Introduction to Botany

Alexey Shipunov

Minot State University

Lecture 20

Outline

MINOT STATE UNIVERSITY

Tissues
Origin of tissues

Origin of tissues and organs of plants: first steps

Origin of tissues and organs of plants: first steps

Why did plants go to the land? Which problems did they meet and how did they resolve them? What was the plant way of acquiring tissues comparing with animals?

Tissues
Tissues basics

Definition of tissues and organs

- **Tissue** is a union of cells which have common origin, function, and similar morphology
- **Organ** is a union of different tissues which have common function(s) and origin

Simple and complex tissues

- **Simple tissues** have only one kind of cells
- **Complex tissues** have more than one cell type. This tissue type is unique for plants

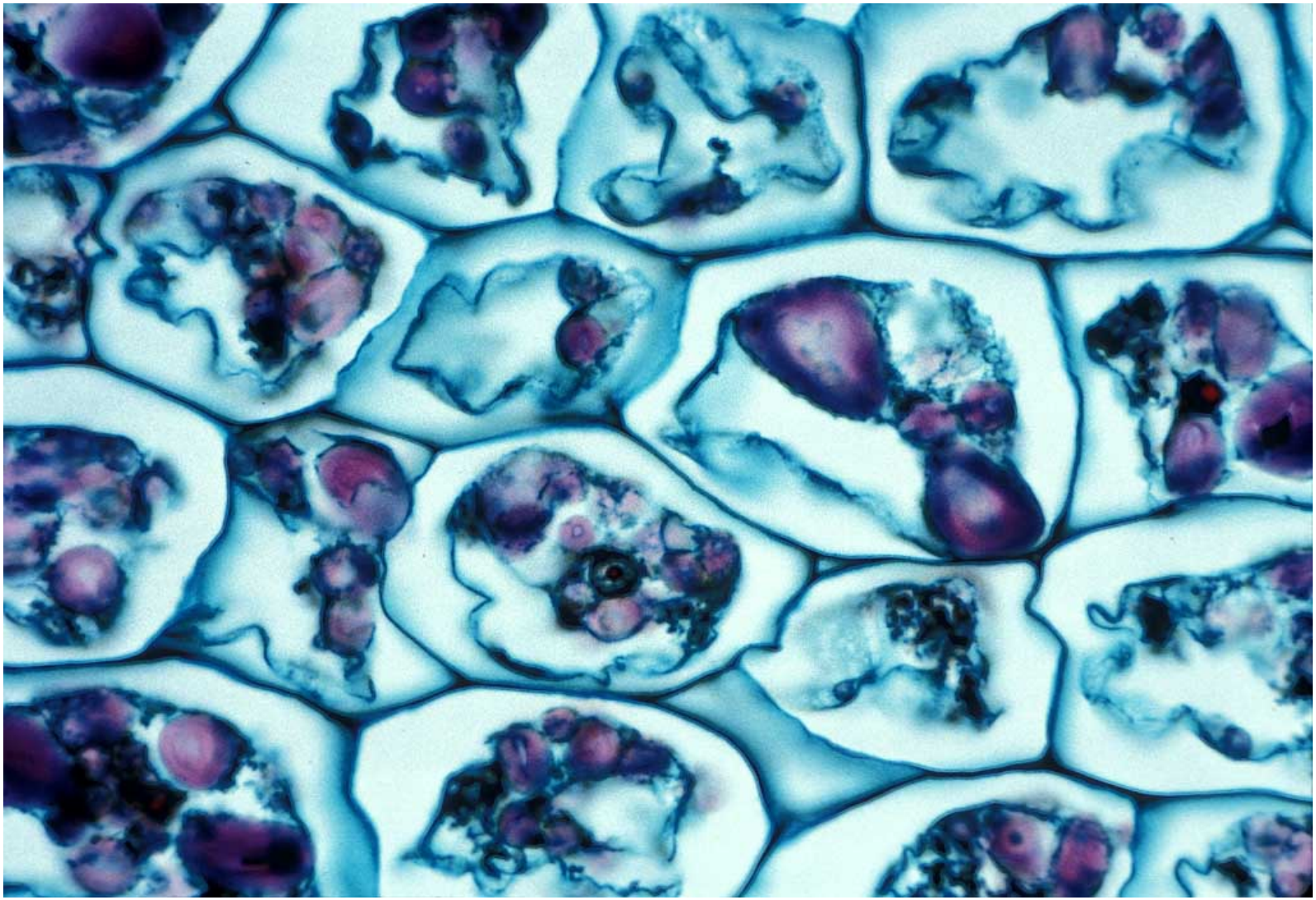
Tissues

First tissues: parenchyma and epidermis

Parenchyma (ground, main tissue)

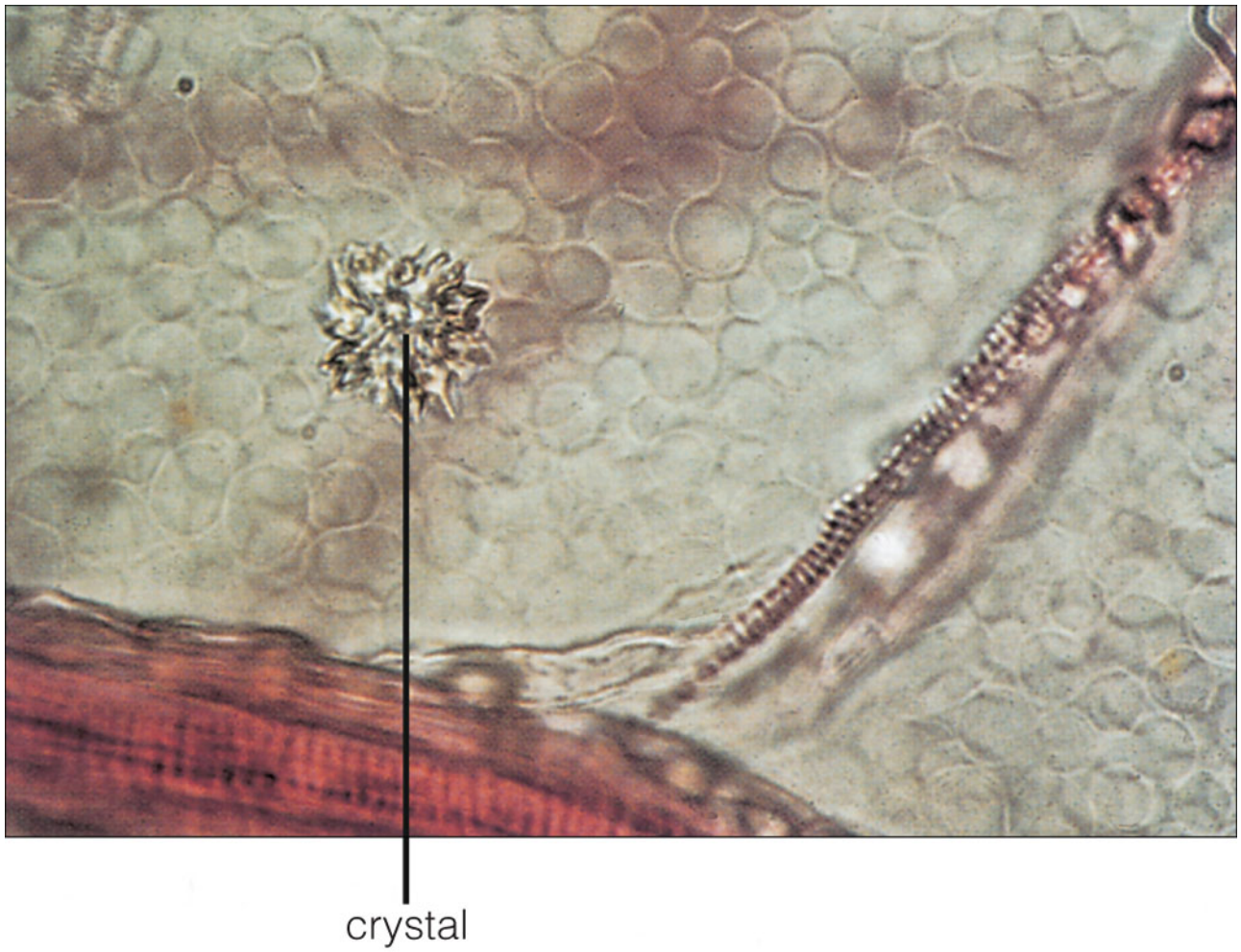
- Spherical or elongated cells
- Thin primary cell wall
- Sometimes, crystal inclusion bodies
- Main functions: photosynthesis and storage

Parenchyma cells of a potato



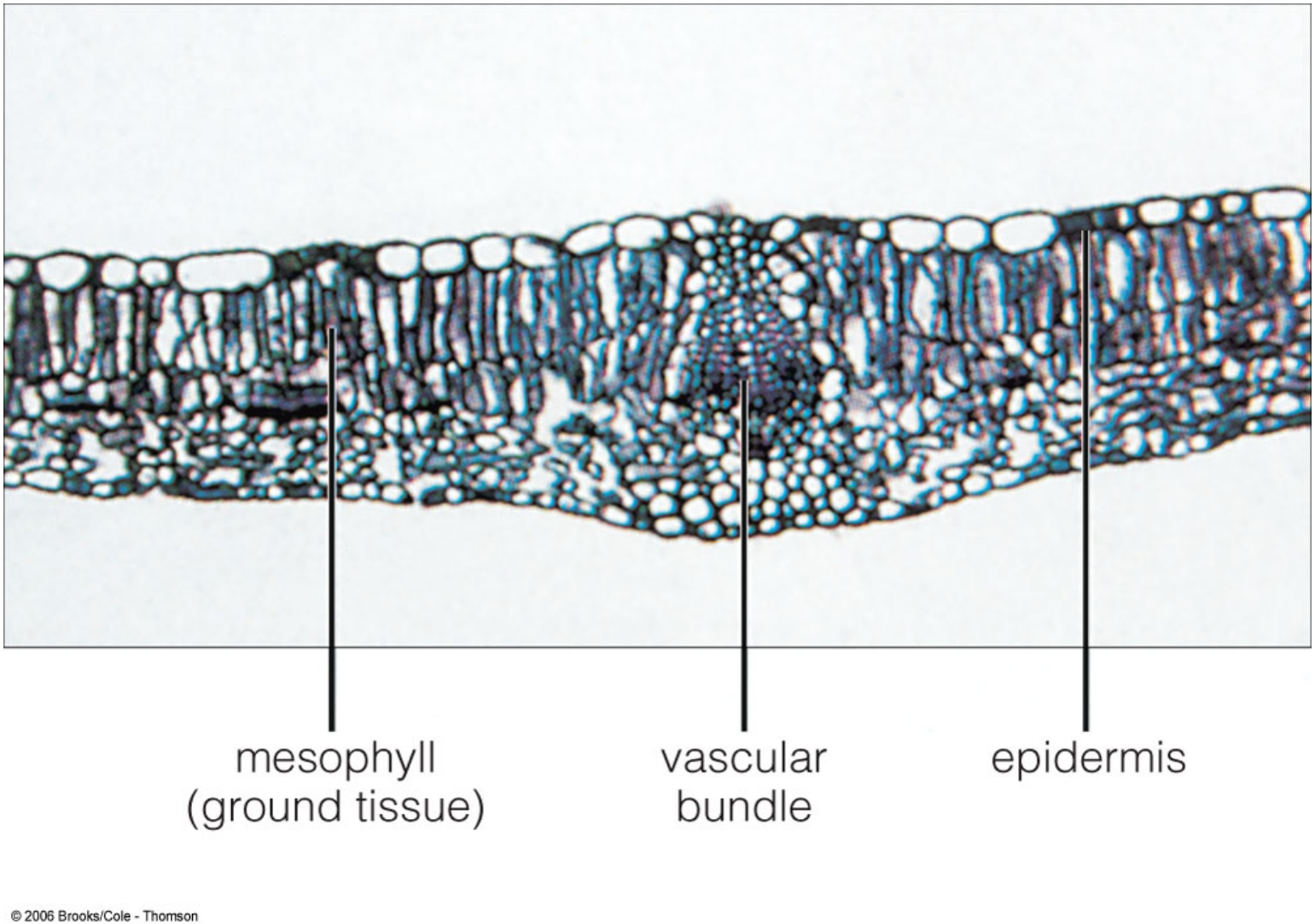
Parenchyma cells of a potato; the central cell shows obvious nucleus with starch stained purple (LM $\times 83$)

