

Introduction to Botany. Lecture 26

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1 Questions and answers

- Quiz

2 Shoot

- Stem
- Development of stem tissues
- Anatomy of the primary stem
- Anatomy of the primary stem
- Components of shoot
- Phyllotaxis



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- Quiz

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Questions and answers

Quiz



Final question (2 points)

What is FU?



Final question (2 points)

What is FU?

- Floral Unit: not necessarily flower, but any stable element of generative shoot system



Shoot Stem



Stem: definition and functions

- Axial vegetative organ of shoot with functions of support and transportation
- Other functions:
 - A Photosynthesis
 - B Storage
- Features:
 - A Radial structure
 - B No root hairs
 - C Continuous growth



Shoot

Development of stem tissues



Protoderm to epidermis

- Stem apex meristem (SAM) produces **protoderm**
- Protoderm cells differentiate into epidermal cells

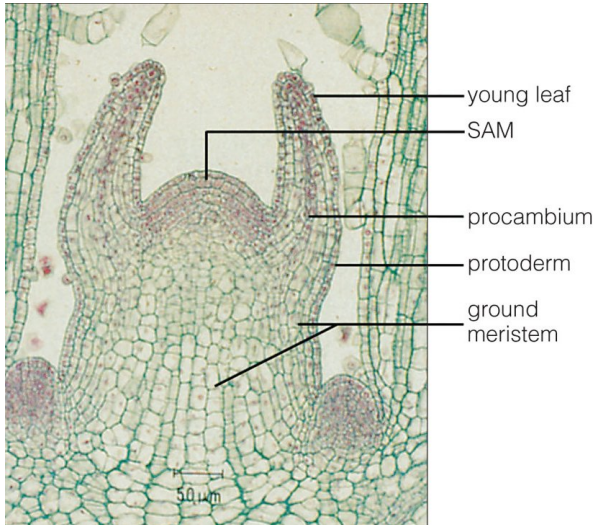


Ground meristem to cortex and pith

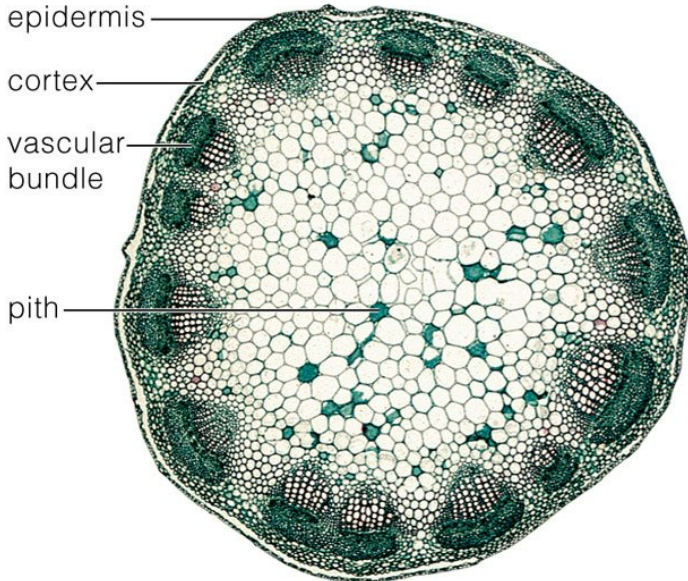
- SAM produces also **ground meristem**
- Ground meristem differentiates into **cortex** and **pith**
- Procambium arises between cortex and pith, it forms vascular bundles or vascular cylinder



