SEETHALAKSHMI RAMASWAMI COLLEGE (AUTONOMOUS)

ACCREDITED AT 'A' GRADE (3rd CYCLE) BY NAAC
AFFILIATED TO BHARATHIDASAN UNIVERSITY
TIRUCHIRAPPALLI – 620 002

LAB MANUAL
II B.Sc., Botany

PRACTICAL PAPER – II

ANATOMY, EMBRYOLOGY, CYTOGENETICS AND BIOMETRY

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PREFACE

The practical study of the subject is of immense value. The laboratory work develops confidence and scientific outlook. Students always need some guidelines to facilitate their work in the laboratory. I hope this will be fulfilled by this lab manual which covers the portions of II B.Sc., Botany of Seethalakshmi Ramaswami College. It includes Anatomy, Embryology, Cytogenetics & Biometry with labelled illustrations and brief descriptions. Plant anatomy covers all topics related to the histological aspects of various plant parts. Embryology deals with anther, ovules and embryo. Cytogenetics includes ultra structure of cell organelles, Mendelian experiments, genetic interactions and solved genetic problems. Biometry includes solved problems of mean, median and mode. The model question paper and spotters are appended.

I express my deep sense of gratitude and indebtedness to our Managing Trustee, Coordinator and Principal Dr.(Mrs) Kanaka Bhashyam for their encouragement and support. I extend my sincere thanks to DBT star college scheme, New Delhi for their Financial Assistance.

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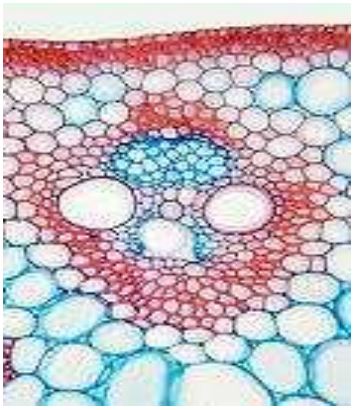
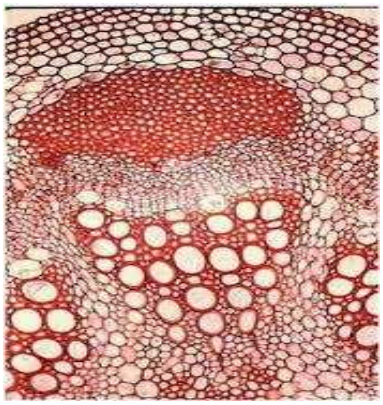
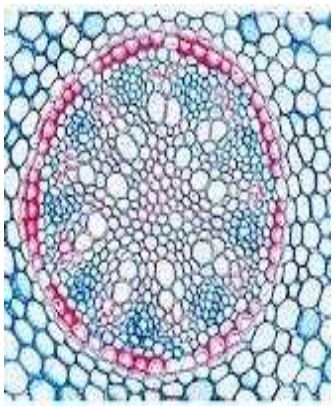
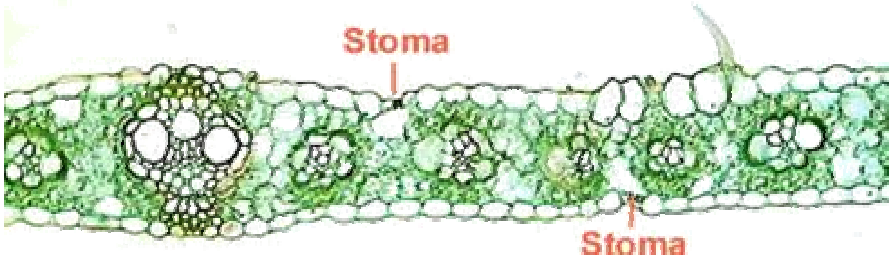
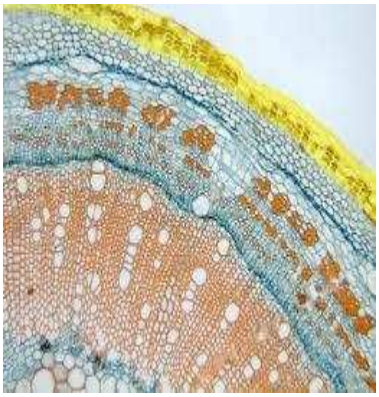
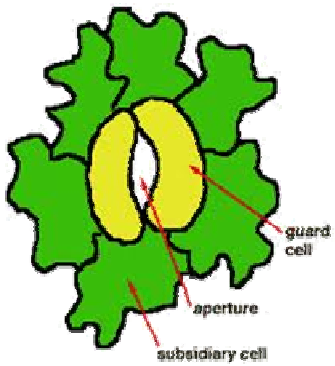




ANATOMY

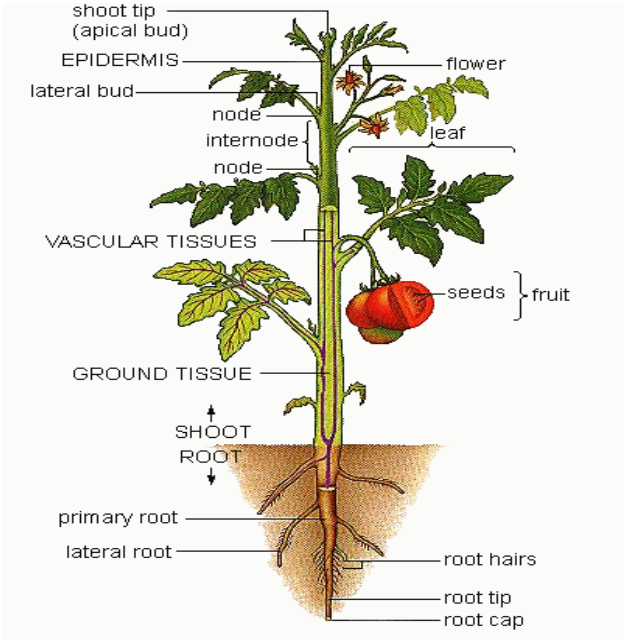






ANATOMY

- The plant body of a typical seed plant basically consists of two parts, the **root** and **shoot.**
- **Leaves** are regarded as **lateral expansions** of stem.
- The primary meristem found in the apical region contributes to the three main types of tissues - **vascular tissues, epidermis** and **cortical tissues**.
- All the tissues derived from apical meristem are commonly called **primary tissue**.
- The **vascular and cork cambium** produces **secondary tissue**.



PRIMARY STRUCTURE OF ROOT

- The epidermis has **unicellular hairs.**
- Cuticle and stomata are absent.
- **Hypodermis** is not differentiated.

- **Cortex** is **broad** and well developed.
- Endodermis distinct with **casparian strips** and **passage cells.**
- Stele is **actinostele**.
- Pericycle is single layered and parenchymatous.
- Vascular bundles are **radial.**
- Xylem is **exarch**.
- Lateral branches arise endogenously i.e. **pericycle.**

PRIMARY STRUCTURE OF STEM

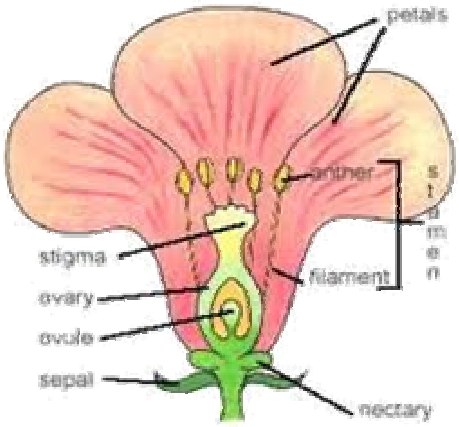
- **Multicellular** hairs are present.
- **Cuticle** and **stomata** are present.
- **Hypodermis** is well marked.
- **Endodermis** indistinct.
- Stele is **polyfascicular siphonostele** in dicots and **atactostele** in monocot.
- Pericycle several layered and mostly **sclerenchymatous**.
- The vascular bundles are **collateral** and **conjoint.**
- Xylem is **endarch** in nature.
- Lateral branches arise exogenously.

STRUCTURE OF LEAF

- The dicot leaves are **dorsiventral** or **bifacial** leaves and monocot leaves are isobilateral leaves.
- The outermost layer is **uniseriate upper** and **lower epidermis**.
- Presence of **bulliform** cells in monocots.

- **Mesophyll** tissue is well differentiated **palisade** and **spongy** parenchyma in dicots.
- Vascular bundles are surrounded by **sclerenchymatous bundle sheeth** in monocot leaf and **parenchymatous** in dicot leaf.
- Bundles are **collateral** and **closed**. Xylem faces towards upper epidermis and phloem towards lower epidermis.
- Presence of **"Y" shaped Xylem** and **protoxylem lacuna** in monocots.

Embryology



- Embryology deals with **structure and development of embryo.**
- Flower is a **reproductive part** of the plant.
- It consists of the floral parts like **calyx, corolla**, **androecium** and **gynoecium**.
- **Androecium** and **gynoecium** are essential organs.
- **Androecium** made up of stamens. Each stamen has filament with anther lobes.
- **Anther** encloses **pollen grains** (Male gametophytes).
- **Gynoecium** made of pistils. Each pistil has **ovary, style** and **stigma.**
- Within the ovary presence of **ovules.**

- Process of transfer of pollen grains from stamens to **stigma of pistils** is called pollination.
- Fertilized egg develops in to embryo. In dicots, embryo has a **suspensor** two **cotyledons,** and an **embryonic axis** with **plumule**, **epicotyls**, **hypocotyl** and **radicle**.

GENETICS

- Branch of science which deals with **heredity** and **variations** among related organisms.
- Mendel is called the father of genetics and his contributions to genetics are called **Mendelism**.
- He worked in ***Pisum sativum*** and produced ratios in Monohybrid & Dihybrid crosses.
- Deviations from Mendelian ratios - **Incomplete dominance, Lethal factors,** and **Interaction of genes.**
- Inheritance of characters through sex - colour blindness in Man.
- Inheritance of characters through cytoplasm - Kappa particles in ***Paramecium***.

BIOMETRY

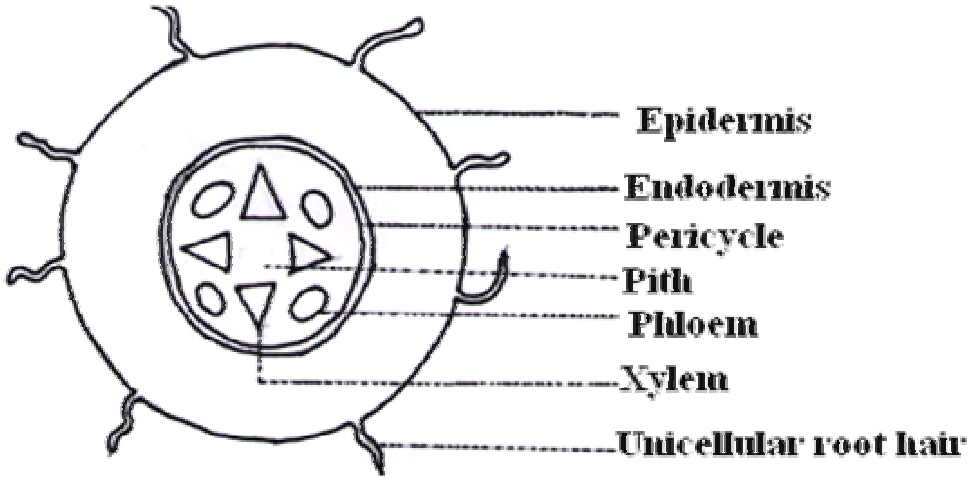
- **Collection, presentation, analysis** and **interpretation** of **numerical data**.
- **Measures** of central tendency a) **Mode** b) **Median** c) **Mode**
- **Mean** is an average. Adding all the values divide by the total number of items.
- Median is **mid value**.
- **Mode** is most **frequently occurring value**.

T.S. OF DICOT ROOT

E.g. BEAN

- Epidermis is **single layered** unicellular root hairs without cuticle.
- Cortex ix broad and **homogenous parenchymatous**.
- Endodermis is single layered with **casparian strips**.
- Uniseriate pericycle.
- Vascular bundles are **radial, closed, tetrarch** with **exarch xylem**.
- Pith is small and **parenchymatous**.

Ground Plan



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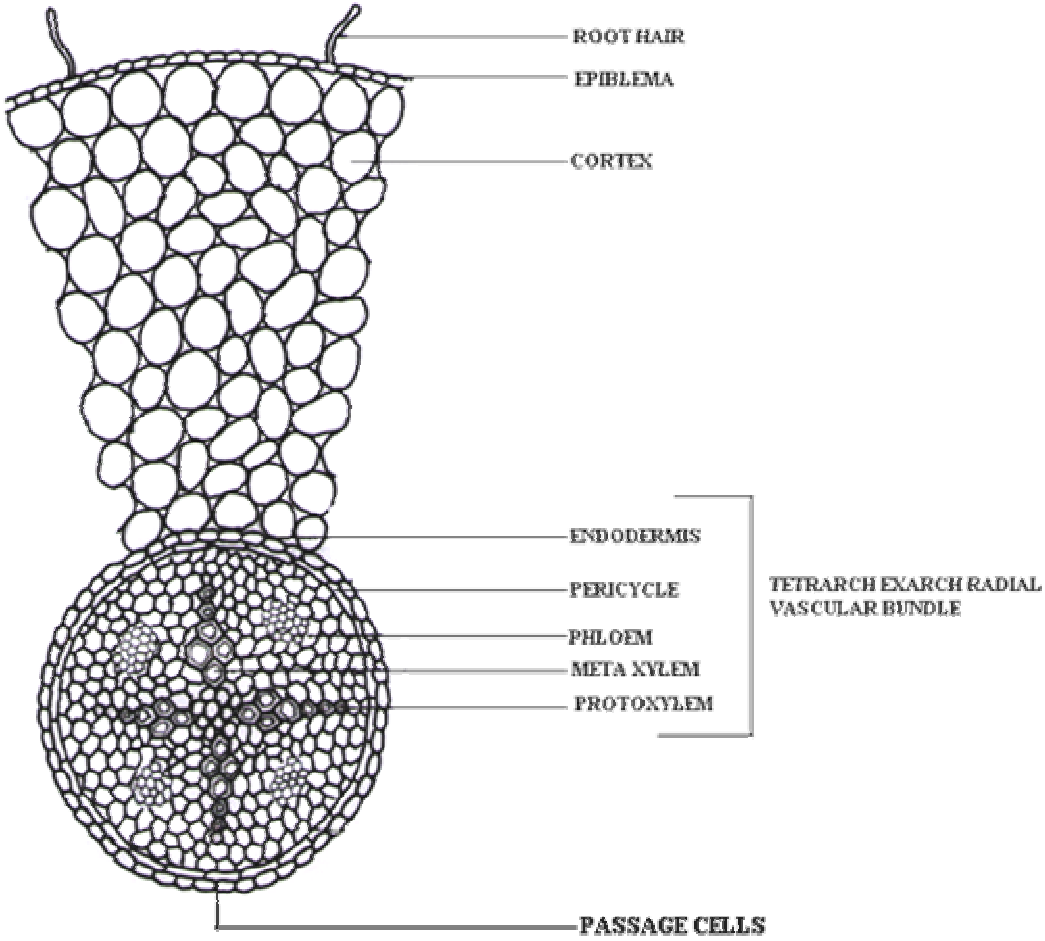
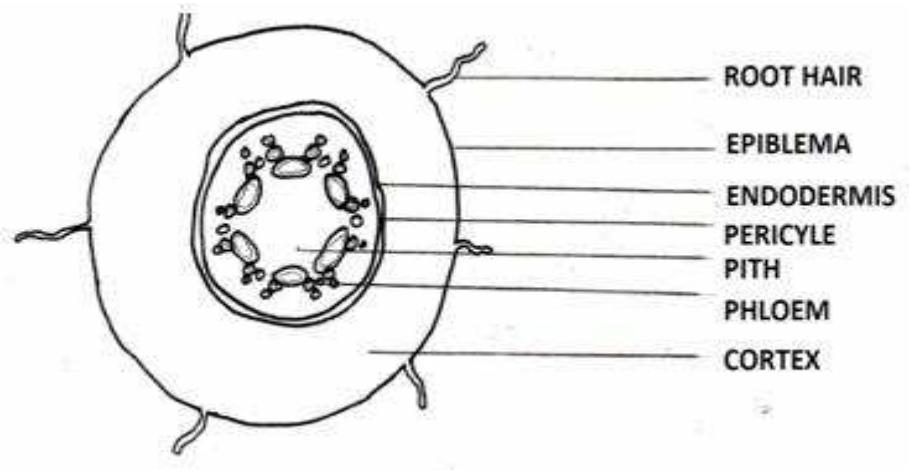


T.S OF MONOCOT ROOT

E.g. *CANNA*

- Epidermis is **single layered** with **unicellular hairs** without cuticle.
- Cortex is broad **parenchymatous** enclosing large space.
- Endodermis is distinct **uniseriate** with thin wall.
- Pericycle is single layered and parenchymatous.
- Vascular bundles are **polyarch, radial, and closed with exarch xylem**.
- Pith is **sclerenchymatous**.

Ground Plan



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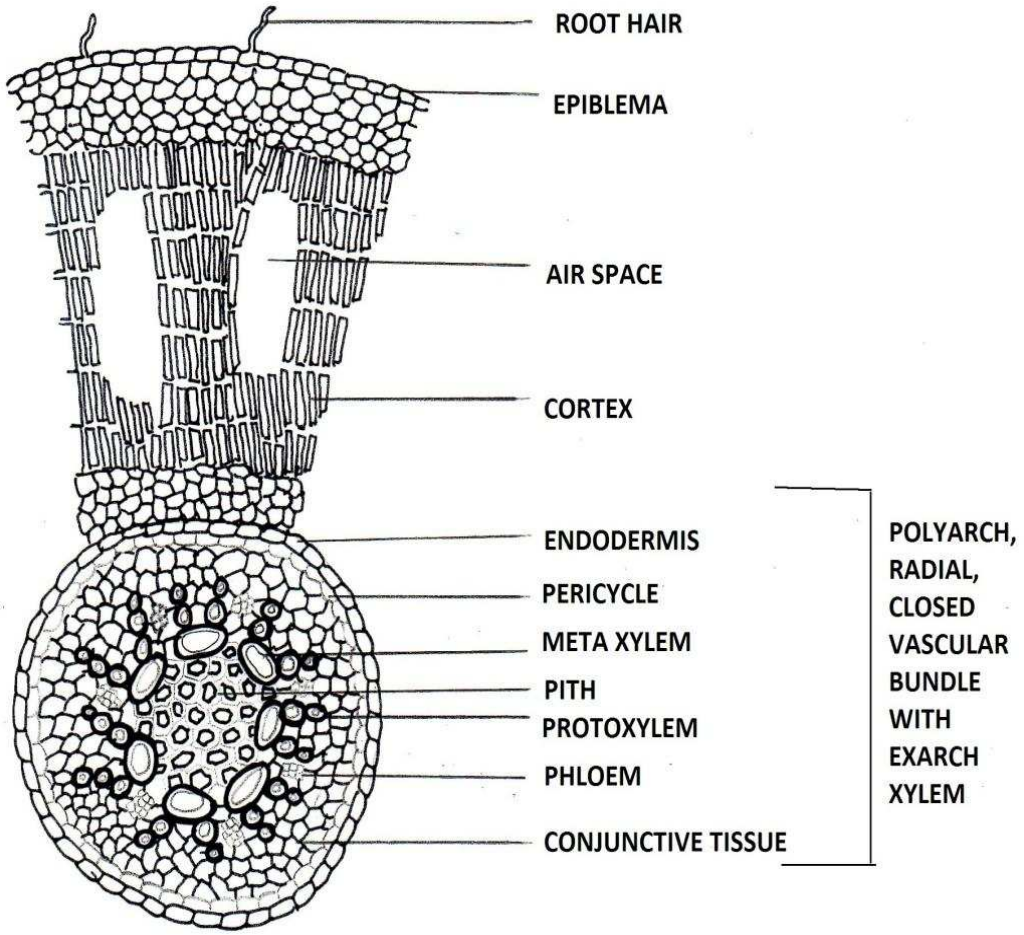
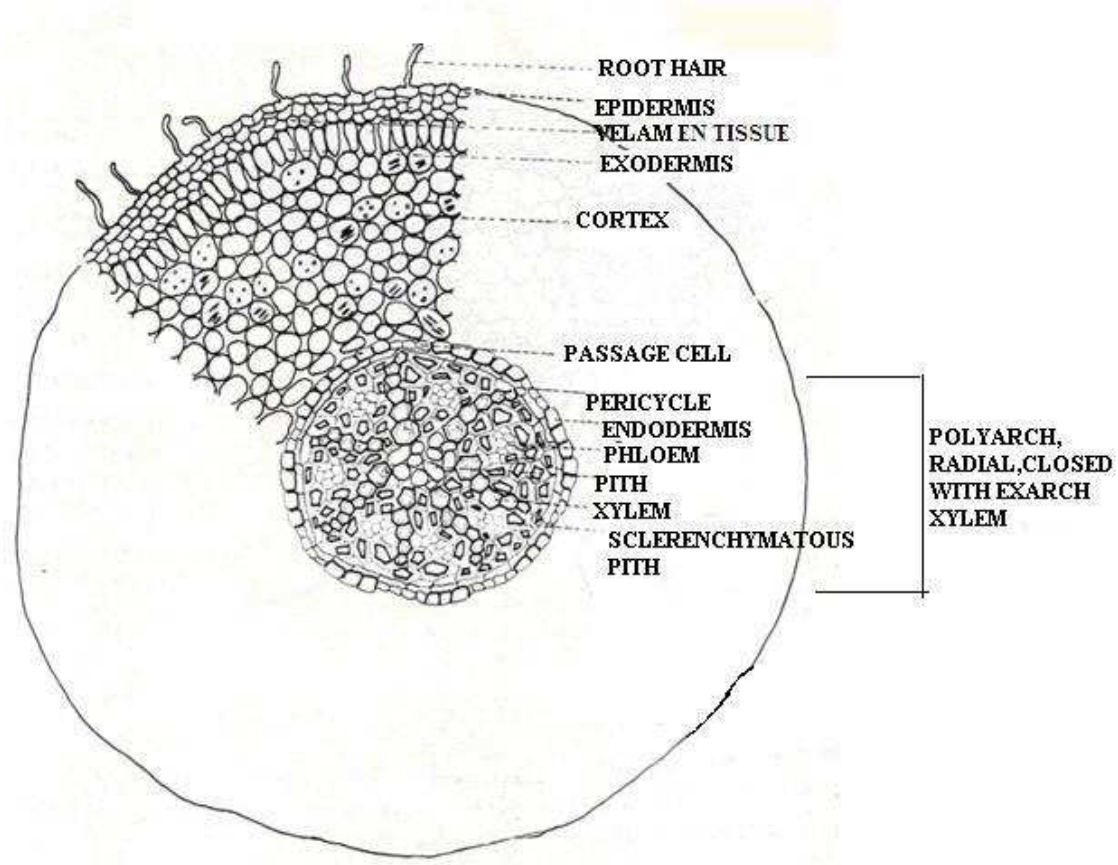


T.S OF ORCHID ROOT

E.g. *Vanda*

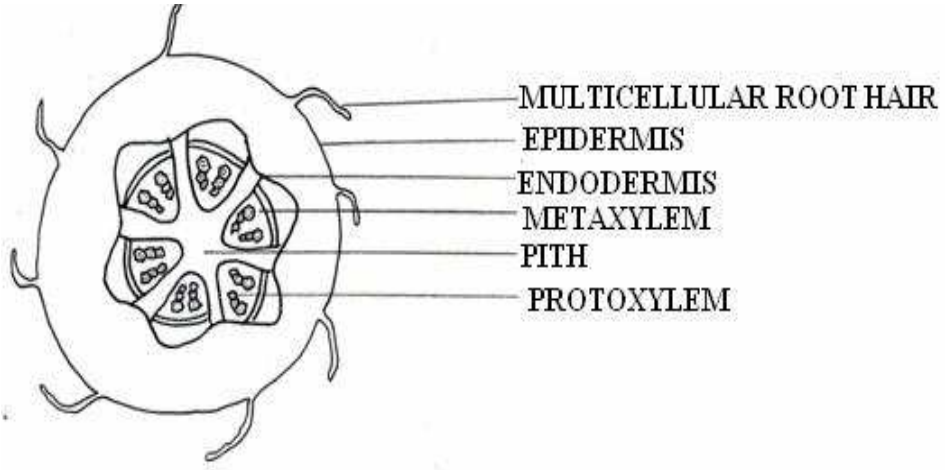
- **Rhizodermis -** Single layered with unicellular hairs.
- **Velamen tissue** - Thin walled parenchymatous, multilayered and absorb atmospheric moisture.
- **Exodermis -** Uniseriate, radially elongated cells.
- Cortex - **Parenchymatous** with intercellular spaces contains starch grains and raphides.
- Stele - **Polyarch, radial, closed with exarch xylem.**
- Endodermis - Single layered with passage cells and **casparian thickenings**.
- Conjunctive tissue - **Sclerenchymatous**.
- Pith **- Parenchymatous**


ROOT HAIR
EPIDERMIS
VELAMEN TISSUE
EXODERMIS
CORTEX
PASSAGE CELL
PERICYCLE
ENDODERMIS
PHLOEM
PITH
XYLEM
SCLERENCHYMATOUS PITH
POLYARCH, RADIAL, CLOSED WITH EXARCH XYLEM

T.S. OF DICOT STEM
E.g. *TRIDAX*

- Epidermis is **single layered** cuticularised with **multicellular hair**.
- Cortex is **heterogenous**. The outer **collenchymatous** and **chlorenchymatous**.
- The endodermis is wavy in outline.
- Pericycle is multilayered **heterogenous** made up of **sclerenchyma** and **parenchyma**.
- Sclerenchymatous pericycle form the **bundle cap**.
- Vascular bundles are **polyarch, conjoint, collateral, open** with **endarch xylem**.
- **Medullary rays** are present between the bundles.
- Pith is broad and **parenchymatous**.

