REPRODUCTION

Vegetative reprodcution is unknown in the pines. They reproduce by means of seeds. Reproduction by seeds involves both reproduction by spores and reproduction by gametes. It also comprises the origin, development and growth to maturity of the gametophytic generation.

Reproduction by Spores

All seed plants are **heterosporous** which means that the reproductive organs called the spores are of two kinds—**microspores** (pollen grains) and **megaspores** (Embryo sacs). They are produced in specialized structures called microsporangia (pollen sacs) and megasporangia (ovules minus their coats) respectively. The sporangia are borne on sporophylls which are organised to form **cones** or **strobili**. The latter are of two kinds, one containing only microsporangia and the other megasporangia. It is customary to call the former as **male cones** or **microsporangiate strobili** and the latter **female cones** or **megasporangiate strobili**, even though they are sporophytic in origin and are not in any way sexual in character. It is more appropriate to call the one as microsporangiate or staminate and the other as megasporangiate or carpellate cones or ovulate cones. *Pinus* is monoecious as it bears both types of cones on the same tree on separate branches.

Plate XIV. A cluster of mature and dehisced male cones of *Pinus roxburghii*.

The Microsporangiate or Staminate or Male Cones (Fig. 13.13, 13.19)

They occur laterally in clusters, each in the axil of a scale leaf at the base of a terminal vegetative bud which they surround. They are concealed amidst last year's foliage. As the vegetative bud grows and expands it develops short or dwarf shoot in the axils of the upper scales. It means that the male cones replace the dwarf shoots at the base of the developing bud or shoot of the current year. They can be seen on the pine tree in the beginning or

Plate XV. Portion of tree of *Pinus roxburghii* bearing male cones.

middle of March in the hills and in January or February in the plains. In *P. wallichiana* they are initiated towards the end of October or beginning of November. The shedding of the pollen grains starts towards the end of April and continues till the beginning of June, depending upon the altitude. The lower the altitude the earlier the cones shed their pollen. The male cones occur in clusters of 15—35 in *P. wallichiana* and up to 50 in *P. roxburghii*.

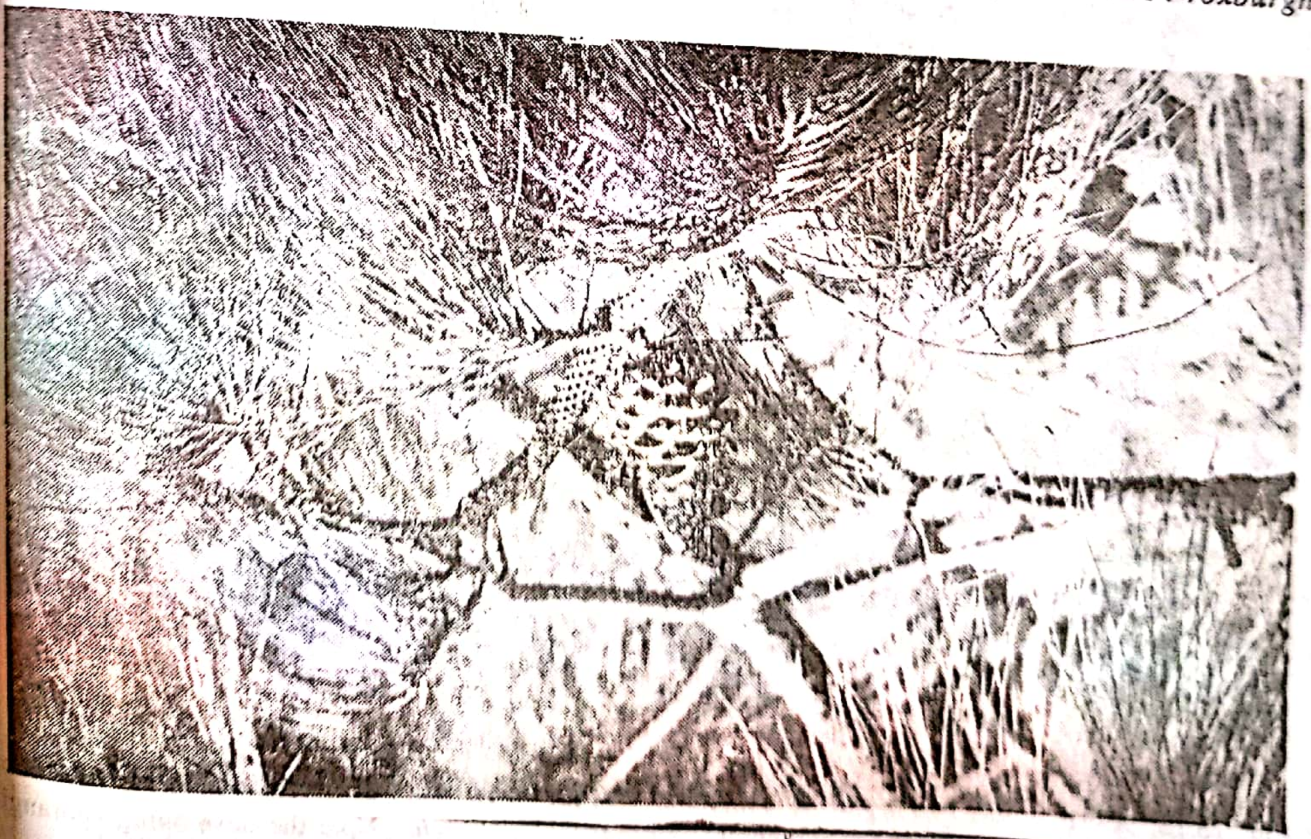

Plate XVI. Twig of Pinus roxburghii bearing a female cone.

Scanned with CamScanner

The male cone is shortly stalked and consists of an elongated central axis, bearing a number of small spirally arranged and closely fitting scale-like **microsporophylls**. The latter are equivalent to the stamens of Angiosperms. Each microsporophyll takes its origin from the

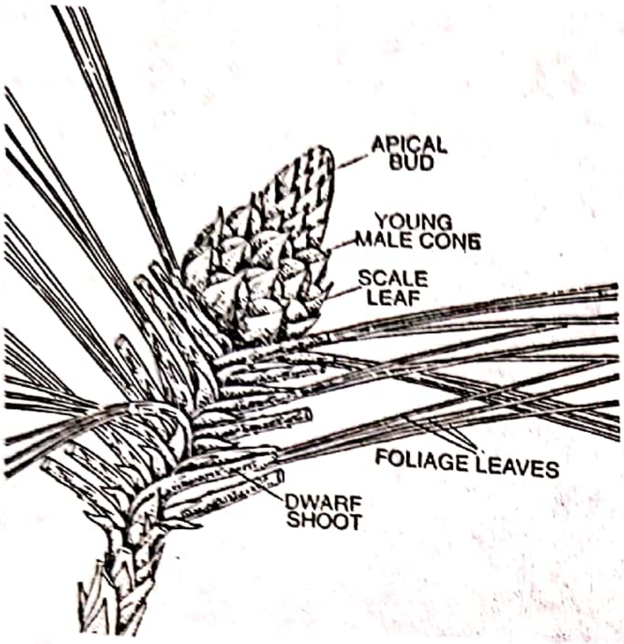

Fig. 13.13. A cluster of very young male cones of *Pinus roxburghii*.

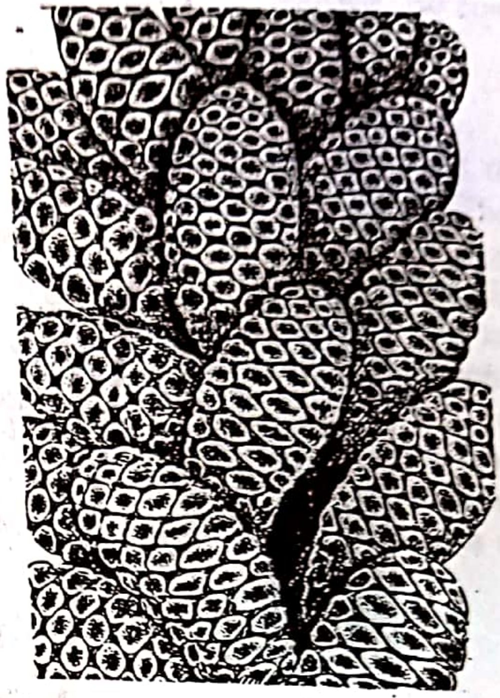

Fig. 13.14. A cluster of young male cones of *Pinus roxburghii*.

