more then two by mitotic division to form sporogenous cells** and later sporogenous differentiated into **microspore mother cells** during the formation of wall of pollen sac.
- Each **microspore mother cell** divide to form four **haploid microspore** or pollen grain by **meiotic division** or **reduction division .**
- During this period spherical bodies are formed inside the Tapetal cells before their disintegration. These spherical bodies are known as **Ubisch-body.** Ubischbody is made up of a **complex substance** called **sporopollenin.** It is the **polymer of carotenoids.**
- After the formation of ubisch body, the tapetum layer degenerates. Ubisch bodies participate in the formation of exine of the microspores inside the pollen sacs. Now thick walled microspores are called **pollen grains.**
- At the initial stage all **four microspores** are attached together with the help of **callose layer.** This group of microspores is called **tetrad.** After some time, this callose layer dissolve by callase enzyme. Which is secreted by tapetum

Note :- Normally each microspore mother cell can form tetrad by meiotic division. But in some plant like **Zostera,** some microspore mother cell become sterile and provide nutrition to rest of microspore mother cell.

Note:- Similarly, tapetum is not well developed in **Gentianaceae family** so some cells of sporogenous tissue become sterile and provide nutrition to remaining sporogenous cells.

Types of tetrads: - The arrangement of the microspores in tetrad condition as follows:-

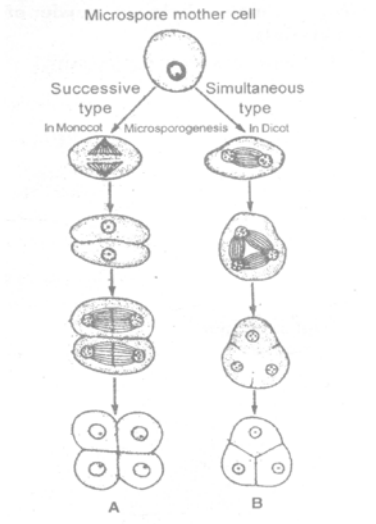
(i) Tetrahedral tetrad: - Four haploid microspores arranged in **tetrahedral** from

(ii) Isobilateral tetrad: - This condition is found in **monocotyledons.** Microspores are arranged at the lateral side of each other.

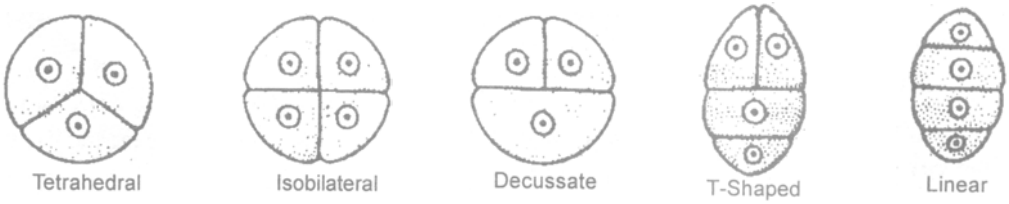
(iii) Decussate Tetrad type:- In this two microspores lies at the right angle of other microspores
Example: - **Magnolia**

(iv) T-Shaped: - Two microspores lie longitudinally and two microspores lie at transverslyin this type of tetrad.
Example :- **Aristolochia** & **Butomopsis.**

(v) Linear tetrad – In this tetrad all four pollens arranged in linear order. e.g. **Halophylla, Halophia.**
All the above type of tetrads are found in **ristolochia elegans.**
Most common type of tetrads is Tetrahedral.



TWO DIFFERENT TYPE OF MEIOTIC DIVISION IN MICROSPORES MOTHER CELL.



DIFFERENT TYPE TETRAD OF ANGIOSPERM

Facts about types of Pollen grains –

(1) In **Asclepiadaceae (Calotropis)** and **Orchidaceae** family, all the pollen grains joined together to form **"Pollinium".**

(2) More then four pollen grains are found in tetrad called **"Polyspory"** e.g. **Cuscuta.**