Ground Plan



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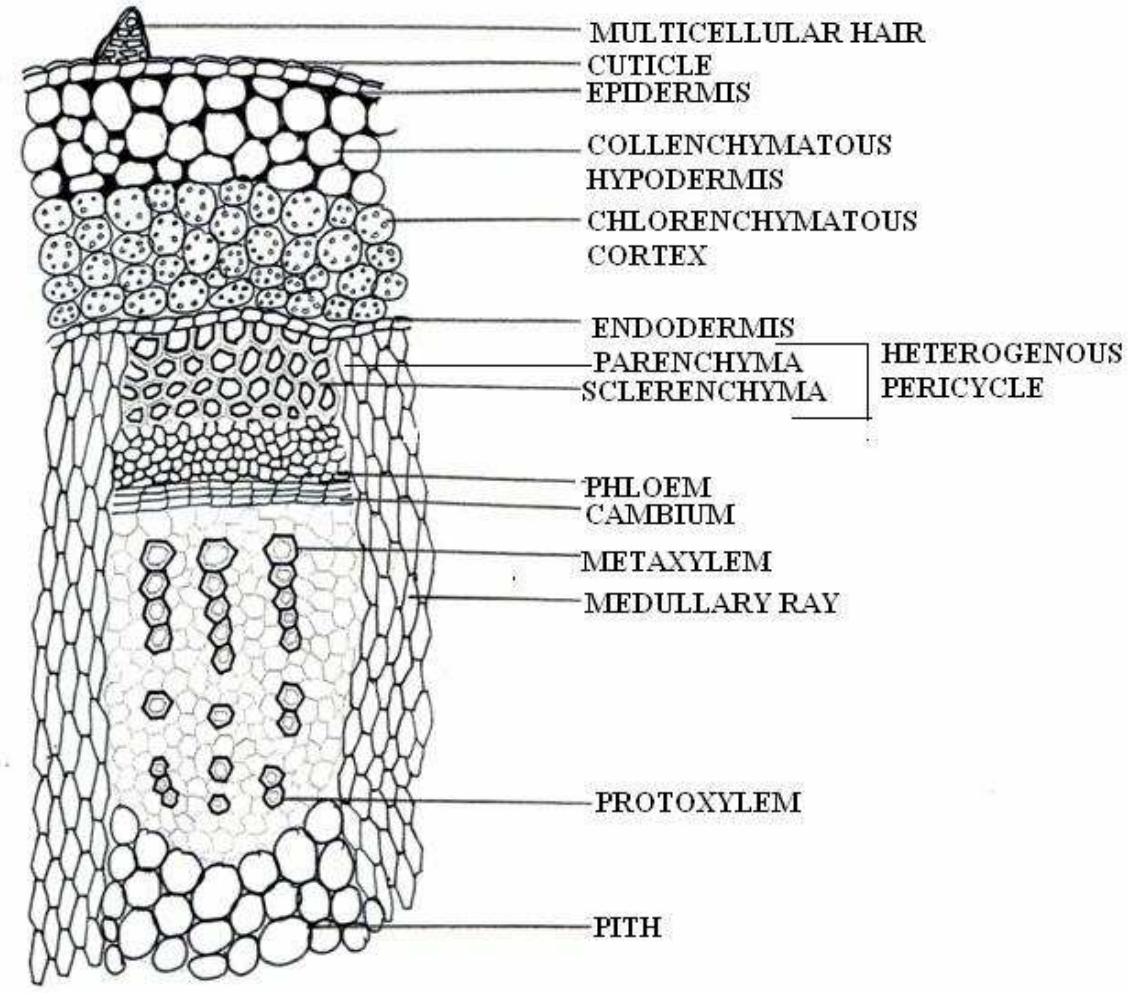


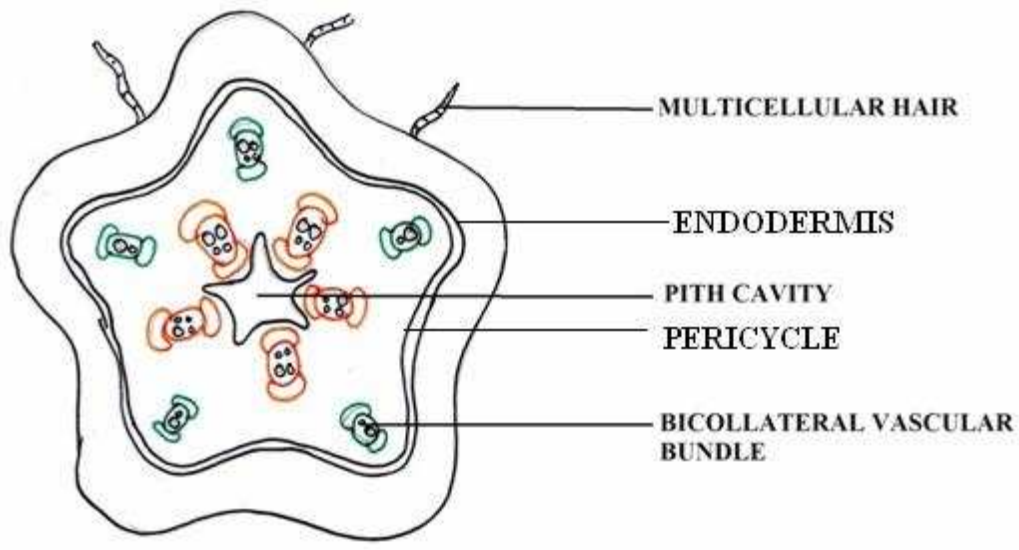
polyarch, conjoint, collateral, open with **endarch xylem**.

T.S OF DICOT STEM

E.g. *CUCURBITA*

- The stem has **five ridges and five furrows**.
- Epidermis is single layered **cuticularised** with **multicellular root hair.**
- Cortex is **heterogenous, collenchymatous** below the ridge and **chlorenchymatous** below the furrows.
- Endodermis is distinct.
- Pericycle is **multilayered** and **sclerenchymatous.**
- Vascular bundles are ten in number arranged in **two rings**. The outer five small bundles seen below the ridges and inner larger bundles below the furrows.
- The vascular bundles are **bicollateral, open with endarch xylem.**
- Pith is **hollow**.

Ground Plan



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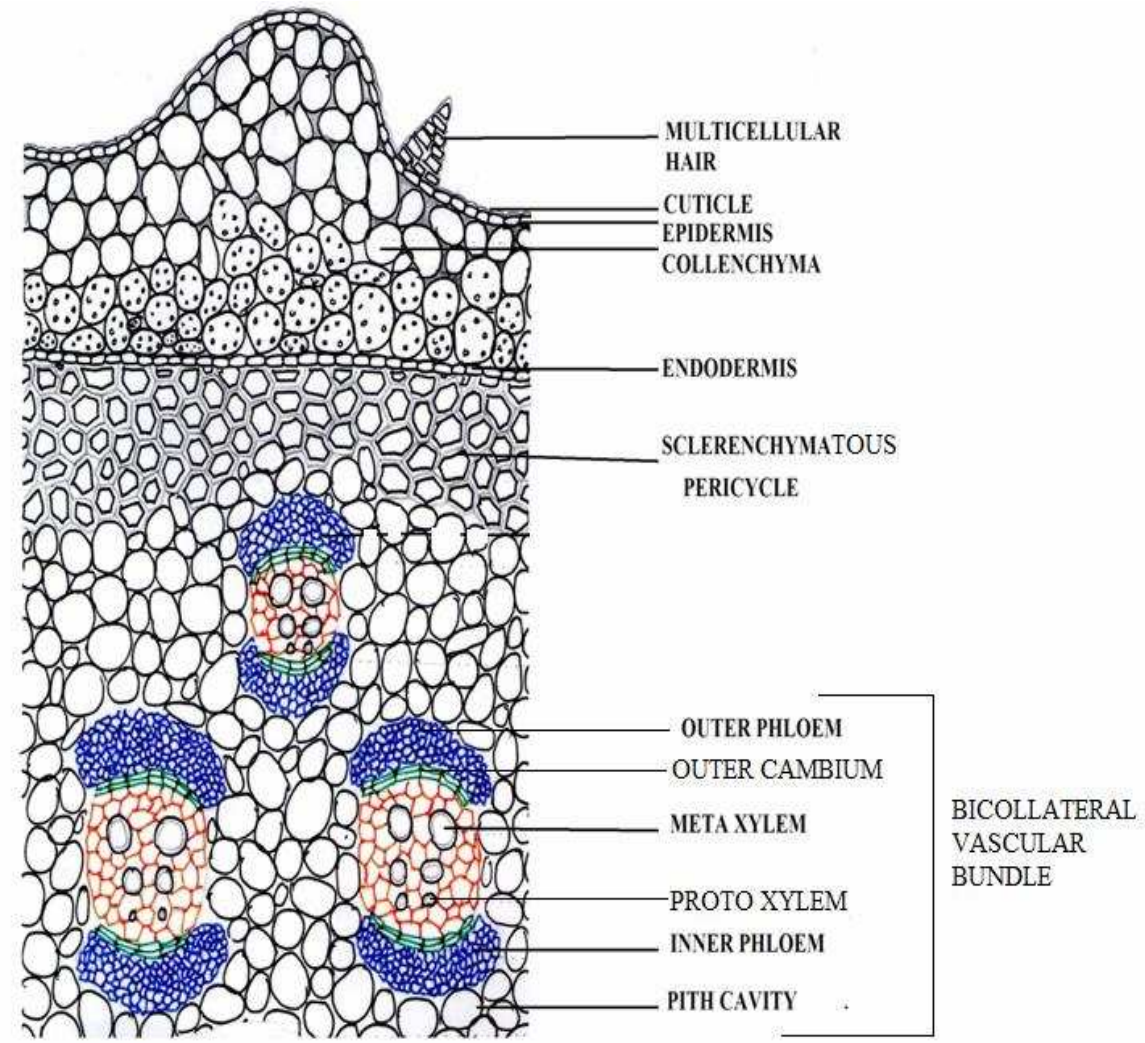
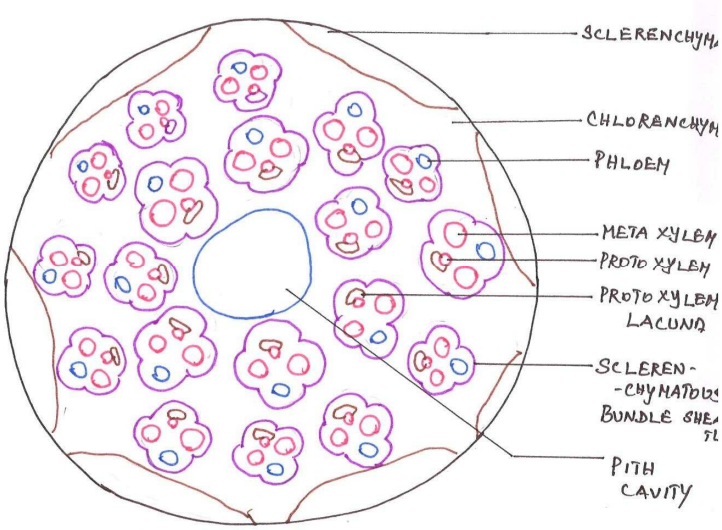


T.S. OF MONOCOT STEM
Eg. *Bambusa*

- **Uniseriate**, **cuticularised** epidermis.
- Hypodermis **heterogenous - chlorenchymatous** and **sclerenchymatous.**
- Ground tissue - **parenchymatous**.
- Many vascular bundles are **scattered** in the ground tissue.
- Bundles - **collateral, closed with endarch xylem**.
- Bundles are surrounded by **sclerenchymatous bundle sheath**.
- **Xylem - 'y' shaped** with **two meta xylem**, one **protoxylem** and **protoxylem lacuna**.
- **Phloem** with **companion cells**.
- Pith - **hollow**.

Ground Plan



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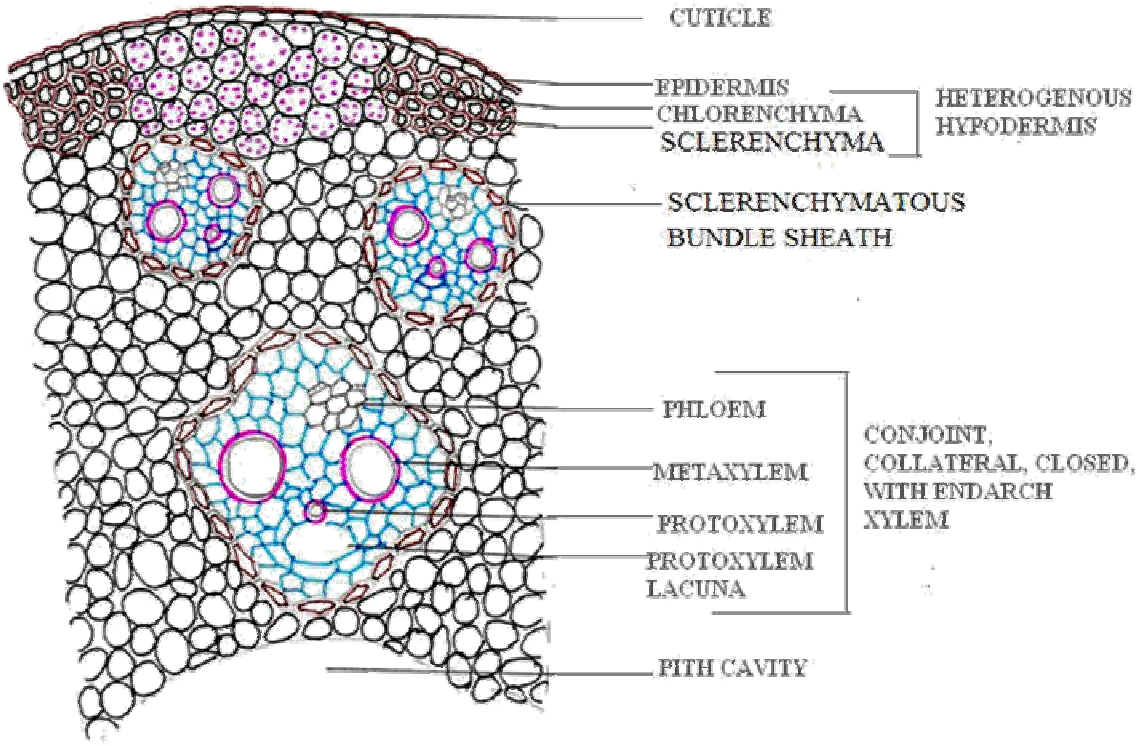
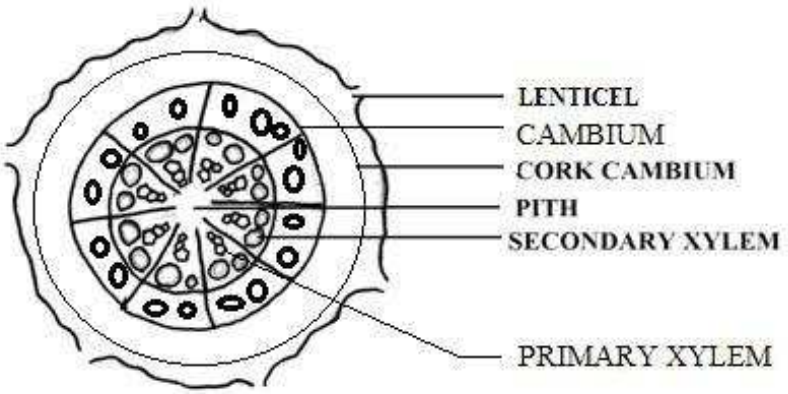


SECONDARY GROWTH IN DICOT STEM

E.g. *Anona*

- The outer most layer is **periderm** replacing the epidermis.
- Presence of **heterogenous cortex** is followed by secondary phloem which is interrupted by bundles of **phloem fibres**.
- Primary and secondary medullary rays are present in between the secondary vascular tissues.
- Secondary xylem consists of **vessels** and **tracheids.**
- Primary **endarch xylem** present in the **parenchymatous pith**.

Ground Plan



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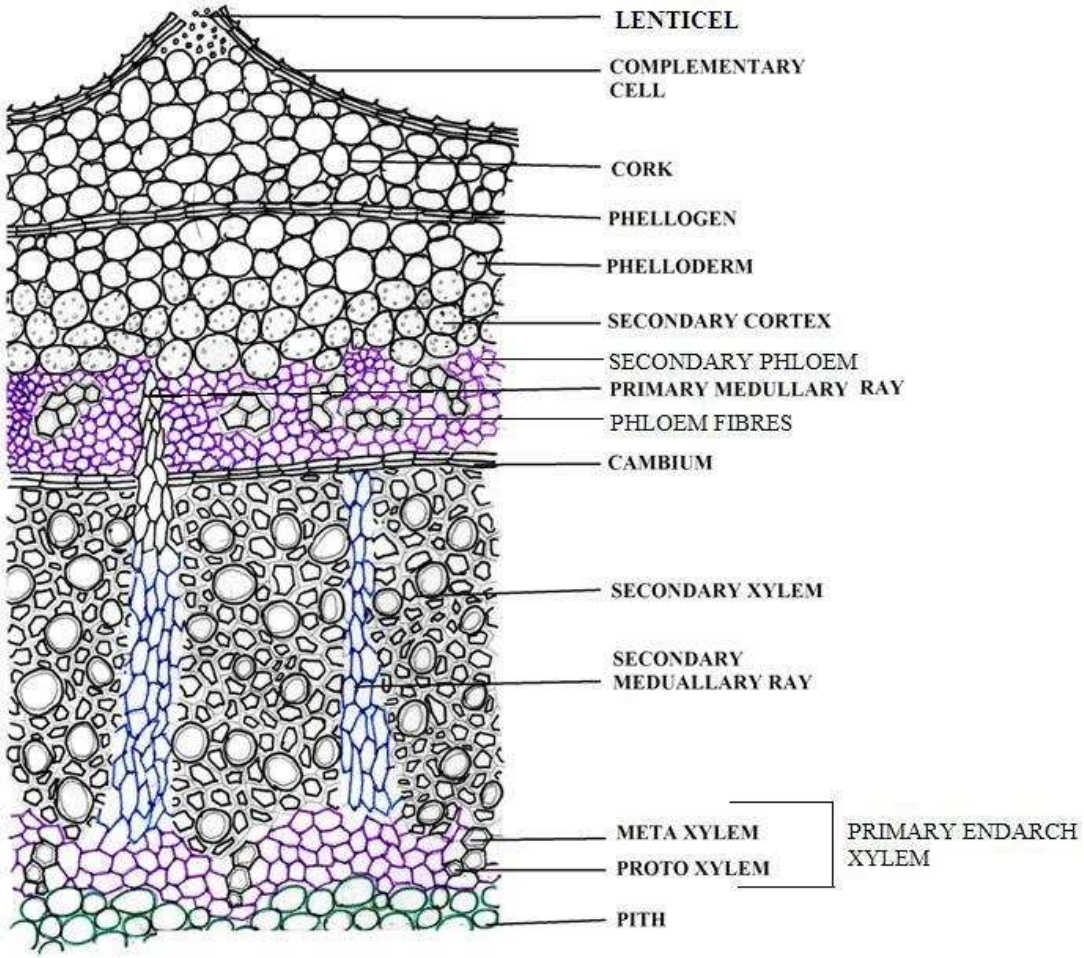
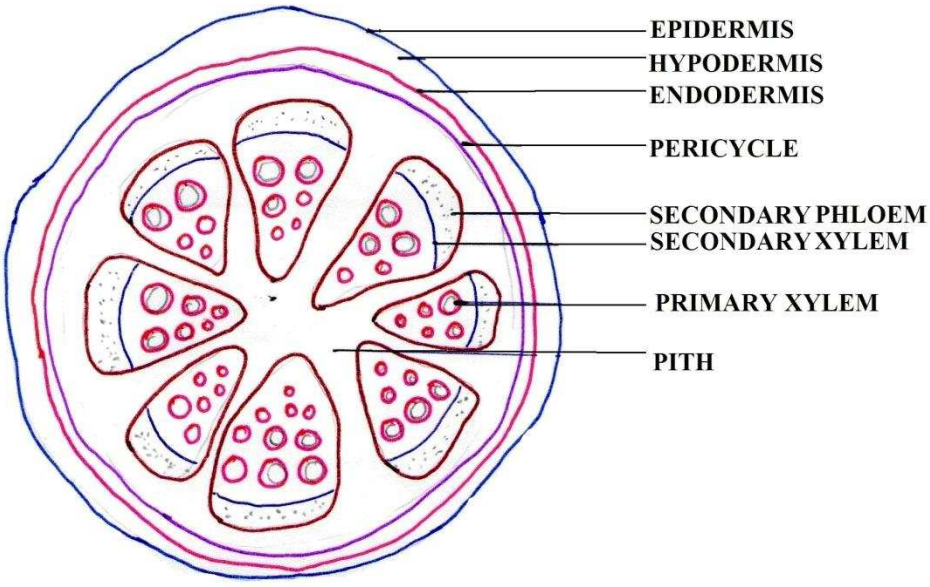


ANOMALOUS SECONDARY GROWTH

E.g. *Aristolochia*

- **Anomalous feature – Bifurcation of vascular bundles** and **fissured xylem.**
- At the time secondary **growth inter and intrafascicular cambium** fuses to form normal cambium but this **cambium behaves abnormally**.
- Secondary **vascular tissues** formed in the **intrafascicular region** and **parenchyma** cells in the **interfascicular** region.
- The bundles are remaining **discrete**.
- In older stem the intra fascicular cambium behaves abnormally and cuts off parenchyma cells results in **fissured xylem**.
- **Phellogen** cuts both **phellem** and **phelloderm**.
- **Lenticels** are also found.