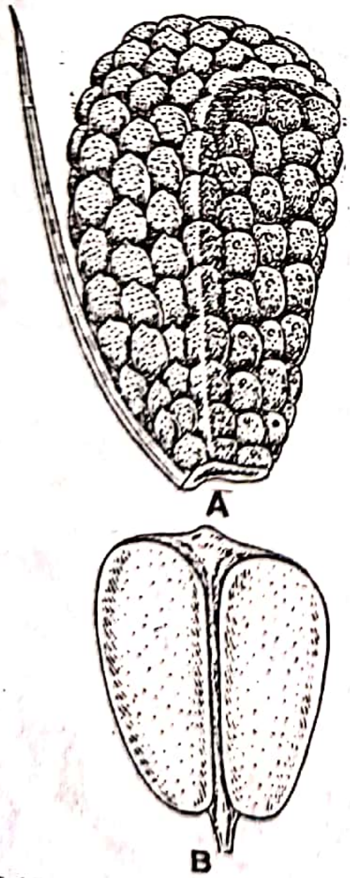

Fig. 13.15. A—B. *Pinus roxburghii*. A. Fully developed male cone. B. A microsporophyll bearing two undehisced microsporangia.

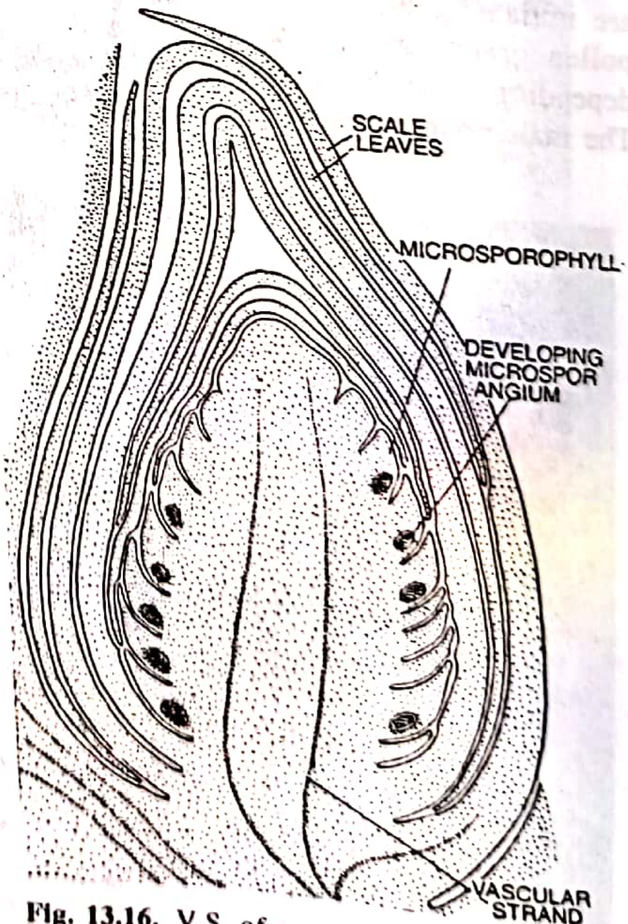

Fig. 13.16. V.S. of a very young male cone of *Pinus roxburghii*. Note the developing sporangia.

central axis, runs out horizontally to end in a sterile flattend head, the tip of which is turned up so as to fit over the micorosprophyll above it. It bears two **microsporangia** or **pollen sacs** as swellings on the lower surface of its horizontal position. The microsporophyll is attached to the axis by a short stalk. The sporangia are filled with numerous winged **microspores**. A number of scales at the base of the male cone remain small and sterile, usually 8—10. The young cones are green or reddish purple, but become yellow or dark brown at the time of shedding.

Development of Microsporangia (Figs. 13.20, 13.21)

The microsporangium arises as a group of cells on the lower surface of the microsporophyll. The hypodermal cells divide and form the outer **parietal cells** and inner **archesporial cells**. The former divide anticlinally and periclinally to form a 4 layered wall of the sporangium. The cychesporial cells divide to form sporogenous cells which ultimately differentiate into **microspore mother cells** that are polygonal in outline and contain prominent nuclei and vacuolated cytoplasm. The innermost wall layer differentiates into tapetum whose cells have prominent nuclei and dense cytoplasmic contents. At the tetrad stage the tapetal cells become binucleate. Soon they break down and form a continuous layer of cytoplasm around the spore tetrads. It is consumed by the time the microspores have divided to form the prothallial cells. The outer wall layer is called the epidermis. In a mature microsporangium its cells become radially elongated and its tangential walls develop bands of thickening (Fig. 13.20, G, H). The cells of the second layer remain thin-walled. The cells of the third layer become tangentially elongated and the first to degenerate. The second layer degenerates when the microspores are mature. The microspore mother cells undergo meiosis

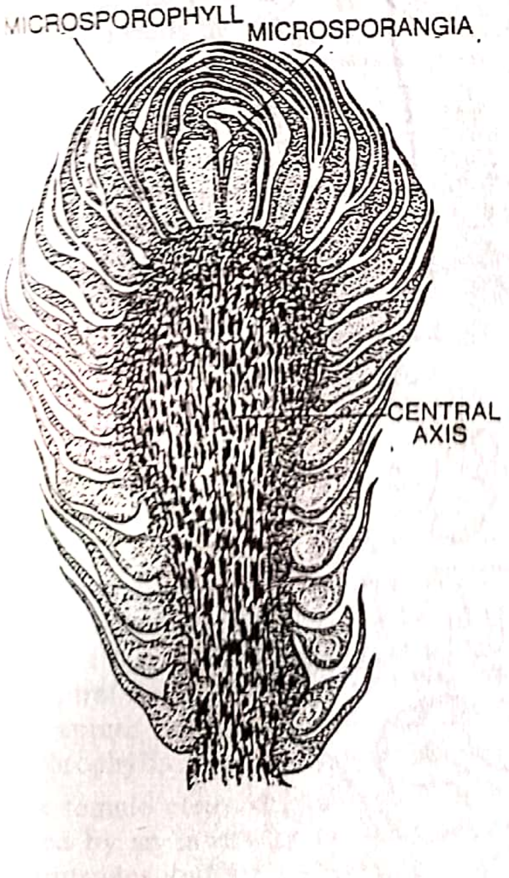

Fig. 13.17. L.S. young male cone with fully developed microsporangia.

