PINUS

Division: Coniferophyta

Class: Coniferopsida

Order: Coniferales

Family: Pinaceae

Genus: *Pinus*

External Morphology of Pinus:

1. Pinus is a large, perennial, evergreen plant.

2. Branches grow spirally and thus the plant gives the appearance of a conical or pyramidal structure.

3. Sporophytic plant body is differentiated into roots, stem and acicular (needle-like) leaves (Fig. 26).

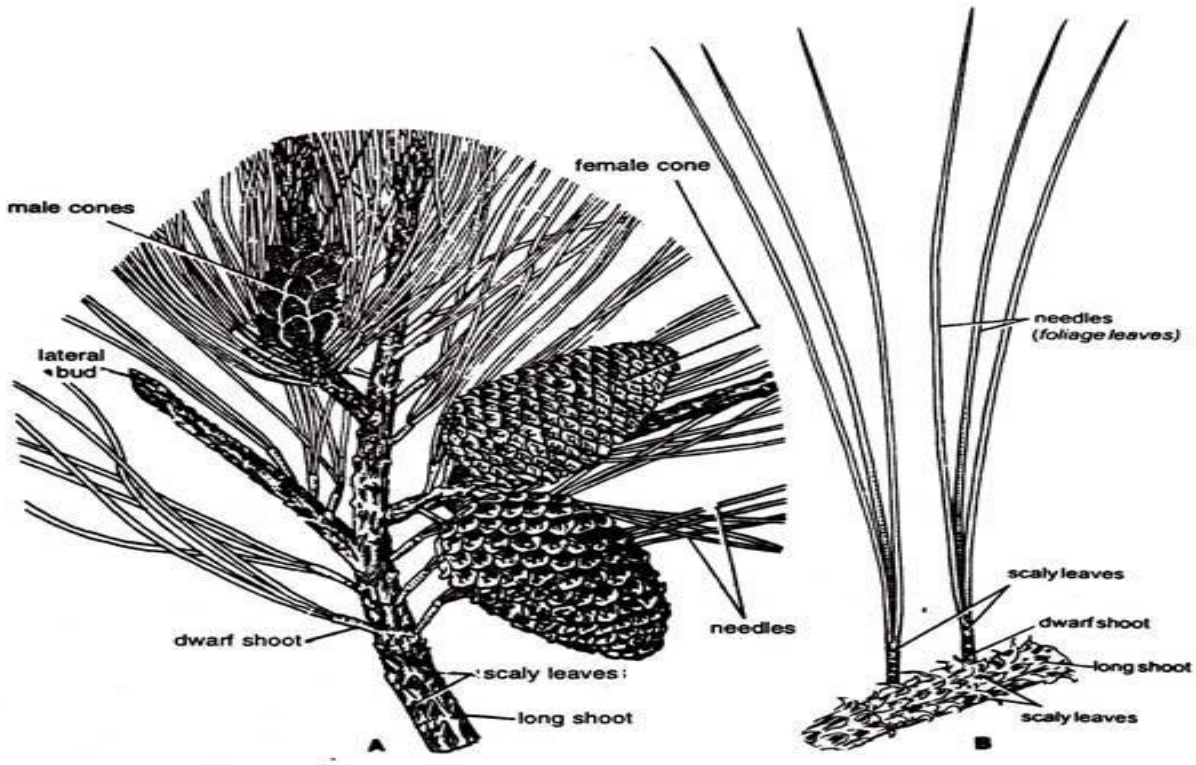

Fig. 26. Pinus gerardiana. A, Branch of a mature plant bearing male and female cones; B, A part of stem showing two types of shoots.

4. A tap root with few root hair is present but it disappears soon. Later on many lateral roots develop, which help in absorption and fixation.

5. The ultimate branches of these roots are covered by a covering of fungal hyphae called ectotrophic mycorrhiza.

6. The stem is cylindrical and erect, and remains covered with bark. Branching is monopodial.

7. Two types of branches are present: long shoots and dwarf shoots. These are also known as branches of unlimited and limited growth, respectively.

8. Long shoots contain apical bud and grow indefinitely. Many scaly leaves are present on the long shoot.

9. Dwarf shoots are devoid of any apical bud and thus are limited in their growth. They arise on the long shoot in the axil of scaly leaves.

10. A dwarf shoot (Fig. 27) has two scaly leaves called prophylls, followed by 5-13 cataphylls arranged in 2/5 phyllotaxy, and 1-5 needles.

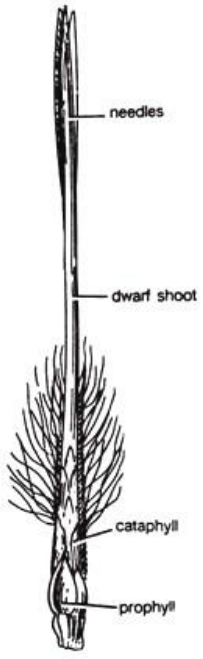

Fig. 27. Pinus roxburghii. A young dwarf shoot.

11. The leaves are of two types, i.e., foliage and scaly.

12. Scaly leaves are thin, brown-coloured and scale like and develop only on long as well as dwarf shoots.

13. Foliage leaves are present at the apex of the dwarf shoots only.

14. Foliage leaves are large, needle-like, and vary in number from 1 to 5 in different species.

15. A spur (Fig. 28) is called unifoliar if only one leaf is present at the apex of the dwarf shoot, bifoliar if two leaves are present, trifoliar if three leaves are present, and so on.

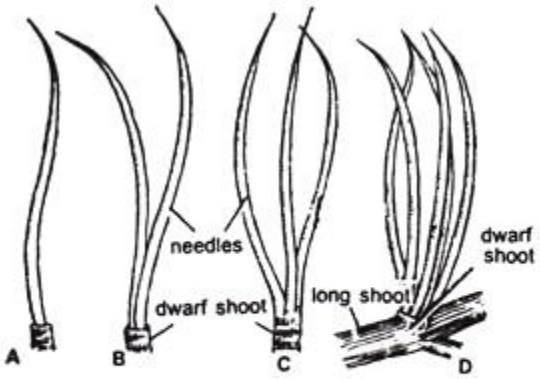

Fig. 28. Pinus. Spurs of different species. A, Monofoliar (Pinus monophylla); B, Bifoliar (P. sylvestris); C, Trifoliar (P. gerardiana); D, Pentafoliar (P. wallichiana).