Ground Plan



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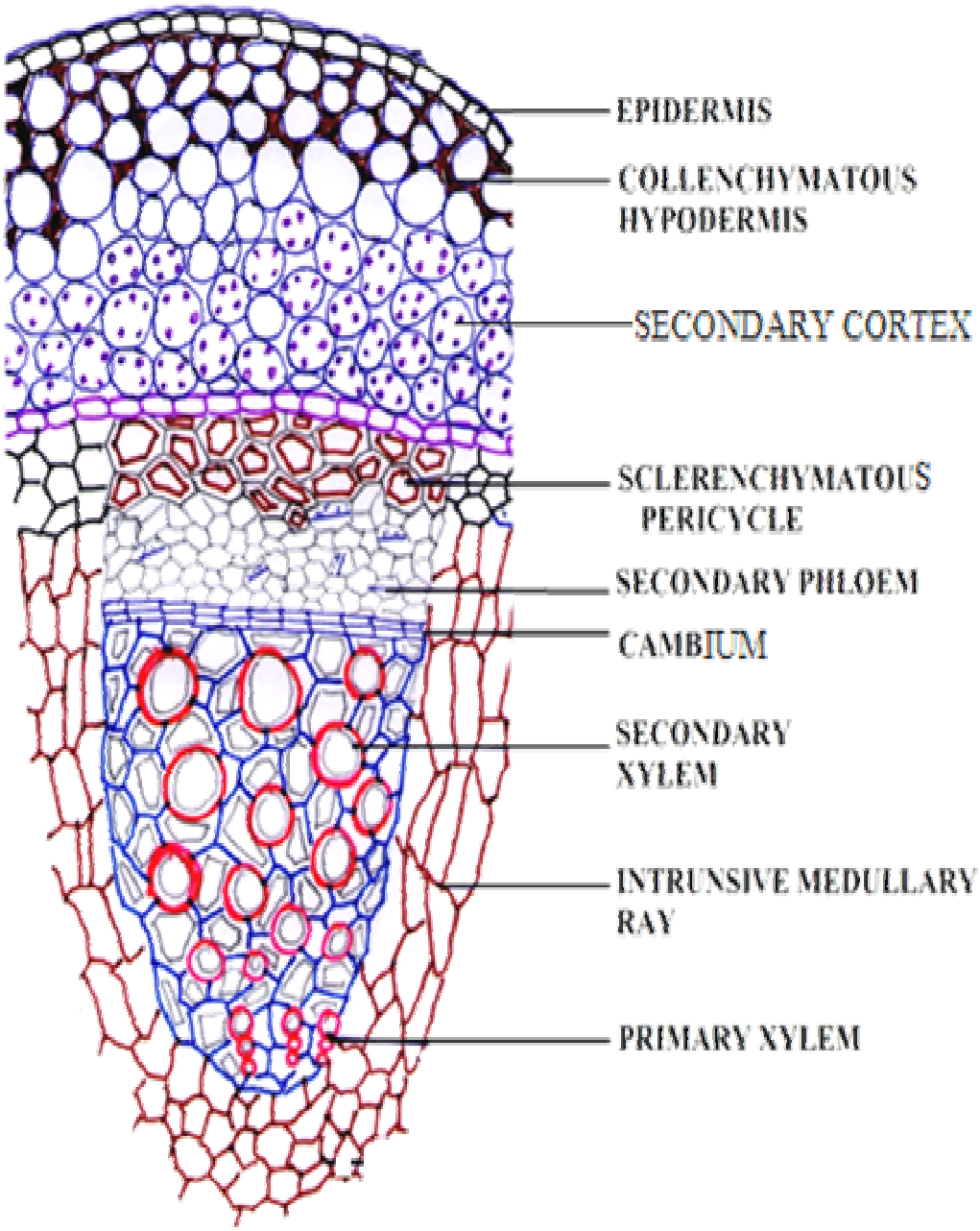
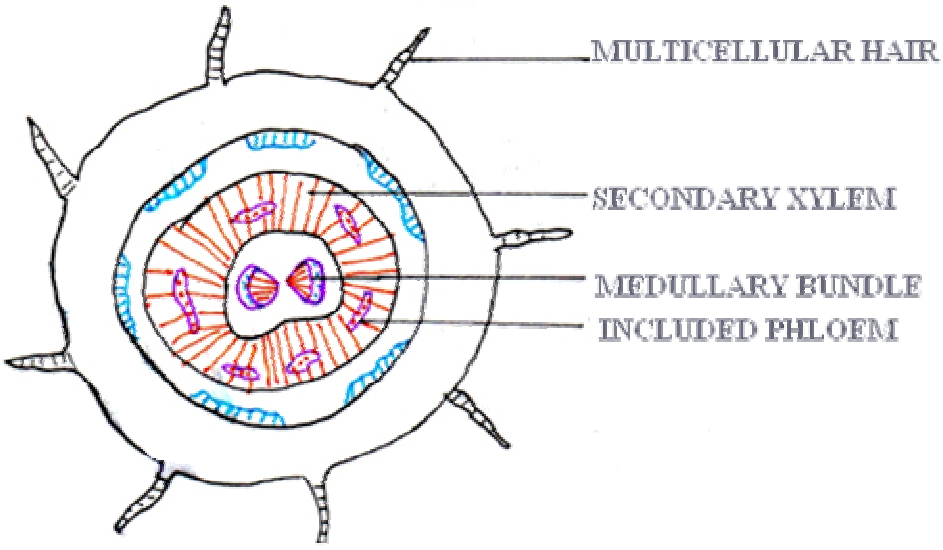


E.g. *Achyranthes*

- Anomalous feature - **Included phloem** or **interxylary phloem**.
- Normal cambium is absent.
- Accessory cambium behaves abnormally forming secondary xylem **alternating with conjunctive tissue** on the inner side and secondary phloem above the xylem and parenchyma above conjunctive tissue on outer side.
- After sometime, the cambial strip lying below the phloem become inactive and **new arcs of cambium** develop from the parenchyma lying above it.
- The newly formed arc of cambium similarly cuts off secondary xylem and conjunctive tissue on the inner side and secondary phloem & parenchyma on the outer side.
- As the result, the secondary phloem formed by the **first cambium gets enclosed** by secondary xylem and conjunctive tissue.
- It is known as **interxylary phloem** or **included phloem.**

Ground Plan



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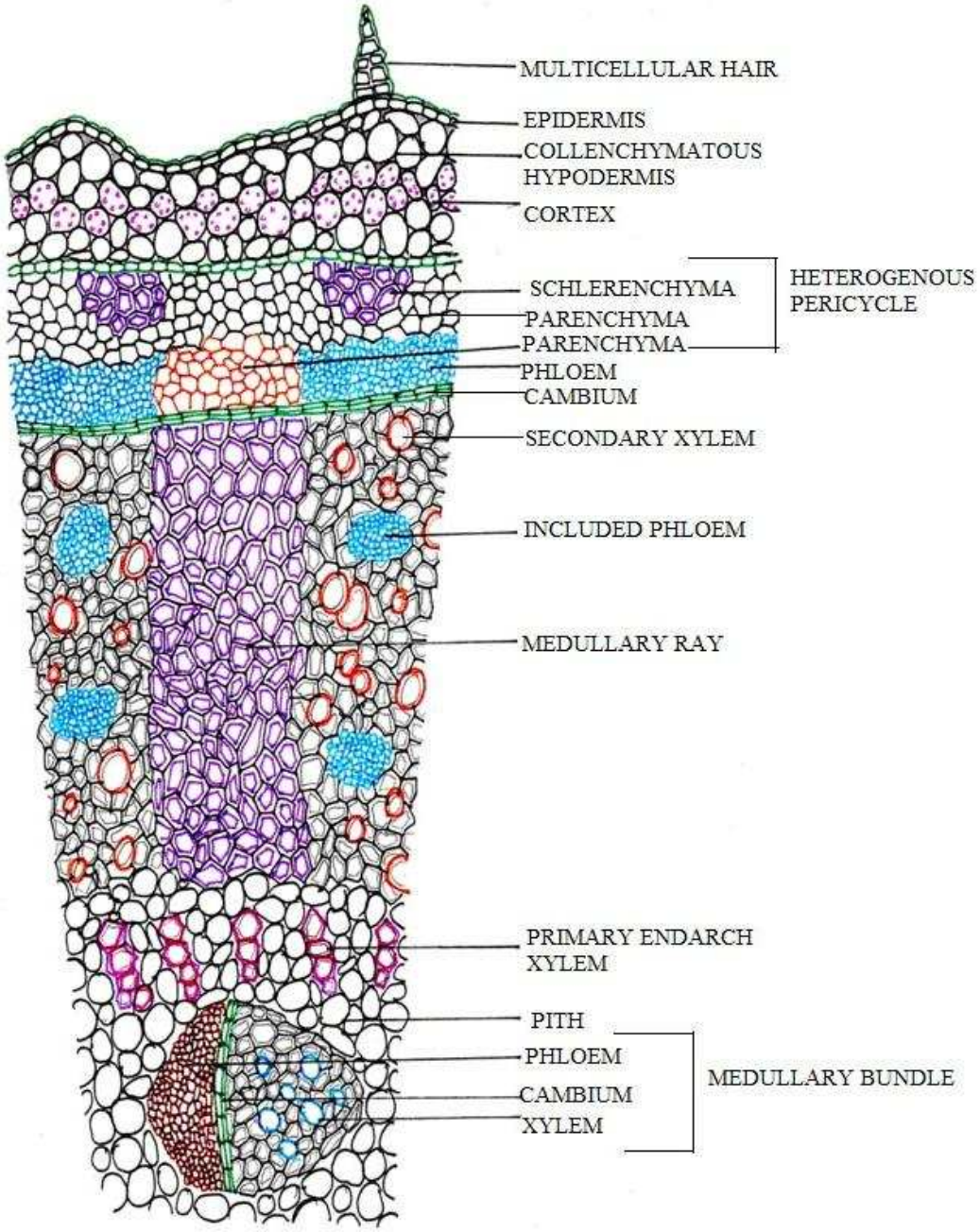
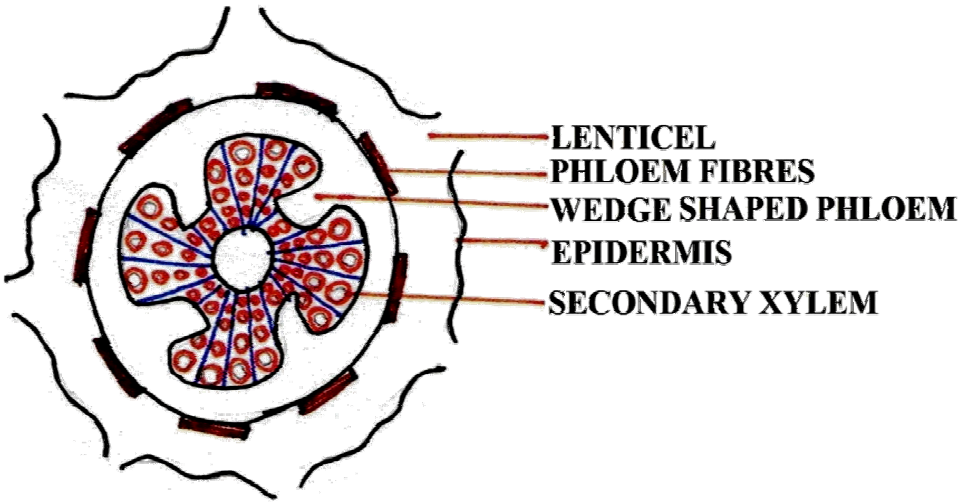


E.g. *Bignonia*

- **Anomalous feature – Wedge shaped phloem.**
- Inter and intrafascicular cambium fuses to form **normal cambium ring**.
- In the beginning cambial activity is normal – it cuts more amount of xylem on the inner side and less of phloem on the outside.
- After some time at **four diagonal places** the cambium cuts **less amount of xylem** inner side and more amount of phloem on the outer side.
- As the result **four deep wedges** of phloem are formed.
- After a short period, four more wedges are also formed.
- The mature stem of ***Bignonia*** has **four big sized and four small sized wedges** of phloem projecting in to the xylem.
- Phloem fibres are present in the phloem.

Ground Plan



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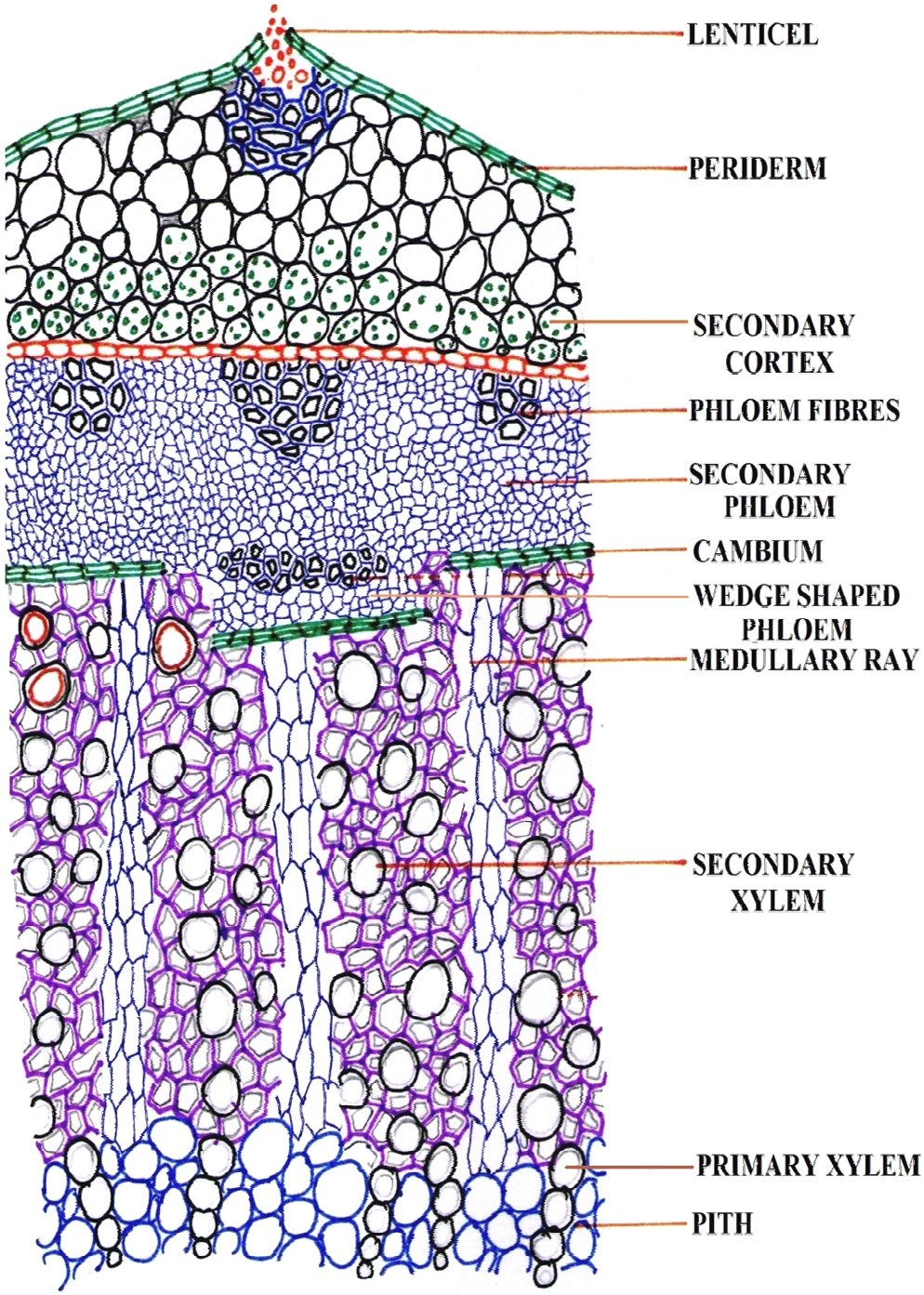
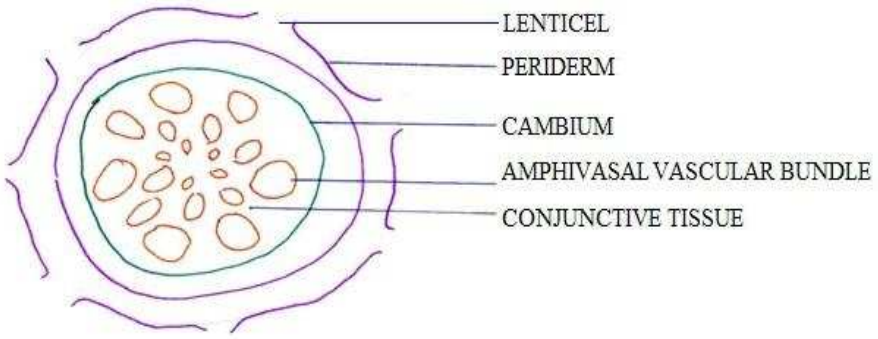


ANOMALOUS SECONDARY GROWTH IN MONOCOT STEM

E.g. *Dracaena*

- The anomalous feature in ***Dracaena*** is the formation of **Amphivasal** vascular bundle.
- The young Dracaena stem has following structures sclerenchymatous hypodermis, **closed, collateral, scattered bundles** with **endarch xylem.**
- During secondary growth, cambium originates from outer cells of ground tissue.
- Cambium cut off **outer parenchymatous** and **inner sclerenchymatous** tissue and **xylem** in alternate patches.
- After sometime, the cambium cut off **phloem above xylem**. Again it cuts xylem, so phloem encircled by xylem. The bundle is called **amphivasal vascular bundle**. It is surrounded by **sclerenchymatous bundle sheath**.
- After short period the **cambium cuts xylem** on the inner side, at those places **where it was previously forming the parenchyma in the place of xylem.**
- Similarly the activity of the cambium goes on changing regularly and more rings of vascular bundles are formed.
- Cork cambium produces both **phelloderm** and **cork.**

Ground Plan



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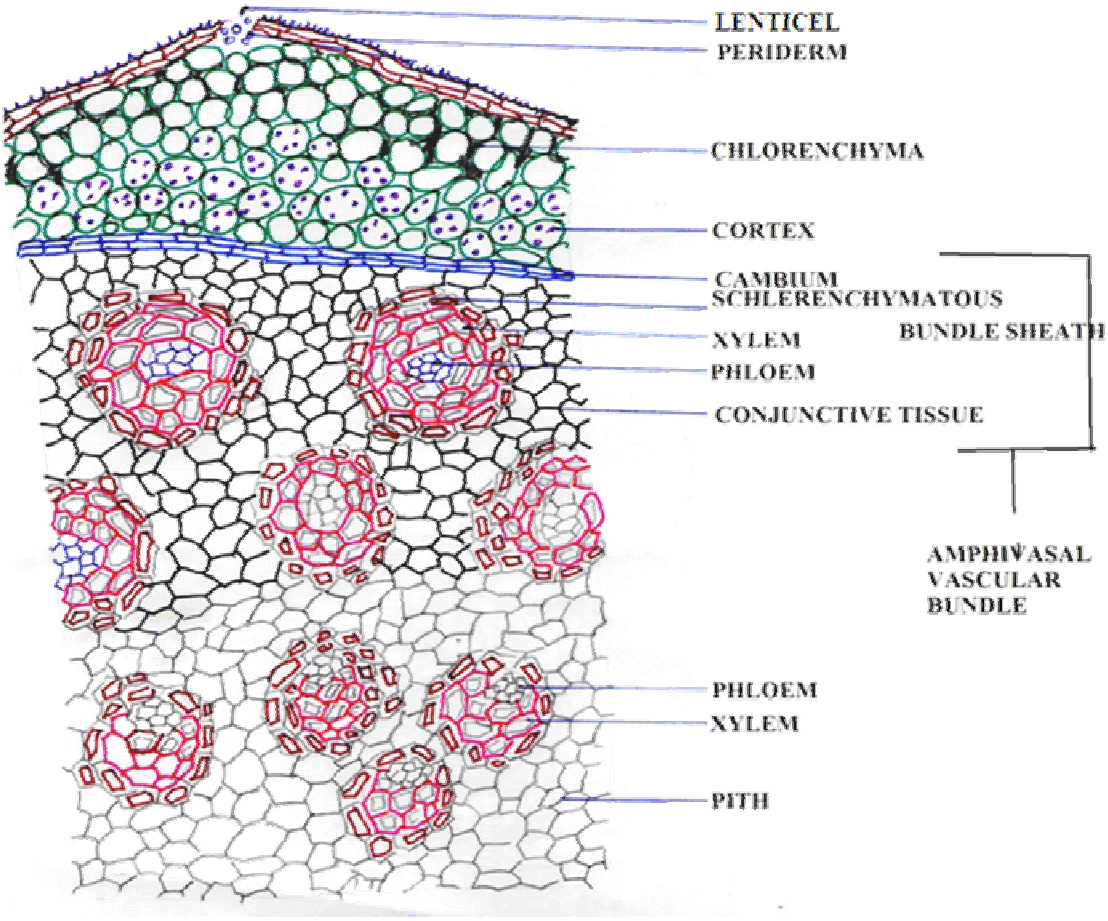
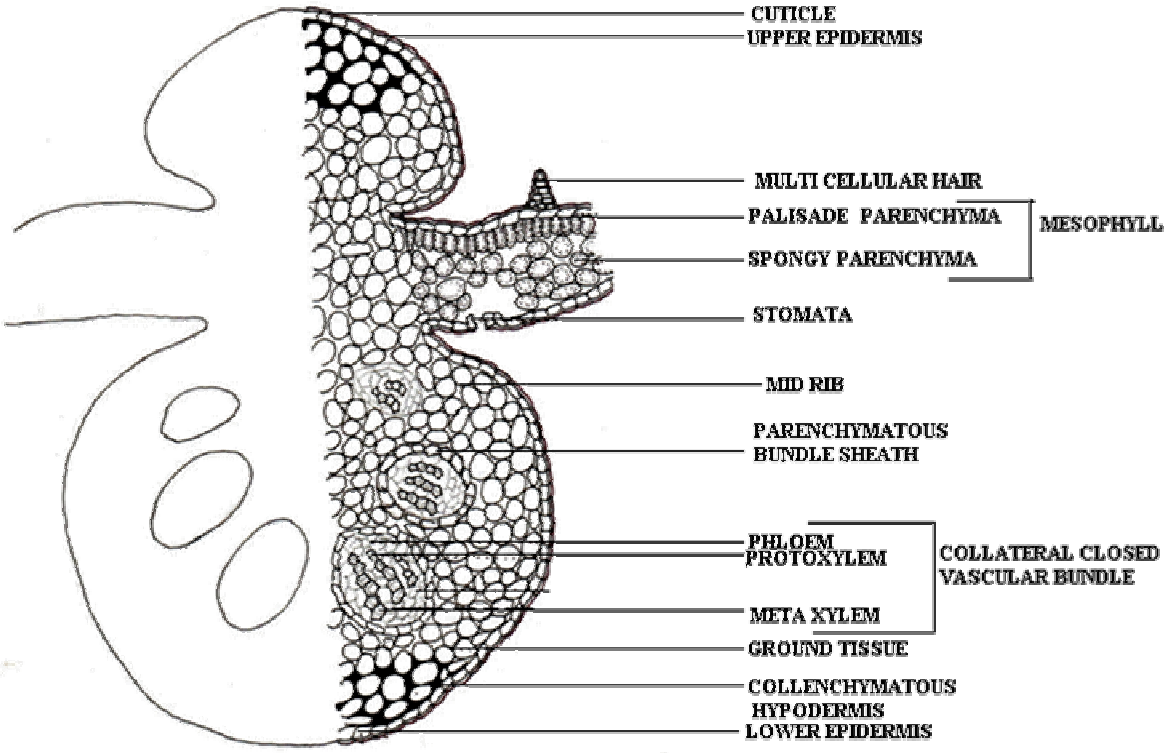


T.S. OF DICOT LEAF

E.g. *Helianthus annuus*

- Leaf is bounded by two **epidermal layers** with **cuticularized** bearing **multicellular hairs** and **stomata**.
- Stomata are distributed **more on lower epidermis** than the upper epidermis.
- Mesophyll tissue is well differentiated into **palisade** and **spongy parenchyma**.
- The vascular bundles are distributed in the midrib.
- In laminar portion **xylem** faces towards the **upper epidermis** and **phloem** towards the **lower epidermis**.
- In the midrib region **hypodermis** is **collenchymatous.**

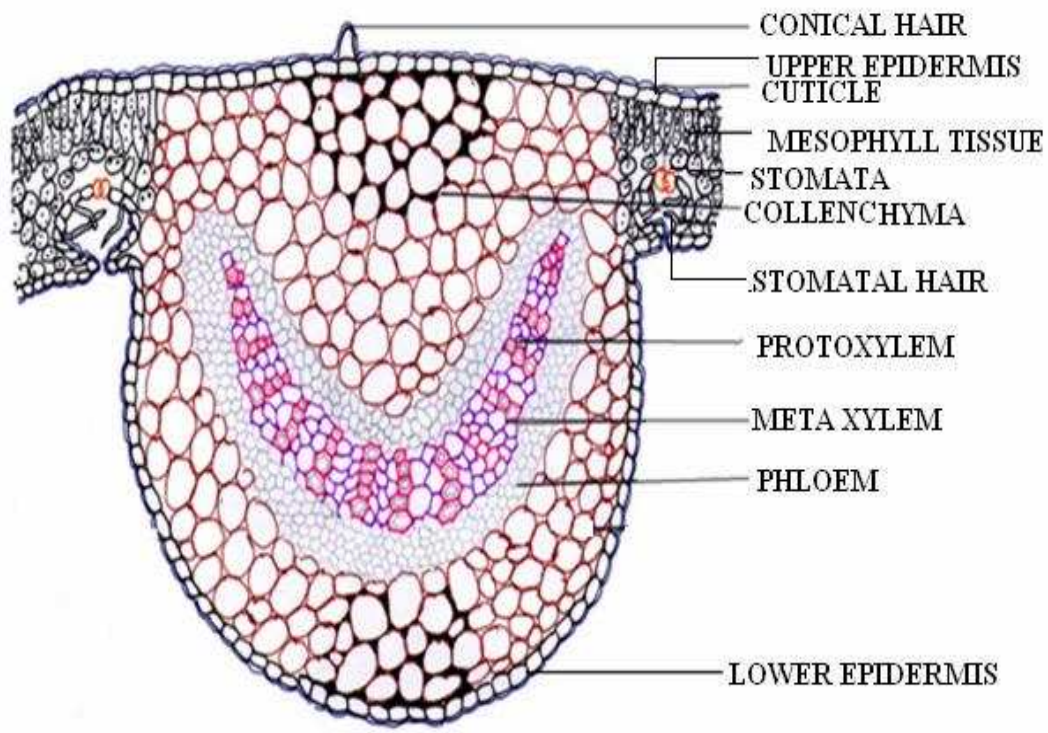


E.g. *Nerium*

- The upper and lower epidermis is covered with **thick cuticle**.
- The lower epidermis is provided with **sunken stomata** and covered by **stomatal hairs**.
- The mesophyll tissue consists of palisade and spongy parenchyma.
- The vascular bundles are **crescent shaped**.