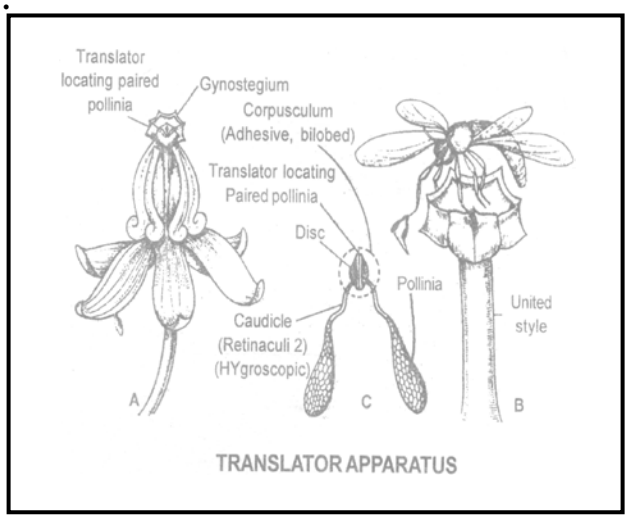
(3) In some plants, four pollen of tetrad join together permanently are called **"Compound pollens"** e.g.
Drosera, Typha, Drimys and **Elodea.**

(4) Pollinium of **Calotropis** is called **"Translator apparatus".**

(5) **Compound**pollensof**Mimosaceae(Mimosa)** family contains 6-8 or 64 pollen grains stick together to form a small unit that is called **"Massullae"** e.g. **Mimosa** and **Neottia** plants.

(6) **Pollen grains** of some plants present in air cause **allergy** are called **"aero allergens"** e.g.**Chenopodium,parthenium, Sorghum,** and **Amaranthus.** [**"Hay fever"** is caused by pollens of **Ambrosia.]**

(7) In **Cyperaceae** family only one pollen grain is formed from pollen mother cell. e.g., **Cyperus.**



TRANSLATOR APPARATUS

(8) **Largest pollen – Mirabilis.**

(9) **Smallest pollen – Myosotis.**

(10) **Longest pollen - Zostera (Filiformpollen)**

(11) **Eight nucleated embryo sac** type of **pollen** is found in **Hyacinthus.** [This type of pollen grain discovered by **Nemec.** So it is called **Nemec phenomenon]**

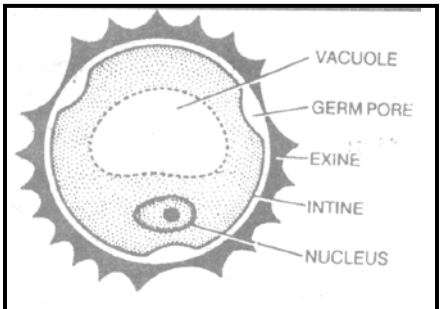
(12) Dumble shaped pollens are found in **Vinca herbacea.**

[C] STRUCTURE OF MICROSPORE OR POLLEN GRAIN:

Pollen grain is the first cell of a male gametophyte.

☞ **Pollen grain** is termed as **immature male gametophyte.** Usually, they are in round shape. Pollen grain surrounded by **two distinct layers.** The **other layer** (wall) is **thick, rigid** and ornamented, **called** exine. This layer is formed by **cutin** and **sporopollenin.** Sporopollenin is **highly resistent6 material.** It is **nonbiodegradable.**

☞ Due to the presence of sporopollenin, **fossils of pollen grain** are always found in **good condition .** The presence of fossils of pollengrains can forecast the presence of **natural resources** like **petroleum, coals** etc. in the earth.



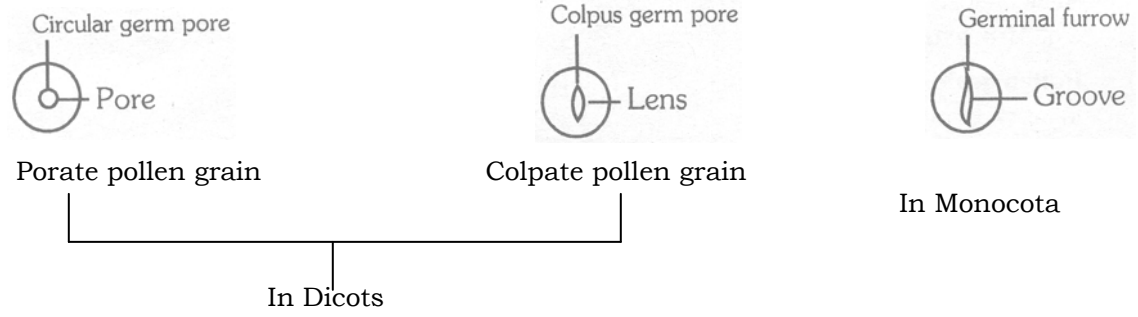
STRUCTUREOF POLLENGRAINS

- The **internal layer** is **thin, soft** and **elastic** in nature. It is called **intine.** It is made up of **pectin** and **Cellulose** or **pecto-cellulose.**
- Usually, at few places on outer surface exine is absent or present in the form of thin layer.. These thin places are called **germ pore.** The intine comes out through the any one germ pore during the germination of pollen grain in the form of **pollen tube.**
- The **number of germpore, structure** and **ornamentation** of exine is a significant feature of **taxonomy.**
- A detail study of pollen grains is called **Palynology.**
- There **colpus type (slit type)** of germpore are present in pollen grain of **Capsella.** This type of pollen grains are called **tricopate.** Only one germ pore is present in monocots and pollen grain is called monocopate.
- The plants in which pollination takes place by **insects,** their pollen grains having **oily layer** around the pollen grain. It is called **pollen-kitt.** It is composed of lipids and carotenoids.