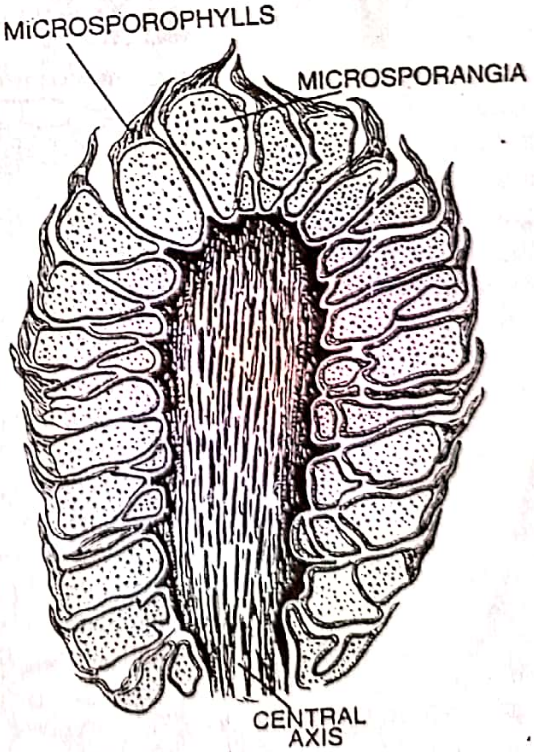

Fig. 13.18. L.S. mature male cone of *P. roxburghii.*

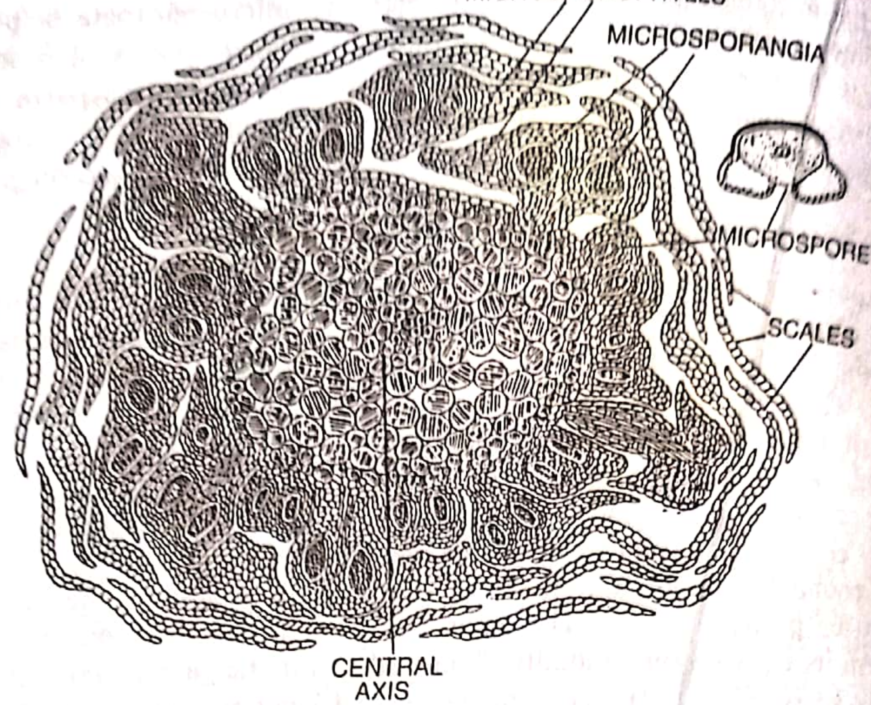

Fig. 13.19. T.S. mature male cone of *P. roxburghii*. Also note the pollen grain or microspore.

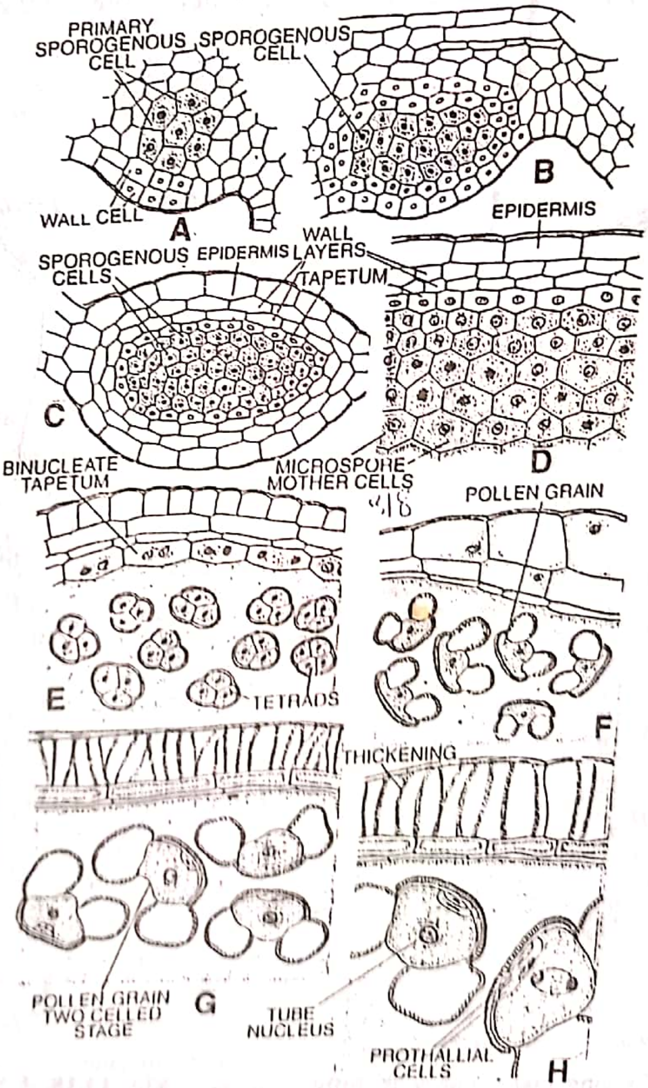

Fig. 13.20. **(A—H)** *Pinus wallichiana*. Stages in the development of microsporangium (After Konar)

to form tetraheural tetrads of microspores. Sometimes isobilateral tetrads are also formed. Later the spores separate from the tetrads. They are haploid and two winged. The mature microsporangium is an elongated sac-like structure surrounded by its outermost wall or the epidermis and enclosing a large number of microspores or the pollen grains. In *P. roxburghii*, according to Konar (1960) the microsporangium dehisces by a longitudinal slit.

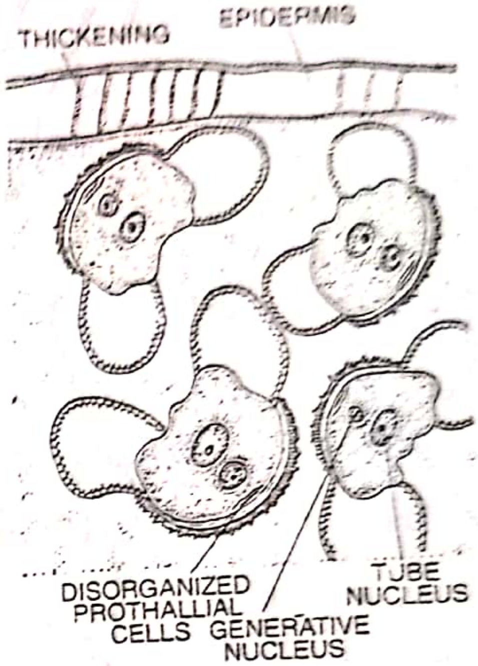

Fig. 13.21. *Pinus wallichiana*. Part of mature microsporangium.

Microspore (Fig. 13.20 G, H and Fig. 13.21)

It is unicellular. The spore wall becomes much thickened and differentiated into a three-layered coat. The outer exine, the middle **exointine** and the innermost **intine**. The exine is cuticularized. It covers the spore only on one side. The rest of the spore is covered by the exo-intine. The latter separates from the intine on the side where spores have been in contact with other spores in the tetrad and becomes inflated into two baloon-like expansions or wings. These are not cells but air sacs or bladders. They render the grains extremely light for their size and thus facilitate dispersal by wind. Before liberation the microspores begin to germinate and form extremely reduced male gametophyte. Their germination is thus **precocious**. The pollen grains are **heteropolar** and radiosymmetric and consist of a body or '**corpus**' and the air sacs or '**sacci**'. It has a single aperture or **tenuitas** at its distal end. The wings or sacci are separated from the body or the corpus by the saccate **nexine** or the inner layer of exine. The nucleus lies towards the distal end.