Xerophytics characters

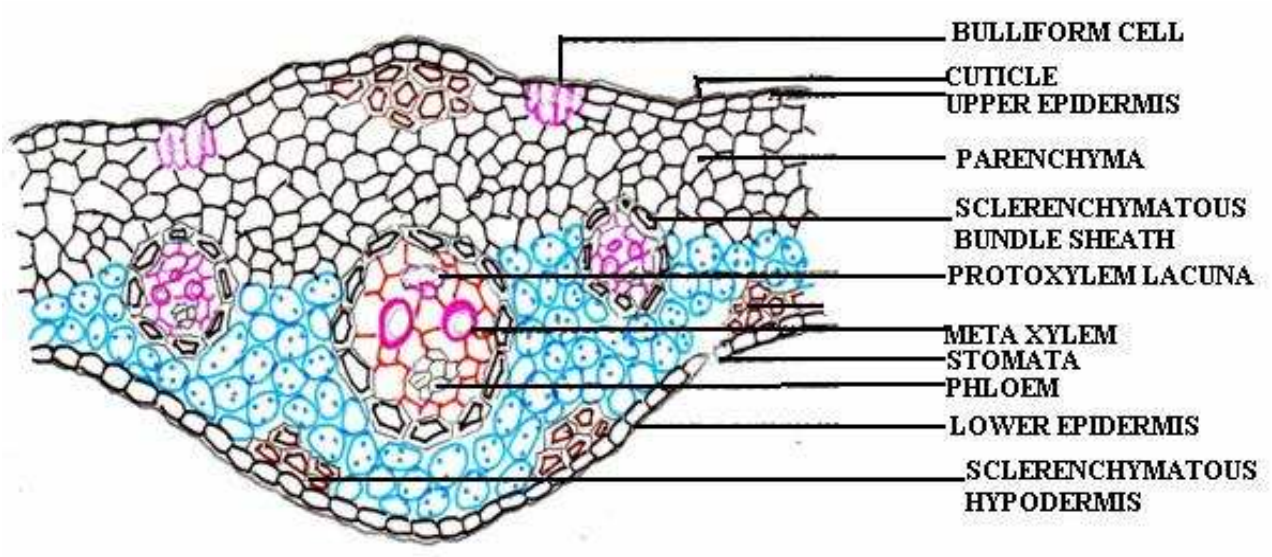
- Presence of **thick cuticle**.
- **Well developed xylem**.
- **Sunken stomata** confined to lower epidermis covered with stomatal hairs.
- Well developed mesophyll tissue.



TS OF MONOCOT LEAF

E.g. GRASS

- In grass leaf the upper epidermis has **ridges and furrows**.
- The stomata occur on the epidermis.
- Thin walled, colourless and large **bulliform cells** or **mota**r cells are situated along the grooves of upper epidermis which help in the rolling of leaves to prevent excess of transpiration.
- Mesophyll consists of chlorenchyma and parenchyma.
- Many vascular bundles are situated along the length of the lamina.

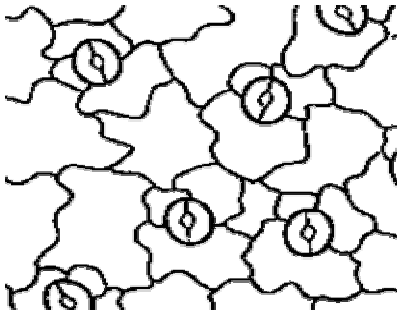


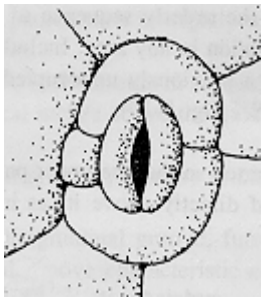
TYPES OF STOMATA

RANUNCULACEOUS STOMATA

E.g. *Cephalandra*

- The stomata are surrounded by indefinite number of subsidiary cells.
- They do not differ from the epidermal cells.

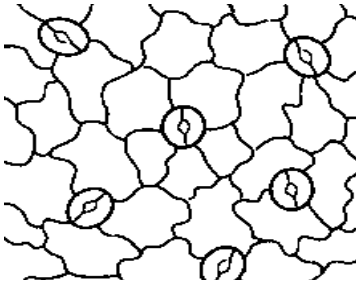




RUBIACEOUS STOMATA

E.g. *Ixora*

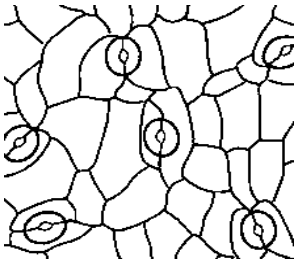
- One (or) more subsidiary cells are present.
- Longitudinal axis parallel to the guard cells.

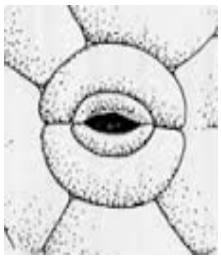


CRUCIFEROUS STOMATA

E.g. *Brassica*

- Usually three subsidiary cells surrounded the one cell being smaller than the other two.

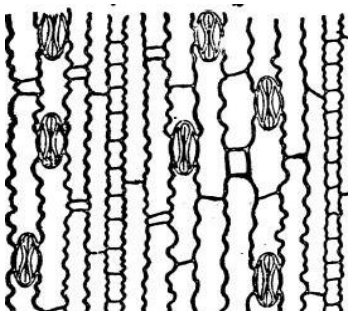


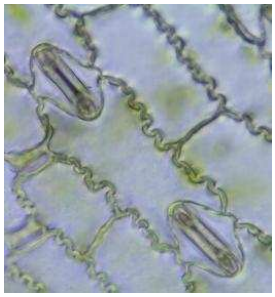


GRAMINACEOUS STOMATA

E.g. GRASS

- Guard cells are dumb-bell shaped narrow in middle and elongated at both end central narrow part has very thick wall and the bulbous ends has thin wall.

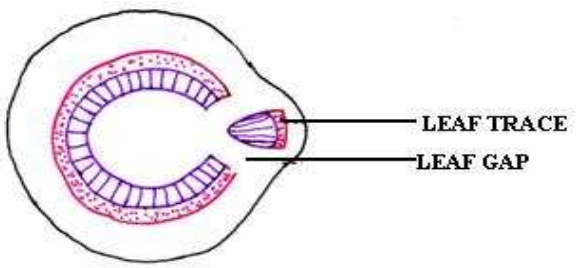




NODAL ANATOMY

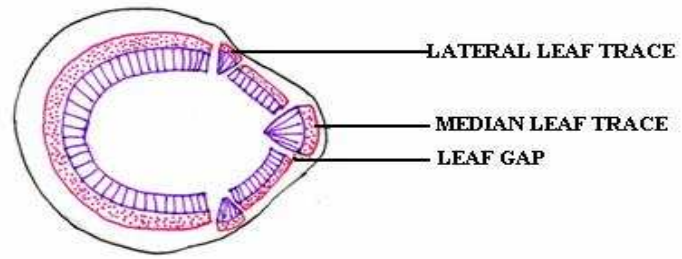
UNILACUNAR NODE

- The node with single leaf gap of leaf is known as unilacunar node. **E.g.** ***Justica, Anona.***



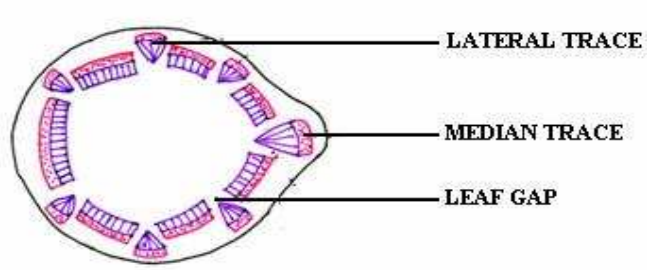
TRILACUNAR NODE

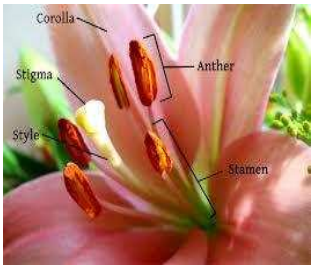
- The node with three leaf gaps and three leaf traces is known as trilacunar node. Among the traces median one is larger and two lateral traces are smaller in size. **E.g.** ***Polyathia.***

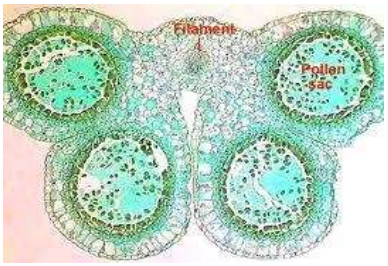


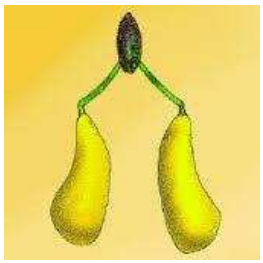
MULTILACUNAR NODE

- The node with many leaf gaps and traces of leaf is known as multilacunar node.
- One is larger and median in position.
- Other lateral traces are smaller in size. **E.g.** ***Aralia***.

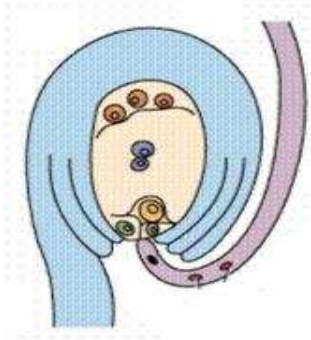


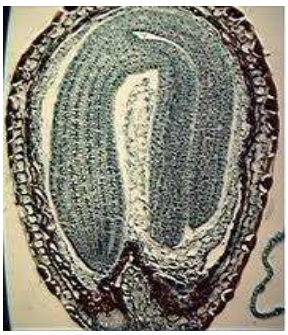






EMBRYOLOGY

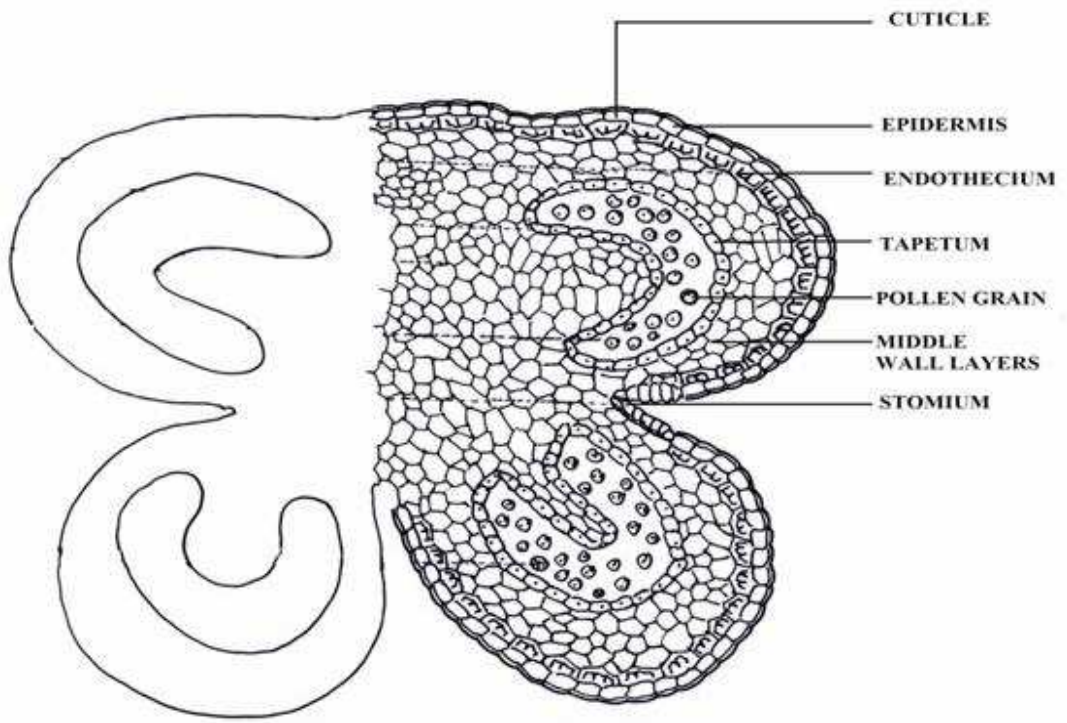




T.S OF ANTHER

E.g. *Kigelia*

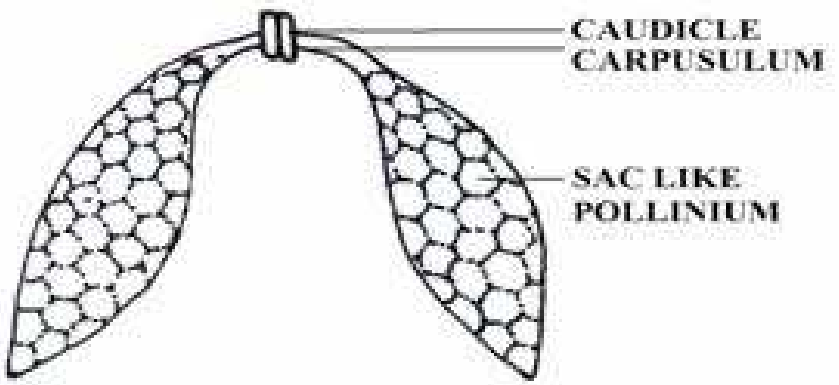
- T.S of mature anther shows **four microsporangia**.
- Each microsporangium is bounded by epidermis, endothecium, middle wall layers and tapetum.
- Two anther lobes are attached by connective tissue.
- Microsporangia encloses pollen sacs.
- Thin walled stomium found in between two microsporangia



TRANSLATOR

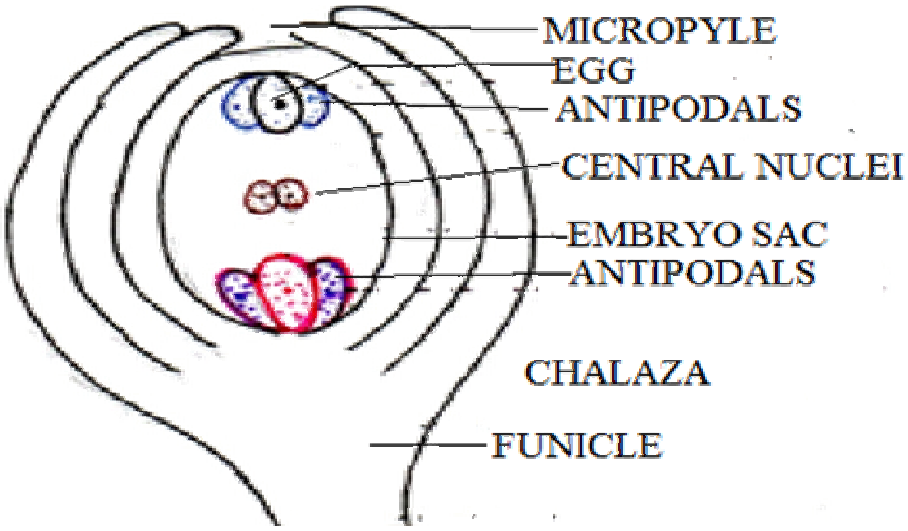
E.g. *Daemia*

- All the pollen grains in a sponangium remain together to form a single mass called **pollinium**.
- Presence of translator is an unique feature in *Daemia.*
- Each translator cnsists of **caudicle, carpusulum** and **pollinium**.



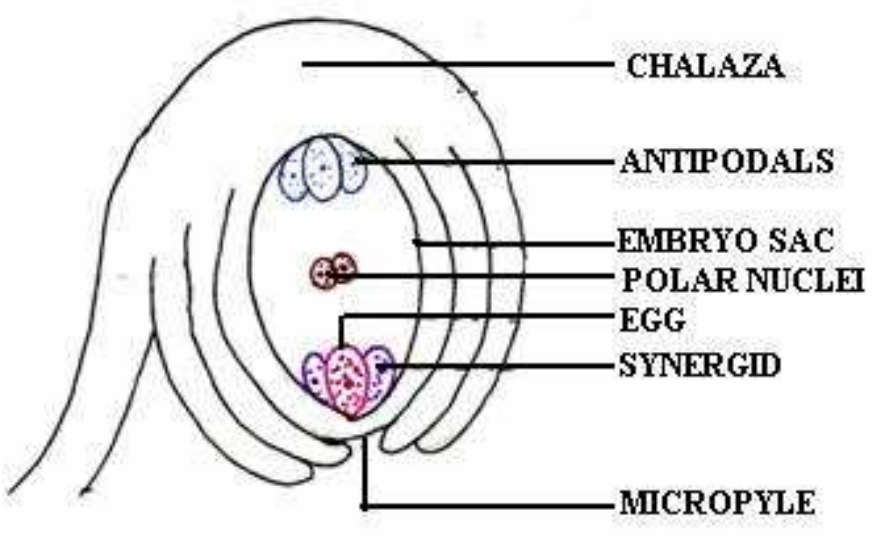
STRUCTURE OF ORTHOTROPOUS OVULE

- Orthotropous ovule is **straight**.
- Funicle is short.
- **Micropyle, chalaza** and **funicle** are in straight line.
- Ovule is enclosed by two integuments.
- Embryosac consists of **egg apparatus**, **2 polar nuclei** and **3 antipodals**.



STRUCTURE OF ANATROPOUS OVULE

- Anatropous ovule is an **inverted ovule**.
- The ovule bends & the integuments fuse with **funicle** forming the **raphae**.
- The ovule is covered by two integuments.
- Embryosac consists of **egg apparatus**, **two polar nuclei** and **3 antipodals**.



DEVELOPMENT OF DICOT EMBRYO

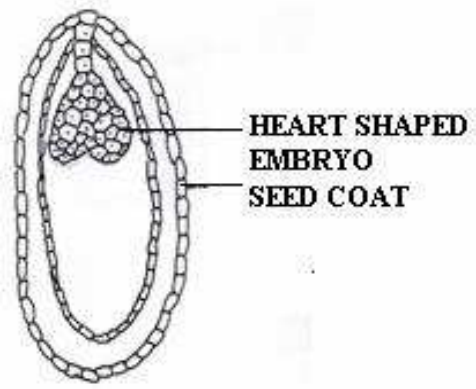
The zygote formed after fertilization divides transversely to form upper basal called lower terminal cell.

GLOBULAR STAGE

- This stage of embryo is named after the **globular shaped** of developing embryo.
- The outer cells of these embryo formed **dermatogen** and inner cell give rise to **periblem** and **plerome**.

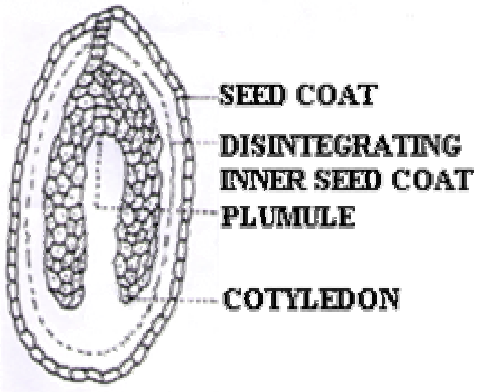
HEART SHAPED EMBRYO

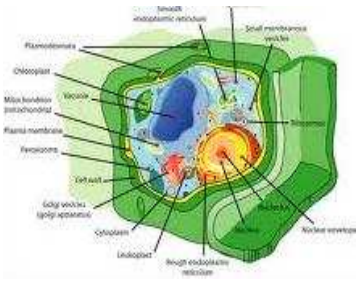
- This shows the presence of lateral **cotyledons** develop one on either side of these apex which are terminal in position. **Procambium** gets differentiated in **central region** of the **stem**.

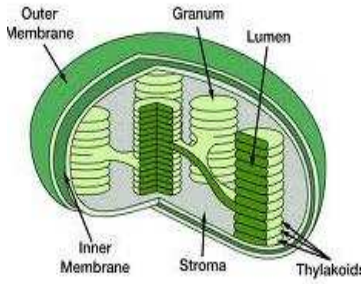


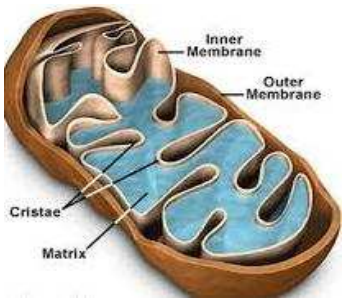
COTYLEDONARY STAGE

- Embryo consists of **two cotyledons** which are attached to the embryonic axis.
- The mature embryo is **horse shoe shaped** due to curvature of cotyledon.
- The embryo is attached by means of a basal **suspensor**.
- The embryo axis is end in the **plumule**.
- The axis below the cotyledon is called **hypocotyl** with **radicle**.

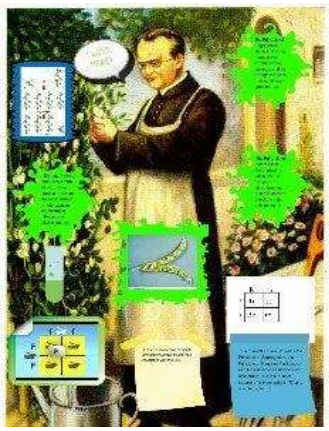


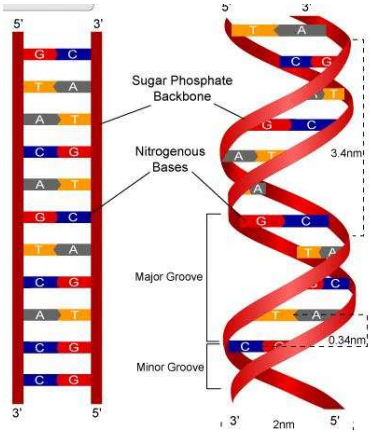


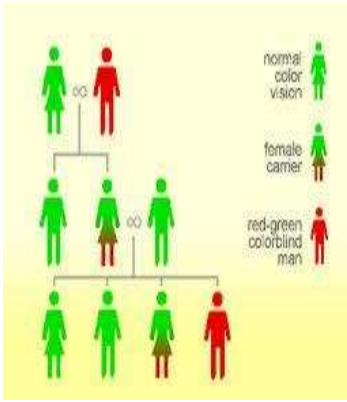




CYTOGENETICS



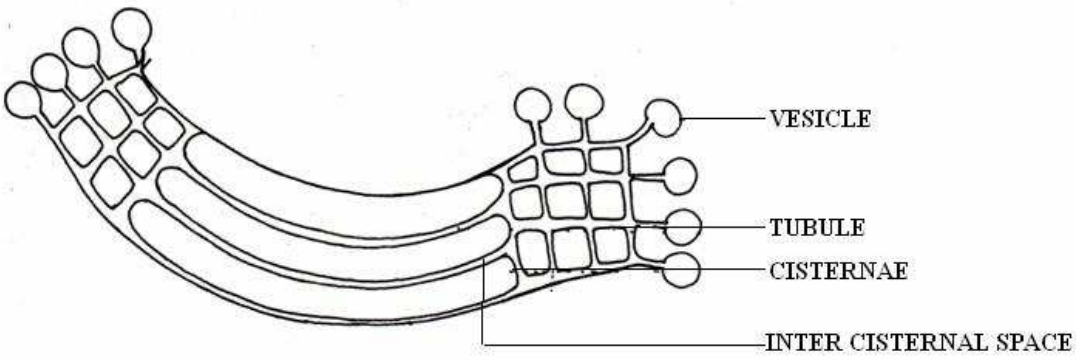




STRUCTURE OF DICTYOSOME

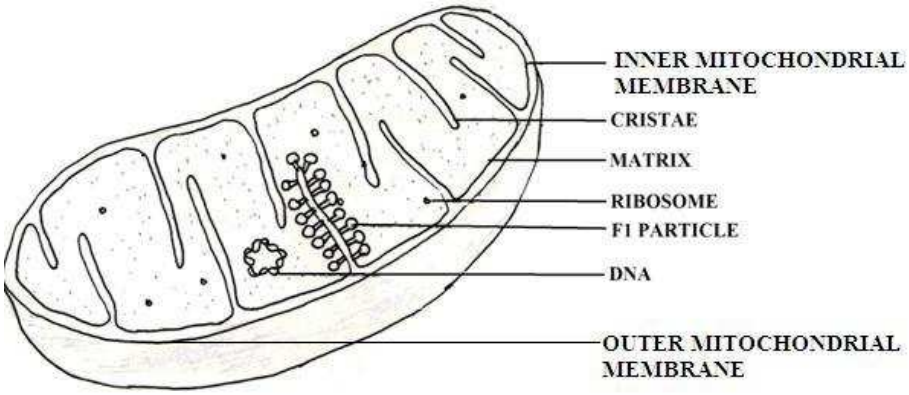
- Dictyosome or Golgi complex is a cytoplasmic organelle.
- It consists of 4 components.

