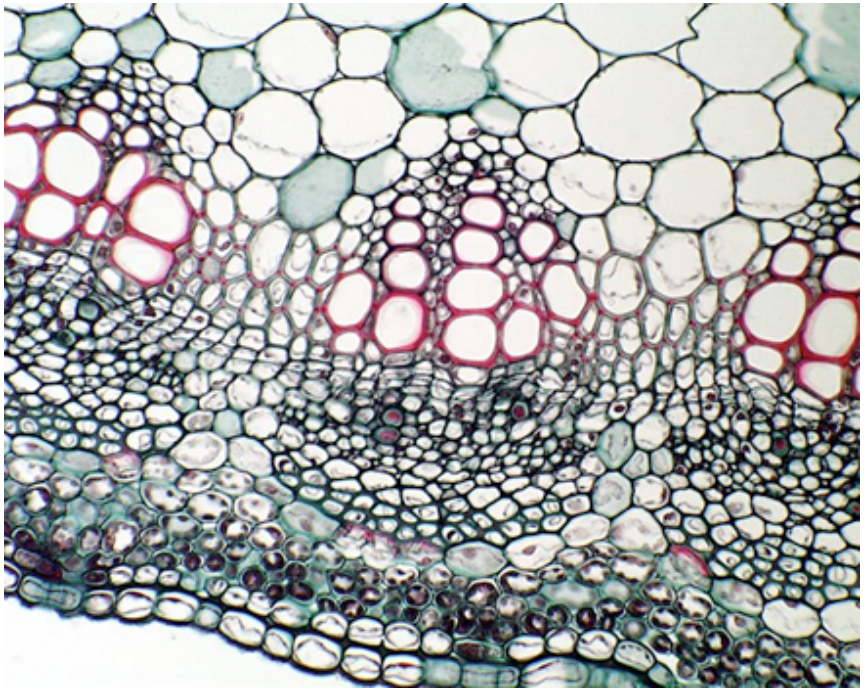
Plant Cells and Tissues
An Evolutionary Perspective



Web Notes

Are not available on Learn@UW

There will be not links to the notes. To access them you must know the url.

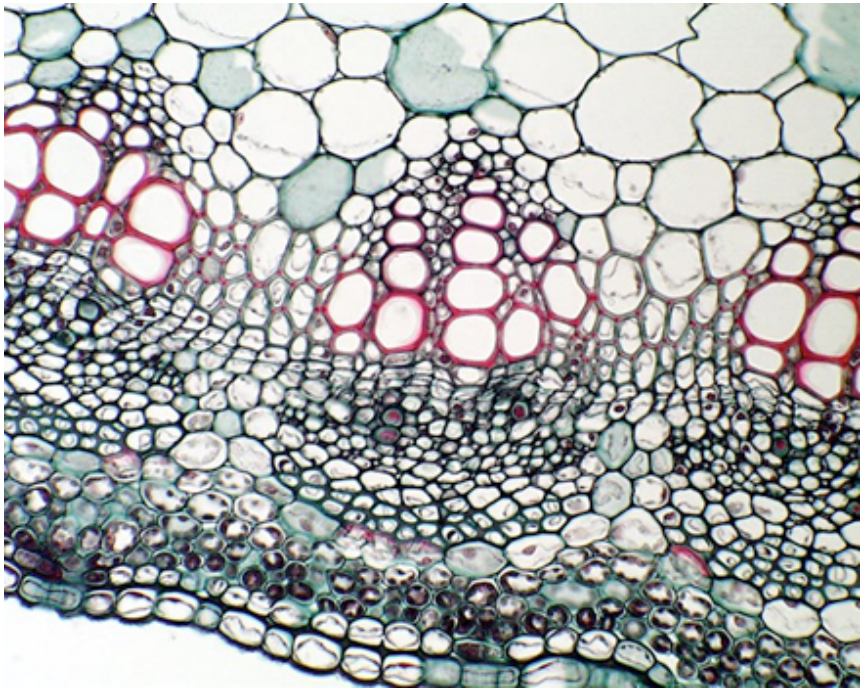
http://botit.botany.wisc.edu/Anatomy/

Web Resources on the Lab Site

http://botit.botany.wisc.edu/Anatomy/Glossary

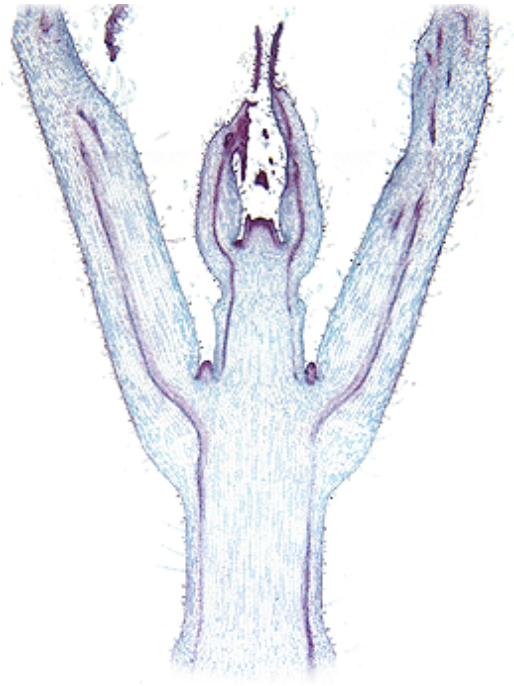
http://botit.botany.wisc.edu/botany_130/Laboratory.html

Plant Cells and Tissues
An Evolutionary Perspective



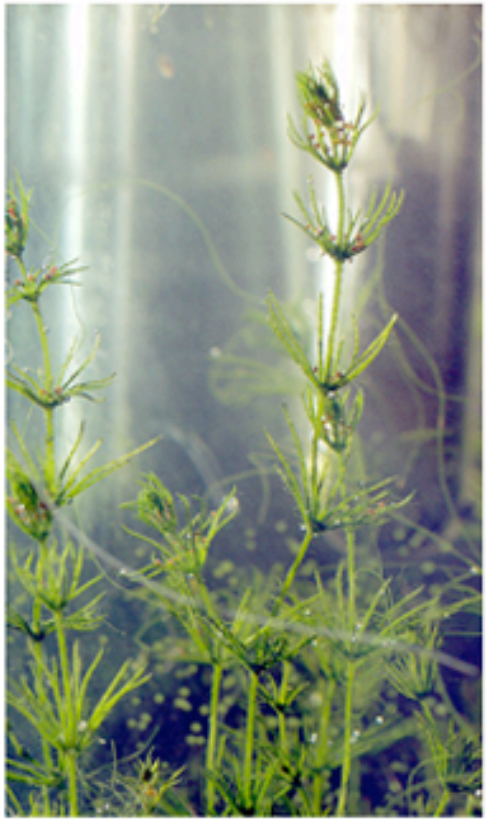
Plants are structurally complex

All the cells of a plant are genetically identical, but the information is expressed in different ways in different places at different times in a synchronized fashion.

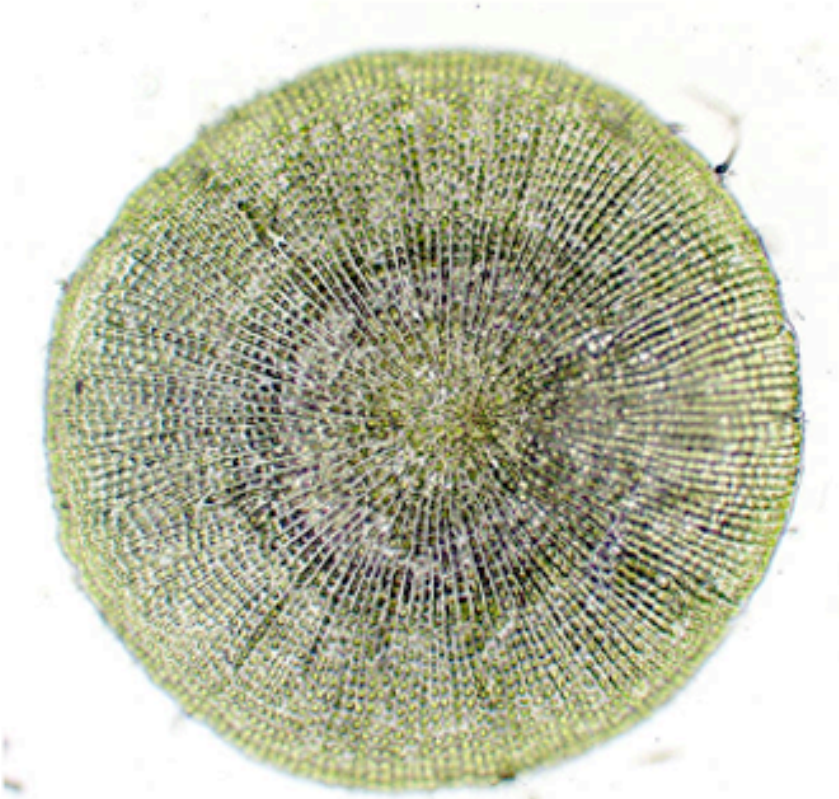


….. but plants arose from structurally simple ancestors

Plants Arose from the Green Algae During the Silurian Period Over 400 Million Years Ago



Chara



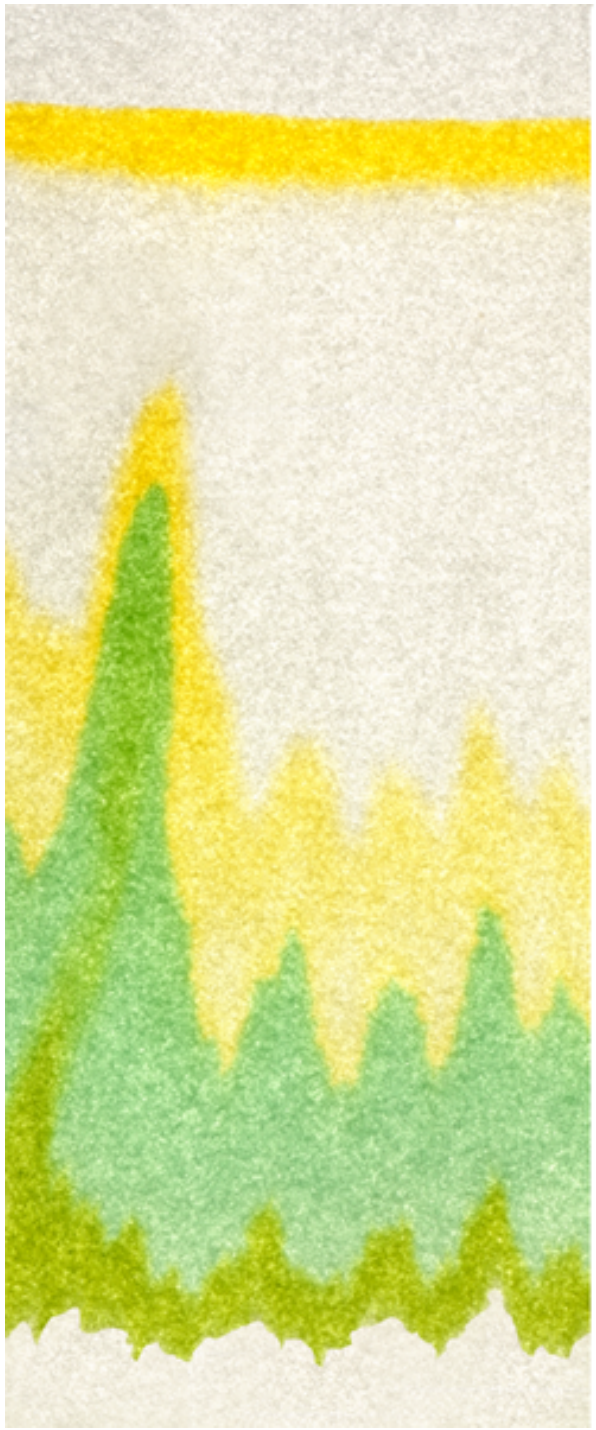
Coleochaete

Evidence That Plants Arose from the Green Algae

- **Pigmentation**

Chara

Coleochaete



Carotene

Xanthophyll

Chlorophyll a

Chlorophyll b

Evidence That Plants Arose from the Green Algae

- **Pigmentation**
- **Cellulose in their cell walls**

Chara

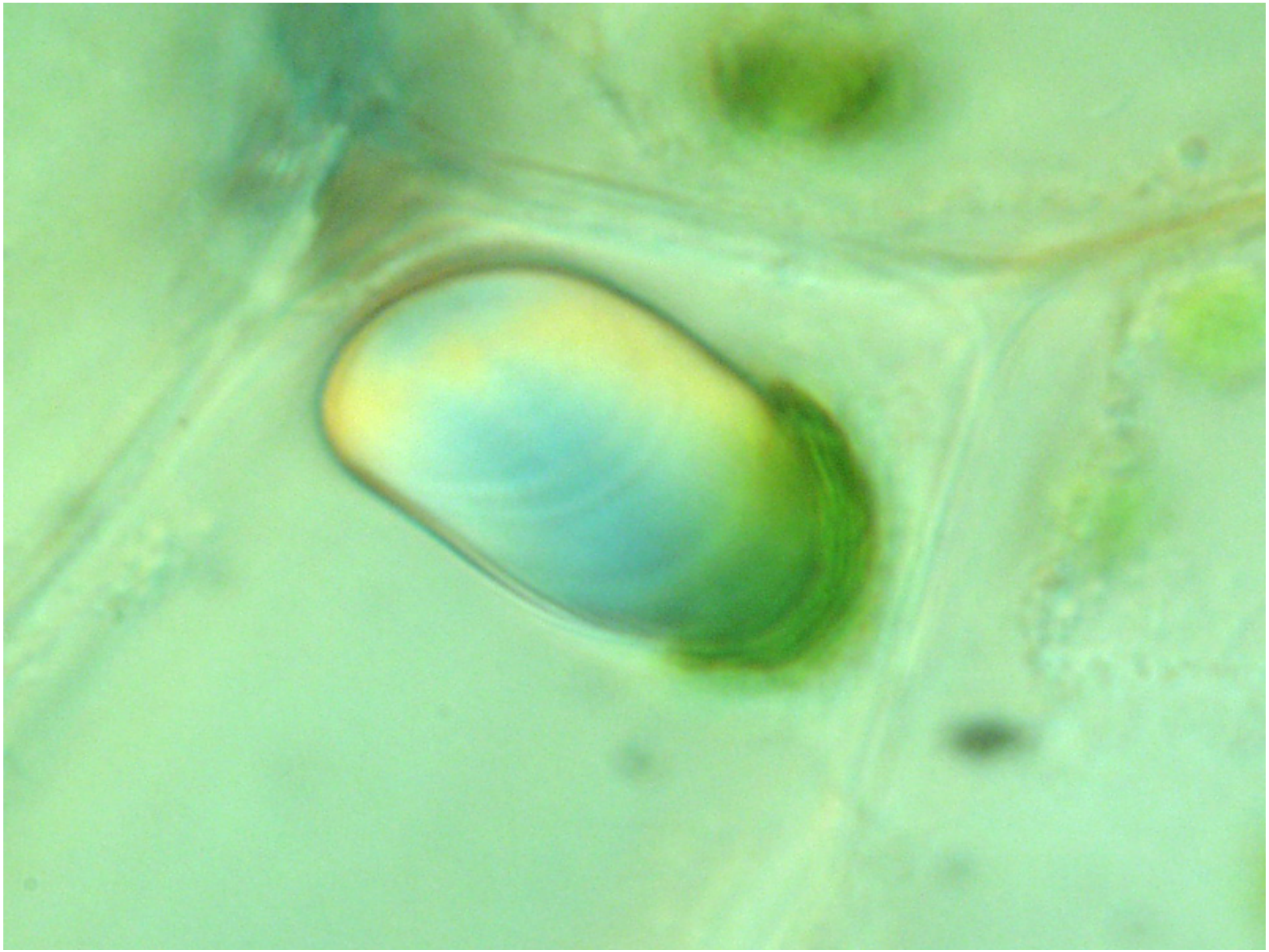
Coleochaete

Evidence That Plants Arose from the Green Algae

- **Pigmentation**
- **Cellulose in their cell walls**
- **Starch stored in the plastid**

Chara

Coleochaete



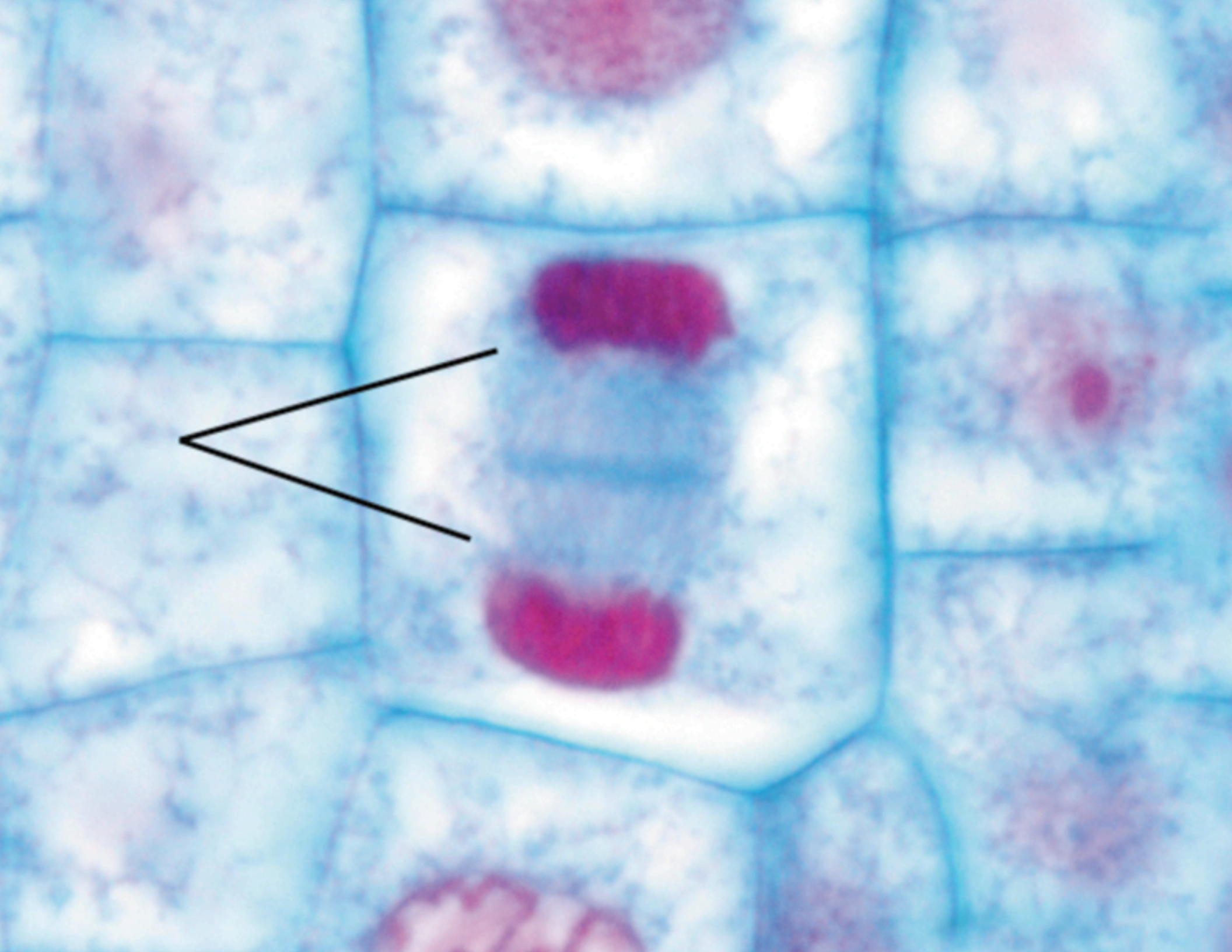
Evidence That Plants Arose from the Green Algae