The Megasporangiate or Ovulate Cones (Figs. 13.22—13.28)

They are fewer in number and arise single or in a small cluster or two to four, each as a bud in the axial of a scale leaf towards the end of the new shoots of unlimited growth which do not bear the male cones. They occur below the terminal bud each terminating a short lateral, axillary branch thus replacing in position a newly formed long short. The female cones in position, therefore, correspond with the buds which grow out the following year into long shoots. When young it is a small, erect, reddish to pinkish structure, which stands erect on a short stalk covered with scales (Figs. 13.22—13.26). Like the male cone it consists of a central axis (Figs. 13.27, 13.28) which bears paired scales in a close spiral. The lower scale of the pair is small. It is spoken of as the **bract scale**. It is leathery and directly attached to the cone axis. The upper scale of the pair is larger, thicker and stouter. It is the **ovuliferous scale**. It develops from the upper surface of the bract scale and bears two ovules side by side on its upper side as two small white swellings. The bract scale is larger than the ovuliferous scale before pollination but later it grows bigger than the bract scale. The ovuliferous scale is woody and wedgeshaped with its broader sterile end, the **apophysis** directed outwards. The bract scales are thus concealed from view. The surface of the cone is marked by rhomboidal areas each with a small central conical point—the **umbo**. The rhomboidal areas are the outlines of the broad sterile apices or apophysis of the ovuliferous scales. There are about 80—90 megasporophylls in a single female cone.

The female cones originate in March in the plains and in February in the hills and are protected by an involucre of bract scales. The cone axis elongates in April and the cone thus protrudes out of its involucre of scales. Young cones are pale green but near pollination time the colour changes to reddish purple and finally it becomes brownish. The cones close and become compact after pollination. The seeds are shed when the cone is 22 months old.

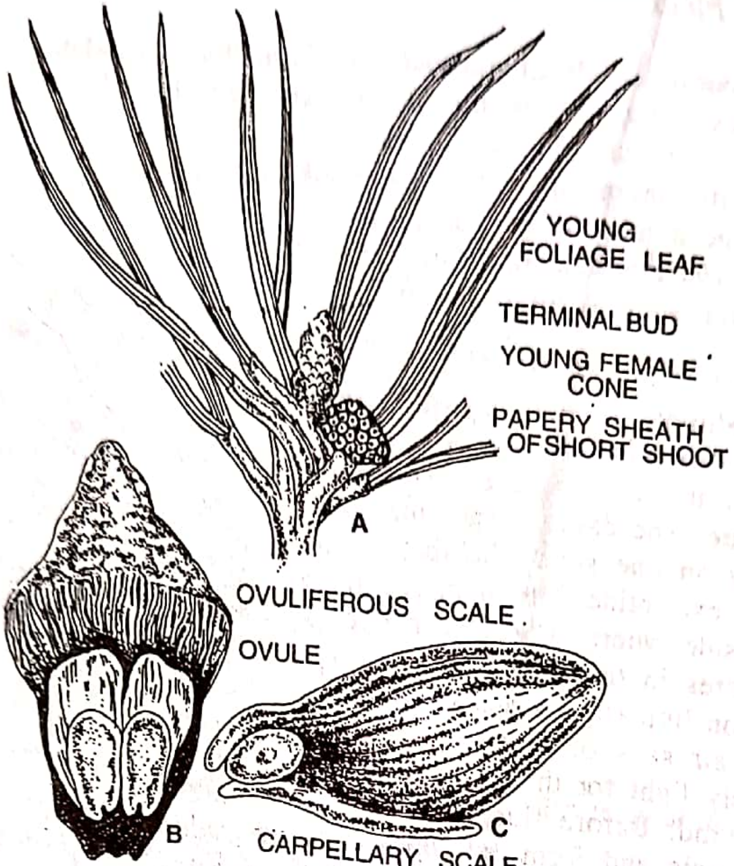

Fig. 13.22. *Pinus sylvestris.* A. Showing long shoot bearing dwarf shoots with two needles. Also note the apical bud and a young female cone. B. Megasporophyll bearing two seeds. C. A section through megasporophyll showing ovule.

Morphology of the Bract and Ovuliferous Scales

The nature of the paired scales has long been a debated question. Sachs and Eichler looked upon the cone as a simple flower with the central axis comparable to receptacle or thalamus of the angiospermic flower bearing open carpels—the bract scales. According to their view the ovuliferous scale corresponds to the **ligula** or **placenta**. Kubart and Bessey considered it to be equivalent to an axil or enlargement of the chalaza of the two ovules.

Fig. 13.23. A three-month old female cone of *Pinus roxburghii.*

Fig. 13.24. A six month old female cone of *Pinus roxburghii* enlarged X2.

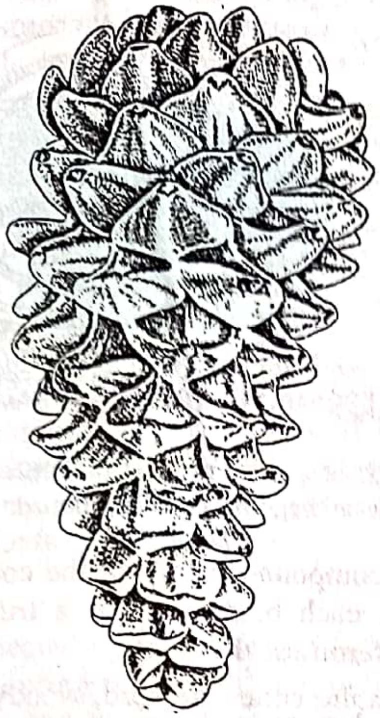

Fig. 13.25. A three year old female cone of *Pinus wallichiana*.

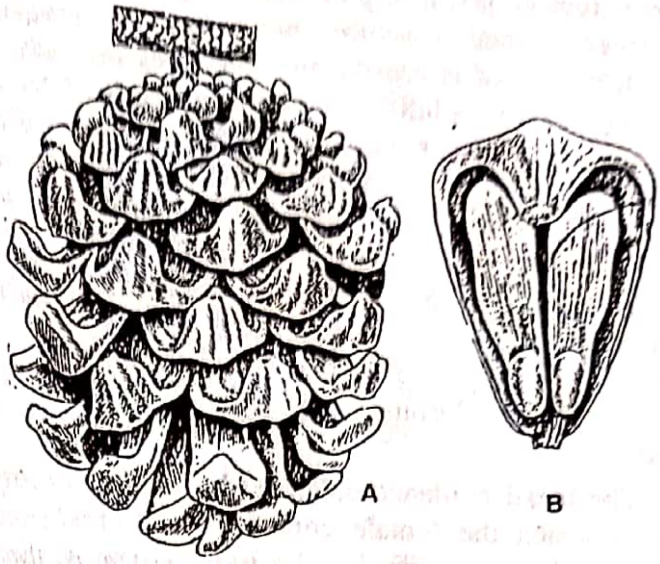

Fig. 13.26. A—B. ***Pinus roxburghii.*** **A.** Four year old female cone of ***Pinus roxburghii.*** **B.** An ovuliferous scale.

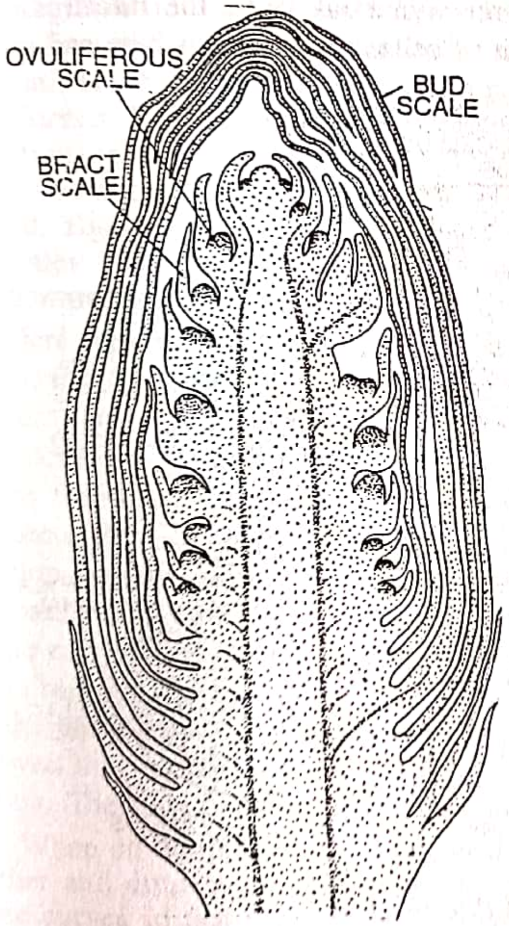

Fig. 13.27. L.S. of a young female cone of *Pinus wallichiana*. Note the well developed bract scales and developing ovuliferous scales.

