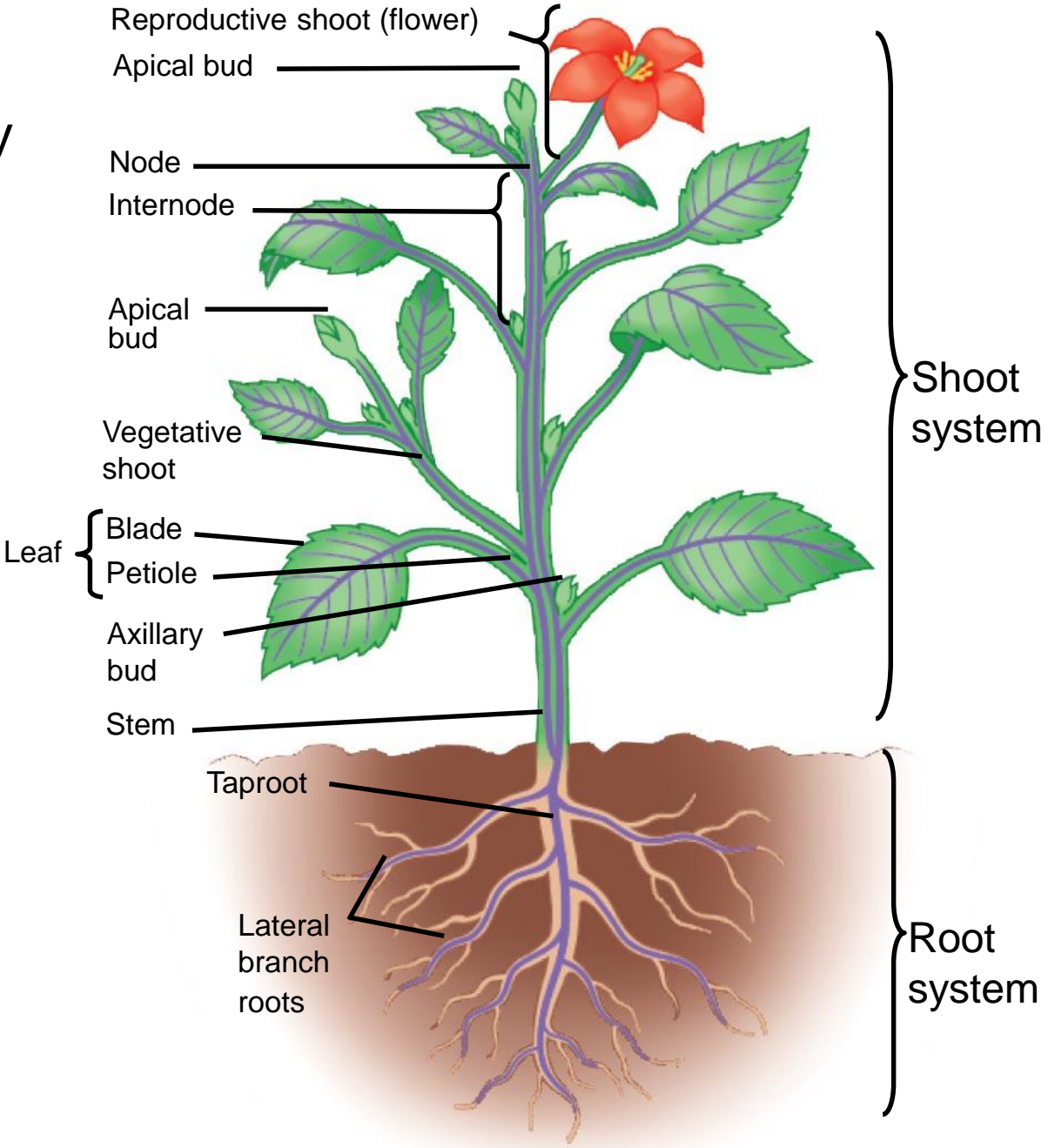


Struktur Tanaman: Organ, Jaringan dan Sel Tanaman

Struktur Tanaman tersusun atas hierarki : Tanaman, organ, jaringan, sel

- Tanaman tersusun atas organ-organ. Organ-organ tersusun dari berbagai jaringan, jaringan tersusun dari sel-sel,
- *Tanaman mempunyai tiga organ dasar: akar, batang dan daun.*
- Ketigaorgan dasar tersebut terorganisasi menjadi sistem perakaran (a **root system**) dan sistem tajuk (**shoot system**)
- *Akar tergantung dari ketersediaan gula dan karbohidrat lain yang dihasilkan oleh fotosintesis yang dilakukan oleh shoot system*
- *Tajuk atau tunas tergantung pada ketersediaan air dan hara mineral yang diserap oleh sistem perakaran(**root system**).*

Flowering Plant Morphology

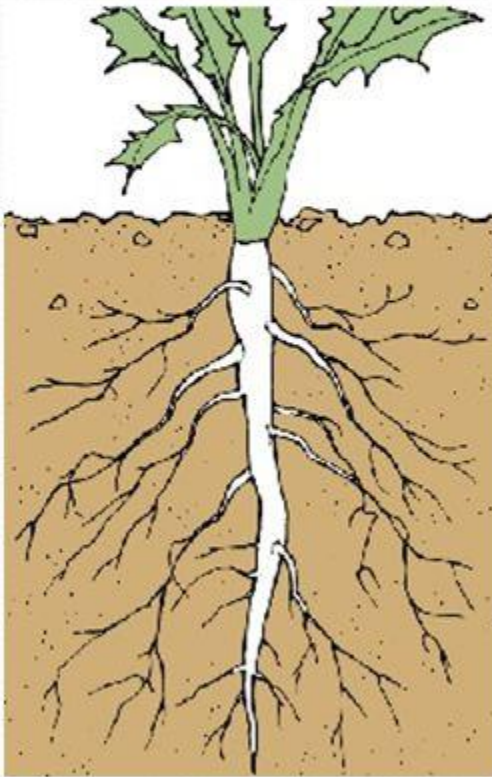


Tiga Organ Dasar tanaman : Akar, Batang, Daun

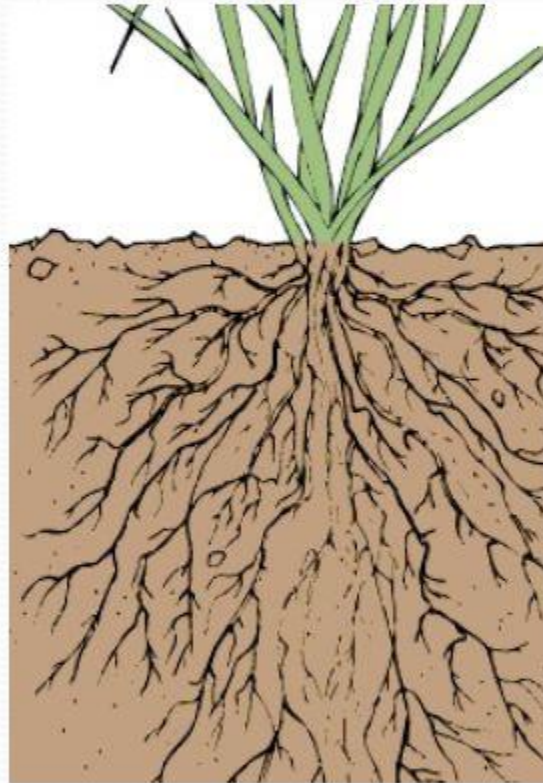
Akar adalah organ multiselular yang berfungsi:

- Menancapnya tanaman ke tanah*
- Menyerap air dan hara mineral*
- Menyimpan bahan makanan*

AKAR dan SISTEM PERAKARAN



Tap root



Fibrous roots

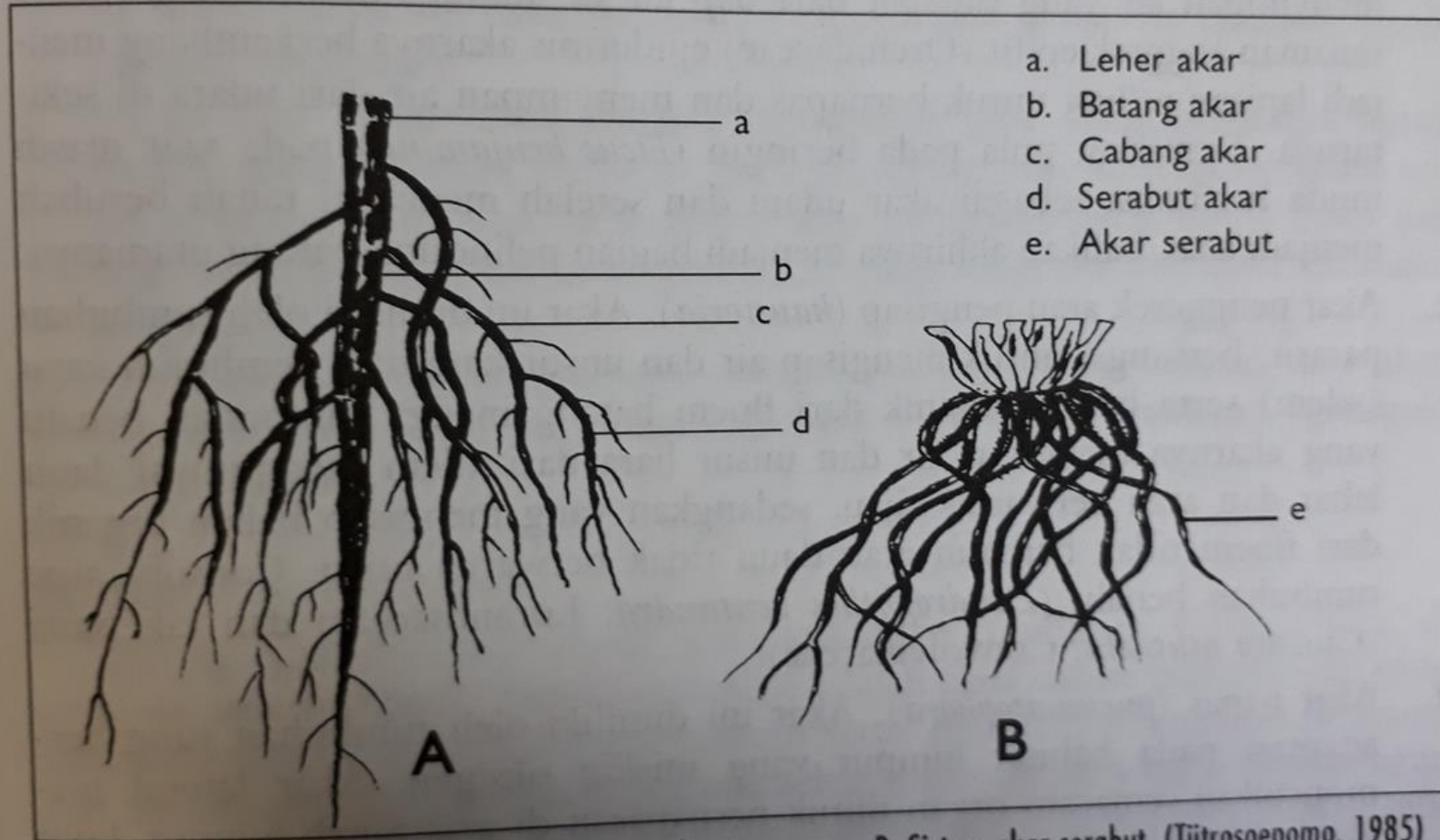
- Functions of roots;
 - absorb water
 - absorb minerals ions
 - support and anchor
 - sometimes used for food storage

Sistem perakaran tunggang terdiri dari satu akar utama vertikal yang membentuk cabang-cabang akar, atau akar-akar lateral.

Contoh tanaman berakar tunggang: pada tanaman yang bijinya berkeping 2 (dikotil) maka dipastikan tanaman tersebut memiliki akar tunggang contoh: mangga, jeruk, rambutan, jambu, durian, belimbing, dll.

Sistem perakaran serabut terdiri dari banyak yang ukurannya hampir sama yang keluar dari pangkal batang berbentuk serabut. Sistem perakaran ini banyak dijumpai pada tanaman yang bijinya berkeping satu: monokotil.

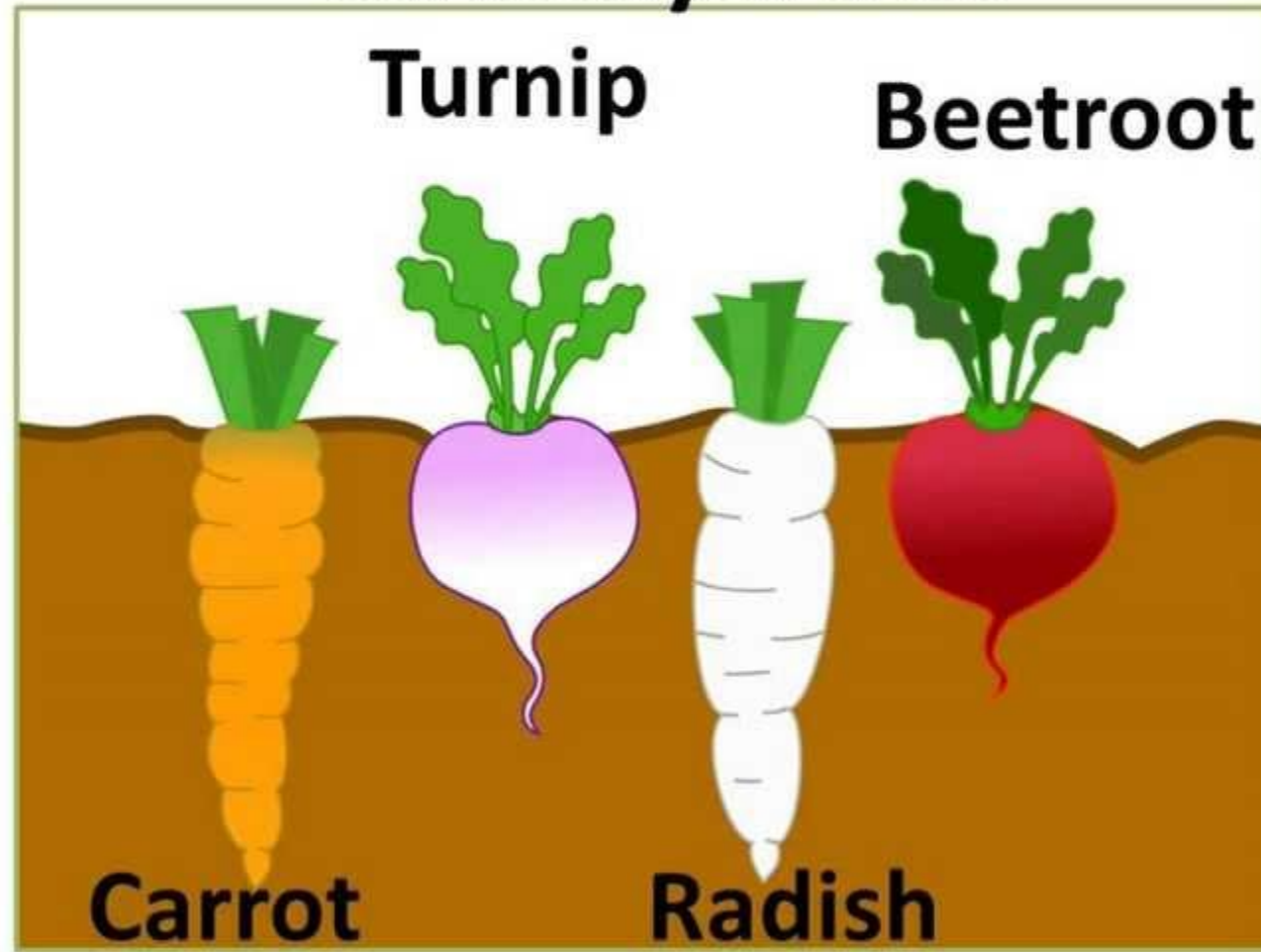
biet gula (*Beta vulgaris*).

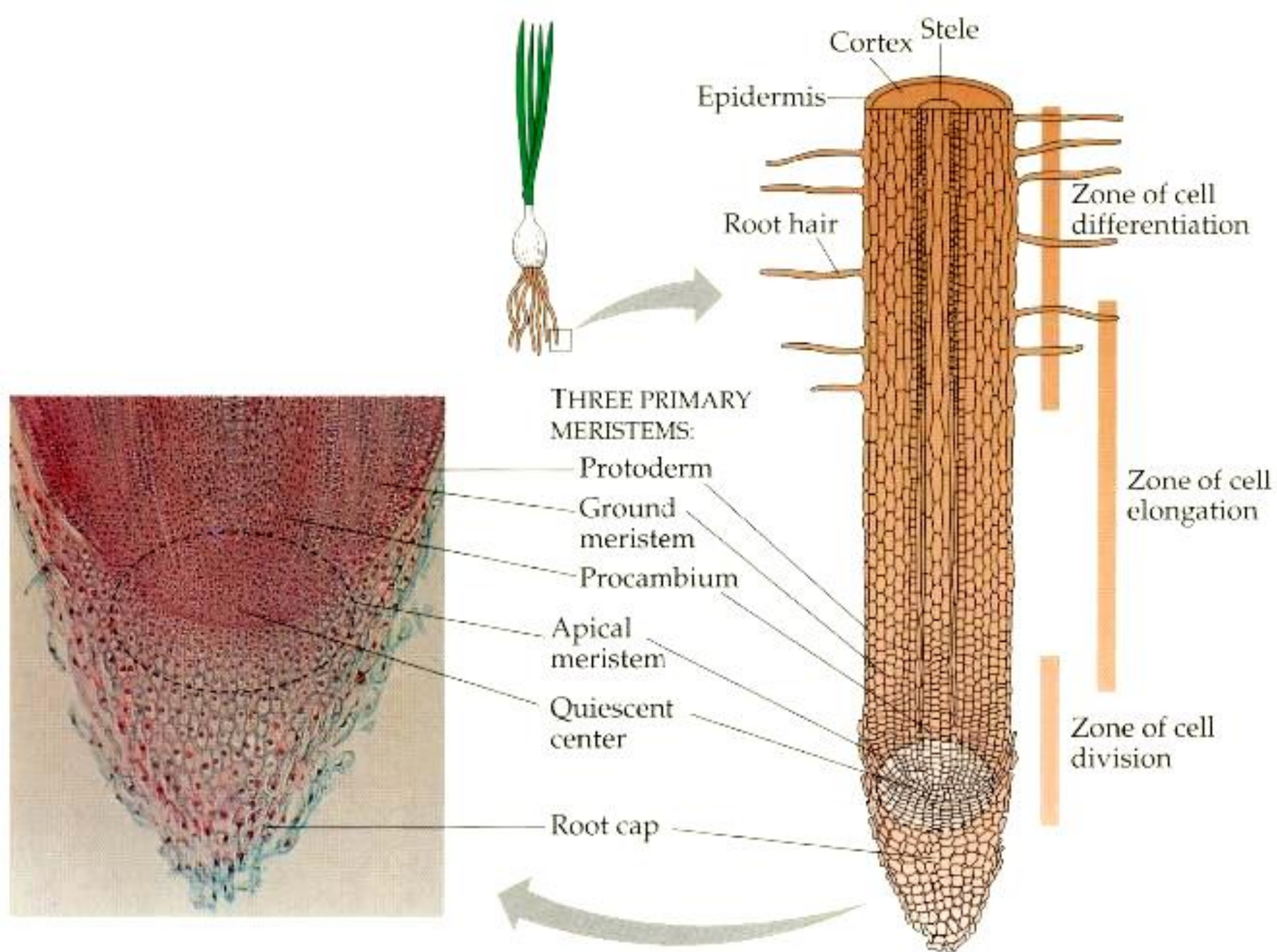


- a. Leher akar
- b. Batang akar
- c. Cabang akar
- d. Serabut akar
- e. Akar serabut

Gambar 1.1 Skema akar tumbuhan: A. Sistem akar tunggang, B. Sistem akar serabut (Tjitrosoepomo, 1985)

Excess food stored in form of carbohydrates







Akar radikula: akar yang tumbuh keluar dari biji yang berkecambah.