Parenchyma with crystals



Parenchyma cells often include crystals (e.g., of calcium oxalate)

Photosynthetic parenchyma

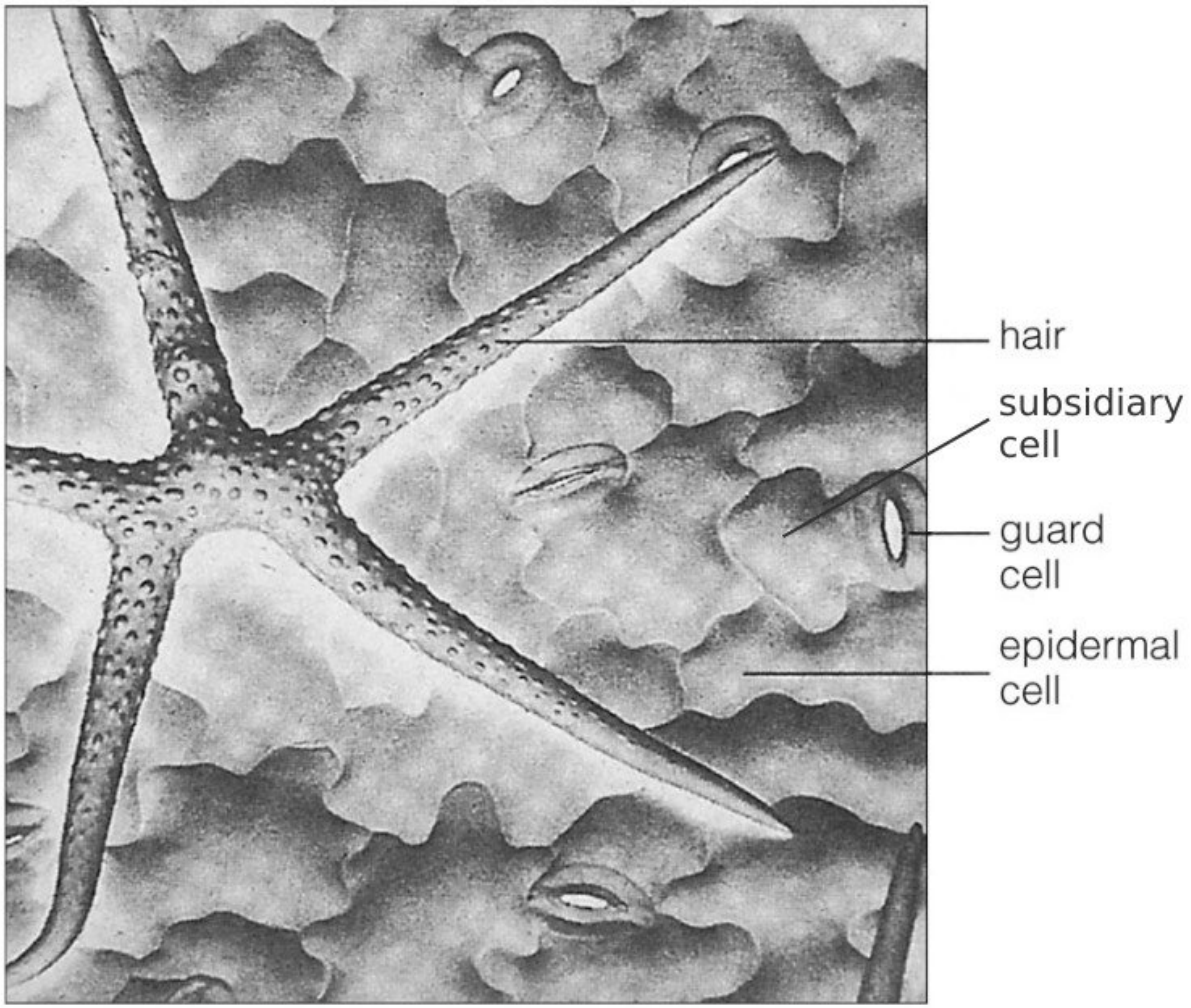


Photosynthetic parenchyma (mesophyll) in lilac (*Syringa vulgaris*) leaf

Epidermis: the complex tissue

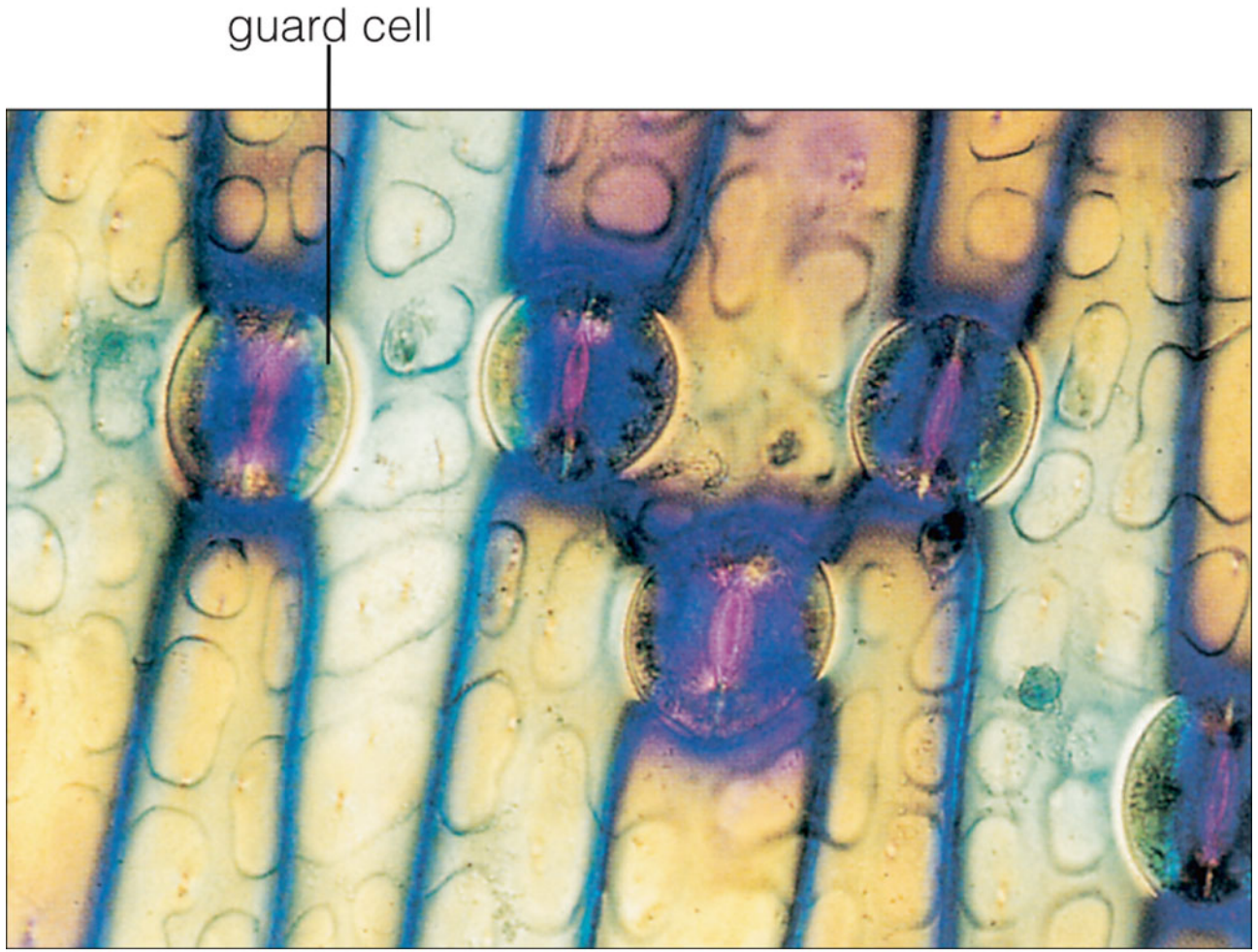
- Complex tissue of different cell types:
  - A Epidermal cells
  - B Stomata cells:
    - Guard cells
    - Subsidiary cells
  - C Trichomes
- Shapes and chemical compounds vary
- Main functions: gas exchange, transripration, defense

Epidermal cells



Three kinds of Shepard's purse (*Capsella bursa-pastoris*) epidermal cells

Stomata



Stomata with guard cells and pores (*Iris* sp.)

More about plants$_2$ classification

- Mosses (Bryophyta)
- Ferns and allies (Pteridophyta)
- Seed plants (Spermatophyta)
  - Conifers (Pinopsida)
  - Some other classes of seed plants
  - Angiosperms (Magnoliopsida)
    - Monocots (Liliidae)
    - Other subclasses of angiosperms (together: “dicots”)

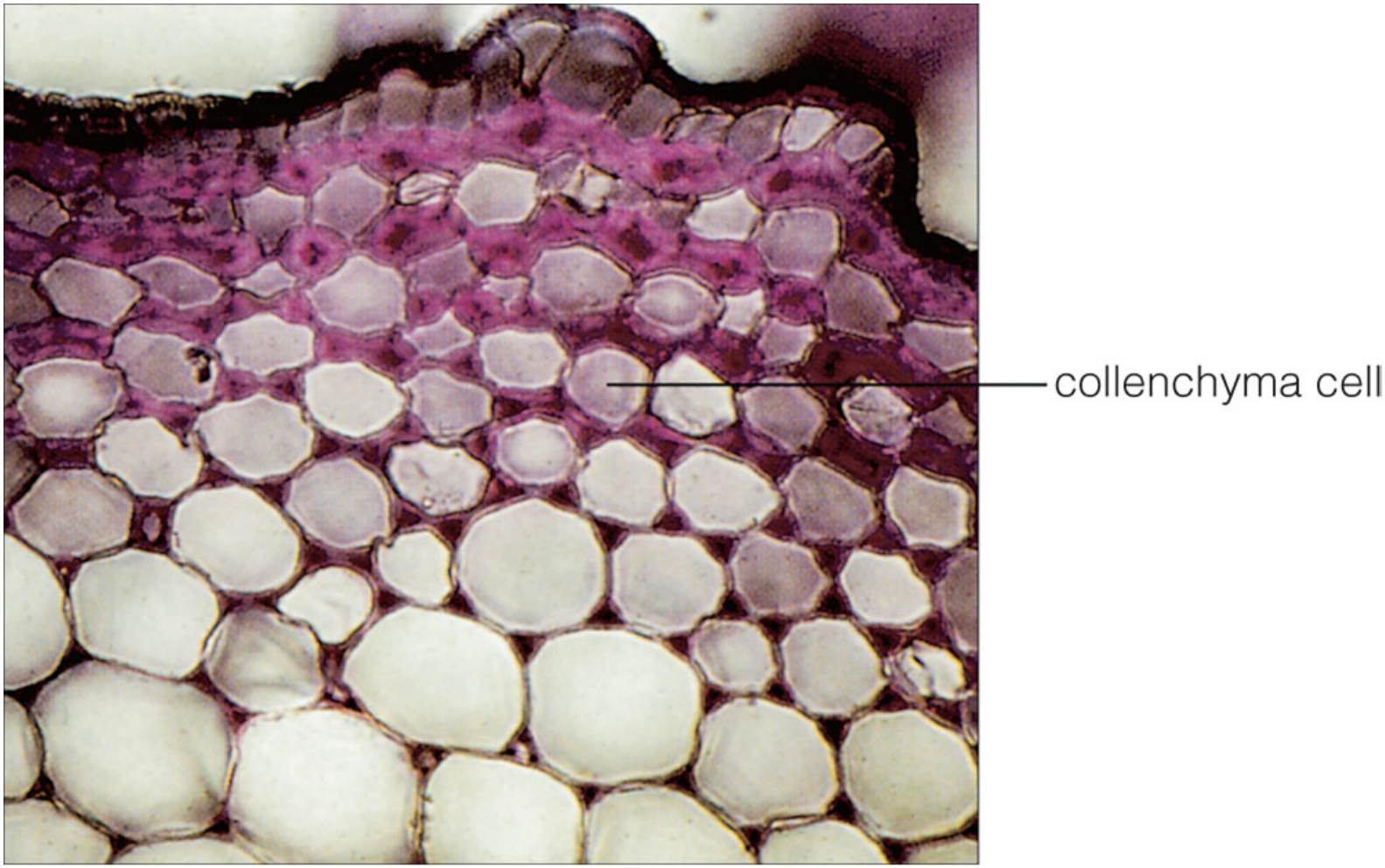
Tissues

Step two: skeleton. Supportive tissues

Collenchyma: living supportive tissue

- Elongated cells
- Thick primary cell wall (pectins + cellulose)
- Main functions: mechanical support of young stems and leaves