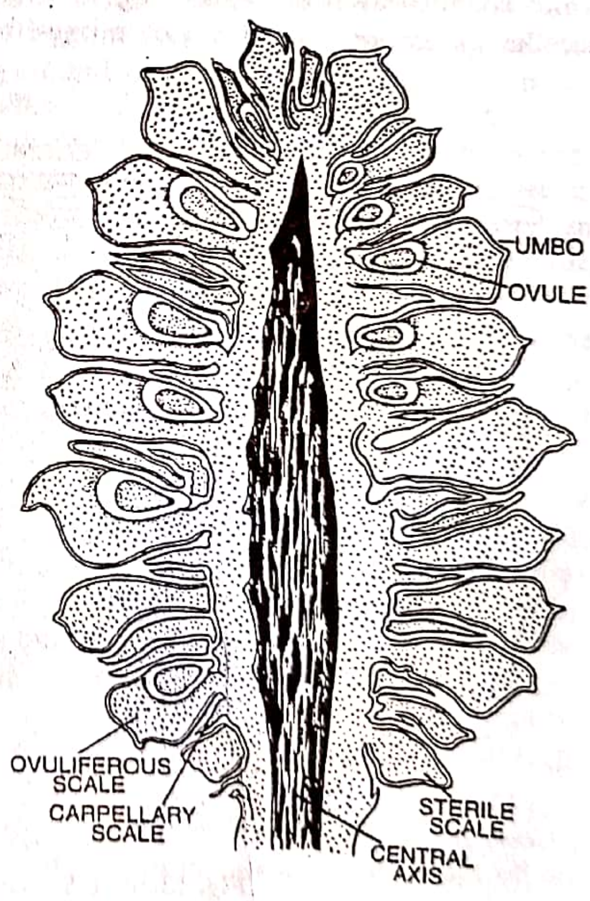

Fig. 13.28. V.S. mature female cone of *Pinus roxburghii*.

Delpino looked upon it as the two lateral lobes of the bract scale which have been turned inwards and fused together. Hirmer opined that the bract and the ovuliferous scales are the two branches of a sporophyll which has forked vertically. It is held by many botanists that since the ovuliferous scale is axillary to the bract scale in position, it is, therefore, a branch. According to their view the bract scale corresponds to the scale leaf and the ovuliferous scale to the dwarf shoot. This view is not supported by the vascular supply to the ovuliferous scale. It is of leaf type.

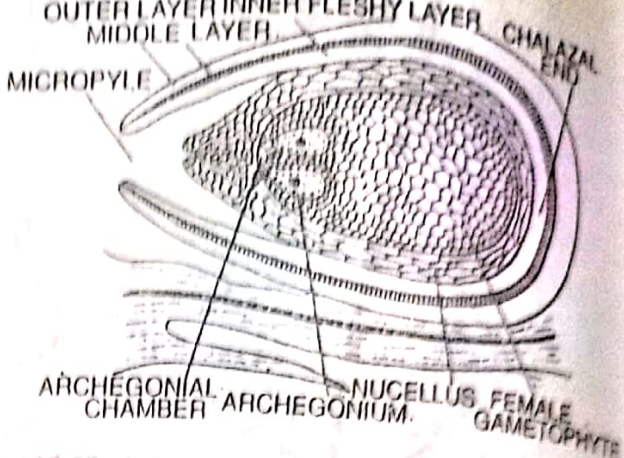

Fig. 13.29. L.S. of a mature ovule of *Pinus roxburghii*. The archegonia have developed.

The fossil evidence collected by Florin favours the compound theory of the cone according to which the female cone is an inflorescence with each bract scale as a true bract in whose axil is a modified and a reduced shoot, the ovuliferous scale.

The ovulate cones take three years to mature. The mature cones are hard, woody and very large in size.

Development of the Ovule (Figs. 13.29—13.30)

On the upper surface near the base of the ovuliferous scale the ovule arises as a small white rounded swelling consisting of a group of parenchymatous cells, the **nucellus**. The nucellus increases in size and soon a ring-like outgrowth of cells arises from its base and grows

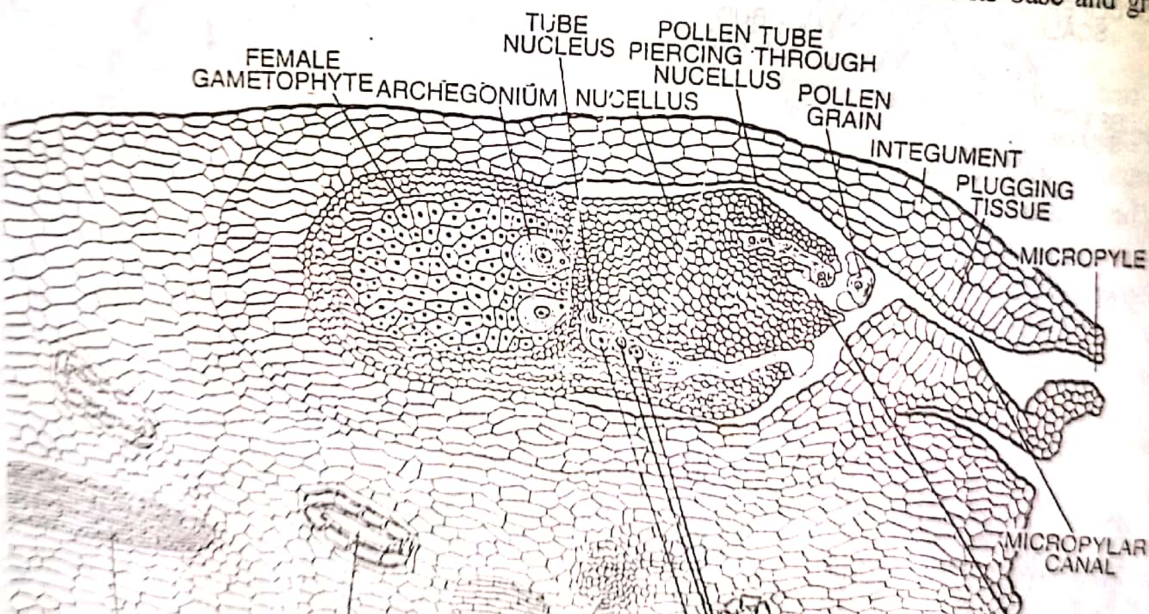

Fig. 13.30. L.S. mature ovule of *P. roxburghii*.

up around it forming a covering layer called the **integument**. The latter encloses the nucellus completely leaving only a narrow passage, the **micropyle** at the top. The micropyle faces the base of the scale and is directed obliquely downwards towards the axis of the cone.

The micropyle leads to the top of the nucellus. The integument is free from it near its micropylar end. About the time, pollination takes place, a hypodermal cell with denser contents appears near the apex of the nucellus in *P. roxburghii* (Konar, 1960). It enlarges to form a single large archesporial cell which divides to form an outer **primary parietal cell** and the inner **sporogenous cell** which functions as the **megaspore mother cell** (Fig. 13.32). The parietal cell divides repeatedly to form the *spongy tissue*. The megaspore mother cell divides by *meiosis* into a tetrad of four small haploid megaspores, (Fig. 13.33) arranged in a row. Of these three degenerate and only one, the innermost normally enlarges into a functional **megaspore**, (Fig. 13.34) which develops into a female gametophyte. In *P. wallichiana* the archespordal cell is deep seated (Konar and Ramchandani, 1958) and acts as megaspore mother cell, which undergoes reduction division to form a linear row of three haploid megaspores. In this case the upper diad does not undergo meiosis II. Pollination takes place at this stage. The structure of the ovule shows that it is more than a megasporangium. The nucellus of the ovule which forms the megaspores is comparable to the megasporangium of the vascular cryptogams. The outer sheath or integument of the ovule is an extra structure which is unrepresented in the megasporangium of lower vascular plants (Pteridophyta).