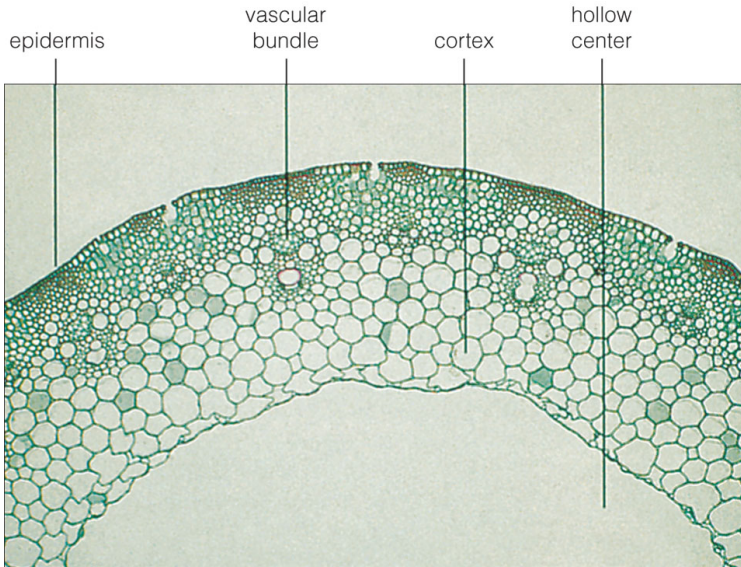
Three primary meristems: procambium, protoderm and ground meristem



Young stem with primary tissues



Older stem with hollow in the center



© 2006 Brooks/Cole - Thomson



Procambium to xylem and phloem

- Outer layers of procambium form **primary phloem**
- Inner layers become **primary xylem**
- Middle layer could be completely spent **or** will make cambium for the secondary thickening
- Sometimes outermost layers of procambium form **pericycle** (parenchyma cells)
- In some cases, inner layers of cortex could form **endoderm**

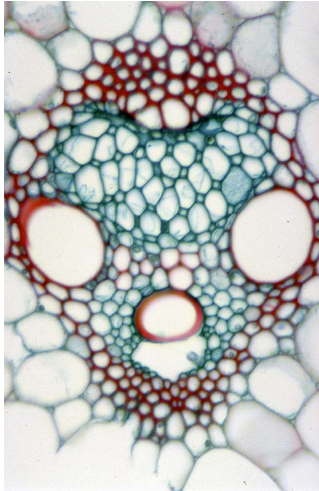


Shoot

Anatomy of the primary stem



Vascular bundle (monocot)



Corn (*Zea mays*) mature stem cross-section showing single vascular bundle, Brightfield (LM ×400)



Summary

- SAM produces **protoderm** and **ground meristem**, ground meristem differentiates into **cortex** and **pith**
- Procambium forms **vascular bundles** or vascular cylinder