Rambut-rambut akar adalah: modifikasi sel-sel epidermis akar menjadi akar-akar halus seperti rambut. Rambut akar bertanggung jawab terhadap penyerapan hara.

Akar adventif (adventitious roots)

Akar yang tumbuh dari bagian-bagian tanaman selain radikula (bakal akar pada kecambah), misalnya akar yang tumbuh dari setek.



Modifikasi akar

Many plants have modified roots



Prop roots



Storage roots



“Strangling” aerial roots

Buttress roots



Pneumatophores



Modified roots



Prop roots - *support tall top heavy plants*

Modified Roots



Pneumatophores - “air roots” enable root systems to capture oxygen

Modified Roots



Buttress roots - support tall trunks of some tropical trees “like butters.”

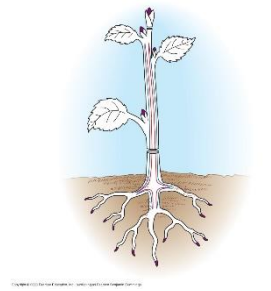
BATANG : organ tanaman yang terdiri dari buku (nodes) dan ruas (internodes)

Buku adalah tempat pada batang dimana daun menempel/ duduk.

Ruas adalah bagian batang yang berada diantara dua buku.

Mata tunas lateral atau axillary bud adalah struktur yang mempunyai potensi untuk membentuk tuans lateral, atau cabang.

- **Mata Tunas Apical** atau mata tunas terminal : mata tunas yang terletak di, is located near the shoot tip and causes **elongation** of a young shoot.



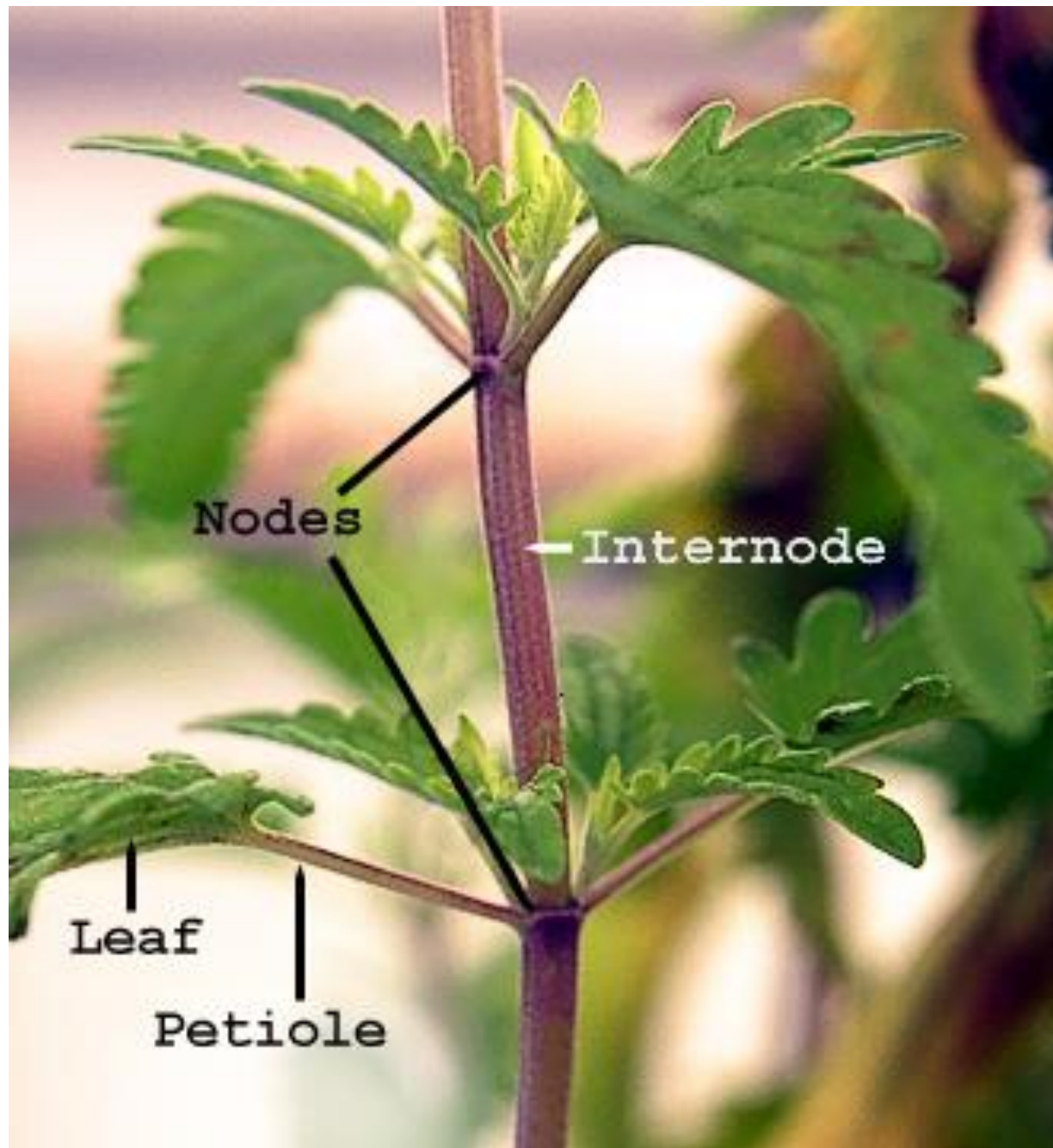
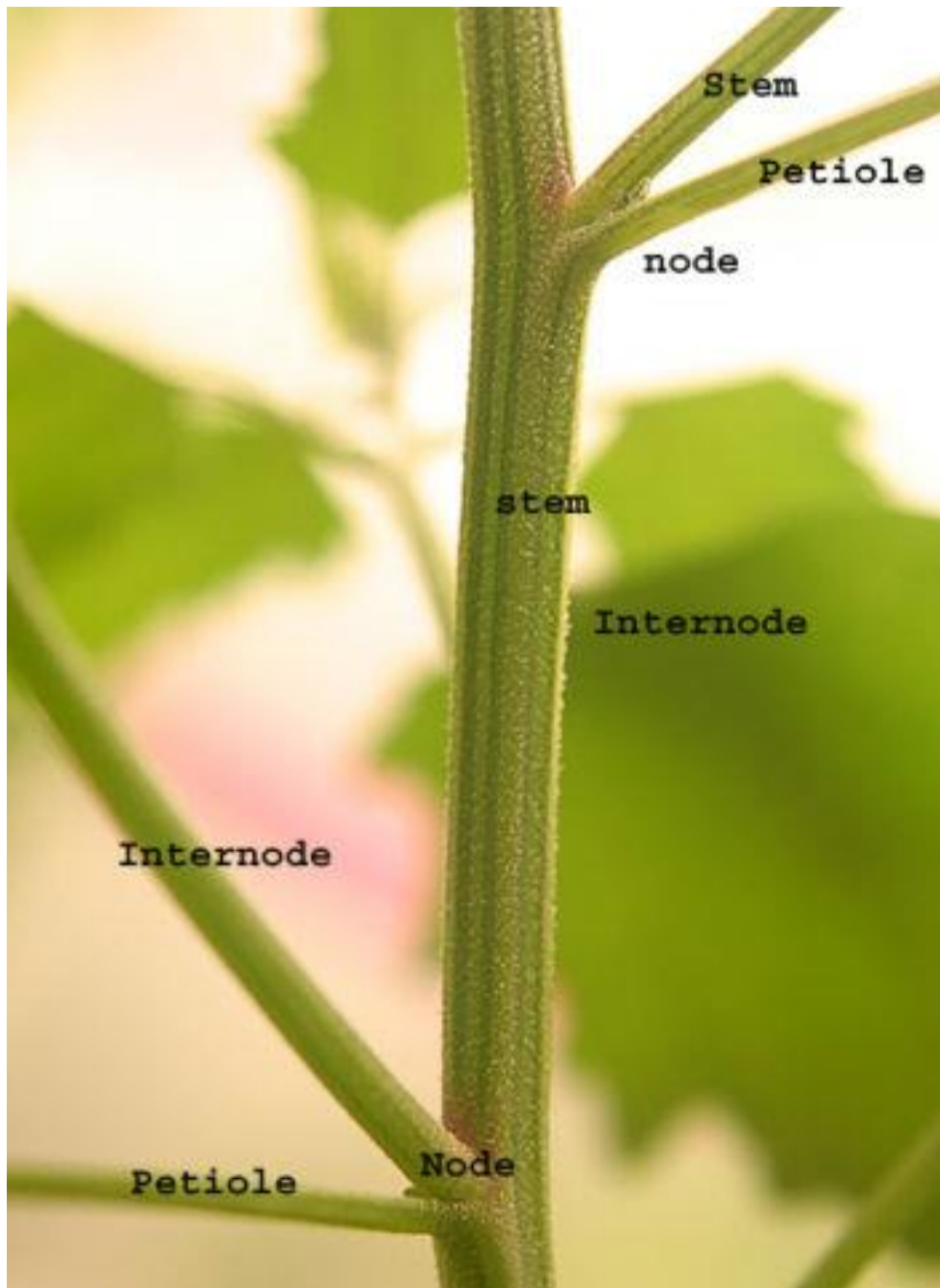




FUNZUG.COM







Daun = Organ tanaman utama yang berfotosintesis

Daun umumnya terdiri dari lembaran pipih dan sebuah tangkai yang disebut tangkai daun atau petiol, yang menggabungkan daun ke buku-buku batang.

Tanaman monokotil dan dikotil mempunyai susunan tulang daun yang berbeda. Tulang daun adalah jaringan pembuluh pada daun.

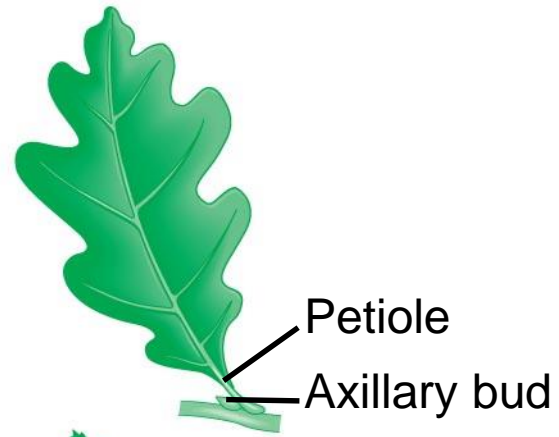
Kebanyakan tanaman monokotil mempunyai susunan tulang daun paralel atau sejajar.

Kebanyakan dikotil mempunyai susunan tulang daun yang bercabang (menyirip, menjari, dsb).

Simple
vs.
Compound
Leaves

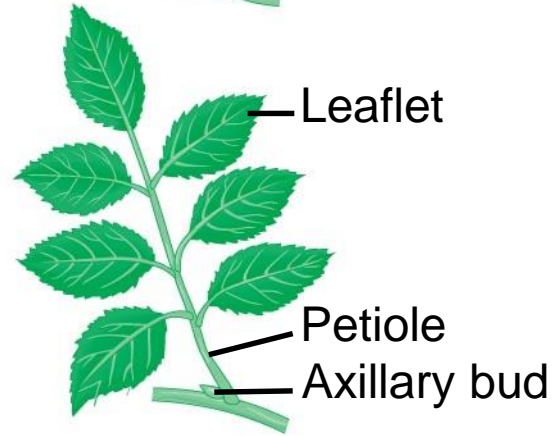
Daun sederhana: daun tunggal

(a) Simple leaf



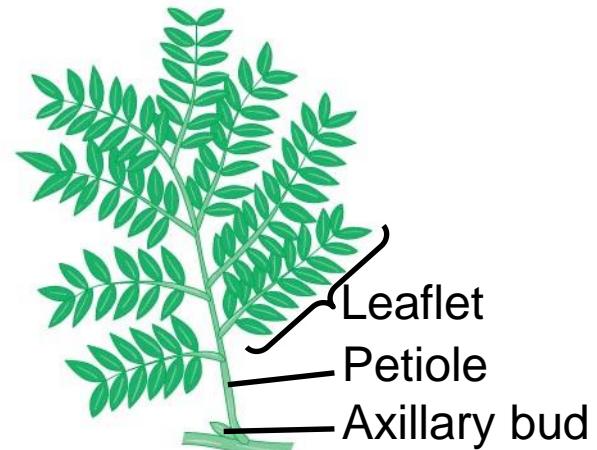
Daun majemuk

(b) Compound leaf

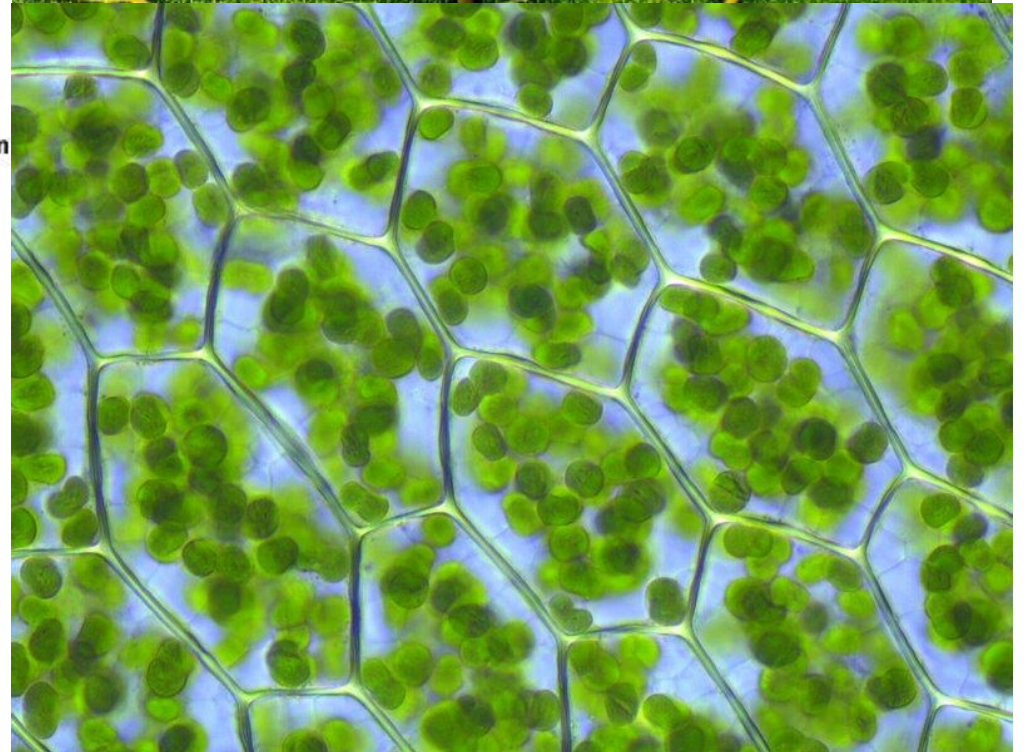
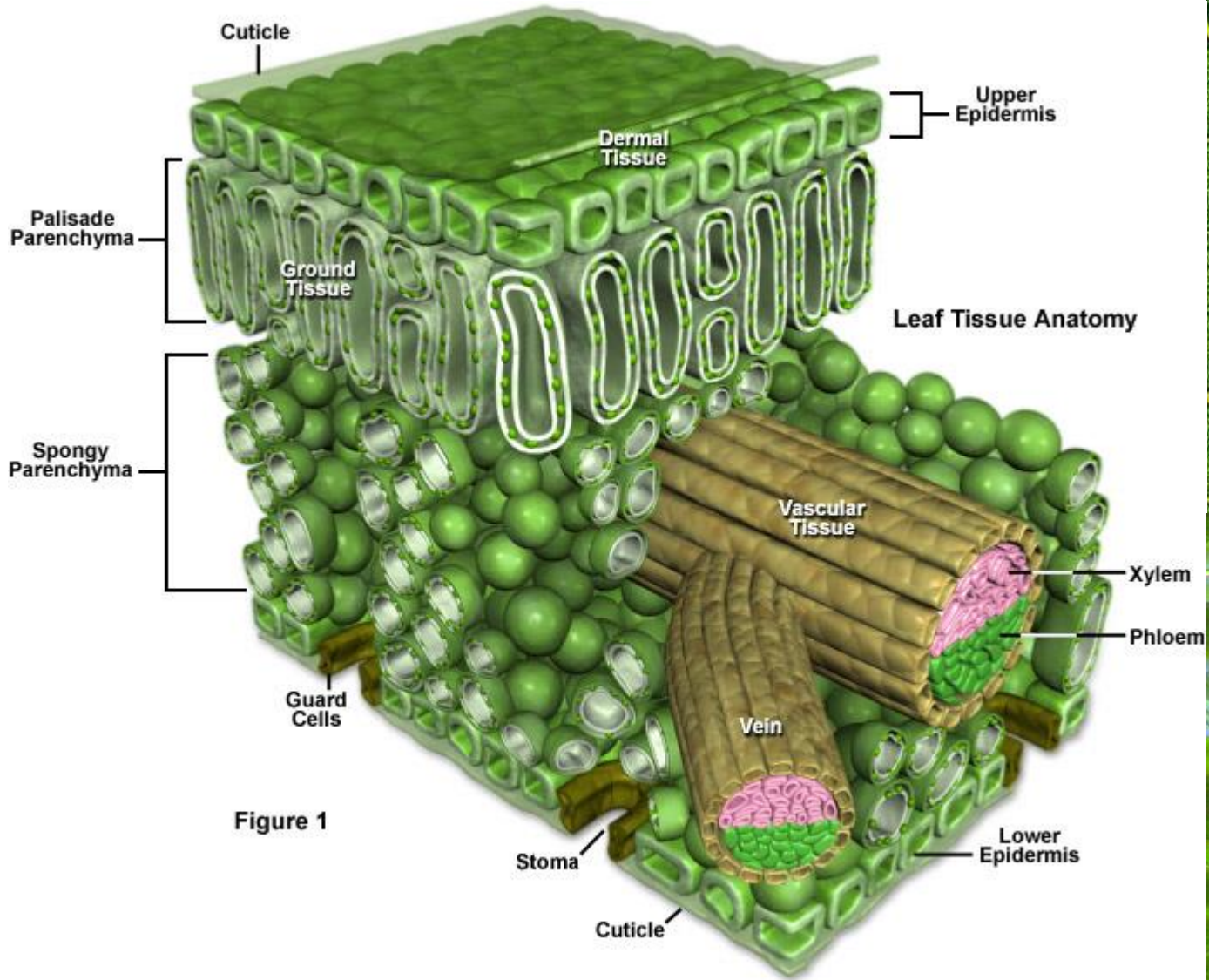


Daun majemuk berganda

(c) Doubly compound leaf







- Beberapa spesies tanaman telah berevolusi memodifikasi daunnya mempunyai berbagai fungsi:

- Sulus: untuk melekatkan tanaman ke ajir.