Function of pollen kitt:-

(i) This oily layer protects the pollen grain from the harmful ultraviolet rays.
(ii) Its sticky surface helps to attach with the insects.
(iii) Its yellow colour attracts the insects. Pollen kit is present on the pollens of Capsella.

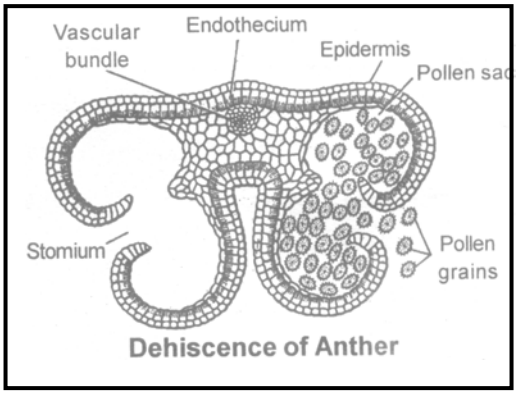
Type of Germpore:-



[D] DEHISCENCE OF ANTHER:

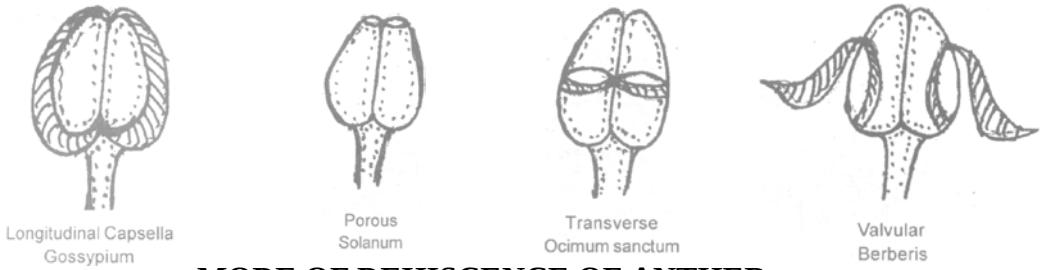
During the maturation of anther , various changes are takes place in walls of anther.

- In the beginning , middle layer degenerates due to absorption of food by tapetum.
- When the micropores are formed inside the pollen sacs, at the same time ubisch bodies are formed in cells of tapetum, then after it degenerates. Ubisch bodies participate in the formation of exine of pollens.
- In this way, in a **mature anther** only **two layers epidermis** and **endothecium** are present in the form of outer covering.
- The sterile tissues are present between both the pollen sacs of each anther lobe degenerate. So both pollen sacs of each anther lobe fuse together to form single pollen sac.



- Therefore, in the **T.S. of manture anther** only **two pollen sacs** are present.
- **Dehiscence** of anther takes place during the **dry season.** Due to the **hygroscopic nature** of endothecium. loss of water takes place from the cell of endothecium.
- Walls of endothecial cells try to contract due to the loss of water but **inner** and **radial walls do not contract** due to presence of **fibrous thickening** whereas **outer thin walled** of endothecium contract and become **concave** or **incurved.**

- Incurving of outer walls exert **pulling force** or **tension** over the entire . Due to tension, thin walled **stomial cells breaks off** and dehiscence of anther takes place and pollen and pollen grains are present in pollen sacs released into the atmosphere.
- **Dehiscence** of anther in **Angiosperms** either **longitudinal** or **Apical pore,** or **Transvrse** or **Valvular type.** Dehiscence of anther of **Capsella** is **longitudinal.**



MODE OF DEHISCENCE OF ANTHER

[E] MICRO-GAMETOGENESIS OR DEVELOPMENT OF MALE AMETOPHYTE:

In **flowering plants, pollen grain** or **microspore** considered as **first cell** of **male gametophyte.** Germination or development of pollen grain takes place before dehiscence of anther is called **precocious development.** Development of pollen also takes place at **mother place** [inside pollensac of anther] is called **In-situ development.**

(i) Pre Pollination development –

In the beginning of the process, only nucleus of pollen divided by **unequal mitotic division resulting two unequal size** of nucleus are formed. Small nucleus present near the wall is called **generative nucleus** and large nucleus present inside the cytoplasm is called **Tube** or **Vegetative nucleus.**

Both the nucleus surrounded by cytoplasm and it becomes dense, then after again followed by **unequal cytokinesis,** resulting **two unequal size** of the **cells** are formed.