Some of the species with different types of spurs are as follows:

(i) Pinus monophylla-unifoliar (having only one needle);

(ii) P. sylvestris-bifoliar (having two needles);

(iii) P. gerardiana-trifoliar (having three needles);

(iv) P. quadrifolia-quadrifoliar (having four needles);

(v) P. wallichiana-pentafoliar (having five needles).

Anatomy of Different Parts of Pinus:

T.S. Young Root:

1. Outermost layer of the circular roots is thick-walled epiblema with many root hair.

2. Epiblema is followed by many layers of parenchymatous cortex.

3. Inner to the cortex is present a layer of endodermis and many layers of pericycle.

4. Vascular bundles are radially arranged and diarch to tetrarch with exarch protoxylem.

5. Protoxylem is bifurcated (Y-shaped) towards the periphery, and in between each bifurcation is present a resin cannal (Fig. 29).

6. Phloem is present alternate to the protoxylem.

7. Pith is poorly-developed or absent.

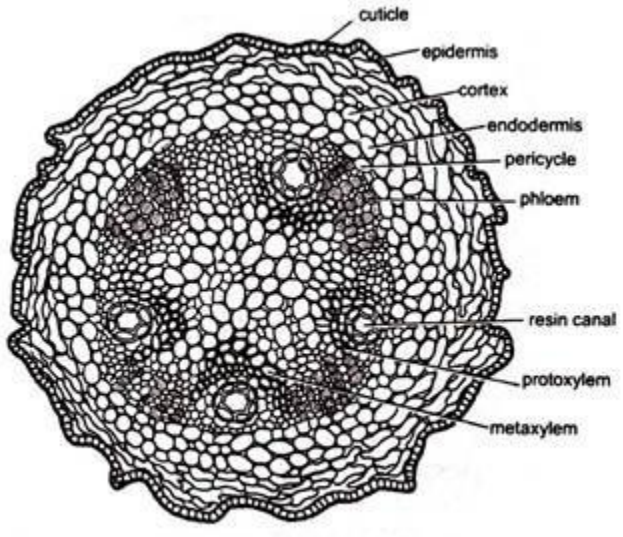

Fig. 29. Pinus. T.S. young root (diagrammatic).

T.S. Old Root Showing Secondary Growth:

1. On the outer side are present a few layers of cork, formed by the meristematic activity of the cork cambium.

2. Cork cambium cuts secondary cortex towards inner side.

3. Many resin canals and stone cells are present in the secondary cortex, the cells of which are separated with the intercellular spaces.

4. Below the phloem patches develop cambium, which cuts secondary phloem towards outer side and secondary xylem towards inner side.

5. Crushed primary phloem is present outside the secondary phloem (Fig. 30).

6. Many uniseriate medullary rays are present in the secondary xylem.

7. Primary xylem is the same as in young roots, i.e., each group is bifurcated (Y-shaped) and a resin canal is present in between the bifurcation.

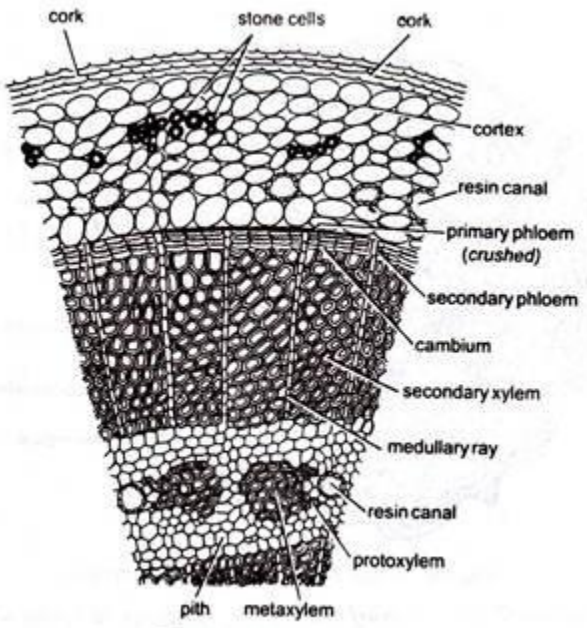

Fig. 30. Pinus. T.S. old root.

T.S. Long Shoot (Young):

1. Many leaf bases are present on the stem (Fig. 31), due to which it appears wavy in outline.

2. Outermost single-layered, thick-walled epidermis is heavily cuticularized and followed by multilayered cortex.

3. A few outer layers of cortex are sclerenchymatous, and some inner layers are parenchymatous.

4. In the inner layers of cortex are present many resin canals.

5. The stele is eustelic or polyfascicular endarch siphonostele.

6. Vascular bundles are conjoint, collateral, open and endarch, and resemble greatly with that of a dicot stem. 5-10 vascular bundles are arranged in a ring.

7. Endodermis and pericycle are indistinguishable.

8. Narrow xylem rays connect the cortex and pith.

9. Endarch xylem consists of only tracheids.

10. Phloem is present on the ventral side and consists of sieve cells, sieve plates, phloem parenchyma and some albuminous cells.

11. Intrafascicular cambium is present in between the xylem and phloem.

12. Many leaf traces are also present.

13. A small parenchymatous pith is present in the centre of stem.

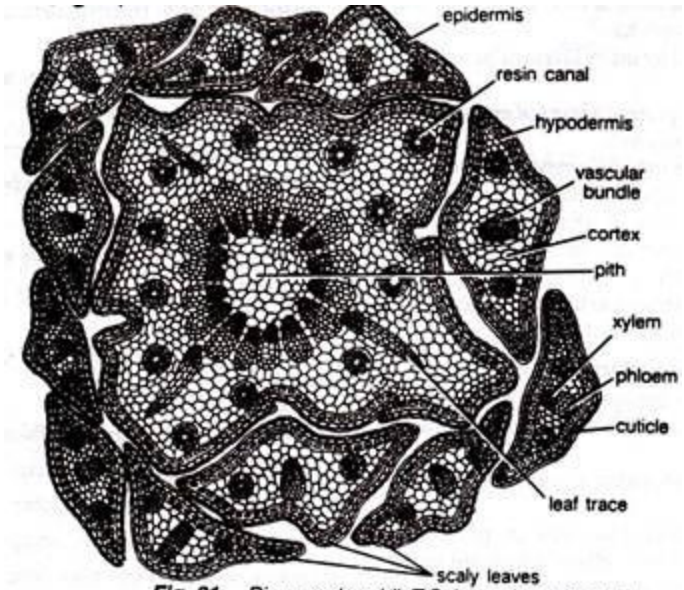

Fig. 31. Pinus roxburghii. T.S. long shoot (young).

