

# Introduction to Botany. Lecture 27

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## 1 Questions and answers

## 2 Root

- Root morphology
- Anatomy and development of roots
- Origins of root tissues
- Water transport in roots
- Diversity of roots



## 1 Questions and answers

## 2 Root

- Root morphology
- Anatomy and development of roots
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# Previous final question: the answer

What is ataktostele?



# Previous final question: the answer

What is ataktostele?

- Dispersed vascular bundles (monocots)

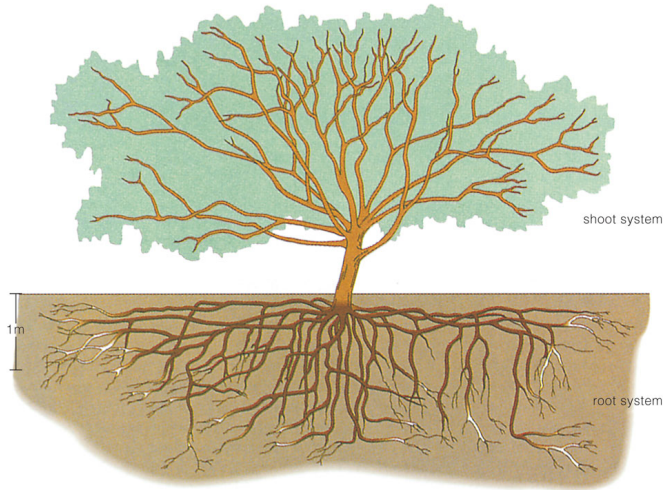


# Root

## Root morphology



# Root system and shoot system



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# Definition and functions

- Axial vegetative organ with a function of soil nutrition
- Other functions:
  - ① Anchor
  - ② Synthesis
  - ③ Storage
  - ④ Communication
- Features:
  - ① No leaves
  - ② Geotropic growth
  - ③ Locates in soil or water





# Types of roots

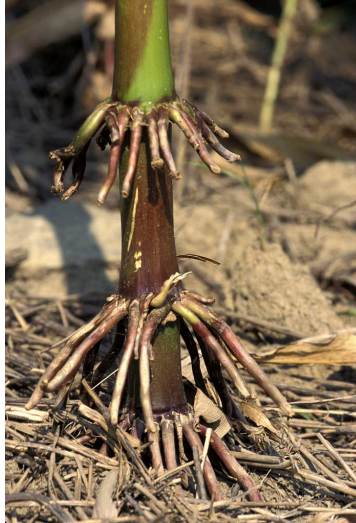
- Primary root: originates from root of seedling
- Secondary (lateral) roots: originate from primary roots
- Adventitious roots: originate from stems



# Primary root



# Adventitious roots

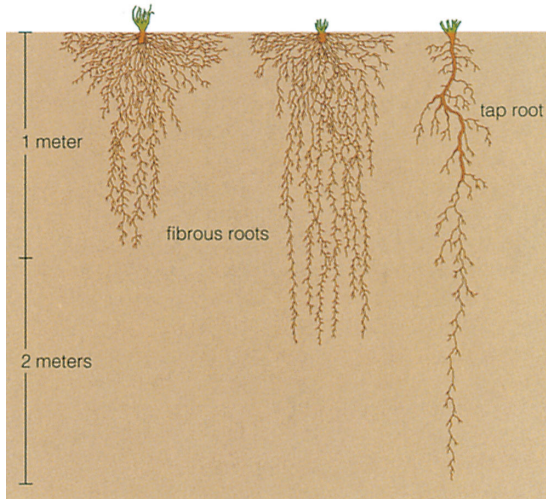


# Root systems

- Tap root system: with well developed primary root (most seed plants)
- Fibrous root system: without clearly visible primary root (monocots, ferns)



# Fibrous and tap root systems



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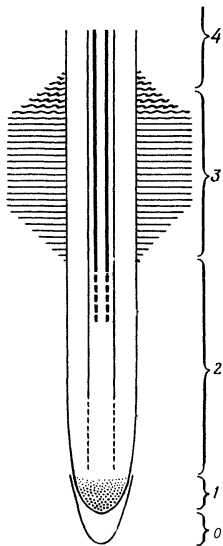


