PLANT ORGANS - ROOTS

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- Vegetative plant organs are **roots, stems**, and **leaves.** The reproductive organs are variable and in flowering plants, they are represented by the **flower, seed** and **fruit.**

1. THE ROOT SYSTEM

- **Roots anchor the plant in the soil**, **absorb water and nutrients and store excess food for future needs.** Roots anchor the plant in one of two ways or sometimes by a combination of the two.

- The first is to occupy a large volume of shallow soil around the plants **base with a fibrous (diffuse) root system, one consisting of many thin, profusely branched roots.**

- Since they grow relatively close to the soil surface, they **effectively control soil erosion.** Fibrous roots capture water as it begins to percolate into the ground and must draw their mineral supplies from the surface soil before the nutrients are leached to lower levels.

- When dissected, the arrangement of the cells in a root is **root hair, epidermis, periblem, cortex, endodermis, pericycle** and, **lastly, the vascular tissue in the centre of a root to transport the water absorbed by the root to other places of the plant.**

- Growth from apical meristems is known as **primary growth**, which encompasses **all elongation.**

- **Secondary growth** encompasses **all growth in diameter**, a major component of woody plant tissues and many non-woody plants. For example, storage roots of sweet potato have secondary growth but are not woody. **Secondary growth occurs at the lateral meristems, namely the vascular cambium and cork cambium. The former forms secondary xylem and secondary phloem, while the latter forms the periderm.**

- In plants with **secondary growth, the vascular cambium, originating between the xylem and the phloem,** forms a **cylinder of tissue along the stem and root. The vascular cambium forms new cells on both the inside and outside of the cambium cylinder,** with those on the inside forming secondary xylem cells, and those on the outside forming secondary phloem cells. As secondary xylem accumulates, the "girth" **(lateral dimensions)** of the stem and root increases. As a result, tissues beyond the secondary phloem (including the epidermis and cortex, in many cases) tend to be pushed outward and are eventually "sloughed off" (shed).

- The **cork cambium** begins to form the **periderm**, consisting of protective cork cells containing **suberin**. In roots, the **cork cambium originates in the pericycle**, **a component of the vascular cylinder.**
- The pericycle is a cylinder of **parenchyma or sclerenchyma cells that lies just inside the endodermis** and is the outer most part of the stele of plants.

- The vascular cambium produces new layers of secondary xylem annually. The xylem vessels are dead at maturity but are responsible for most water transport through the vascular tissue in stems and roots.
- **A tap root system sends one or two rapidly growing, sparsely branched roots straight down into the soil to draw from deep water tables and mineral supplies.**

- Trees distribute their roots in a wide circle where water absorbing root tips occupy a "drip zone", an area beyond the leaf canopy where rain is channelled from the foliage above. **Because the main purpose of roots is to probe the soil for water and minerals at a distance from the plant, primary growth is their most important growth process.**

- Most new cells produced are laid down behind the growing tip. There, they augment the length of the root and when the cells elongate, the root tip pushes its way through the soil with considerable force. To protect the tip, **the root produces cells ahead of itself forming a root cap (these are sacrificed to protect the meristem).**

- Root cap cells are readily rubbed off, but are quickly replaced from within, much like our skin when it dries and peels off from the surface. When root cap cells are ruptured by sharp soil particles, their protoplasm forms a slimy coat lubricating the root tip as it works its way through the soil and around large objects. The first root that comes from a plant is called the **radicle.**

Six major functions of roots are:

- absorption of water and inorganic nutrients,
- anchoring of the plant body to the ground, and supporting it,
- storage of food and nutrients,
- vegetative reproduction,
- hormone synthesis,
- gas exchange.

- In response to the concentration of nutrients, roots also synthesise **cytokinin,** which acts as a signal as to how fast the shoots can grow. **Roots often function in storage of food and nutrients.** The roots of most vascular plant species enter into **symbiosis with certain fungi to form mycorrhizae**, and **a large range of other organisms including bacteria** also closely associate with roots.

Water absorption takes place a short distance back in an area where a fuzzy band appears around the root. This band is formed by thousands of projecting root hairs. Root hairs are extensions of the outer root cells and increase, several hundred fold, the organs absorptive surface area. The width of the root hair zone remains constant.

- During continued root growth, new hairs form just above the growing tip, while old ones, at the top of the group, shrivel and die. Branching begins in the slightly older root sections, some distance from the tip. Branch roots originate deep inside the parent root and tend to grow at right angles to it, better to explore other regions of soil around the plant. Each branch is an exact duplicate of the root that produced it, with the same methods of growth, a set of root hairs and the capacity to form branches of its own.

SPECIALIZED ROOTS:

The roots, or parts of roots, of many **plant species have become specialized to serve adaptive purposes.**

Adventitious roots arise out-of-sequence from the more usual root formation of branches of a primary root, and instead originate from the stem, branches, leaves, or old woody roots. **They commonly occur in monocots and pteridophytes**, but also in many dicots, such as clover (*Trifolium*), ivy (*Hedera*), strawberry (*Fragaria*) and willow (*Salix*). Most aerial roots and stilt roots are adventitious. In some conifers adventitious roots can form the largest part of the root system.

- **Aerating roots**: roots rising above the ground, especially above water such as in some mangrove genera (*Avicennia*, *Sonneratia*). In some plants like *Avicennia* the erect roots have a large number of breathing pores for exchange of gases.

- **Aerial roots: roots entirely above the ground, such as in ivy (*Hedera*) or in epiphytic orchids.** Many aerial roots, are used to receive water and nutrient intake directly from the air. In some Epiphytes - plants living above the surface on other plants- aerial roots serve for reaching to water sources or reaching the surface, and then functioning as regular surface roots.

- **Contractile roots:** they pull bulbs or corms of monocots, such as hyacinth and lily, and some taproots, deeper in the soil through expanding radially and contracting longitudinally. They have a wrinkled surface.

- **Coarse roots:** Roots that have undergone secondary thickening and have a woody structure. These roots have some ability to absorb water and nutrients, but their main function is transport and to provide a structure to connect the smaller diameter, fine roots to the rest of the plant.

- **Fine roots:** Primary roots usually less than 2 mm diameter that have the function of water and nutrient uptake. They are often heavily branched and support mycorrhizas. These roots may be short lived, but are replaced by the plant in an ongoing process of root 'turnover'.

- **Haustorial roots:** roots of parasitic plants that can absorb water and nutrients from another plant, such as in mistletoe (*Viscum album*) and dodder.
- **Propagative roots:** roots that form adventitious buds that develop into aboveground shoots, termed suckers, which form new plants, as in Canada thistle, cherry and many others.

- **Proteoid roots or cluster roots:** dense clusters of rootlets of limited growth that develop under low phosphate or low iron conditions in Proteaceae and some plants from the following families Betulaceae, Casuarinaceae, Elaeagnaceae, Moraceae, Fabaceae and Myricaceae.

- **Stilt roots:** these are adventitious support roots, common among mangroves. They grow down from lateral branches, branching in the soil.

- **Storage roots:** these roots are modified for storage of food or water, such as carrots and beets. They include some taproots and tuberous roots.

- **Structural roots:** large roots that have undergone considerable secondary thickening and provide mechanical support to woody plants and trees.

- **Surface roots:** These proliferate close below the soil surface, exploiting water and easily available nutrients. Where conditions are close to optimum in the surface layers of soil, the growth of surface roots is encouraged and they commonly become the dominant roots.

- **Tuberous roots:** A portion of a root swells for food or water storage, e.g. sweet potato.