

VIVEKANANDA COLLEGE  
THAKURPUKUR  
KOLKATA-700063

NAAC ACCREDITED 'A' GRADE



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Name of the Teacher: Mrs. Rinku Halder Sahu  
Name of the Department: Botany (Morning)

# *Life cycle of Pinus*

## External Morphology :

*Pinus* is a large perennial evergreen plant. Branches grow spirally and thus the plant gives the appearance of a conical or pyramidal structure. The sporophytic plant body is differentiated into **root, stem and needle like leaves**.

### **1. Root:**

- *Pinus* shows a typical tap root system.
- The tap root (**long root**) persists but several lateral roots (short or **dwarf root**) grow extensively with poorly developed root hairs.
- The roots of *Pinus* is characterised by ectotrophic mycorrhizal association with about 50 different fungal species. The predominant species that form ectotrophic mycorrhiza belong to *Boletus, Clavaria, Amantia and Scleroderma* of the Basidiomycota.
- The dwarf roots divide dichotomously and several hyphae penetrate the intercellular spaces in the cortical cells constituting Hartig's net and mantle.
- Thus a symbiotic association is formed between the roots and the fungi where the plant is benefited by increasing the surface of the root for absorption of water and nutrients from soil.

## 2. Stem:

- The stem of *Pinus* is woody, cylindrical and erect with rough uneven scaly bark that peels off.
- The branches are pseudomonopodial and are restricted to the upper part of the stem.
- The branches develop spirally in the axil of scale leaves present on the upper part of the stem, giving the tree a pyramid-like or pagoda-like appearance (Fig. 1.57A).
- There are two types of branches — the long shoot and the dwarf shoot, thus the branches are dimorphic (Fig. 1.57B).

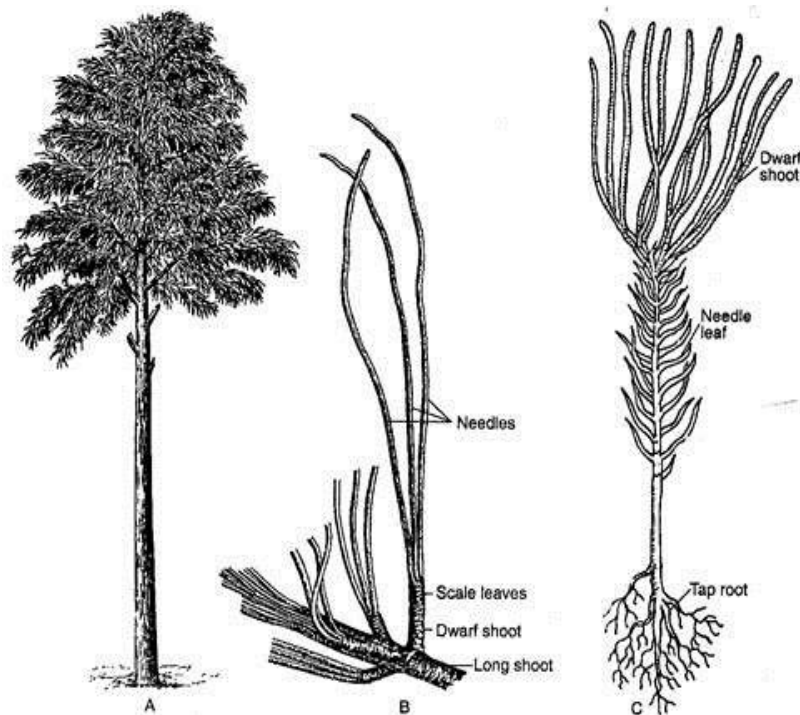


Fig. 1.57 : A. A *Pinus* tree, B. Long shoot and dwarf shoots of *Pinus*, C. A *Pinus* seedling

### **a. Long Shoots:**

- These are the branches of unlimited growth bearing an apical bud enclosed in bud scales.
- Each long shoot develops in the axil of a scale leaf, thus this branch bears only scale leaf.
- These branches shorten gradually towards the tip, thus giving the tree a pyramid-like or pagoda-like appearance.
- The long shoot falls off leaving a scar on the stem.