Angled collenchyma

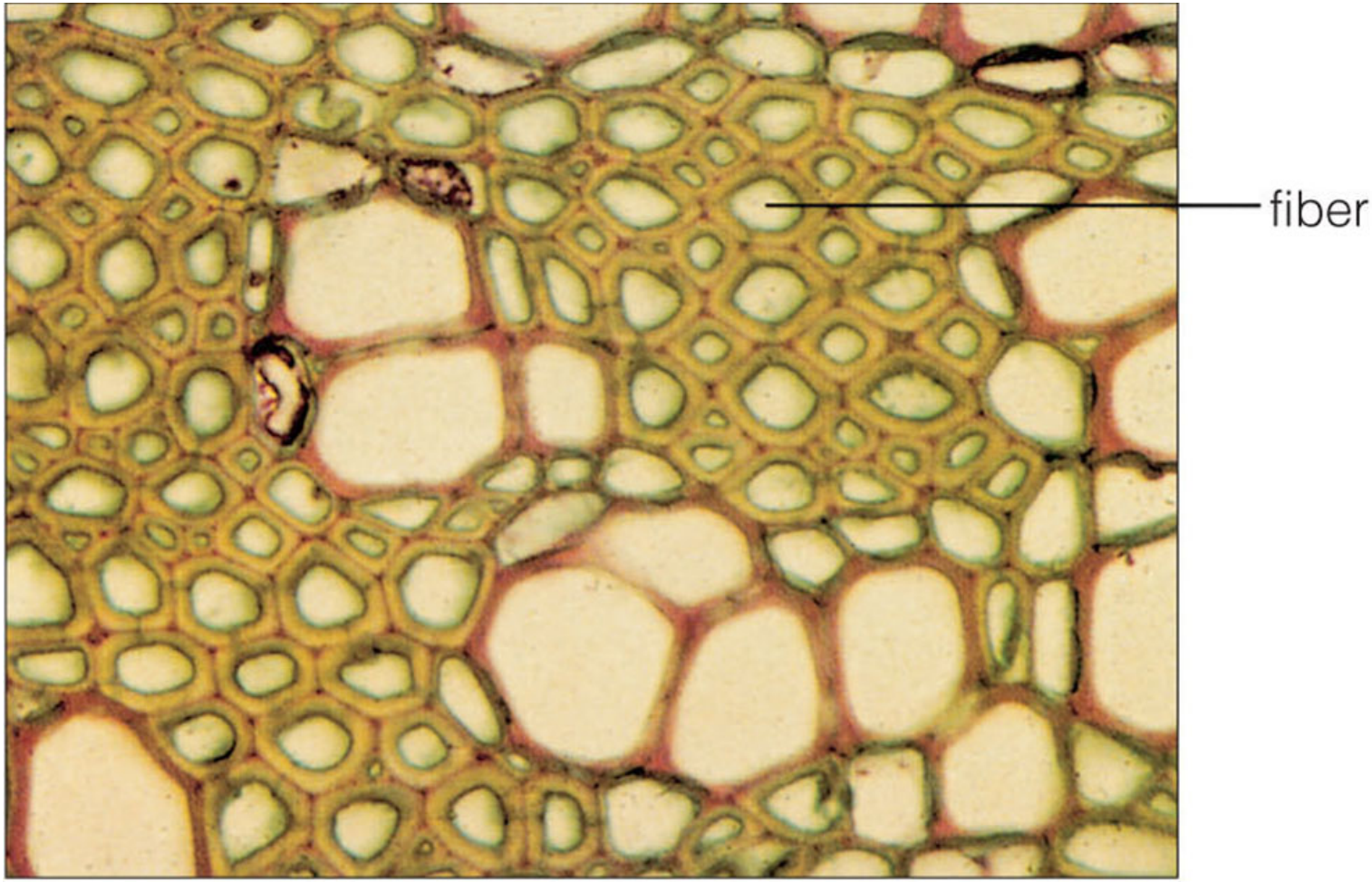


Collenchyma cells of marigold (*Calendula officinalis*)

Sclerenchyma: dead supportive tissue

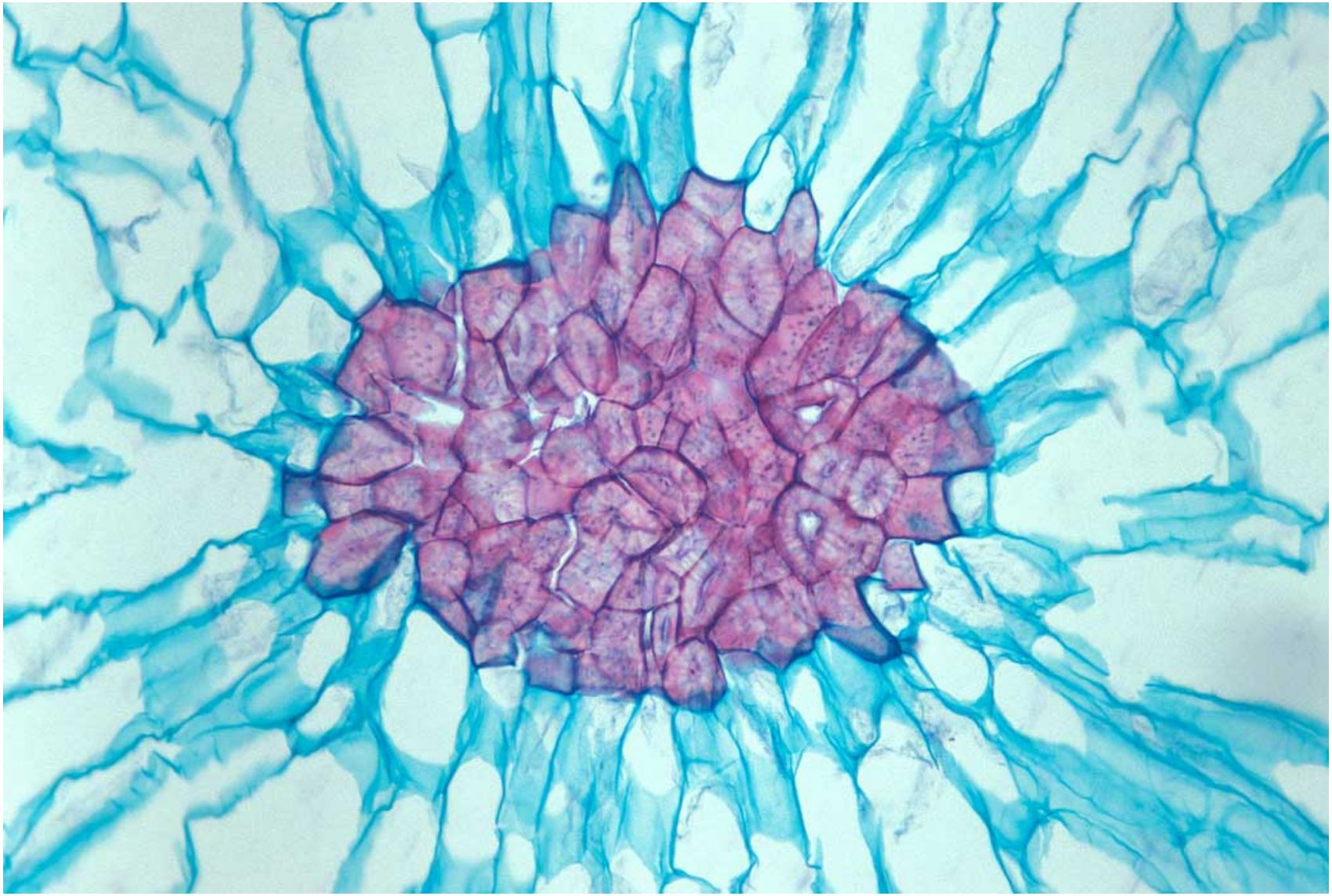
- Long cells (sclerenchyma fibers) or short crystal-like cells (sclereids)
- Dead cells with thick secondary cell wall, rich of lignin
- Supports weight of older plant organs, makes fruits non-edible before they become rip, makes stems firm

Sclerenchyma fibers



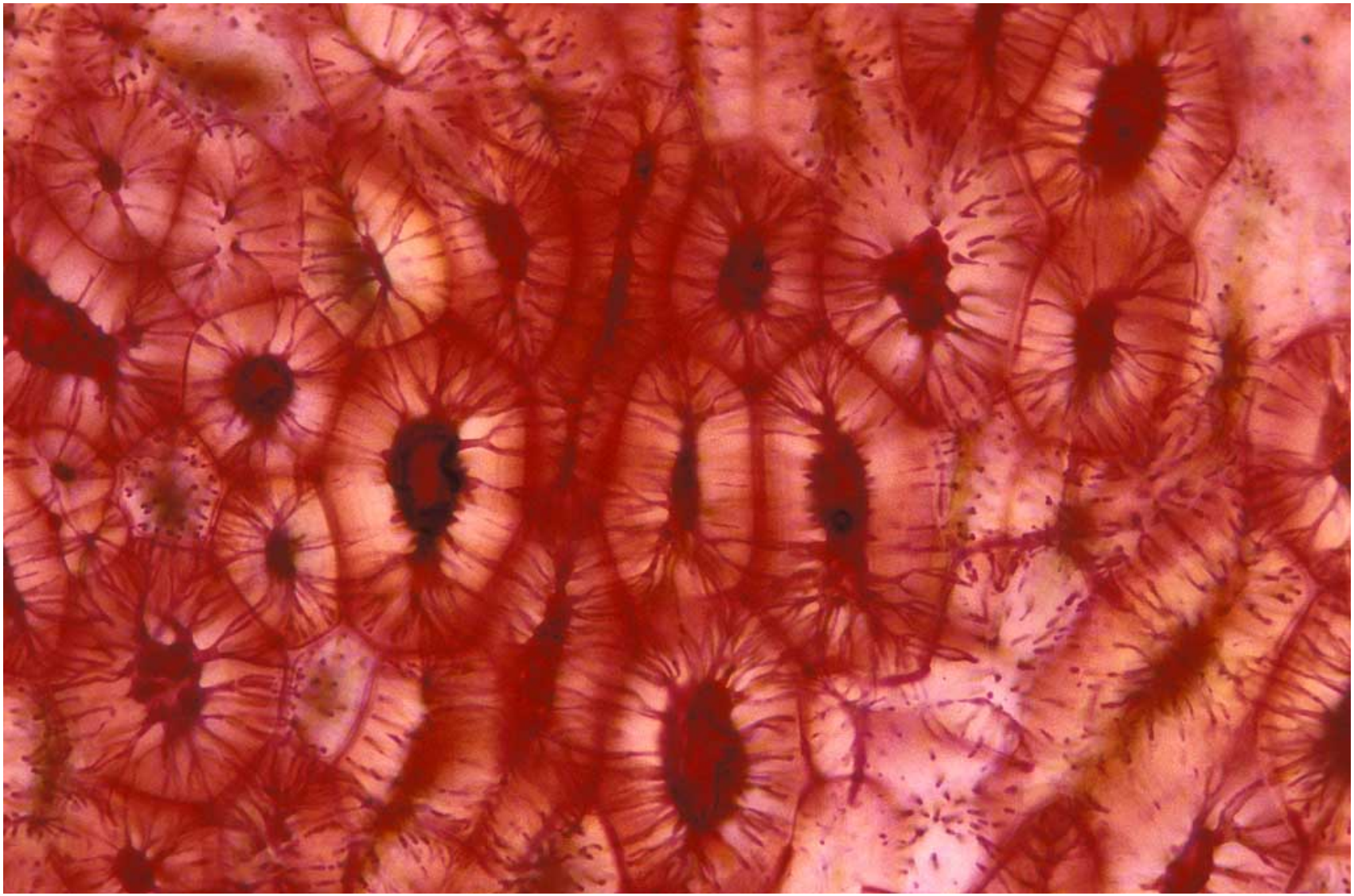
Cross-section of sclerenchyma fibers in geranium (*Pelargonium* sp.)