  1. **Cisternae** 2. **Tubules** 3. **Vesicles** 4. **Vacuoles**
- Cisternae are elongated **flattened sacs** filled with **fluids** and are arranged one above the other to form **stacks**.
- Presence of **intercisternal** space between **cisternae**.
- From the distal end of **cisterna**, complex net work like structure called **tubules**.
- From the periphery of the golgi complex, presence of **vesicles** and **vacuoles**.
- **Functions:** Formation of **Acrosome**, cell wall formation, secretion, **glycosylation**, **lysosome** formation etc.



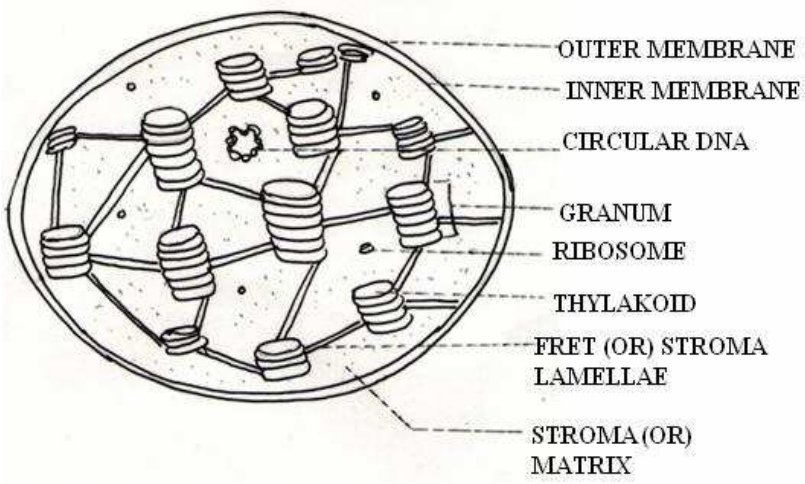
MITOCHONDRIA

- Granular or thread like cytoplasmic organelle - **Power house of cell**.
- They are covered by two unit membranes. And thickness is 60A°.
- Presence of **outer & inner chamber** or **matrix**.
- Inner membrane gives **cristae.**
- Inner matrix is filled with protein, lipid, enzymes, co-enzymes, minerals like **S, Fe & Cu**,
- **Vitamins**, **RNA**, **Ribosome** and **circular DNA.**
- Inner & outer membrane contains **F_1 particles**.
- Functions: **Respiration, Protein synthesis**, **energy supply**.



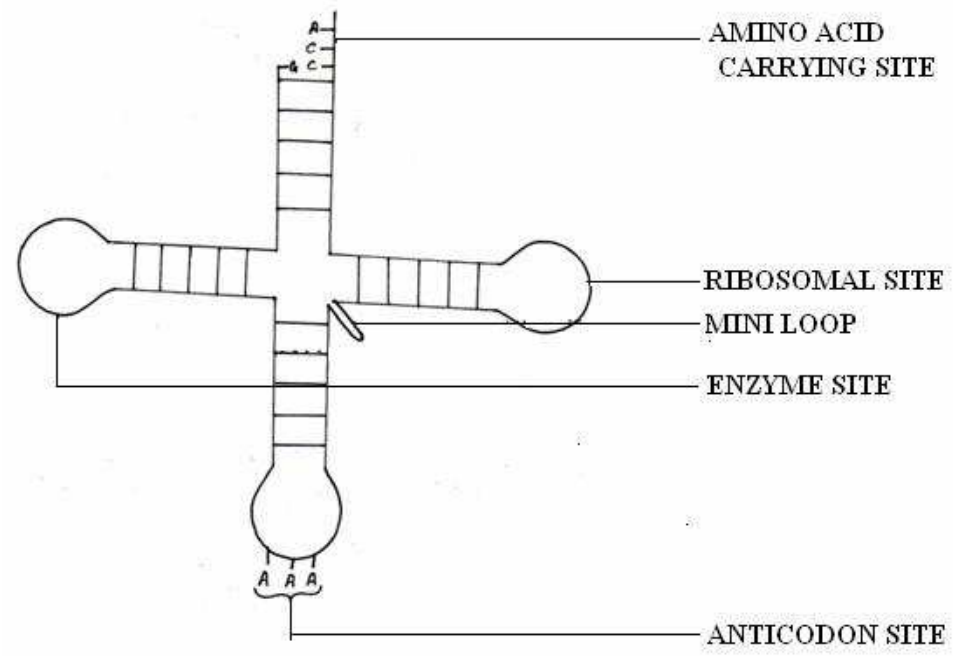
CHLOROPLAST

- Large **cytoplasmic** organelle.
- The chloroplast bounded by **two unit membranes**.
- Outer membrane - **smooth**, freely **permeable**.
- Inner membrane - folded, **selectively permeable**.
- Inner membrane encloses the space called **sroma** or **matrix**.
- Matrix contains **lipid**, **proteins, minerals, ribosomes**, **RNA, circular DNA, carbohydrate** and **Grana**.
- The grana are connected by **frets** or **stroma lamellae**.
- 10 – 100 thylakoids are arranged one above the other to form stacks of coins called **Grana**.
- Thylakoid membrane has **chlorophyll pigments**.
- **Functions: Photosynthesis**, protein synthesis & **starch storage**.



STRUCTURE OF tRNA

- Transfer RNA - **single stranded**, folded itself to form **clover leaf** shaped.
- It is made up of **73-95 nucleotides**.
- It has 5′ and 3′ ends. **3′** is ending with **CCA** and **5′** is ending with **G** or **C**.
- tRNA has 5 sites
  - **i. Ribosomal site**
  - **ii. Enzyme site**
  - **iii. Anticodon site**
  - **iv. Aminoacid carrying site**
  - **v. Mini loop**
- Each tRNA shows specificity in carrying **amino acids**.
- Mini loop or variable arm contains unusual amino acids.
- **Function**: **Protein synthesis**.

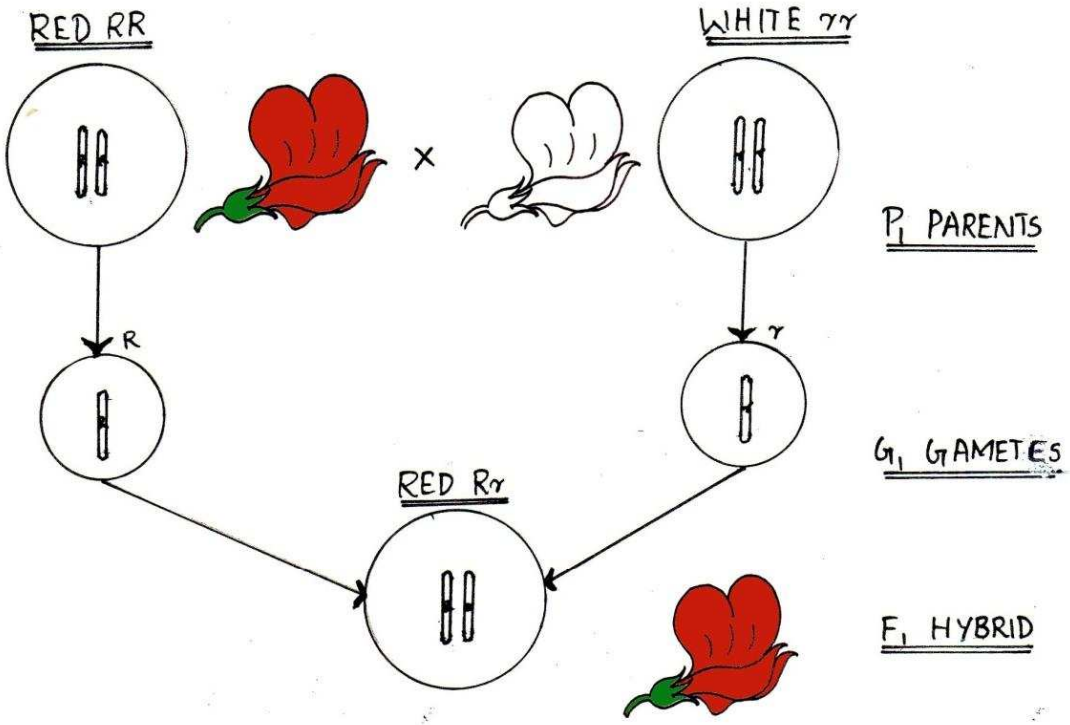


MONOHYBRID CROSS

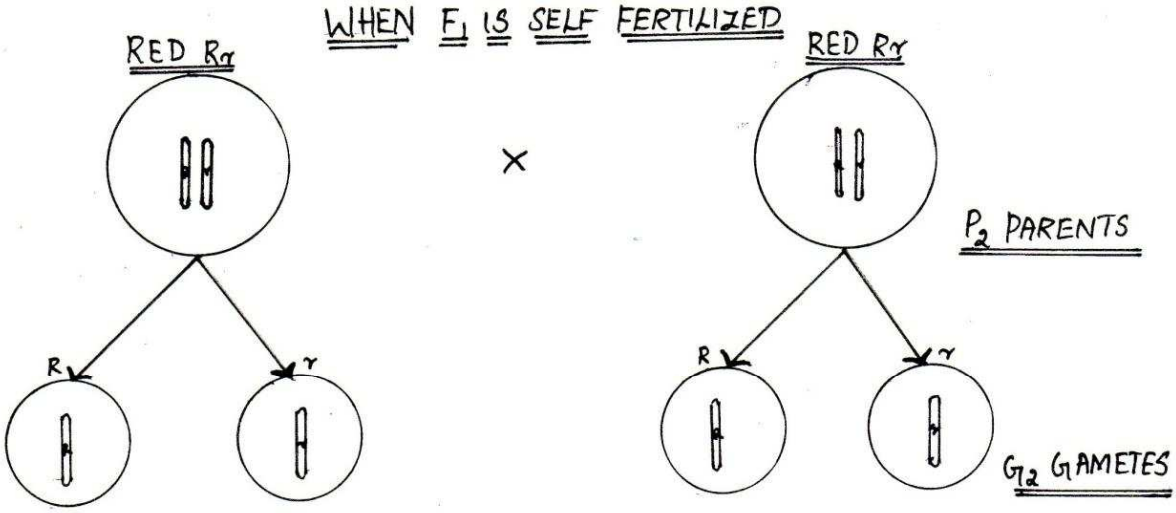
Monohybrid cross is a cross between two plants differing in a single pair of contrasting characters. A cross between pure red (**RR**) and pure white (**rr**) flowered variety. The off springs of the $\mathbf{F_1}$ generation are all red. When this is selfed, the $\mathbf{F_2}$ is produced in the ratio of **red: white**. The checker board shows that **1/3** of the red is homozygous having the genotype **(RR**) which always breed true & remaining **2/3** being heterozygous **(Rr)** and pure recessive white flower **(rr)** always breed true.

Phenotypic ratio = 3RED: 1WHITE

Genotypic ratio = 1RR:2Rr:1rr



WHEN F_1 IS SELF FERTILIZED



PHENOTYPIC RATIO:

SQ. NO: 1, 2, 3 – 3 RED

SQ. NO: 4 – 1 WHITE

3 RED : 1 WHITE

F_2 HYBRID

♀ \ ♂	R	r
R	RR (1)	Rr (2)
r	Rr (3)	rr (4)

GENOTYPIC RATIO:

SQ. NO:- 1 - HOMOZYGOUS RED [RR]

SQ. NO:- 2, 3 - HETEROZYGOUS RED [Rr]

SQ. NO:- 4 - HOMOZYGOUS WHITE [rr]

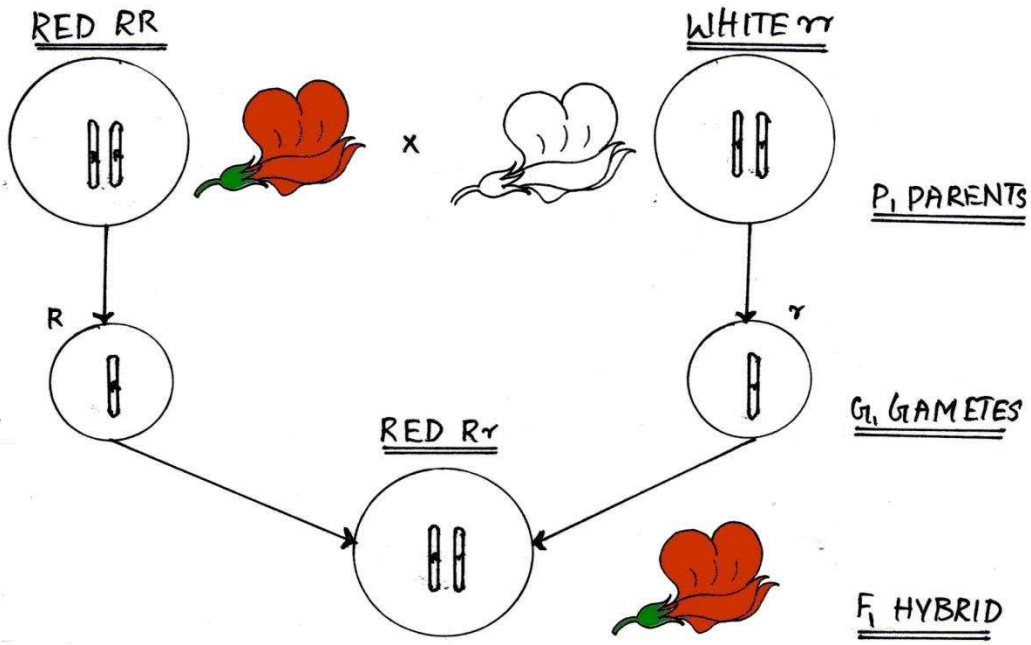
1 RR : 2 Rr : 1 rr

MONOHYBRID BACK CROSS

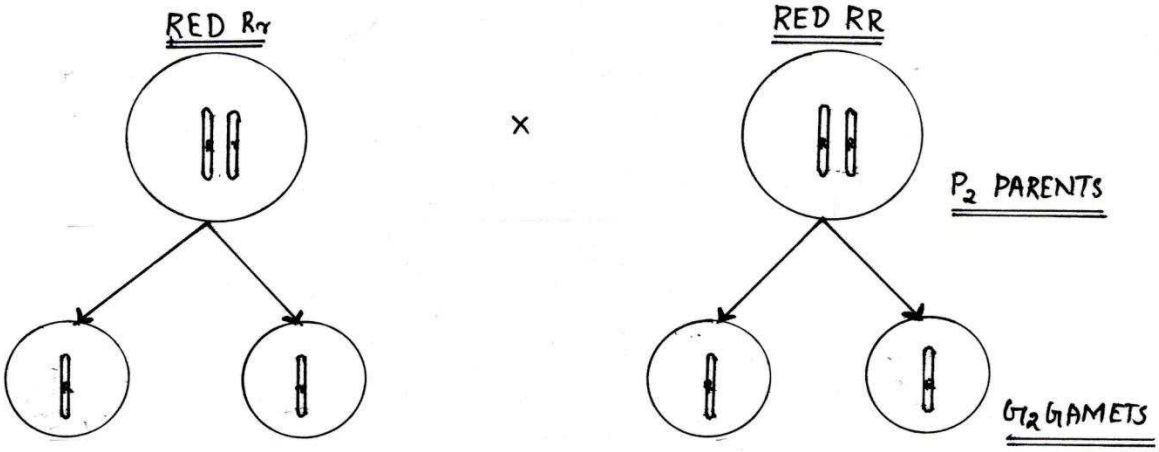
Monohybrid back cross is the cross between the F_1 hybrids with their dominant parents. Here, the **F_1** red flowered variety is crossed with its dominant parent. The dominant parent will produced only one type of gametes **(R)** and **F_1** hybrid will produce two types gametes **R & r.** This back cross will be **all are red**. The ratios are

Phenotypic ratio = all are red

Genotypic ratio = 1RR: 1Rr



WHEN F_1 IS CROSSED WITH DOMINANT PARENTS



PHENOTYPIC RATIO:

SQ.NO: 1,2,3,4 - RED

ALL ARE RED

F_2 HYBRID

♂ / ♀	R	r
R	RR	Rr
R	RR	Rr

GENOTYPIC RATIO:

SQ.NO: 1,3 - 2 HOMOZYGOUS RED[R

SQ.NO: 2,4 - 2 HETEROZYGOUS RED [Rr

2 RR : 2 Rr

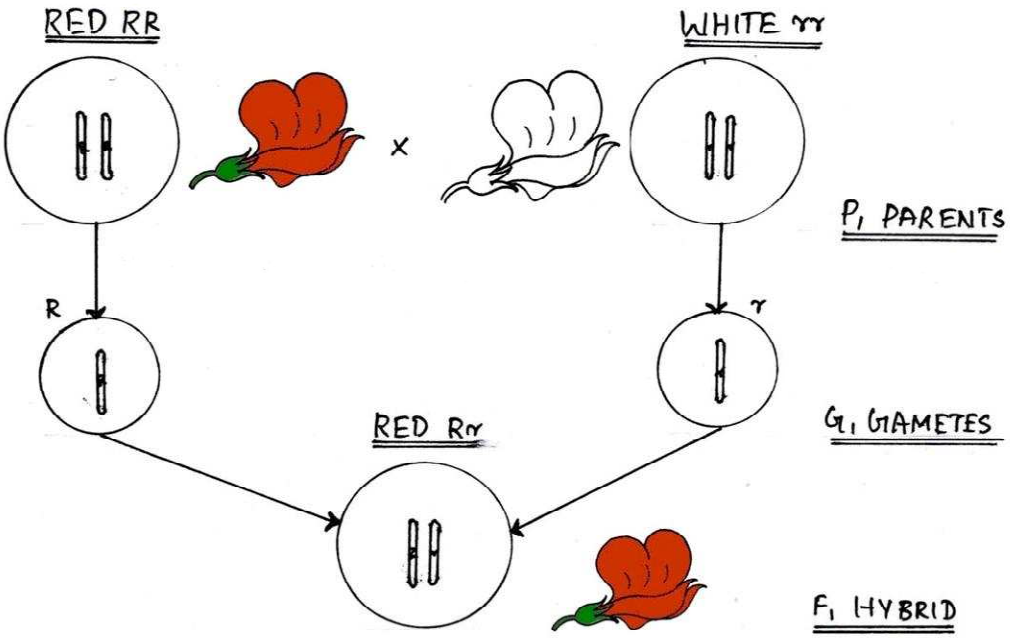
1RR: 1Rr

MONOHYBRID TEST CROSS

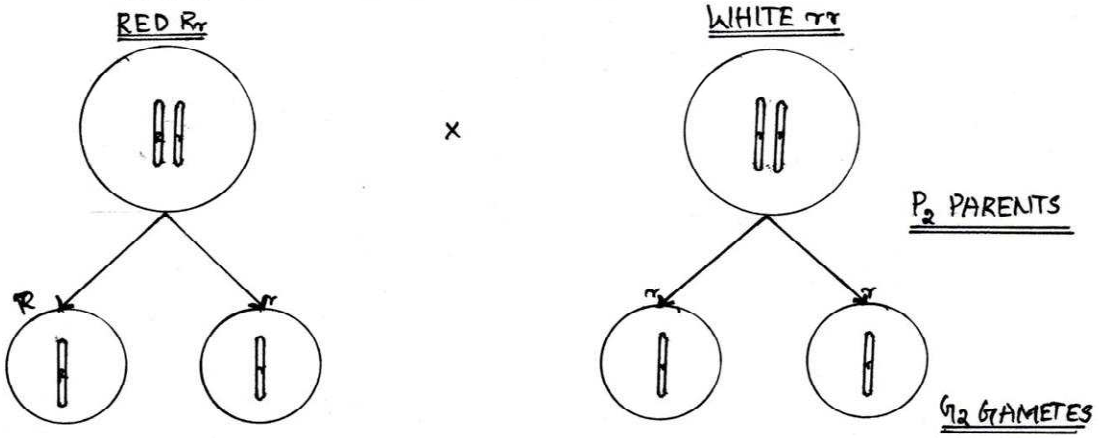
Monohybrid test cross is a cross between F_1hybrid with its recessive parent. In this cross the **F_1** hybrid **Rr** will produce two types of gametes such as **'R'** and **'r'**. The recessive homozygous parents will produces only type of gamete **(r)**. The offspring in the **F_2**shows that, the genotype as well as the phenotypic ratios remains the same. The significance of test cross is that to find out the **heterozygosity** nature of the parents. The ratios are

Phenotypic ratio = 1RED: 1WHITE

Genotypic ratio = 1Rr: 1rr



WHEN F_1 IS CROSSED WITH RECESSIVE PARENTS



PHENOTYPIC RATIO:

Sq.No: 1, 2 - 2 RED

Sq.No:-3, 4 - 2 WHITE

1 RED : 1 WHITE

F_2 HYBRID

♂ / ♀	r	r
R	Rr	Rr
r	rr	rr

GENOTYPIC RATIO:

Sq.No:- 1, 2 - 2 HETEROZYGOUS RED [Rr]

Sq.No:- 3, 4 - 2 HOMOZYGOUS WHITE[rr]

1 Rr : 1 rr

INCOMPLETE DOMINANCE

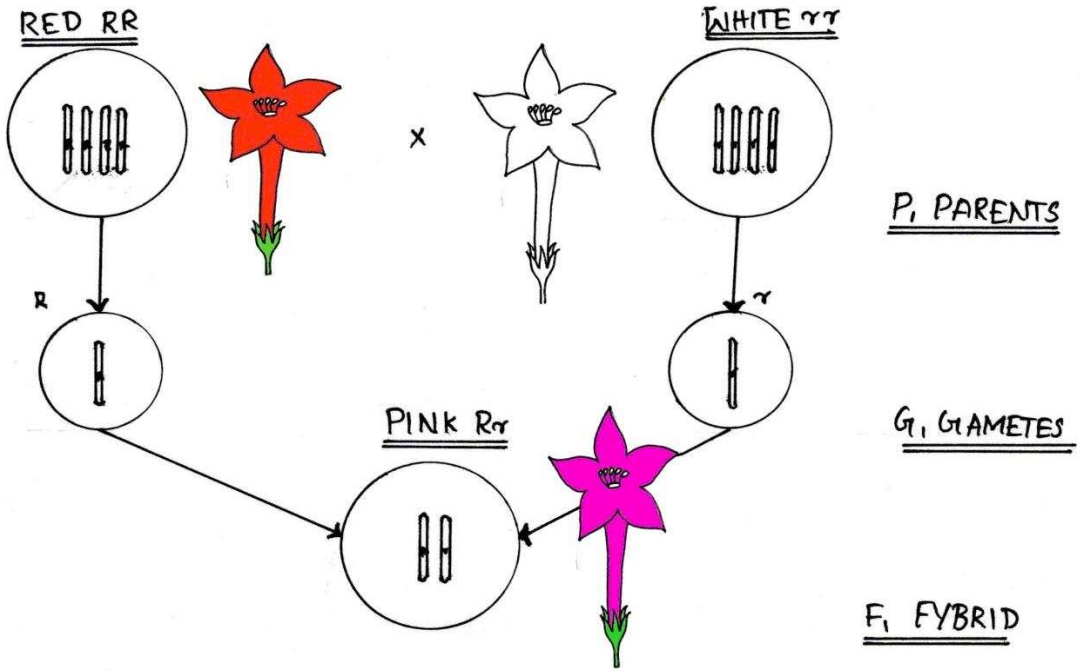
In a heterozygous, **dominants allele does not completely mask the phenotypic expression of the recessive allele** and therefore an **intermediate phenotype** appears in the $\mathbf{F_1}$ generations. This is called incomplete dominance.