- **Pigmentation**
- **Cellulose in their cell walls**

Chara

Coleochaete

- **Starch stored in the plastid**
- **Some green algae undergo cell division by means of a phragmoplast**



Evidence That Plants Arose from the Green Algae

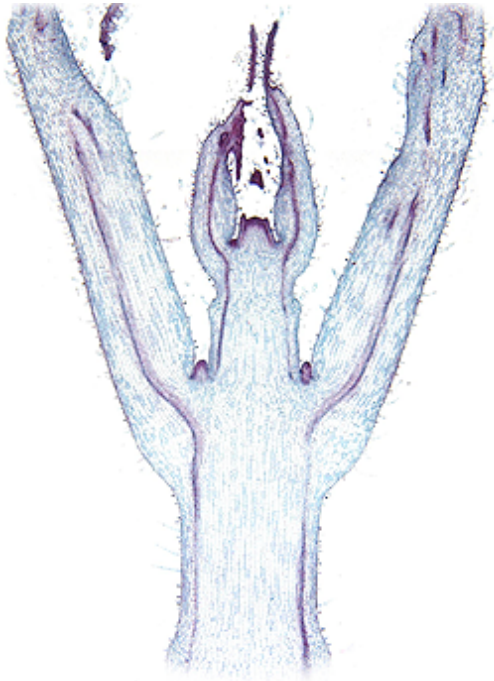
- **Pigmentation**
- **Cellulose in their cell walls**

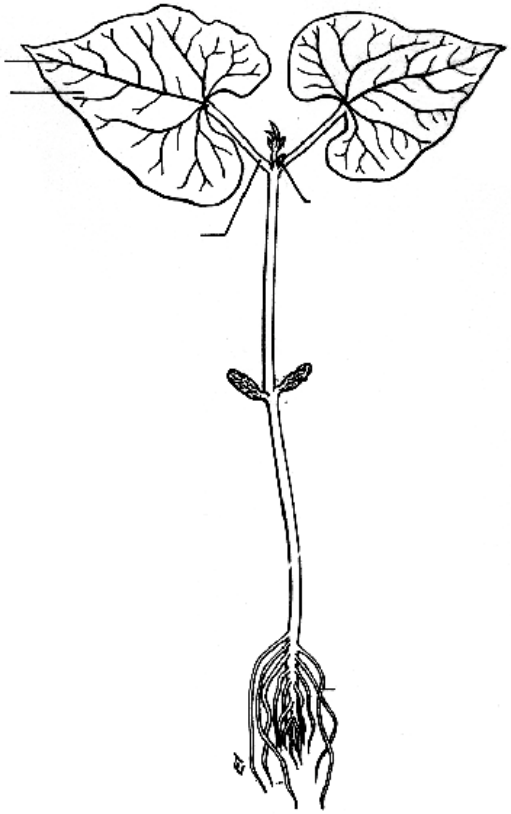
Chara

Coleochaete

- **Starch stored in the plastid**
- **Some green algae undergo cell division by means of a phragmoplast**

The structural complexity of plants evolved in response to the challenges of life on land





Plants can be considered simply as a group of the green algae that have become adapted for life on land.

Chara

Coleochaete

Sequoiadendron

Challenges for Colonizing the Land

Dehydration

Support

Transport of Water and Minerals

Transport of Photosynthate

Fertilization

Solutions (Adaptations)

Dehydration ----------> Dermal tissue

Support ----------> Secondary Walls

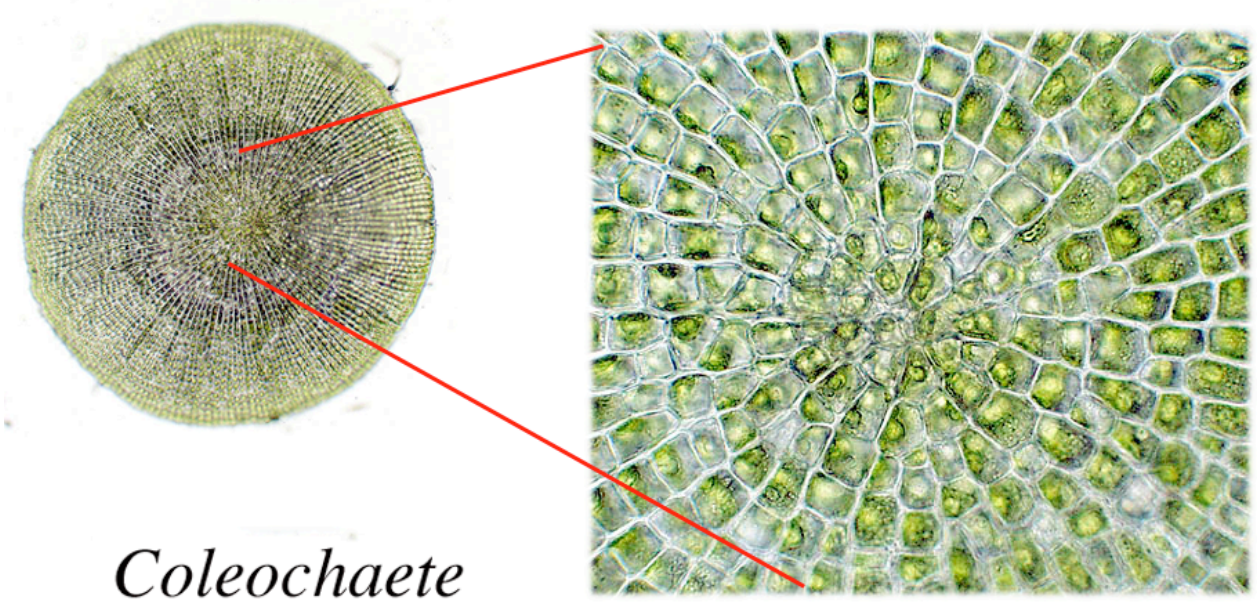
Transport of Water and Minerals ----------> Xylem Tissue

Transport of Photosynthate ----------> Phloem Tissue

Fertilization ----------> To be considered later

Vascular plants are made up of three tissue systems which are represented in each plant organ.

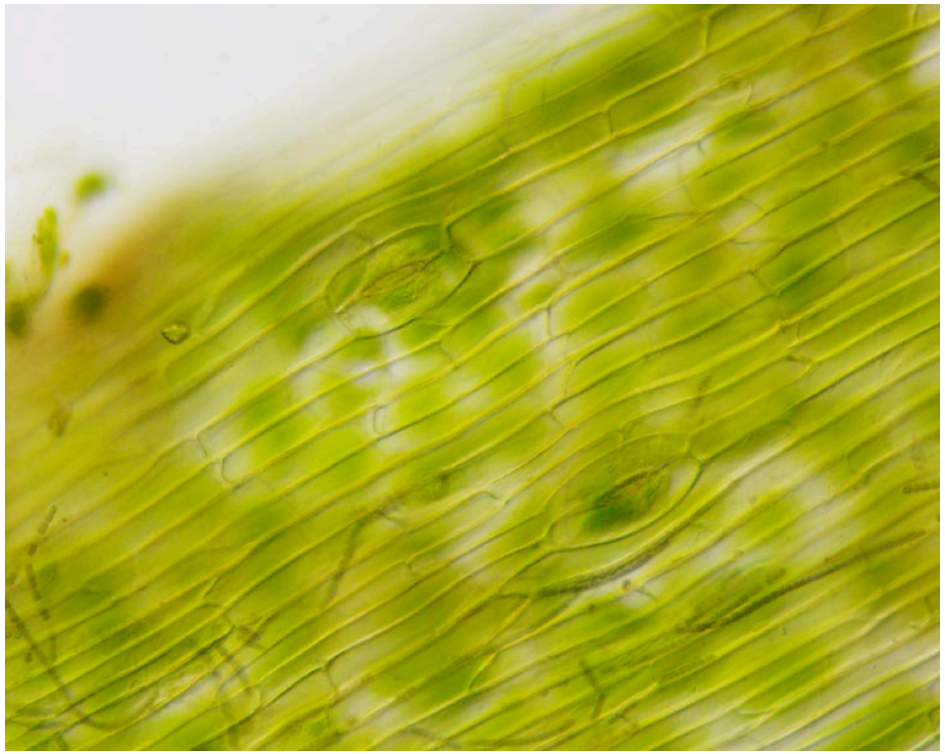
Ground Tissue System



Coleochaete

Includes cells and tissues like those found in the green algae

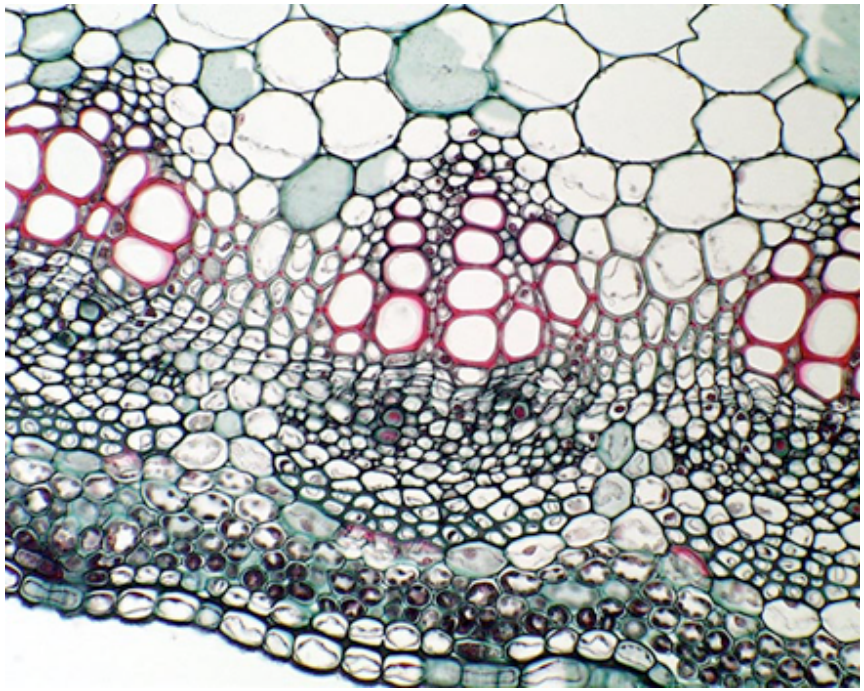
Dermal Tissue System - found in all plants

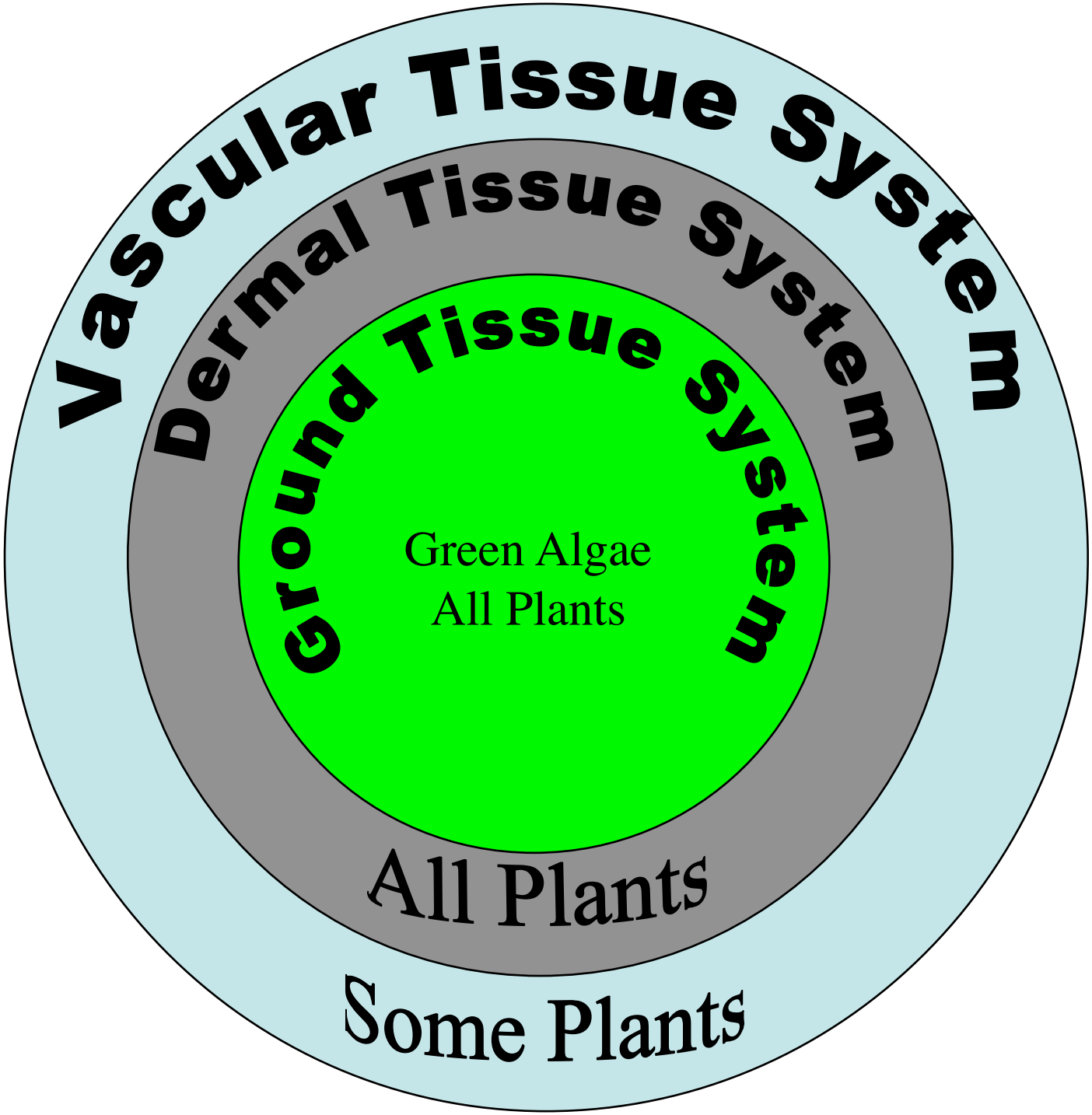


Dermal tissue of a hornwort, a non-vascular plant

Vascular Tissue System

Are tissues that transport substances long distances in a plant.




Vascular Tissue System
Some Plants
Dermal Tissue System
All Plants
Ground Tissue System
Green Algae
All Plants


Ground Tissue System
Green Algae
All Plants

Cells and Tissues of the Ground Tissue System

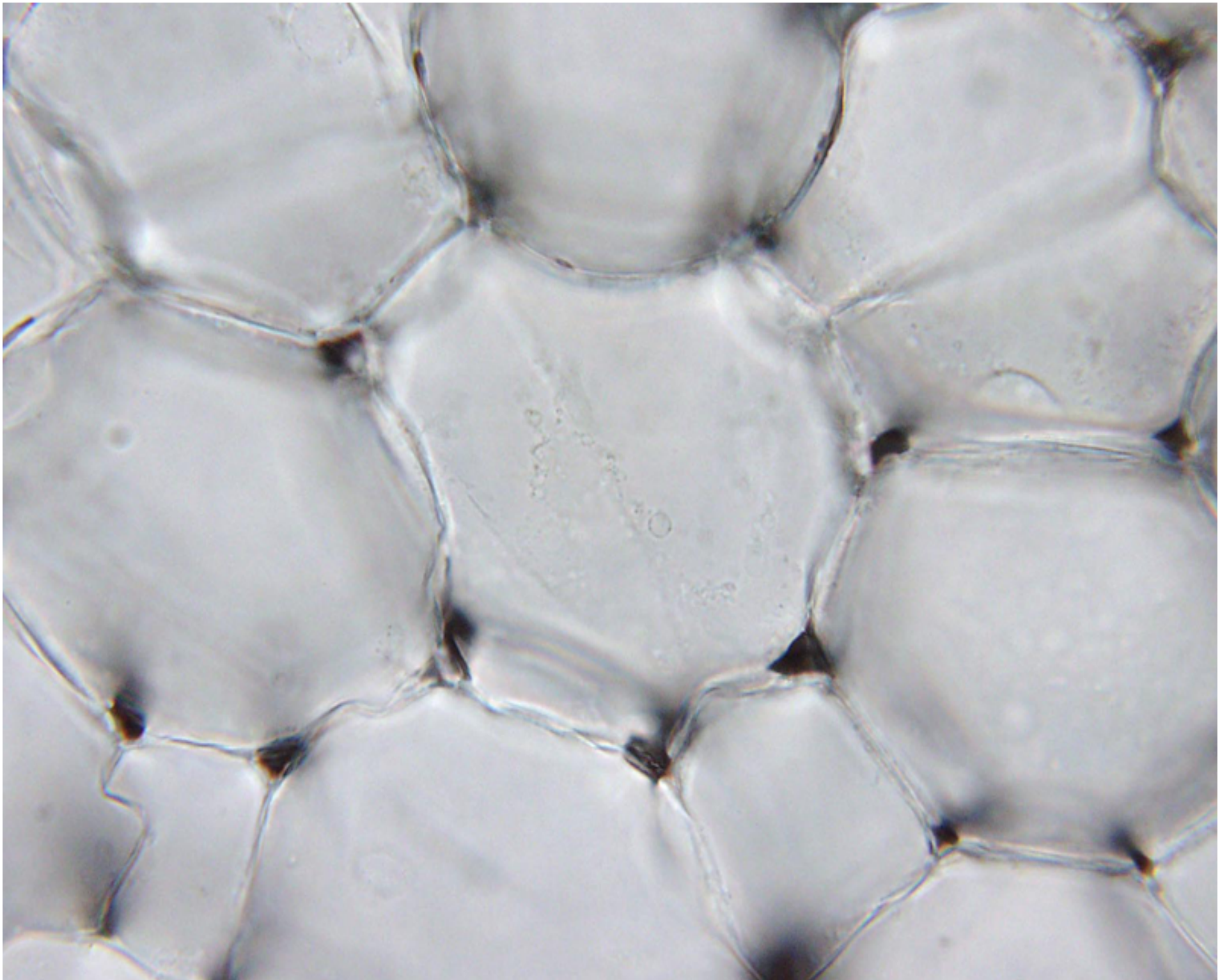
Parenchyma Tissue Composed of Parenchyma Cells

Parenchyma

Parenchyma cells are living, undifferentiated plant cells usually lacking a secondary cell wall.

