

Introduction to Botany. Lecture 15

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Reminder

- **Monday lab:** two in each team, each team please bring **tape-measure, 4 wooden sticks** (or long pencils), and **white or red thread**

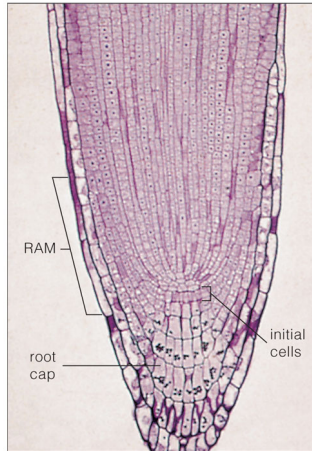
Outline

- 1 Roots and root systems
 - Development of root tissues
 - Anatomy of root
 - Morphology of root

Structure of root tip

- Initial cells (quiescent center)
- RAM
- Primary meristems
- Root tip growing both forward (root cap) and backward (other root tissues), initial cells determine the direction of growth
- If root tip touch barrier, it starts to make rotating movements

Root tip

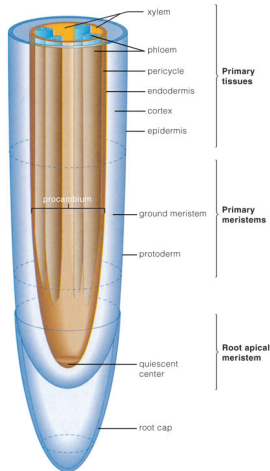


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The sequence of development

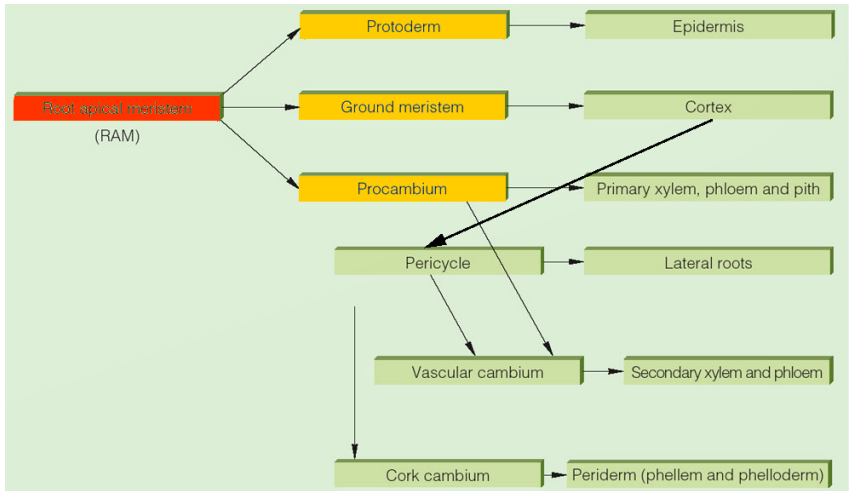
- RAM → Primary meristems (protoderm, ground, procambium)
- Protoderm → Rhizoderm (root epidermis)
- Ground meristem → Cortex → Pericycle
- Procambium → Primary xylem and phloem, vascular cambium (part)
- Pericycle → Vascular cambium (part) and cork cambium
- Cork cambium → Periderm
- Vascular cambium → Secondary xylem and phloem