In ***Mirabilis jalapa*** a cross is made between red and white flowered varieties to yield pink flower. When the pink flower $\mathbf{F_1}$ hybrid was selfed. It segregated in the ratio of **1RED:2PINK:1WHITE**. Here, the phenotypic ratio and the genotypic ratios were the same. The gene for the red colour **(R)** was not completed dominant over the recessive gene. This type of inheritance was known as incomplete dominance.

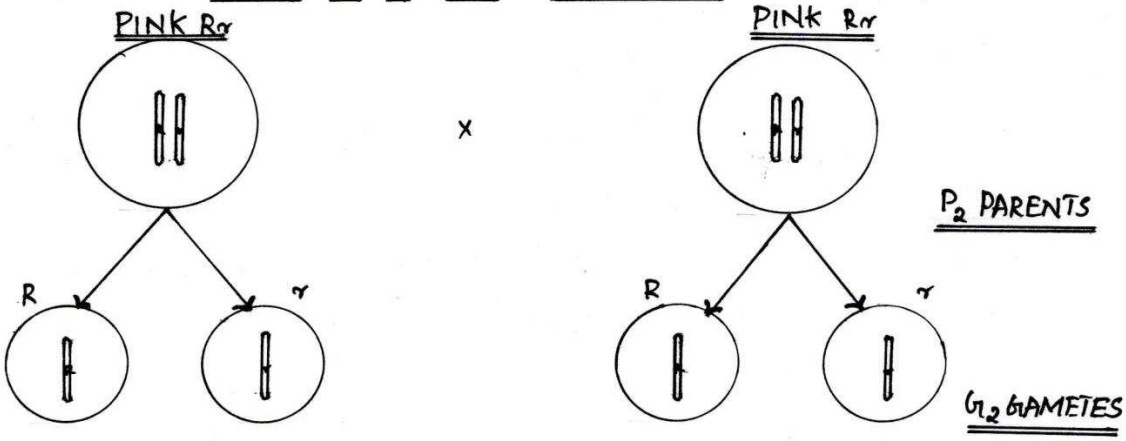
The ratios are

Phenotypic ratio = 1RED:2 PINK:1WHITE

Genotypic ratio = 1rr:2Rr:1rr



WHEN F_1 IS SELF FERTILIZED



PHENOTYPIC RATIO:

SQ. NO: 1 - 1 RED

SQ. NO: 2,3 - 2 PINK

SQ. NO: 4 - 1 WHITE

1 RED : 2 PINK : 1 WHITE

F_2 HYBRID

♂ \ ♀	R	r
R	RR (1)	Rr (2)
r	Rr (3)	rr (4)

GENOTYPIC RATIO:

SQ. NO: 1 - 1 HOMOZYGOUS RED [RR]

SQ. NO: 2,3 - 2 HETEROZYGOUS PINK [Rr]

SQ. NO: 4 - 1 HOMOZYGOUS WHITE [rr]

1 RR : 2 Rr : 1 rr

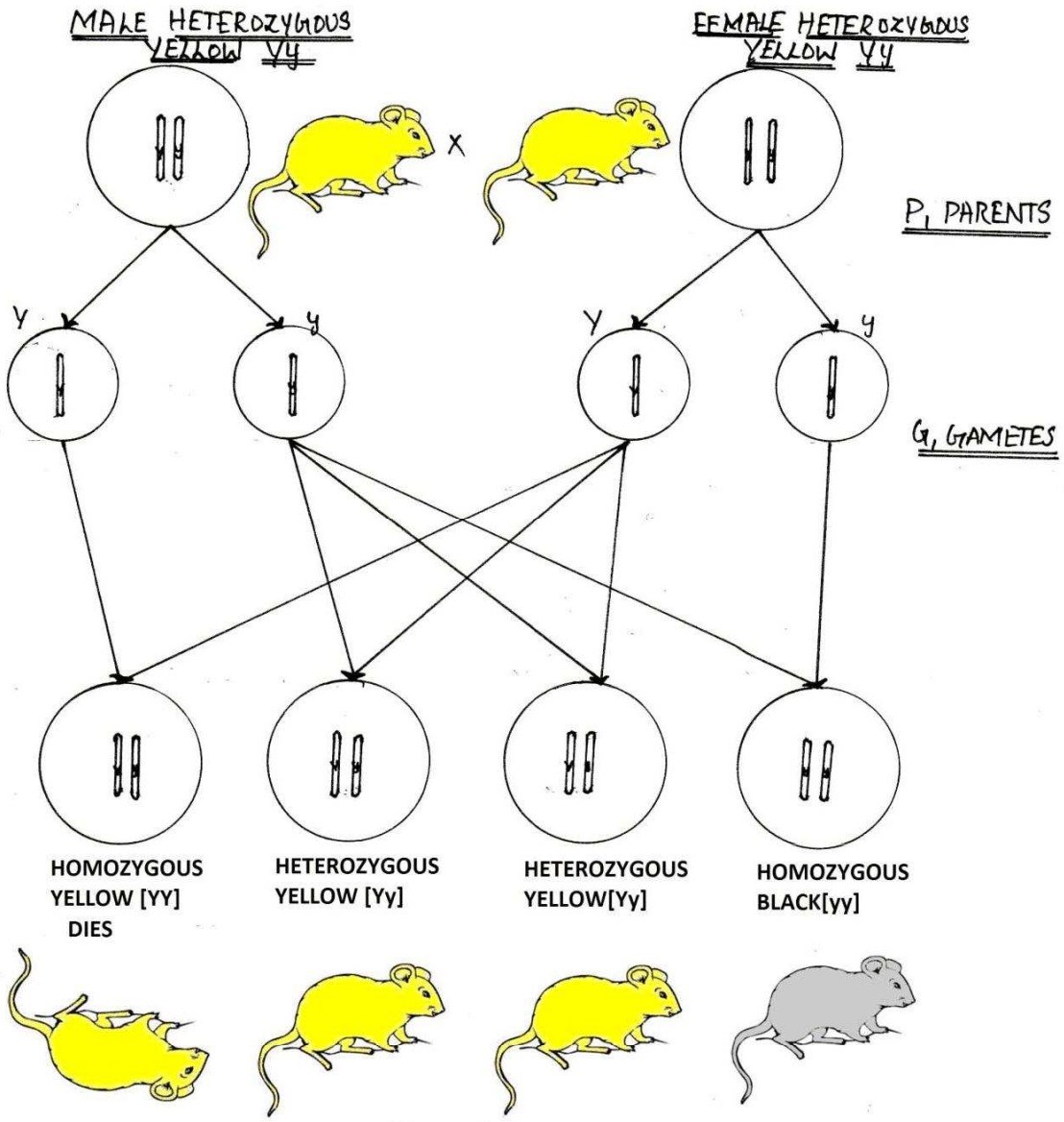
LETHAL FACTOR

Lethal genes are mutant genes, which **have no effect on the phenotype but influence the viability** of the organisms and the individual fails to survive.

In 1905 a French geneticist **L. Cuenot** reported lethal genes in mouse body colour .yellow body colour is dominant over brown colour. In this cross two heterozygous yellow body colour mice are crossed. The $\mathbf{F_1}$ checker board shows that 2 heterozygous yellow **(YY)** do not exist because two dominant genes fails to survive. So the ratios are,

Phenotypic ratio =2YELLOW: 1BROWN

Genotypic ratio = 2Yy: 1yy



PHENOTYPIC RATIO:

SR.NO: 2,3 – 2 YELLOW

SR.NO: 4 – 1 Black

2 YELLOW : 1 BLACK

F_2 GENERATION

♂ \ ♀	Y	y
Y	YY DIES	Yy YELLOW
y	Yy YELLOW	yy BLACK

GENOTYPIC RATIO:

SR.NO: 2,3 – 2 HETEROZYGOUS YELLOW [Yy]

SR. NO: 4 – 1 HOMOZYGOUS BLACK [yy]

2 Yy : 1yy

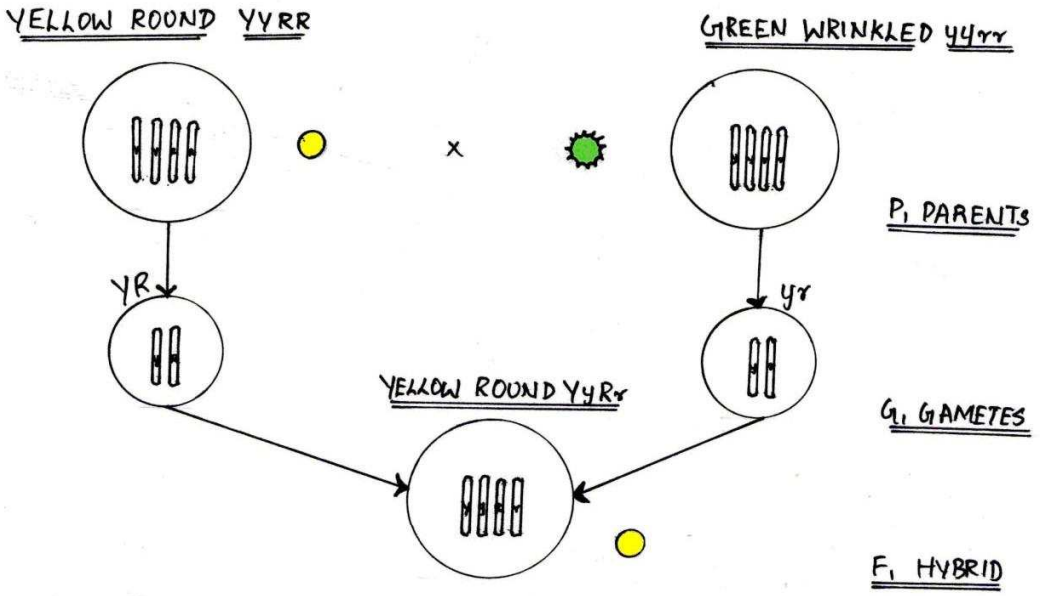
DIHYBRID CROSS

Dihybrid cross is a cross made between two plants that are differing in two pairs of contrasting traits. When a cross is made between a pea plant varieties having **yellow cotyledon** colour **(Y)** is dominant over **green wrinkled (r).** Hence the pure breeding yellow cotyledon, round wrinkled parent is represented by the genotype **YYRR** and the pure breeding green wrinkled parent is represented by the genotype **yyrr**. During gamete formation the paired genes of a character as sort out independently of the other pair. The $\mathbf{F_1}$plants are **YyRr** i.e. yellow cotyledon with round wrinkled. The $\mathbf{F_1}$ is selfed, dihybrid plants **(YyRr)** produce four types of gametes. They are **YR, Yr, yR, yr**. The male also produces 4 types of gametes. The four types of female gametes fuse with the 4 type of the male gametes at random. Hence there are 16 possible combinations. This can be clearly understood by checker board, out of these 16, 9 yellow cotyledons with round seeds, 3 yellow cotyledons with wrinkled, 3 green cotyledons with round seeds and 1 green cotyledon with wrinkled seeds.

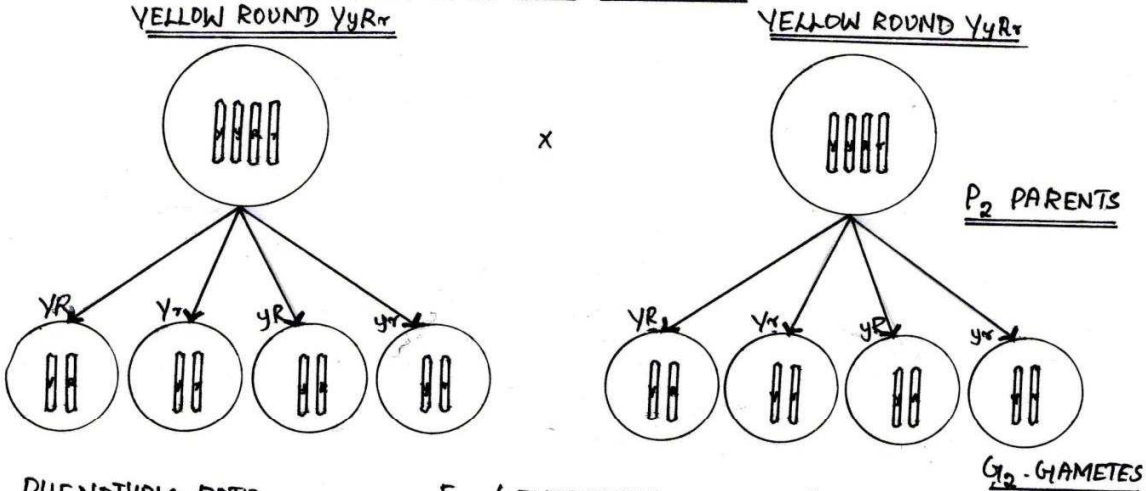
Phenotypic ratio = **9** yellow cotyledons round seeds
3 yellow cotyledons wrinkled seeds
3 green cotyledons round seeds
1 green cotyledons wrinkled seeds
9:3:3:1

Genotypic ratio =

1YYRR:2YYRr:2YyRR:4YyRr:1YYrr:2Yyrr:1yyRR:2yyRr:1yyrr



WHEN F_1 IS SELF FERTILIZED



PHENOTYPIC RATIO

SQ.NO:- 1, 2, 3, 4, 5, 7, 9, 10, 13 - 9 YELLOW ROUND

SQ.NO:- 6, 8, 14 - 3 YELLOW WRINKLED

SQ.NO:- 11, 12, 15 - 3 GREEN SMOOTH

SQ.NO:- 16 - 1 GREEN WRINKLED

9 : 3 : 3 : 1

F_2 GENERATION

♀ / ♂	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

GENOTYPIC RATIO

SQ.NO:- 1 - 1 YYRR

SQ.NO:- 2, 5 - 2 YYRr

SQ.NO:- 3, 9 - 2 YyRR

SQ.NO:- 4, 7, 10, 13 - 4 YyRr

SQ.NO:- 6 - 1 YYrr

SQ.NO:- 8, 14 - 2 Yyrr

SQ.NO:- 11 - 1 yyRR

SQ.NO:- 12, 15 - 2 yyRr

SQ.NO:- 16 - 1 yyrr

1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

COMPLEMENTARY FACTOR

"Two or more dominant genes occurring in different loci of the same chromosome or different chromosomes interact with one another to produce a character but neither of them produces that character in the absence of the other."

Bateson and Punnet studied the inheritance of flower colour in sweet pea ***Lathyrus odoratus***. There are two varieties of pea plants one producing red flower and other white flower.

When the 2 pure breeding white flowered varieties of sweet pea are crossed, the $\mathbf{F_1}$ generation are all purple, when this is selfed $\mathbf{F_2}$ produces purple and white varieties in the ratio of **9:7.**

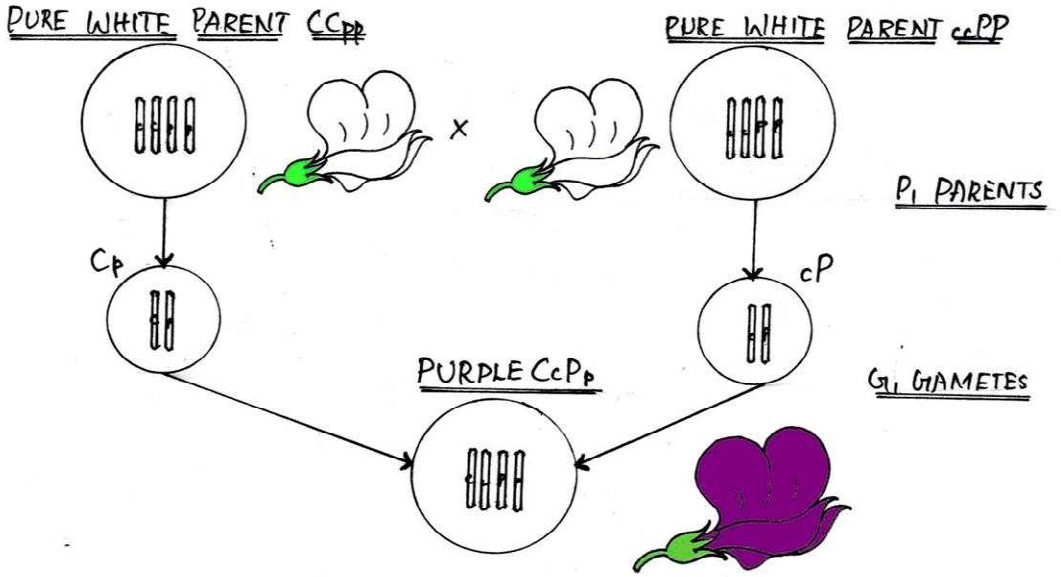
Bateson found that a dominant gene **'C'** is responsible for the production of **chromogen**, when this gene is recessive **'c'** the chromogen cannot be produced. Similarly another dominant gene **'A'** is responsible for the production of the enzyme or activator which converts the chromogen into anthocyanin. When the gene is recessive **'a'** the enzyme cannot be produced and thus chromogen cannot be produced and thus chromogen cannot be converted into anthocyanin.

Gene C→ chromogen

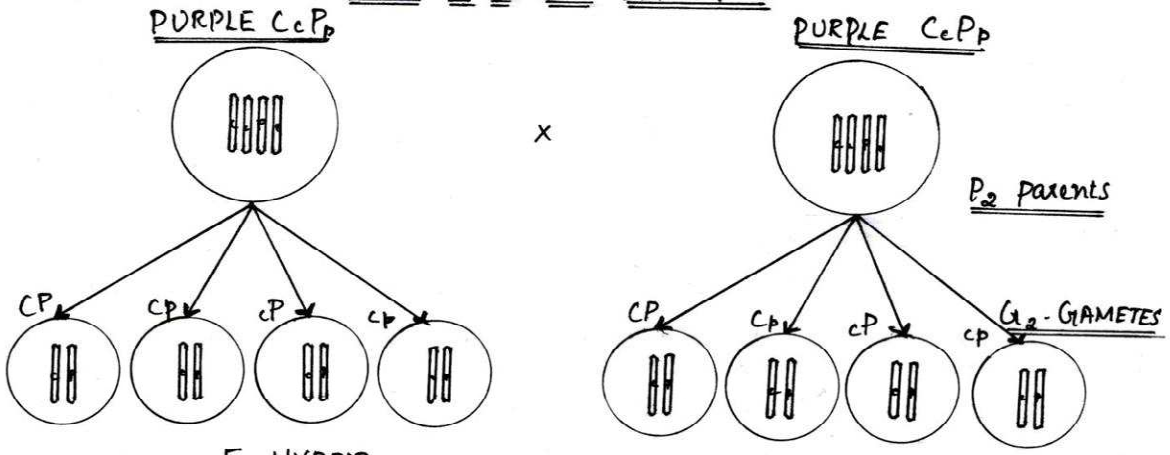
GeneA→ Activator or enzyme

Chromogen + activator anthocyanin (red)

Both the non –allelic genes C and A are complementaryin nature. In the absence of either one or both of the complementary genes white flowers are produced.



WHEN F_1 IS SELF FERTILIZED



F_2 HYBRID

♀ \ ♂	CP	Cp	cP	cp
CP	CCPP	CCPp	CcPP	CcPp
Cp	CCPp	CCpp	CcPp	Ccpp
cP	CcPP	CcPp	ccPP	ccPp
cp	CcPp	Ccpp	ccPp	ccpp

PHENOTYPIC RATIO

SQ.NO:- 1, 2, 3, 4, 5, 7, 9, 10, 13 – 9 PURPLE

SQ.NO:- 6, 8, 11, 12, 14, 15, 16 – 7 WHITE

9 PURPLE : 7 WHITE

SUPPLEMENTARY FACTOR

Supplementary genes are two independents pairs of genes which interact in such a way that one dominant gene will produce its effect whether the other gene is present or not, but the second one producer its effect only in the presence of the first.

Example:

Coat colour mice. Inheritance of coat colour in mice was studied by **Castle**.

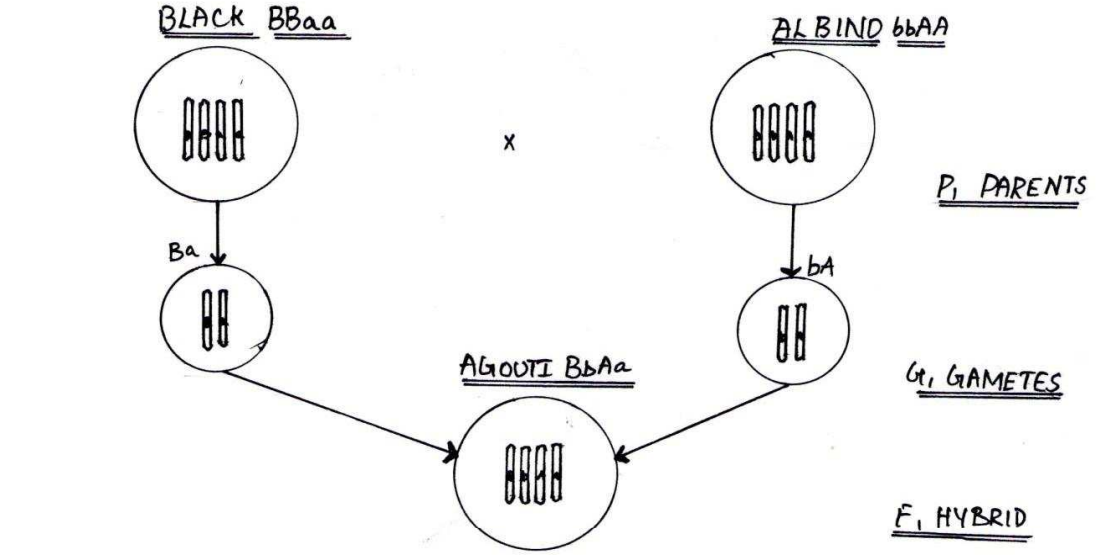
There are different varieties of mice. They are agouti (grey), black and albino (white). Agouti colour is dominant to both black and albino. Black dominant to albino but recessive to agouti. Albino is recessive to both agouti and black.

Agouti > Black > Albino

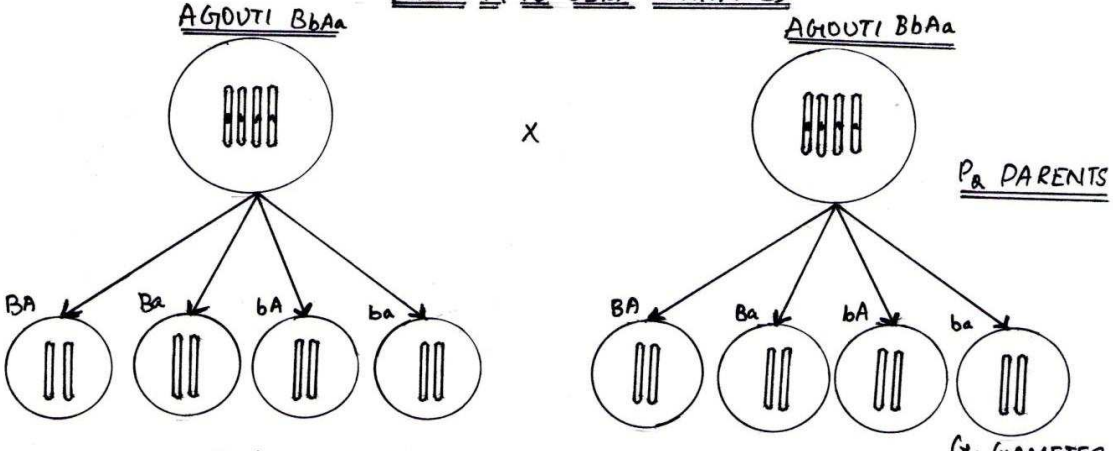
Agouti produced by dominant gene **A** in the presence of another dominant gene **B**. Dominant gene **A** produced albino. The recessive condition of the gene causes albino.

When black mice **(BBaa)** are crossed with albino **(bbAA),** the $\mathbf{F_1}$ are agouti **(BbAa).** The $\mathbf{F_1}$ is selfed the $\mathbf{F_2}$ shows agouti, black & albino.