Larger cell in which **large nucleus** is present known as **Vegetative cell** and **smaller cell** in which **small nucleus** is present, called **generative cell.**

Now **pollen grains** come in bicelled and **binucleated stage.** In Angiosperms **pollination of pollen grains** take place in **bicelled** and **binucleated stage.** The development gametophyte take place inside the pollen grain is also known as **endosporic development.**

This stage of pollen grain is called **immature** or **partially developed male gametophyte.**

Generative cell detached from the wall and changed into **vermiform** or **spindle shaped** structure and enter inside the vegetative cell.

(ii) Post Pollination development –

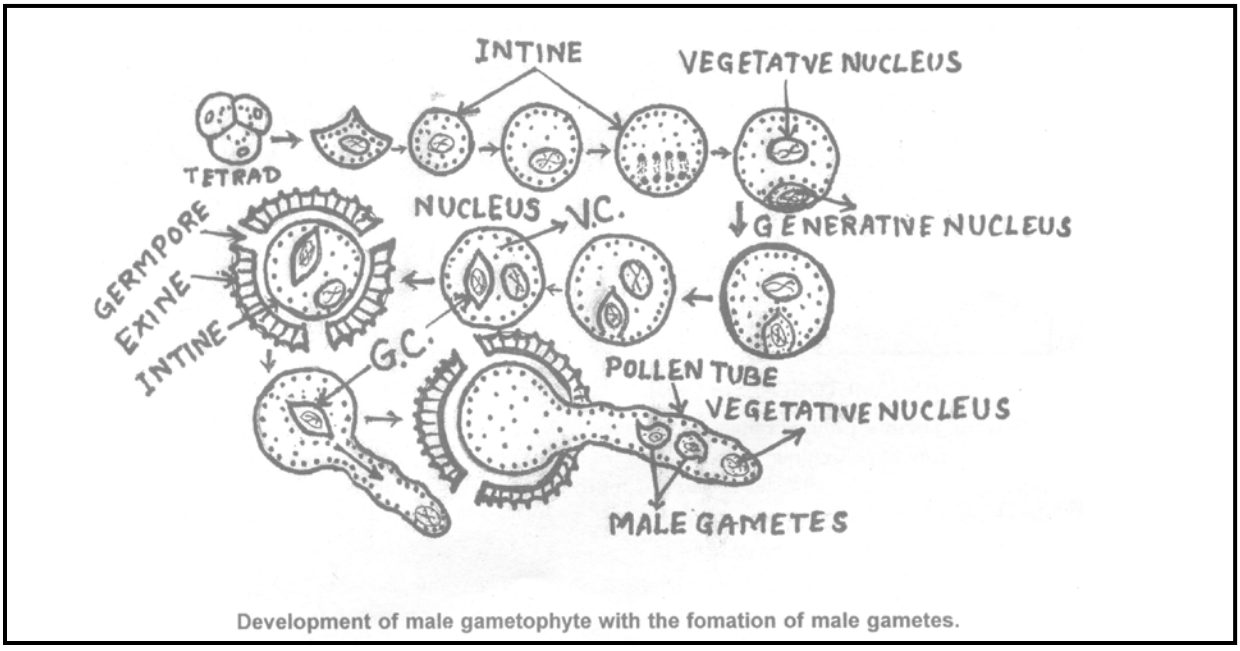
Rest of the further **development of pollen grain** [Immature male gametophyte] takes place on the **stigma** of Carpel after pollination.

Pollens absorb moisture and sugar content from the stigma. Due to this volume of internal contents of cytoplasm increased. It exerts pressure on the both outer layers. Because of this pressure intine comes out through any one germpore in the form of tube like structure called **pollen tube.**

First of all **vegetative nucleus** enter into the pollen tube and assumes **terminal** [tips] position. This spindle shaped generative now enter into the pollen tube.

Inside the pollen tube, **generative** cell divides **mitotically** and to form a two **non motile male gametes.** Now **male gametophyte** comes in **three celled structure** in which **one vegetative cell** and **two male gametes** are present.