- Duri : mekanisme pertahanan diri dan menghemat transpirasi.

- Sebagai organ reproduksi aseksual: cocor bebek.

Some plant species have evolved modified leaves that serve various functions

▶ Tendrils
cling



◀ Spines "prickly" *Photosynthesis is carried out mainly by the fleshy stems*



◀ Storage Leaves *succulent plant leaves store water*



▶ Reproductive leaves
Little plantlets fall off and take root in the soil



Bracts
*Look like petals
Attract pollinators*



Tendrils = Modified Leaves



Tendrils -- **cling** --> **thigmotropism**

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Ice Plant Leaves Store Water: Succulent Plants: Desert Adaptation



Storage leaves

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Organ Tanaman Yang Terspesialisasi

Bulb (Umbi Lapis) : Struktur batang pendek di bawah permukaan tanah yang tertutup oleh lapisan-lapisan daun berdaging sebagai organ penyimpan makanan.

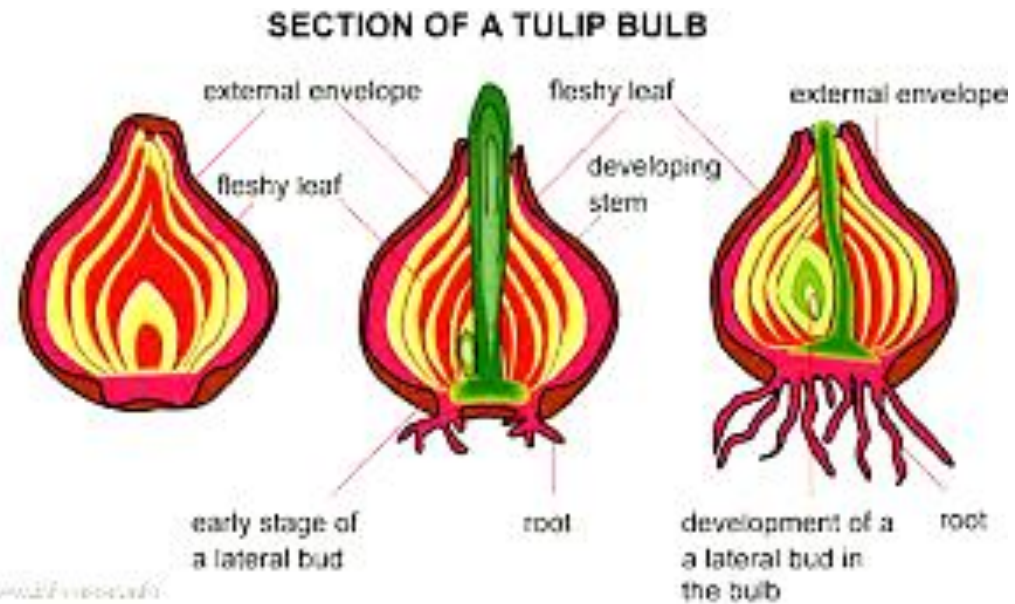
Contoh: Bawang merah, bawang bombai, bawang putih, Lily, Daffodil.

Tunicate bulb: Umbi lapis yang diselimuti oleh lapisan membran kering (*tunic*) yang mencegah umbi dari kekeringan dan kerusakan mekanis: bawang bombai, bawang merah, tulip.

Non-tunicate bulb: Bulb tanpa kulit atau lapisan membran yang menyelimutinya.
Contoh: Bulb bunga Lily.



Umbi lapis ber-tunicate pada tulip.







Corm: Struktur modifikasi batang berbentuk bulat dengan filotaksis.
Contoh : gladiol, crocus.

Tuber: Struktur modifikasi batang yang berfungsi sebagai cadangan makanan (karbohidrat) dengan mata tunas tersusun dalam filotaksis (contoh : kentang).

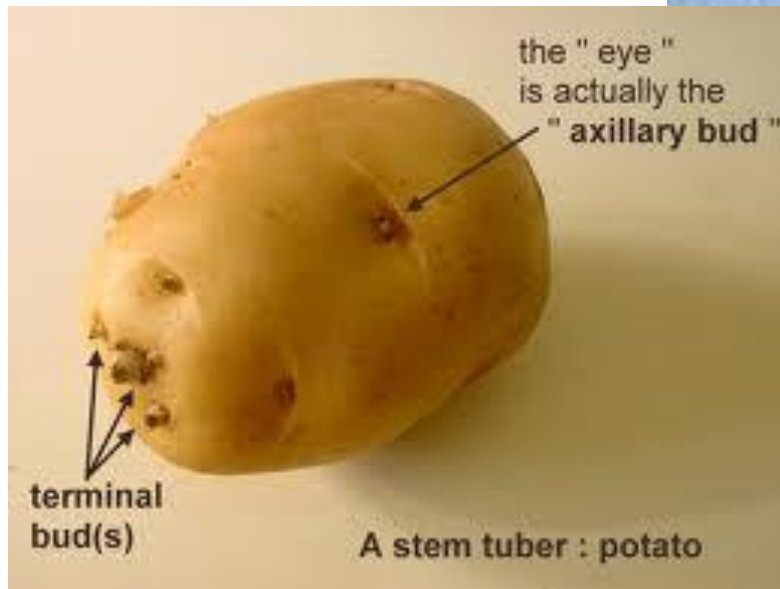


Corm gladiol



Tuber

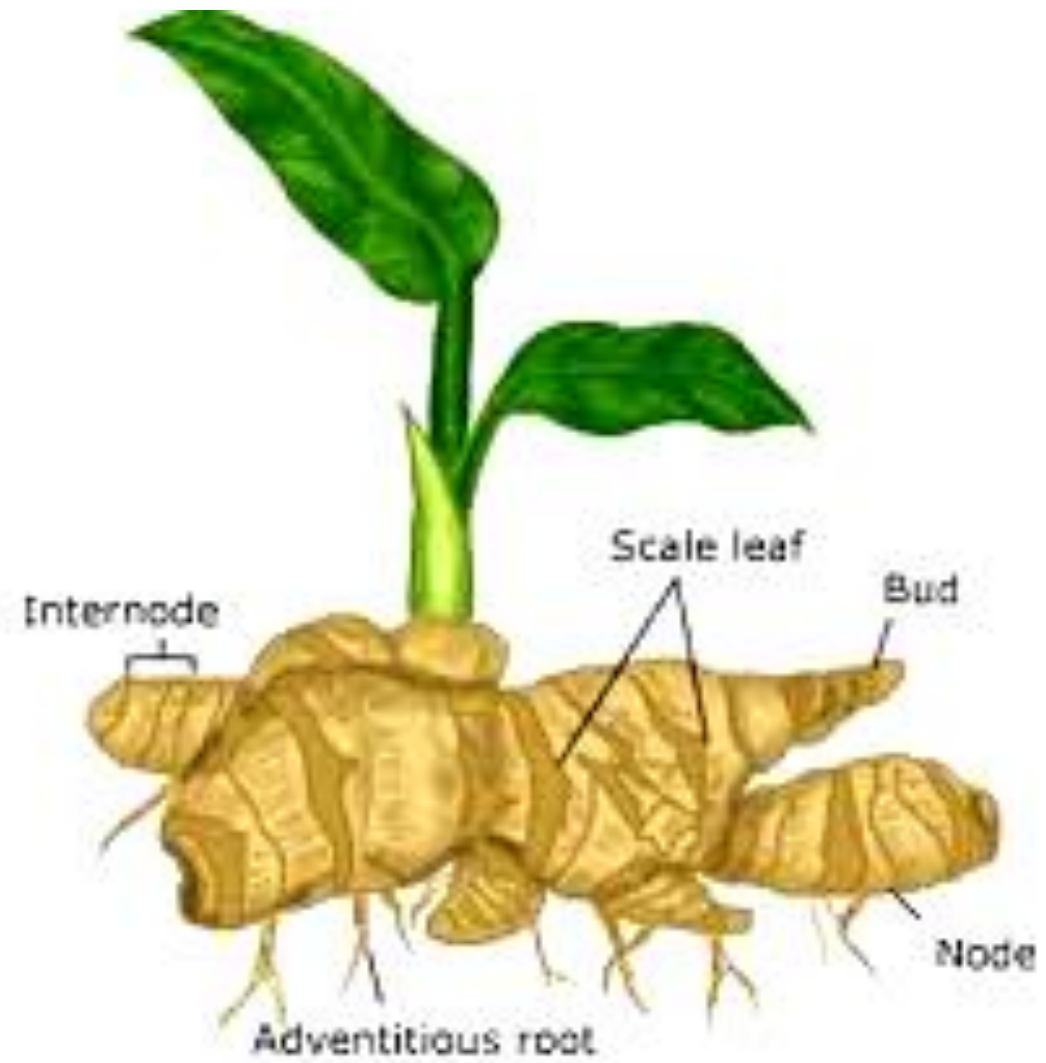
: SRUKTUR MODIFIKASI BATANG.



Rhizome: Batang yang membesar di bawah permukaan tanah. Contoh: jahe, pisang, kencur, laos, kunyit dsb.

Stolon: Batang yang menjulur di atas permukaan tanah. Contoh : *Cynodon dactylon* (rumput bermuda)

Umbi Akar: Struktur modifikasi akar yang berbentuk umbi. Dari umbi akar dapat tumbuh tunas-tunas adventif, lalu di dasar tunas adventif akan terbentuk akar adventif. Contoh: Ubi jalar.



Rhizoma





Stolon

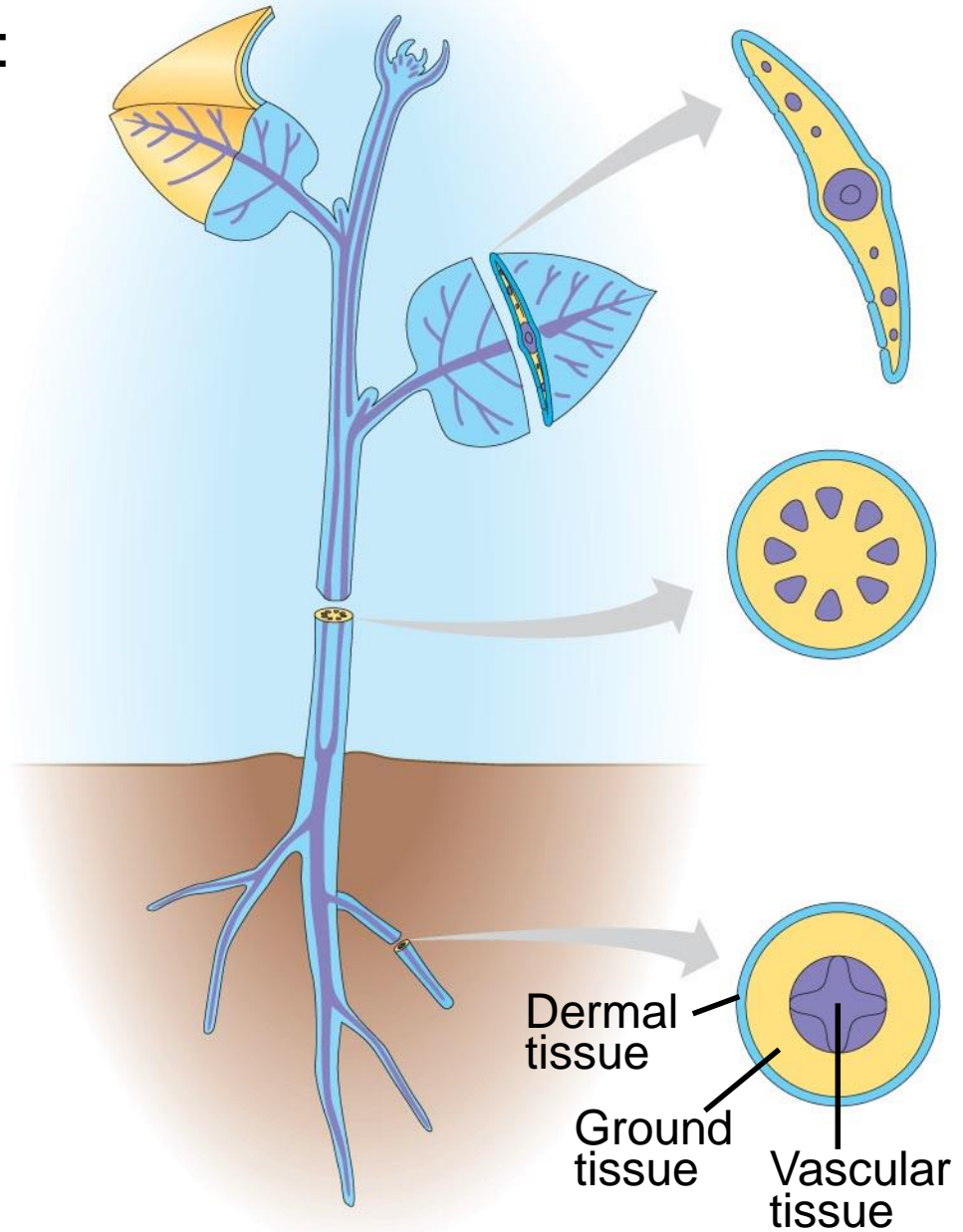


Perbanyak tanaman dengan umbi akar

Tissue System:

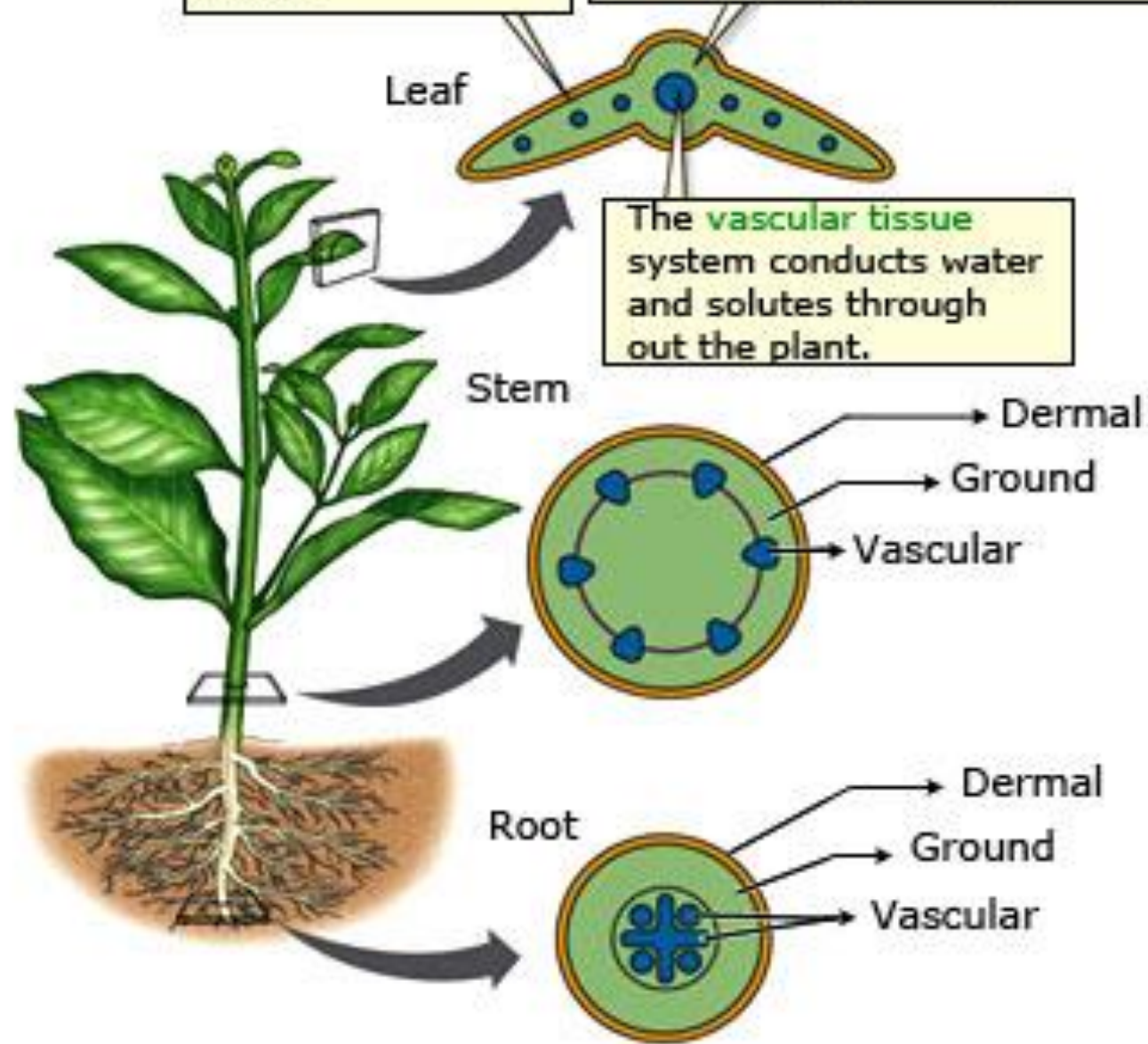
Each plant organ has:

- * dermal
- * vascular and
- * ground tissues



The **dermal tissue** system is the outer covering of the plants

The **ground tissue system** carries out photosynthesis, stores photosynthesis products, and help support the plants



Leaf

The **vascular tissue** system conducts water and solutes through out the plant.