Phenotypic ratio = 9 AGOUTI:3ALBINO:4ALBINO



WHEN F1 IS SELF FERTILIZED



F2 GENERATION

♂ \ ♀	BA	Ba	bA	ba
BA	BBAA	BBAa	BbAA	BbAa
Ba	BBAa	BBaa	BbAa	Bbaa
bA	BbAA	BbAa	bbAA	bbAa
ba	BbAa	Bbaa	bbAa	bbaa

PHENOTYPIC RATIO

Sr.NO:- 1,2,3,4,5,7,9,10,13 - 9 AGOUTI

Sr.NO:- 6,8,14 - 3 BLACK

Sr.NO:- 11,12,15,16 - 4 ALBINO

9 AGOUTI : 3 BLACK : 4 ALBINO

CUMULATIVE FACTOR

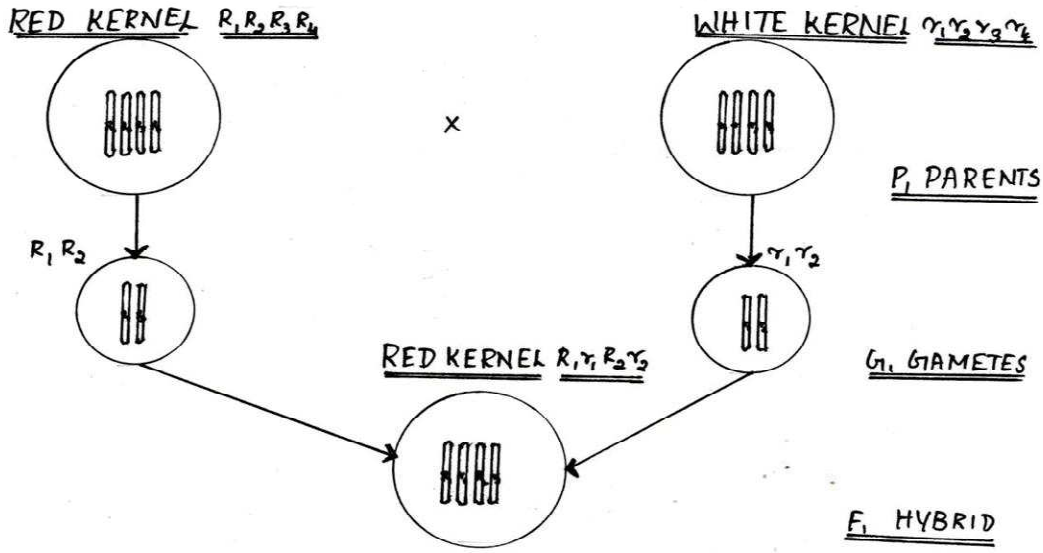
The inheritance of two or more non-allelic genes controlling a single quantitative character in a cumulative fashion is called multiple gene inheritance. These genes are called **multiple genes** or **polygenes**. Such gene produces a small effect on the character so the inheritance is also called cumulative inheritance.

Colour of wheat kernel

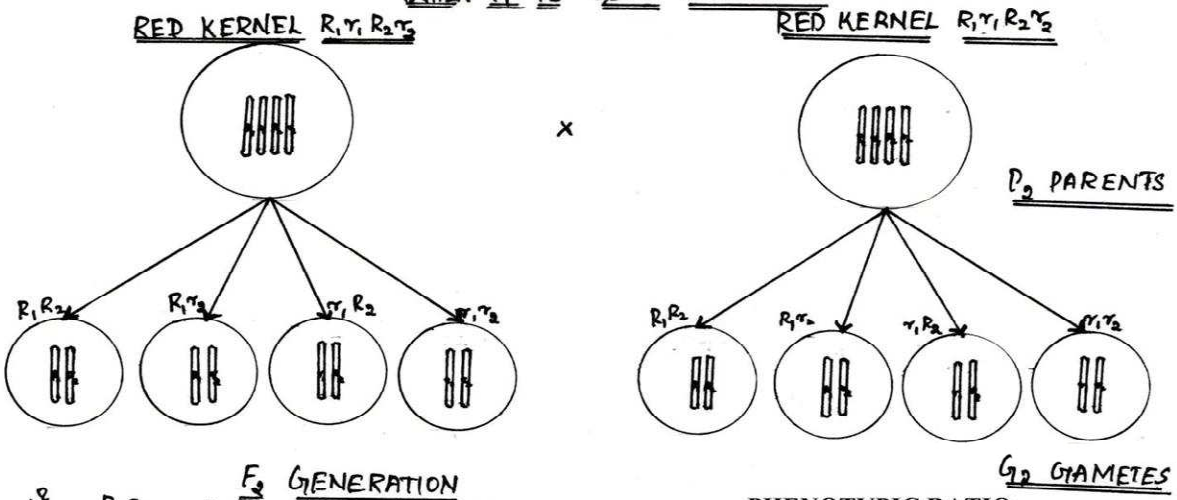
A whole gram or seed of a cereal such as wheat, paddy and barely etc. are called kernel.

Kernel colour in wheat is a quantitative character and its inheritance was studied by swedish geneticist. H. Nilsson Ehle in 1908. When a cross between red kernel **($R_1R_1R_2R_2$)**, white kernel **($r_1r_1r_2r_2$)** and **F_1** is medium red**. F_1** is self-fertilized in F_2. **The phenotypic ratio is 1 dark red: 4 red: 6 medium red: 4 light red: 1 white.**

No of contributing	phenotype	Phenotypic ratio
4	Dark red	1 coloured
3	red	4 coloured
2	Medium red	6 coloured
1	Light red	4 coloured
0	Albino/ white	1 colourless



WHEN F_1 IS SELF FERTILIZED



F_2 GENERATION

♂ / ♀	R_1R_2	R_1r_2	r_1R_2	r_1r_2
R_1R_2	$R_1R_1R_2R_2$	$R_1R_1R_2r_2$	$R_1r_1R_2R_2$	$R_1r_1R_2r_2$
R_1r_2	$R_1R_1R_2r_2$	$R_1R_1r_2r_2$	$R_1r_1R_2r_2$	$R_1r_1r_2r_2$
r_1R_2	$R_1r_1R_2R_2$	$R_1r_1R_2r_2$	$r_1r_1R_2R_2$	$r_1r_1R_2r_2$
r_1r_2	$R_1r_1R_2r_2$	$R_1r_1r_2r_2$	$r_1r_1R_2r_2$	$r_1r_1r_2r_2$

PHENOTYPIC RATIO

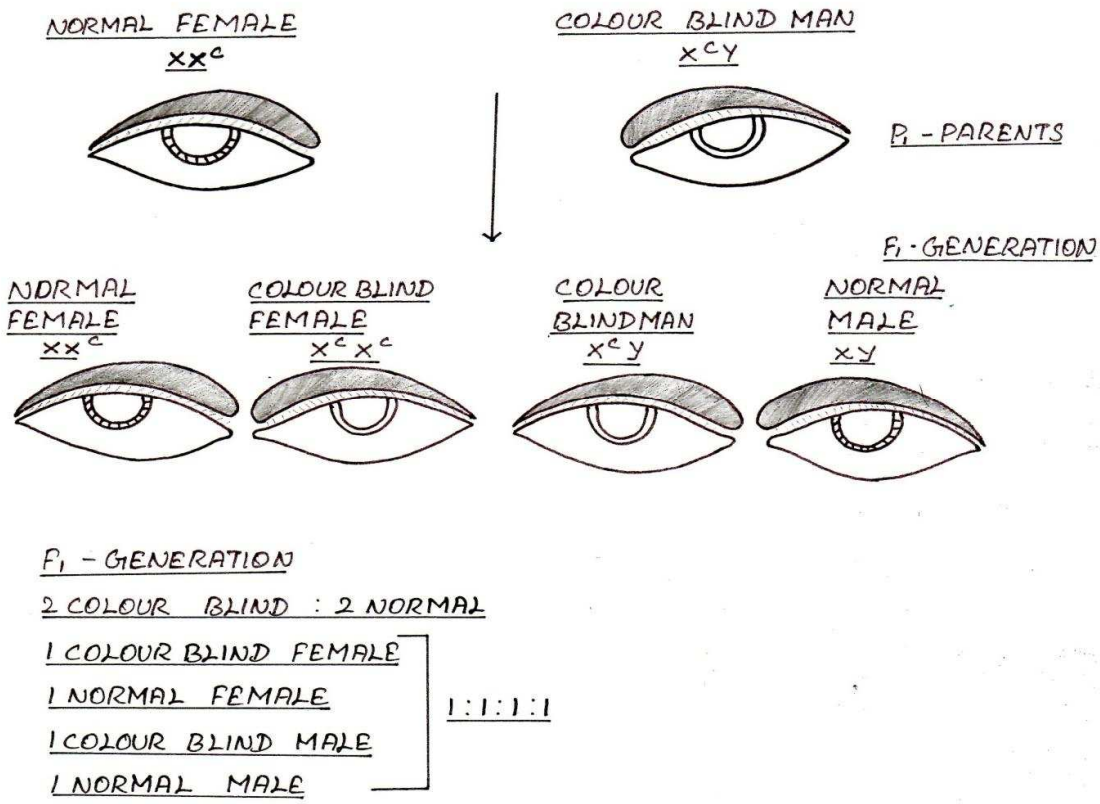
SQ.NO:1 = 1 DARK RED
SQ.NO:2,3,5,9 =4 RED
SQ.NO:4,6,7,10,11,13 = 6 MEDIUM RED
SQ.NO: 8,12,14,15 = 4 LIGHT RED
SQ.NO:16 = 1 WHITE

1:4:6:4:1

SEX LINKED INHERITANCE

COLOUR BLINDNESS IN MAN

In Man colour blindness is due to a recessive gene **c** which is present in the **X** chromosome when a carrier female marries a colour blind man the off springs are produced in the ratio of **1 colour blind female : 1 normal female : 1 colour blind male : 1 normal male**. The female carries the gene for colour blindness from father to his grand son. So this type of inheritance which is coupled with sex chromosome (**X**) known as sex linked inheritance.



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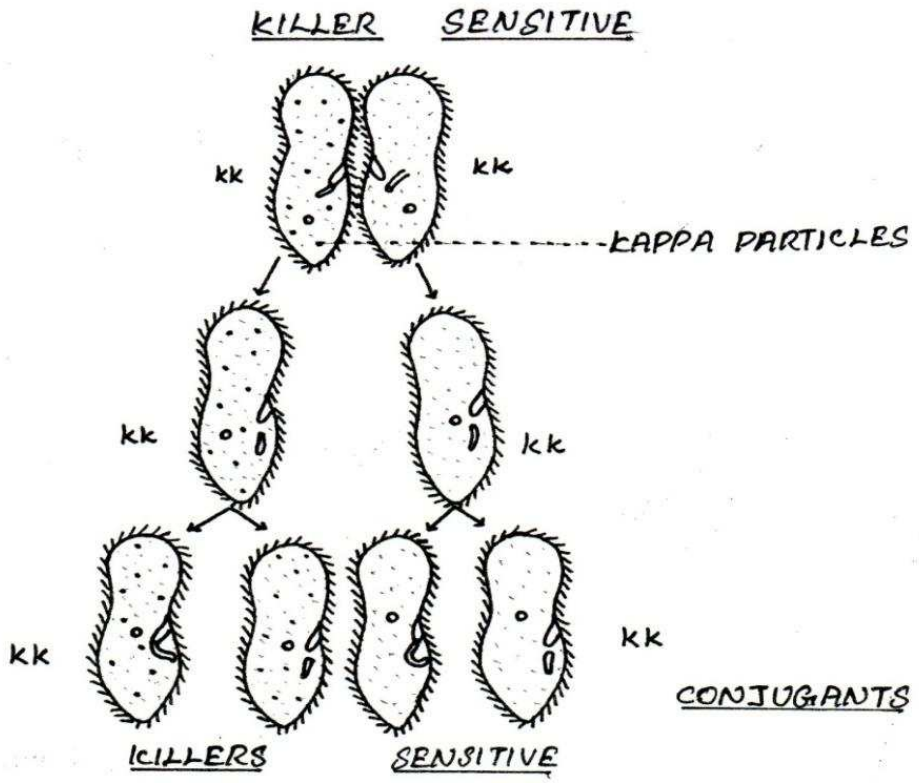
CYTOPLASMIC INHERITANCE

KAPPA PARTICLES IN PARAMECIUM

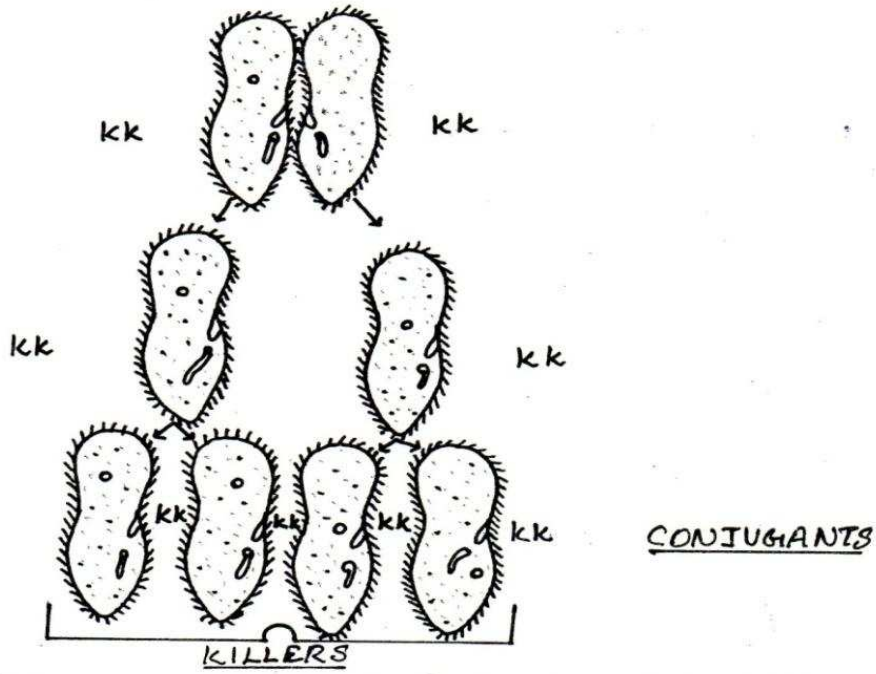
The transfer of characters controlled by plasmagenes is called **cytoplasmic inheritance or extrachromosomal inheritance.**

There are two strains of paramecium - **killer and sensitive**. Killer strain produces a toxic substance called **paramecin** that kills the other type. The production of **paramecin** in killer type is controlled by cytoplasmic particles known as **kappa particles.** The sensitive strains lack these particles. The kappa particles pass from one generation to the next generation in the process of cell division. They are transferred through the cytoplasm. Multiplication is controlled by a dominant nuclear gene **K.**

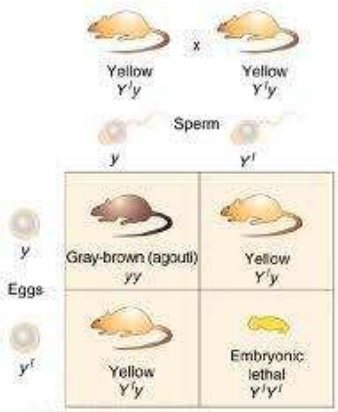
When killers **KK** conjugate with non-killers **kk,** the exconjugants are **Kk.** But the development of a particular type depends upon the **duration of cytoplasmic exchange**. In normal case of conjugation the nuclear material alone is exchanged and there is no exchange of cytoplasmic materials. In such cases, each exconjugants gives rise to the organisms of its own type .i.e. killer exconjugant produces kill and non-killer produces non - killer. Sometimes the conjugation period is prolonged and the cytoplasmic bridge between the two conjugants is larger, the cytoplasmic material & nuclear material are also exchanged. So that the sensitive types are converted into killer type. This shows that the *Paramecium* becomes a killer when it receives kappa particles and it becomes the sensitive when it does not receive kappa particles.

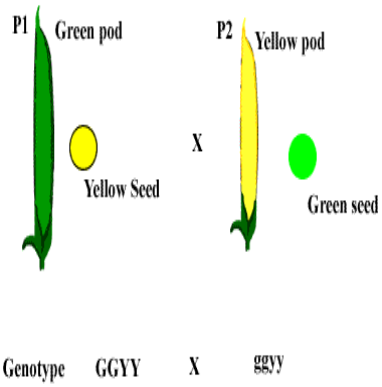


CONJUGATION WITHOUT CYTOPLASMIC EXCHANGE

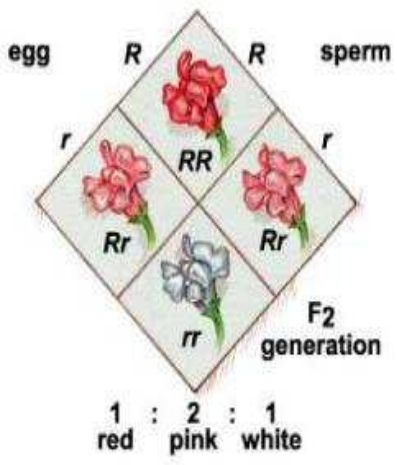


CONJUGATION WITH CYTOPLASMIC EXCHANGE





GENETICS & BIOMETRY PROBLEMS



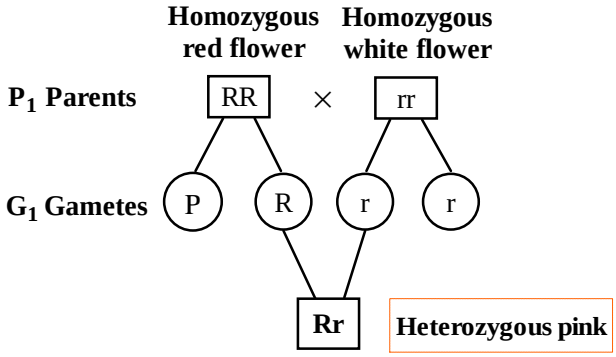
$$\overline{X} = \frac{\Sigma fx}{\Sigma f}$$

$$\overline{X} = \frac{\Sigma f \, mid \, x}{\Sigma f}$$

GENETIC PROBLEMS

I) In ***Mirablis jalapa*** a plant hybrid for red flower **(R)** and white **(r)** is pink **(Rr)**. One pink plant is crossed to a homozygous red another to a white. Give the genotypic and phenotypic ratios in which the offsprings are produced in each case.

In ***Mirablis jalapa*** red flower **RR** are crossed with white **rr**



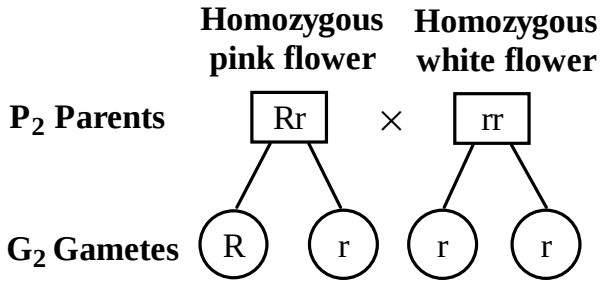
F_1 hybrid

Red flowers **R** is incompletely dominant over white flowers **r** . So in the F_1 hybrid is pink Rr intermediate colour.

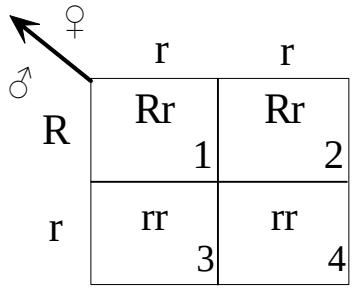
Case-I

Test cross

When a pink plant or F1 hybrid [Rr] is crossed to a white [rr].



F_2 generation



Phenotypic ratio

Sq No. s: 1 and 2 : 2 Heterozygous pink

Sq No. s: 3 and 4 : 2 homozygous white **1:1**

Genotypic ratio

Sq No. s: 1and 2 : 2 Rr

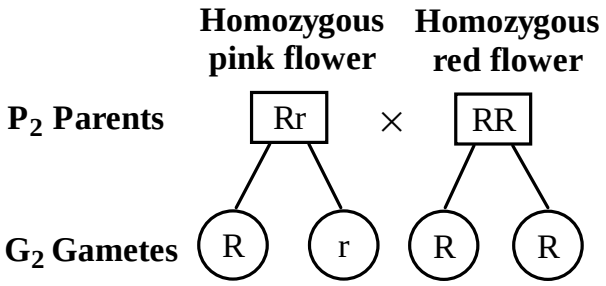
Sq No. s: 3 and 4 : 2rr

2Rr:2rr is **1:1**

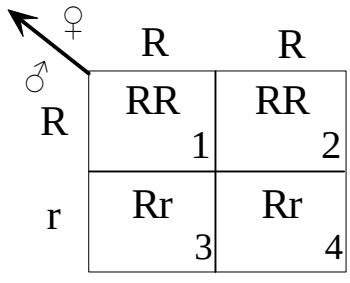
Case-II

Back cross

When a pink plant (or) F_1 hybrid **Rr** is crossed to a red **RR**



F_2 generation



Phenotypic ratio

Sq No.s: 1 and 2 : 2 Homozygous red

Sq No.s: 3 and 4 : 2 Heterozygous pink

Genotypic ratio

Sq No.s: 1and 2 : 2 RR

Sq No.s: 3 and 4 : 2Rr

2RR:2Rr is **1:1**

II. In Peas, tall plant habit is dominant over dwarf. If a plant homozygous for tall is crossed with homozygous for dwarf. What will be the appearance of

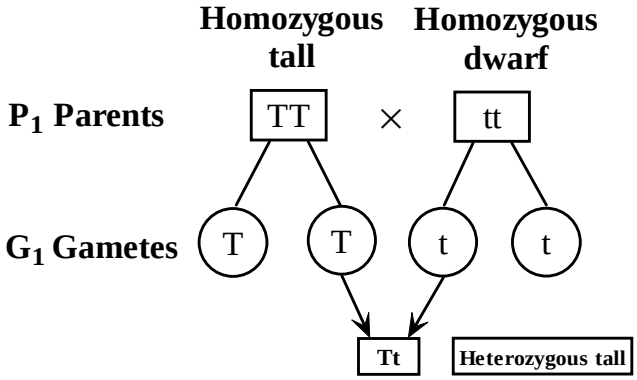
a. F_1

b. F_2

c. Of the offspring of the cross of F_1 with its tall parent.

d. With its dwarf parent.

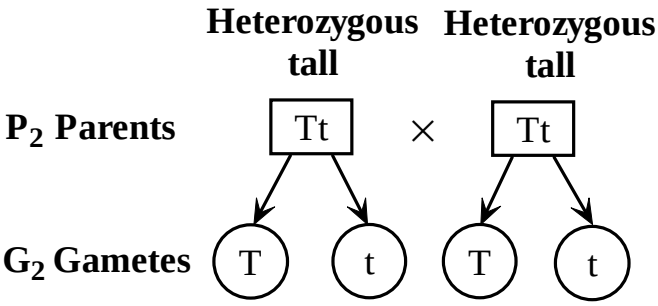
a. In pea, tall plant **Tt** is dominant over dwarf **tt**



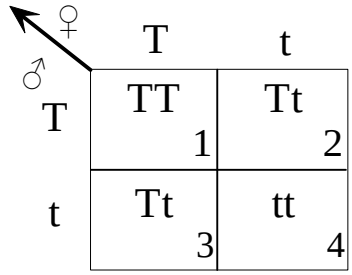
F_1 hybrid

Answer:

1. The appearance of F1 hybrid is Heterozygous tall.
2. When F1 self fertilized



F_2 generation



Phenotypic ratio

Sq No: 1 Homozygous tall

Sq No: 2&3 Heterozygous tall

Sq No: 4 Homozygous dwarf

Phenotypic ratio 3tall : 1 dwarf **3:1**

Genotypic ratio

Sq No 1: 1TT

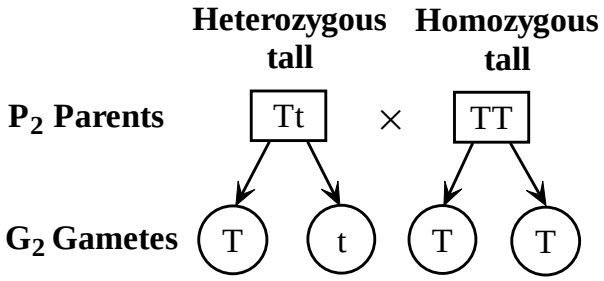
Sq No 2&3: 2 Tt

Sq No 4: 1tt

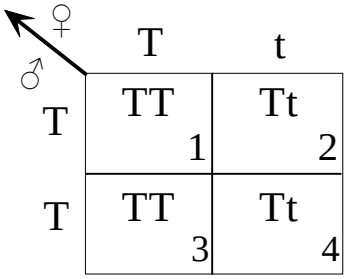
= 1TT:2Tt:1tt

1:2:1

c) When offspring of F1 crossed with Tall parent. This is a back cross



F_2 generation



Phenotypic Ratio

Sq No: 1 & 3 : 2 Homozygous tall

Sq No: 2 & 4 : 2 Heterozygous tall

Ratio: **1:1**

Genotypic Ratio

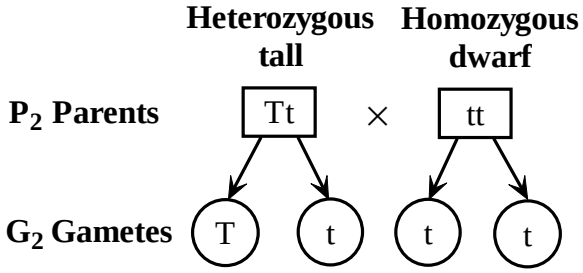
Sq No: 1 & 3 : 2 TT

Sq No: 2 & 4 : 2 Tt

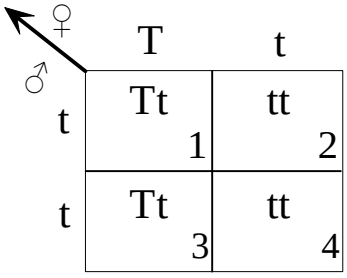
Ratio: **1:1**

All are tall

d) When F1 hybrid is crossed with dwarf parent- Test cross



F_2 generation



Phenotypic Ratio

Sq No: 1 & 3 : 2 Heterozygous tall

Sq No: 2 & 4 : 2 Homozygous dwarf

2 Tall : 2 dwarf

Ratio: **1:1**

Genotypic Ratio

Sq No: 1 & 3 : 2 Tt

Sq No: 2 & 4 : 2 tt

Ratio: **1:1**

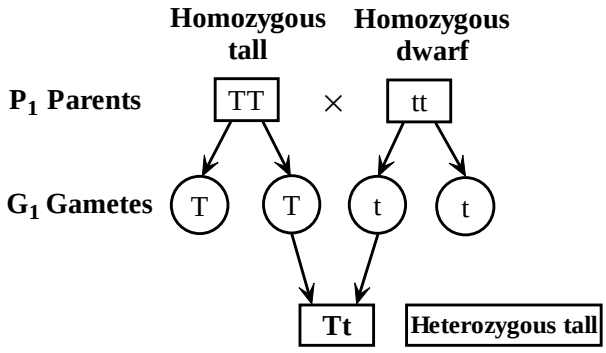
III) A tall plant is crossed with dwarf one produces offsprings of which, one half is tall and other half is dwarf. What is the genotype of the parents?