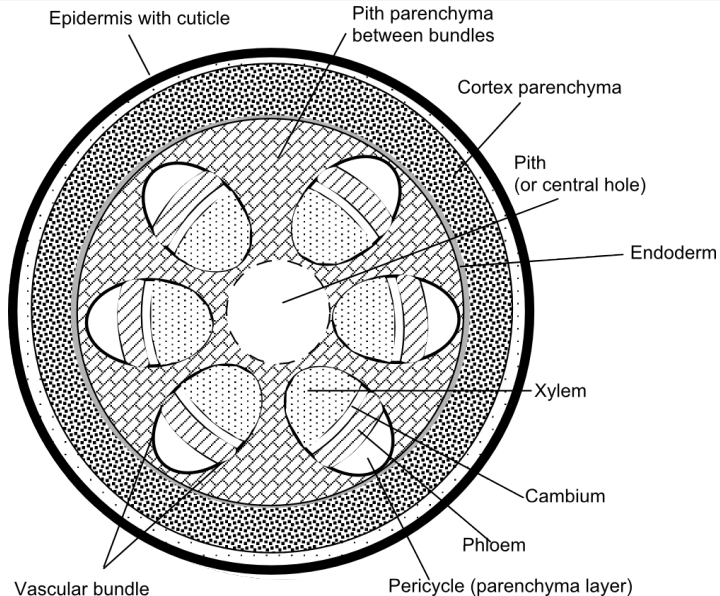


Shoot

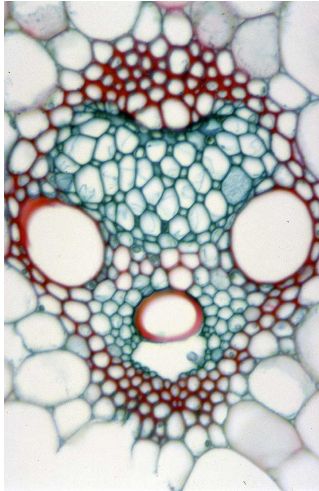
Anatomy of the primary stem



Primary structure of stem



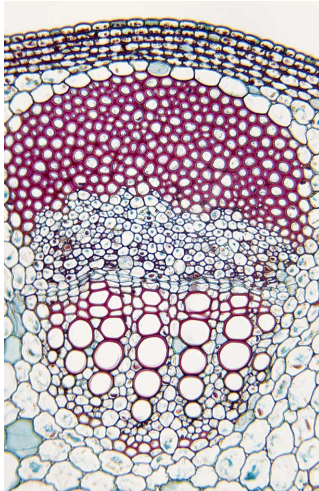
Vascular bundle (monocot)



Corn (*Zea mays*) mature stem cross-section showing single vascular bundle, Brightfield (LM ×400)



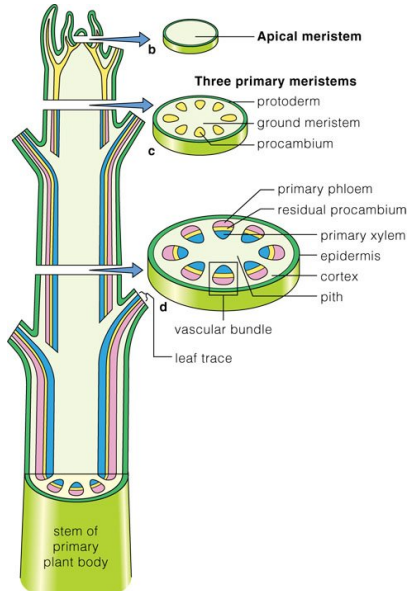
Vascular bundle (asterid)



Wild Sunflower (*Helianthus* sp.) with nearly mature vascular bundle
(LM $\times 35$)



Origin of vascular bundles

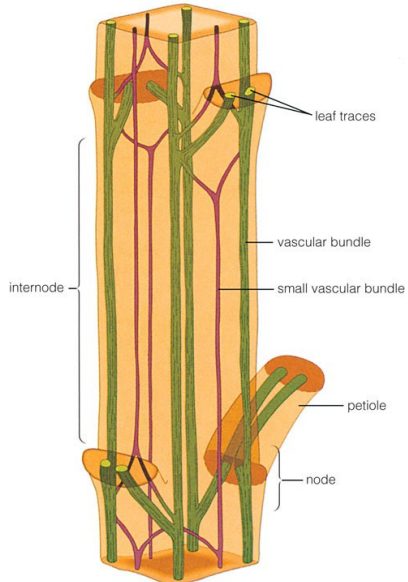


Vascular bundles

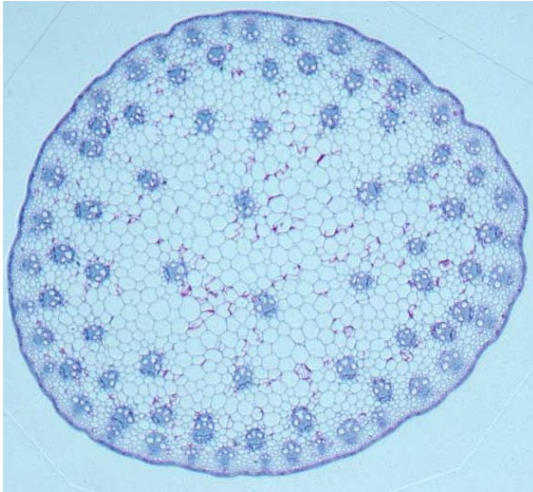
- Vascular bundles connect leaves and stems
- In many plants, they form **ring** on the cross-section of stem (“dicot” stem)
- Monocot stems usually have **dispersed** vascular bundles