Stone cells



Stone cells (kind of sclereids) in pear fruit (*Pyrus communis*)

Sclereids from cherry pit



Sclereids from cherry (*Prunus* sp.) pit (LM $\times$400)

Tissues

Step three: construction sites. Meristems

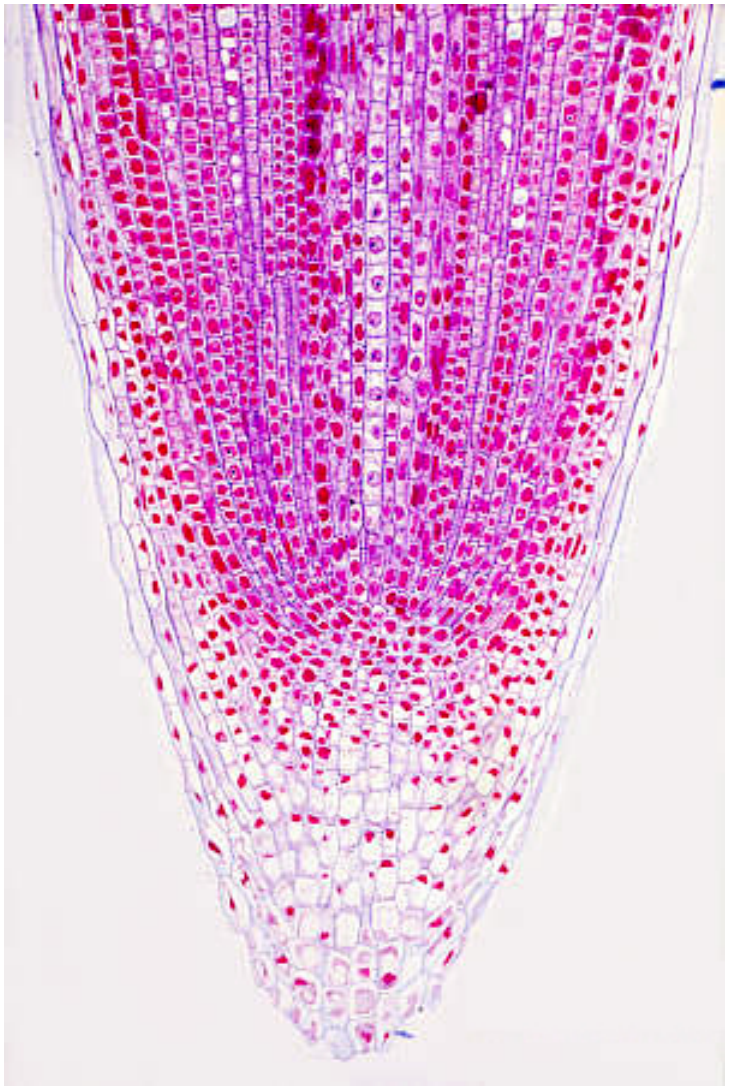
Meristems: apical

- Centers of plant development
- Locate on the very ends of roots (RAM) and shoots (SAM)
- Produce intermediate primary meristems which form all primary tissues

SAM

Coleus sp. stem apical meristem (LM $\times$100); primordia (embryonic leaves) are visible.

RAM



Corn (*Zea mays*) root apical meristem (© D. Webb)

Lateral meristem: cambium

- Originates from procambium which in turn originates from apical meristems
- Usually arises between two vascular tissues
- Main function: thickening. Produces secondary vascular tissues

Primary and secondary tissues

- Primary tissues originate from stem or root apex through primary meristems
- Secondary tissues originate from lateral meristems

Additional meristems

- **Intercalary** meristems: locate in stems, regulates stem elongation
- **Marginal** meristems are leaf-specific, they regulate leaf shape
- **Repair** meristems help to cure wounds, they form buds and roots in unusual places

Tissues

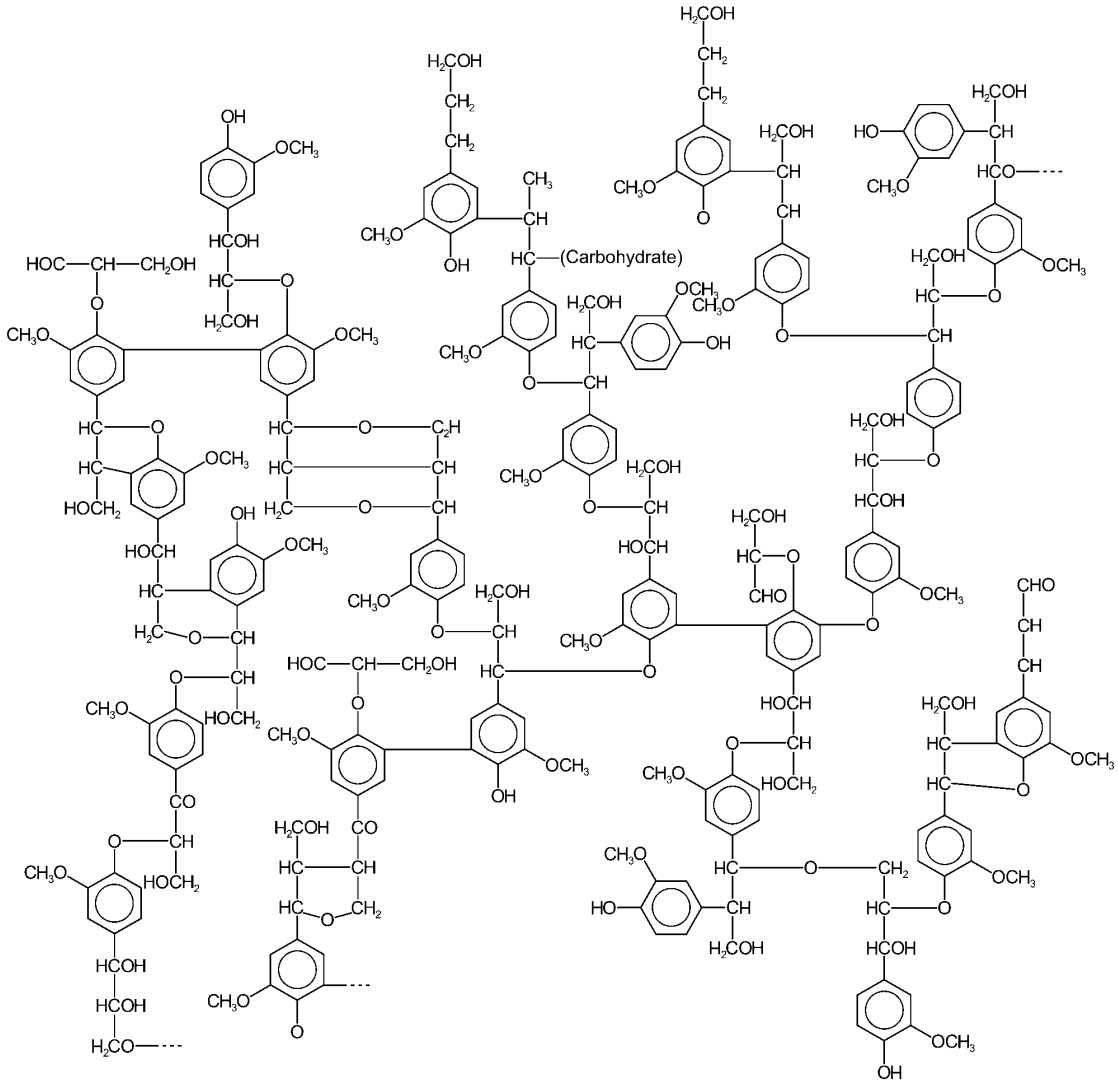
Origin of tissues: the summary

Origin of tissues and organs of plants: first steps

- Plants were pushed on land for many reasons, including competition
- First challenge: drying. Response: **epidermis** and **parenchyma**.
- Second challenge: new level of competition. Response: growing up!
- Problem: big weight. Response: **collenchyma**.
- Competition grows, plants growing even higher. Weight grows. They also need to get rid of turgor dependency. Response: use lignin not only for epidermis surface (cuticle) but also for secondary cell walls—**sclerenchyma**.
- Competition grows again, plants need to grow faster. Solution: **meristems**.
- Size of plant is too big for plasmodesmata transportations. Solution: vascular tissues, **xylem** and **phloem**.

MINOT STATE UNIVERSITY

Lignin



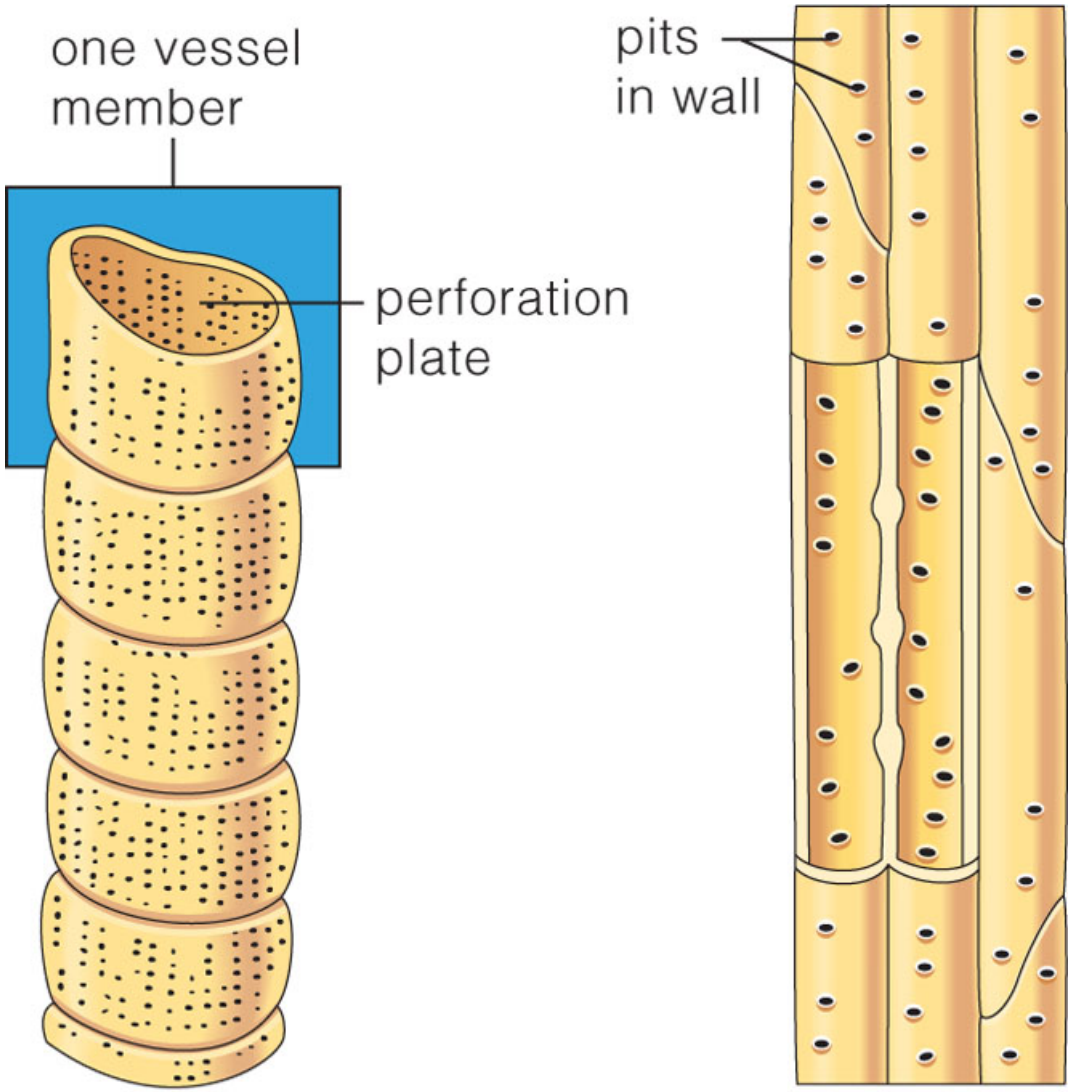
Phenolic and other “plastic” compounds (e.g., lignin) were initially developed for spore distribution with a wind, then used in cuticle, then in the secondary