# Root

## Anatomy and development of roots



# Root zones



- Root cap
- Root meristem
- Elongation zone
- Absorption zone
- Maturation zone

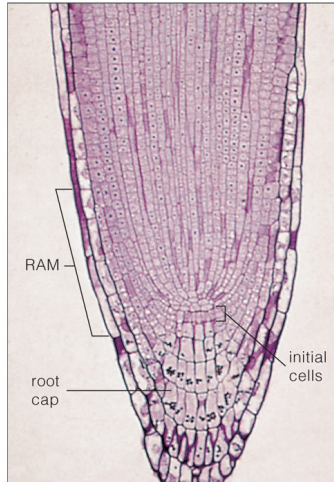
# Structure of root tip

- Initial cells (quiescent center)
- RAM
- 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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# 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



# Periphery of root

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  - **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), part of cortex modified into **velamen**

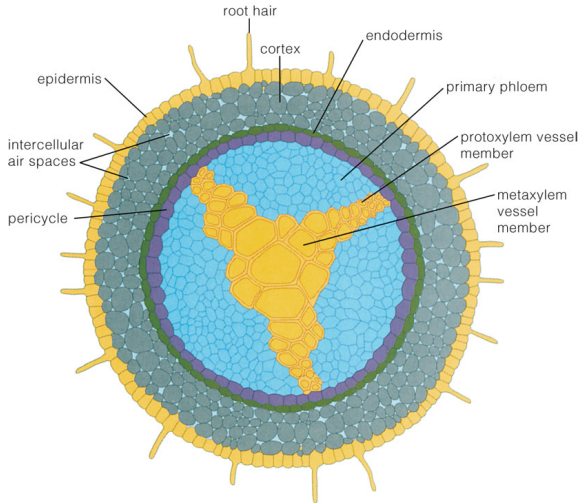


# Root center: vascular cylinder

- 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



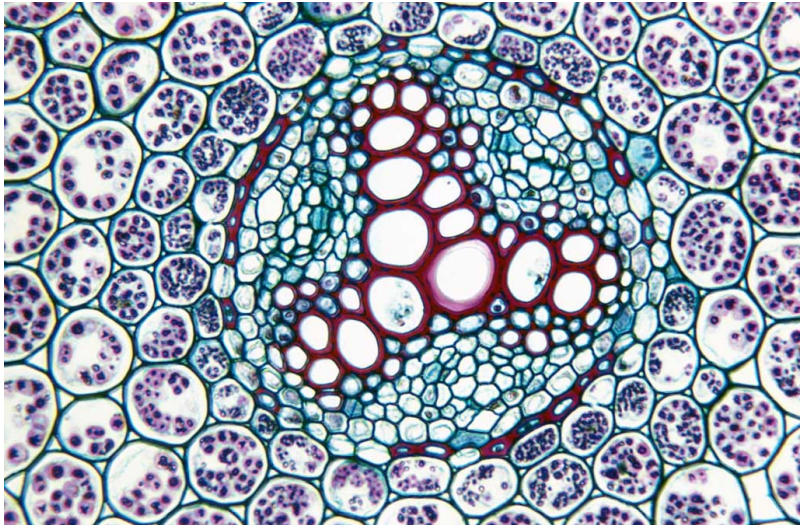
# Vascular bundle

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

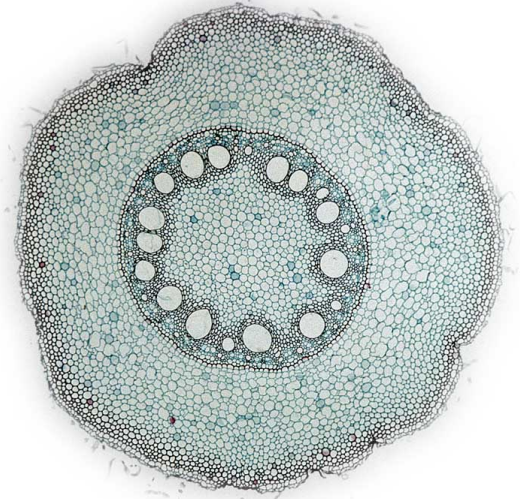




# Radial structure of root vascular bundle in buttercup (*Ranunculus* sp.)



# Root of monocot (*Zea mays*)

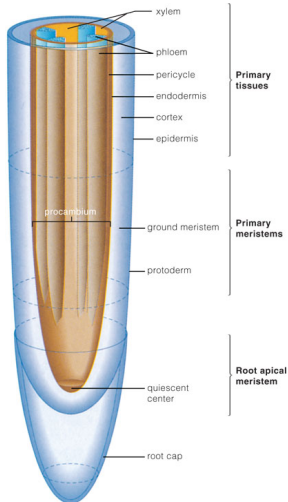