Pollination

It is effected by the wind and is, therefore, **anemophilous**. It takes place towards the end of May or during the month of June in the hills. In plains or at lower altitudes it takes place towards the end of February or mid March. At this period the ovulate cone is young. It is about the time of meiosis which means that the megaspores have been established (Fig. 13.33). The development of the embryo sac is subsequent to this event. The ovuliferous scales which prior to pollination fit tightly over one another, open out providing ready access for pollen grains to the ovules. The microsporangium or pollen sac opens by a medium longitudinal slit along its under side. On slight shaking the tree, which is producing pollen, will emit clouds of yellow dust which rise into the air and colour the whole landscape in the pine forests. The yellow dust is formed by countless numbers of pollen grains rather the immature tiny male gametophytes. They are light in weight and buoyant due to the wings. Upon liberation they float upon the air and settle down only slowly. Much of the pollen is wasted. Those that chance to be blown by the wind to the female cones are trapped between the scales. From there they roll down to obliquely tilted scales and finally come to rest close to the micropyle of the ovule.

Here they are caught in a drop of sticky substance, the **pollination drop** exuded from the micropylar end secreted by the nucellus and fills the micropyle up to the rim. As the pollination drop dries some of the pollen grains are drawn into the micropyle and on to the apex of the nucellus. This completes pollination. In *Pinus* and other conifers, pollination, therefore, means the transfer of pollen from the staminate cone (microsporangia) to the ovules in the ovulate cones. Here the pollen is left deposited in such a position that the part which will develop into the pollen tube is in contact with the nucellus. The pollination drop contains sucrose, glucose and fructose (McWilliams, 1958). It is secreted at night and usually dries up in the early hours of morning. In *Pinus* the winged pollen grains are so placed in the pollination drop that their germinal furrows become closely adpresed to the nucellus. The retraction of the pollination drop resembles the guttation phenomenon. Squillace and Bingham (1958) showed that in *Pinus monticola*. Dougl. *ex* Lamb., cross pollination is preferred to self pollination. The time between pollination and fertilization is about a year in *Pinus*.

When all the pollen grains are shed and microsporangia are empty the male cones rapidly wither and drop. After pollination the ovuliferous scales close up again and the stalk of the cone curves so that it becomes inverted.

The microsporangiate cones occur on the lower branches and the megasporangiate generally on the upper branches. Thus, position of the cones on the pine tree ensures cross pollination because the pollen does not blow vertically upward.

Reproduction by Gametes

(a) Male Gametophyte (Fig. 13.31)

The microspore or the pollen grain is the pioneer structure of the male gametophyte. It begins to germinate even before liberation and develops into a very much reduced male gametophyte. The microspore nucleus divides by a periclinal wall and forms a very small **prothallus cell** on the side of the grain farthest from the wings, (also called **capula**) and a large **central cell** (Fig. 13.31, B). The central cell again cuts off a **second prothallial cell** on the top of the first (Fig. 13.31, C). The two, prothallial cells represent the last vestige of the vegetative tissue of the gametophyte. They exactly correspond to the gametophyte of a fern but differ in being smaller and parasitic upon the parent generation. The prothallial cells soon degenerate (Fig. 13.31, D) and disappear. The nucleus of the large central cell called the **antheridial cell** divides again and a large rounded cell is formed towards the capula or the degenerating prothallial cells. It is the **generative cell** (Fig. 13.31, D). The other is called the **tube cell** and is towards the **tenuiftas** or the **germ furrow**. In order to see these details mount the mature pollen grains in iron aceto-cermin to which a drop of strong hydrochloric acid (HCl) has been added. The grains should lie with the wings facing downwards. At this stage when the male gametophyte consists of four cells two small vegetative prothallial cells, a generative cell and a tube cell, the pollen grain is shed.

Further development takes place, when it is lodged in the ovule and has made contact with the tip of the nucellus. The exo-intine ruptures between the wings, the tube cell protrudes and grows out to form a delicate **pollen tube** (Fig. 13.31, D, E, F). The tube nucleus moves down to its advancing tip whereas the generative cell remains in the grain end. The pollen tube grows down into the nucellar tissue upon which it is now dependent for its nourishment and protection. The pollen tube rests for about a year in this condition. The ovuliferous scales, during this period, have thickened and closed the cone completely. The ovule is not yet ready for fertilization. Hence further growth of the male or microgametophyte is arrested. It rests throughout the late summer and following winter resuming activity in the following April. (second year). The pollen tube becomes active again. It penetrates the nucellar tissue. It is an agent of fertilization as is in the angiosperms and does not serve as a nutritive haustorium as is the case in the cycads. The **generative cell** divides to give rise to a barren **stalk cell** (or **sterile cell**) and a fertile **body cell** (or **spermatogenous cell**). The former develops no further (Fig. 13.31, E). The body cell along with protoplasmic contents of the tube cell and stalk cell, passes down the pollen tube. On its way the body cell divides into two unequal cells with scanty protoplasm and large nuclei. These are the **male cells** or the **gametes**. The gametes are formed only a week before fertilization. Konar (1960) observed that in *P. roxburghii* the male gametes are equal in size in the beginning but become unequal due to enlargement of one of them.

Many important changes take place in the female cone during the protracted interval of about thirteen months between pollination and the actual act of fertilization. After pollination the stalk of the cone curves so that the cone becomes inverted. It increases considerably in size and turns green. The cone axis elongates and thickens. The **ovuliferous scales** thicken and become enlarged. Their broad sterile ends fit tightly over one another so as to form rhomboidal areas on the outer surface of the cone. The **bract scales** remain small and concealed. The development of the ovules within continues. The cones are about 4—5 cm long by the end of the first year. The growth is continued rapidly in the second year.