Stem

Dermal

Ground

Vascular

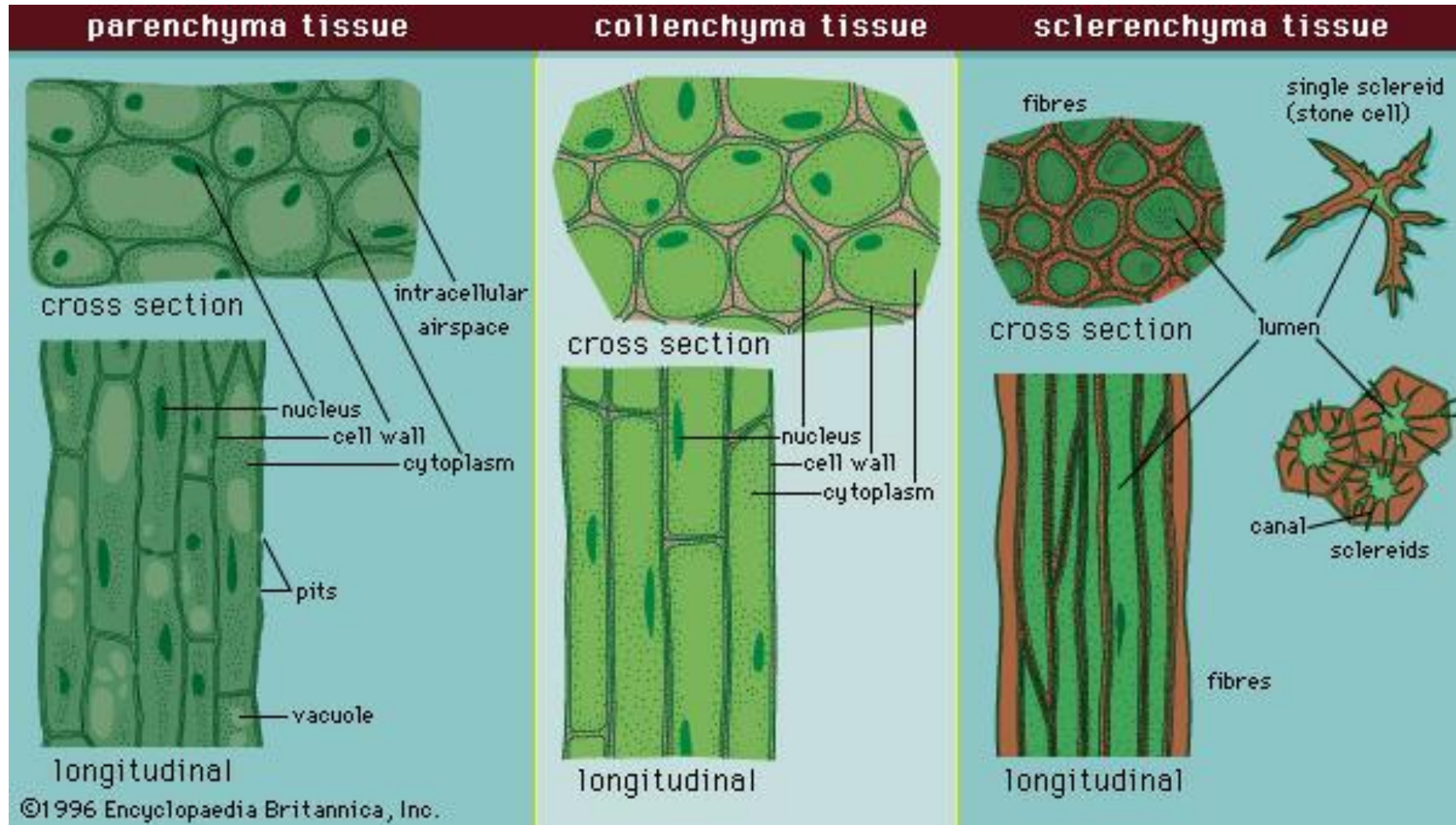
Root

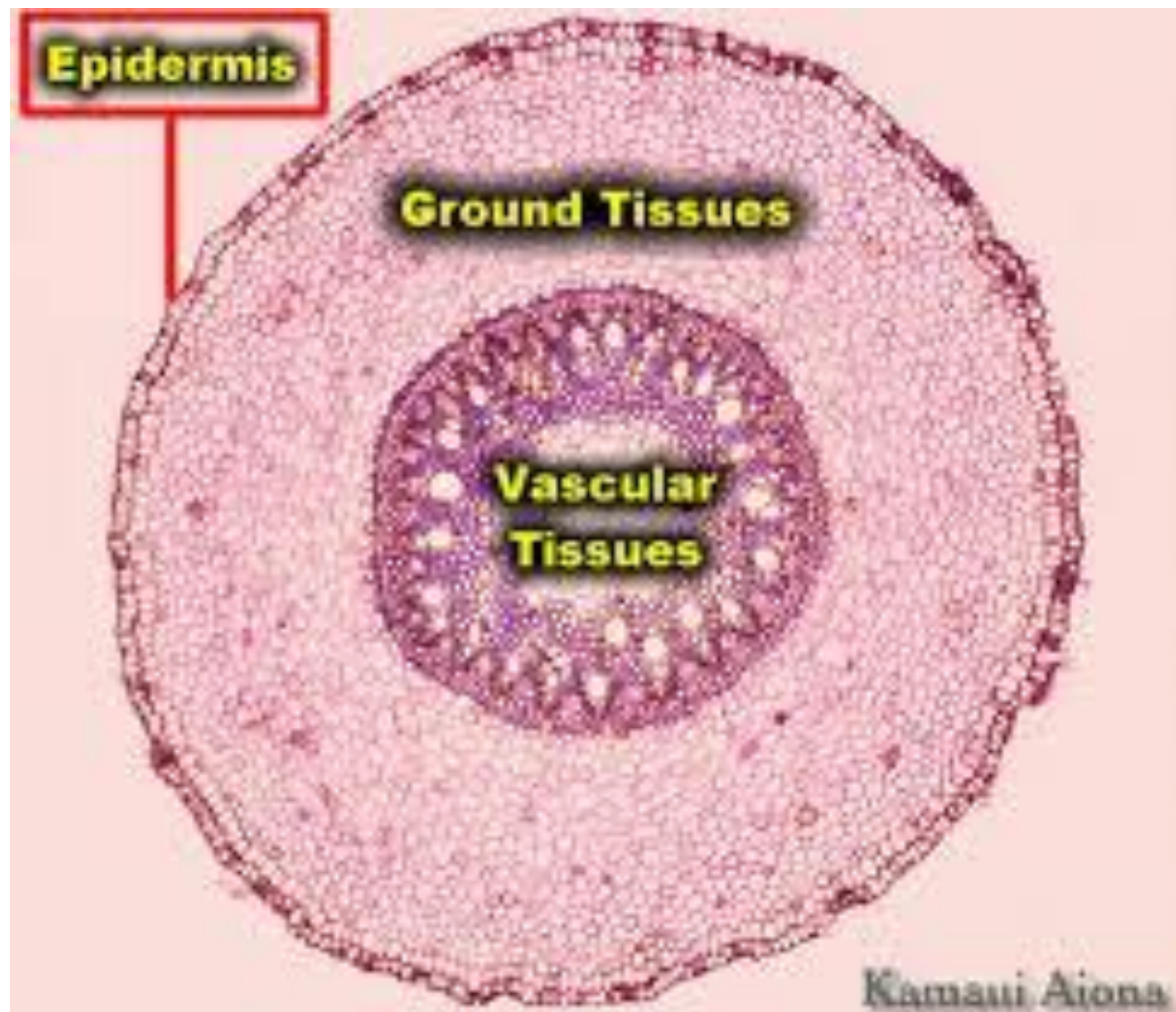
Dermal

Ground

Vascular

Ground Tissue terdiri dari:





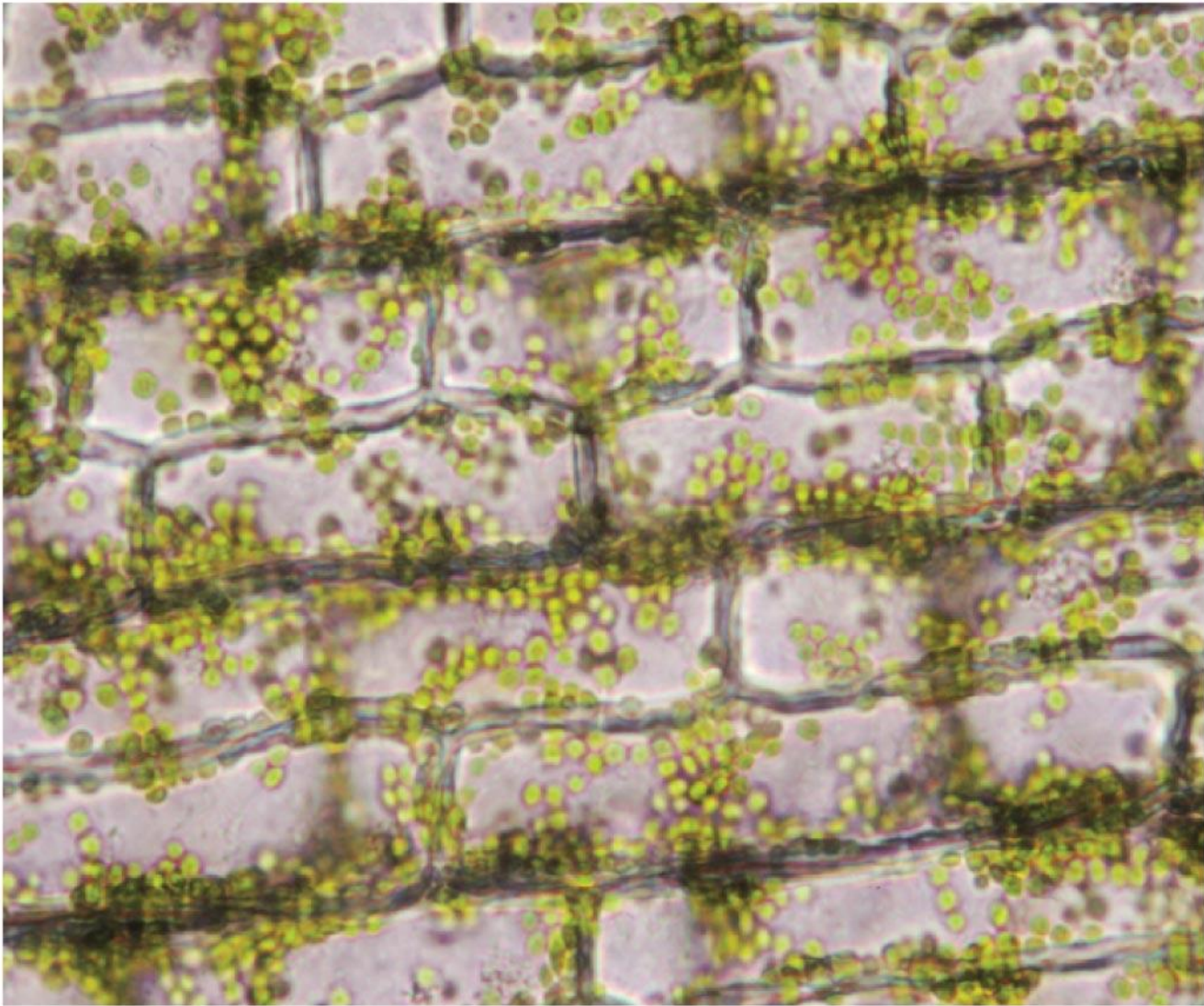
- In **nonwoody** plants, the **dermal tissue system** consists of the **epidermis**.
- A waxy coating called the **cuticle** helps prevent water loss from the epidermis.
- In **woody** plants, protective tissues called **periderm** replace the epidermis in older regions of stems and roots.
- *Trichomes* are outgrowths of the shoot epidermis and can help with insect defense.

- The ***vascular tissue system*** carries out long-distance transport of materials between roots and shoots.
- ***Xylem*** conveys ***water and dissolved minerals*** upward from roots into the shoots.
- ***Phloem*** transports ***organic nutrients*** from where they are made to where they are needed.

- Tissues that are neither dermal nor vascular are the **ground tissue system**.
- Ground tissue internal to the vascular tissue is **pith**; ground tissue external to the vascular tissue is **cortex**. Both have plastids for **storage**.
- *Ground tissue includes cells specialized for storage, photosynthesis, and support.*

Tipe – tipe sel tanaman terspesialisasi berdasarkan fungsinya:

- **Parenchyma** – jaringan penyokong yang mempunyai dinding sel yang tipis dan fleksibel, berfungsi untuk fotosintesis, jaringan penyimpan.
- **Collenchyma** – jaringan penyokong : yang mempunyai dinding sel lebih tebal, sebagai penyokong yang fleksibel.
- **Sclerenchyma** - ground: mempunyai dinding sel sekunder yang tebal mengandung lignin yang berfungsi untuk pensupport yang kokoh dan kuat.
- Xylem – pembuluh vaskuler: sel-sel pengangkut air dan hara mineral.
- Phloem – pembuluh vaskuler pengangkut gula /hasil fotosintesis dari daun ke seluruh bagian tanaman.



Parenchyma cells in *Elodea* leaf,
with chloroplasts (LM)

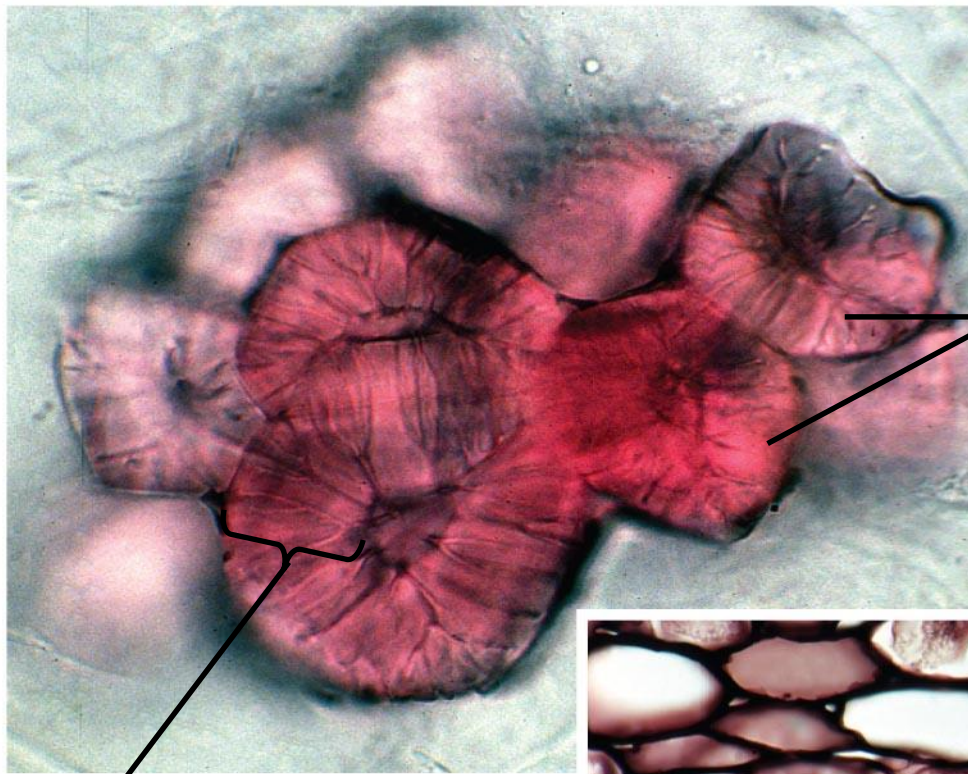
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60 μm

Sclerenchyma Cells

- **Sclerenchyma cells** are **rigid** because of thick **secondary walls** strengthened with **lignin**.
- They are dead at functional maturity.
- There are two types:
 - **Sclereids** are short and irregular in shape and have thick lignified secondary walls.
 - **Fibers** are long and slender and arranged in threads.

Fig. 35-10c

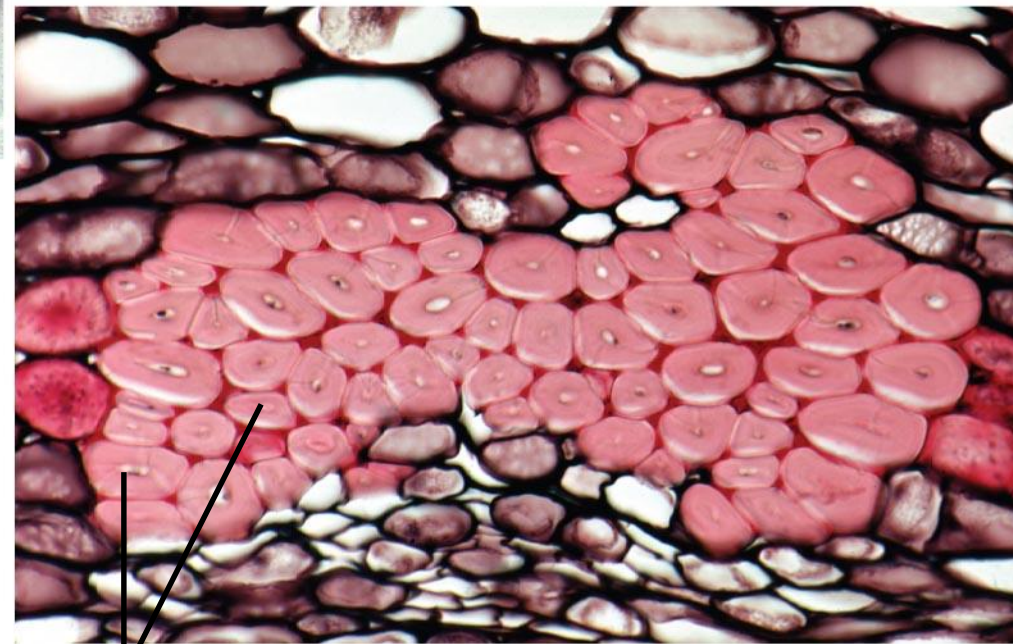


5 μm

Sclereid cells in pear (LM)

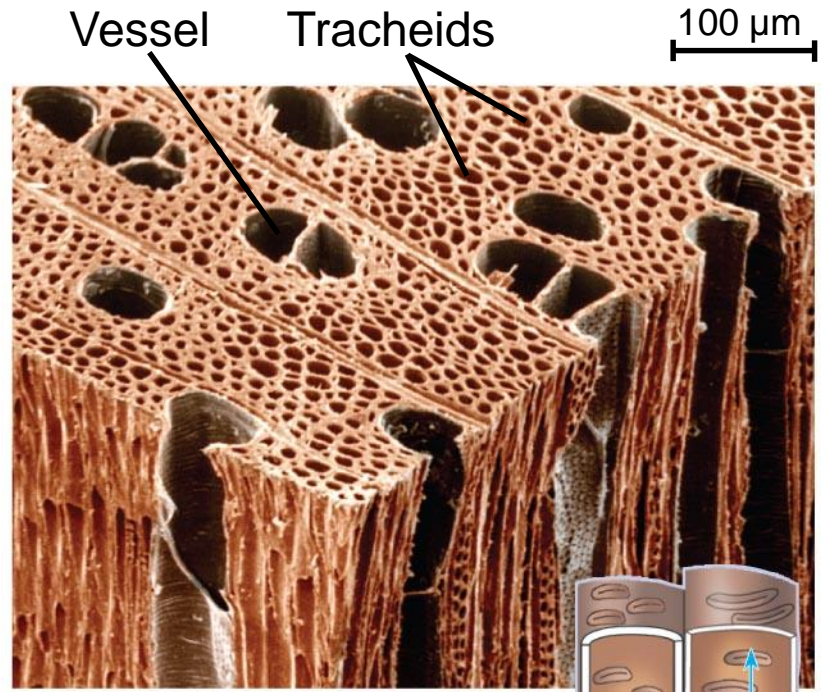
25 μm

Cell wall



Fiber cells (cross section from ash tree) (LM)

Differentiated Plant Cells in the Xylem - Dead at Maturity



Tracheids and vessels (colorized SEM)

Perforation plate

Vessel element

Vessel elements, with perforated end walls

Pits

Tracheids

Water-Conducting Cells of the Xylem

The two types of water-conducting cells, **tracheids** and **vessel elements**, are dead at maturity

- **Tracheids** are found in the xylem of all vascular plants.
- **Vessel elements** are common to most angiosperms and a few gymnosperms.
- Vessel elements align end to end to form long micropipes called **vessels**.