### **b. Dwarf Shoot:**

- These are the branches of limited growth and also known as short shoots, or foliar spurs. The dwarf shoots are borne on long shoots and develop in the axil of scale leaves (Fig. 1.57B).
- Each dwarf shoot bears two opposite scaly leaves and needle-like foliage leaves.
- Dwarf shoots fall off every two or three years leaving scars on the stem.

## **3. Leaf :**

*Pinus* exhibits leaf dimorphism bearing two types of leaves, the **scale leaves** and the **green acicular foliage leaves called needles**.

### **a. Scale Leaves:**

- These are thin, small and membranous and are dark-brown in colour present on both the long and the dwarf shoots (Fig. 1.57B).
- They are non-photosynthetic and provide protection to the young buds.
- The scale leaves that are borne on the dwarf shoot have a distinct midrib and are known as cataphylls. At maturity scale leaves fall-off.

### **b. Foliage Leaves:**

- These are green (photosynthetic), acicular, needle-like borne only on the dwarf shoot and remain persistent for several years.
- The dwarf shoot bearing a group of needles is called a foliar spur.
- The number of needles in a spur is constant for a species and is a criterion used in identification of a species. For example, *P. monophylla* spur contains a single needle, *P. merkusii* spur bears two needles, *P. roxburghii* has three needles, *P. quadrifolia* has four needles and *P. wallichiana* has five needles per spur.

## *Internal Structure:*

### *i. Root:*

Anatomically, the primary (long) root of *Pinus* is diarch to tetrarch which resembles a typical dicot root. The following structures are discernible from outside inward:

- epidermis with unicellular root hairs,
- the starch filled parenchymatous cortex,
- a single- layered endodermis with typical casparian bands,
- a multilayered pericycle
- followed by a diarch or tetrarch radial vascular bundle and the starch-filled pith.
- The protoxylem of the vascular bundle is bifurcated forming a 'Y'-shaped structure and each arm is associated with a resin duct.
- The metaxylem consists of pitted tracheids. The phloem is present in an alternate position to xylem and consists of sieve cells and parenchyma.
- The secondary growth in the roots starts very early. The cambium develops below the primary phloem and produces secondary xylem centripetally towards the pith and secondary phloem centrifugally towards the cortex (Fig. 1.58).
- The cambium in the region of resin ducts cuts off parenchymatous xylem rays (uni- or multiseriate).

- The root, in a later stage, shows a more or less similar configuration with that of a stem.

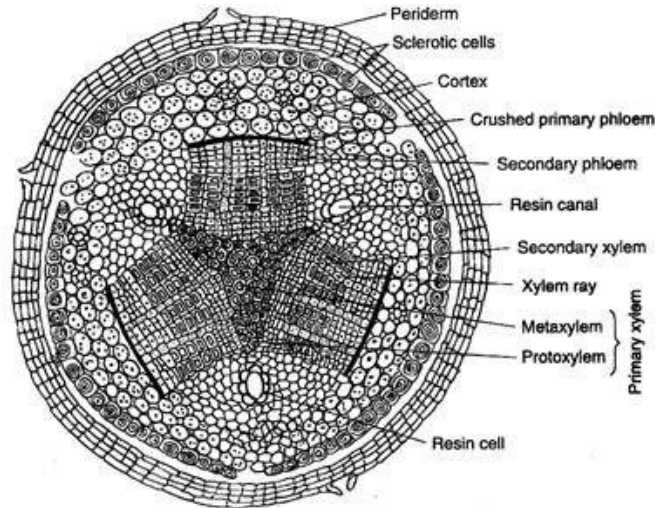


Fig. 1.58 : *Pinus*. T.S. of an old root

- The extra stelar secondary growth in root also takes place soon after the commencement of intrastelar secondary growth.
- The phellogen (cork cambium) which differentiates in the outer region of the pericycle, cuts off phellem (cork cells) towards the outer side and phelloderm (secondary cortex) towards the inner side.
- Several resin canals are formed in the phelloderm.
- The cell layers from epidermis to endodermis are sloughed off and eventually the highly suberised and tanniniferous cork becomes the outer protective layer.