Typically, parenchyma cells are totipotent. Each cell retains the ability to grow into a whole plant. This makes genetic engineering much easier with plants than with animals.

Parenchyma tissue is a type of simple tissue consisting entirely of parenchyma cells.

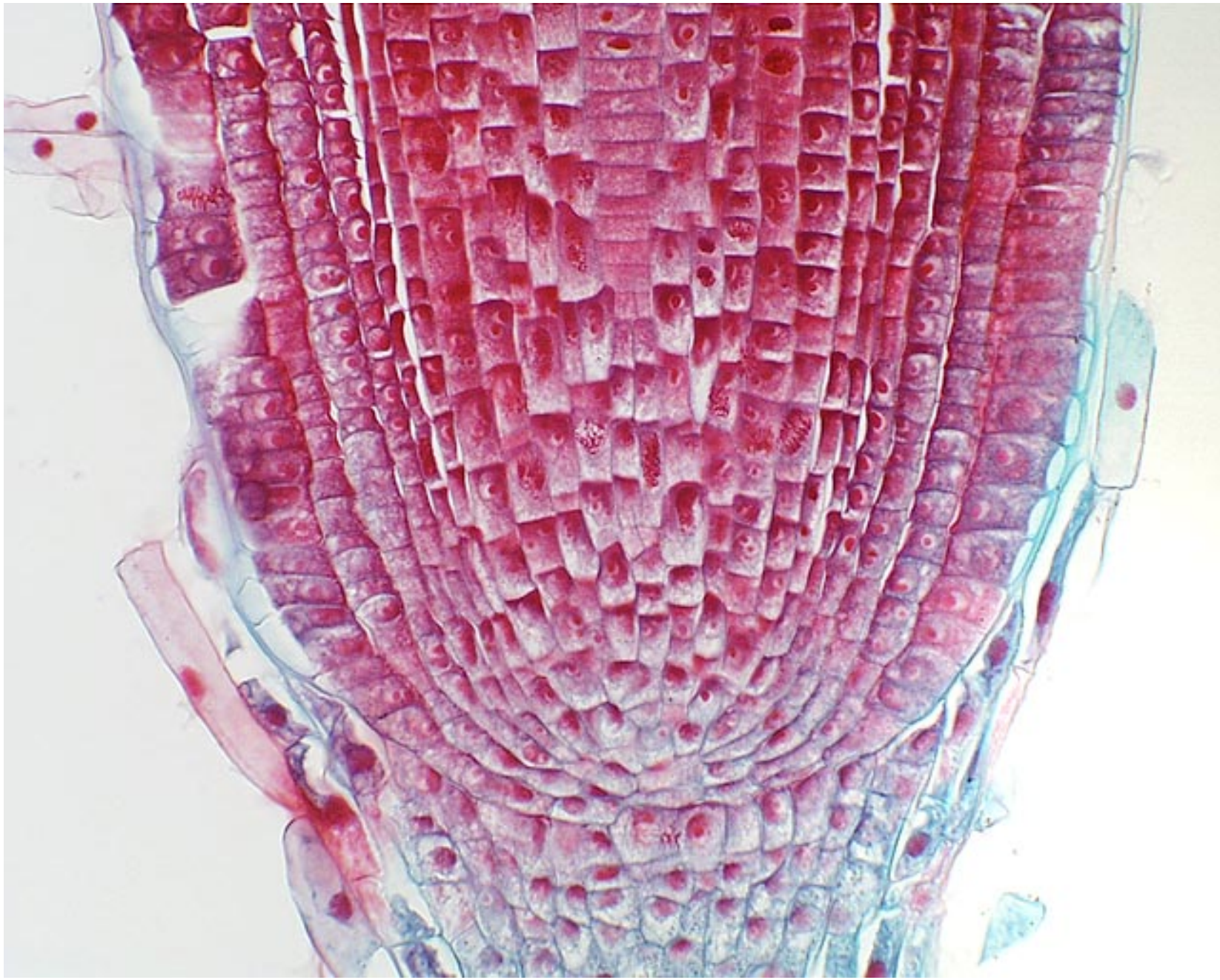


Ground Tissue System

Parenchyma Tissue Composed of Parenchyma Cells

Function:

Growth/Wound Healing/Reproduction



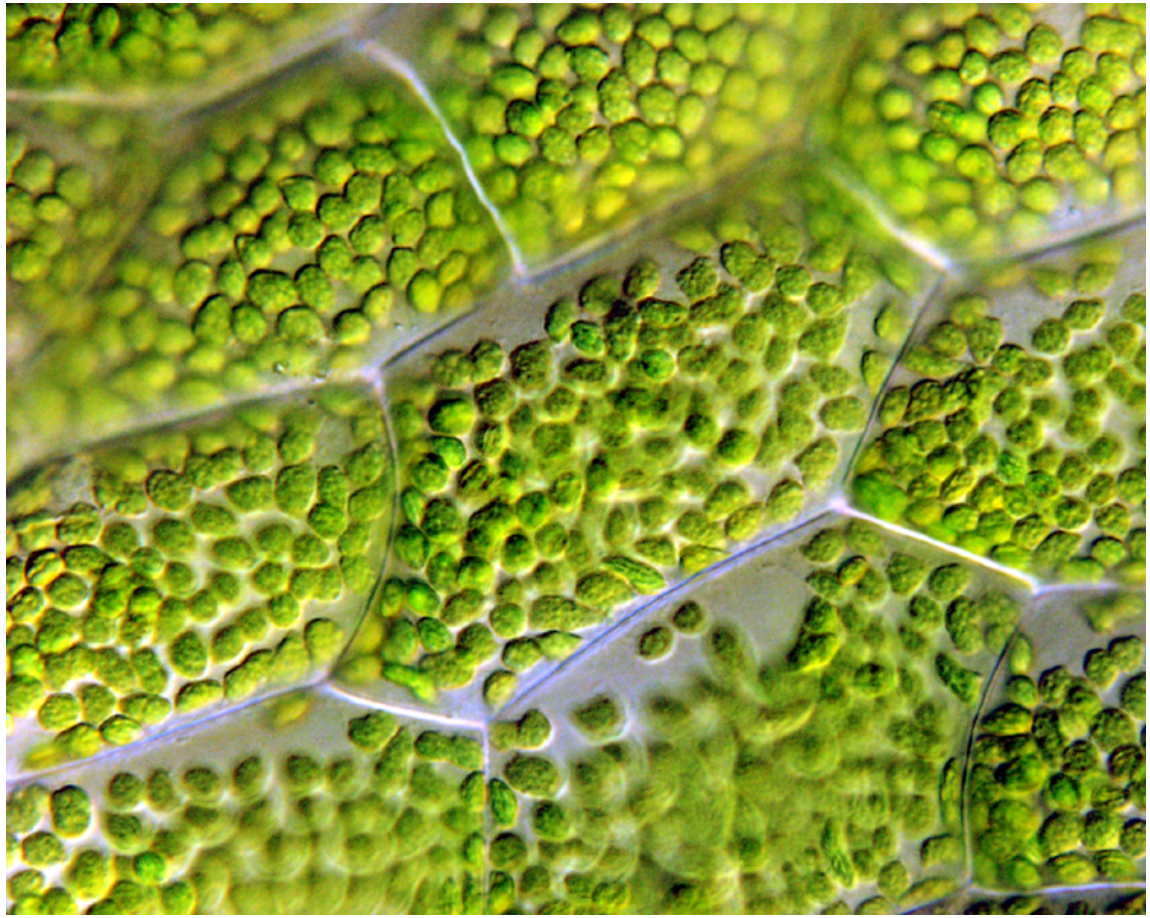
Cells and Tissues of the Ground Tissue System

Parenchyma Tissue Composed of Parenchyma Cells

Function:

Growth/Wound Healing/Reproduction

Photosynthesis



Cells and Tissues of the Ground Tissue System

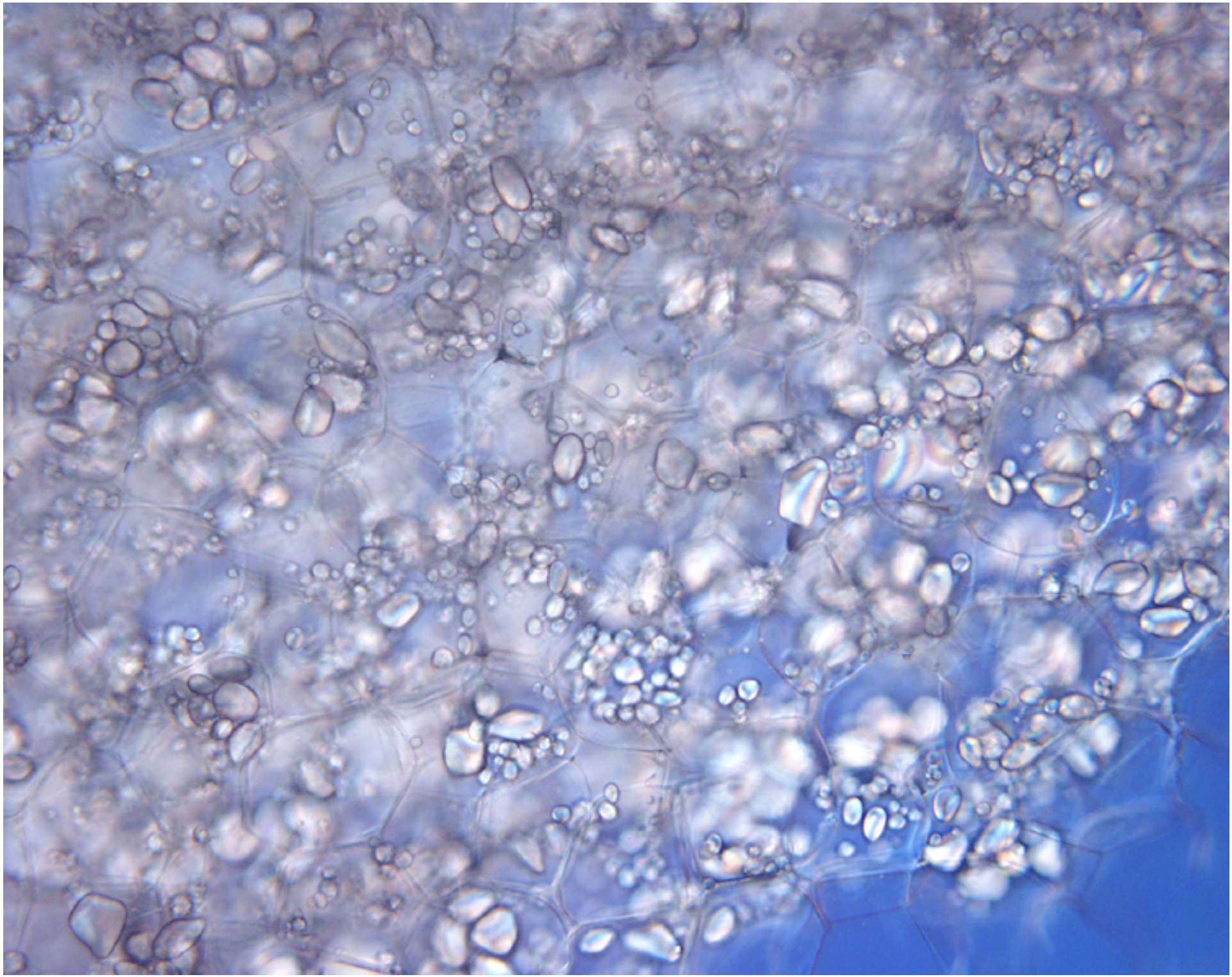
Parenchyma Tissue Composed of Parenchyma Cells

Function:

Growth/Wound Healing/Reproduction

Photosynthesis

Storage



Ground Tissue System

Parenchyma Tissue Composed of Parenchyma Cells

Function:

Growth/Wound Healing/Reproduction

Photosynthesis

Storage

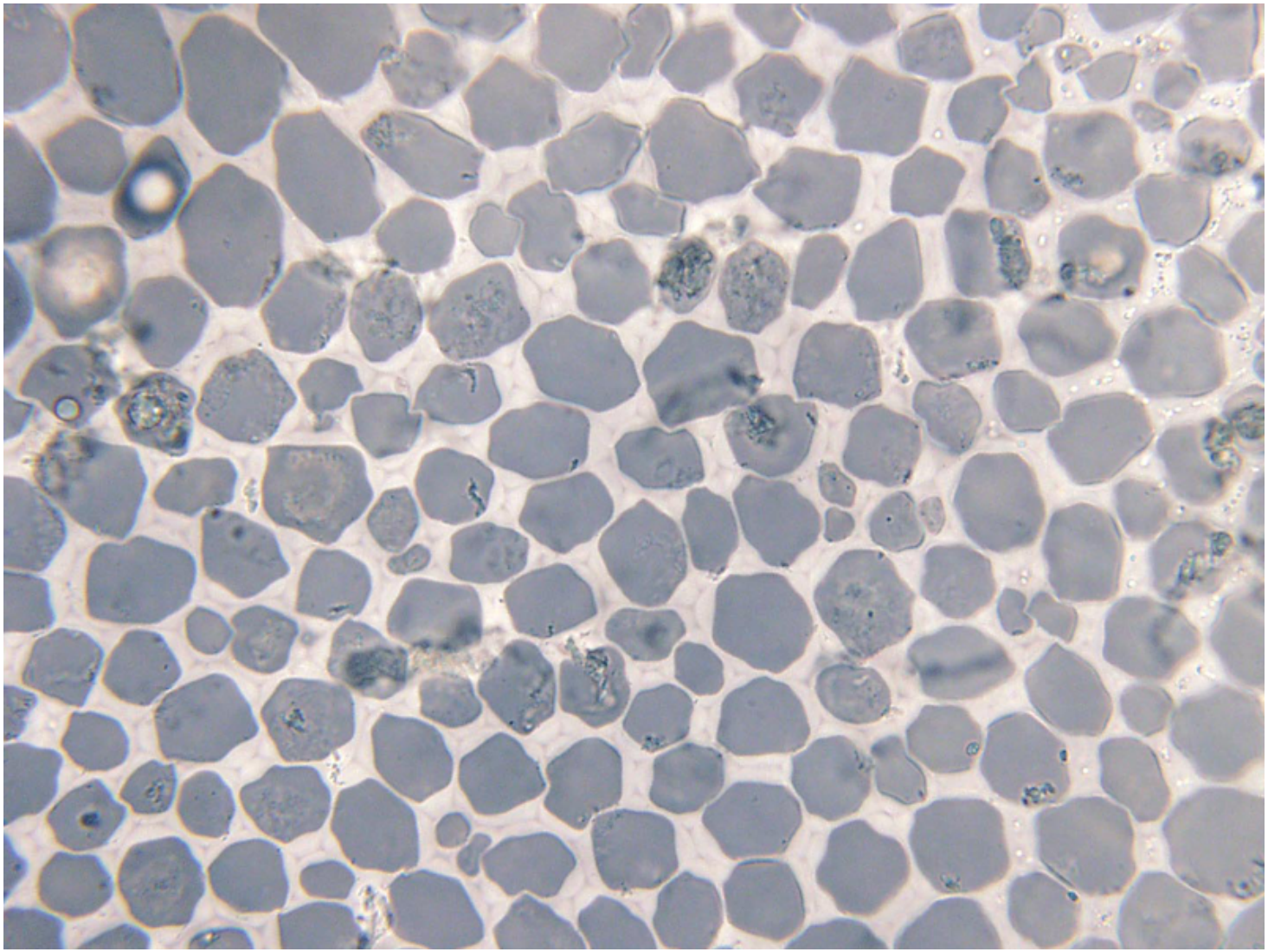
Cells and Tissues of the Ground Tissue System

Collenchyma Tissue Composed of Collenchyma Cells

Is a simple tissue consisting only of collenchyma cells

Collenchyma cells are living cells with thickened primary walls. They never have secondary walls.