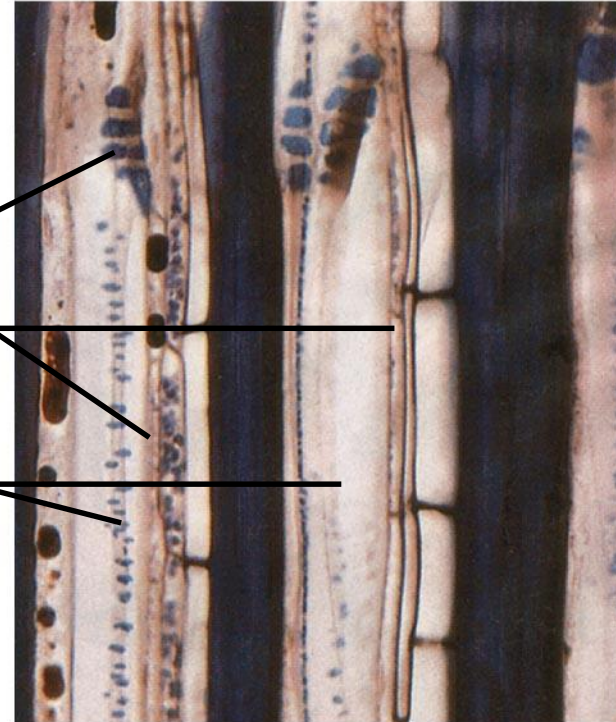
Differentiated Plant Cells



Sieve-tube element (left) and companion cell: cross section (TEM)

3 μm

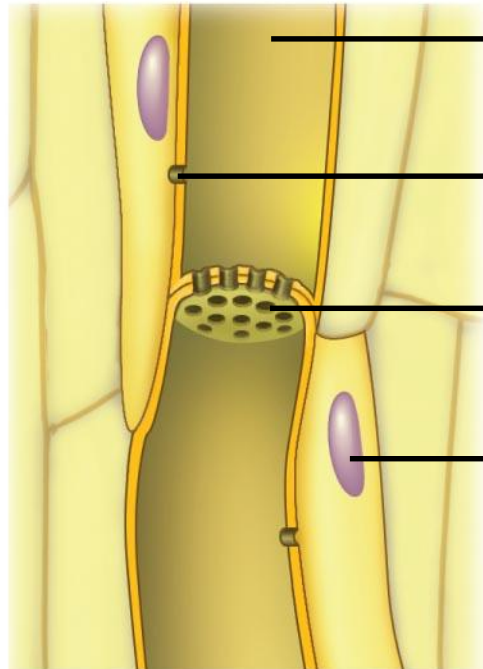
Sieve-tube elements: longitudinal view (LM)



Sieve plate

Companion cells

Sieve-tube elements

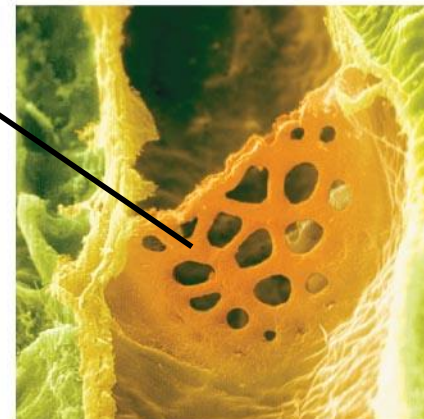


Plasmodesma

Sieve plate

Nucleus of companion cells

Sieve-tube elements: longitudinal view



30 μm

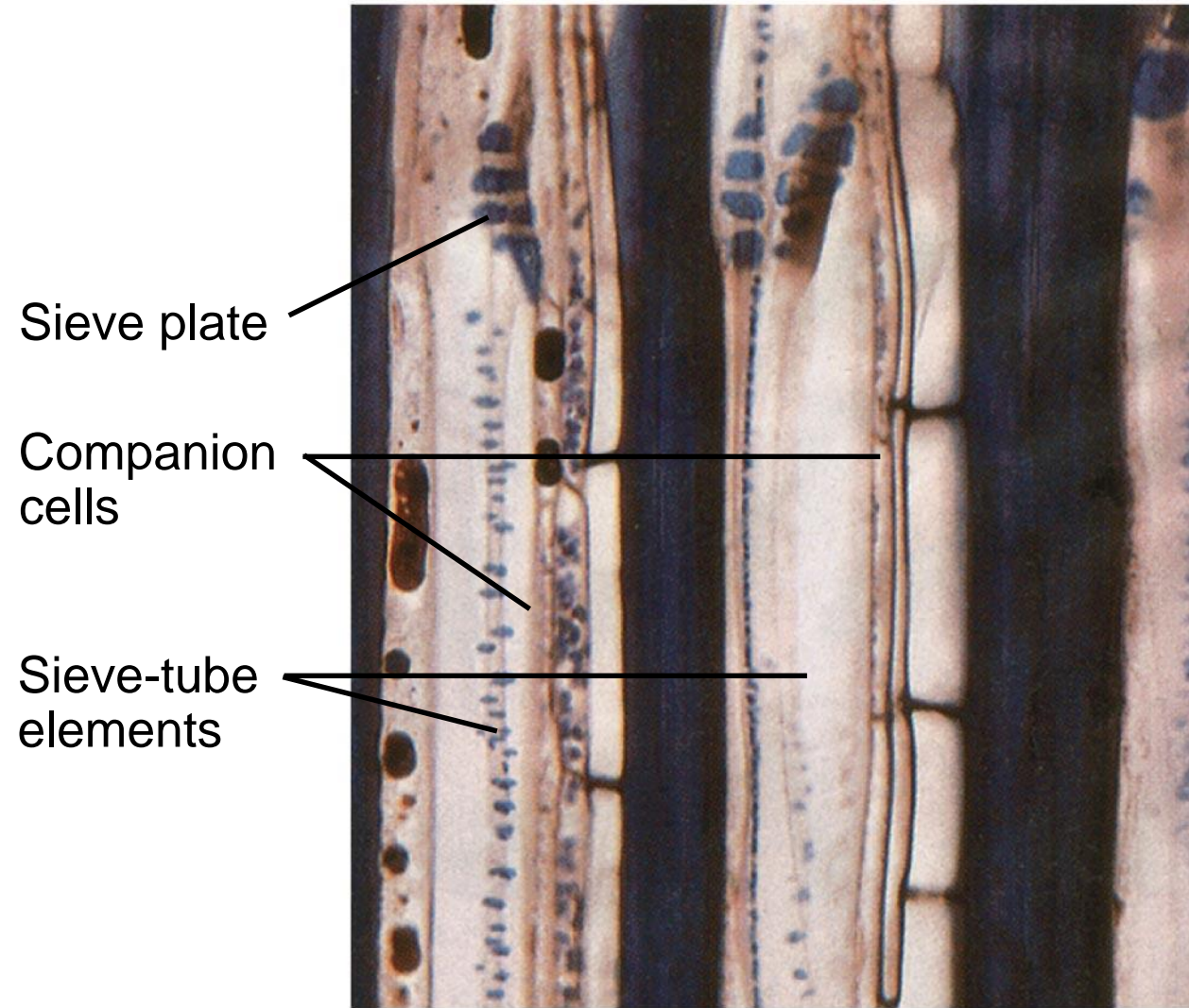
10 μm

Sieve plate with pores (SEM)

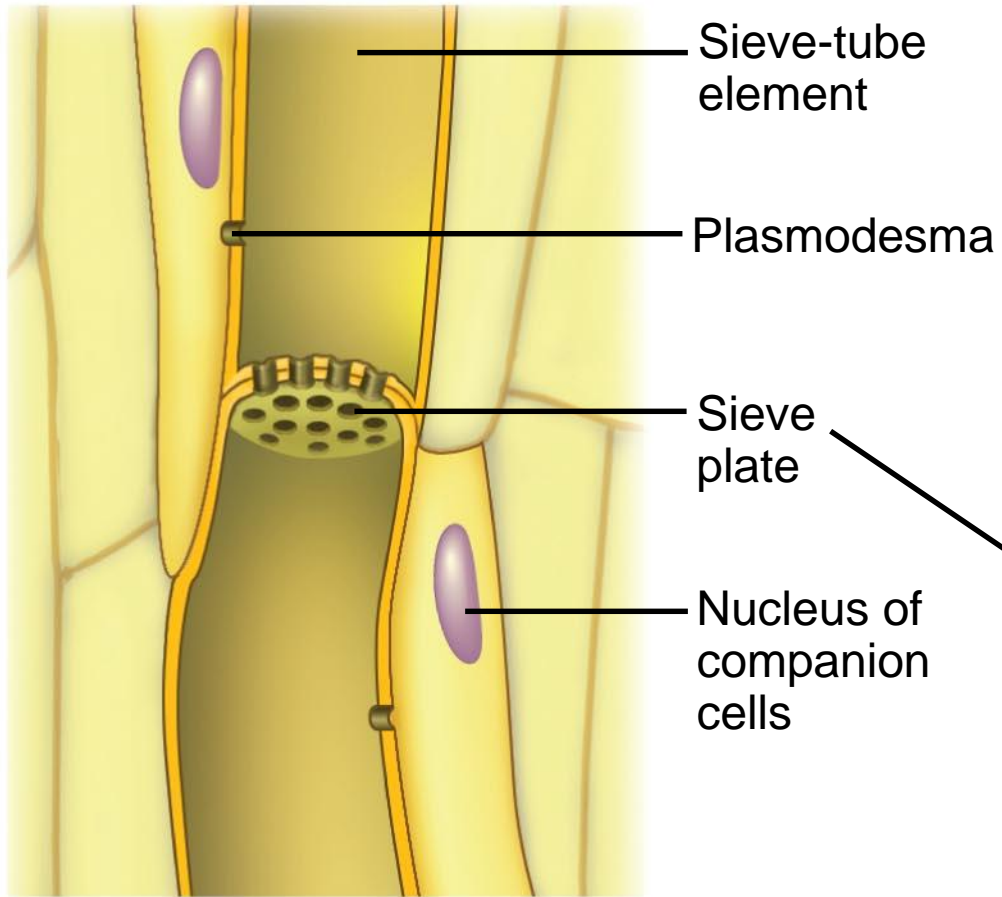
Sugar-Conducting Cells of the Phloem

- **Sieve-tube elements** are alive at functional maturity, though they lack organelles.
- **Sieve plates** are the porous end walls that allow fluid to flow between cells along the sieve tube.
- Each sieve-tube element has a **companion cell** whose nucleus and ribosomes serve both cells.

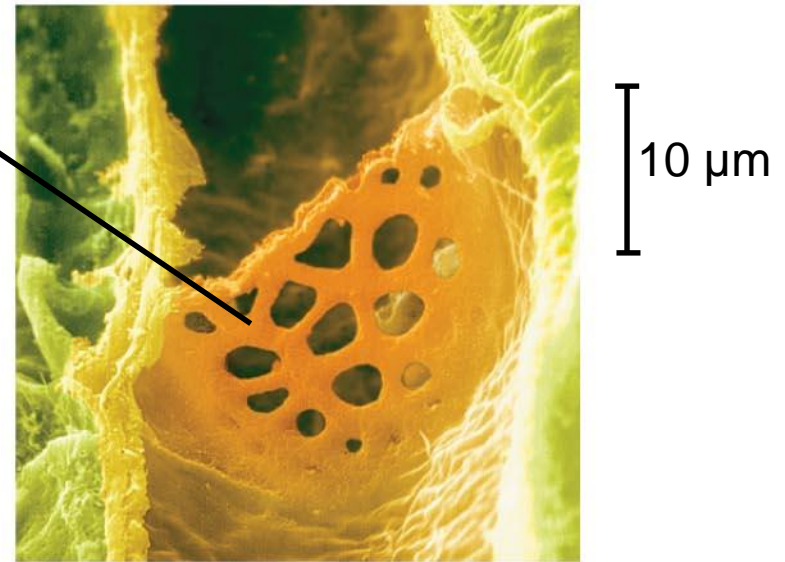
Sieve-tube elements:
longitudinal view (LM)



30 μm



Sieve-tube elements:
longitudinal view



Sieve plate with pores (SEM)

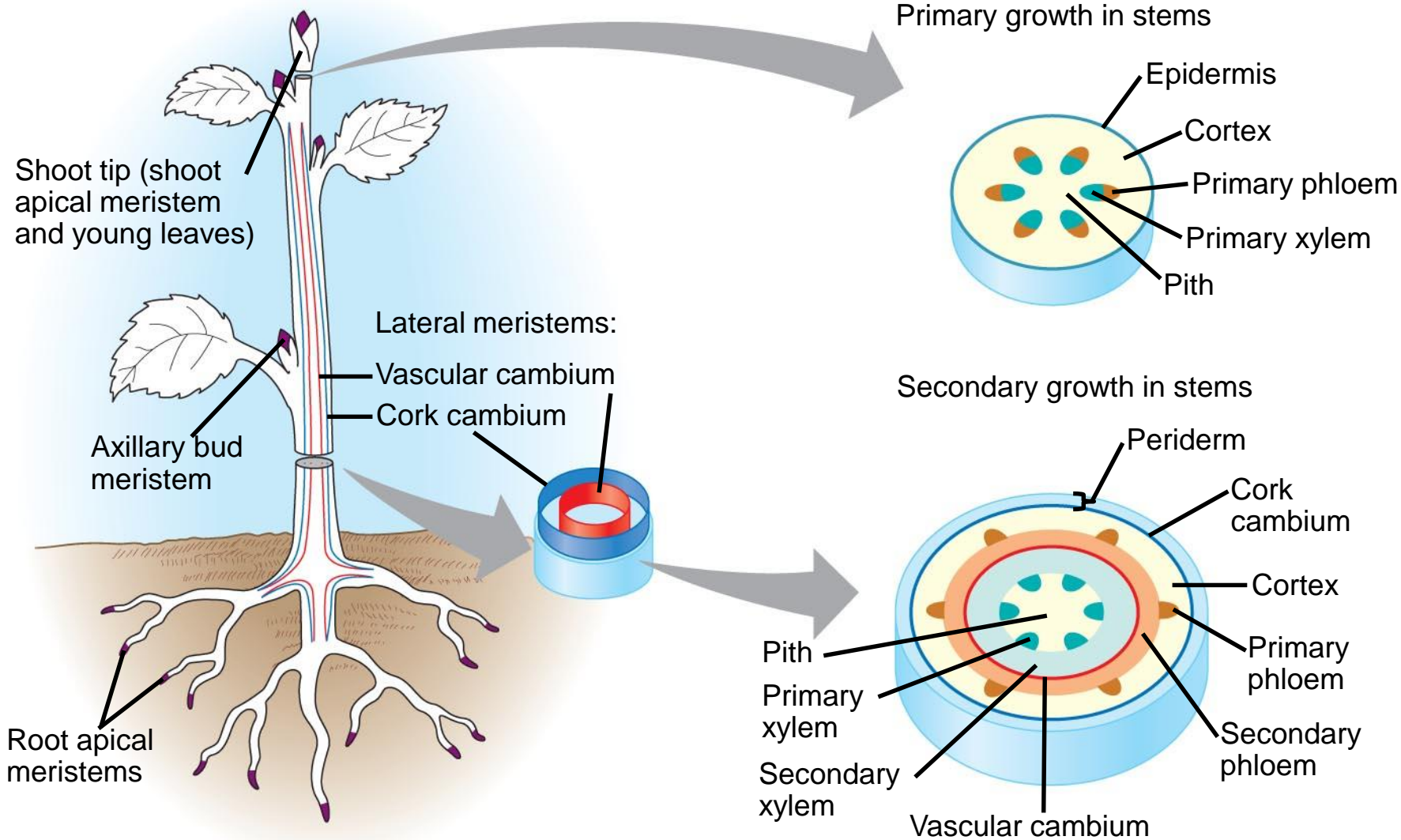
Meristems Menghasilkan sel-sel yang akan menjadi organ baru

- Beberapa tanaman dapat tumbuh terus sepanjang hidupnya tanpa henti, pola pertumbuhan tanaman seperti ini disebut **pertumbuhan indeterminate**.
- Beberapa tanaman dapat tumbuh sampai pada ukuran tertentu, lalu berhenti memanjang, pola pertumbuhan tanaman seperti ini disebut **pertumbuhan determinate**.

- **Meristems** are **growth regions** - have perpetual embryonic tissue that allows for indeterminate growth.
- **Apical meristems** are located at the **tips** of roots and shoots and at the axillary buds of shoots.
- Apical meristems **elongate** shoots and roots, a process called **primary growth**.

- ***Lateral meristems*** add ***thickness*** to woody plants, a process called ***secondary growth***.
- There are two lateral meristems: the vascular cambium and the cork cambium.
- The ***vascular cambium*** adds layers of vascular tissue called ***secondary xylem = wood*** and secondary phloem.
- The ***cork cambium*** replaces the epidermis with ***periderm***, which is thicker and tougher.

