Section B: Absorption of Water and Minerals by Roots

1. Root hairs, mycorrhizae, and a large surface area of cortical cells enhance water and mineral absorption
2. The endodermis functions as a selective sentry between the root cortex and vascular tissue
Introduction

- Water and mineral salts from soil enter the plant through the epidermis of roots, cross the root cortex, pass into the stele, and then flow up xylem vessels to the shoot system.
Fig. 36.7
(1) The uptake of soil solution by the hydrophilic epidermal walls provides access to the apoplast, and water and minerals soak into the cortex along this route.

(2) Minerals and water that cross the plasma membranes of root hairs enter the symplast.

(3) Some water and minerals are transported into cells of the epidermis and cortex and inward via the symplast.

(4) Materials flowing along the apoplastic route are blocked by the waxy Casparian strip at the endoderm.

(5) Endodermal and parenchyma cells discharge water and minerals into their walls.

• The water and minerals now enter the dead cells of xylem vessels and are transported upward into the shoots.
1. Root hairs, mycorrhizae, and a large surface area of cortical cells enhance water and mineral absorption

- Much of the absorption of water and minerals occurs near root tips, where the epidermis is permeable to water and where root hairs are located.
  - Root hairs, extensions of epidermal cells, account for much of the surface area of roots.
  - The soil solution flows into the hydrophilic walls of epidermal cells and passes freely along the apoplast into the root cortex, exposing all the parenchyma cells to soil solution and increasing membrane surface area.
• As the soil solution moves along the apoplast into the roots, cells of the epidermis and cortex take up water and certain solutes into the symplast.
  
  • Selective transport proteins of the plasma membrane and tonoplast enable root cells to extract essential minerals from the dilute soil solution and concentrate them hundred of times higher than in the soil solution.
  
  • This selective process enables the cell to extract $K^+$, an essential mineral nutrient, and exclude most $Na^+$. 

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• Most plants from partnerships with symbiotic fungi for absorbing water and minerals from soil.

• “Infected” roots form mycorrhizae, symbiotic structures consisting of the plant’s roots united with the fungal hyphae.

• Hyphae absorb water and selected minerals, transferring much of these to the host plants.

• The mycorrhizae create an enormous surface area for absorption and can even enable older regions of the roots to supply water and minerals to the plant.

Fig. 36.8
2. The endodermis functions as a selective sentry between the root cortex and vascular tissue

- Water and minerals in the root cortex cannot be transported to the rest of the plant until they enter the xylem of the stele.
  - The endodermis, the innermost layers of the root cortex, surrounds the stele and functions as a last checkpoint for the selective passage of minerals from the cortex into the vascular tissue.
  - Minerals already in the symplast continue through the plasmodesmata of the endodermal cells and pass into the stele.
Those minerals that reach the endodermis via the apoplast are blocked by the *Casparian strip* in the walls of each endodermal cells.

- This strip is a belt of suberin, a waxy material that is impervious to water and dissolved minerals.

These materials must cross the plasma membrane of the endodermal cell and enter the stele via the symplast.

- The endodermis, with its Casparian strip, ensures that no minerals reach the vascular tissue of the root without crossing a selectively permeable plasma membrane.

- The endodermis acts as a sentry on the cortex-stele border.
• The last segment in the soil -&gt; xylem pathway is the passage of water and minerals into the tracheids and vessel elements of the xylem.

• Because these cells lack protoplast, the lumen and the cells walls are part of the apoplast.

• Endodermal cells and parenchyma cells within the stele discharge minerals into their walls.

• Both diffusion and active transport are probably involved in the transfer of solutes from the symplast to apoplast, entering the tracheids and xylem vessels.