T.S. Long Shoot (Old):

1. Secondary growth, similar to that of a dicotyledonous stem, is present in the old stem of Pinus.

2. Cork cambium cuts cork towards outer side and a few layers of secondary cortex towards inner side.

3. Many tannin-filled cells and resin canals are distributed in the primary cortex.

4. Cambium cuts secondary phloem towards outer side and secondary xylem towards inner side (Fig. 32).

5. Primary phloem is crushed and pushed towards outer side by the secondary phloem.

6. In the secondary xylem, annual rings of thin-walled spring wood (formed in spring season) and thick- walled autumn wood (formed in autumn season) are present alternately. Such a compact wood is called pycnoxylic (Age of the plant can be calculated by counting the number of these annual rings).

7. Below the secondary xylem are present a few groups of endarch primary xylem.

8. Some of the medullary rays connect the pith with the cortex and called primary medullary rays while the others run in between secondary xylem and secondary phloem and called secondary medullary rays.

9. Central part of the stem is filled with the parenchymatous pith.

10. Resin canals are present in cortex, secondary xylem, primary xylem and rarely in the pith.

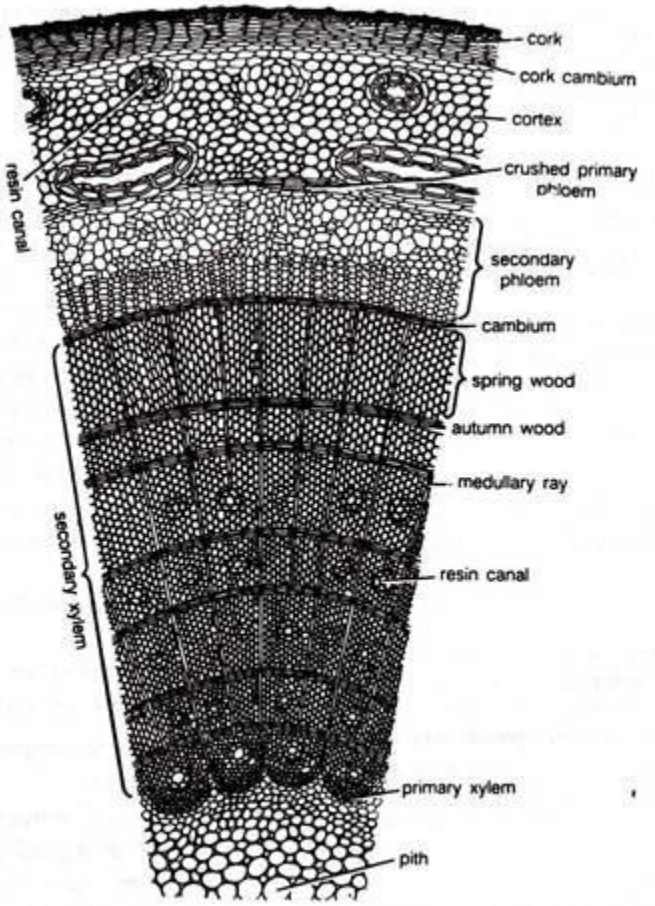

Fig. 32. Pinus. T.S. of a two-year old long shoot.

Tangential Longitudinal Section (T.L.S.) of Wood:

In T.L.S. the longitudinal section is cut along the tangent of the wood.

Following structures are visible:

1. Bordered pits and medullary rays are present in sectional view.

2. Each border pit is enclosed by a pit chamber bounded by a pit membrane and contains a centrally located swollen torus (Fig. 33).

3. Tracheids are composed of rectangular cells. Middle lamella is very clear.

4. Many uniseriate medullary rays are present.

5. In the xylem region medullary rays contain a centrally located starch cell surrounded by tracheidial cells.

6. Albuminous cells are also present in medullary rays in phloem region.

7. Pith is absent.

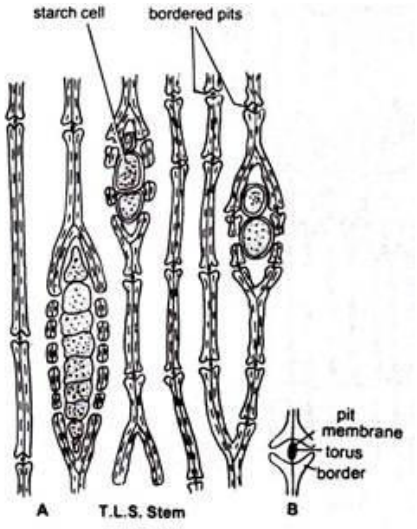

Fig. 33. Pinus. A, T.L.S. wood (a part); B, A magnified bordered pit.

Radial Longitudinal Section (R.L.S.) of Wood:

In R.L.S., the stem is cut along the radius, and so the pith is also visible.