Vascular bundles and leaf traces



Monocot stem



Corn (*Zea mays*) stem (LM $\times 4$)

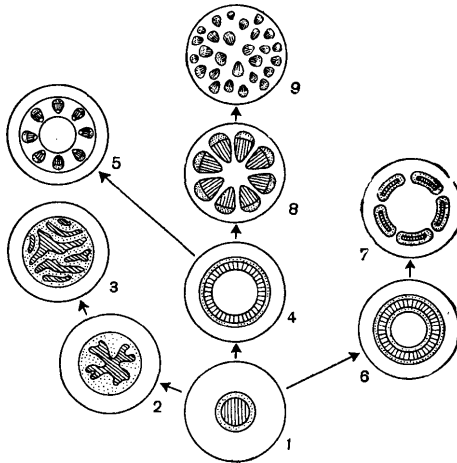


Steles

- **Stele** is an overall configuration of primary vascular system of plant stem
- The most important kinds of steles are: **protostele**, **solenostele**, **eustele** and **ataktostele**



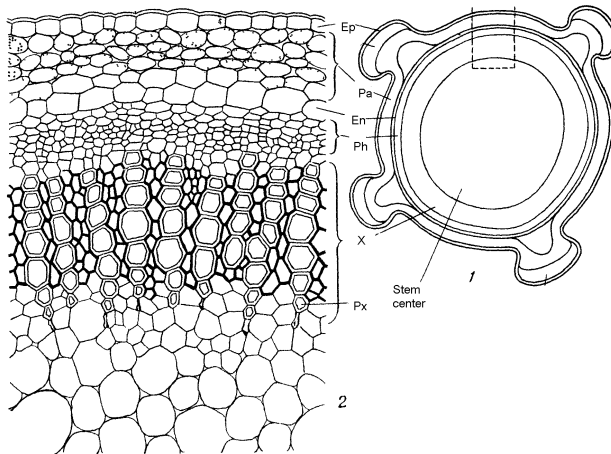
Diversity of steles



(1) is protostele, (4) solenostele, (8) eustele (“dicot” stem), (9) atactostele (monocot stem)



Vascular cylinder: alternative to ring of bundles



Sometimes, vascular bundles are so dense that they form almost a cylinder. We may call this vascular cylinder “solenostele” (#4 on the scheme of steles)



Shoot

Components of shoot

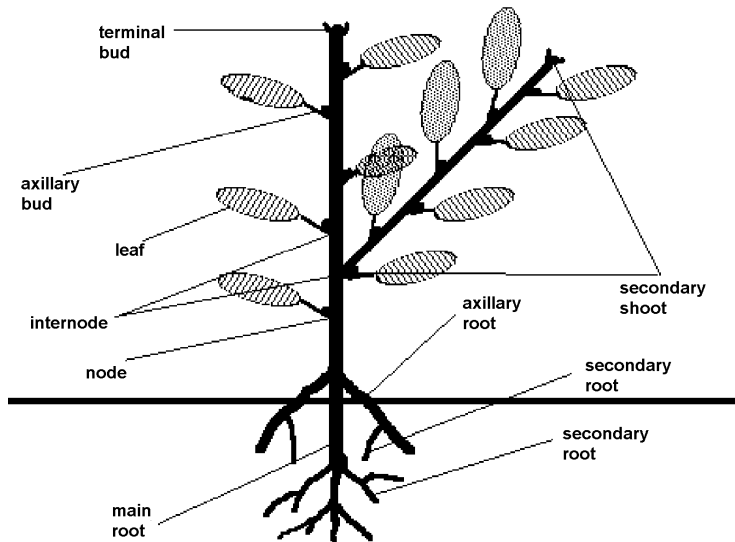


Components of vegetative shoot system

- A Main and secondary shoots
- B Terminal and axillary (lateral) buds
- C Nodes and internodes
- D Leaves