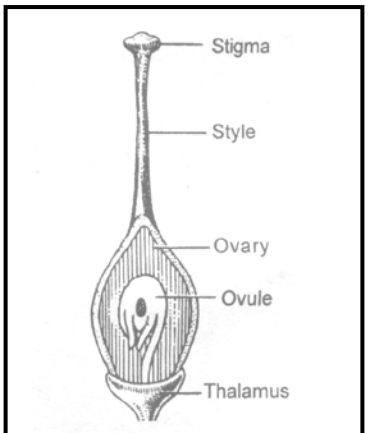
This **three celled stage represents the mature male gametophyte of Angiosperm[Capsella also] .** Male gametophyte is **highly reduced** and completely **depends** on sporophyte.
First of all pollen tube discovered by G.B. Amici Portulaca plant.
Longest pollen tube is found in Zea mays.



Development of male gametophyte with the fomation of male gametes.

[v] FEMALE REPRODUCTIVE ORGAN – GYNOECIUM

Gynoecium is the **female reproductive organ.** The free **unit** of gynoecium is called **pistil** or **carpel.Carpel** is also known as **megesporophyll.**
The **carpel** is differentiate into **three** distinct region-
[i] **Stigma** [ii] **Style** [iii] **Ovary**
The free end of the carpel which receives pollen grain is called **stigma.**A long, narrow tubular structure is present in between the stigma and ovary called **tyle.**
he basal swollen part of the carpel is called **ovary.**
The ovules is also known as **megasporongia** which are borne on a cushion- like tissue called **placenta** in the ovary.
One or **more then one** ovules are present inside the ovary.
The **gynoecium** of the **Capsella** is **bicarpellary, syncarpous, unilocular and superior.**
It becomes bilocular due to the formation of **false septum** or **replum** at maturity.



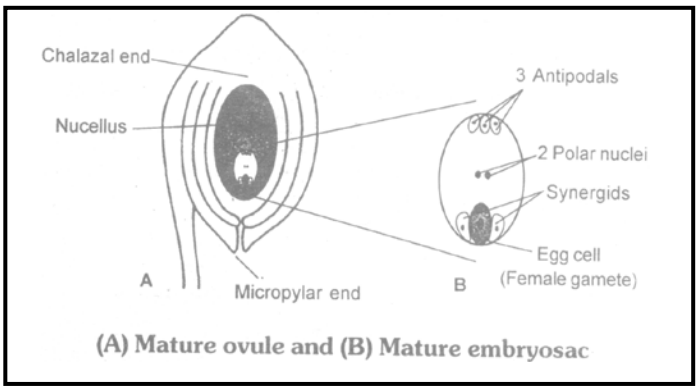
A typical gynoecium (= pistil)

[A]STRUCTURE OF OVULE OR EGASPORANGIUM

A ridge or stalk like out growth is formed from the placenta of the ovary on which body of ovules are present. Each ovule attached to the placenta by means of a thin stalk called **funicle or** funiculus /Funiculum
The point of attachment of the funicle with the ovule is called **hilum.**
The main region of the ovule is composed by mass of parenchymatous cells called **nucellus. Nucellus** is the **main part of ovule.** The nucellus is covered by **one** or **two** coats called **integuments.**

– In most of the ovule, funicle is attached to the main body of ovule for some distance (at lateral side) to form a ridge like structure known as **Raphe**

– Vascular tissues are present inside the funiculus which supply food material from the placenta to the body of ovule.



(A) Mature ovule and (B) Mature embryosac

SPECIAL INTEGMENTS-

(i) **ARIL --** It is the type of **third integuments** which de3velops from funicle at the **base** of the ovule.

(ii) ARILLODE -- It develops from the tips of the outer integument and grows downwards and surrounds the entire ovule e.g. **Pithecolobium** (Inga dulce)

(iii) **SARCOTESTA--** When outer integument becomes fleshy then it is called sarcotesta e.g. **Magnoliaceae** (Magnolia).