Following other details are visible:

1. It is bounded externally by cork, cork cambium, secondary phloem and crushed primary phloem.

2. Bordered pits surrounded by bars of Sanio in tracheids are seen in surface view.

3. Uniseriate medullary rays run horizontally.

4. In the xylem region thick medullary ray cells are surrounded by ray tracheids (Fig. 34).

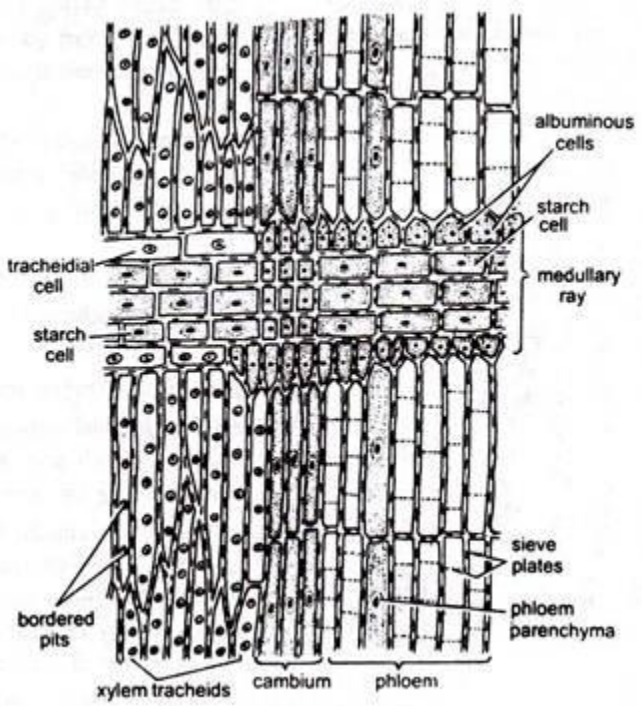

Fig. 34. Pinus. R.L.S. Stem.

5. Thin-walled ray parenchyma is also present.

6. Xylem is separated from phloem with the help of cambium.

7. Albuminous cells are present in medullary ray in the phloem region.

8. Phloem consists of sieve tubes, sieve plates and phloem parenchyma.

9. Pith is present.

T.S. Dwarf Shoot (Young):
It is exactly similar to that of T.S. of young long shoot except following differences:
1. The number of the resin canals present in the cortex is not indefinite but generally six (Fig. 35).

Though it is variable in different species.

2. The number of the vascular bundles is also generally six. However, it is also variable in different species.

3. Pith in dwarf shoot is comparatively smaller than the long shoot.

4. Structure of the vascular bundles is same, i.e., conjoint, collateral, open and endarch.

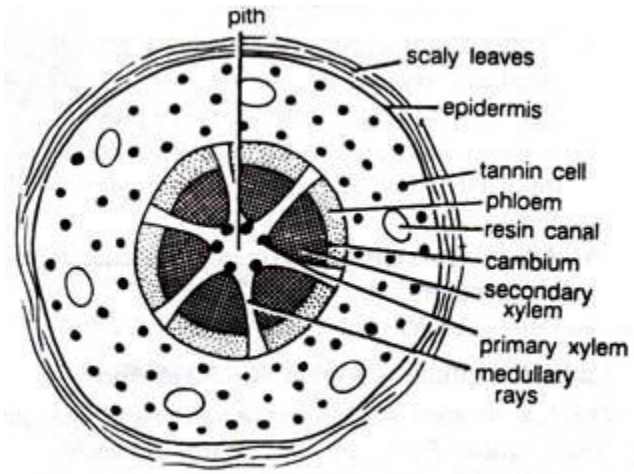

Fig. 35. Pinus. T.S. dwarf shoot.

T.S. Dwarf Shoot (Old):

1. It is also similar to old long shoot in many aspects.

2. Cork, cork cambium and secondary cortex are not normally present, but the epidermis surrounded externally by scaly leaves and followed internally by multilayered cortex is present.

3. Inner to the cortex is crushed primary phloem, secondary phloem, cambium and secondary xylem with medullary rays (Fig. 36). Protoxylem is endarch.

4. A small pith with some tannin cells is present in the centre.

If a section of distal end of dwarf shoot is cut, the needles get separated, each having the same structure. In a bifoliar spur two needles are present while in a trifoliar spur there are present three foliage leaves or needles (Fig. 37).

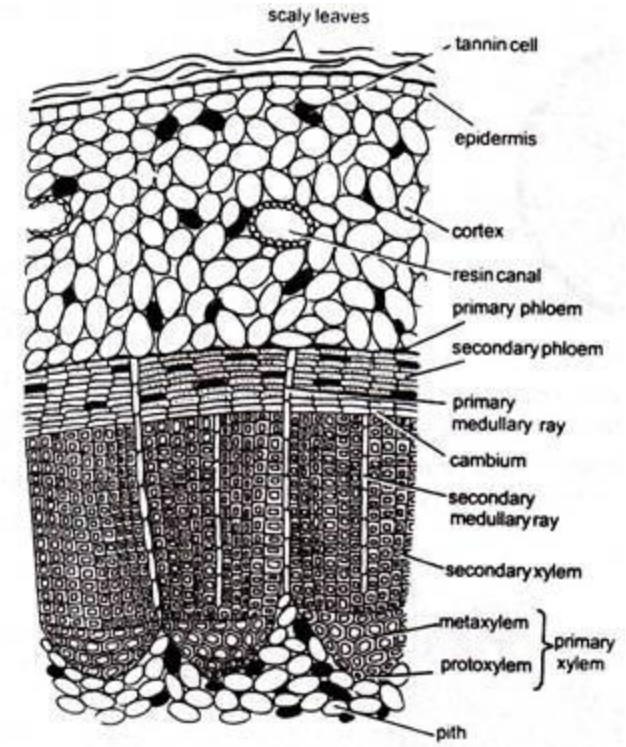

Fig. 36. Pinus. T.S. old dwarf shoot (a part cellular).

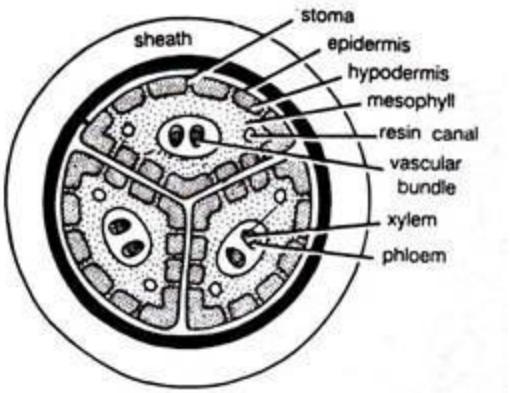

Fig. 37. Pinus. T.S. upper part of dwarf shoot showing the formation of three needles in a trifoliar spur.

T.S. Needle (Foliage Leaf):

1. It is circular in outline in Pinus monophylla, semicircular in P. sylvestris and triangular (Fig. 38) in P. longifolia, P. roxburghii, etc.