# Root

## Origins of root tissues

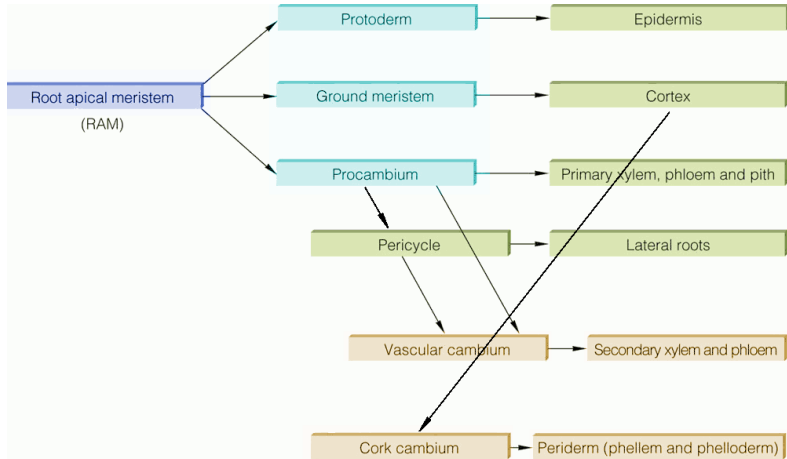


# Development of tissues



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# Origins of tissues



# Root

## Water transport in roots



# Rhizoderm and osmosis

- The existence of root hairs dramatically increases the surface of absorption
- Every root hair cell increase the internal concentration of large molecules, typically organic acids
- Process of concentration requires ATP
- As a result, osmosis water flow starts from soil to root cells



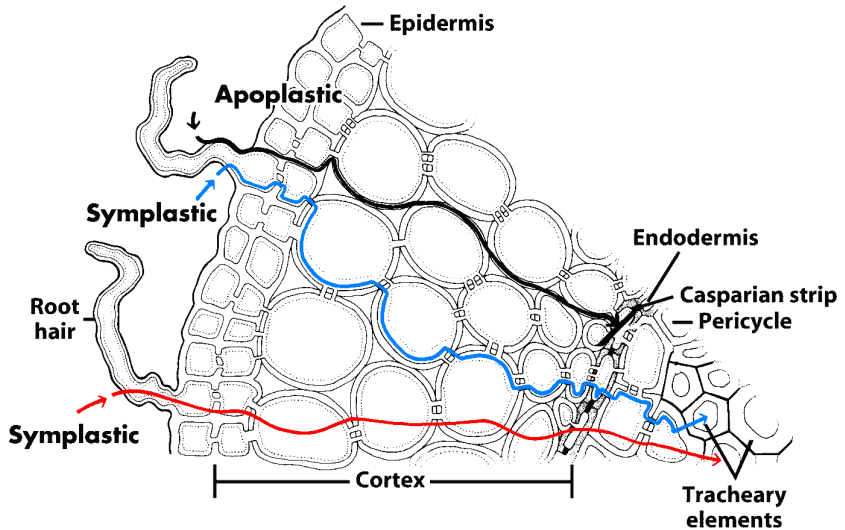
# Endoderm and root pressure

- From rhizoderm to endoderm, transport of water is both symplastic and apoplastic
- In the endoderm cells, Caspari stripes stop apoplastic transport and therefore forced symplastic transport
- This is a high-energetic process requires ATP
- As a result, water will be pushed up from root: this is the root pressure