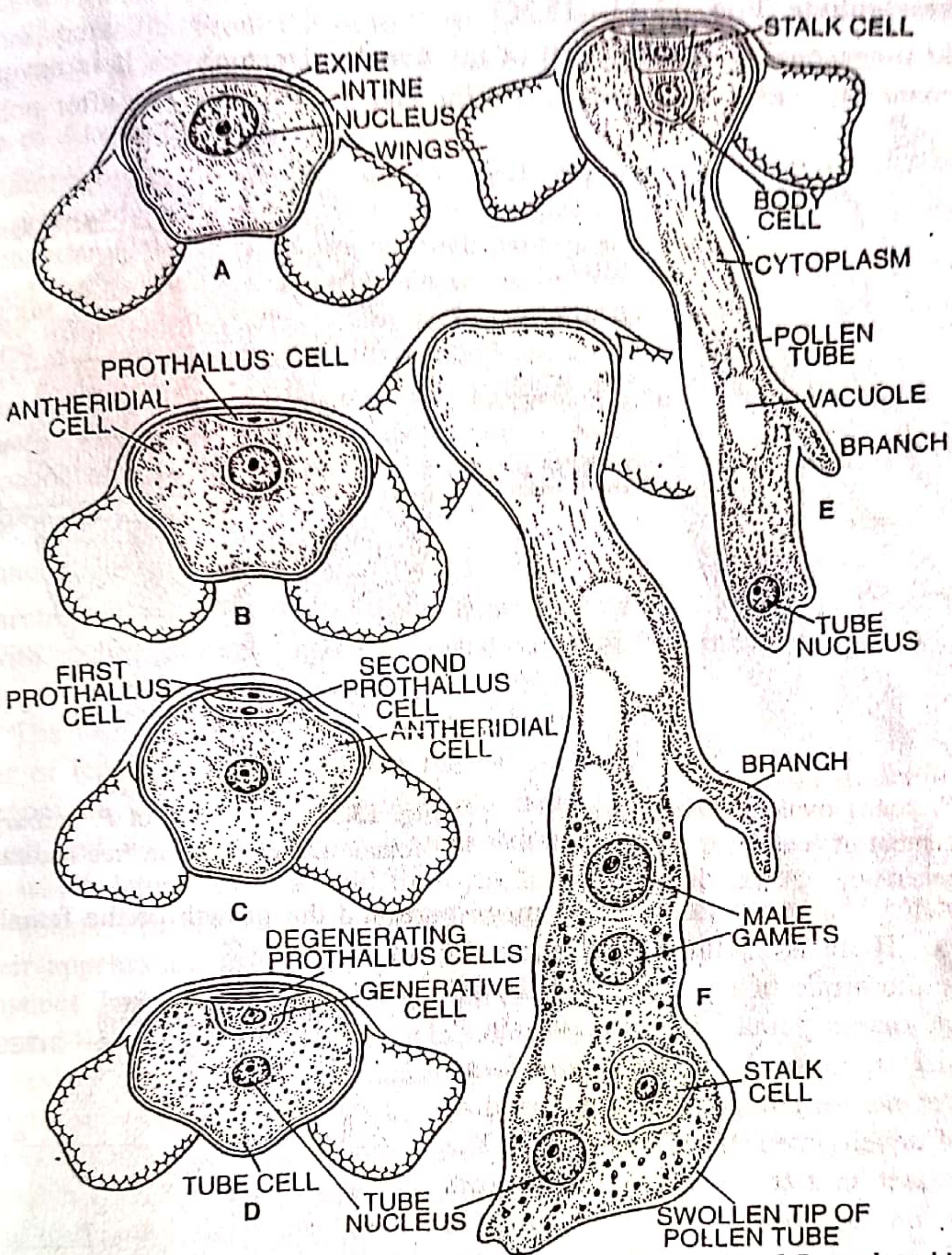

Fig. 13.31. Germination of the microspore or pollen grain of *P. roxburghii.*

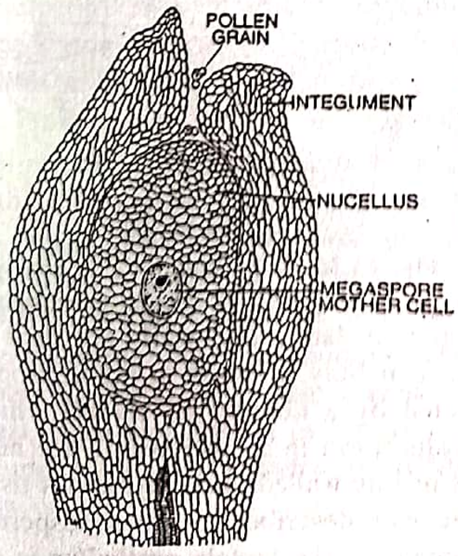

Fig. 13.32. V.S. young ovule of *P. roxburghii* showing a megaspore mother cell in the nucellus.

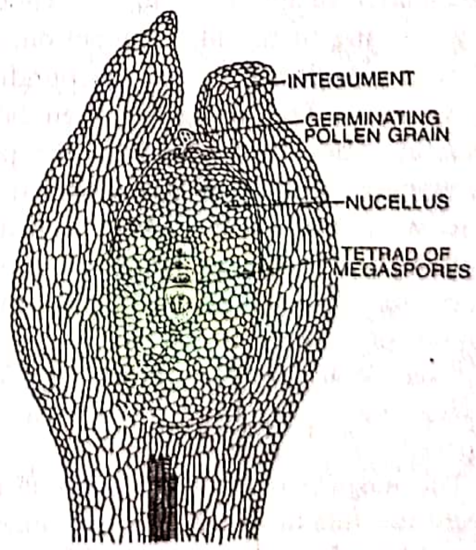

Fig. 13.33. V.S. young ovule of *P. roxburghii* showing a tetrad of megaspores (haploid) in the nucellus.

(b) Female Gametophyte (Figs. 13.32—13.36)

The haploid **megaspore** is the first cell of the female gametophyte. It is never shed and is retained permanently within the nucellus. By the end of first year *i.e.*, after pollination, it

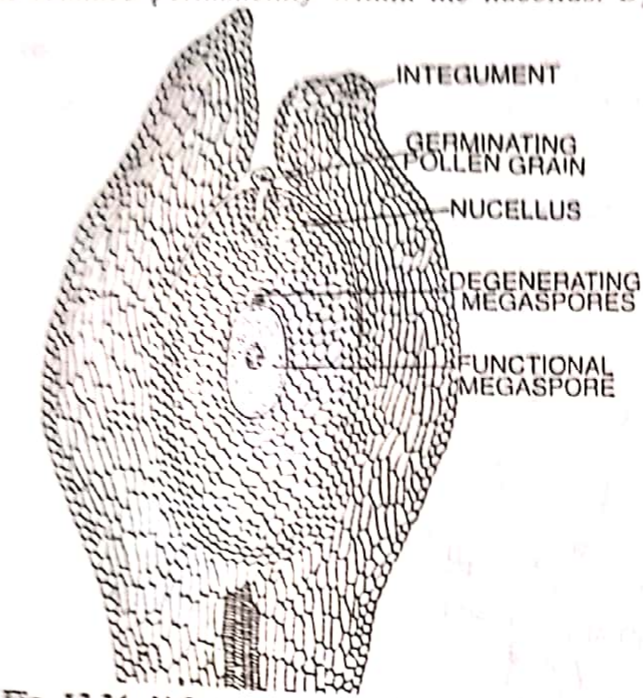

Fig. 13.34. V.S. young ovule of *P. roxburghii* showing enlargement of functional megaspore and degeneration of other three.

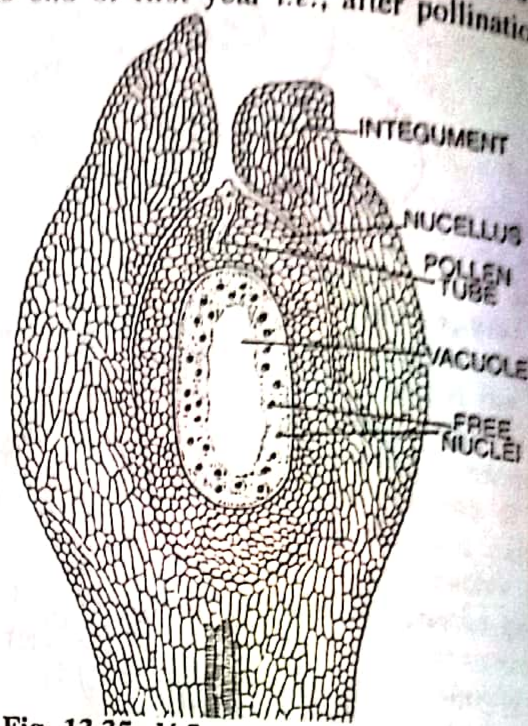

Fig. 13.35. V.S. ovule of *P. roxburghii* with female gametophyte in free nuclear stage.

starts to germinate. The germination of the megaspore and the growth of the female prothallus is very slow. There is an interval of about 13 months between the origin of megaspoe and the development of the mature female gametophyte. In *P. wallichiana* and *P. roxburghii* the megaspore forms a few free nuclei before entering upon a period of rest. The rest of development takes place later. The megaspore increases in size. Its nucleus undergoes a series of divisions approximately elèven times in succession. This results in the production of about two thousand five hundred nuclei. These daughter nuclei, according to the old conception, become arranged in a peripheral layer surrounding a large central vacuole. The walls are then laid between these nuclei. They first appear at the periphery of the megaspore. Later the gametophyte is entirely filled up with free nuclei. There is also a gradual accumulation of reserve food materials in the gametophyte. The embryo sac is surrounded by a few layers of spongy tissue that are absorbed completely later. The walls are then laid between them. Wall formation starts by the second week of May. Starting at the micropylar end and extending to the base. Wall formation is effected by a number of alveoli which grow centripetally. Nuclear divisions followed by cross walls result in an increase in the number of cells. The megaspore is now filled with a solid mass of thin-walled parenchymatous tissue. It is evidently the female prothallus but sometimes erroneously described as the endosperm. It has neither chlorophyll nor rhizoids. The megaspore containing the female prothallus is enclosed