2. Outermost layer is epidermis, which consists of thick-walled cells. It is covered by a very strong cuticle.

3. Many sunken stomata are present on the epidermis (Fig. 38).

4. Each stoma opens internally into a substomatal cavity and externally into a respiratory cavity or vestibule.

5. Below the epidermis are present a few layers of thick-walled sclerenchymatous hypodermis. It is well-developed at ridges.

6. In between the hypodermis and endodermis is present the mesophyll tissue.

7. Cells of the mesophyll are polygonal and filled with chloroplasts. Many peg-like infoldings of cellulose also arise from the inner side of the wall of mesophyll cells.

8. Few resin canals are present in the mesophyll, adjoining the hypodermis. Their number is variable but generally they are two in number.

9. Endodermis is single-layered with barrel-shaped cells and clear casparian strips.

10. Pericycle is multilayered and consists of mainly parenchymatous cells and some sclerenchymatous cells forming T-shaped girder, which separates two vascular bundles (Fig. 38). Transfusion tissue consists of tracheidial cells.

11. Two conjoint and collateral vascular bundles are present in the centre. These are closed but cambium may also present in the sections passing through the base of the needle.

12. Xylem lies towards the angular side and the phloem towards the convex side of the needle.

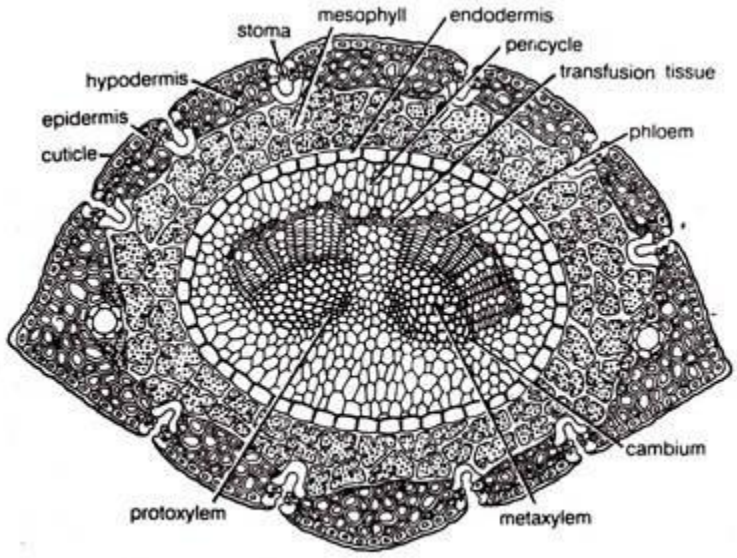

Fig. 38. Pinus. T.S. needle.

Reproductive Structures of Pinus:

1. Plant body is sporophytic.

2. Pinus is monoecious, and male and female flowers are present in the form of cones or strobili on the separate branches of the same plant.

3. Many male cones are present together in the form of clusters, each of which consists of many microsporophylls. The female cones consist of megasporophylls.

4. The male cones on the plant develop much earlier than the female cones.

Male Cone:

1. The male cones develop in clusters (Fig. 39) in the axil of scaly leaves on long shoot.

2. They replace the dwarf shoots of the long shoot.

3. Each male cone is ovoid in shape and ranges from 1.5 to 2.5 cm. in length (Fig. 40).

4. A male cone (Fig. 41) consists of a large number of microsporophylls arranged spirally on the cone axis.

5. Each microsporophyll is small, membranous, brown-coloured structure.

6. A microsporophyll (Fig. 41) is comparable with the stamen of the flower of angiosperms because it consists of a stalk (=filament) with a terminal leafy expansion (= anther), the tip of which is projected upwards and called apophysis.

7. Two pouch-like microsporangia (= pollen sacs) are present on the abaxial or undersurface of each microsporophyll. In each microsporangium are present many microspores (= pollen grains).

8. Each microspore or pollen grain is a rounded and yellow-coloured, light, uninucleate structure with two outer coverings, i.e., thick outer exine and thin inner intine (Fig. 42).

9. The exine protrudes out on two sides in the form of two balloon-shaped wings. Wings help in floating and dispersal of pollen grains.

10. A few microsporophylls of lower side of cone are sterile. Sporangia are also not present on the adaxial surface of each microsporophyll of the male cone.

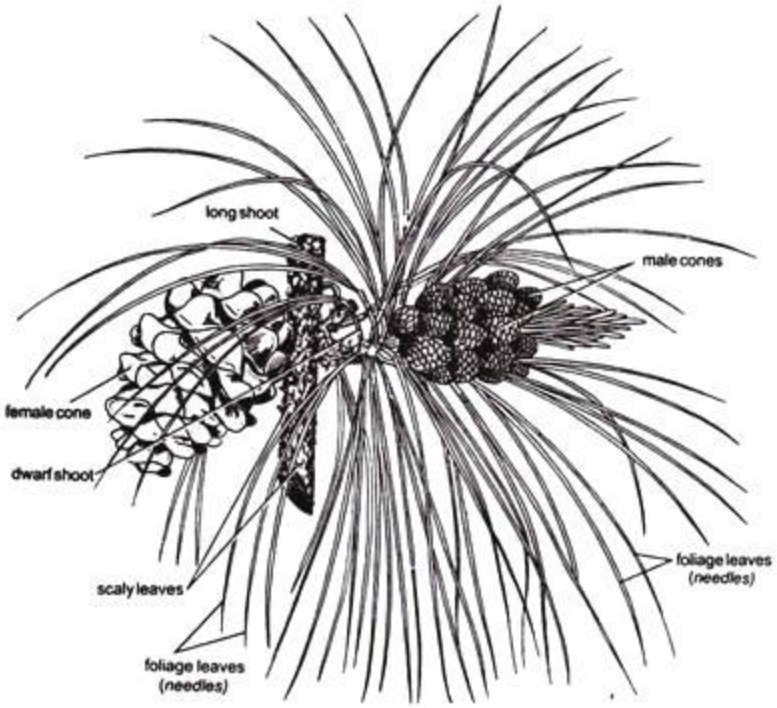

Fig. 39. Pinus. A long shoot bearing cluster of male cones and a mature female cone.