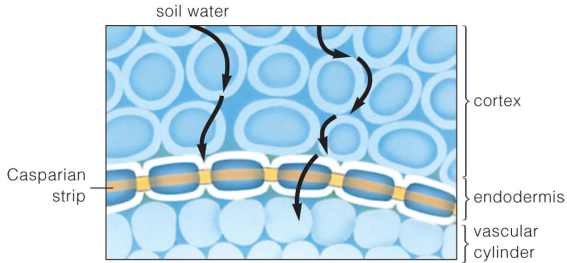




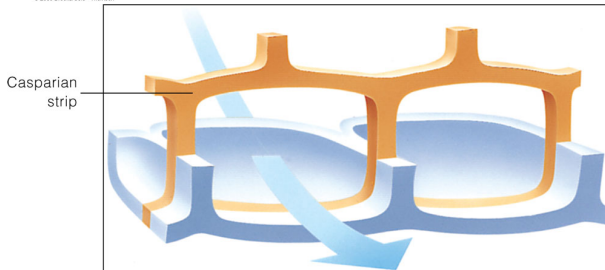
# Apoplastic and symplastic transport in the root



# Casparian strips

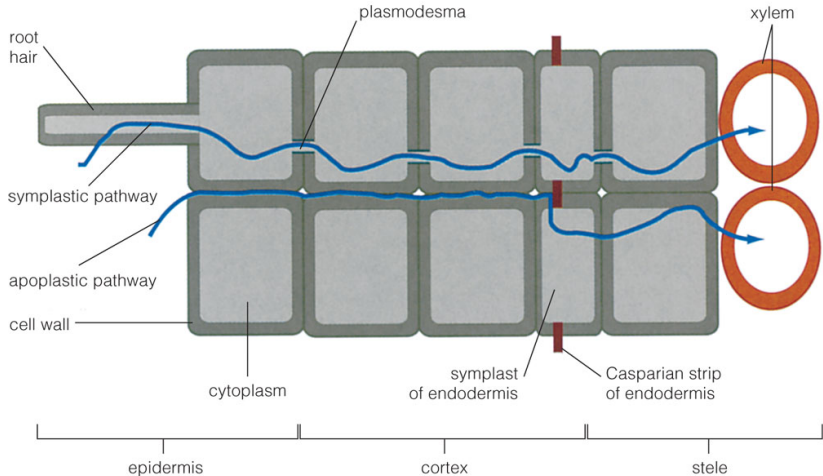


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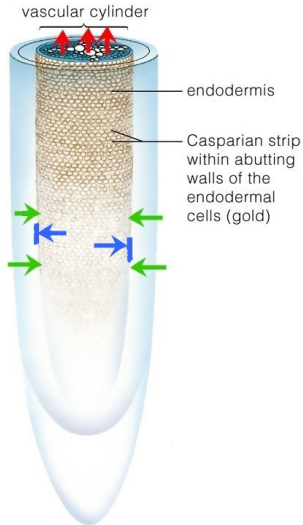
# How Casparian strips are working



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# Origin of root pressure



# Root

## Diversity of roots

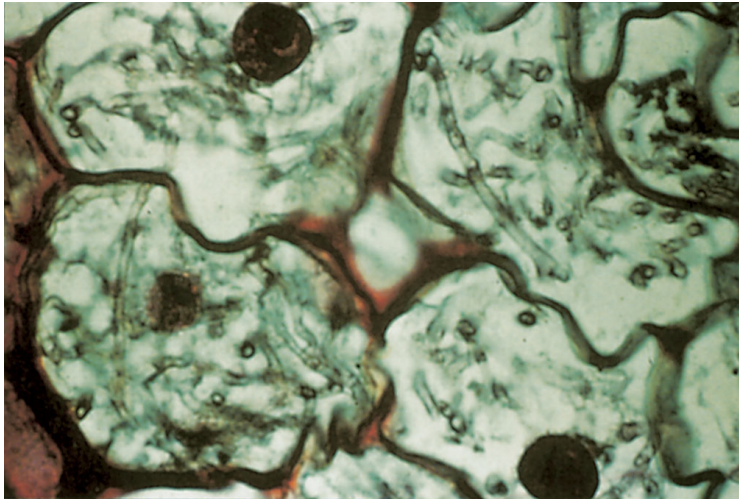


# Modifications of roots

- Adventive buds with root origin (many plants)
- 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)
- Defensive, spiny roots (ivy)
- Photosynthetic roots (some orchids)