Tissues
Step four: pipes. Vascular tissues

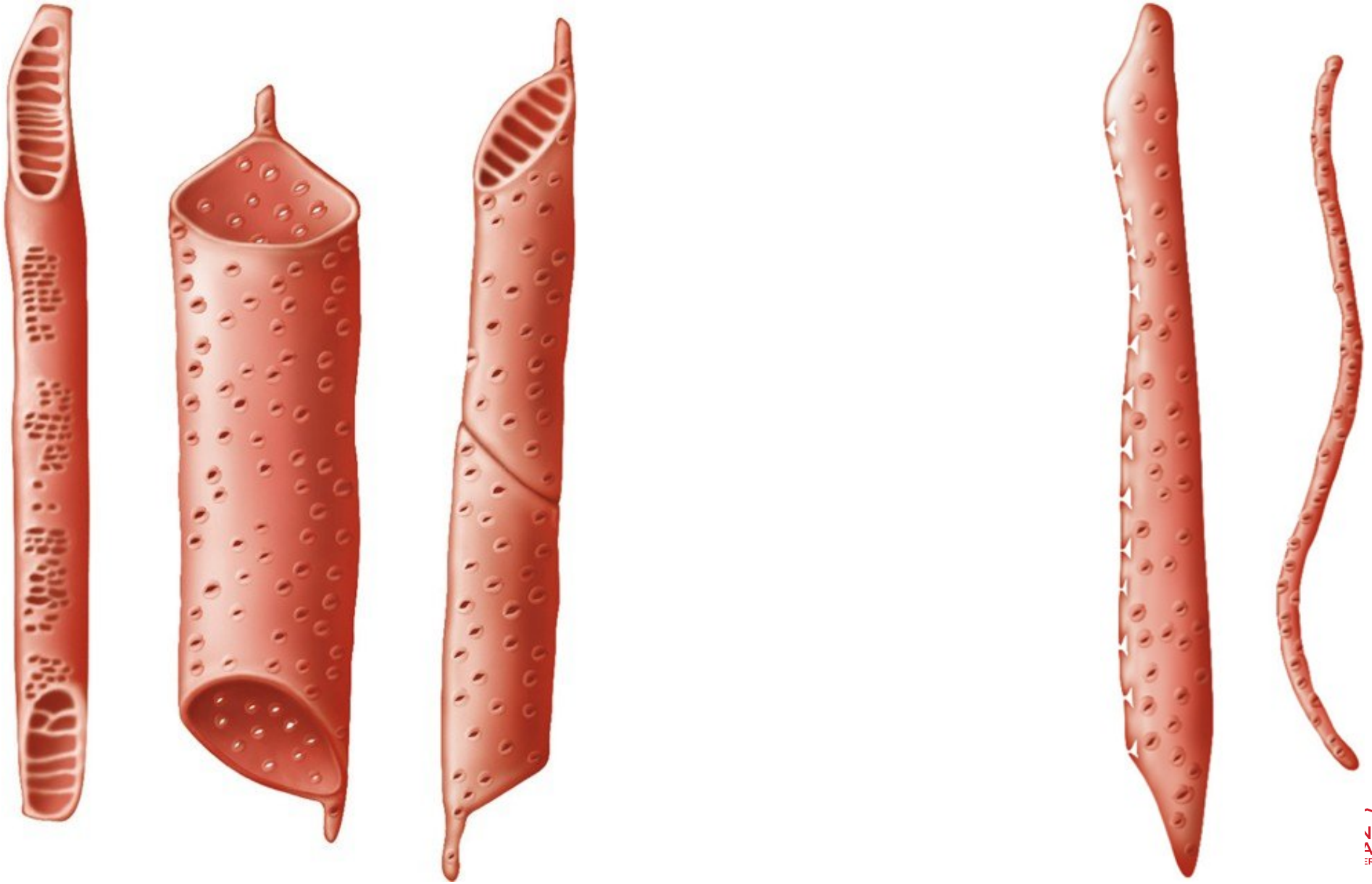
Vascular tissues: Xylem

- Occurs in vascular bundles or vascular cylinder
- Types of cells: **tracheary elements** (tracheids and vessel members), **fibers**, and **parenchyma**
- Tracheids have pits; vessel members have perforations; all of them are dead cells
- Gymnosperms have only tracheids; flowering plants have tracheids + vessel elements together
- In flowering plants, primary xylem has mostly tracheids and vessels with scalariform perforations; secondary xylem has mostly vessels with open perforations
- Xylem elements (except parenchyma) are rich of lignin and are main components of wood
- Main functions: water transport and mechanical support