Collenchyma Tissue

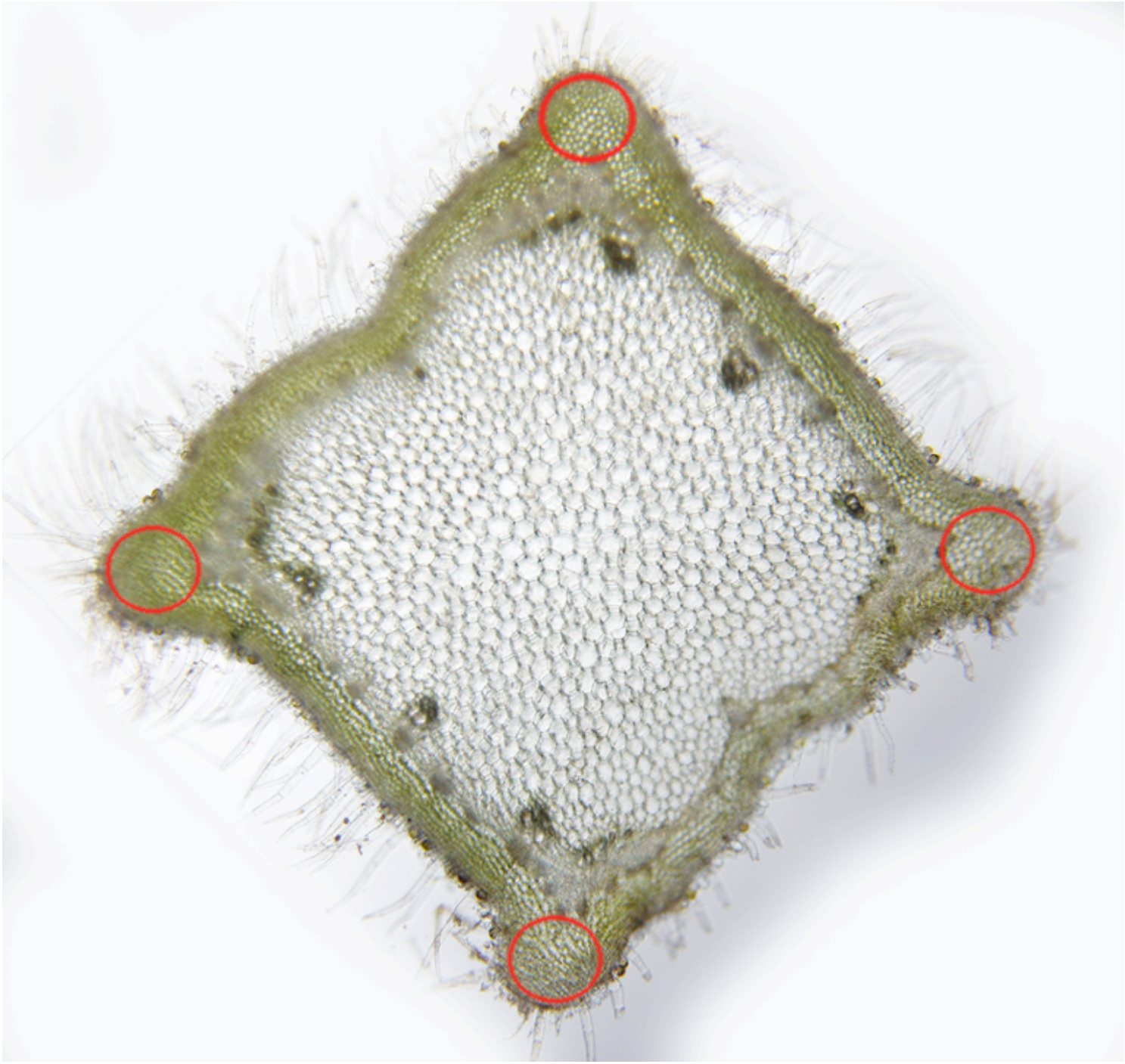


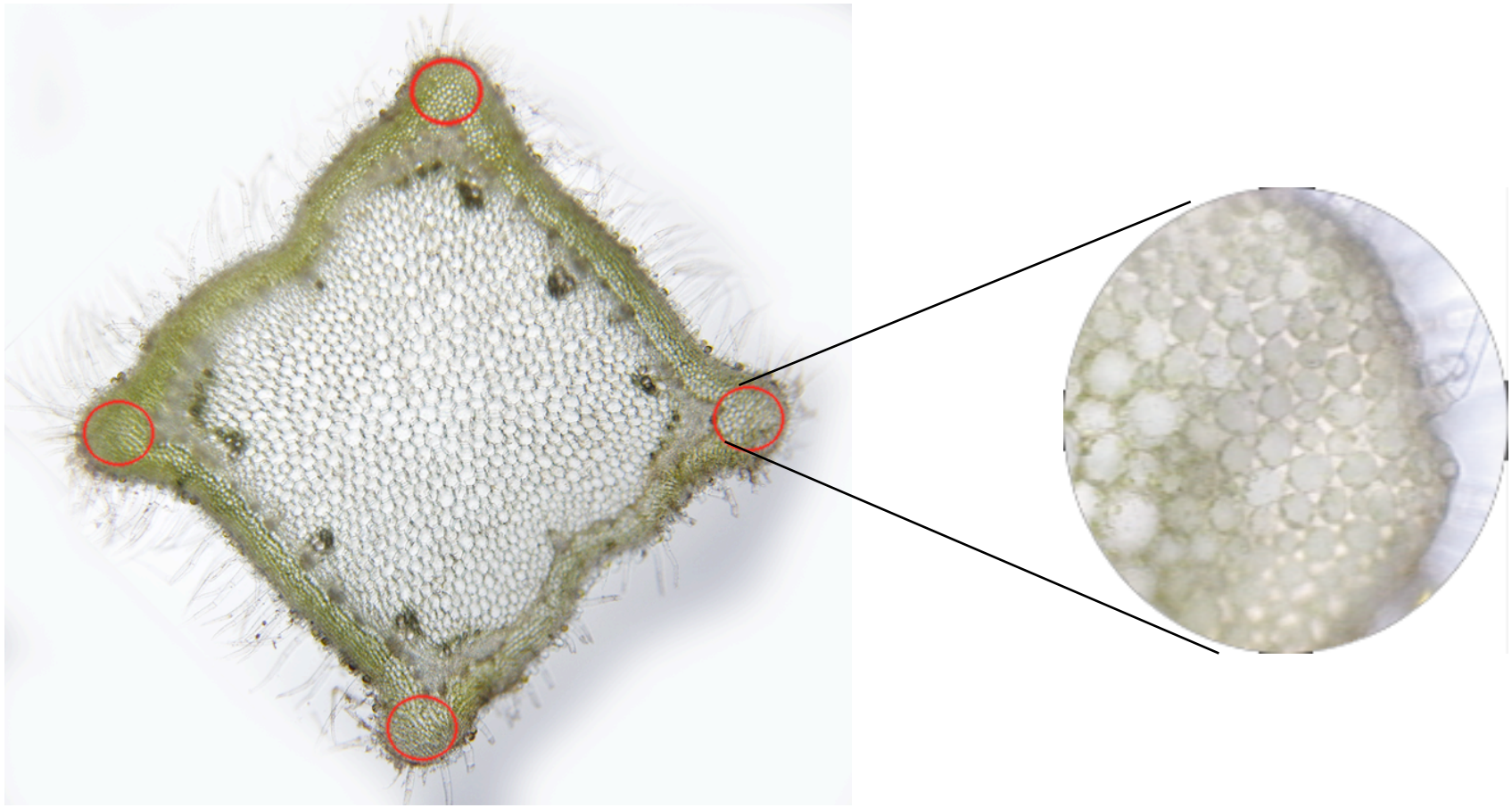
Cells and Tissues of theGround Tissue System

Collenchyma Tissue Composed of Collenchyma Cells

Function:

Support in herbaceous tissues





Collenchyma acts in opposition to turgor pressure, And, together, they lend rigidity to the plant

Cells and Tissues of the Ground Tissue System cont.

Sclerenchyma

Sclerenchyma (hard) cells develop a secondary wall, and are not involved in transport.

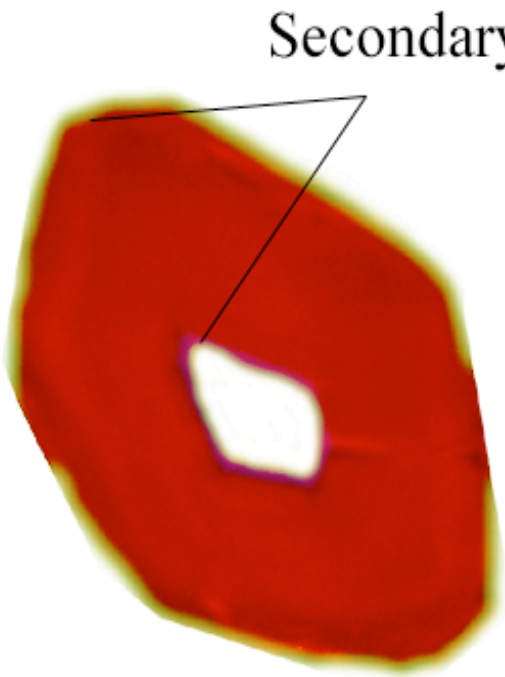
Sclerenchyma lends integrity to plant tissues, and/or they serve to support and protect the plant.

There are two types of sclerenchyma cells.

Fibers

Fibers

Longitudinal View (macerated Bark)



Cross Section

Cells and Tissues of the Ground Tissue System cont.

Sclerenchyma

Sclerenchyma (hard) cells develop a secondary wall, and are not involved in transport.

Sclerenchyma lends integrity to plant tissues, and/or they serve to support and protect the plant.

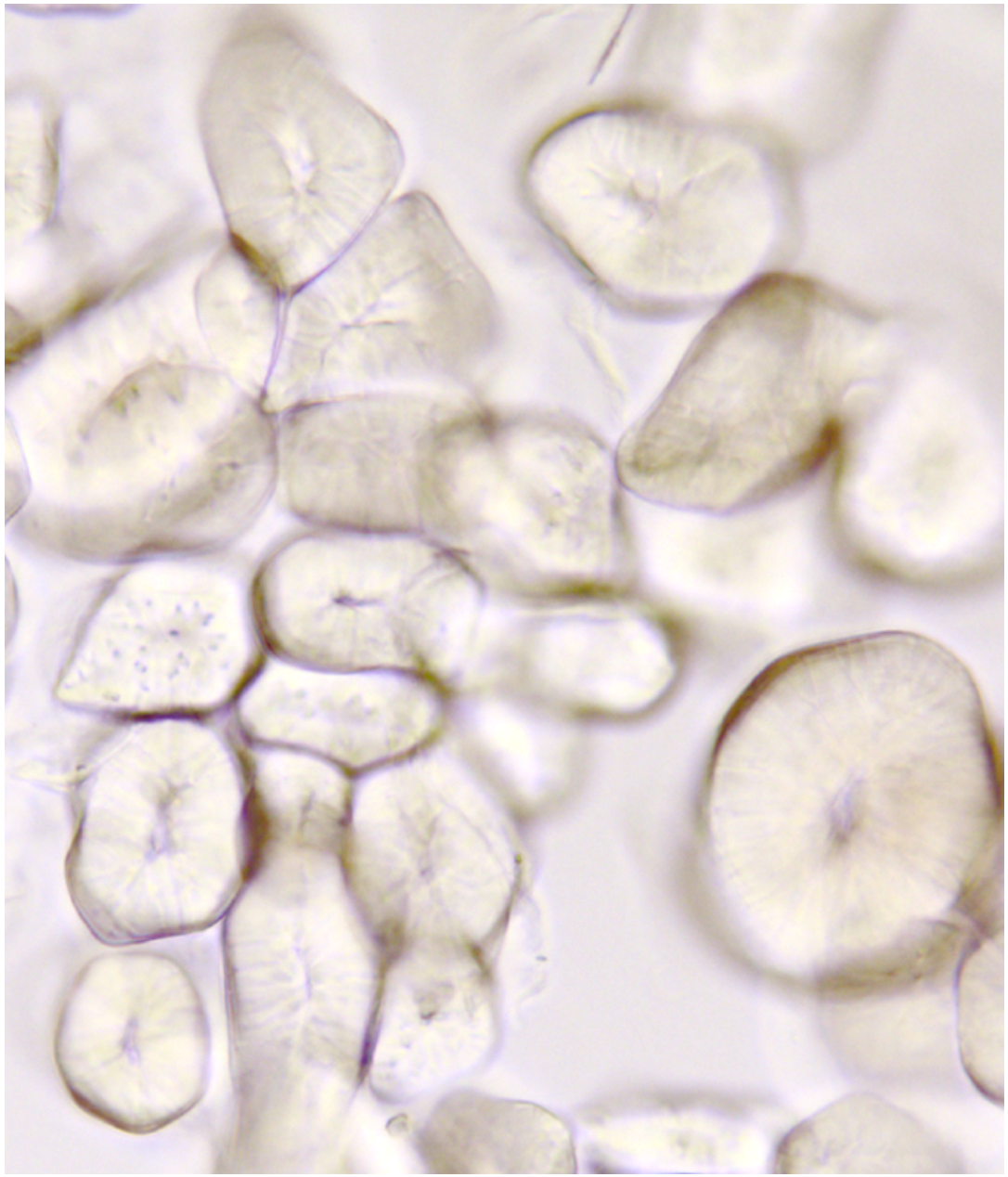
Sclerenchyma can be found in all three tissue systems.

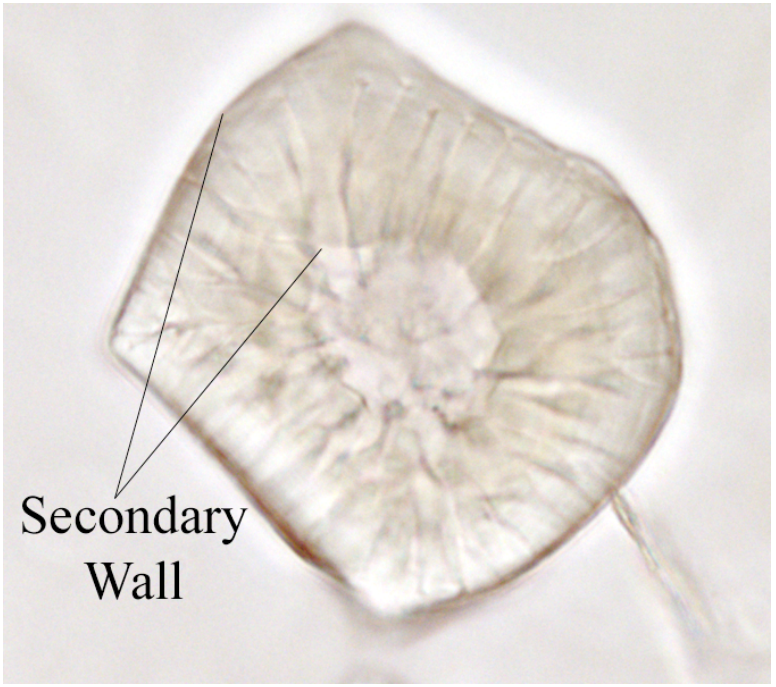
There are two types of scherenchyma cell that you should know.

Fibers

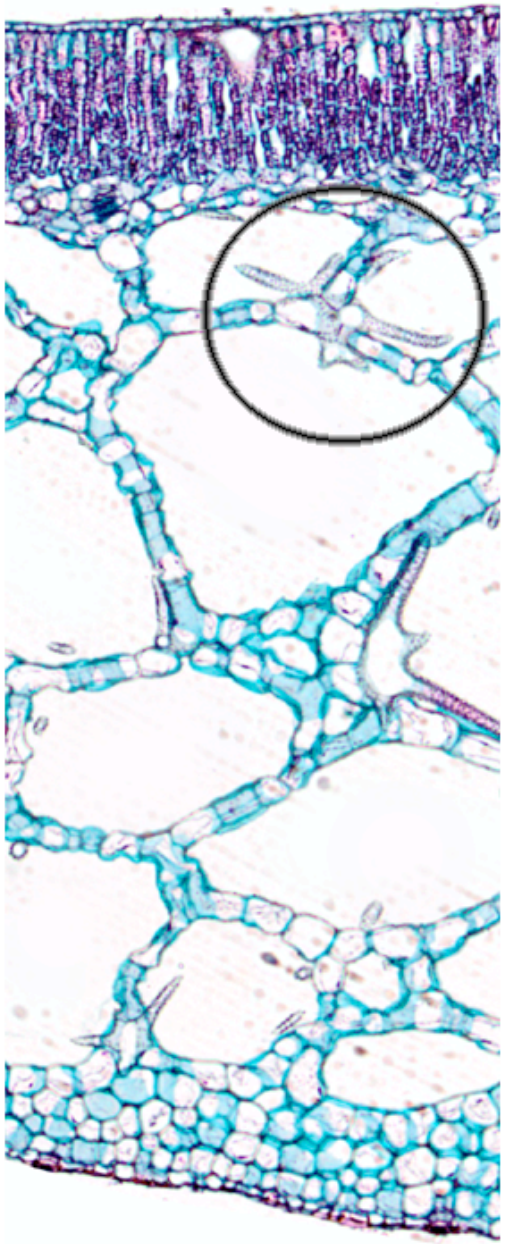
And Sclereids

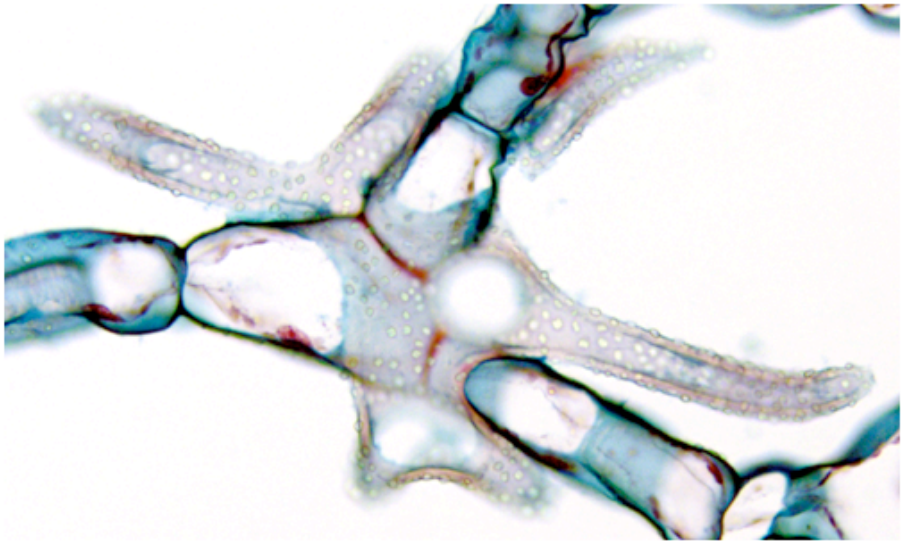
Unbranched Sclereids: Stone Cells

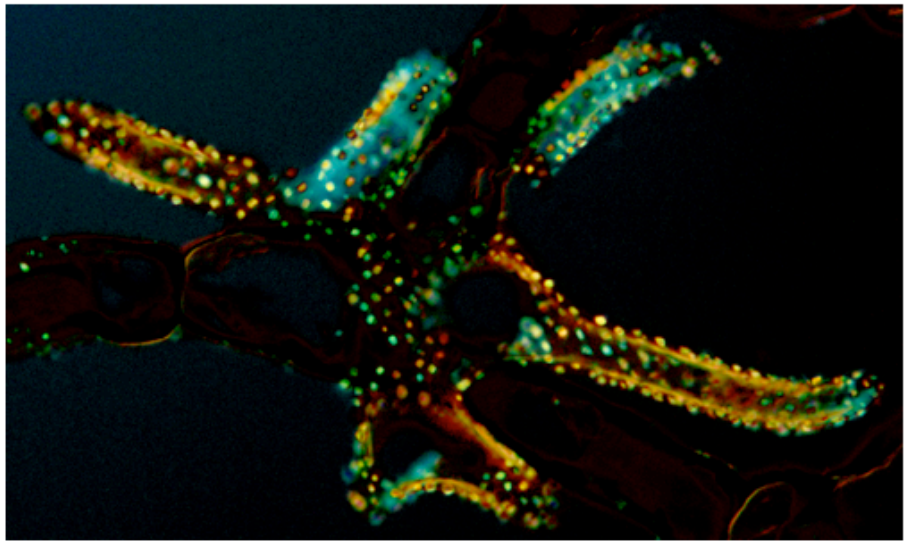




Branched Sclereids (astrosclereids)







We will not see pure sclerenchyma tissue in lab, but it is common. One example is the stone of a peach.