- Anatomically, the dwarf root is more or less similar with the long root. However, the dwarf roots are devoid of root cap, resin ducts, starch in cortical cells and secondary growth.

## ***ii. Stem:***

Internally, a *Pinus* stem is similar to that of a dicot stem. In T.S., stem exhibits wavy outline due to the appressing of surrounding scale leaves and dwarf shoots.:

In T.S. of young stem the following regions are discernible from outside inward (Fig. 1.59A):

- the heavily cutinised single-layered epidermis;
- a few-layered thick sclerenchymatous hypodermis;
- a several-layered thick parenchymatous cortex with prominent resin canals and some tannin- filled cells;
- an indistinct single-layered endodermis;
- a 2-3 layered pericycle;
- a ring of 5-9 vascular bundles separated from each other by medullary rays and a parenchymatous pith at the centre.
- The young stem exhibits an endarch siphonostelic configuration broken up by leaf gaps.
- Each vascular bundle is of conjoint, collateral and open type.

- The medullary rays are narrow due to the closeness of two adjacent vascular bundles.
- The tracheids are arranged in radial rows. The protoxylem of tracheids have spiral thickening and the metaxylem have reticulate thickening. The phloem is made up of sieve cells and parenchyma with occasional albuminous cells.

### **Secondary Growth in Thickness:**

- The fascicular cambium joins with the interfascicular cambium forming a complete cambium ring that cuts off a continuous cylinder of secondary xylem towards the inside and secondary phloem towards the outside (Fig. 1.59B).
- The cambium also produces secondary medullary rays at places.
- The secondary xylem is composed of tracheids.
- The secondary phloem consists of sieve cells arranged in rows. The sieve cell is provided with sieve area on the radial wall throughout its length.
- The tracheids are more or less quadrilateral in cross-section and are provided with bordered pits on radial walls (Fig. 1.59D).
- The mature tracheids develop a thickened border in the form of crescentic bars in between the pits. These are known as Crassulae or Bars of Sanio (Fig. 1.59F). According to Sanio (1873) the crassulae are rod-shaped horizontal thickenings in the

middle lamella due to the deposition of cellulose or pectin between radial walls of tracheids. However, Mauseth (1988) described them as refraction patterns using electron microscopy.

- The vascular rays continue to increase in radial length indefinitely. They are of two types — uniseriate rays and multiseriate or fusiform rays. The uniseriate ray varies in height from 1- 12 cells (Fig. 1.59E). The multiseriate ray is more than one cell wide and many cells in height which is associated with a centrally-placed resin canal.
- The areas of contact between the ray cells and tracheids are called the cross-fields. There are one to two large pits per cross-field. The wood of pinus is pycnoxylic which shows annual ring formation comprising of spring wood and autumn wood (Fig. 1.59C).
- In the wood of a mature stem, there is a clear demarcation between the outer lighter zone, the sapwood and the inner darker region, the heartwood. With age, the sapwood generally gets transformed into heartwood that becomes resinous, rich in phenolic compounds. The wood is characterised by the absence of vessels, wood parenchyma and fibres, although fibre tracheids may occur in late wood.
- The extra stelar secondary growth takes place by the cork cambium or phellogen which forms cork on the outer side and secondary cortex on the inner side. Later, the original cork

cambium is replaced by successive layers of phellogen deeper and deeper (Fig. 1.59B) into the cortex. So rough uneven scaly bark is formed that peels off.

- Anatomically, the dwarf shoot is similar to that of long shoot except for its diameter.