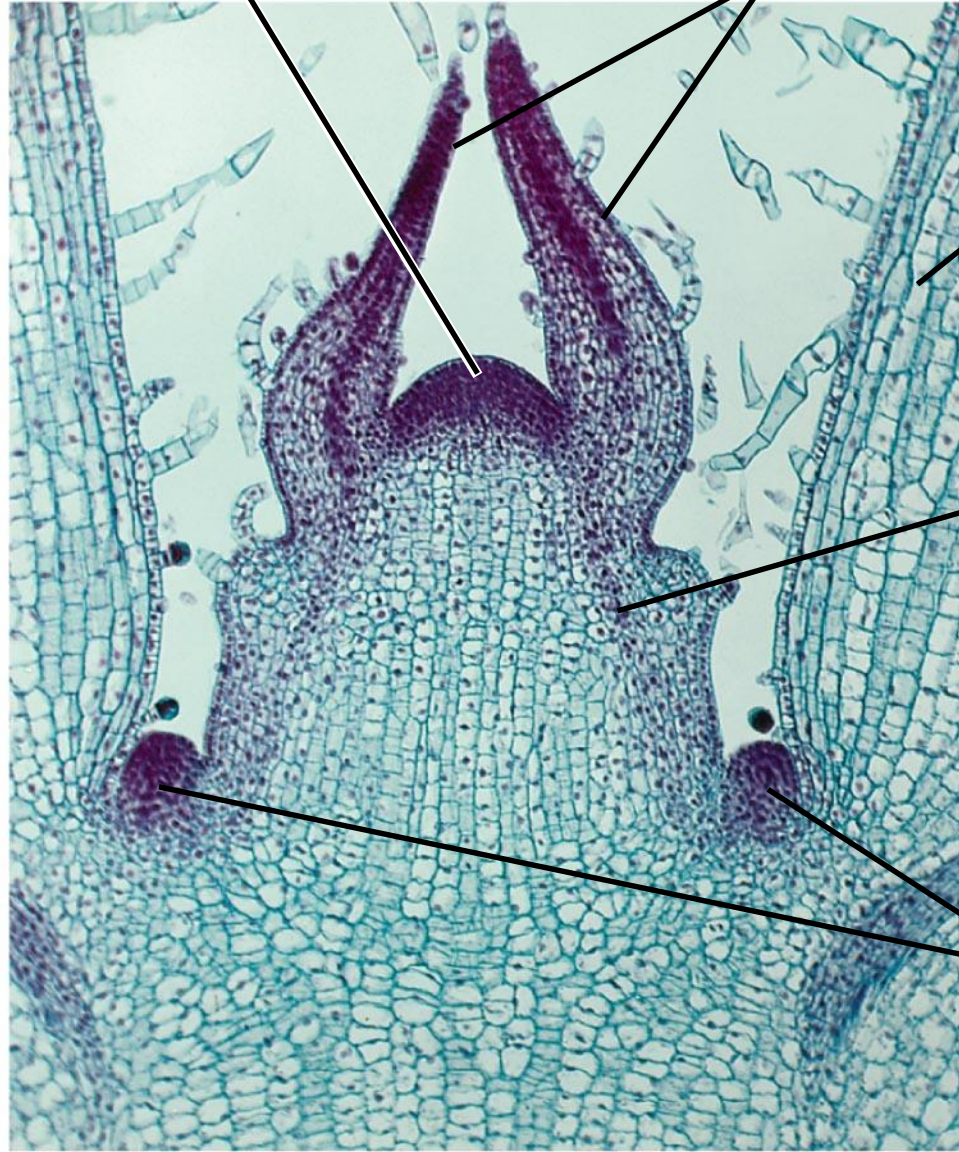
An overview of primary and secondary growth



Shoot tip

Shoot **apical meristem**

Leaf primordia



Young leaf

Developing vascular strand

Axillary bud meristems

0.25 mm

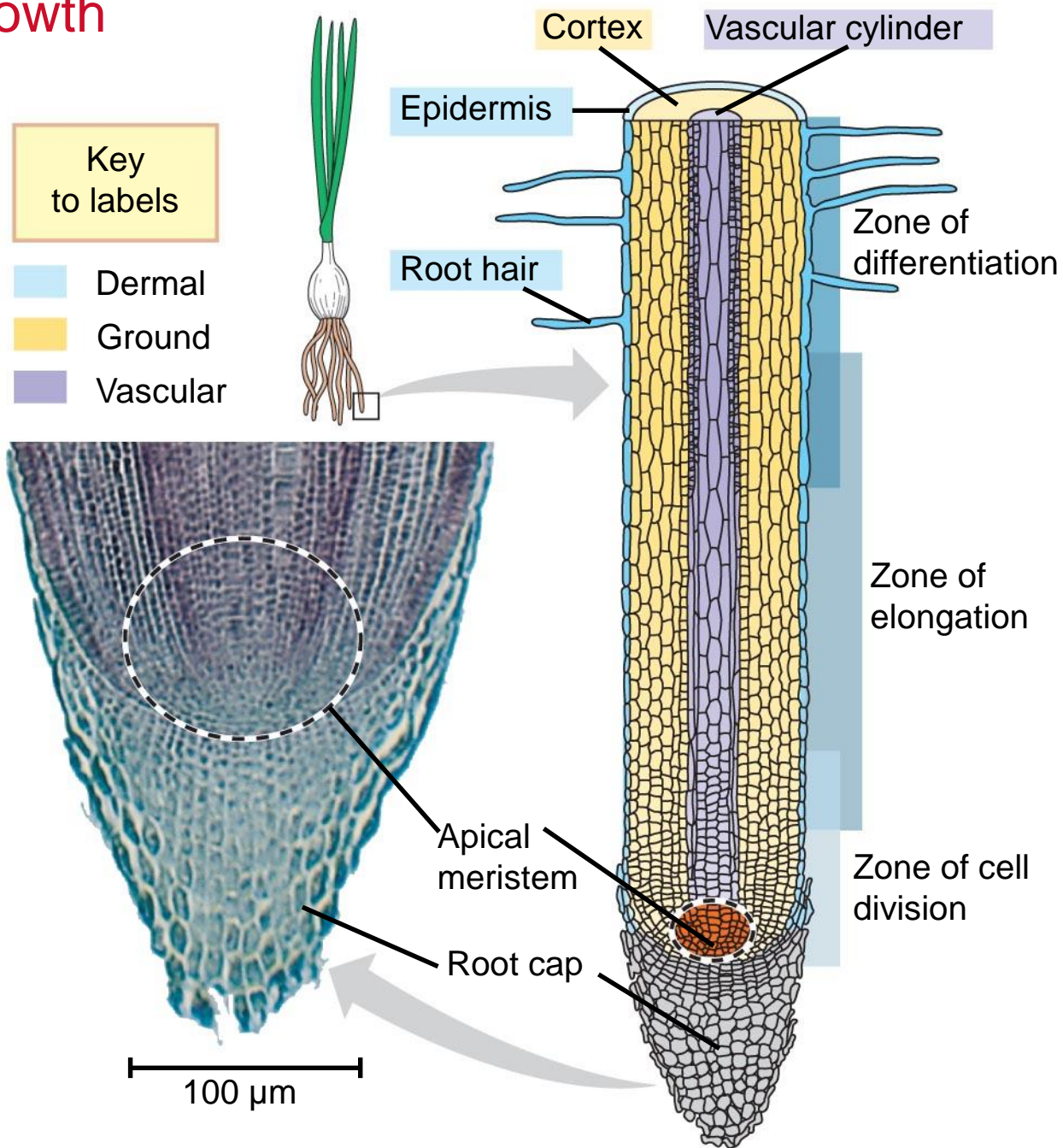
Primary Growth of Shoots - Apical Meristems

- A shoot apical meristem is a dome-shaped mass of dividing cells at the shoot tip.
- Axillary buds develop from meristematic cells left at the bases of leaf primordia.
- Lateral shoots develop from axillary buds on the stem's surface.
- In most eudicots, the vascular tissue consists of vascular bundles that are arranged in a ring.

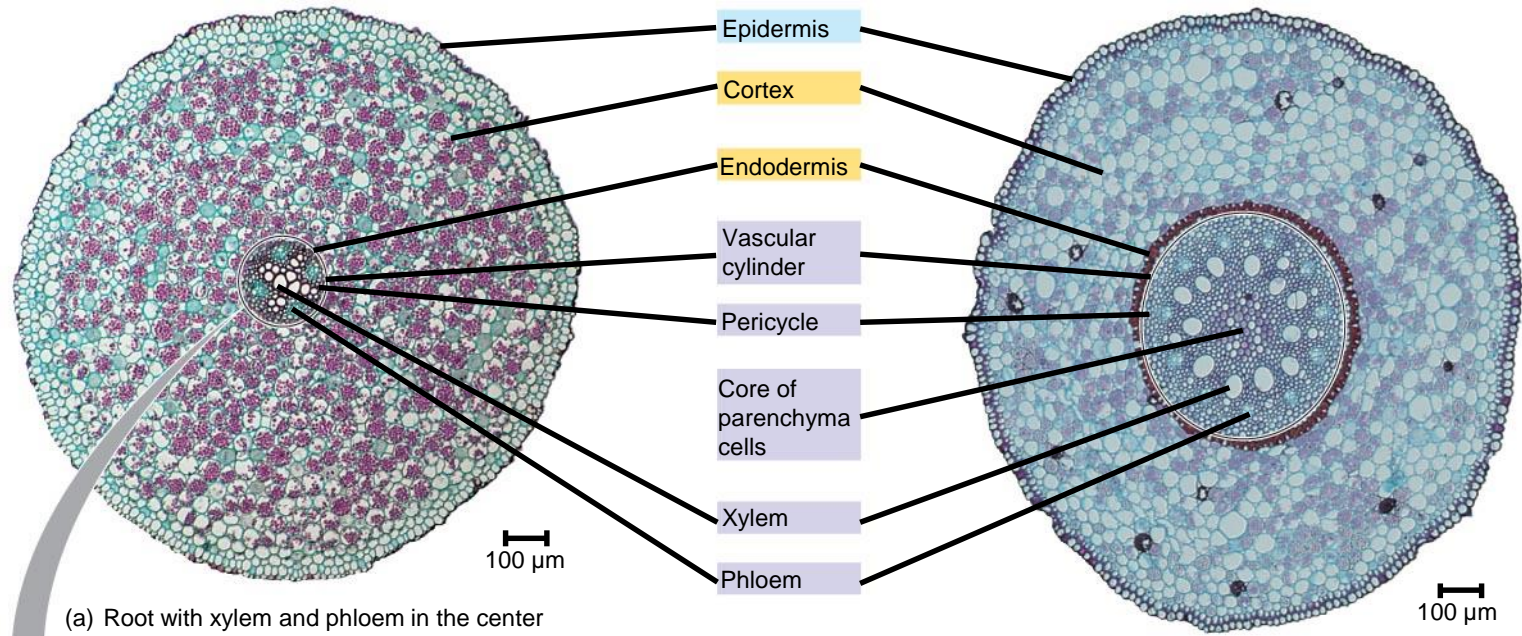
Primary Growth - Lengthens Roots and Shoots

- The **root tip** is covered by a **root cap**, which protects the **apical meristem** as the root pushes through soil.
- **Growth** occurs just behind the root tip, in three zones of cells:
 - Zone of **cell division**
 - Zone of **elongation**
 - Zone of **maturation - differentiation.**

Primary growth of a root

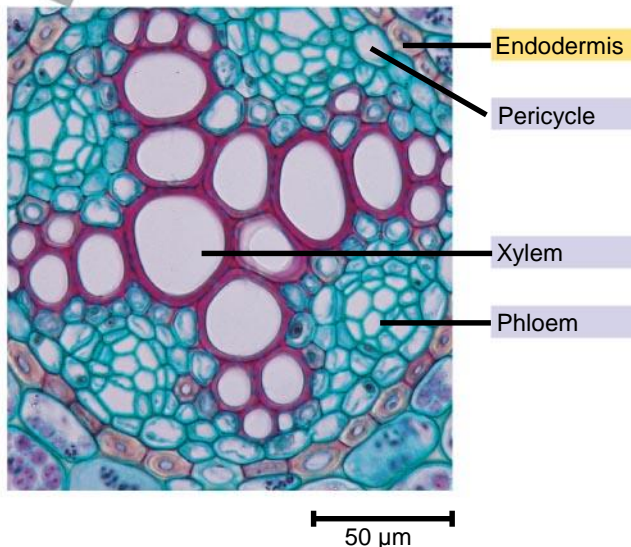


- The primary growth of roots produces the epidermis, ground tissue, and vascular tissue.
- In most roots, the stele is a vascular cylinder.
- The ground tissue fills the cortex, the region between the vascular cylinder and epidermis.
- The innermost layer of the cortex is called the **endodermis**.



(a) Root with xylem and phloem in the center (typical of eudicots)

(b) Root with parenchyma in the center (typical of monocots)

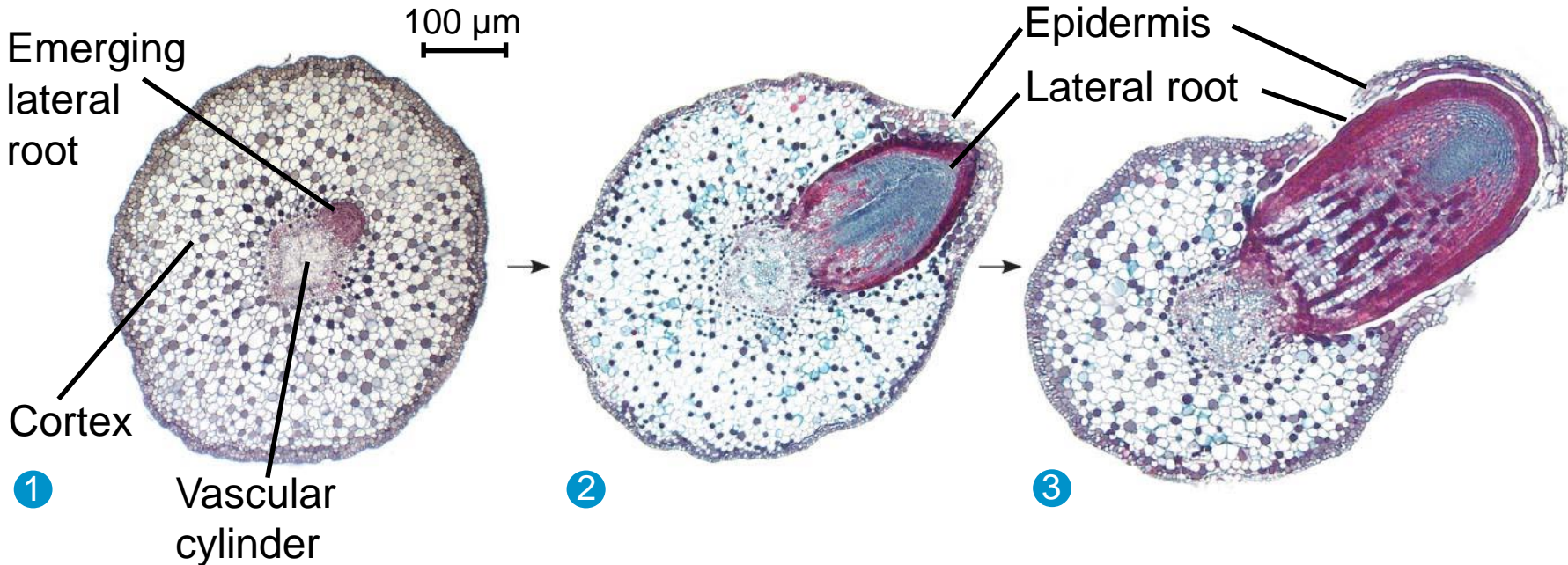


Key to labels

- Dermal
- Ground
- Vascular

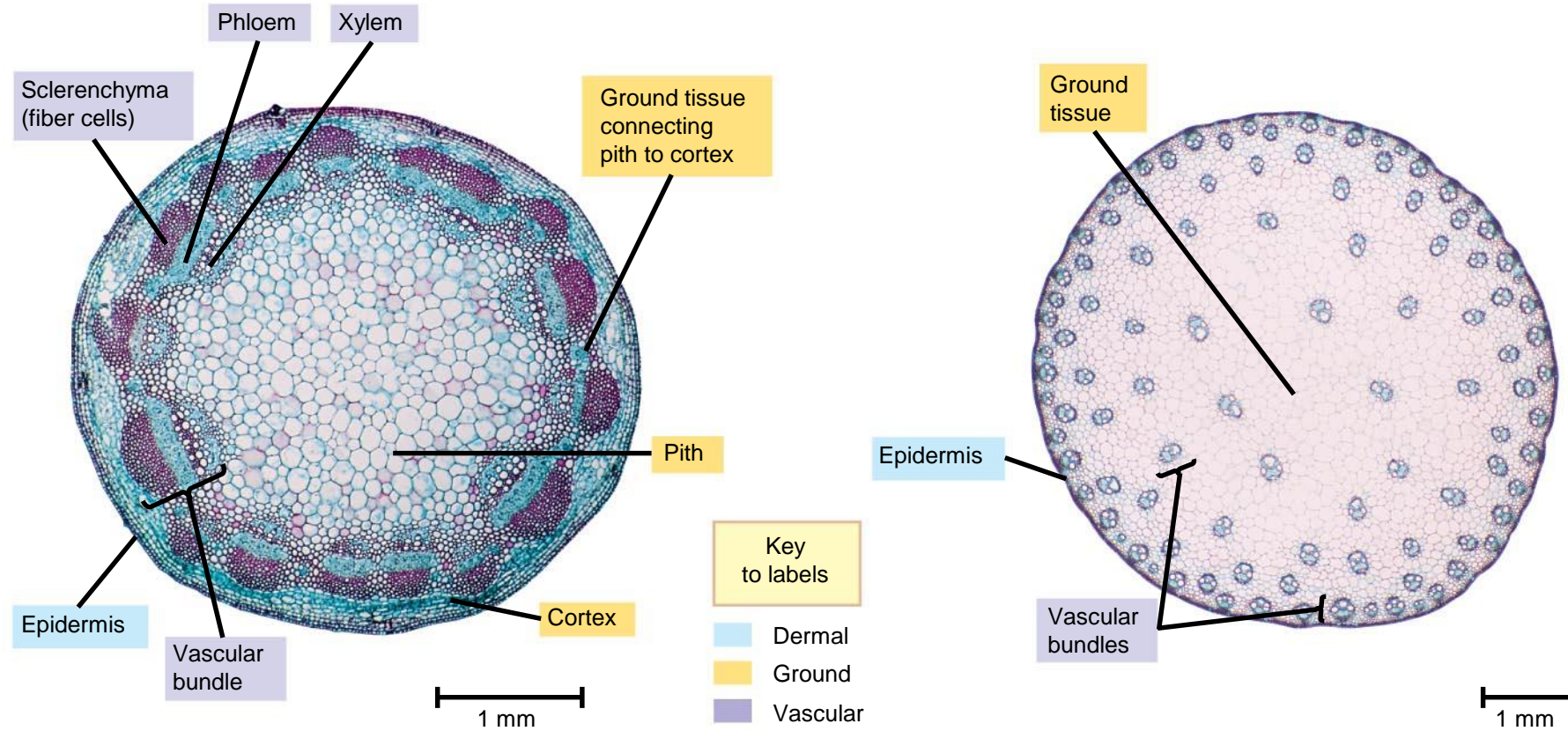
Organization of primary tissues in young roots

Lateral roots arise from within the pericycle, the outermost cell layer in the vascular cylinder



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Organization of primary tissues in young stems



(a) Cross section of stem with vascular bundles forming a ring (typical of eudicots)

(b) Cross section of stem with scattered vascular bundles (typical of monocots)

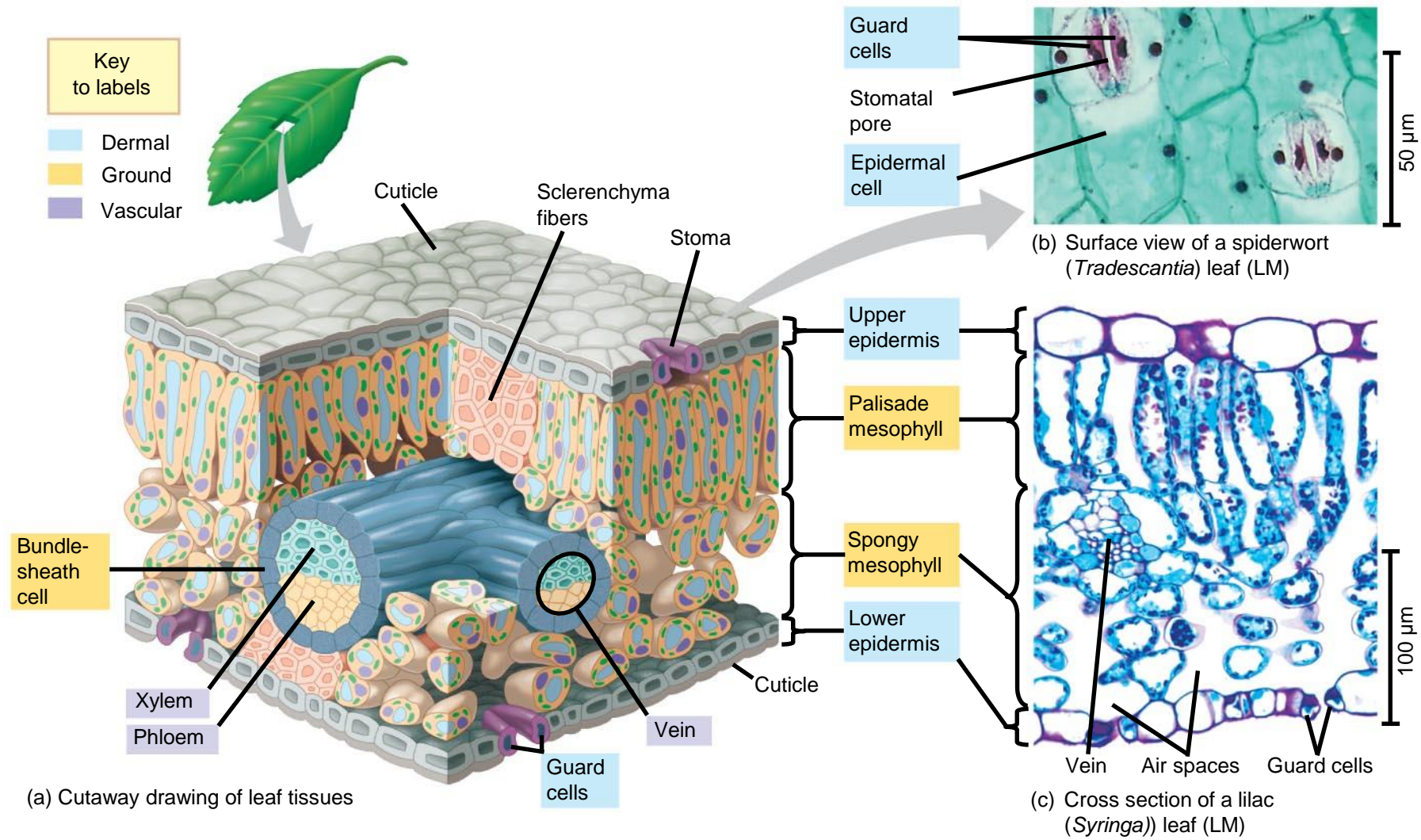
- In most monocot stems, the vascular bundles are scattered throughout the ground tissue, rather than forming a ring.