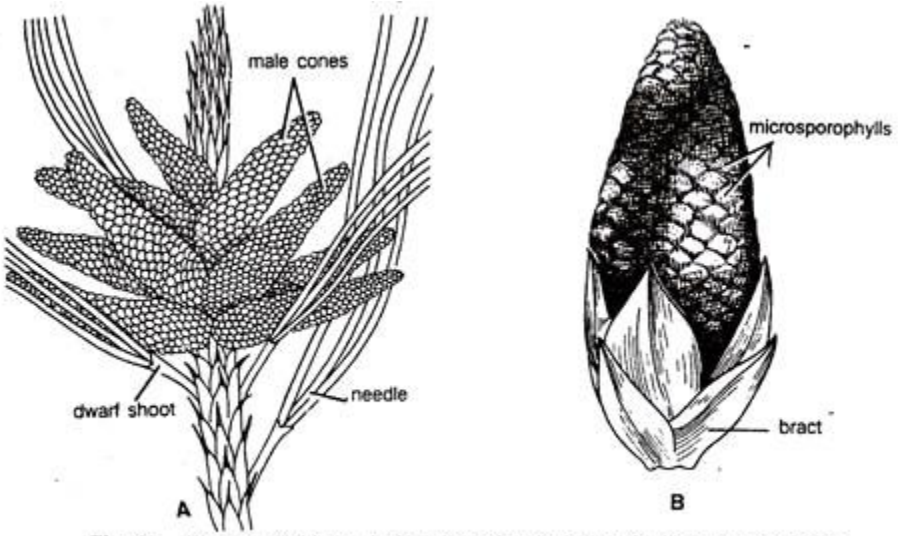

Fig. 40. Pinus wallichiana. A, A cluster of male cones; B, A single male cone.

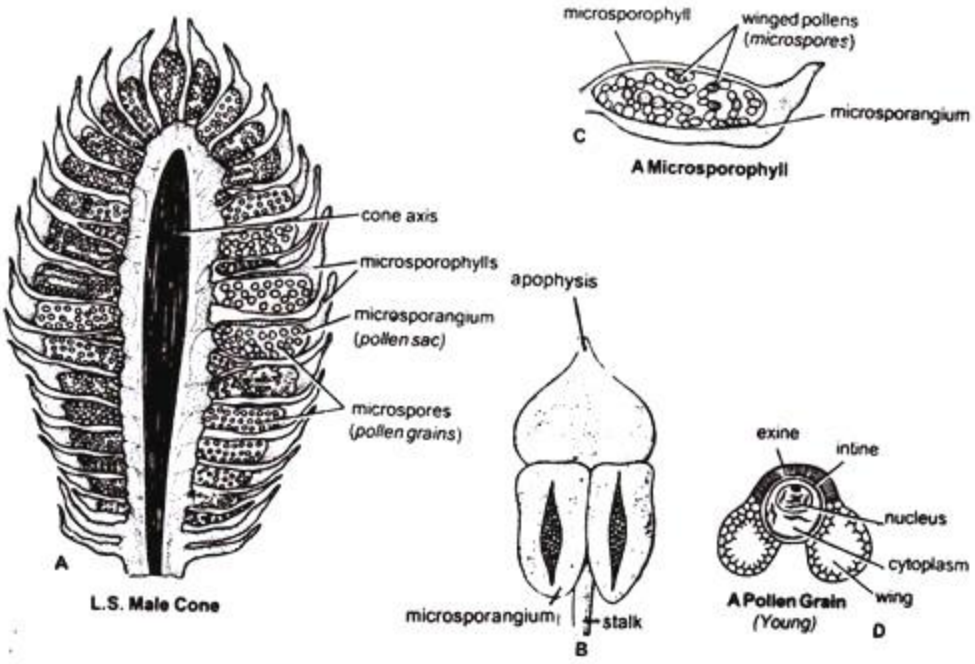

Fig. 41. Pinus. A, L.S. male cone; B, A single microsporophyll with microsporangia in surface view; C, A microsporophyll; D, A young pollen grain.

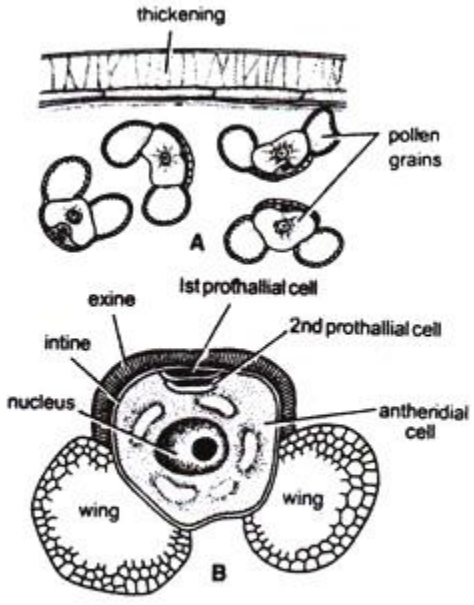

Fig. 42. Pinus. A few pollen grains and a mature winged pollen grain.

Female cone:

Observe the external features and longitudinal section of a young female cone and also study 1st year, 2nd year and 3rd year female cones.

1. Female cone develops either solitary or in groups of 2 to 4.

2. They also develop in the axil of scaly leaves on long shoots (Fig. 43) like male cones.

3. Each female cone is an ovoid, structure when young but becomes elongated or cylindrical at maturity.

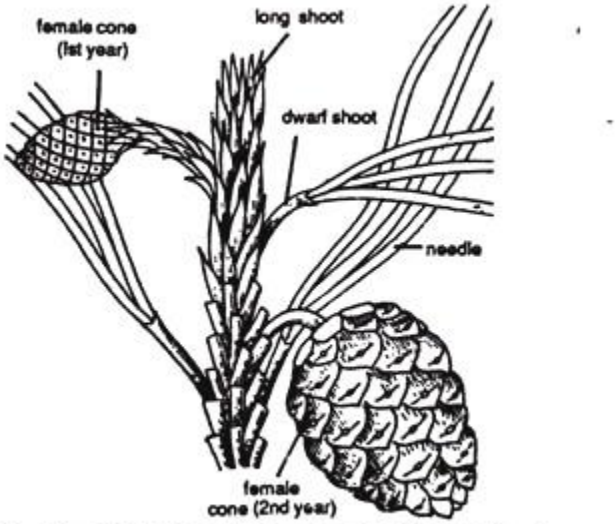

Fig. 43. Pinus. A fertile long shoot bearing 1st and 2nd year female cones.