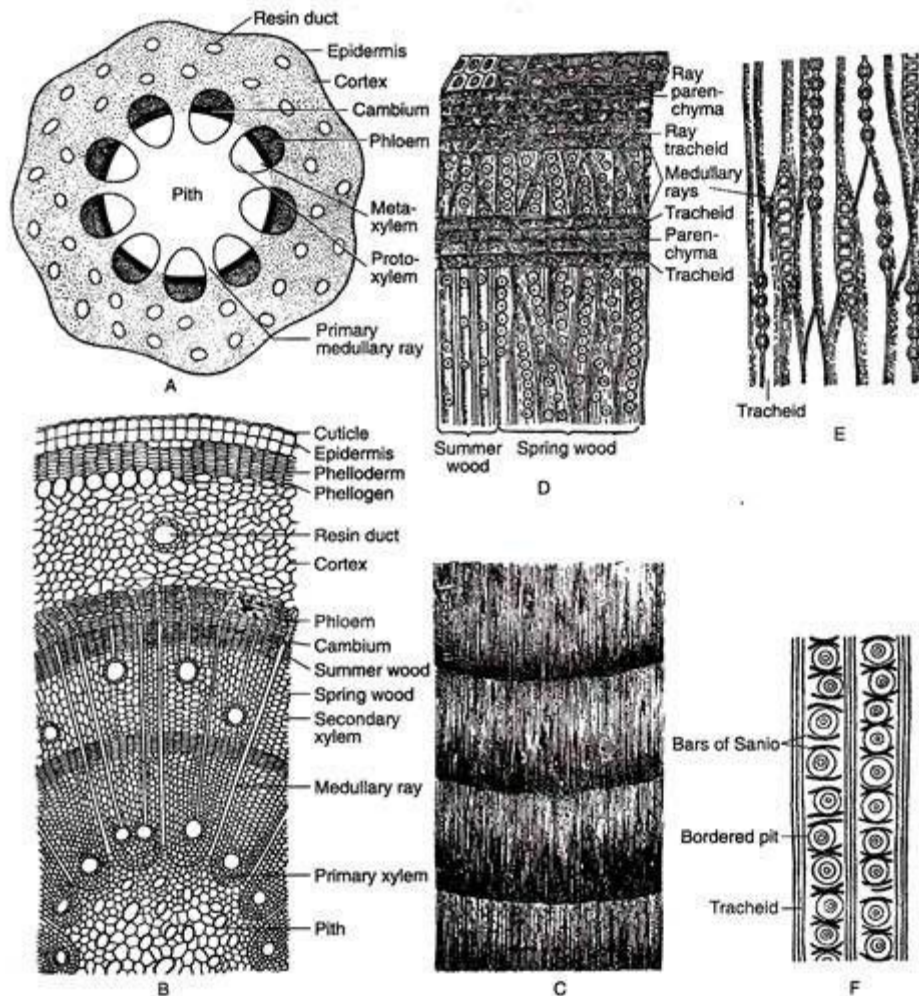


Fig. 1.59 : *Pinus* : A. T.S. of young stem (diagrammatic), B. T.S. of two-year old stem, C. T.S. of wood showing annual rings, D. R.L.S. of secondary wood, E. T.L.S. of secondary wood, F. Tracheids showing Bars of Sanio

### **iii. leaf:**

In T.S., the outline of the needle may vary considerably depending upon the number of needles in a spur. For example, the outline of the needle is circular in *P. monophylla* (spur bears a single needle), semicircular in *P. merkusii* (spur bears two needles), triangular in *P. roxburghii* (spur bears three needles).

In T.S. of a needle (Fig. 1.60), the following regions are discernible from outside inward:

1. the dermal layer (epidermis and hypodermis),
2. the mesophyll tissue,
3. and a centrally-placed monarch or diarch stele.