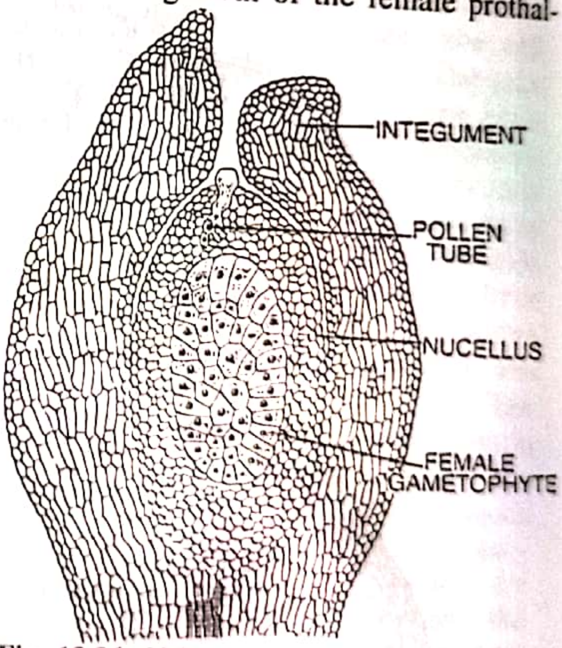

Fig. 13.36. V.S. ovule of *P. roxburghii* with young cellular female gametophyte.

in the nucellus (diploid tissue). Neither of them is detached from the parent plant. Its growth is, therefore, parasitic. From the superficial cells of the female prothallus are developed 2-4 archegonia in *P. roxburghii* (Konar, 1960) and one to two archegonia in *P. wallichiana*.

Structure of Archegonium (Fig. 13.37)

Each archegonium consists of a short neck and a swollen venter. The neck consists of four cells arranged in a single tier in *P. roxburghii* (Konar 1960) and *P. wallichiana* (Konar and Ramchandani 1956). There are no neck canal cells. The venter contains the **oospheré** or the egg and the **ventral canal cells.** Venter is embedded in the tissue of the prothallus but cells of the prothallus adjacent to the neck, grow faster than the neck cells so that the neck eventually lies in a depression, usually called the archegonial chamber.

The archegonia are fully formed by the end of June. It is indeed interesting that the formation of male and female gametophytes is so co-ordinated that the egg is ready for fertilization before the tip of the pollen tube containing the two male cells has pierced the archegonium.

Development of Archegonium

The archegonial initials appear in the first week of May. They are superficial cells larger in size, with prominent nuclei and vacuolated contents. The initial divides by a periclinal wall into an upper **primary neck cell** and a lower **central cell.** The former divides by two vertical walls into a tier of four cells that constitute the neck of the archegonium. The central cell undergoes rapid enlargement and its cytoplasm shows conspicuous vacuoles, which later disappear and the cytoplasm becomes dense. Proteid vacuoles or para nuclei make their appearance in the cytoplasm. By this time a distinct **Jacket layer** of cells surrounds the central cell. These cells have large nuclei and can be easily made out from the surrounding female gametophyte cells. The nucleus of the central cell divides into two daughter nuclei and a wall is laid down between them to form a small lenticular **ventral canal cell** and a large **egg cell.** The former soon degenerates. The egg nucleus migrates towards the centre and enlarges considerably. At maturity the cytoplasm of the egg becomes fibrillar with fibrils radiating from the nucleus to the periphery. Proteid vacuoles are also present.

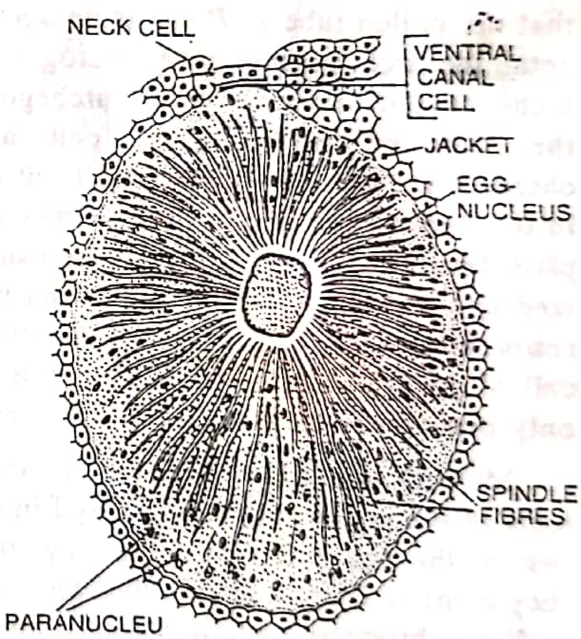

Fig. 13.37. A mature archegonium of *Pinus wallichiana* (After Konar).

The mature female gametophyte is a small ovoid thallus. During its growth the megaspore crushes and consumes most of the surrounding nucellar tissue reducing it eventually to a thin membrane and a cone of tissue at the end towards the micropyle. It is the **nucellar beak**. Its cells contain abundant starch.

The megaspore with its contained female prothallus corresponds to the embryo sac of the angiosperms. The latter is also a gametophyte. The female gametophyte of the *Pinus* differs from that of an angiosperm in certain respects. It is a more massive structure consisting of a large number of cells. Besides the reproductive structures, *i.e.*, the archegonia are far more complex.

The archegonia of *Pinus* are essentially like those of the ferns differing in, (*i*) both the venter and the neck are embedded in the tissue of the prothallus, (*ii*) the larger size of the venter and the enclosed oosphere and (*iii*) a smaller and simpler neck without neck canal cells. The fern prothallus is a large green independent structure which is anchored to the substratum by means of rhizoids. It bears both megagametes and microgametes. The *Pinus* female prothallus is small ovoid prothallus which is neither green nor has any rhizoids. It is parasitic upon the parent plant and bears only megagametes.

Fertilization

The pollen tube, whose growth is arrested in the winter of the first year after it has penetrated a short distance into the nucellus, resumes growth in the month of April when the female cone is running into its second year. The generative cell divides into a **stalk and body cell**. The body cell then divides into two male cells, or microgametes but no wall is formed separating the cytoplasm of one from the other. The male cells are non-motile. In this respect these differ from the motile gametes of the Cycads. They float within the pollen tube. Meanwhile the pollen tube has passed entirely through the nucellus and reached the female prothallus. As in the Cycads it has to pierce a relatively short distance from the tip of the nucellus to the female prothallus whereas in the angiosperms it must penetrate the tissue of the style and the cavity of the ovary to reach the ovule. From there it passes into the micropyle and penetrates the nucellus. Finally the tip of the pollen tube enters the neck of the archegonium after rupturing it and swells at its tip. It is evident that the pollen tube in *Pinus* is an agent of fertilization whereas in the Cycads it does not enter the archegonium. The microgametes in Cycads are discharged in the liquid in the archegonial chamber over the archegonia and enter their necks to effect fertilization. In the *Pinus* the two non-motile cells and the other contents of the pollen tube are discharged into the venter, where all but one male cell disintegrate. The pollen tube ruptures in the venter. The nucleus of the surviving male cell unites with that of the egg to accomplish fertilization which process is usually completed in the last week of June. The fertilized egg secretes a wall round it and becomes **oospore** or **zygote**. This act of fertilization restores the double chromosome number in the nucleus. The zygote, therefore, is the first cell of the sporophyte. More than one archegonium may be fertilized in a single ovule but only one comes to maturity, others perish.

McWilliams (1958) gave a vivid account of fertilization in *Pinus*. Shortly before the contents of the pollen tube are released into the venter, a receptive vacuole appears in the upper part of the egg cytoplasm. The functional male nucleus approaches the female nucleus and they come in contact or sink into each other. Their membranes at the point of contact dissolve and the chromatin material in each nucleus condenses to form a prophase-like configuration and later the chromatin transforms into distinct chromosomes.

During the winter of second year the cones change their colour from green to brown and the following spring, *i.e.*, during its third year the woody cones reach maturity. They become dry. Their ovuliferous scales separate from one another. The seeds are then shaken out.