Quadrant II – Transcript and Related Materials

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Notes

Microsporophyll

The stamen (or Microsporophyll) is the male reproductive organ of the plant. A single stamen typically consists of an elongated stalk,- the filament and at the tip of which is present -the anther (or microsporangium). A typical anther is a bilobed structure, the lobes of which are connected by a structure called Connective. The anther is usually bilobed (also called bicelled, dithecous or tetrasporangiate) structure, each lobe of which comprises of two pollen sacs or microsporangia. In mature and dehiscing anthers, the two microsporangia of each lobe appear as a single mass due to breakdown of the partition tissue.

In some plants like Moringa, Wolfia and members of family Malvaceae, the anther are monothecous, ie they have a single lobe with two microsporangia. These may also be called unicelled or bisporangiate. In Arceuthobium (a parasitic mycelial dicot), there is a single microsporangium per anther.

Development of Microsporangium

The young developing anther consists of a mass of homogenous, meristematic cells bounded by a single layered epidermis. As the anther develops, it assumes a four lobed appearance, each lobe giving rise to a microsporangium. Development of microsporangium take place as follows:

i. In the first stage of development, hypodermal cells in each lobe assume large size, elongate radially and the nucleus becomes conspicuous. These highly prominent cells constitute the archesporium and show considerable variations. In a cross section, a single archesporial cell may be seen, as in *Boerhaavia* and *Dionaea*, or a plate of cells as in *Urginea* and *Ophiopogon*. In the longitudinal plane, the row of archesporial cells may be one cell thick as in *Enalus*, or two cell thick as in *Boerhaavia* or several celled in thickness as in *Urginea*.
ii. The archesporial cells divide by a periclinal division, cutting off an outer primary parietal layer and an inner primary sporogenous layer.
iii. The cells of primary parietal layer divide by a number of anticlinal and periclinal divisions to form 2 to 5, concentric-layered anther wall.
iv. (iv) The primary sporogenous cells may function directly as the spore mother cells or may undergo one or two mitotic divisions to form a large number of spore mother cells (also called Pollen mother cells or PMC).

Structure of anther wall

The anther wall is derived from the parietal layer and consists of—

(i) an epidermis.

(ii) endothecium.

(iii)middle layers. and

(iv) tapetum.

(i) Epidermis. It is the outermost layer, made up of flattened and greatly stretched cells. In Arceuthobium, the epidermal cells develop fibrous thickenings and is known as *exothecium*. The epidermis provides protection to the developing anther.

(ii) Endothecium. The single layered endothecium consists of radially elongated cells, which develop fibrous bands, arising from the inner tangential wall and terminating near the outer wall of each cell. The endothecium is not a continuous layer all around microsporangium, but its cells remain thin-walled and form a strip of thin walled cells along the line of dehiscence, called *stomium* in each anther lobe. The fibrous bands, the differential expansion of the outer and inner walls and the hygroscopic nature of the endothecial cells, all combine to bring about dehiscene of the anther. Spores are released through stomium.

(iii) Middle layers. Middle layers consist of two or three layers of flattened cells, which are of short duration. In some plants, the cells are persistent and function as storage centre for starch, which is used during pollen development.

(iv) Tapetum. It is the inner most layer composed of a single layer of cells with dense cytoplasm and prominent nuclei. In most angiosperms, the tapetum is Of dual origin, since the outer part is formed by the parietal layer and the inner portion is derived from the connective tissue. In some plants like *Alectra thomsoni*, dimorphic tapetum is found, i.e. tapetal cells of different origin with different morphology

On the basis of behaviour, two types of tapetum are known.

(a) Amoeboid (Invasive or Periplasmodial). The cell wall of such tapetal cells ruptures and moves into the sporangial mass. The protoplasts of tapetal cells intrude between pollen mother cells and developing pollen grains. After intrusion, the tapetal protoplasts fuse with each other and form a mass or Periplasmodium,

Mepham and Lane (1969) studied periplasmodial tapetum in *Tradescantia* and found it to be a highly organised and functional structure. They discovered that the breaking of the cell wall or tapetal cells took place after meiosis in pollen mother cells and tapetal plasmodium infiltrated between the pollen mother cells. It remains present till the maturity of the pollen grains. At maturity and drying up of the anther, the tapetal plasmodium gets dehydrated and coated over the pollen grain surface and helps in the formation of exine (pollen wall).