Ground Tissue System

- Includes:
  - Parenchyma cells and tissue
  - Collenchyma cells and tissue
  - Sclerenchyma cells and tissue

- These are not exclusively found in the ground tissue


Dermal Tissue System
Ground Tissue System
Green Algae
All Plants
All Plants

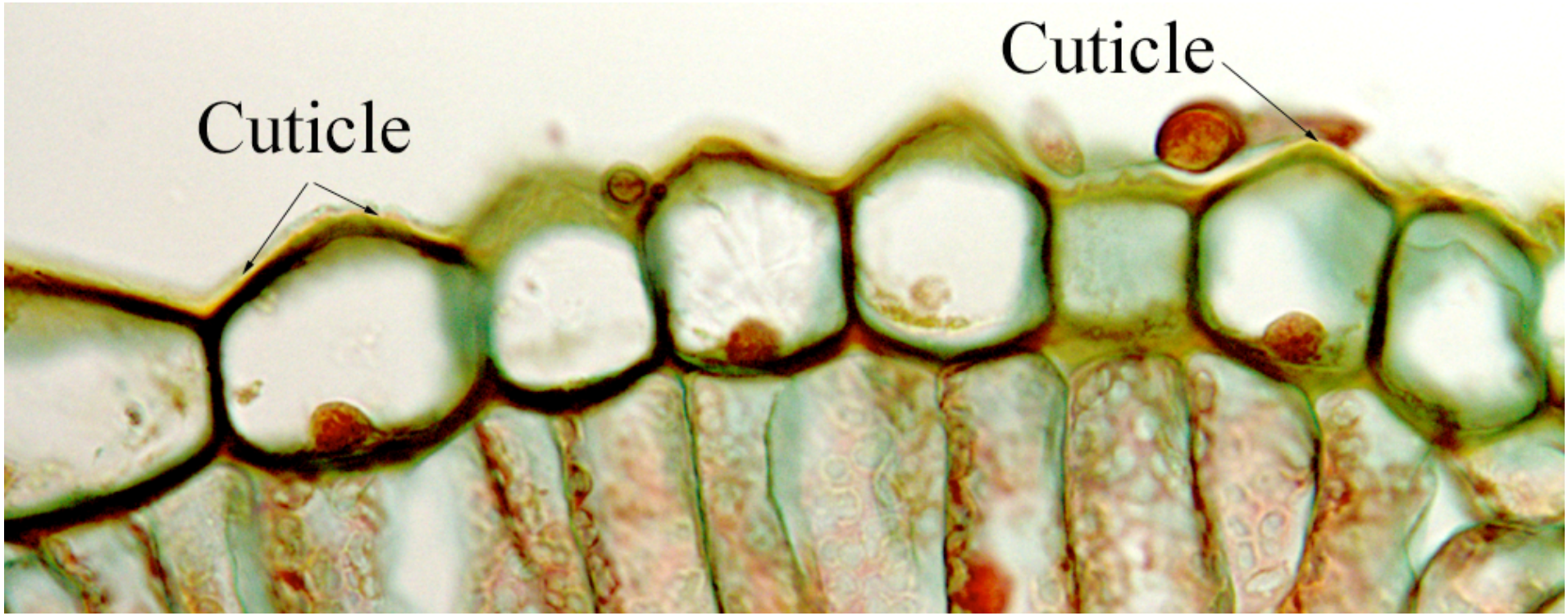
Dermal Tissue System

In herbaceous plants, an epidermis makes up the dermal tissue system.

Cell types of the epidermis

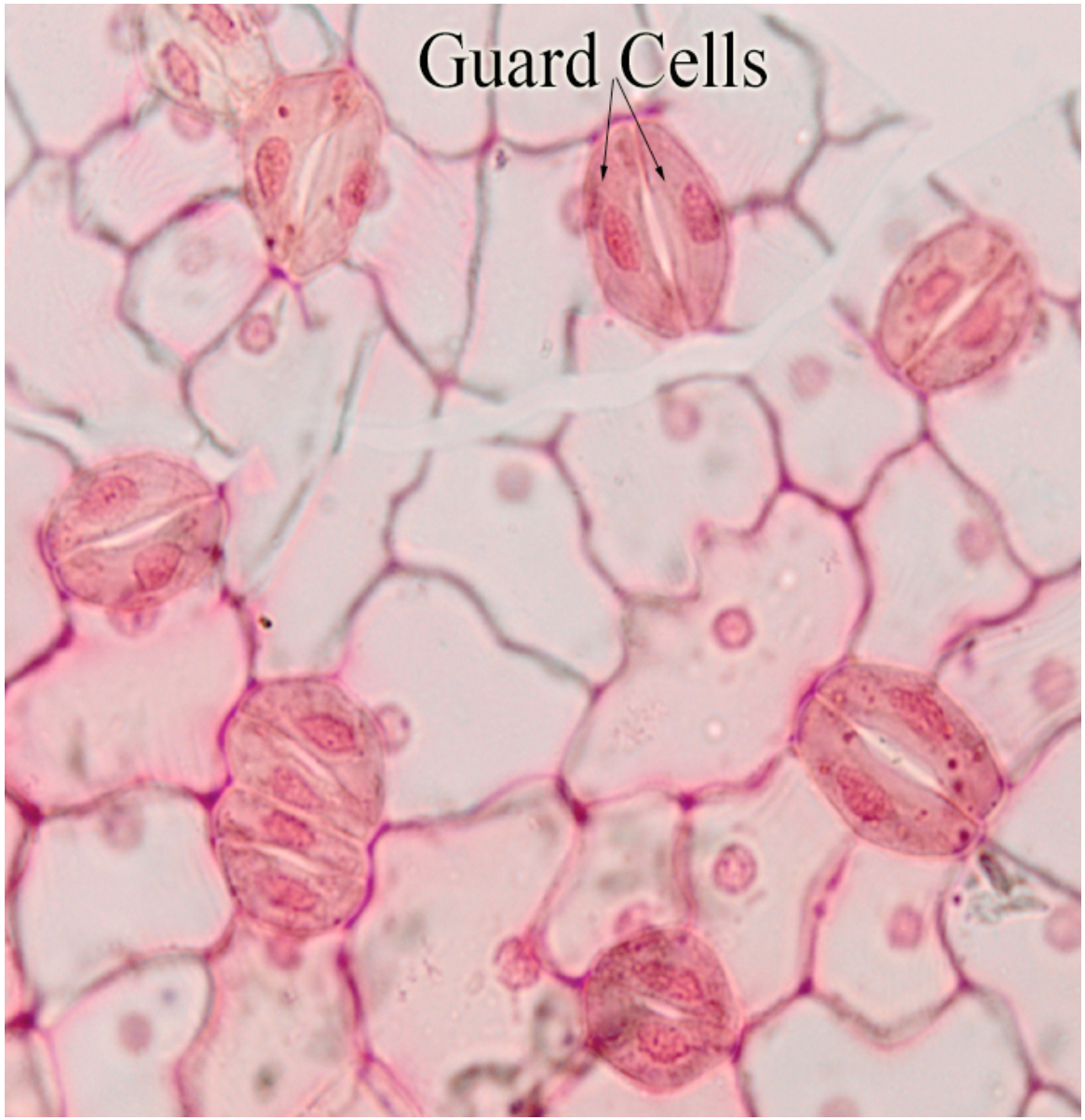
Basal Cells of the Epidermis

Basal Cells of the Epidermis of the Shoot



As the cuticle is air-tight as well as water-proof it must be perforated to allow for gas exchange.

If these openings are bounded by guard cells then these are called stomata.

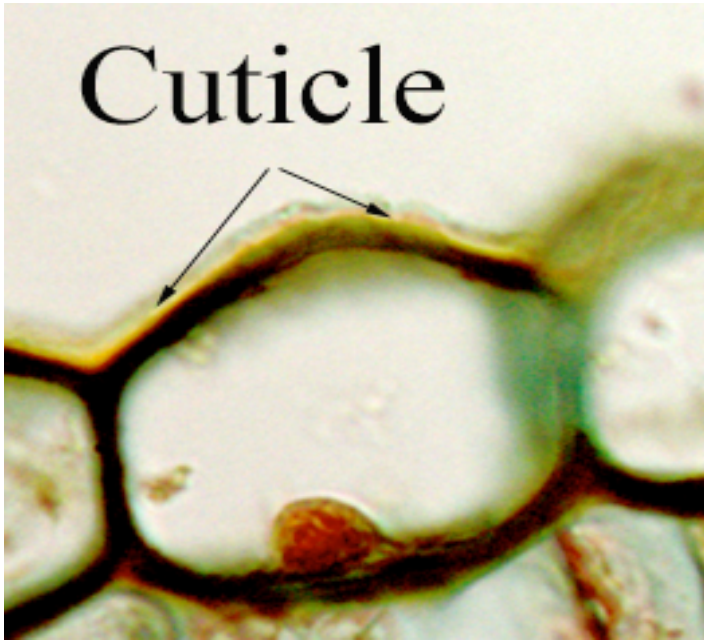


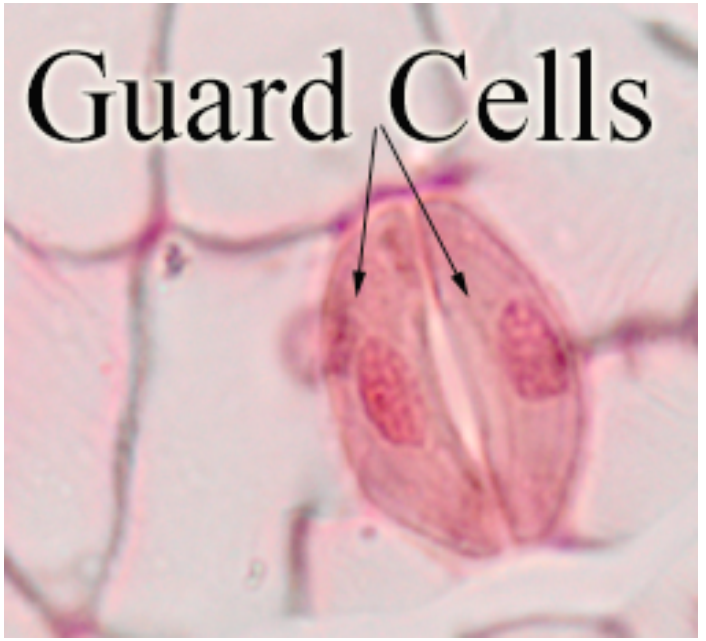
Dermal Tissue System

Herbaceous plants have an epidermis. In the shoot, the epidermis includes……

Basal Cells of the Epidermis

And Guard Cells





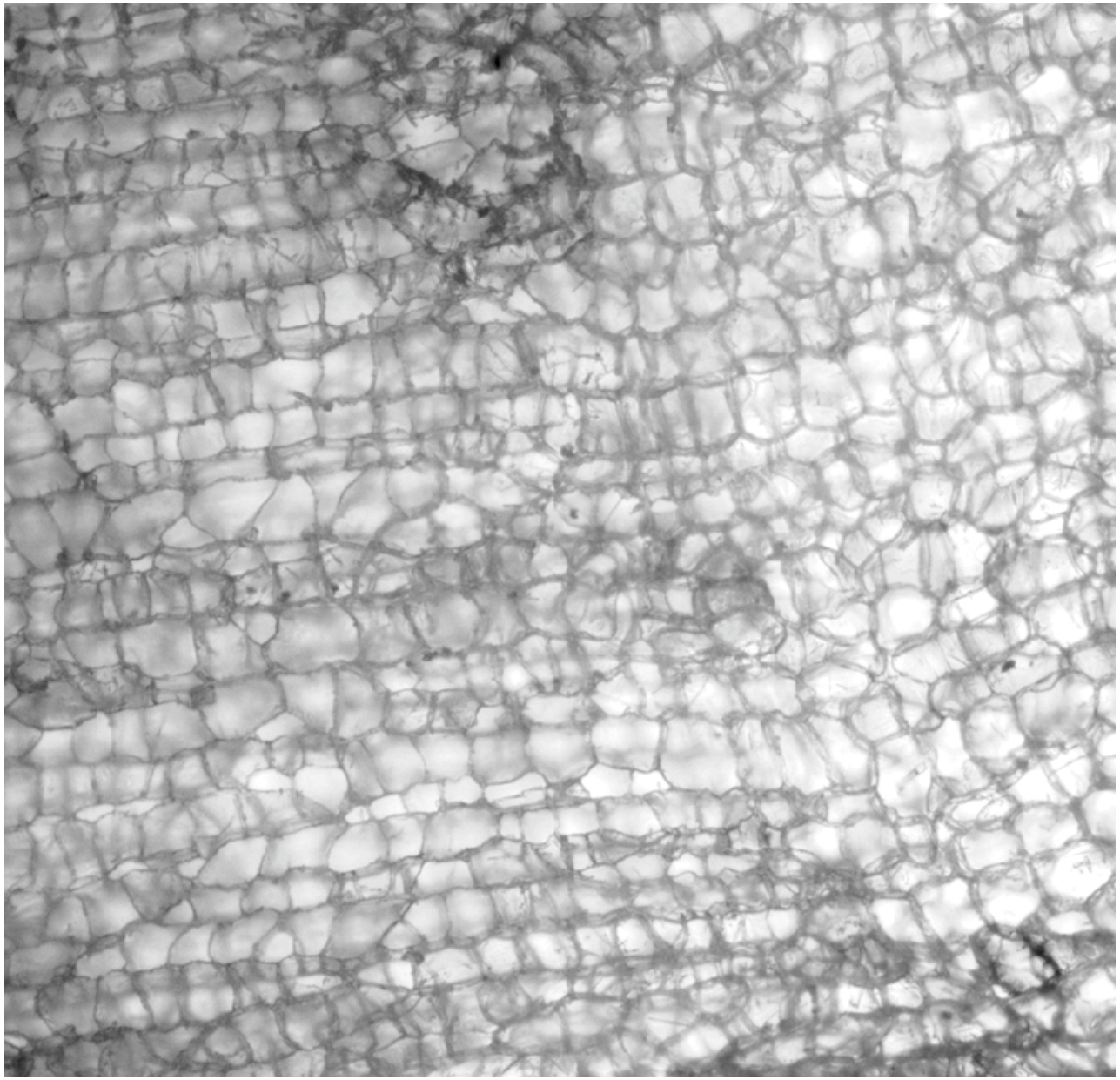
Dermal Tissue System

In woody plants the epidermis is replaced by a periderm. Periderms include cork which functions like the epidermis in retaining water.

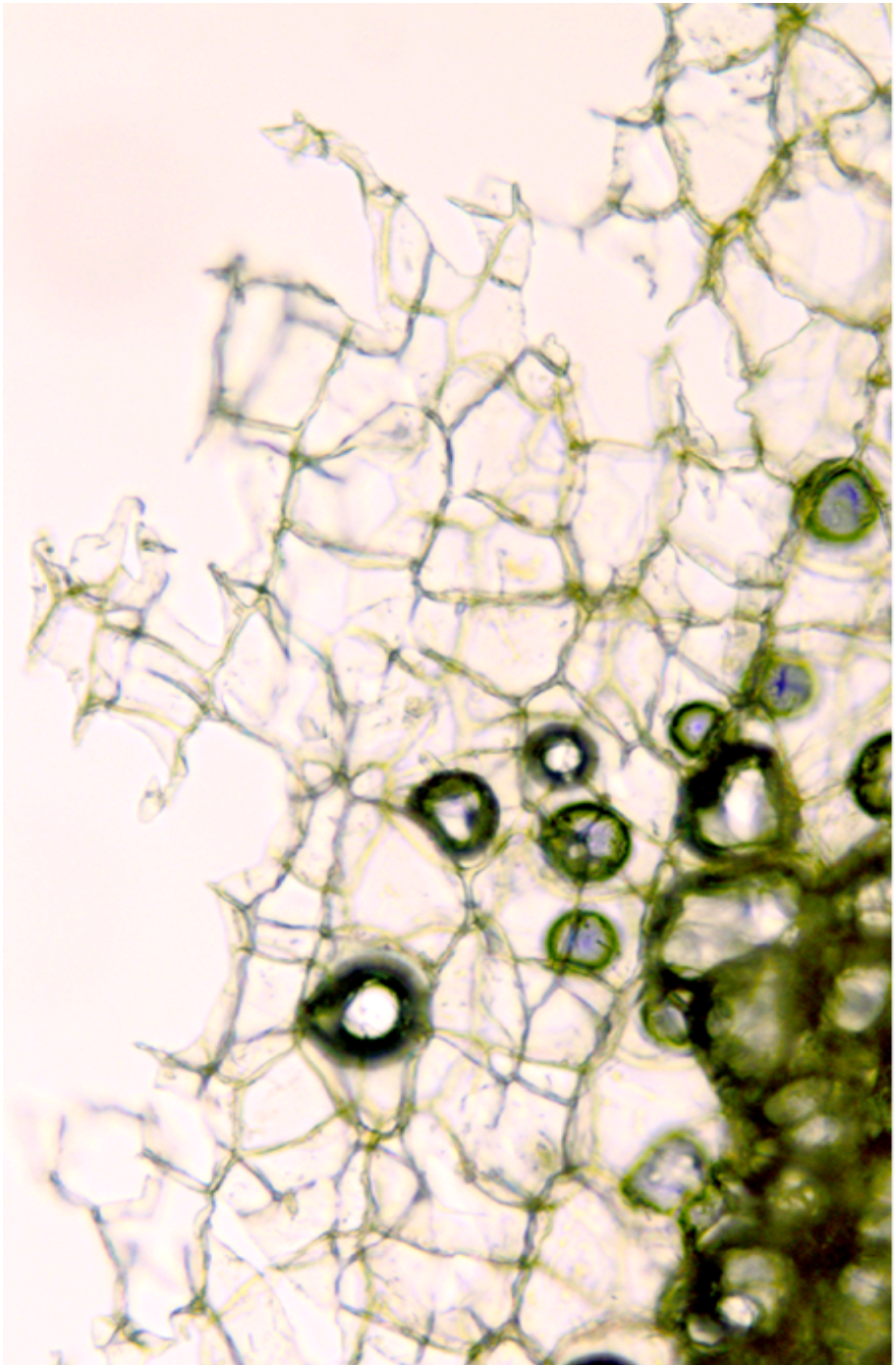
Cork is both a cell type and a tissue type.

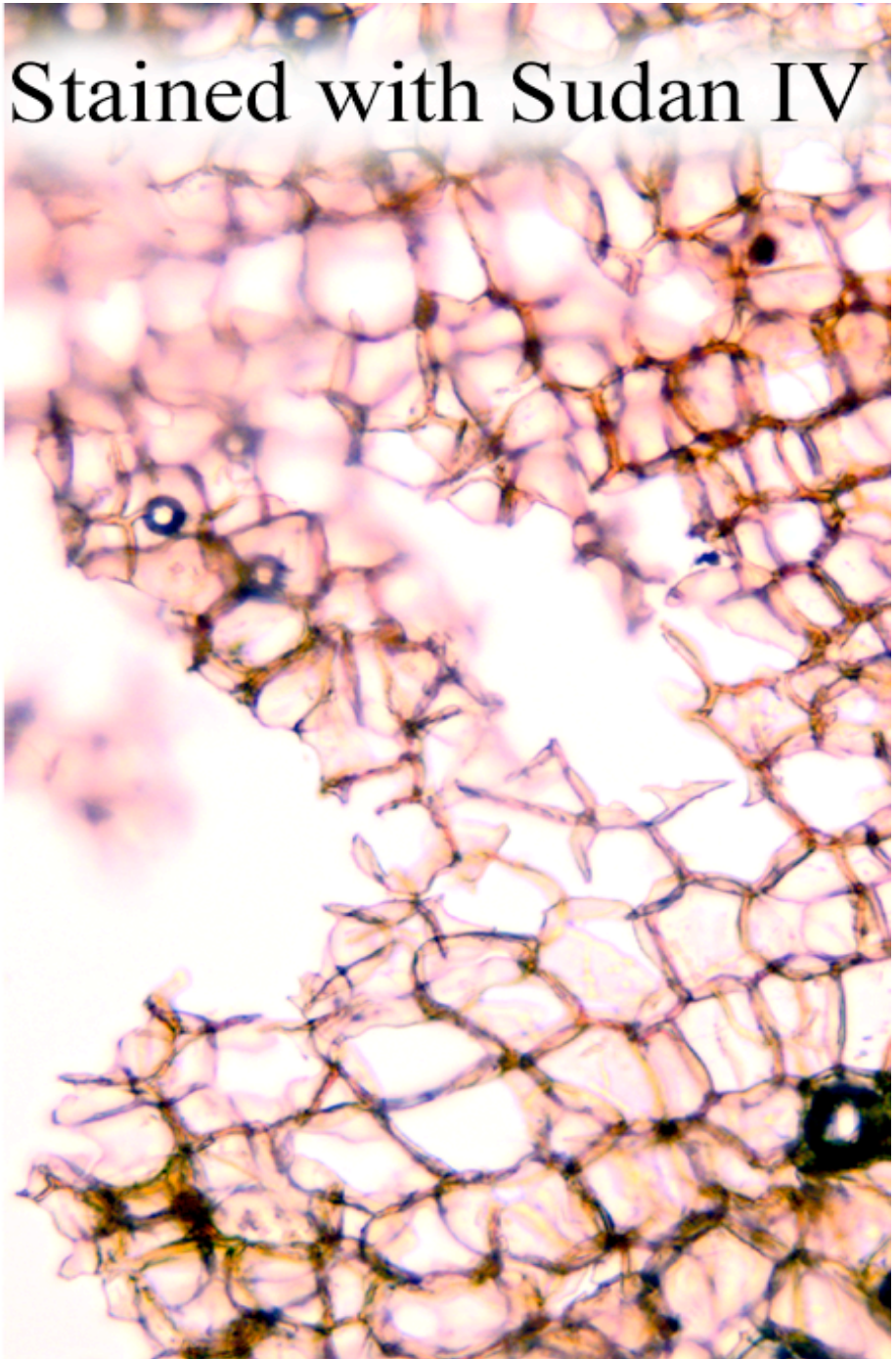
The word “cell” was first used in a biological context in 1665 by Robert Hooke to describe the units that make up the tissue of a wine cork.