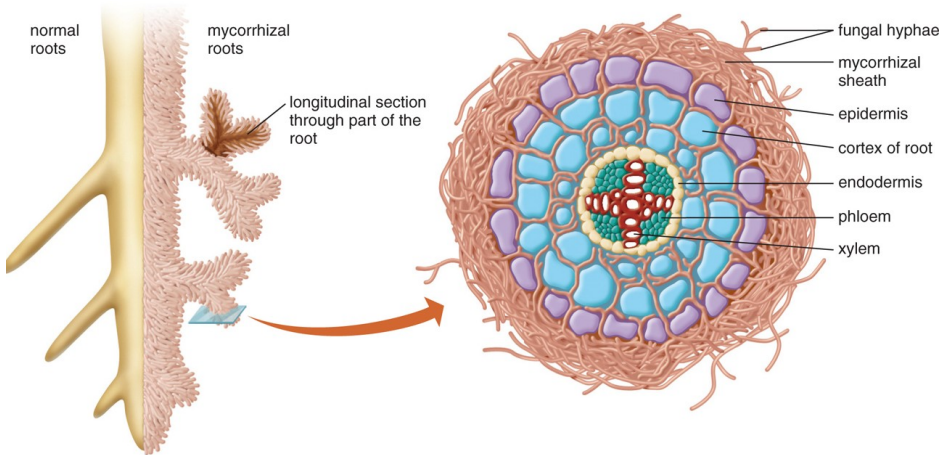
# Endotrophic mycorrhizae in *Corallorhiza* orchid



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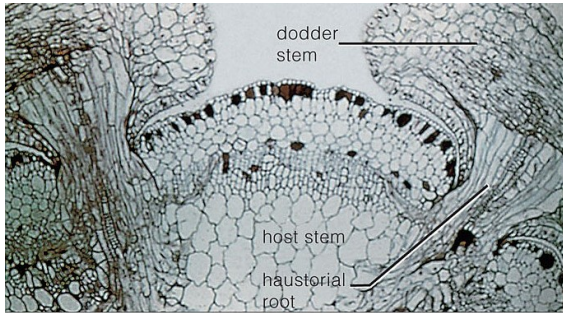


# Ectotrophic mycorrhizae of trees





# Haustoria of *Cuscuta* (dodder)



# Nodulated roots of soybean (*Glycine max*)



# Contractile roots of *Hyacinthus orientalis*



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# Supportive roots of mangrove plants



# Supportive roots of *Pandanus* sp.



# Defensive spiny roots of ivy (*Hedera* sp.)



# Photosynthetic aerial roots of orchids





# Table of modifications

Function	Stem	Leaf	Root
Expansion	...	Plantlets	Adventive buds
Storage	...	Succulent leaves	Storage roots
Photosynthesis	...	DEFAULT	Some aerial roots
Defense	...	Spines, scale	Root spines
Support	DEFAULT	Leaf ten-drills	Hauatoria, aerial and contractile roots
Interactions	...	Traps, "sticky tapes", urns	Mycorrhizae, nodulated roots





# Final question (2 points)



# Final question (2 points)

What are adventitious roots?



# Summary

- **Root** is an axial vegetative organ with a function of soil nutrition
- **Rhizoderm** and **absorption zone** are the most physiologically important parts of root
- 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



A. Shipunov.

*Introduction to Botany* [Electronic resource].

2010—onwards.

Mode of access:

[http://ashipunov.info/shipunov/school/biol\\_154](http://ashipunov.info/shipunov/school/biol_154)



Th. L. Rost, M. G. Barbour, C. R. Stocking, T. M. Murphy.

*Plant Biology*. 2nd edition.

Thomson Brooks/Cole, 2006.

*Chapter 7.*