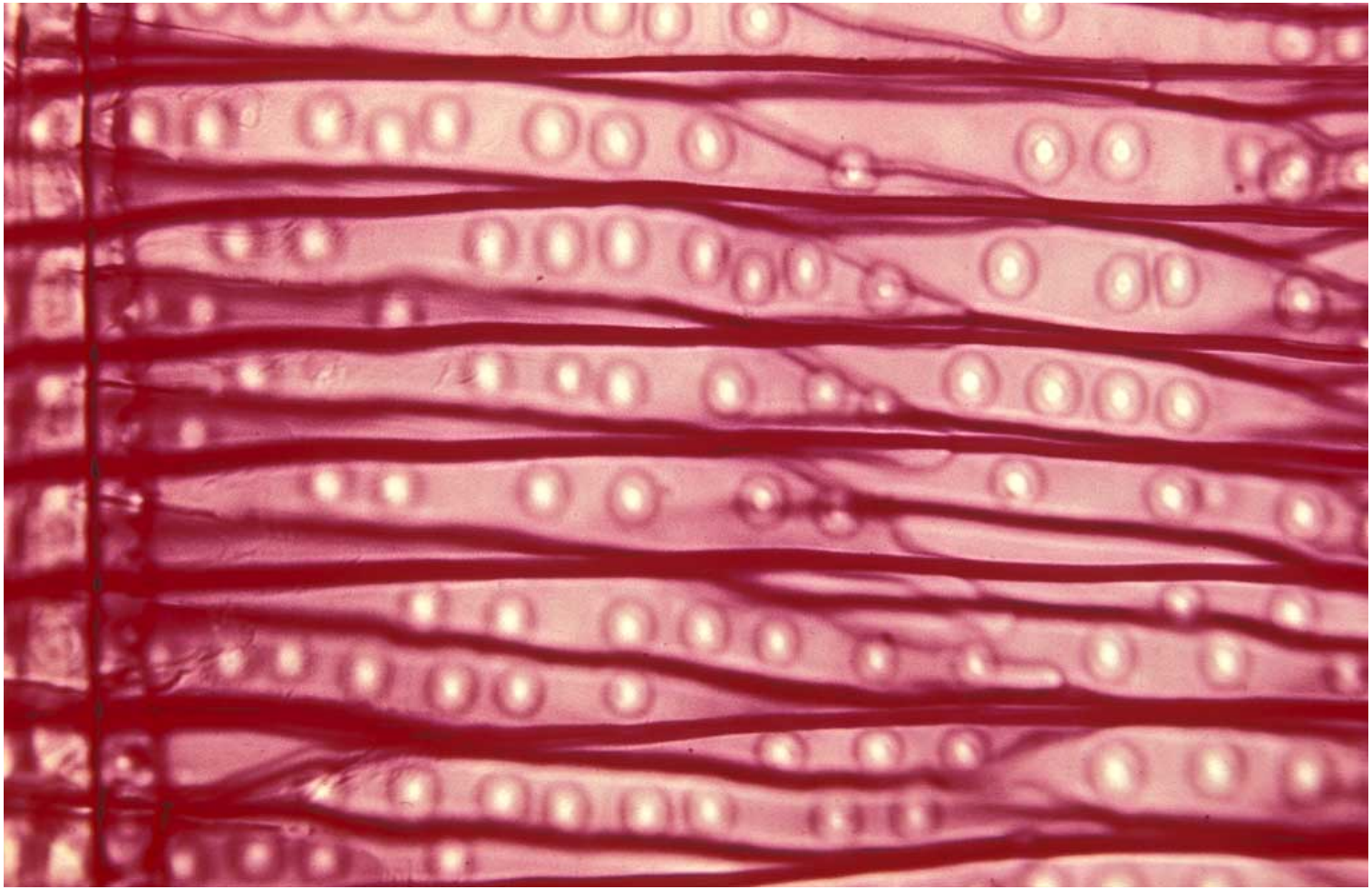
Vessel members vs. Tracheids



Vessel members vs. Tracheids

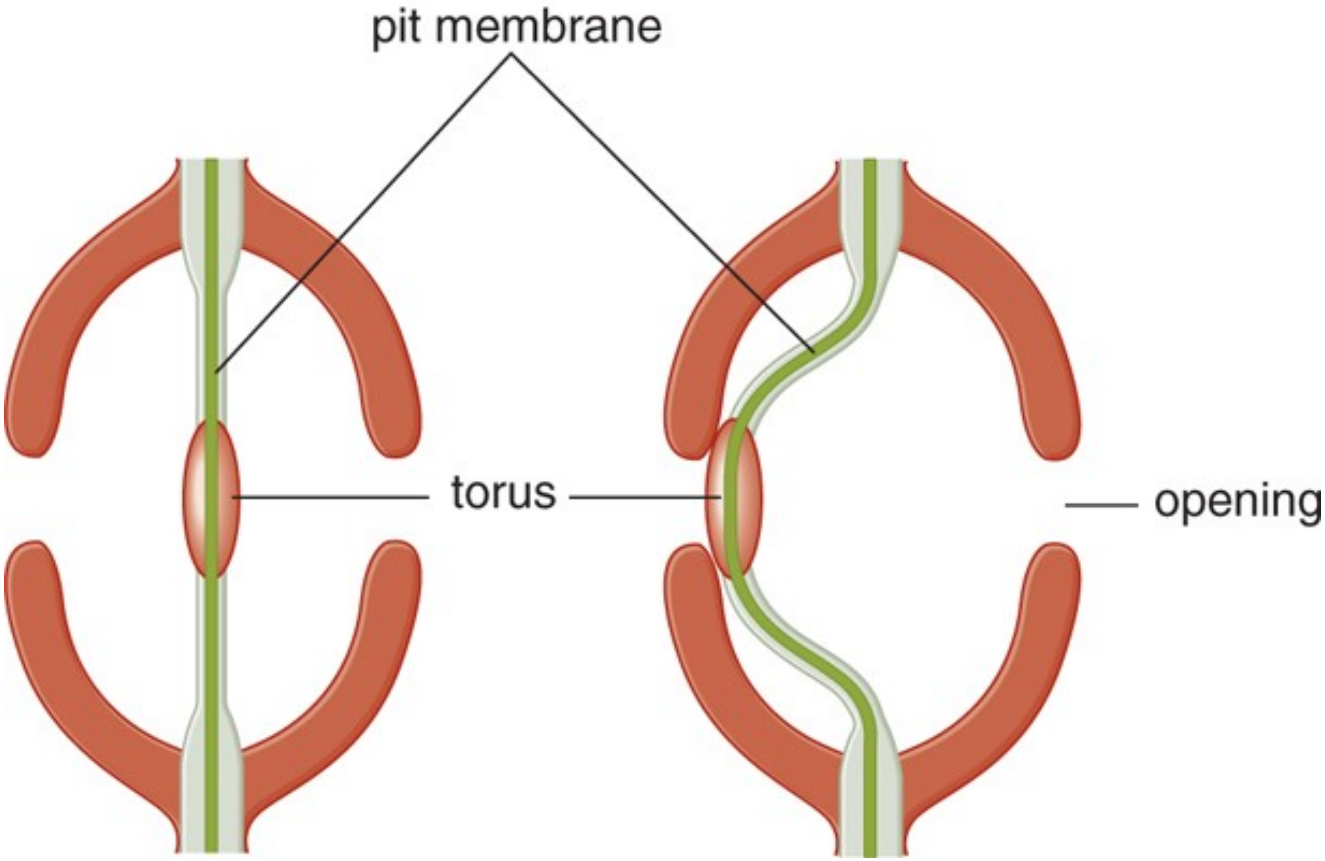


Tracheids



Pine (*Pinus* sp.) tracheids with pits

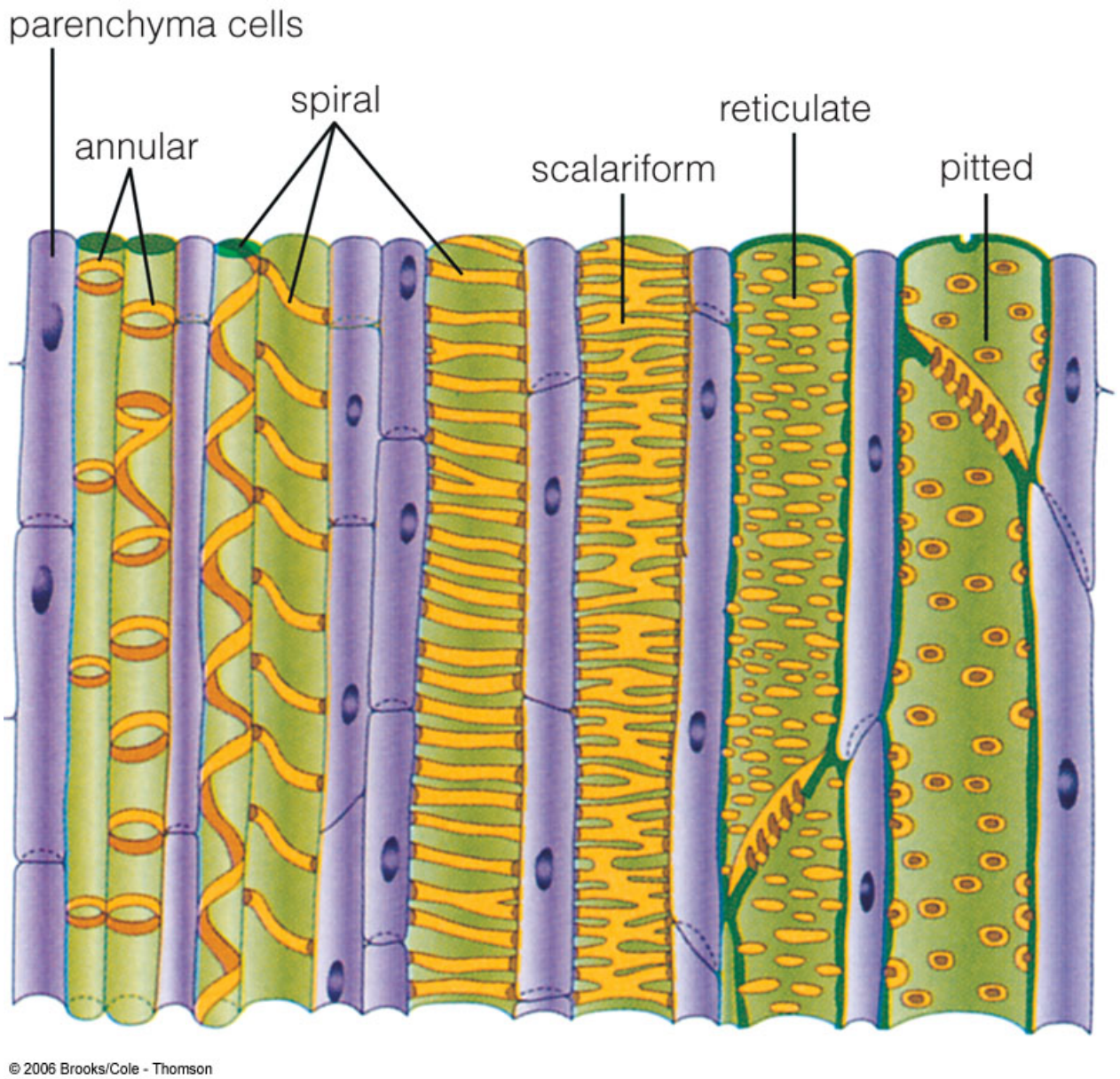
Pit is NOT a direct connection



Vessels

Ash (*Fraxinus americana*) secondary xylem with vessels (LM $\times$26)

Perforations

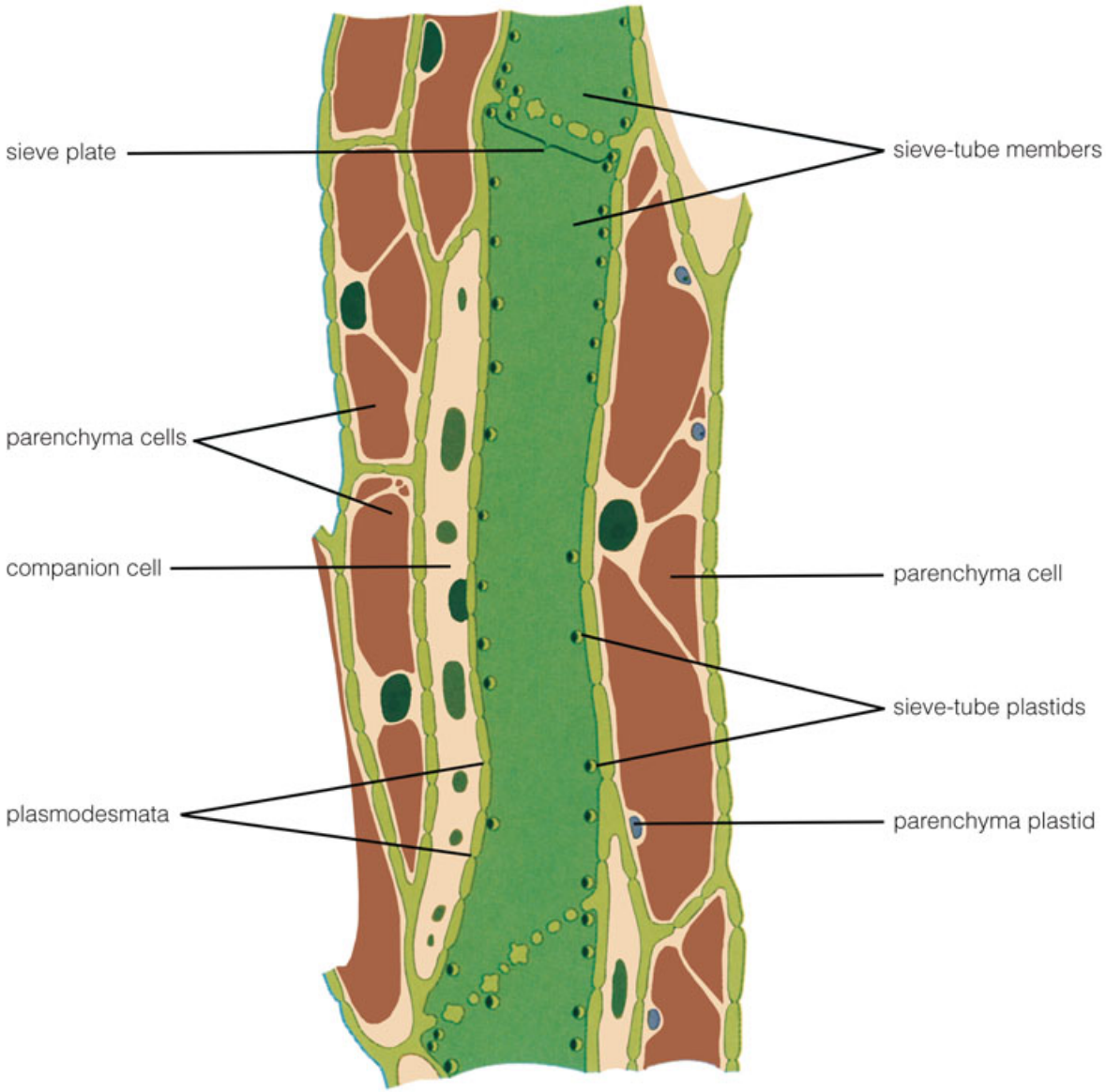


Scalariform perforations: direct connections

Phloem

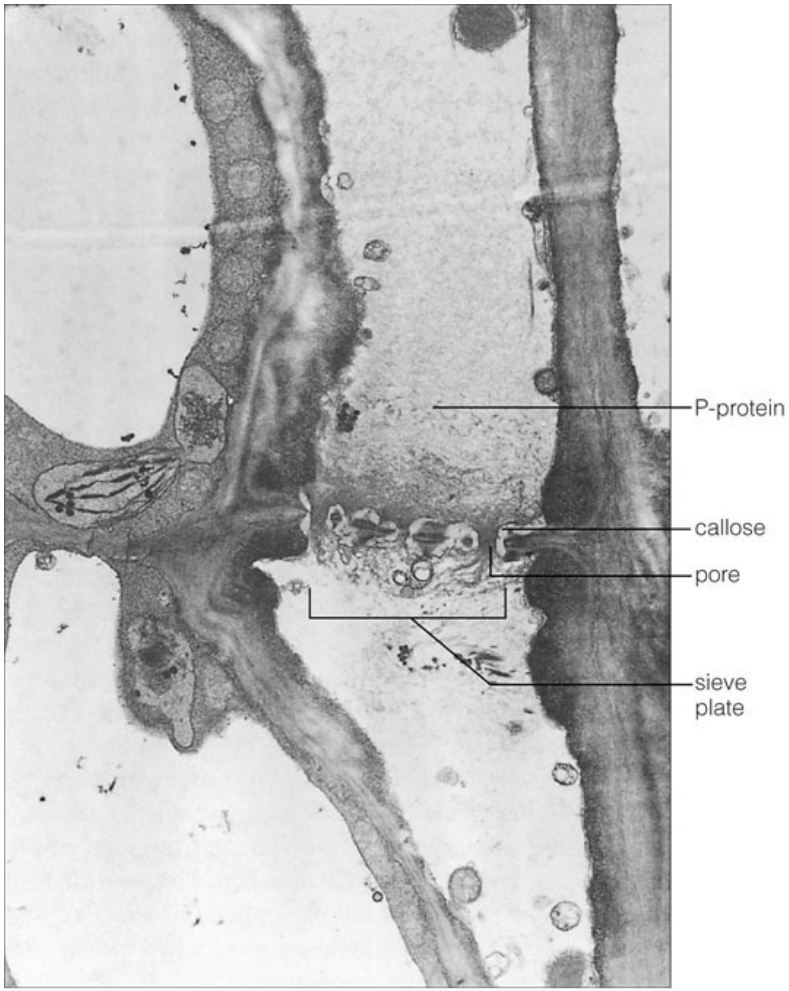
- Usually occurs adjacent to a xylem
- Types of cells: **sieve tube cells**, **companion cells**, **fibers** and **parenchyma**
- Sieve tube cells have plastids and perforation (sieve) plates between cells but no nuclei, companion cells have nuclei
- However, in gymnosperms there are *no* companion cells and sieve tube cells *have* nuclei
- Secondary phloem usually has more fibers than primary phloem
- Main functions: sugar transport and mechanical support