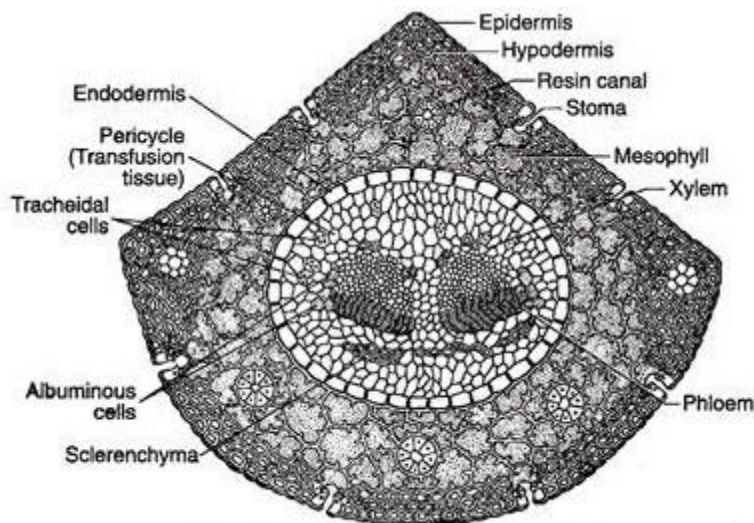


Fig. 1.60 : *Pinus roxburghii*. T.S. of needle

- The epidermis (Fig. 1.60) is single-layered, made up of heavily cutinised isodiametric lignified cells.
- It is interrupted by many haplocheilic deeply **sunken stomata** consisting of two guard cells surrounded by 6-9 subsidiary cells.
- The hypodermis (Fig. 1.60) is made up of 2-3 layers of thick-walled sclerenchymatous cells which are often interrupted by sub-stomatal cavities.
- The mesophyll tissue consists of 3-5 layers of polygonal chlorenchymatous cells with densely packed starch grains (Fig. 1.60). The **mesophyll cells show peg-like or plate-like infolding of the wall projecting into the cell cavity**, thus increasing the photosynthetic area of these cells to compensate for the reduced area of the needle leaves.
- The mesophyll cells may be categorised into four different types depending upon their position, — (a) external – next to hypodermis, (b) internal – adjacent to endodermis, (c) medial – neither come in contact with hypodermis nor with endodermis, (d) septal – come in contact with both the hypodermis and the endodermis forming a septum.
- The mesophyll tissue is interspersed with resin ducts just below the hypodermis. Each resin duct is made up of a layer of secretory epithelial cells, surrounded by sclerenchymatous sheath.

- Next to mesophyll is a single-layered endodermis which is composed of barrel-shaped cells with casparian strips on their radial walls (Fig. 1.60).
- The endodermis is followed by a multi-layered pericycle consisting of three types of cells, viz. parenchymatous cells densely filled with starch grains, **albuminous cells** near the phloem filled with proteins and starch grains, and tracheidal cells near the xylem with bordered pits on their tangential and transverse walls (Fig. 1.60).
- All the cells of the pericycle help in conduction of water and minerals, thus they are often termed **transfusion tissue**. A sheath of sclerenchymatous fibres is present in the pericycle around the phloem.
- The stele of *Pinus* is either monarch or diarch type. On the basis of the number of vascular bundles, *Pinus* may be categorised into two distinct groups – Haploxyton, having a single vascular bundle in needle, and Diploxyton, having two bundles placed at an angle to each other (Fig. 1.60). The vascular bundles are conjoint, collateral and open with adaxial xylem and abaxial phloem.
- The bundles consist of protoxylem and metaxylem elements. The tracheary elements are arranged in radial rows which alternate with rows of parenchymatous cells and albuminous cells. The phloem is composed of sieve cells and parenchyma. The

cambium is present in a vascular bundle which gives rise to secondary phloem and little or no secondary xylem.

<b>Distinctions between Haploxyton and Diploxyton pines</b>	
<b>Haploxyton pines</b>	<b>Diploxyton pines</b>
1. They are the soft pines.	1. They are the hard pines.
2. There is a single vascular bundle in the needle.	2. There are two vascular bundles in the needle.
3. The umbo (tip of the apophysis of ovuliferous scale in the mature cone) is either terminal or dorsal.	3. The umbo is always dorsal.
4. In stem, ray tracheids have smooth walls and tangential pits are developed after one year's growth.	4. In stem, ray tracheids have dentate or reticulate walls and tangential pits are not formed at the end of a year's growth.