When a tall parent is crossed with dwarf plant the offsprings one half is tall and other half is dwarf.

This is a test cross.

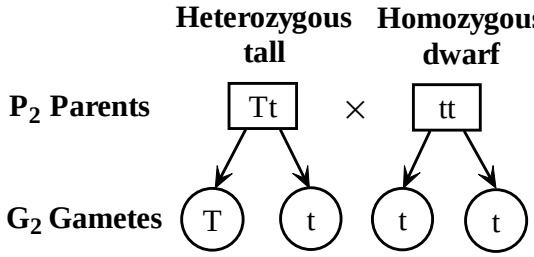
Test cross

Test cross can be defined as a cross between F_1 hybrid with its recessive parent.

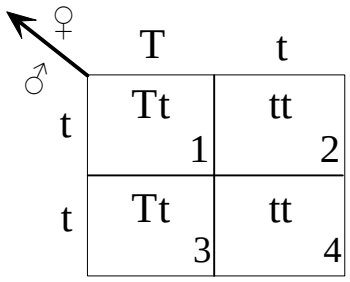


F_1 hybrid

When F1 is crossed with recessive parent



F_2 generation



Phenotypic ratio

Sq No.s: 1 and 3 : 2 Heterozygous tall

Sq No.s: 2 and 4 : 2 homozygous dwarf

Ratio: **1:1**

Genotypic ratio

Sq No.s: 1and 3 : 2 Tt

Sq No.s: 2 and 4 : 2tt

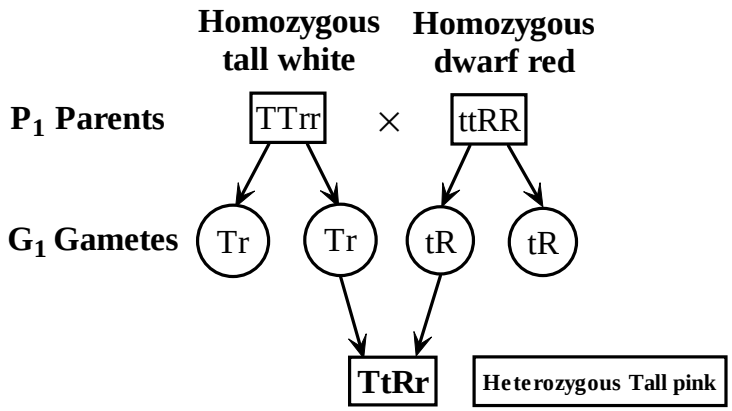
2Tt:2tt

Ratio: **1:1**

IV) In S***napdragons***, tall (T) is dominant to dwarf (t) and red flowers (R) are incompletely dominant to white (r), the hybrid being pink. A pure tall white is crossed to a pure dwarf red and the F_1 are self fertilized. Give the F_2 phenotypic ratio and genotypic ratio if the F1 are self fertilized.

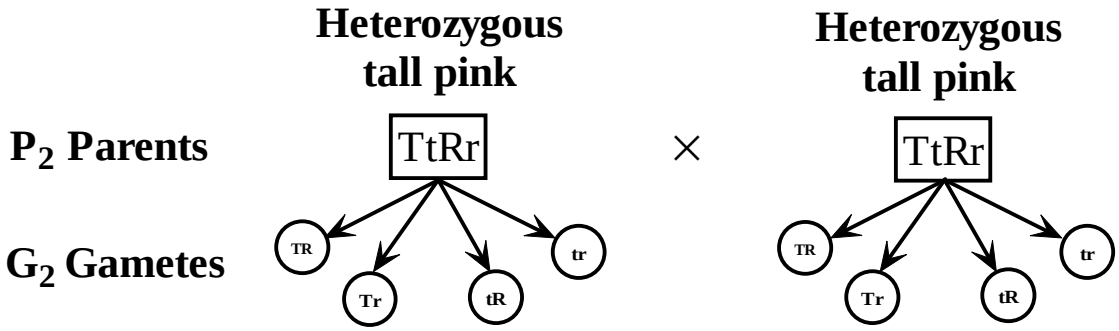
In ***Snapdragons*** tall [T] is dominant over dwarf [t] Red flower [R] is incompletely dominant over white [r].

A pure tall white is crossed with a pure dwarf red.



F_1 hybrid

When F_1 hybrid is self fertilized



F_2 generation

♂ \ ♀	TR	Tr	tR	tr
TR	TTRR 1	TTRr 2	TtRR 3	TtRr 4
Tr	TTRr 5	TTrr 6	TtRr 7	Ttrr 8
tR	TtRR 9	TtRr 10	ttRR 11	ttRr 12
tr	TtRr 13	Ttrr 14	ttRr 15	ttrr 16

Phenotypic ratio

Sq no: 1,3,9 = 3 Tall Red

Sq no: 2,4,5,7,10,13 = 6 Tall Pink

Sq no: 6,8,14 = 3 Tall white

Sq no: 12,15= 2 dwarf pink

Sq no: 11 = 1 dwarf red

Sq no: 16 = 1 dwarf white

Ratio: **3:6:3:2:1:1**

Genotypic ratio

Sq no: 1 = 1TTRR

Sq no: 2,5= 2 TTRr

Sq no: 3,9 = 2 TtRR

Sq no: 4,7,10,13= 4 TtRr

Sq no: 16 = 1 ttrr

Sq no: 6 = 1 TTrr

Sq no: 8,14 = 2 Ttrr

Sq no: 11= 1ttRR

Sq no: 12,15 = 2 ttRr

Ratio: **1:2:2:4:1:1:2:1:2**

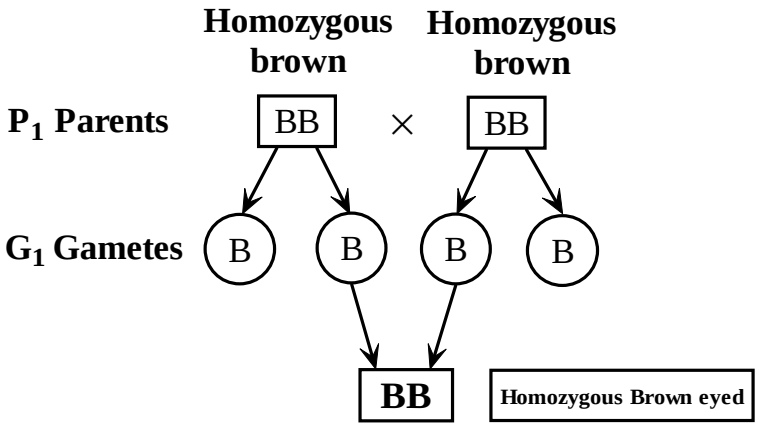
V) In Man, brown eye [B] are dominant to blue [b].

Two brown eyed parents have a blue eyed child what are the genotypes of the parents?

In man brown eyes[B] are dominant to blue [b], when 2 brown eyed people produces blue eyed child, the genotypes of the parents may be:

Case I:

If the parents are homozygous brown

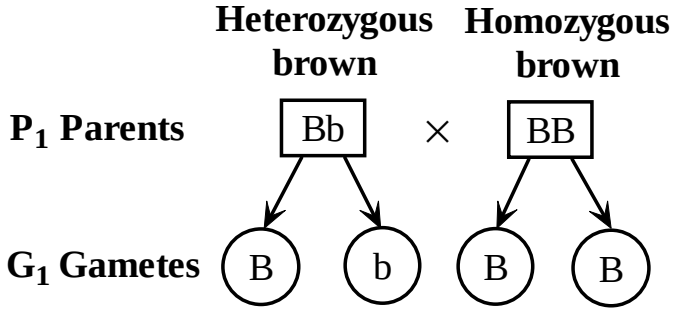


F_1 hybrid

F_1 hybrid BB all are brown eyed so the parents could not be homozygous brown eyed.

Case II:

If any one of the parent is heterozygous brown



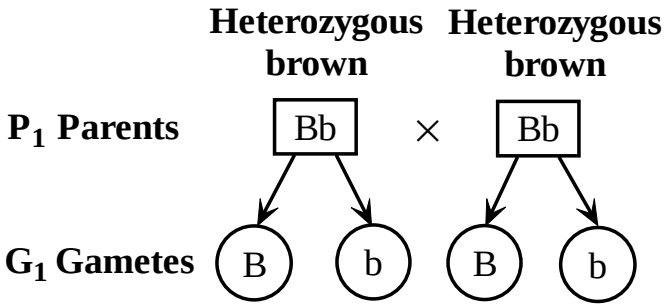
F_1 hybrid

♂ \ ♀	B	B
B	BB Brown eye	BB Brown eye
b	Bb Brown eye	Bb Brown eye

F_1 offsprings → All are brown eyed

Case III:

When both the parents are heterozygous brown eye



F_2 Hybrid ♂♀

♂ \ ♀	B	b
B	BB Brown eye	Bb Brown eye
b	Bb Brown eye	bb Brown eye

Phenotypic ratio

Sq no:1,2,3 = 3 brown eyed

Sq no: 4 = 1 blue eyed

So the genotypes of the parents are **Bb** × **Bb**

BIOMETRY

I Raw data

1) Calculate mean ($\overline{X}$) from the following data

S. No.	1	2	3	4	5	6	7	8	9	10
Marks	33	35	44	34	41	45	39	46	36	47

Step I -Add all the values of variables X (Marks) and find out ΣX.

Step II- Divide ΣX by their number of observations (N).

Solution

S. NO.	Marks(X)
1	33
2	35
3	44
4	34
5	41
6	45
7	39
8	46
9	36
10	47
N = 10	**ΣX = 400**

Formula

$$\overline{X} = \frac{\Sigma x}{N}$$

$\overline{X}$ = Arithmetic mean

ΣX= Sum of all values

N = number of observations

$$\overline{X} = \frac{400}{10} = \textbf{40 marks}$$

II. Discrete series (Grouped data)

2) Calculate the mean for the following data.

No.of children born per family (x)	**0**	**1**	**2**	**3**	**4**	**5**	**6**
No.of families (f)	**7**	**7**	**10**	**5**	**3**	**2**	**1**

Steps

a) **Multiply each value by its frequency (fx)**

b) **Add all the fx (**Σfx)

c) **Divide** Σfx by the total of frequency (N or Σf)

Solution

x	**F**	**Fx**
0	**7**	**0**
1	**7**	**7**
2	**10**	**20**
3	**5**	**15**
4	**3**	**10**
5	**2**	**10**
6	**1**	**6**
	Σf = 35	**Σfx = 70**

Formula

$$\overline{X} = \frac{\Sigma fx}{\Sigma f}$$

$\overline{X}$ = Arithmetic mean

$\overline{X}$ = 70/35

Σfx = The sum of fx

$\overline{X}$ = 2

Σf = Total of frequency

III. Continuous series (Grouped data)

3) From the following, find out the mean

Marks	10-20	20-30	30-40	40-50	50-60	60-70	70-80
No. of students (f)	10	18	20	26	30	28	18

Step I – Find out the mid value of each class (mid x)

Step 2 – Multiply the mid value of each class by the frequency (f).

Step 3 – Add all the products (Σf mid x)

Step 4 – Σf mid x is divided by Σf.

Solution

Marks (X)	Mid x	No. of students (f)	f × mid x
10-20	15	10	150
20-30	25	18	450
30-40	35	20	700
40-50	45	26	1170
50-60	55	30	1650
60-70	65	28	1820
70-80	75	18	1350
		Σf = 150	**Σf mid x = 7290**

Formula

$$\overline{X} = \frac{\mathbf{\Sigma f\, mid\, x}}{\mathbf{\Sigma f}}$$

$\overline{X}$ = Arithmetic mean

Σf mid x = The sum of products

Σf = Total of frequency

$$\overline{X} = \frac{7290}{150} = \mathbf{48.6}$$

4) The following are the marks scored by 11 students. Find out the median marks.

15, 18 , 10 , 14 , 20 , 9 , 21 , 30 ,6 ,10, 13

Solution

Step 1 - First arranging the given marks in ascending order.

6 , 9 , 10 , 10 , 13 , **14** , 15 , 18 , 20 , 21 , 30

Step 2 - Apply the formula

$$\text{Med} = \left[\frac{N+1}{2}\right]^{th} \text{ value (or) item}$$

N = No. of items

N = 11

$$\text{Med} = \left[\frac{11+1}{2}\right]^{th} \text{ item}$$

$$= \frac{12}{2}$$

$$= 6^{th} \text{ item}$$

Median = 14 marks

5) Find the median of the following data, weight of fish in grams.

11, 12, 15, 16, 19, 17

Solution

i. Ungrouped data with uneven numbers

ii. The data are arranged in an ascending order. 11,12,15,16,19,17

iii. Apply the formula

$$\text{Med} = \left[\frac{N+1}{2}\right]^{th} \text{ item}$$

$$= \frac{6+1}{2}$$

$$= \frac{7}{2}$$

$$= 3.5^{th} \text{ item}$$

So the median is in between 3^{rd} and 4^{th} item

3^{rd} item = 15

4^{th} item = 16

Therefore Median = $\frac{15+16}{2}$

Med = $\frac{31}{2}$ = 15.5 gms

Median = 15.5 gms

6) Find the median size of shoe

Size of shoe in inches	**4**	**5**	**6**	**7**	**8**	**9**
Frequency	**10**	**15**	**22**	**16**	**12**	**5**

Solution

1) Arrange the data in ascending or descending order.
2) Find the cumulative frequencies.

Size of shoes in inches (X)	**Frequency (f)**	**Cumulative frequency (f)**
4	10	10
5	15	25
6	22	47
7	16	63
8	12	75
9	5	80
		N = 80

Apply the formula Median

$$\text{Med} = \left[\frac{N+1}{2}\right]^{th} \text{ item}$$

$$\left(\frac{80+1}{2}\right) = \frac{81}{2} = 40.5^{th} \text{ value}$$

Here 40.5^{th} value is in between 25 and 47 of cumulative frequency, so, we take higher cf is 47 and the corresponding x value of cf 47. Hence the corresponding x value of cf 47 is 6.

Median = 6 inches.

7) Calculate the median from the following table

Marks	0-10	10-20	20-30	30-40	40-50
Frequency	22	38	46	34	20

Solution

1) Find the C.F
2) Find out the median class by using N/2

Marks (X)	Frequency (F)	CF
0-10	22	22
10-20	38	60
20-30	46	106
30-40	34	140
40-50	20	160
	N = 160	

$$\textbf{Median} = L + \left[\frac{\frac{N}{2} - CF}{f}\right] \times C$$

Median class = $\frac{N}{2} = \frac{160}{2} = 80$

L - Lower limit of median class.

N - Number of items.

Cf - Cf prior to median class.

C - Class intervals

f - Frequency of median class.

$$\text{Median} = 20\left[\frac{80-60}{46}\right] \times 10$$

$$= 20 + \left[\frac{20}{46}\right] \times 10$$

$$= 20 + (0.434 \times 10) \quad = 20 + 4.34$$

Median = 24.34

8) Determine mode from the following data

50,62,48,50,63,65,50,48,43,62,50,50

Solution

First the data is arranged in the form of array.

43,48,48,50,50,50,50,62,62,63,65

In this data 50 is repeated 5 times

So mode is 50

9) Determine mode from the following data

x	**20**	**25**	**30**	**35**	**40**	**45**	**50**
f	**1**	**2**	**1**	**5**	**1**	**2**	**1**

Solution

Here the value 35 is repeated 5 times.

So mode is 35

10. Calculate the mode for the following data

Marks	0-10	10-20	20-30	30-40	40-50	50-60	60-70
No. of students	4	9	13	15	12	8	3

Solution

The highest frequency can be find out.

Marks	Number of students	
0-10	4	
10-20	9	
20-30	**13**	**f0**
30-40	**15**	**f1**
40-50	**12**	**f2**
50-60	8	
60-70	8	

Formula

$$\text{Mode (Mo)} = L + \left[\frac{\Delta 1}{(\Delta 1 + \Delta 2)} \right] \times c$$

L - Lower limit of modal class

$\Delta_1 = f_1 - f_0$

$\Delta_2 = f_1 - f_2$

C - class interval

f_1 = frequency of the modal class

f_2 = frequency of the succeeding modal class

f_0 = frequency of the proceeding modal class

Highest frequency (f_1) is 15

Class interval 10

f_1 =15, f_0 =13, f_2 = 12

$\Delta 1 = f_1 - f_0 = 15-13 = 2$

$\Delta 2 = f_1 - f_2 = 15-12 = 3$

$$\text{Mode} = 30 + \frac{2}{[2+3]} \times 10$$

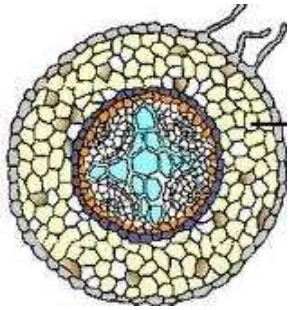
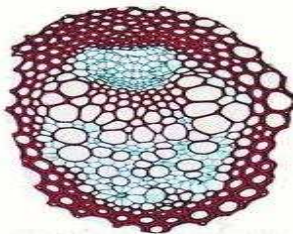
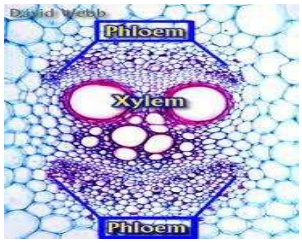
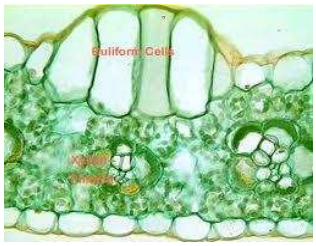
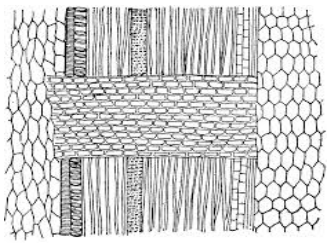
$$= 30 + \left[\frac{2}{5}\right] \times 10$$

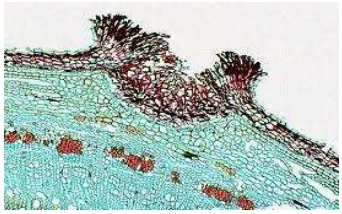
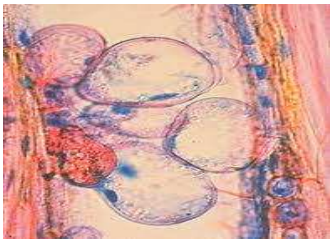
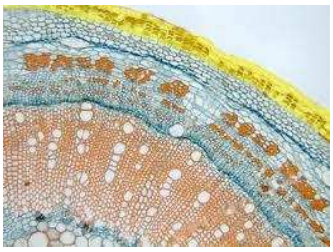
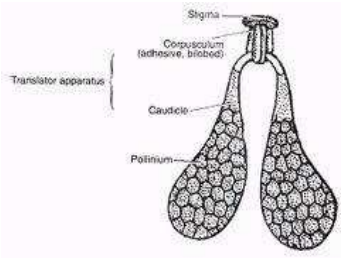
$$= 30 + (0.4 \times 10)$$

$$= 30 + 4$$

Mode = 34

SPOTTERS

1	**Radial vascular bundle**: Xylem and phloem arranged in different radius. **E.g. Root**	
2	**Collateral vascular bundle**: Xylem and phloem arranged in same radius. **E.g. Stem**	
3	**Bicollateral vascular bundle**: On both the sides of xylem phloem and cambium is present i.e. outer cambium & outer phloem and inner cambium & inner phloem. **E.g. *Cucurbita***	
4	**Bulliform cells**: In monocot leaves a few epidermal cells are large and empty called **bulliform** cells or motorcells. It helps in rolling of leaves during dry weather.	
5	**Medullary rays or pith rays**: The elongated parenchymatous cells present in between the vascular bundles. **Function**: help in lateral conduction of water and food.	
6	**Annual rings or growth rings**: In T.S of stem shows early and late wood appear in the form of distinct concentric rings. It helps to find out the age of a tree.	

7	**Lenticels**: The minute pore in the periderm of woody stem meant for **gaseous exchange** filled with loosely arranged **complementary cells**.	
8	**Tyloses**: An outgrowth of **xylem parenchyma** in the lumen of **tracheids or vessels**. It helps in **maturation of wood**.	
9	**Periderm:** Secondary protective tissue derived from the **phellogen**. It consists of **phellem, phelloderm** and **phellogen.**	
10	**Pollinium:** All the pollen grains in a sporangium remain together to form a single mass called **pollinium.** It has **carpusculum, caudicle and pollinia. E.g. *Daemia***	

MODEL QUESTION

Time: 3 hours **Max. Marks: 100**

1. Cut transverse sections of specimen **'A', 'B'** and **'C'**. Stain and mount in glycerine. Identify giving reasons. Submit the slides for valuation.

   (Slide-3, identification-1, reasons-4, diagram-2) **(3 × 10 = 30)**

2. Dissect and mount the given specimen **'D'.**

   (1 × 4 = 4)

3. Work out the genetic problem **'E'.**

   (1 × 10 = 10)

4. Draw diagram, identify and write notes on '**F', 'G', 'H' 'I', 'J'** and **'K'.**
   (**Identification-1, notes-4, diagram-1)** **(6 × 6 = 36)**

5. Comment on **'L'**.

   (1 × 10 = 10)

90

Record 10

Total 100

KEY

A. Epiphytic Root **(Orchid)**/Monocot Stem ***(Bambusa)/***Dicot stem (***Tridax)***

B. Monocot root (***Canna***) Dicot old Stem (***Annona***)/Dicot Leaf (***Nerium***)

C. Anomalous Secondary Growth ***(Bignonia/Achyranthes/ Aristolochia)***

D. Embryo mounting/Pollinium mounting.

E. Genetics Problem.

F. Bicollatral or radial Vascular Bundle/Lenticel/growtn rings/ periderm/tyloses.

G. Stomata (**Paracytic**/**Graminaceous**)

H. Nodal Anatomy **(Unilocunar/Trilacunar)**

I. T.S Of Anther/Ovule (**Orthotropous**/**Anatropous**)

J. Chloroplast/Mitochondria/Dictyosome/t-Rna.

K. Lethal Factor/Complementary Factor/Supplementary Factor

L. Biometry(**Mean**/**Median**/**Mode**)