(b) Secretory (Glandular or Parietal). In such tapetum, the cells remain in the original position and nourish the growing pollens. The tapetal cells secrete nourishing substances into the microsporangium (anther sac) throughout the pollen development and degenerate only after pollen maturity. This type of tapetum is commonly found in angiosperms.

An interesting feature of secretory type of tapetum is the presence of a number of spherical bodies, the **pro-Ubisch bodies**, along with mitochondria, plastids and dictyosomes. The pro-Ubisch bodies are of lipid nature and make their appearance during sporogenesis. As cell division proceeds, the number of pro-Ubisch bodies increases and a marked shifting of position towards the region nearest to the anther cavity, is seen. At the tetrad stage Of spores, these increase further in number and get surrounded by a layer of ribosomes. Eventually, the pro-Ubisch bodies are extruded from tapetal cells and pass through the tapetal cell membrane into the space between membrane and the spore cell wall. Over here, these are rapidly coated with sporopollenin and are known as ***Ubisch bodies.*** Ubisch bodies are spheroidal in shape. Functionally, these play a decisive role in organising exine pattern as clearly evidenced in case of *Mirabilis jalapa* and *Silene pendula*.

Tapetal membrane. In both types of tapetum, an additional membrane called tapetal membrane is found, In the secretory type of tapetum, the Ubisch bodies are arranged on this membrane. The functional significance of this layer is very clear.

Cell division in tapetal cells. A significant feature of tapetum is the nuclear behaviour. It may be of following types:

(a) Endomilosis. In this type of cell division, duplication of the chromosomes and the separation of the chromatids occur without disorganisation of nuclear membrane. Since spindle formation does not take place in this process, a large polyploid nucleus is formed, e.g. *Cucurbita pepo*.

(b) Formation of restitution nuclei. In this type of cell division, chromosome duplication and chromatid separation occur normally till the early anaphase stage, later the two sets or chromosomes rejoin within a common nuclear membrane. nucleus containing double set or chromosomes is known as restitution nucleus.

(c) Multinucleate condition. In some cages. e.g. *Mimusops elen*gi and *Iodina rhombhifolia*, during mitotic division. nuclear division is not followed by cell wall formation, hence tapetal cell becomes multinucleate.

(**d) polyteny. Polytcny** is the condition in which the number of chromonemata in each chromosome increases. It has also been reported in certain cells.

Functions or tapetum. The different functions of the tapetum may be summarised as follows:

1. primary use of tapetum is to provide nourishment to the developing rollen grains.
2. During the post-meiotic stage, the tapetum plays an important role in the formation of pollen wall.

3. The amoeboid type of tapetum is responsible for producing callase enzyme which causes degradation of callose wall of the microspore tetrads. Callase is essential for normal differentiation of spore tetrad.

4. The tapetum is responsible for transferring two important substances, (i) pollen kit and (ii) tryphine. Pollen kit is a mixture of carotenoids and hydro- phobic liquids, whereas tryphine consists of hydrophilic substances and proteins.

5. The pollen wall contains specific proteins, partly contributed by the tapetum. When the pollen grains are moistened, these proteins are release and are the cause of hay fever and pollen allergy.

6. The proteins present in the pollen wall have great biological significance, i.e. in the recognition of compatible pistils. If the pollen falls on an incompatible Stigma. these proteins produce callose plugs to inhibit the formation of pollen

Sporogenous tissue

The primary sporogenous layer forms the sporogenous tissue and gives to the microspore mother cells or pollen mother cells (PMC). The sporogenous tissue may function directly-as the microspore mother cells or undergo a series of mitotic divisions before sporogenesis. In either case, the cells of the last mitotic division function as microspore mother cells. The PMC are polygonal in shape and closely packed, but as the anther increases in size, these become loosely
arranged and rounded in shape. All spore mother cells have the potential of forming pollen grains, however, some of them disintegrate and act as nourishing tissue for the developing pollen grains.

Microsporogenesis. Each PMC (2n) undergoes meiotic division to form a group Of four microspores. The four microspores so formed are collectively called pollen tetrad. During the meiosis in PMC, two patterns of cell wall formation are found.

(i) Successive type. In successive type of cytokinesis. each nuclear division is successively followed by cell wall formation. The first nuclear division of meiosis is accompanied by cell wall formation, which is of centrifugal type, i.e. a cell plate is formed in the centre and then extends laterally, resulting in the formation of two haploid cells, i.e. a dyad. The two cells of the dyad undergo the second meiotic division (meiosis II), which is followed by wall formation and results in a tetrad of haploid cells, arranged in an isobilateral manner. This type of cytokinesis is commonly found in monocots.