(iv) **OPERCULUM--** It is a stopper or break like structure which is formed on the micropyle. It is formed due to the elongation of inner integuments. e.g. **Lemnaceae** family **(Lemna).**

(v) CARUNCLE OR STROPHIOLE -- It is formed due to the proliferation (out growth) of outer integuments over the micropyle. e.g. **Ricinus communis (Castor) .** It is **formed by sugary contents so helps in absorption of water during germination of** seeds and dispersal of seeds by ants called **myrmecochory.**

(vi) **COMA --** In some of the plants unicellular filaments like structures are present on the seed which is formed by cells of outer surface of outer integument . Such seeds are known as **"Comose seeds "** e.g. **Calotropis** and **Gossypium.**

– A place from where **funicle** and **integuments** arise is called **Chalaza.** Integument is absent just opposite to the chalaza, so that a narrow passage (pore) is formed which is called **micropyle.**

– **Micropyle** in **bitegmic ovule** has two parts **--outer region** which is surrounded by **outer integument** is Called **exostome.**

– The **inner part** of micropyle which is surrounded by **inner integument** called **endostome.**

– In most of the Angiosperm entire part of the nucellus is utilized by developing embryo sac but in some of the Angiosperm some part of the nucellus remain inside the ovules that part of the nucellus present inside the seed in the form of a thin layer known as **perisperm** is commonly found in **Piperaceae (Piper nigrum)** and Zingiberaceae Families (Turmeric, Ginger)

☞ Some filaments are attached with funicle [some times placenta] are known as **"Obturators".**

☞ The function of Obturators is to guide the passage of pollen tube towards the micropyle inside the ovary.

TYPES OF OVULE ON THE BASIS OF INTEGUMENTS :

A **single integumented** ovule is called **unitegmic ovule –**example- members of **Gamopetalae** and **Gymnosperm.**

Two integumented ovule is called **bitegmic** ovule . Example – In most of **Angiosperm** [Polypetalae – **Capsella** and **Monocots**].

☞ The ovule in which **integuments are absent** in called **Ategmic ovule** e.g. **Olax, Liriosma , Loranthus & Santalum.**

TYPES OF OVULES ON THE BASIS OF NUCELLUS –

(i) **Tenuinucellate –** The nucellus is either less developed or present in the form of single layer.

Example **:**- **Gamopetalae group.**

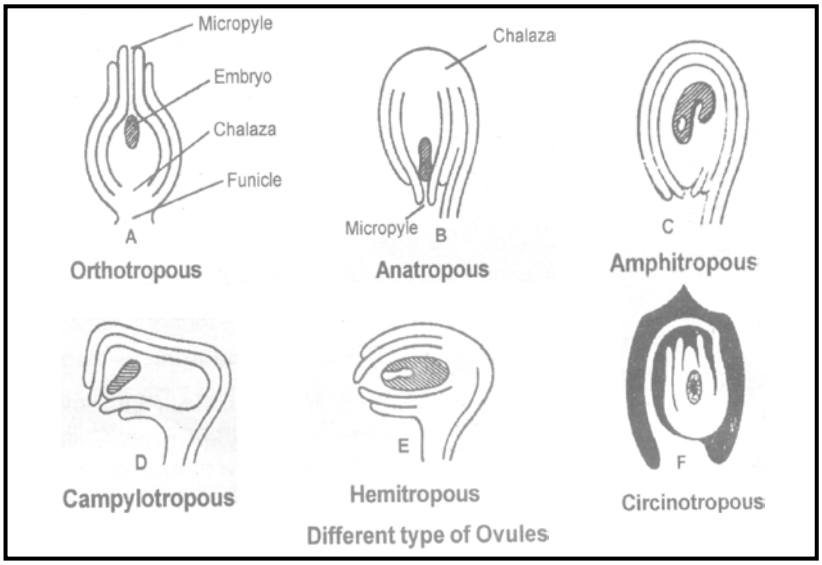
(ii) **Crassinucellate :-** The nucellus is massive type i.e., it is made up of many layers.
Example :- **Polypetalae group** and **Monocots**

☞ The **nucellus degenerates** in plants of **Compositae** family and **integument** becomes **active** to form a **nucellus like tissue.** This is called **endothelium or integumentary tapetum.** It is **polyploidy** structure.

☞ The **nucellus dissolves** in the members of **Podostemaceae** family to form a **nutritional cavity.** This is termed **pseudoembryo-sac.**

[B] TYPES OF OVULES:

There are **six** different **types of ovules** are found in **Angiosperms** on the **basis of relationship** of the **micropyle , chalaza,** and **hilum** with body of the ovule and **orientation on the funiculus:**



Different type of Ovules

[i] ATROPO US OR ORTHOTROPOUS:-

The body of ovule is upright in position . The **micropyle, chalaza** and **hilum** in one **straight line**, so that this ovule is called straight or upright ovule. Example:- **Betel, Piper, Polygonum** and in **Gymnosperms.** It is the **most primitive and most simple type of ovule of Angiosperms.**
Raphe is absent.