Development of tissues



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Origins of tissues



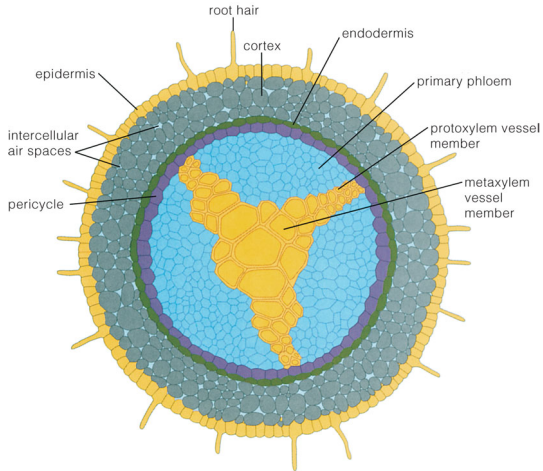
Periphery of root

- Rhizoderm (root epidermis): fast-degrading cells
- Cortex, which includes also:
 - Endoderm: 1-cell layer with specialized cell walls, located on the border with vascular cylinder
 - And (sometimes) exoderm: similar to endoderm but located just under rhizoderm
- In some plants (i.e., orchids), cortex modified into velamen

Root center: vascular cylinder

- Pericycle
- Vascular tissues located in the center
- No central hollow, central parenchyma presents in monocot roots

Anatomy of root



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Pericycle

- Long-lived parenchyma cells served as half-meristem
- Initiates development of lateral roots
- Contributes to vascular cambium
- Contributes to cork cambium

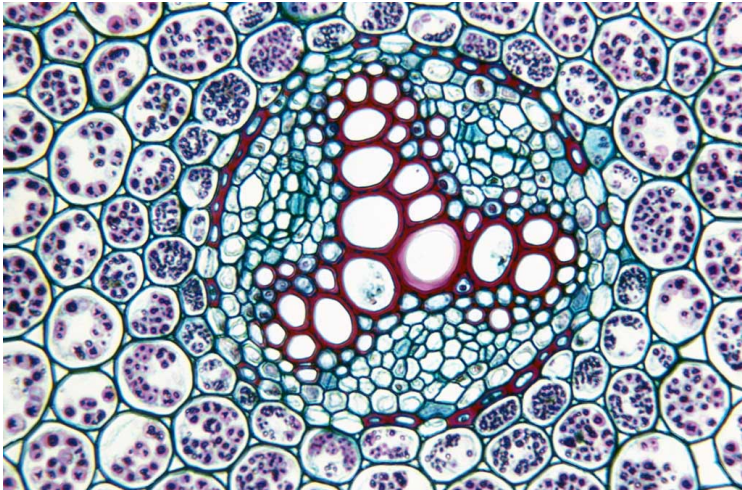
Development of lateral roots



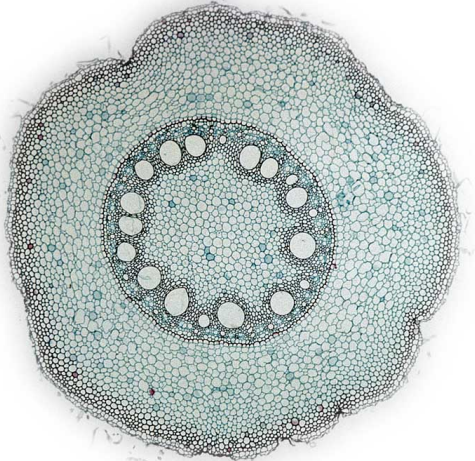
Vascular bundle

- Only one!
- Has radial (star-like) symmetry
- Protoxylem arranged in rays, multiple in monocots, 2-4 in other plants

Radial structure of root vascular bundle in buttercup (*Ranunculus* sp.)



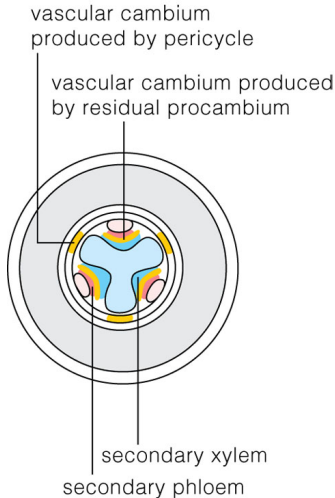
Root of monocot (*Zea mays*)