Tissue of a Wine Cork



Cork Tissue is Water-proof





Dermal Tissue System

Cell Types

Basal Cells of the Epidermis

Guard Cells

Cork Cells

Dermal Tissue System

Tissues/Structures

Herbaceous Growth

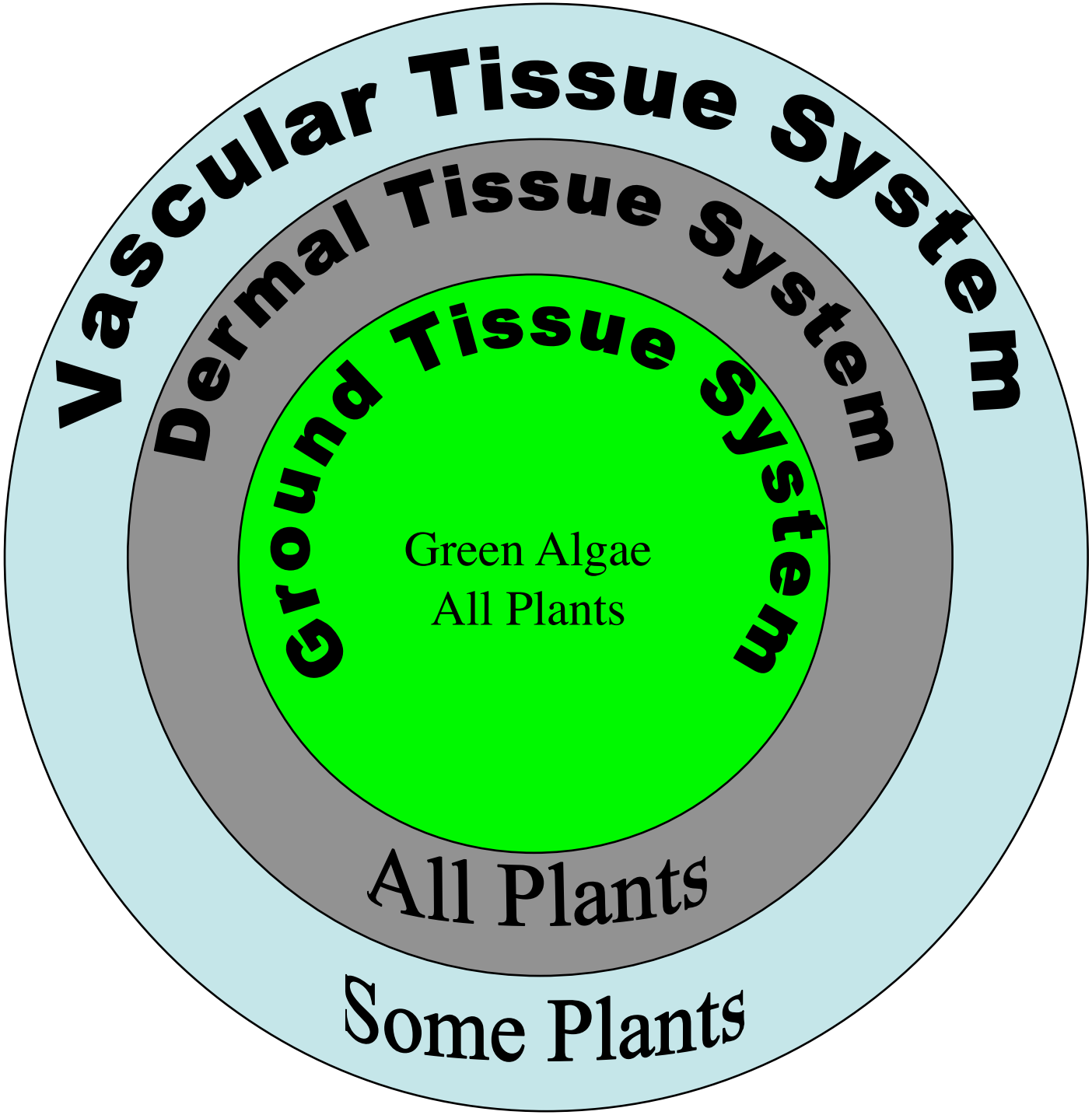
Epidermis

Cuticle

Stomata

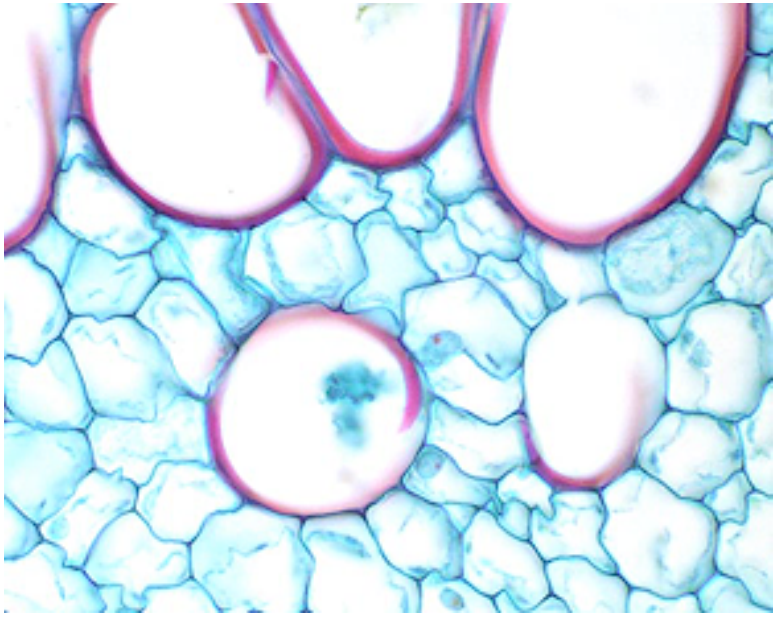
Woody Growth

Periderm with Cork Tissue


Vascular Tissue System
Some Plants
Dermal Tissue System
All Plants
Ground Tissue System
Green Algae
All Plants

Vascular tissue is necessary for a plant to become tall.

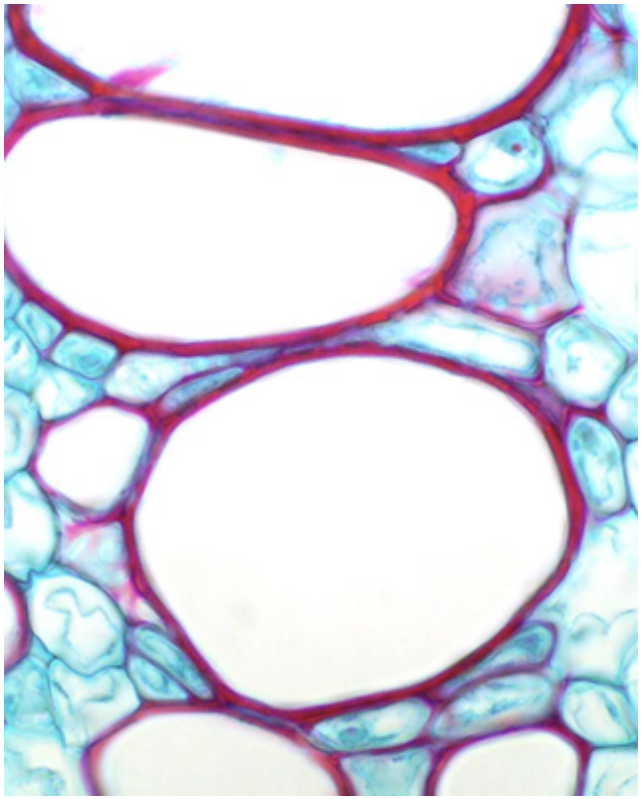
Vascular plants have cells with secondary walls that include lignin



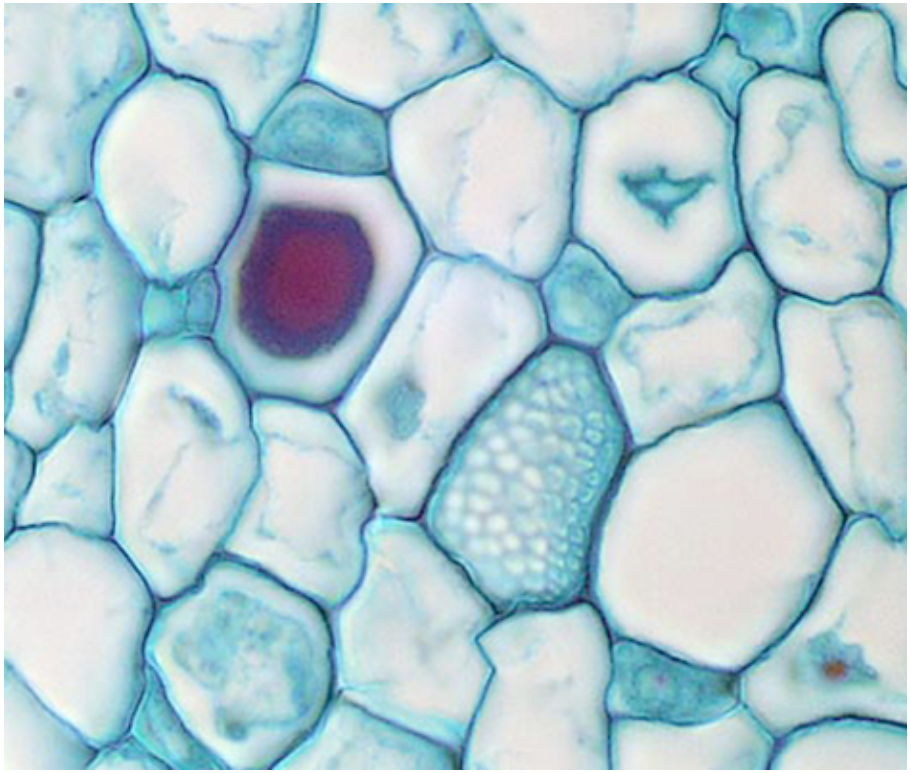
But why not simply remain short?

Because of competition for light.

The Vascular Tissue System includes two types of tissues .



Xylem

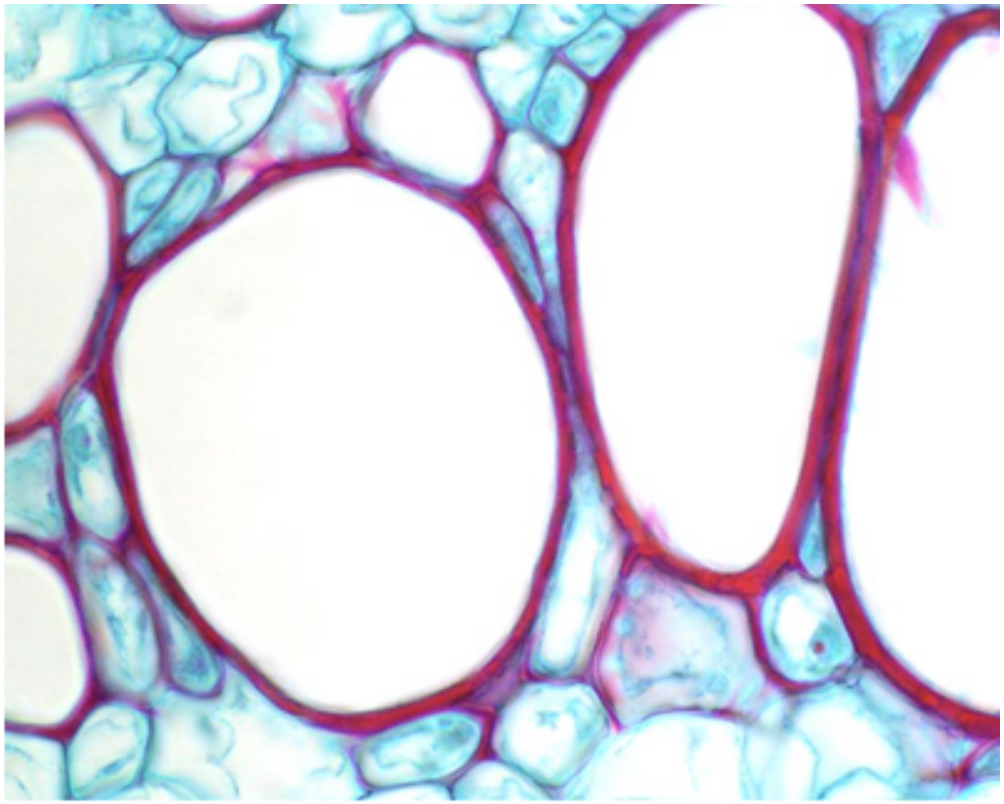


Phloem

Both xylem and phloem are complex tissues in that they are made up of more than one cell type. Simple tissues are made of one cell type such as parenchyma, collenchyma and sclerenchyma tissues.

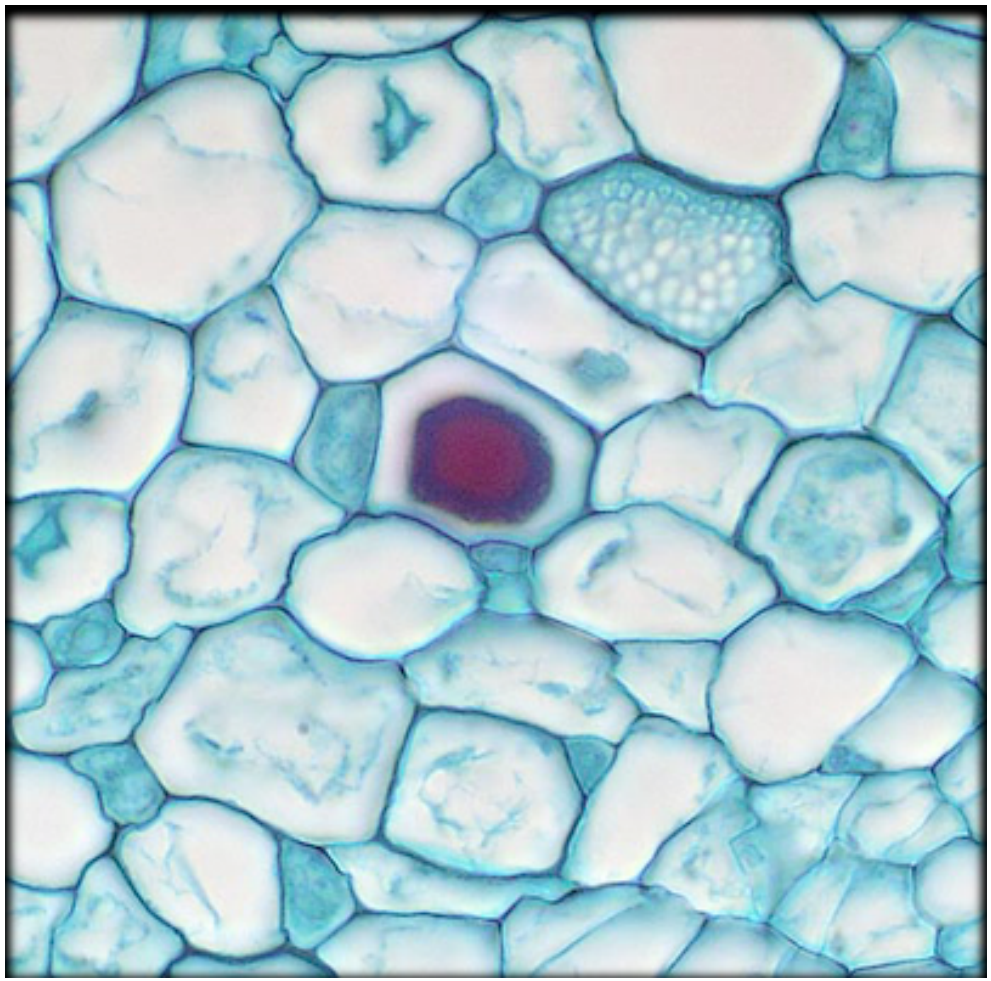
Vascular Tissue System

Xylem: Moves water and minerals up the plant
……and provides support to the plant.



Vascular Tissue System

Phloem: Moves photosynthate (usually sucrose) around the plant



Environmental Pressures Shaping the Evolution of Xylem and Phloem

The evolution of xylem is a direct response to the unique challenges of life on land relating to water transport and support.

The evolution of phloem is not specific to the challenges of life on land, but was simply a response to the challenge of becoming a large photo-autotroph. Large photo-autotrophs invariably need to fuel a significant amount of non-photosynthetic tissue.

These points are clearly illustrated by the evolution of phloem in the kelps, and also by the reduction of xylem in plants that become adapted to life submerged in water.