Components of shoot



Shoot Phyllotaxis



Arrangement of leaves: phyllotaxis

- One leaf per node: **spiral**, or **alternate** arrangement
- Two leaves per node: **opposite** arrangement, they may be:
 - All in same plane
 - Each pair will rotate on 90°
- > 2 leaves per node: **whorled** arrangement (each whorl can also rotate)
- Each type of phyllotaxis has its own *angle of divergence*



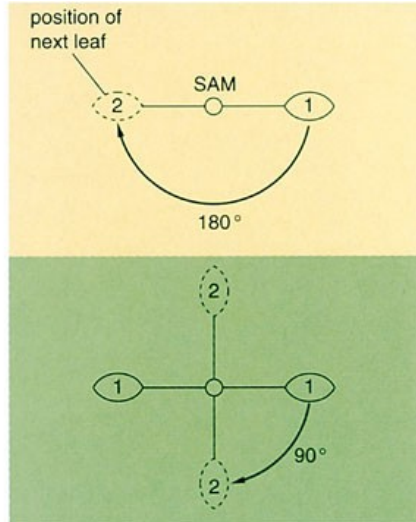
Alternate and opposite phyllotaxes



alternate



opposite



Spiral phyllotaxis: Fibonacci rule

- Multiple types of leaf spiral leaf arrangement mostly follow **Fibonacci rule**
- Formulas of leaf arrangements is very similar to Fibonacci fractions: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, *et cetera*
- Numerator is number of spiral circulations, denominator is number of leaves in a series (counted from zero)
- Denominator gives the number of **orthostychy** (this is plural)

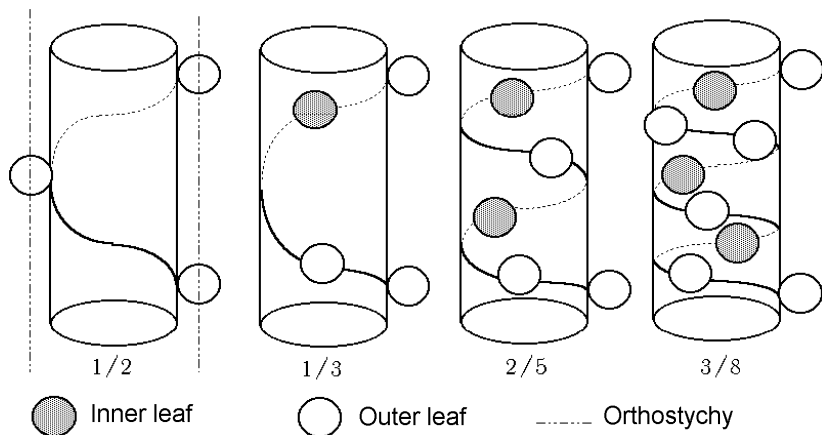


Spiral phyllotaxis: how to make a formula

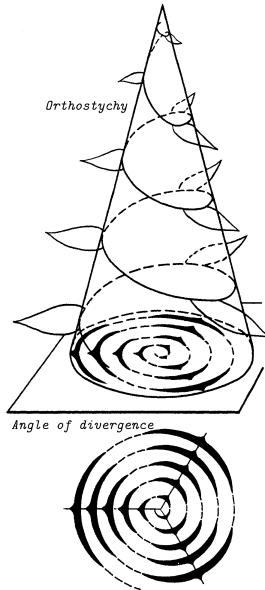
- Take a branch, find any leaf (it will be leaf #0)
- Find the second one which is located in the same position (exactly above or exactly below leaf #0)
- Count how many leaves are in this series (start from 0), this will be a denominator
- Imagine (or use a real thread) a spiral which go from leaf #0 to the last leaf of series, count how many times this spiral circulate the stem—this is a numerator



Spiral phyllotaxis: orthostychy



Spiral phyllotaxis: angles of divergence for $1/3$



Final question (2 points)



Final question (2 points)

What is procambium?



For Further Reading



A. Shipunov.

Introduction to Botany [Electronic resource].

Mode of access:

http://ashipunov.info/shipunov/school/biol_154