Tissue Organization of Leaves

- The epidermis in leaves is interrupted by **stomata**, which allow **CO₂ exchange** between the air and the photosynthetic cells in a leaf.
- Each stomatal pore is flanked by two **guard cells**, which **regulate its opening and closing**.
- The ground tissue in a leaf, called **mesophyll**, is sandwiched between the upper and lower epidermis.

- Below the *palisade mesophyll* in the upper part of the leaf is loosely arranged *spongy mesophyll*, where **gas exchange** occurs.
- The vascular tissue of each leaf is continuous with the vascular tissue of the stem.
- Veins are the leaf's vascular bundles and function as the leaf's skeleton.
- Each vein in a leaf is enclosed by a protective bundle sheath.

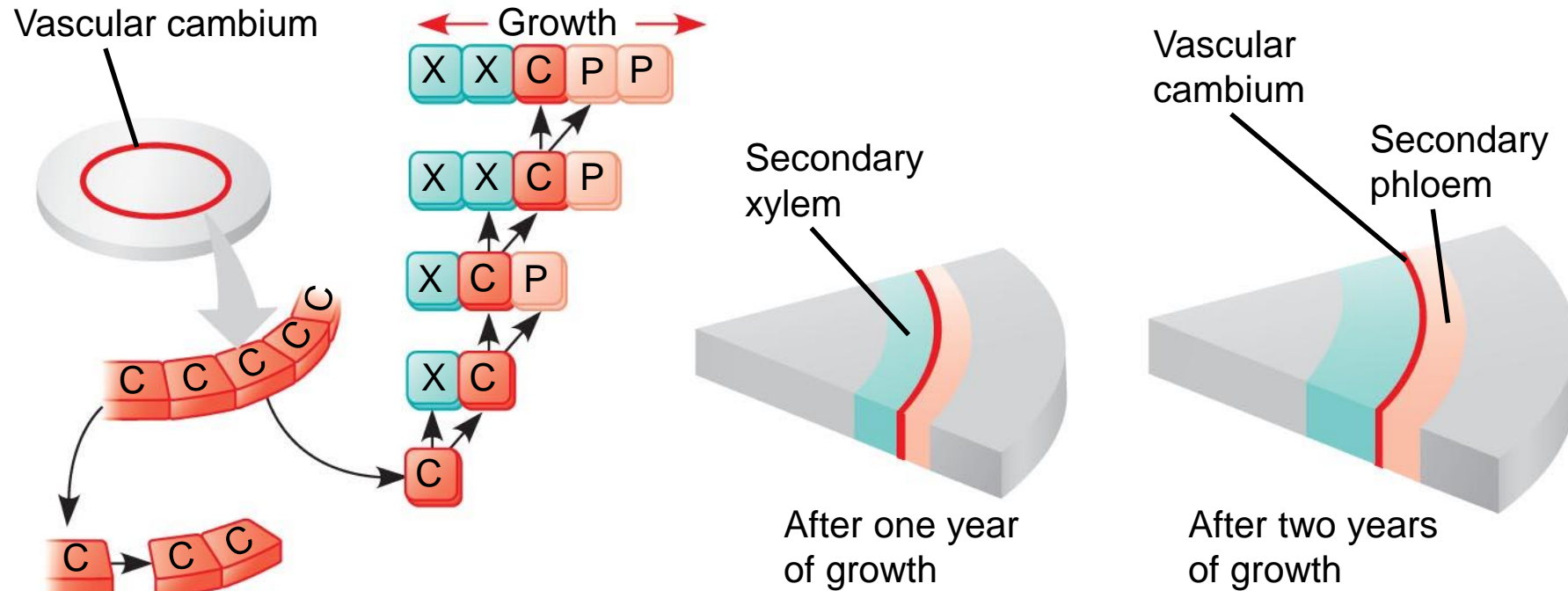
Leaf anatomy



The Vascular Cambium and Secondary Vascular Tissue

- The vascular cambium is a cylinder of meristematic cells one cell layer thick.
- It develops from undifferentiated parenchyma cells.
- In cross section, the vascular cambium appears as a ring of initials.
- The initials increase the vascular cambium's circumference and add secondary xylem to the inside and secondary phloem to the outside.

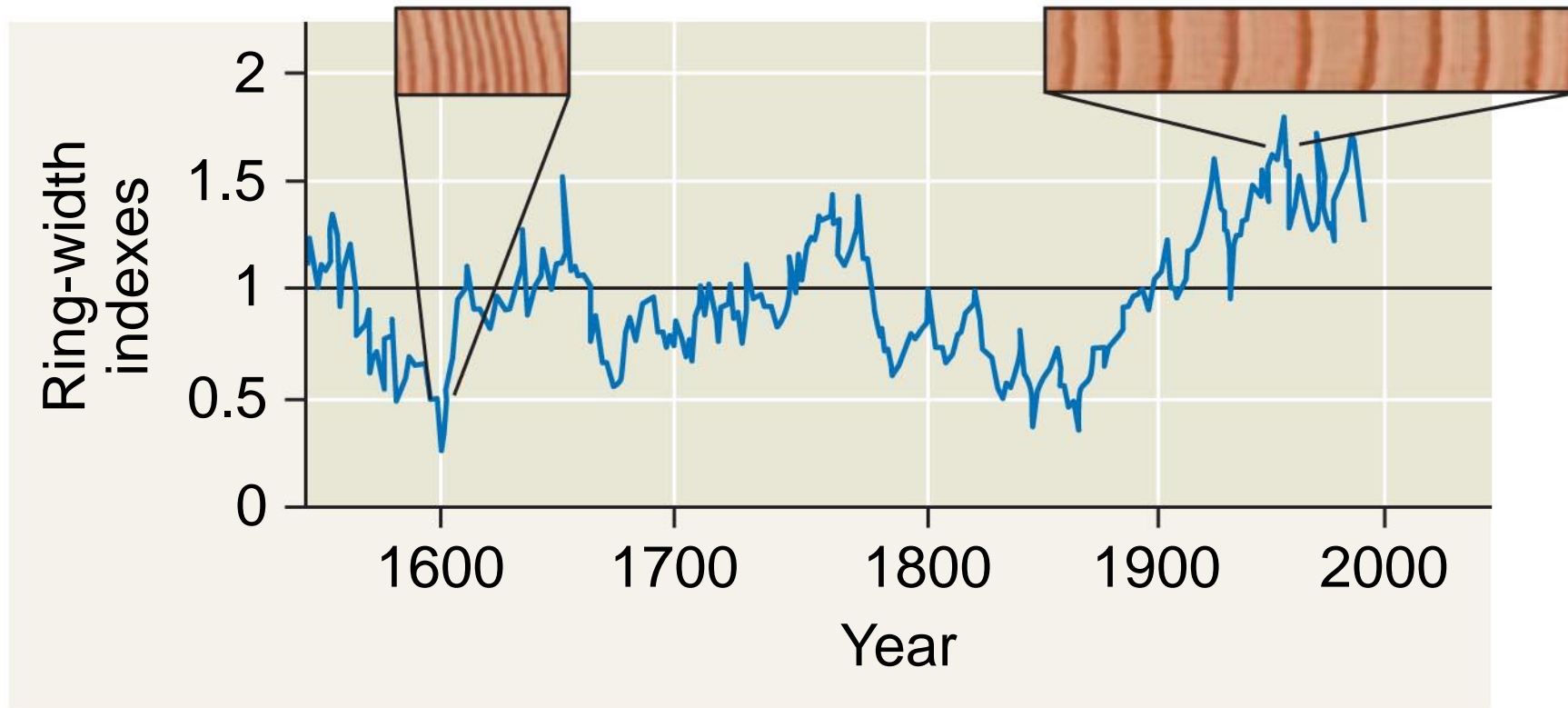
Secondary growth produced by the vascular cambium



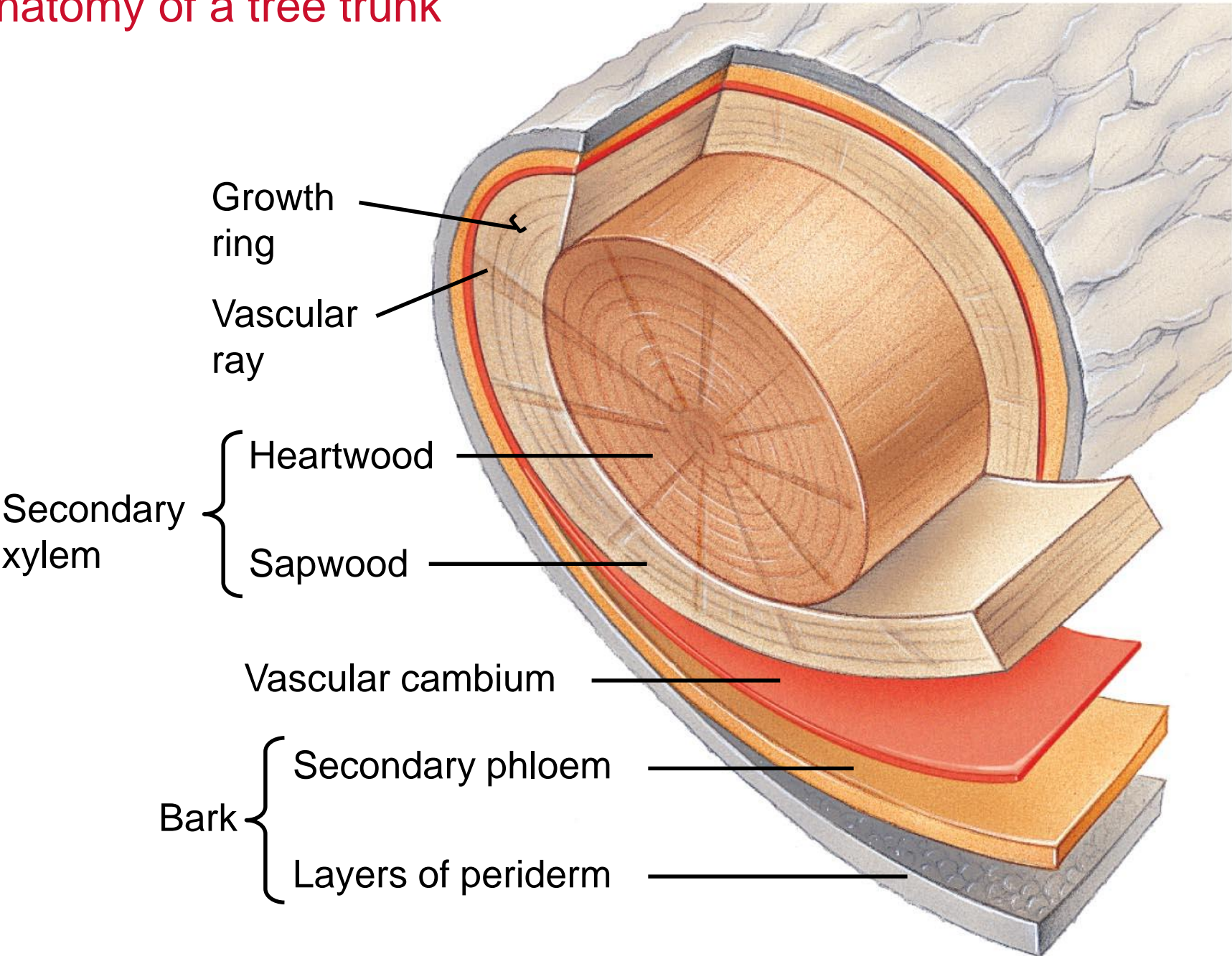
- **Tree rings** are visible where late and early wood meet, and can be used to estimate a tree's age.
- **Dendrochronology** is the analysis of tree ring growth patterns, and can be used to study past climate change.
- As a tree or woody shrub ages, the older layers of secondary xylem, the **heartwood**, no longer transport water and minerals.
- The outer layers, known as **sapwood**, still transport materials through the xylem.
- Older secondary phloem sloughs off and does not accumulate.

Using dendrochronology to study climate

RESULTS



Anatomy of a tree trunk



Is this tree
living or
dead?



The Cork Cambium and the Production of Periderm

- The cork cambium gives rise to the secondary plant body's protective covering, or periderm.
- Periderm consists of the cork cambium plus the layers of cork cells it produces.
- **Bark** consists of all the tissues external to the vascular cambium, including secondary phloem and periderm.
- **Lenticels** in the periderm **allow for gas exchange between living stem or root cells and the outside air.**

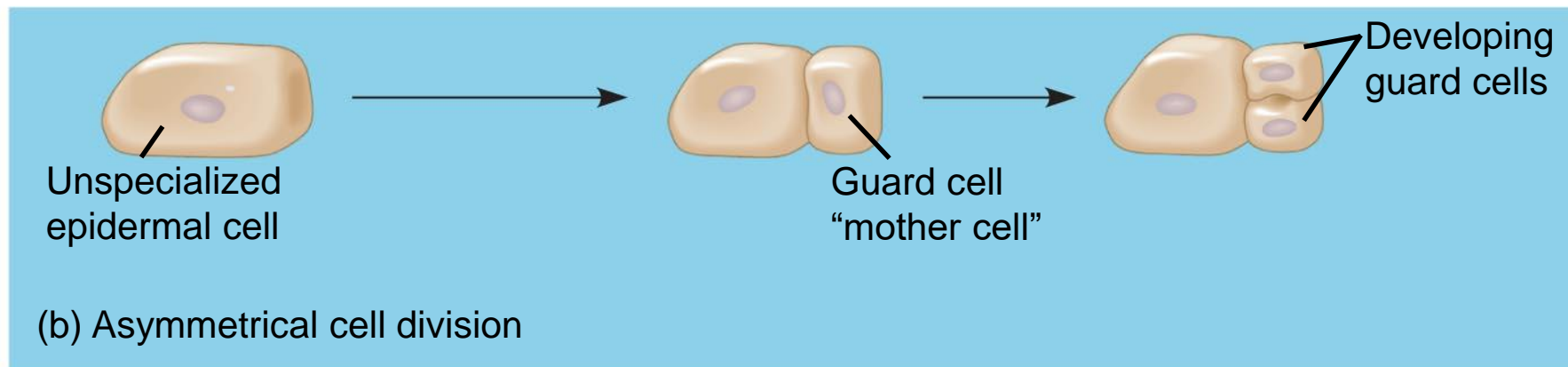
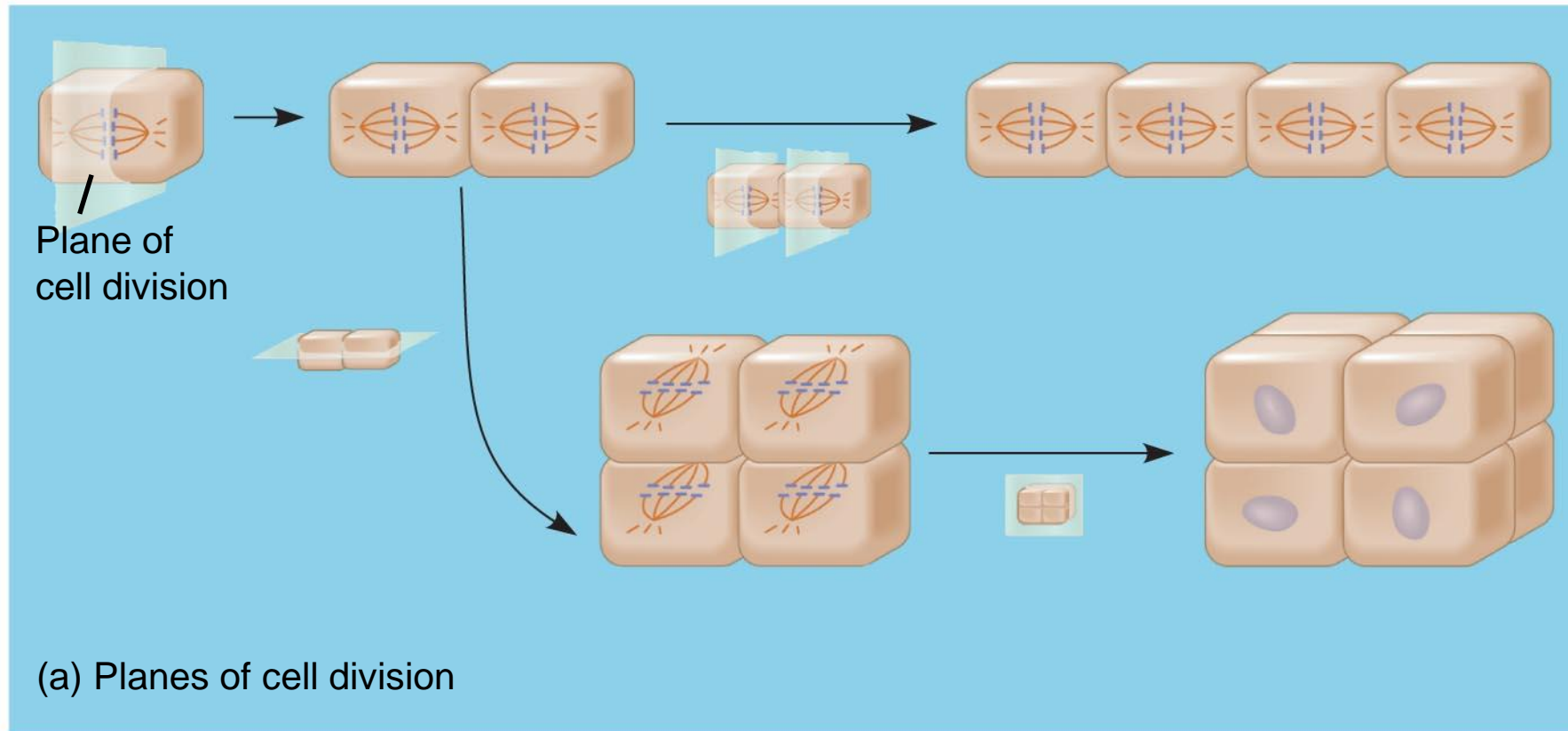
concept 33.3. Growth, morphogenesis, and differentiation produce the plant body

- **Morphogenesis** is the development of body form and organization.
- The three developmental processes of growth, morphogenesis, and cellular differentiation act in concert to transform the fertilized egg into a plant.