(ii) Simultaneous type. In this kind of cytokinesis, meiosis I is not followed by cell wall formation. The diploid nucleus of PMC completes both parts of meiotic division (meiosis I and II) resulting in four haploid nuclei lying in a common mass of cytoplasm of PMC. Cell wall formation now occurs simultaneously in between the four nuclei, resulting in the formation of four haploid cells (microspores). The wall formation is of centripetal type, i.e. wall formation starts from the lateral walls and meet in the centre of the cell. This kind of cytokinesis may lead to the arrangement of microspore tetrads in various ways, and it is common among dicots.

Microspore tetrads. The four spores of a tetrad are completely separated from each other, as well as from other spore tetrads of the same sporangium. However, cytoplasmic connections may exist even in the tetrad stage. The arrangement of spores in the tetrads may show variation, such as tetrahedral, isobilateral, decussate, linear and T-shaped. In *Aristolochia elegans*, all five types of arrangement have been observed.

Abnormal types of microspore arrangement

After meiotic division, the microspores usually separate from one another to form independent pollen grains. However, in *Drosera* and *Drimys*, the four microspores of a tetrad remain together and form ***compound pollen grains***. In many members of Asclepiadaceae and Orchidaceae, all the pollen grains of a pollen sac (microsporangium) remain united in a single mass, known as *pollinium*. A *pollinium* consists of a sac-like structure containing a mass of pollen grains. The anterior end of pollinium is attached to an elongated arm-like structure, the *translator or caudicle*, which in turn is attached to a spherical, knob-like *corpusculum*. Pollinia may be studied in genera like *Calotropis, Asclepias, Coelogyne, Pergularia* etc. An interesting case has been observed in *Hyphaene*, where more than four spores occur in a tetrad, leading to a condition called *polyspory*. In *Hydrilla, Cryptostegia, Typha* and *Juncus,* the microspores remain in groups of four while in members of Mimosoidae, these are found in groups of 8 to 64. In some orchids like *Neottia*, the groups remain enclosed in a frothy structure called *massullae*.

Dehiscence of microsporangium (anther)

The fully developed microsporangium consists of a mass of haploid pollen tetrads enclosed within the sporangial wall. On maturation of the anther, the sporangial wall consists of the epidermis and the endothecium, whereas the middle layers and the tapetum disintegrate. The partition wall between the two anther lobes of one side disintegrates and the two pollen sacs appear as one.

The mass of pollen grains exert pressure on the anther wall which bursts open liberating the pollen grains. Dehiscence of anther may take place by the following methods:

(i) Transverse slit. The anther lobe dehisces by transverse slits, along the breadth, e.g. *Ocimum sanctum*.

(ii) Longitudinal slit. In this method, the anther lobes split by longitudinal slits, e.g. *Hibiscus*, *Gossypium*, *Helianthus* etc.

(iii) By pores. In this type of dehiscence, the pollen grains are liberated through apical pores present on the anther lobes, e.g. *Solanum*.

(iv) By valves. Dehiscence of anther lobes is affected by valves, which open towards the outer side, e.g. *Berberis*.

The haploid pollen grains mark the end of the sporophytic phase and the beginning of the gametophytic phase. Microspore is the first gametophytic cell.

Structure of Pollen grains / Microspores

1. Exine: It is outer thick layer made up of sporopollenin. It contains one or many germ pores. Exine show variation in structure that helps in pollen dispersal
2. Intine: It is inner layer made up of pecto-cellulose, associated with formation of pollen tube.
3. Vegetative cell: It provides the food as well as helps in movement of male gamete
4. Generative cell: It divides mitotically to produce male gamete
5.

Types of pollens based on aperture

1. Types of Apertures:

i. **Porate:** aperture in the form of pore

ii. **Colpat**e: aperture in the form of grove or slit

iii. **Colporate**: aperture with both pore and slit

2. **Position of aperture**: More than one aperture can be arranged either at poles or at equator (Zono-, e.g. Zonocolpate) or on entire surface (Panto-, e.g. Pantoporate)
3. Number of apertures are denoted by using prefix: mono-, di-, tetra-, poly-. E.g. triporate: aperture in the form of three pores