[ii] ANATROPOUS OVULE:-

In this type, the body of the ovule completely turned at **180⁰ angle,** due to unilateral growth of funiculus so it is also called inverted ovule. The chalaza and micropyle lie in straight line. The hilum and micropyle lie side by side very close to each other. This type of ovule is found in **80⁰ families** of **Angiosperms** but not in **Capsella.** In this ovule micropyle facing downward condition. This is the **most common type of ovule** so that it is considered as a **"typical ovule" of Angiosperms.** e.g. Members of **Malvaceae Cucurbitaceae, Solanaceae, Compositae** family. It is also called resupinate ovule

[iii] HEMITROPOUS OR HEMI-] ANATROPOUS OVULE:-

In this ovule, the body of the ovule bent on funicle at 900 angle, i.e., body of ovule present at **right angle** to the funiculus. This is **intermediate type** between **ortho** and **anatropous** ovules. This ovules also called **horizontal ovule** because body of ovules present in horizontal position on the funiculus Micropyle and chalaza are present in the same line but micropyle is situated away from hilum. Example:- **Ranunculus, Primula, Golphimia.**

[vi] CAMPYLOTROPOUS OVULE:-

In this ovule, the body of ovule CURVED (Curvature is not effective) in this way so micropyle and chalaza do not present in straight line. The **embryo sac** and **nucellus** both are present in **curved position** Micropyle comes close to the hilum. Eg.:- **Leguminosae, Capparidaceae, Cruciferae** family **[Capsella]**

[v] AMPHITROPOUS OVULE:-

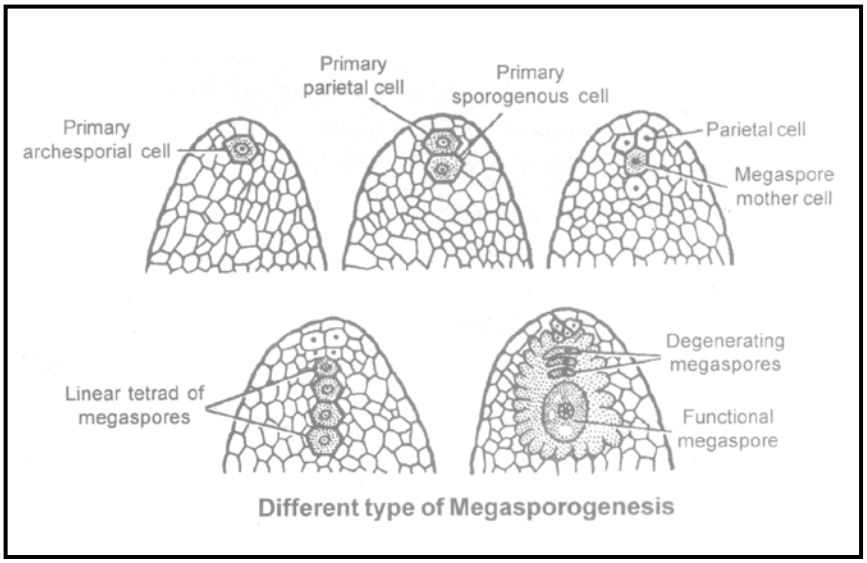
In this type of ovule, **curvature** is more pronounced or effective in the nucellus and due to this effect of nucellus embryo sac becomes **horse shoe shaped.** Micropyle comes close to the hilum. It is also called as transverse ovule. e.g. **Mirabilis , Lemna** and Poppy, **Alisma , Butomaceae** family.

[vi] CIRCINOTROPOUS OVULE:-

This type of ovule , first of all body of ovule inverted once and again turned into straight position due to the growth of funiculus so that body of ovule present on funicle at **360^0** . The entire body of ovule is surrounded by funiculus. It is also known as **coiled ovule.** Micropyle is situated away from hilum .e.g. **Cactaceae family Opuntia.**

[C] MEGASPOROGENESIS :

During the development of ovule , in the beginning of this process. **nucellus** develops form the **placenta** in the form of a small out growth like structure.At this stage, all the cells of nucellus are **undifferentiated** and **homologous and meristematic.** This massof cellssurrounded by single celled thick layer of **epidermis.**



Different type of Megasporogenesis

Any **one hypodermal** cell of nucellus is differentiated and increase in size. It becomes different from rest of the cells due to presence of distinct nucleus. It is called **archesporial cell.** Archesporium divides periclinally to form an **outer primary parietal cell** and **inner Primary Sporogenous cell.** Activity of Primary Parietal cell depends on type of plants. If plant belongs to **Gamopetalae** then it forms **Tenuinucellate** type ovule and if plant belongs to **Polypetalae** then if form **Crassinucellate** type of ovule. The primary sporogenous cell directly act as a **megaspore mother cell.** It divides **meiotically** to form, four haploid **megaspores.**

The four haploid megaspores generally arranged in **linear tetrad .** Generally the lower most or chalazal **megaspore** remains **functional** out of tetrad of megaspores and the **other three** lie towards the micropyle degenerate. The functional megaspore produces female gametophyte. In **most of Angiosperms [Capsella].** Chalazal megaspore remains functional.