Phloem cell types



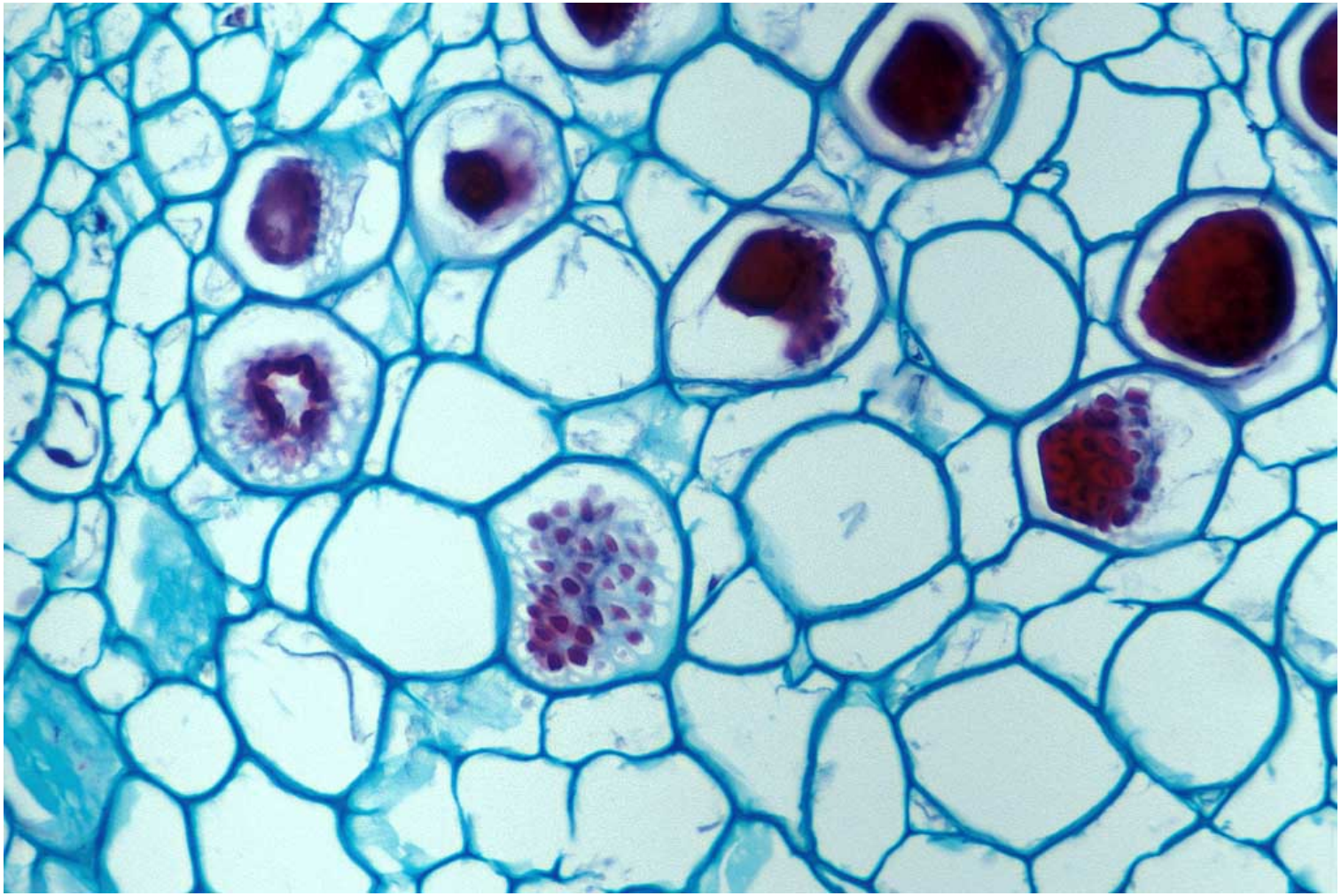
Sieve tubes and phloem parenchyma

Perforation (sieve) plate



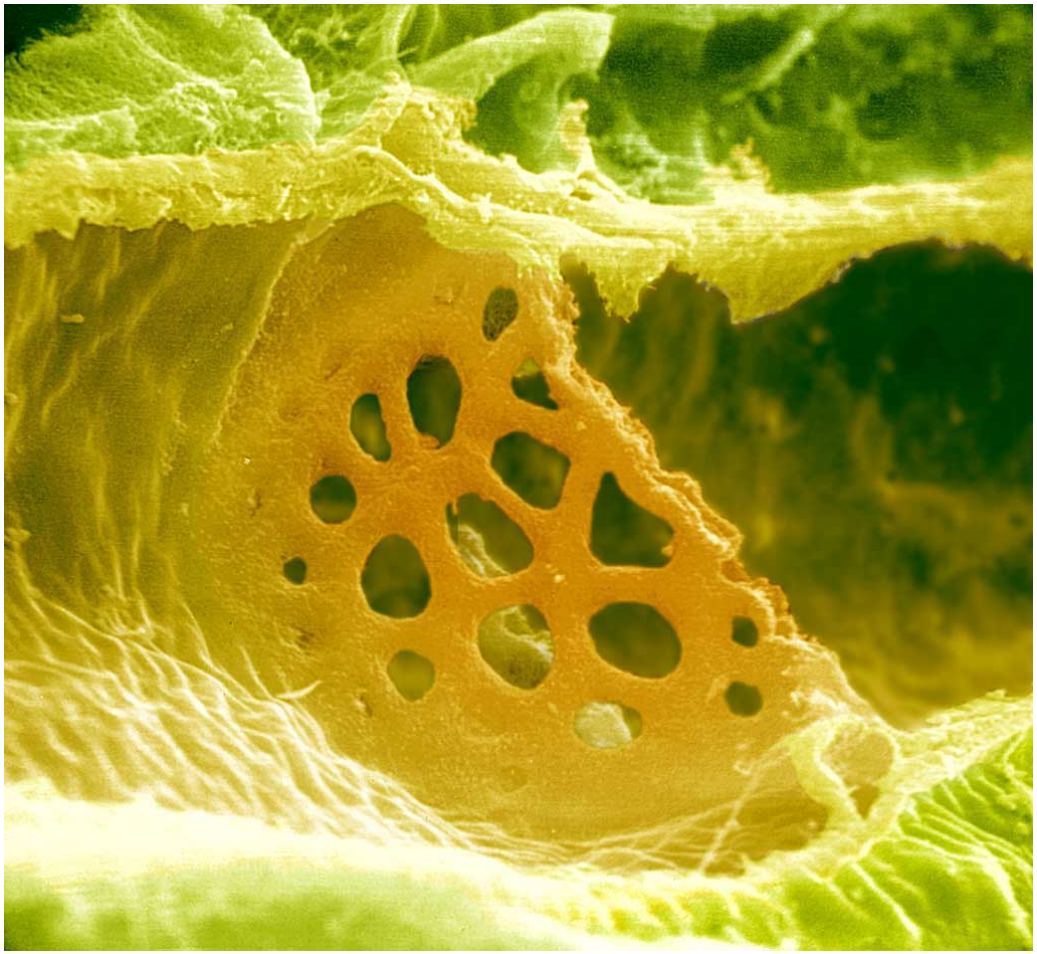
Cross-section (TEM)

Perforation plates: frontal view



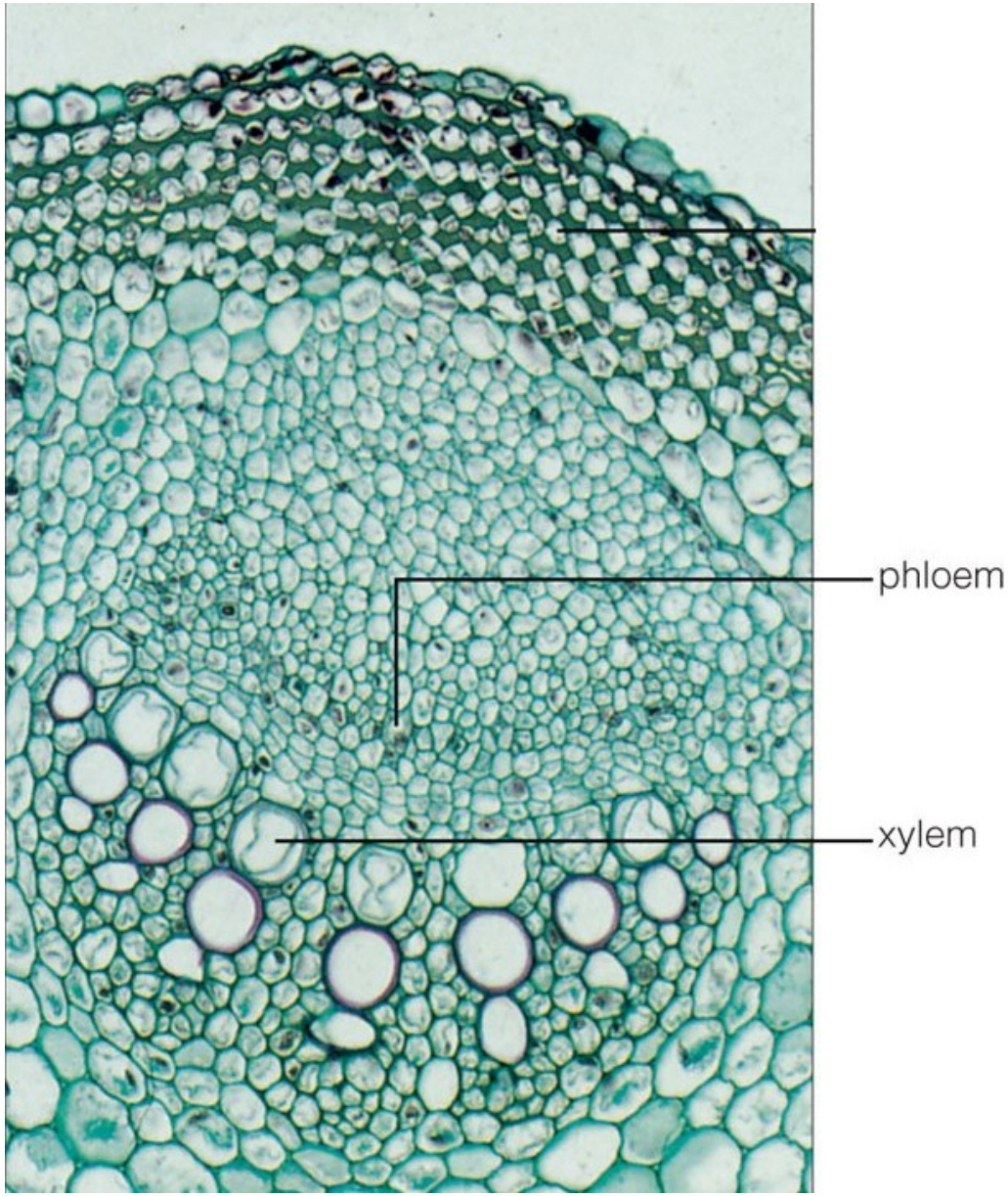
Frontal view (LM)

Plates: pores

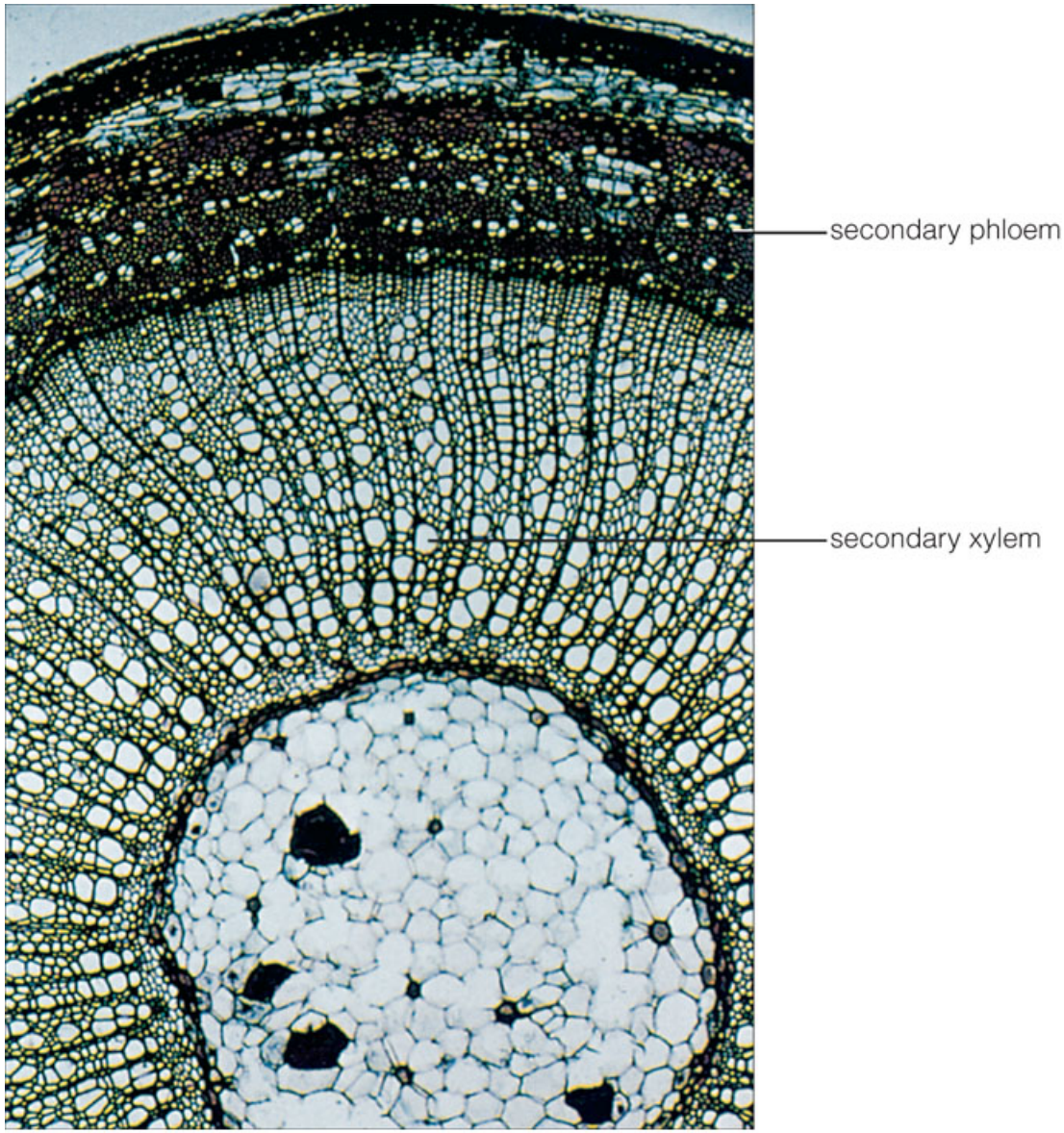


Sieve plate, a pore in the end wall of a sieve-tube member, through which phloem sap flows (SEM $\times$4800)