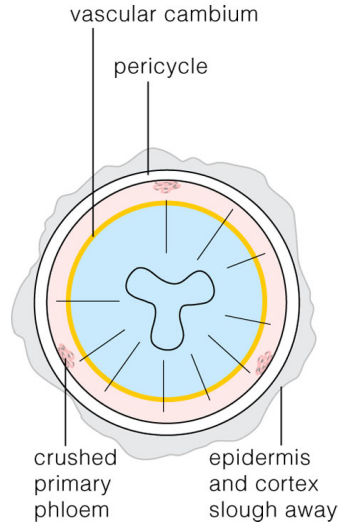
Secondary thickening

- Vascular cambium is produced by both pericycle and residual procambium (located between xylem and phloem)
- Cork cambium appears in cortex

Root thickening

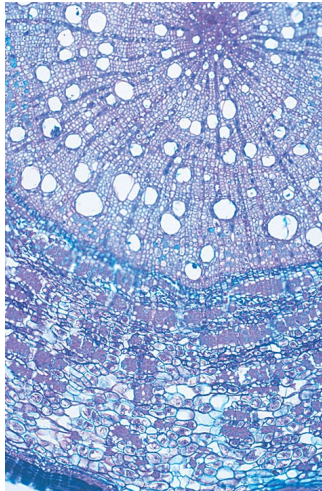


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Secondary root (*Quercus* sp.)



Modifications of roots

- Mycorrhizae: endotrophic (grasses, orchids) and ectotrophic (trees)
- Haustoria (parasites like *Cuscuta*—dodder plant)
- Root nodules (legumes, Fabaceae family)
- Contractile roots (*Hyacinthus* spp.—hyacinth, *Taraxacum* spp.—dandelion)
- Storage roots (*Daucus carota*—carrot, *Armoracia officinalis*—horseradish)
- Supportive roots (many tropical plants)

Aerial roots of ivy (*Hedera* sp.)

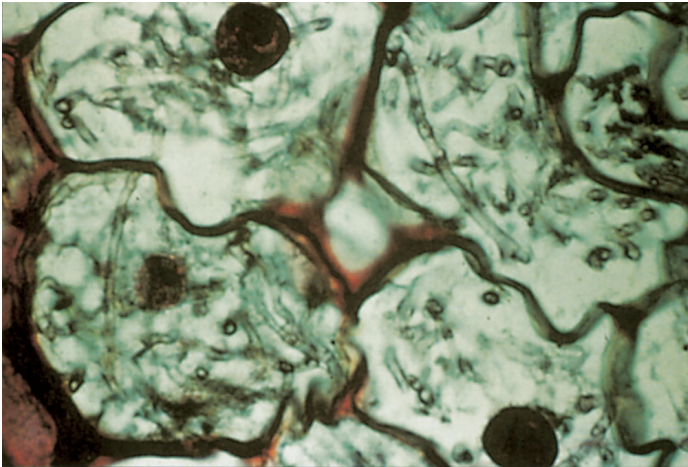


Contractile roots of *Hyacinthus orientalis*



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Endotrophic mycorrhizae in *Corallorhiza* orchid



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Photosynthetic aerial roots of orchids



Nodulated roots of soybean (*Glycine max*)



Supportive roots of mangrove plants



Supportive roots of *Pandanus* sp.



Table of modifications

<i>Function</i>	Stem	Leaf	Root	FU
Expansion	Rhizomes, stolons	Plantlets	Adventive buds	
Storage	Bulbs, corms, tubers	Bulbs	Storage roots	
Photosynthesis	Cladophylls	DEFAULT	Aerial roots	
Defense	Thorns	Spines	Root spines	
Support	DEFAULT	Tendrils	Hauatoria, aerial and contractile roots	
Interactions	Traps, hollows	Traps	Mycorrhizae, nodulated roots	

Summary

- Root differs from stem having rhizoderm, thick cortex, endoderm, long-lived pericycle and radially arranged primary vascular tissues
- Secondary thickening make root more similar to stem
- Root modifications often provide ways of interaction with other organisms: bacteria, fungi and other plants

For Further Reading



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.
Plant Biology. 2nd edition.
Thomson Brooks/Cole, 2006.
Chapter 7.