[D] DEVELOPMENT OF EMBRYOSAC OR FEMALE GAMETOPHYTE-

Megagametogenesis:- Megaspore is the **first** cell of the **female gametophyte.** This megaspore grows in size and obtains nutrition from the **nucellus.** The nucleus of megaspore divides mitotically to form a two nuclei. Each nucleus moves towards the opposite pole and reached at their respective poles. Both the nuclei lie at poles divide twice mitotically. Resulting, four-four nuclei are formed at each [Total 8-nuclei].

Out of the four, one-one nucleus migrates from the both poles [one nucleus from chalazal side and one nucleus from micropylar side] towards the centre. They are known as **polar nuclei.** Both polar nuclei are present in the centre.

Remaining three-three nuclei at each pole surrounded by cytoplasm to form cells as a result of cytokinesis **Three cells** are formed towards the **micropyle** in which one cell is large and more distinct out of three cells. This is called **egg cell** and remaining **two smaller** cells are known as **synergids.** These three micropylar cells collectively known as **egg-apparatus.** [1Egg cell + 2 Synergids]

The three cells are formed toward the Chalaza are called **antipodal cells.** Both the polar nuclei present in the central cell. But just before the process of fertilization they unite or fuse together in the centre to form **secondary nucleus.** It is **diploid in nature [2n]** and one in number.

Therefore , **seven cells** and **eight nucleated** structure is formed . This **eight nucleated** and seven celled **structure** is called **female gametophyte** or **embryosac** of Angiosperms. This type of embryosac is known as **"polygonum type"** because it is discovered by **[Capsella].** Polygonum type of embryosac develops from **single megaspore** so it is also known as **monosporic embryosac.**

☞ Fingers like processes are produced from the outer wall of the synergids are known as **Filiform apparatus.** With the help of these structures, synergids absorb food from the nucellus and transfer to the embryosac. Filiform apparatus is less developed in antipodal cells. Filiform also secrete **chemicals** which attracts the pollen tube.

☞ In some plants, **barrier** are present either above or below the **female gametophyte.** These barrier are made up of thick walled cells of nucellus .They prevent the movement of embryosac towards the chalaza or micropyle. The **barrier** which is present towards the **chalaza** is called **" hypostase"** e.g. **Umbelliferae family and Zostera and Crozophora plants.**

The **barrier** which is present toward the **micropyle** is called **"epistase"** e.g. **Costalia and Costus.**

[E] TYPE OF EMBRYOSACS:-

(i) Monosporic Embryosac – It is of **two types-**

1. **Polygonum type –** It is eight nucleated and seven celled embryosac.
2. **Oenotheratype –** Exceptionally it is **four nucleated** in which only one nucleus in a central cell and three nucleus in egg apparatus . Antipodal cells are absent. [Micropylar megaspore become functional]

(ii) Bisporic Embryosac- It is formed by two megaspores. It means it develop from two nuclear megaspores. It is of **two type –**

1. **Allium type –** Eight nucleated and seven celled [Chalazal megaspores]
2. **Endymion type -** Eight nucleated and seven celled [Micropylar megaspores]

(iii) Tetrasporic Embryosac- It is formed by all four megaspore nuclei because meiosis is not accompanied by Cytokinesis, so that four nuclei of megaspores are formed .

All four nuclei are collectively known as **"Coenomegaspore".**

Generally all the four Nuclear megaspores take part in the formation of the **seven celled** and **eight nucleated embryosac** but different types of embryosacs are also formed. Arrangement of nuclei are not definite in embryo sac in some of Angiosperms. So that different type of embryosacs are formed as follows :-

Types of Terasporic Embryosac	Number of nuclei in Sec. nucleus	Ploidy of endosperm
1. **Adoxa type**	2	3n
2. **Chrysanthemum type**	3	4n
3. **Plumbago type**	4	5n
4. **Plumbagella type**	4	5n
5. **Fritillaria type**	4	5n
6. **Penaea type**	4	5n
7. **Peperomia type**	8	9na