L.S. Female Cone:

1. In the centre is present a cone axis (Fig. 44).

2. Many megasporophylls are arranged spirally on the cone axis.

3. A few megasporophylls, present at the base and at the apex of strobilus, are sterile.

4. Megasporophylls present in the middle of the strobilus are very large and they decrease in size towards the base and apex.

5. Each megasporophyll consists of two types of scales, known as bract scales and ovuliferous scales.

6. Bract scales are thin, dry, membranous, brown- coloured structures having fringed upper part. These are also called carpellary scales.

7. An ovuliferous scale is present on the upper surface of each bract scale.

8. Each oruliferous scale is woody, bigger and stouter than bract scale and it is triangular in shape. A broad sterile structure, with pointed tip, is present at the apex of these scales. This is called apophysis.

9. At the base of upper surface of each ovuliferous scale are present two sessile and naked ovules.

10. Micropyle of each ovule faces towards the cone axis.

11. Each ovule is orthotropous, and it remains surrounded by a single integument, consisting of an outer fleshy, a middle stony and an inner fleshy layer. It opens with a mouth opening called micropyle.

12. Integument surrounds the megasporangium or nucellus.

13. Just opposite the micropyle is present a pollen chamber.

14. In the endosperm or female gametophyte are present 2 to 5 archegonia.

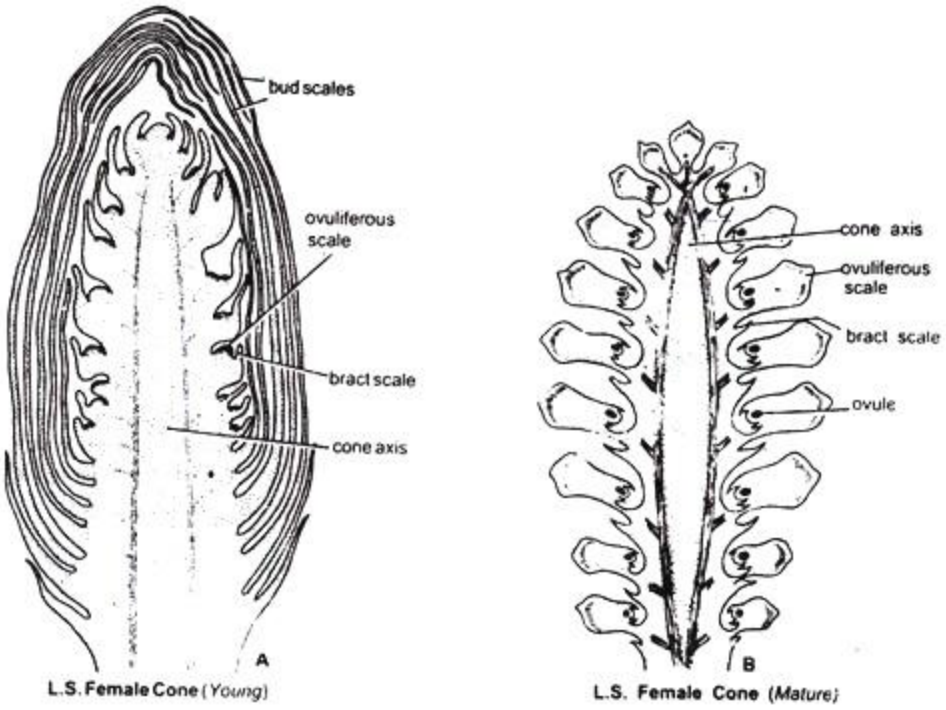

Fig. 44. Pinus. A, L.S. female cone (young); B, L.S. female cone (old).

Female Cone

1. It is elongated or roughly rounded in shape.

2. It is also woody in nature like the 2nd year cone.

3. Megasporophylls (Fig. 47) are loosely arranged.

4. Seeds are dispersed from 3rd year cone.

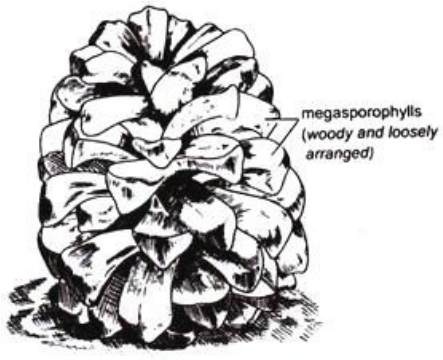

Fig. 47. Pinus. A 3rd year female cone.

Seed:

1. Both the ovules of each ovuliferous scale develop into seeds (Fig. 48).

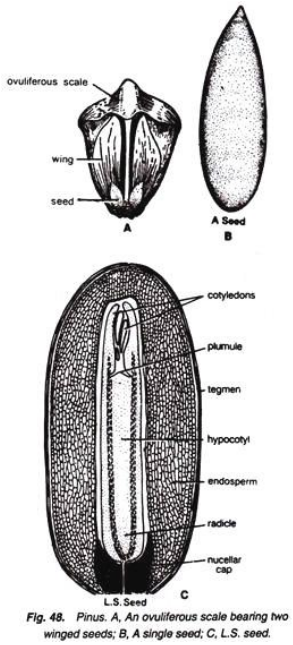

Fig. 48. Pinus. A, An ovuliferous scale bearing two winged seeds; B, A single seed; C, L.S. seed.

2. Each seed contains a large membranous wing formed from the ovuliferous scale.

Anatomy of seed shows following (Fig. 48C) details:

1. It is enveloped by a seed coat developed from the middle stony layer of the ovule.

2. Inner fleshy layer may survive in the form a thin membrane. Outer fleshy layer disappears.

3. A thin, membranous and papery structure, called perisperm, develops inner to the seed coat.

4. Well-developed endosperm is present.

5. In the centre is present the embryo consisting of a hypocotyle, radicle, plumule and 2 to 14 or more cotyledons.

Each ovule (megasporangium) has a mass of **nucellar tissue.** They are surrounded by a single integument. The micropylar end of the ovule is directed towards the central axis. A single megaspore mother cell is differentiated in the nucellus near the micropylar end. This megaspore mother cell undergoes meiosis to form four megaspores. Only the lower most megaspore remains functional. The others disintegrate. Functional megaspore (embryo sac) increases in size. It occupies the major part of the nucellus. Pollination takes place at this stage.