Primary vascular tissues



Secondary vascular tissues

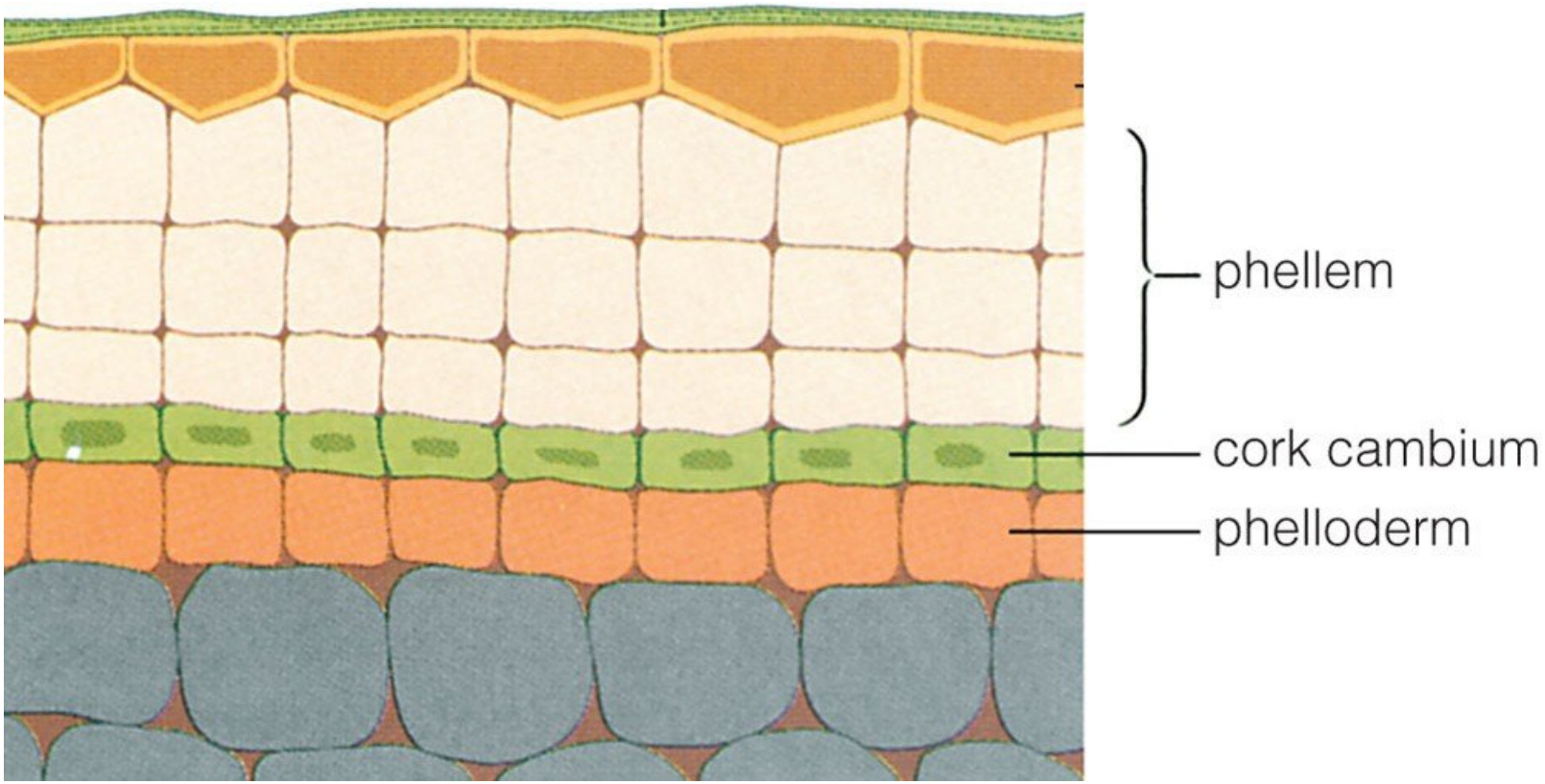


Tissues
Secondary cover: periderm

Secondary dermal tissue: Periderm

- Secondary dermal tissue
- Arises inside the stem ground tissue (cortex), closer to surface
- Complex tissue: includes phellem (cork in the strict sense), cork cambium (phellogen), and phelloderm
- Old periderm includes some other tissues and becomes a bark
- Cells of phellem are dead cells rich of suberin
- Main function is defense

Three cell types of periderm



Cork cambium is another lateral meristem; *phellem* and *phelloderm* are main components of periderm

Tissues

Step five: pumps. Absorption tissues

Poikilo- and homoiohydricity

- **Poikilohydric** plants do not save water, they survive even complete desiccation
- **Homoiohydric** plants save water, they always have similar water content and do not survive after desiccation
- Compare with poikilo- and homoiothermic animals (reptiles vs. mammals)

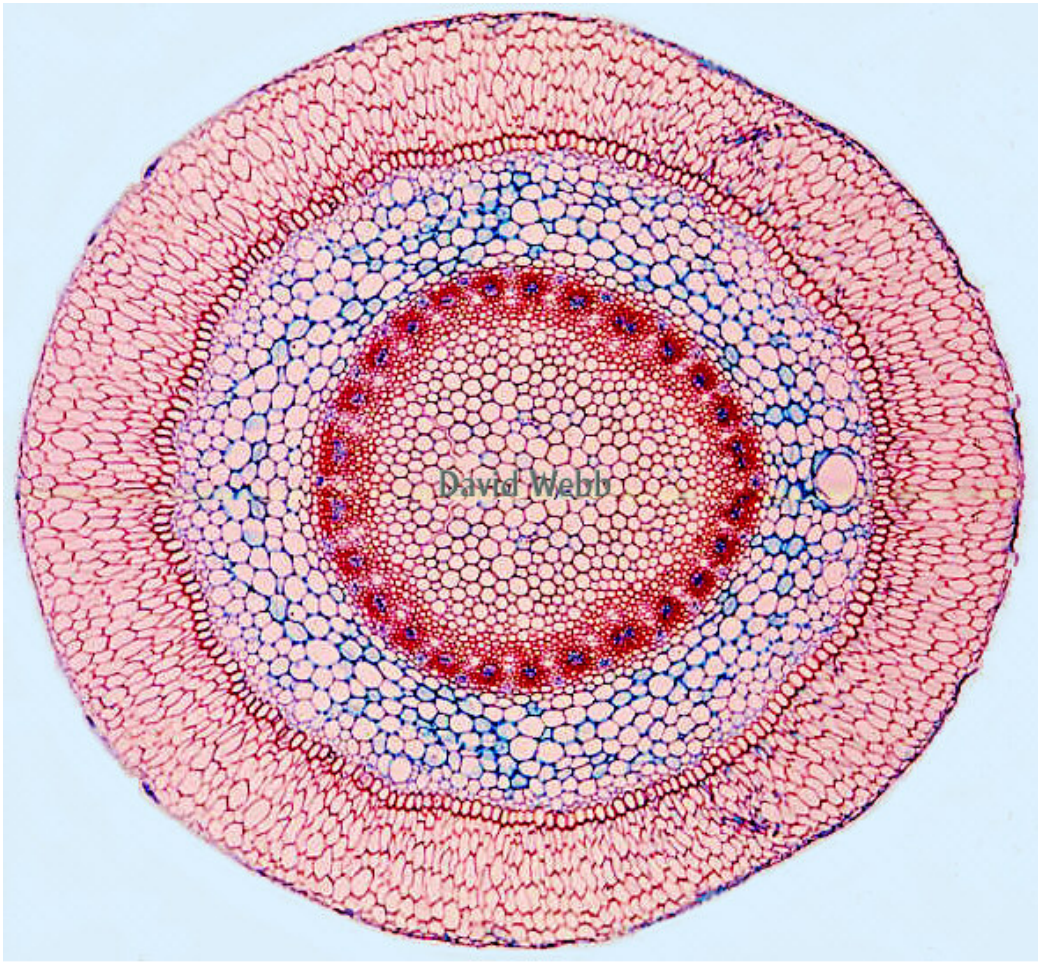
Absorption tissues

- Always primary, simple tissues
- **Rhizodermis**, or root hairs, originates from protoderm, but life span is much shorter than of epidermis
- **Velamen**, originates from root cortex

Rhizodermis

Root hairs of grass seedlings (LM)

Velamen



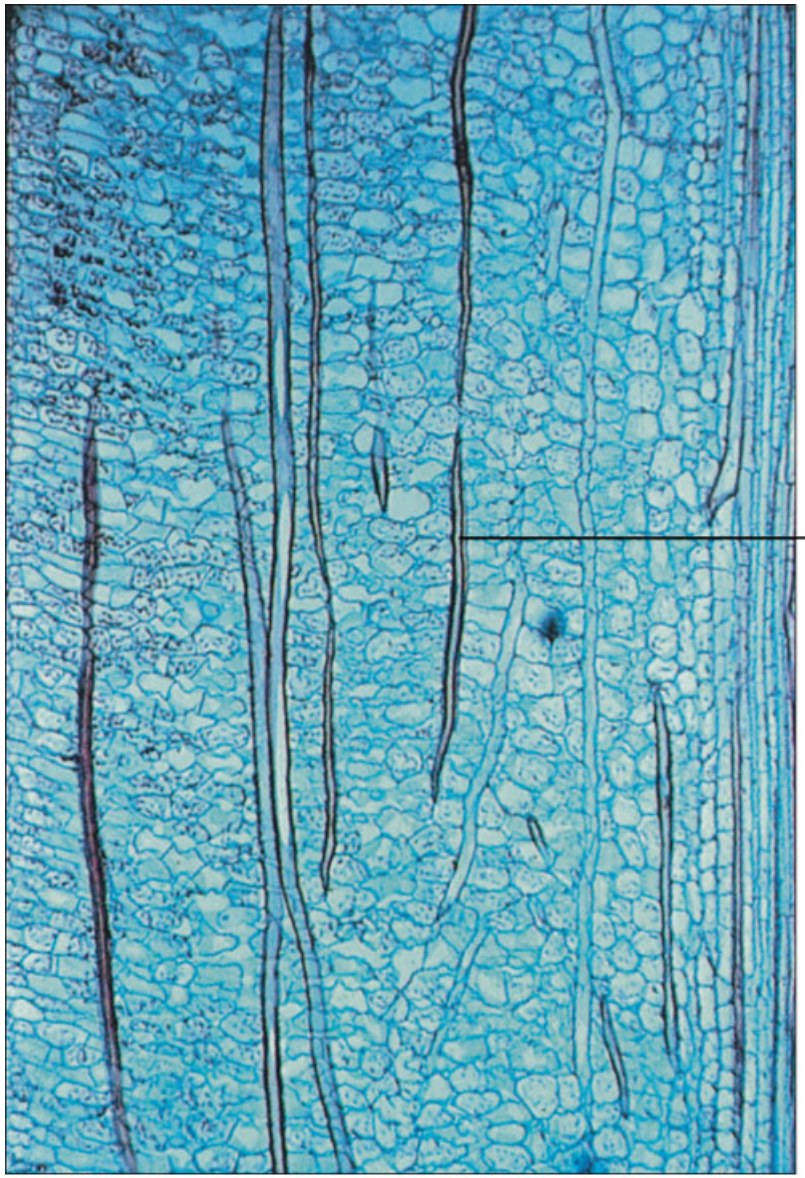
Outer cylinder is a velamen tissue of orchid root (LM)

Tissues
In addition: secretory tissues

Secretory tissues

- Primary, simple or complex tissues
- Spreading across plant body, concentrating in leaves and young stems
- May secrete latex, volatile oils, mucus and other chemicals
- Functions vary: attraction or dis-attraction, communication, defense etc.

Laticifers



Quiz question (3 points)

Quiz question (3 points)

Name 3 forces which drove plants on land.

Summary 1

- The structure of plant body, its organs and tissues is a result of land colonization
- **Complex tissues** have different cell types, **secondary tissues** originate from lateral meristems (i.e., cambium)
- **Parenchyma**, or ground tissue, is a main component of young plant organs
- **Epidermis** is a complex tissue which includes stomata

Summary 2

- **Collenchyma** and **sclerenchyma** are simple supportive tissues
- **Secondary tissues** originate from lateral meristems (i.e., cambium)
- **Xylem vs. phloem**:
  - **State**: dead vs. living cells
  - **Transport**: water vs. sugar
  - **Direction**: up vs. down
  - **Biomass**: big vs. small

MINOT STATE UNIVERSITY

For Further Reading

A. Shipunov.
Introduction to Botany [Electronic resource].
Mode of access:
http://ashipunov.info/shipunov/school/biol_154