Kelps are photo-autotrophs that have become large

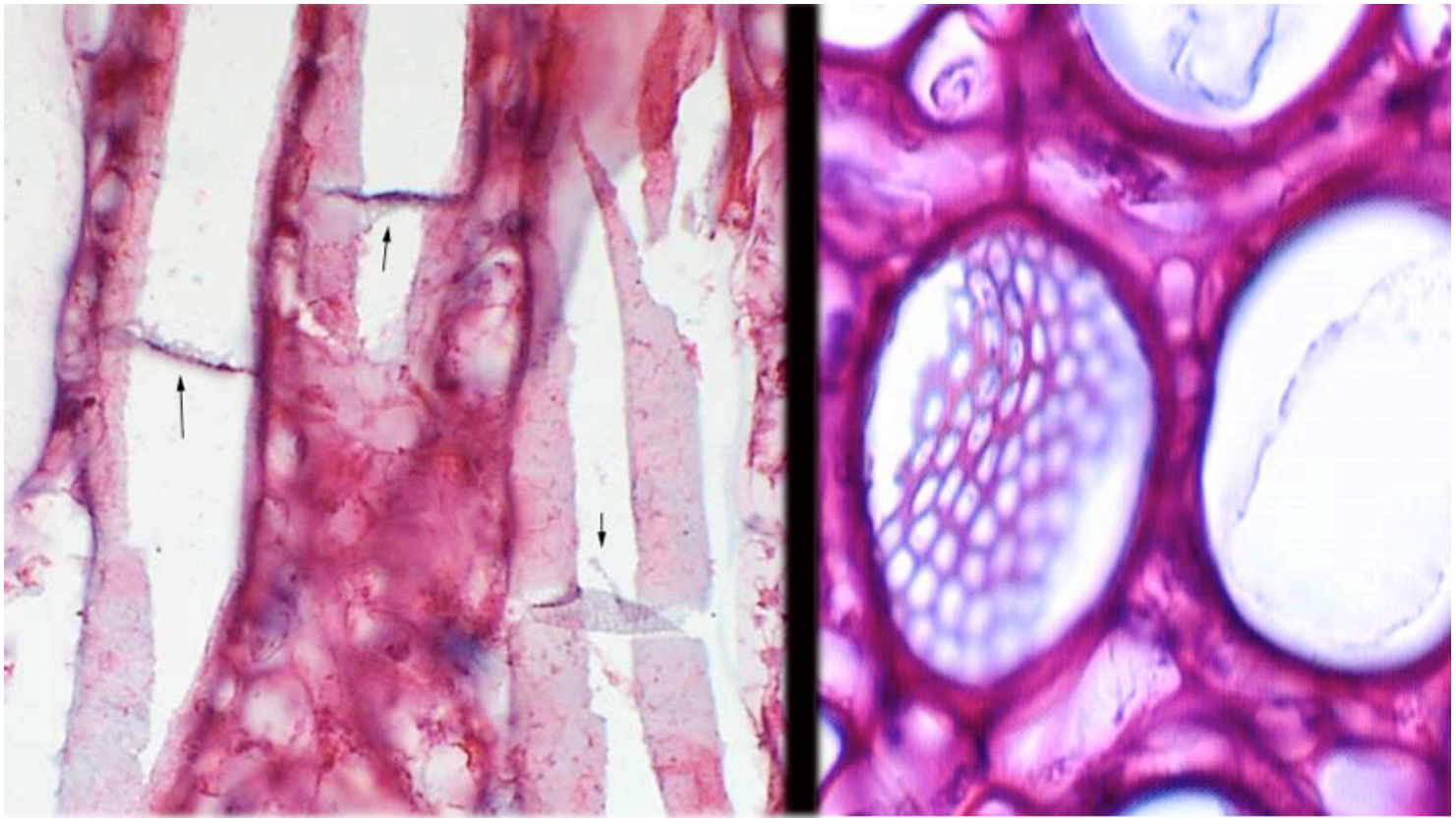
Kelps are supported by water and have no need for a tissue like xylem or cells with secondary walls

The kelp *Macrocyctis*

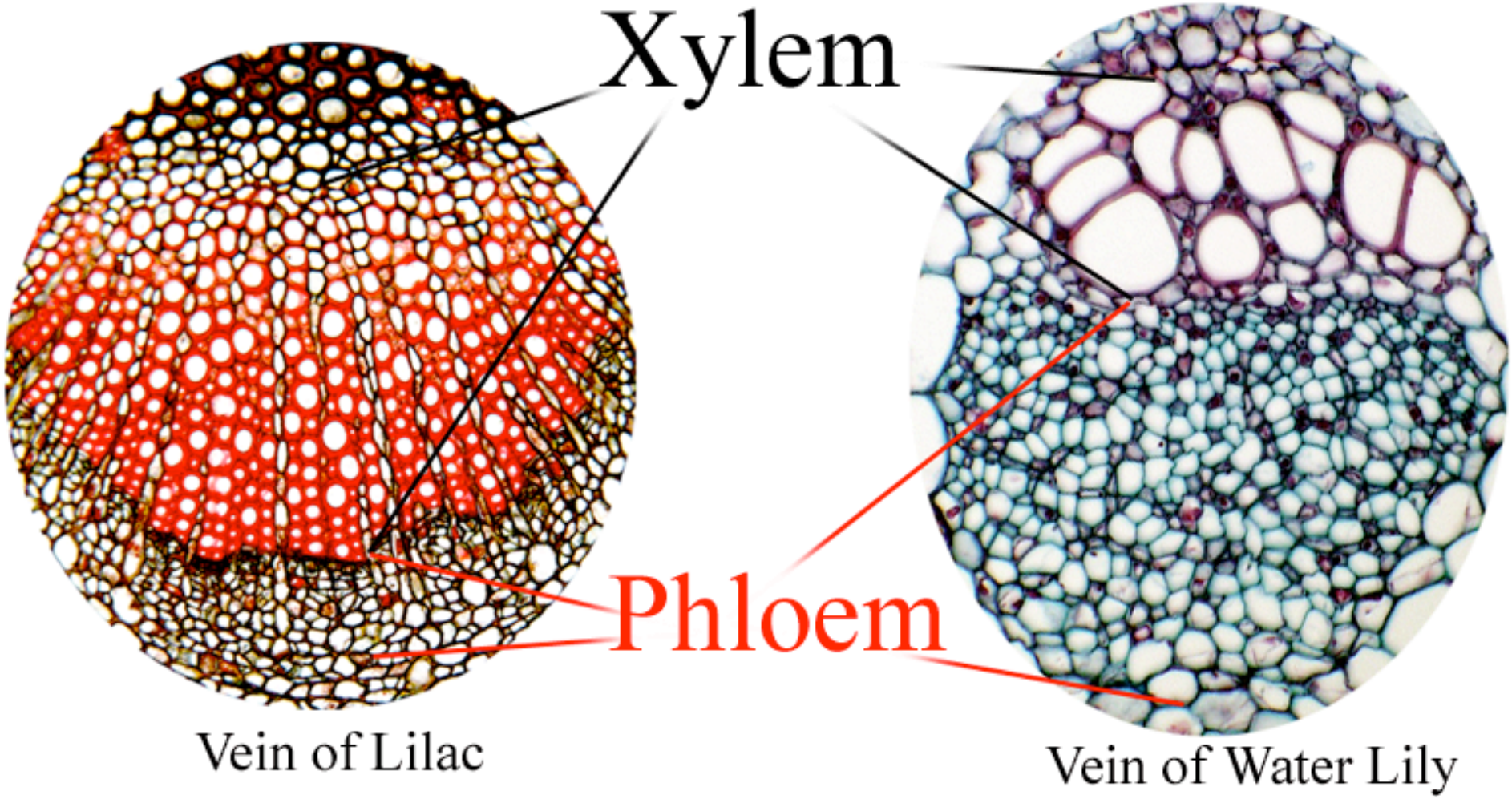
But the lower portion of the plant becomes shaded

The kelp *Macrocyctis*

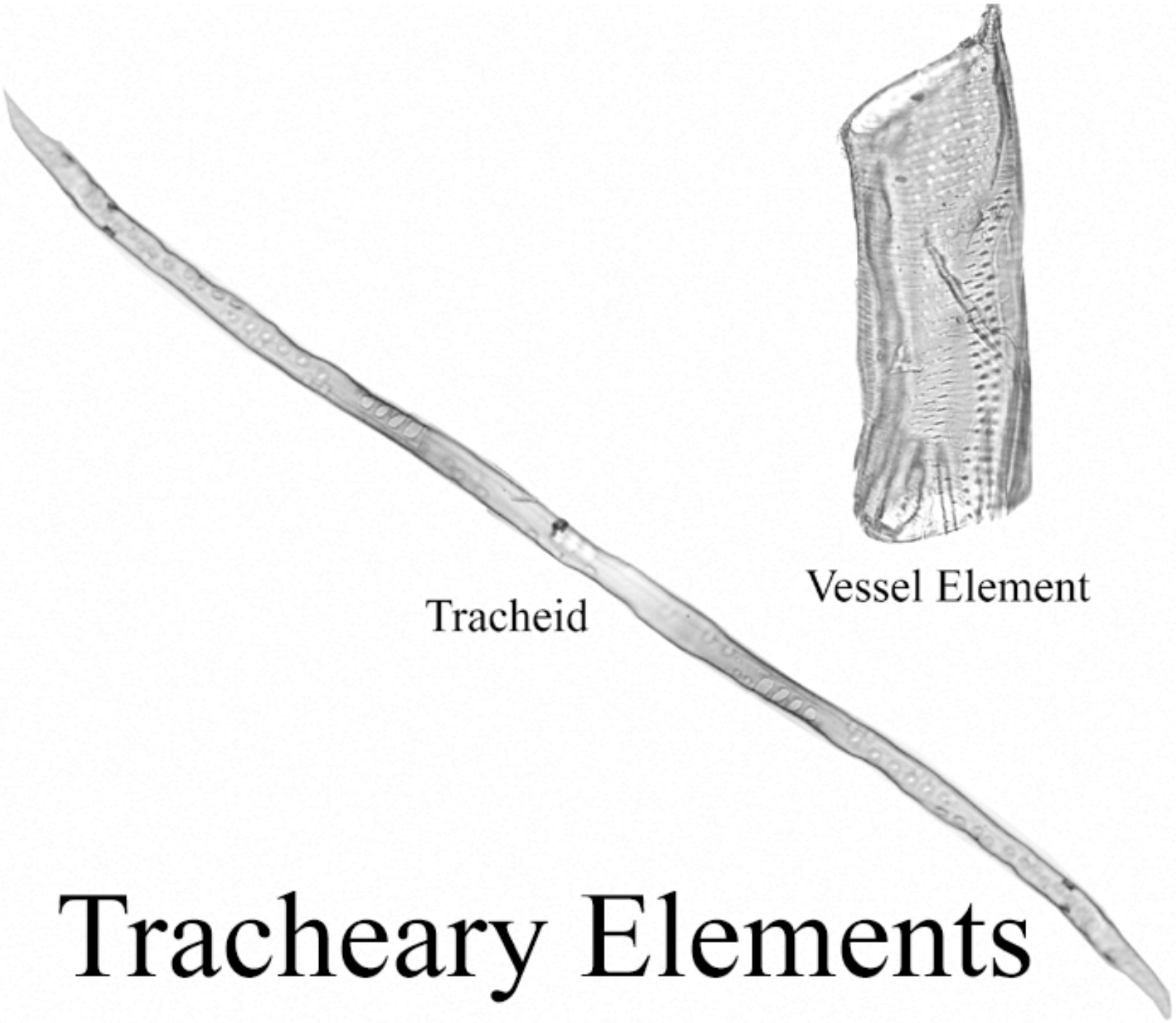
And kelps have independently evolved a type of phloem tissue



Many groups of plants have become adapted for life emmersed in the water


Xylem
Phloem
Vein of Lilac
Vein of Water Lily

Xylem is a complex tissue that includes tracheary elements



Tracheary Elements

Tracheary elements are dead at maturity and have always have a secondary wall.

Water moves through these cells by mass flow.

The pressure inside tracheary elements is less than the ambient pressure and the secandary walls prevent the cells from collapsing.

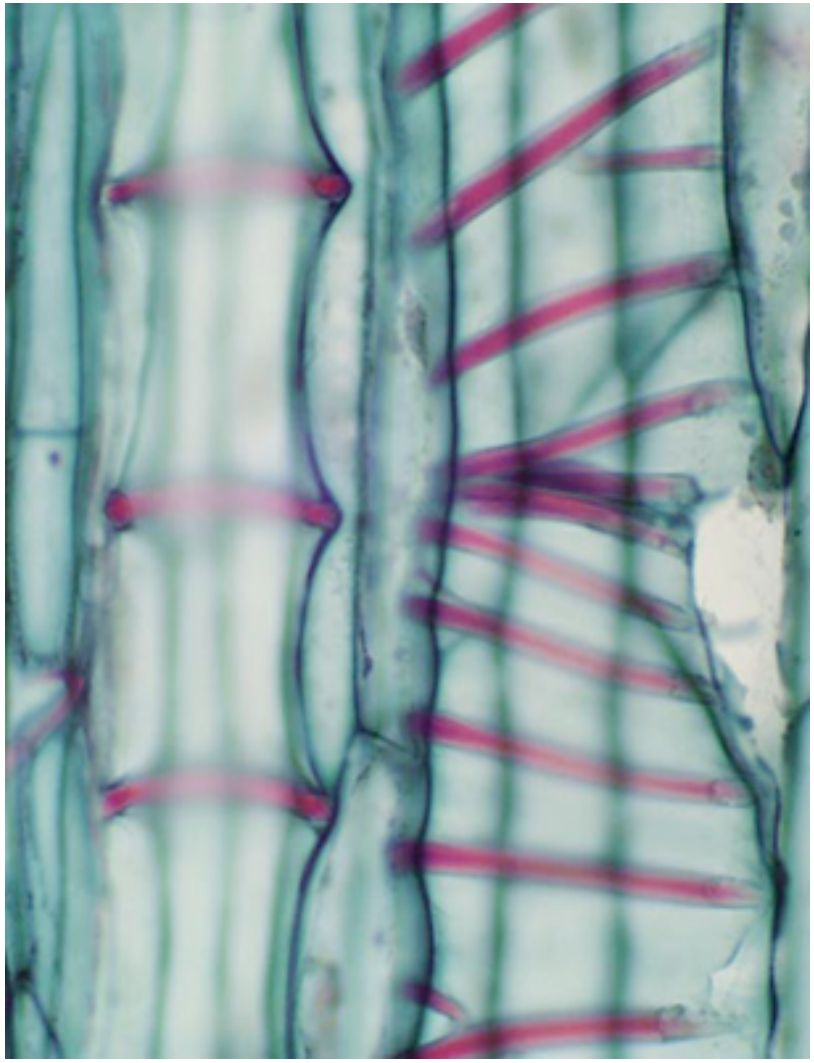
Air pressure can only lift a column of water about 32 feet, and yet plants grow much taller

Cohesion-Tension Theory

Text pages 671 - 675

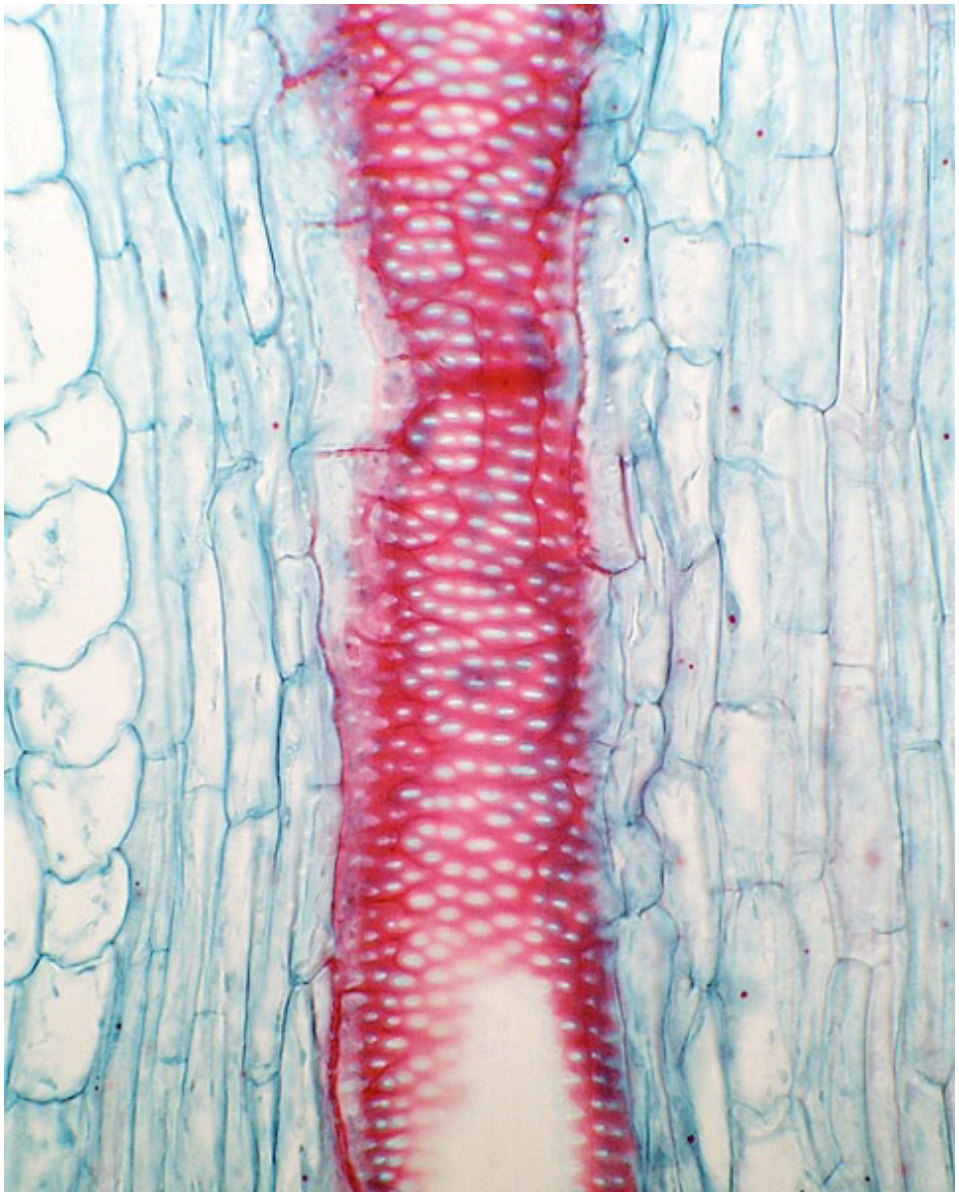
Water is pulled up the tracheary elements, because water molecules stick together (cohere) via hydrogen bonds .