Female Prothallus

The megaspore divides many times to form **female prothallus.** Megaspore wall encloses the female prothallus. Three **archegonia** are produced towards the micropylar end. Each archegonium develops from a single prothalial cell. Archegonia consist of a large **venter** and a **short neck.** The oosphere or egg is very large. It is bounded by the prothalial cells. There is a small ventral canal cell below the neck. The neck is without any neck canal cells. The prothalial tissue enlarges very much in size. It crushes all nueellar tissue except a small amount near the micropylar end.

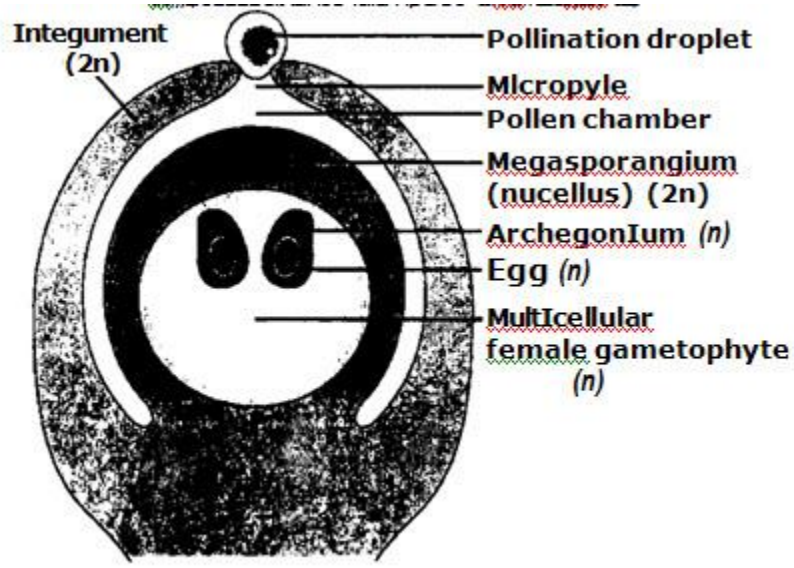

Fig: Ovule with female gametophyte

Pollination

Each ovule secretes a mucilaginous drop at the micropylar end. A gap is produced between the ends of the ovuliferous scales. It forms a passage for the entry of pollen grains. Wind carried pollen grains. The mucilage drop

entangles the pollen grain. Pollen grain is carried through the micropyle to the surface of the nucellus.

Male Prothallus

The pollen grain has two prothalial cells and an antheridial cell. These cells soon disintegrate. Further development of the pollen grain takes place at the surface of the nucellus. The antheridial cell cut off second prothalial cell. It also cut off generative cell adjacent to the prothalial cells. The remaining large cell is known as the **tube cell.** Its nucleus is called **tube nucleus.** Tube nuclers controls the growth of the pollen tube. Exine of the pollen grain ruptures. Intine grows out to form the pollen tube. It grows through the nucellus. But its activity stops till spring. Female cone enlarges very much in size after pollination. Outer ends of the ovuliferous scales increase very much. They meet each other to close the gaps in between them. The cone is covered with a lot of resinous secretions.

The pollen grain resumes its activity in the spring. Generative cell divides into two cells: **stalk cell** and **a body cell** over the stalk cell. Body cell divides into two unequal male cells or sperms. Male cells pass down to the tip of the pollen tube. The pollen tube grows through the nucellus. It passes through the neck of the archegonium and touches the oosphere. One male nucleus fuses with the oosphere to form oospore. The other degenerates. Fertilization is completed in the June of second year.

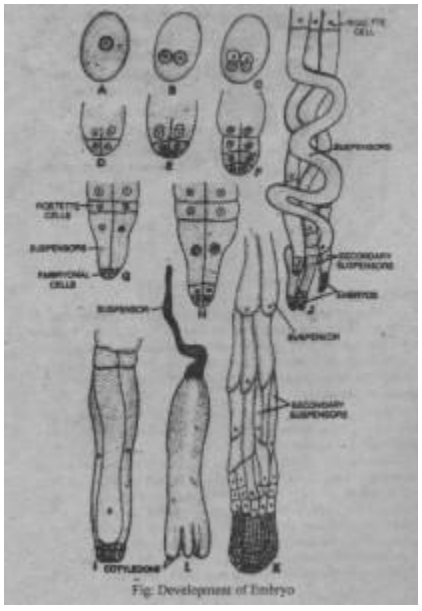

Fig: Development of Embryo

Formation of Embryo and Seed

Diploid nucleus divides thrice to form eight cells. The lower four cells becomes **proembryonal cells.** The upper four nuclei are separated by incomplete cell walls. Four proembryonal divides to produce three tiers of cells:

1. Embryonal cell: The cells of the lower tier become embryonal cells. The four embryonal cells separate from each other. Each develops into a separate embryo independently. Each embryonal cell forms secondary suspensor cells. The formation of more than one embryo from a single fertilized oosphere is called **polyembryony.** Only one embryo reaches maturity. The rest are aborted.

1. **Suspensor cells:** The cells of the middle tier become suspensor cells. Suspensor cells elongate very much. It pushes the developing embryos into the prothalial tissue for nutrition.
2. **Rosette cells:** The cells of the upper most tiers are called the rosette cells. These cells do not take part in the development of the embryo.

A fully developed embryo is in the form a short straight axis. Its **radicle** is present towards the micropylar end. **Plumule** is present towards the inner side. Plumule is surrounded by ten **cotyledons.** The unutilized prothalial tissue forms the **endosperm.** The persistant nucellus tissues near the micropylar end form the **perisperm.** The integument becomes hard testa. Some part of the ovuliferous scale fuses with the developing seed. It makes a large wing for dispersal of seed. The axis of the female cone rapidly increases. It produces gaps in ovuliferous scales. The cone becomes woody for the dispersal of seeds.

Germination of Seed

The radicle grows out. It splits the testa at the micropylar end. This radicle grows down into the soil and forms the **primary root.** The hypocotyl elongates to form a loop. Then it becomes straight. It carries with it the plumule and the cotyledons. The testa is also carried up with the cotyledons. Germination is epigeal.