Secondary walls keep the tracheary elements from collapsing



Vessel elements in an elongating plant stem

Secondary walls also help support the plant



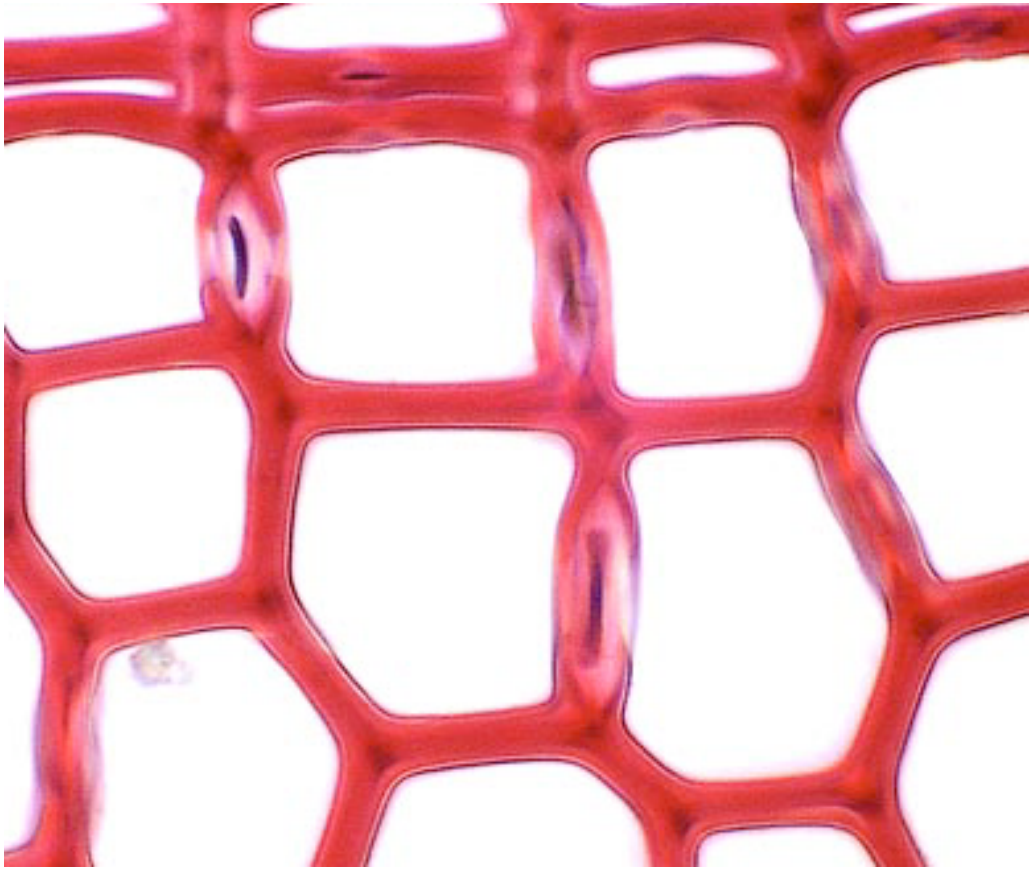
Vessel element with a complete secondary wall

All Tracheary elements have pits

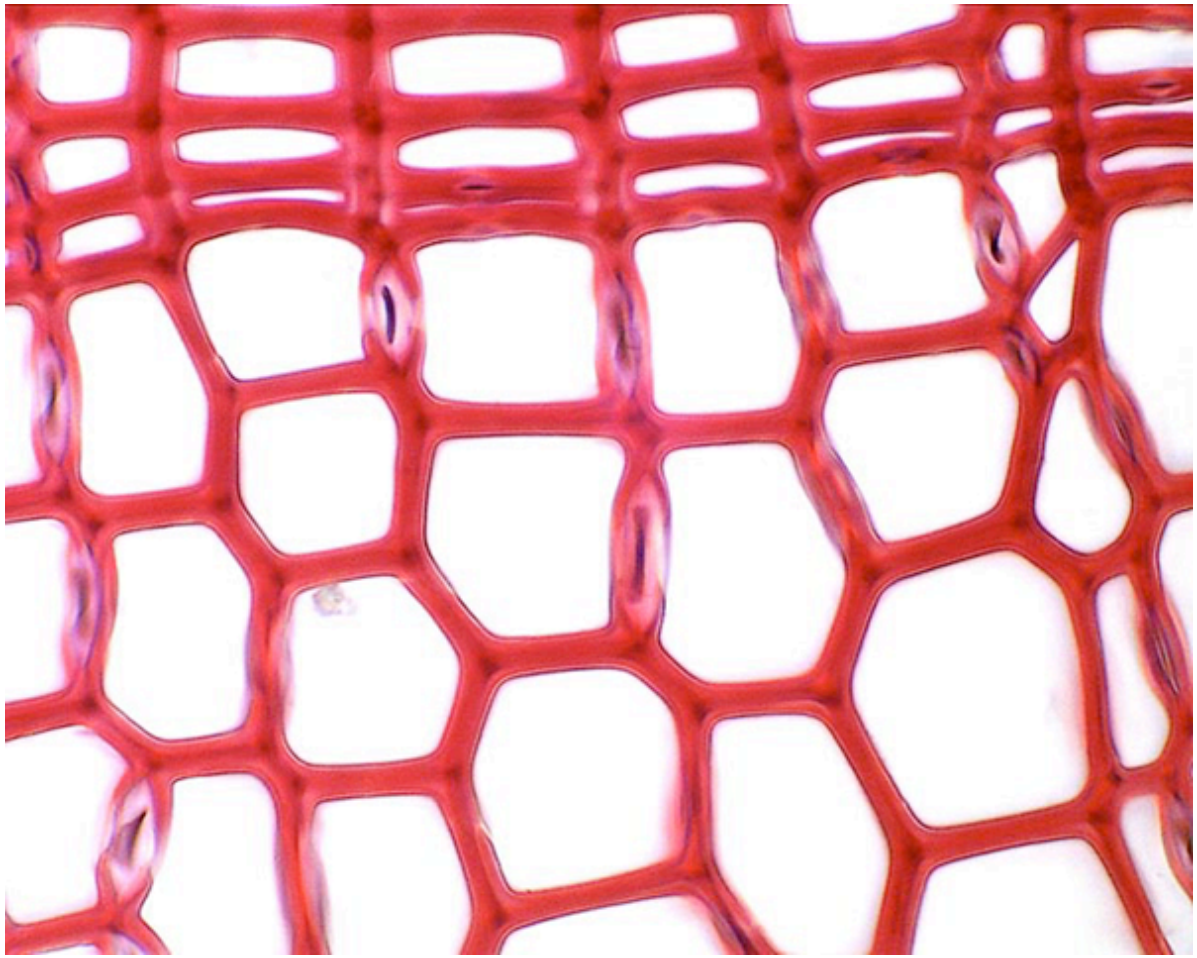
Red = secondary wall

Black = primary wall

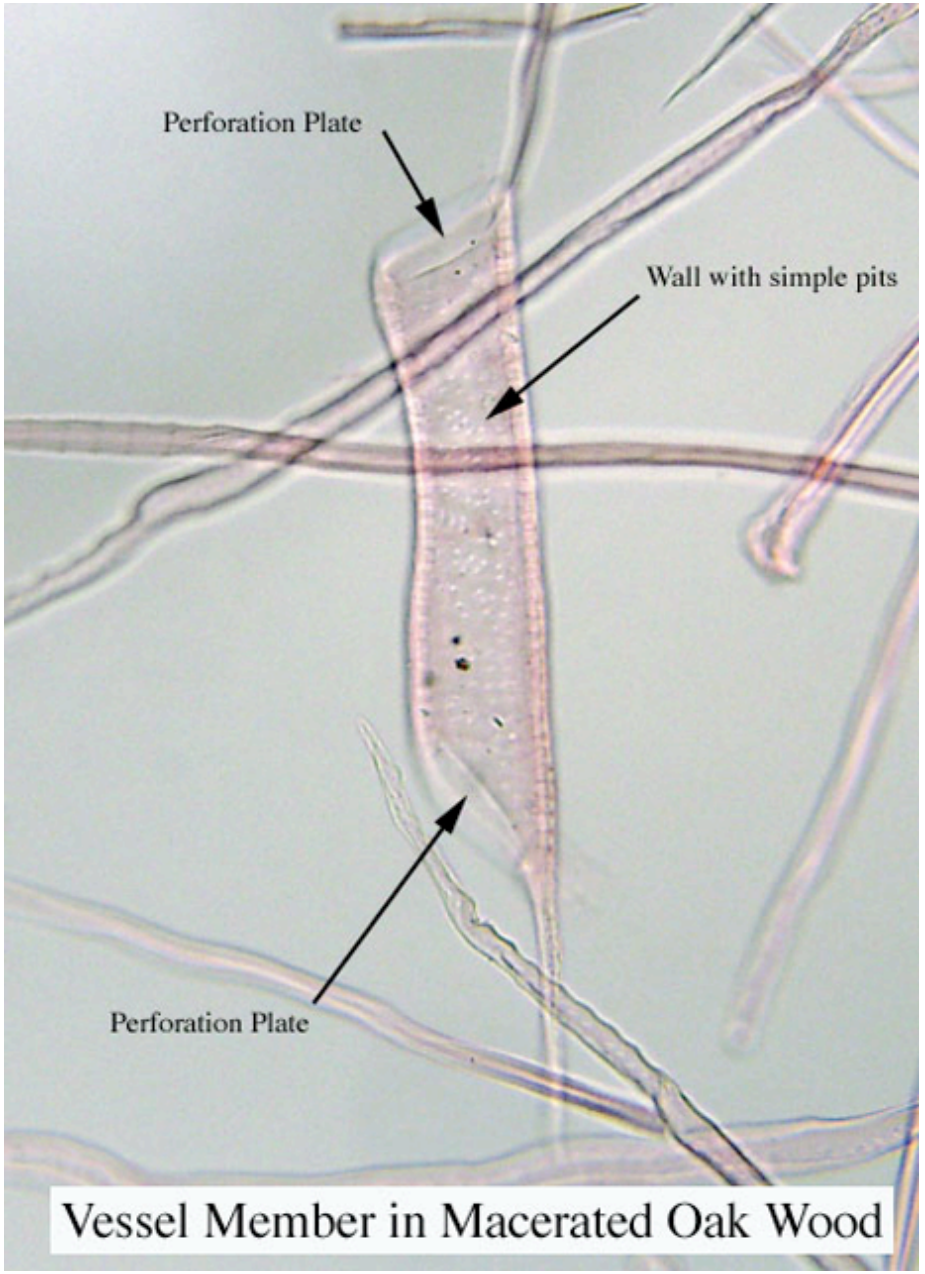
Tracheids only have pits



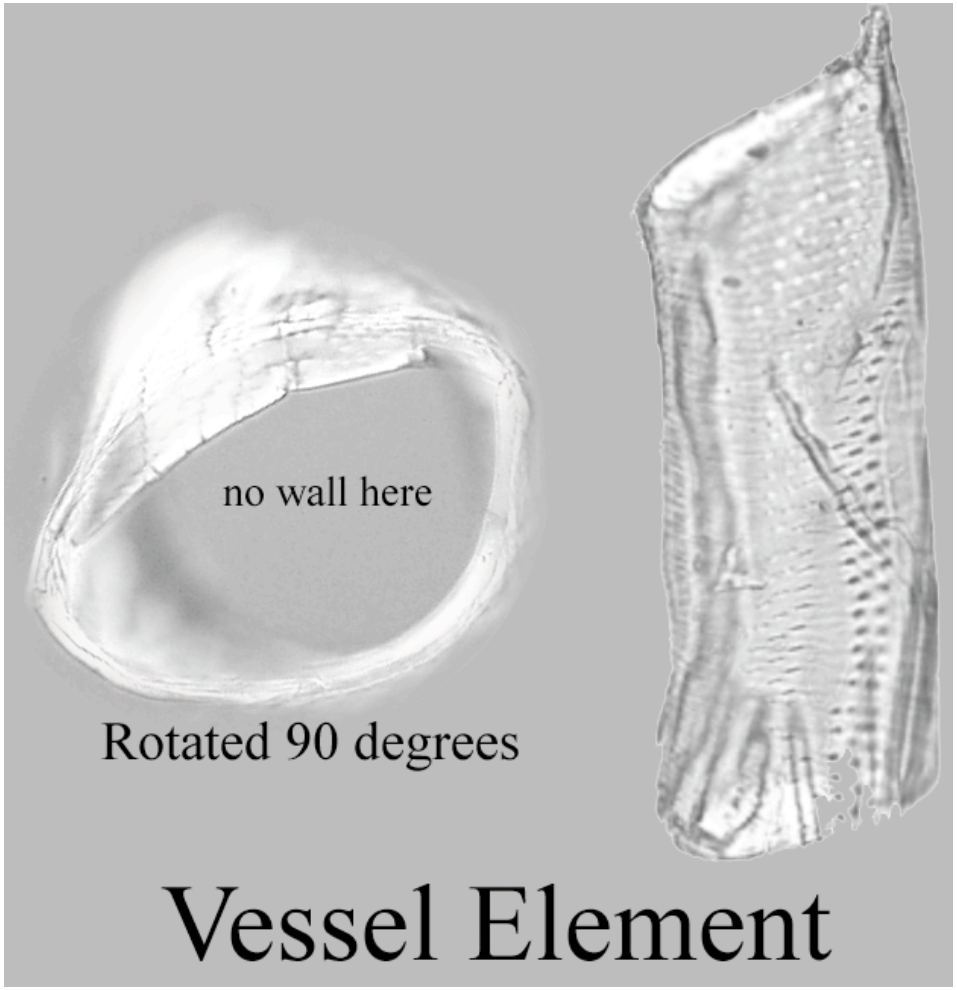
We will consider the structure of tracheids in our lab on the gymnosperms



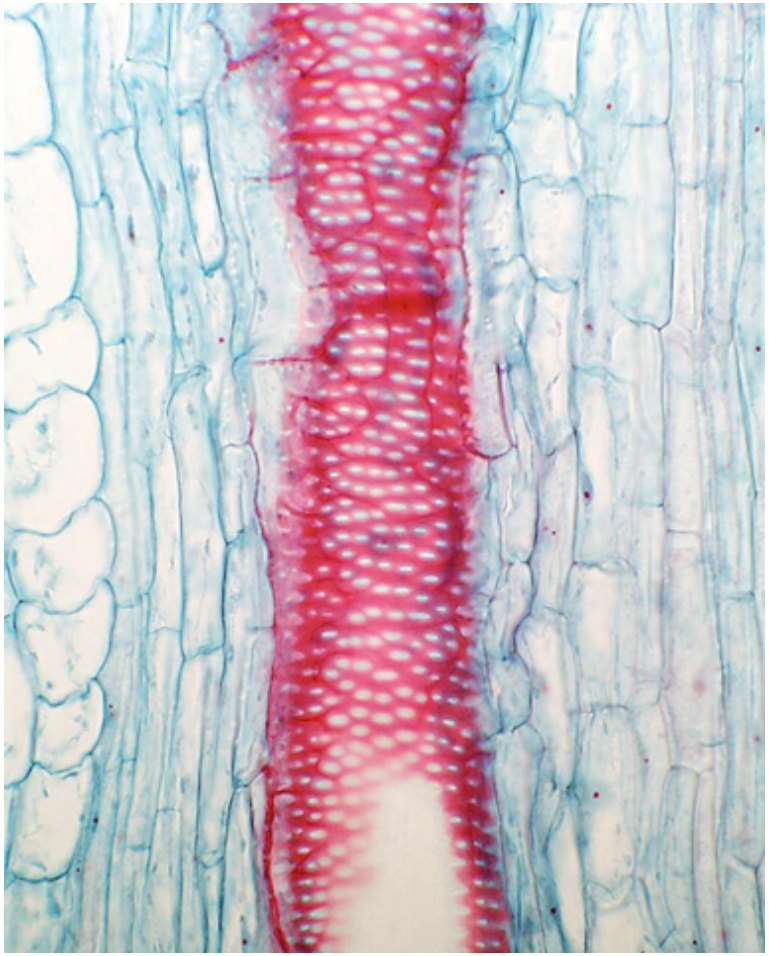
A vessel element is a tracheary element with perforations.



A perforation is an area between tracheary elements where both the primary and secondary wall has been removed.



Vessel elements
together
from a vessel



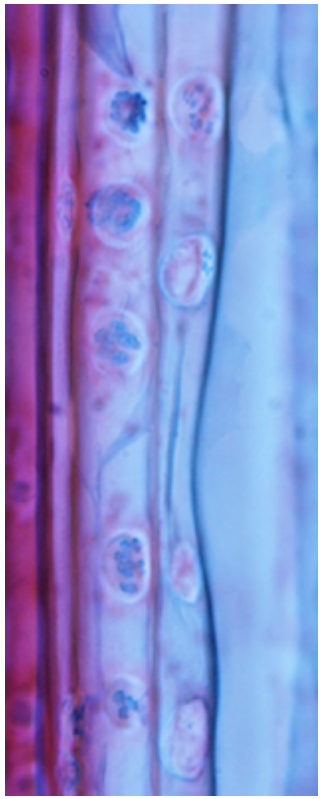
Vessels have independently evolved in six different plant groups.

Flowering plants have them

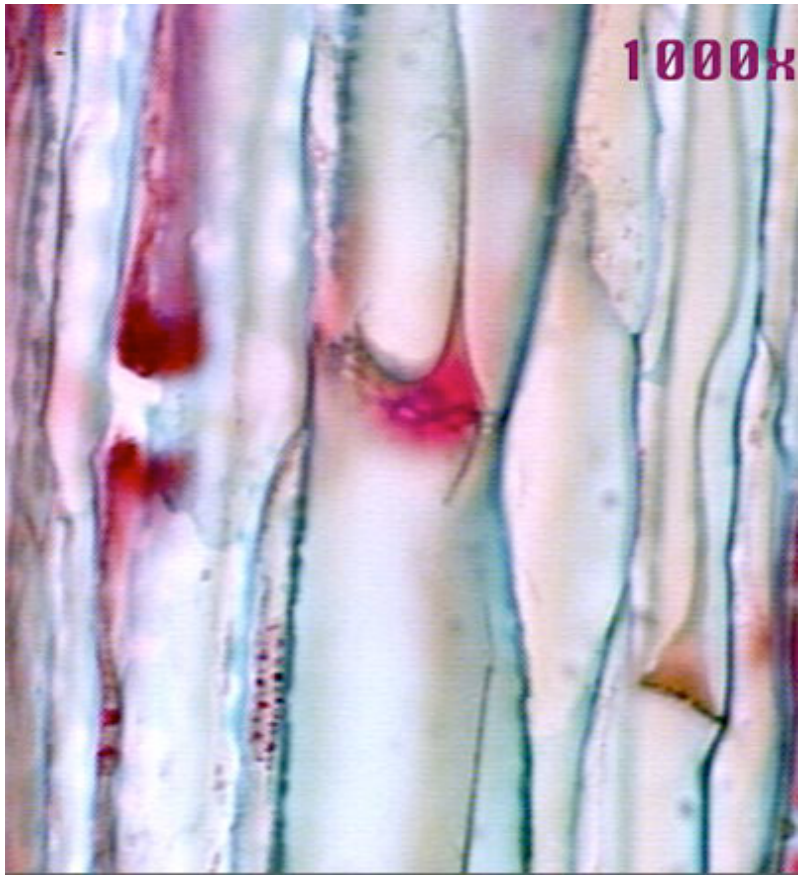
Conifers Don’t

The examples of xylem we will see in the lab all have vessels

Phloem is a complex tissue that includes sieve elements



Sieve Cells
(Conifers)



Sieve-Tube Elements
(Angiosperms)

Sieve Elements Serve as a Conduit for the Movement of Photosynthate

This movement is based on a pressure gradient generated osmotically. To generate this gradient sugar must be loaded at the source and unloaded at the sink. Living membranes are necessary both to control the movement of sucrose and for the osmotic movement of the water into and out of the Sieve tubes.

Read about phloem transport in the text pp. 682 -685.

Sieve elements are greatly reduced.They lose their vacuole, nucleus, and most of the rest of their cellular structure as they mature.

Adjacent sieve elements are interconnected by clusters of pores through which materials flow from one element to another.