Growth: Cell Division and Cell Expansion

- By increasing cell number, cell division in meristems increases the potential for growth.
- Cell expansion accounts for the actual increase in plant size.

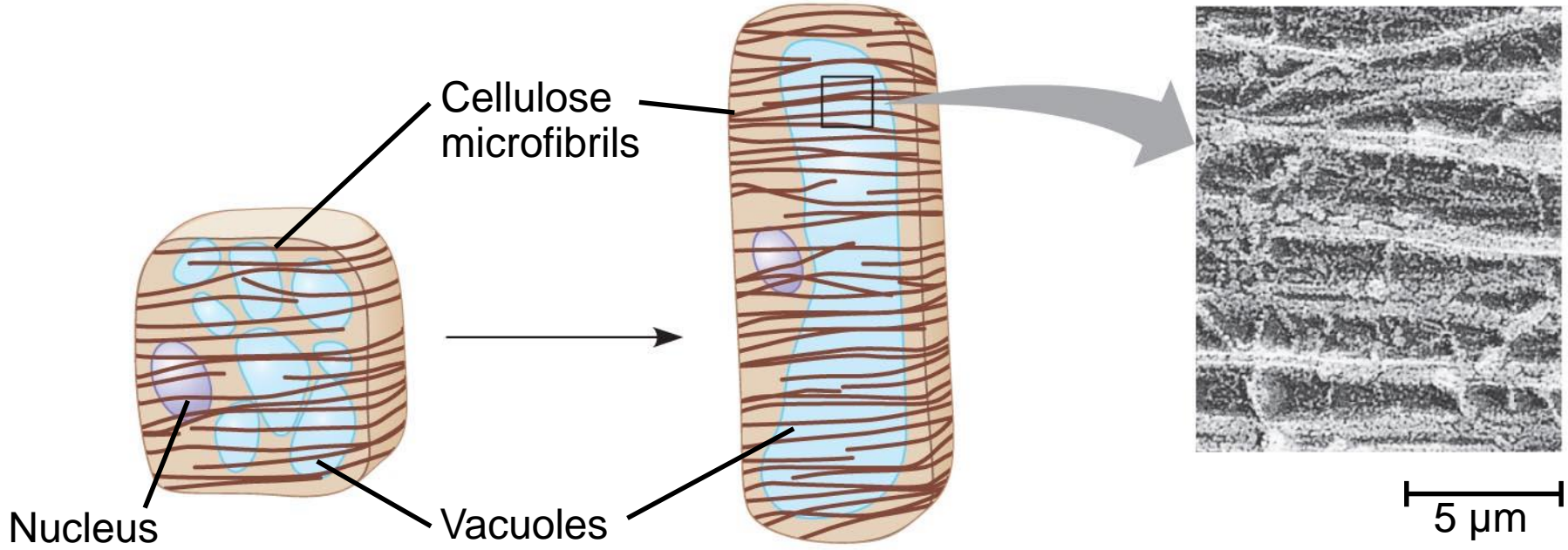
The plane and symmetry of cell division influence development of form



Orientation of Cell Expansion

- Plant cells grow rapidly and “cheaply” by intake and storage of water in vacuoles.
- Plant cells expand primarily along the plant’s main axis.
- Cellulose microfibrils in the cell wall restrict the direction of cell elongation.

The plane and symmetry of cell division influence development of form



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Morphogenesis and Pattern Formation

- **Pattern formation** is the development of specific structures in specific locations.
- It is determined by **positional information** in the form of signals indicating to each cell its location.
- Positional information may be provided by gradients of molecules.
- **Polarity**, having structural or chemical differences at opposite ends of an organism, provides one type of positional information.

Morphogenesis in plants, as in other multicellular organisms, is often controlled by homeotic genes



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Gene Expression and Control of Cellular Differentiation

- In cellular differentiation, cells of a developing organism synthesize different proteins and diverge in structure and function even though they have a common genome.
- Cellular differentiation to a large extent depends on positional information and is affected by homeotic genes.

Location and a Cell's Developmental Fate

- Positional information underlies all the processes of development: growth, morphogenesis, and differentiation.
- Cells are not dedicated early to forming specific tissues and organs.
- The cell's final position determines what kind of cell it will become.

Phase change in the shoot system



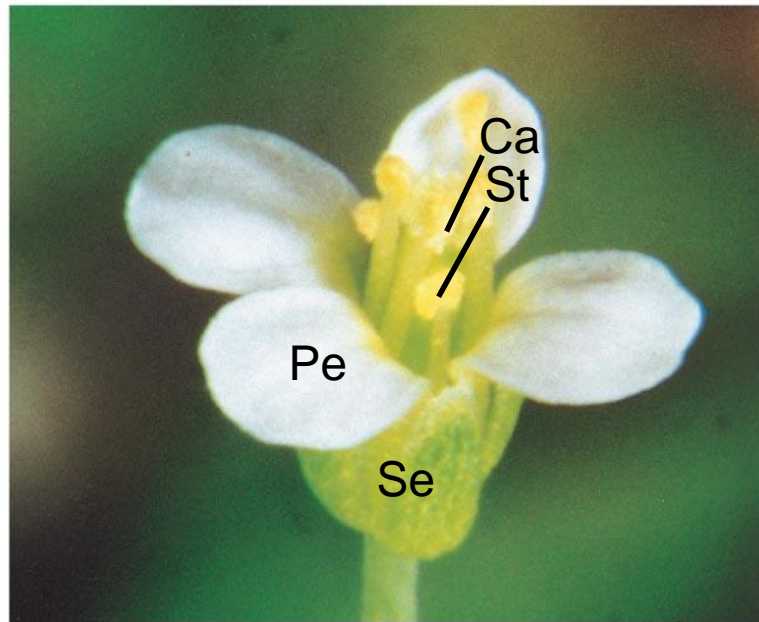
Leaves produced by adult phase of apical meristem

Leaves produced by juvenile phase of apical meristem

Genetic Control of Flowering

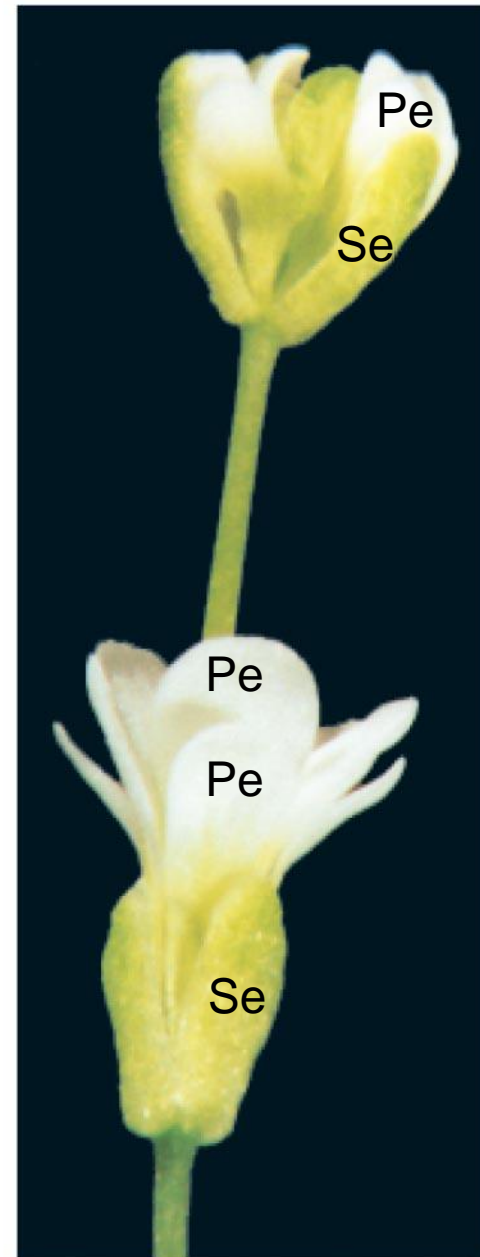
- Flower formation involves a phase change from vegetative growth to reproductive growth.
- It is triggered by a combination of environmental cues and internal signals.
- Transition from vegetative growth to flowering is associated with the switching on of floral **meristem identity genes**.

- Plant biologists have identified several **organ identity genes** = plant homeotic genes. These genes regulate the development of floral pattern.
- A mutation in a plant organ identity gene can cause abnormal floral development.



(a) Normal *Arabidopsis* flower

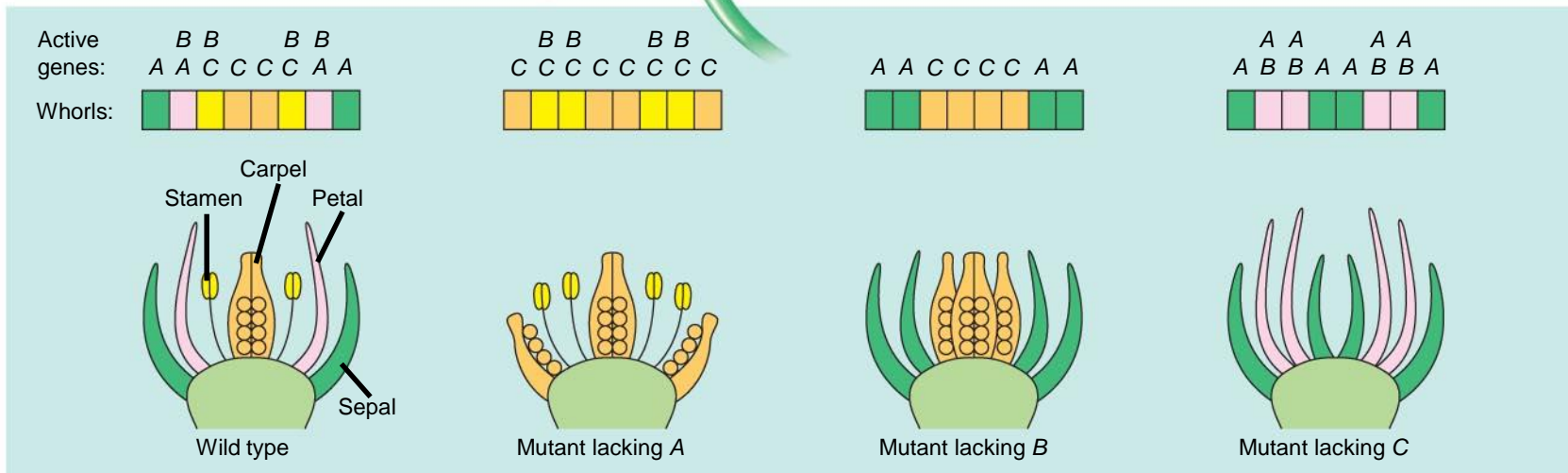
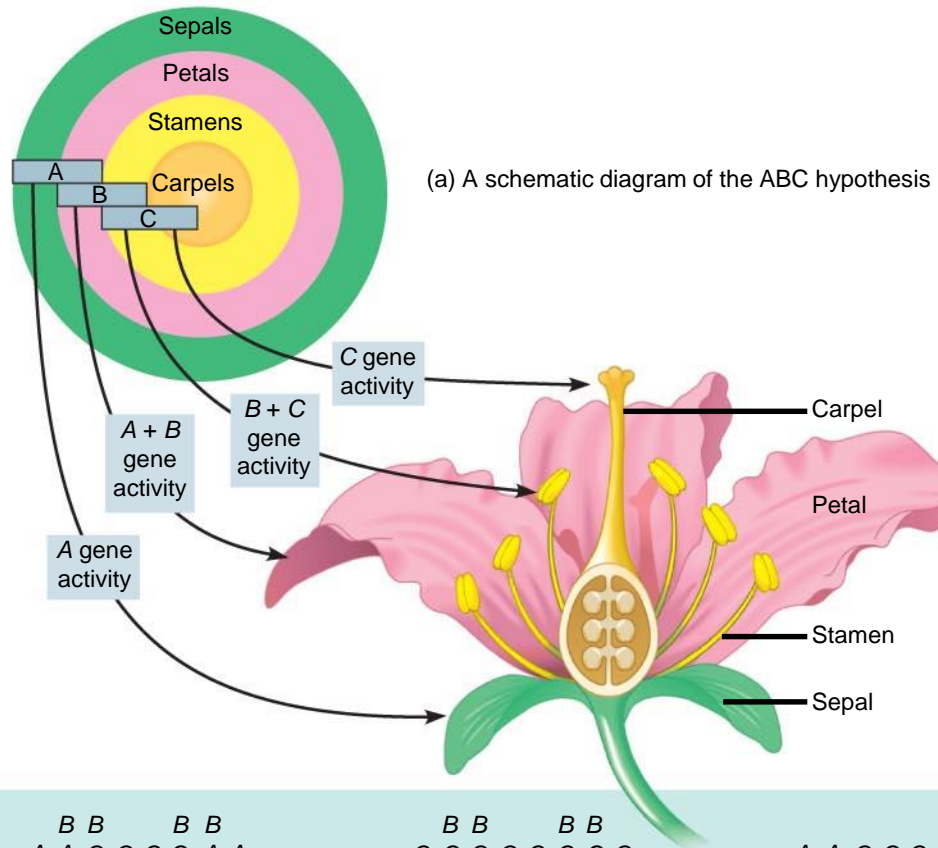
Organ identity genes and
pattern formation in flower
development



(b) Abnormal *Arabidopsis* flower

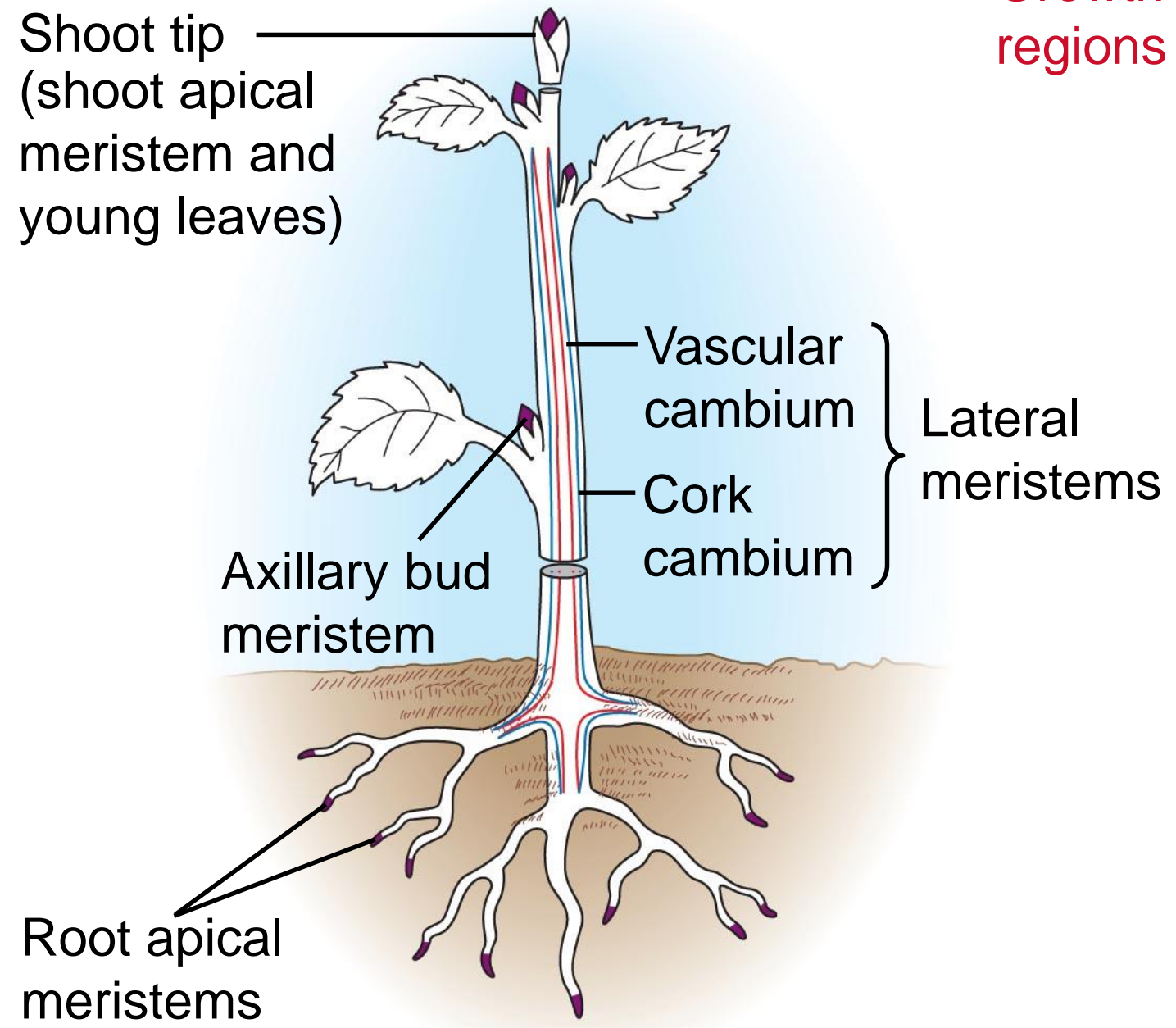
- Researchers have identified three classes of floral organ identity genes.
- The **ABC model** of flower formation identifies how floral organ identity genes direct the formation of the four types of floral organs.
- An understanding of mutants of the organ identity genes depicts how this model accounts for floral phenotypes.

The ABC hypothesis for the functioning of organ identity genes in flower development



(b) Side view of flowers with organ identity mutations

Growth regions



You should now be able to:

1. Compare the following structures or cells:
 - Fibrous roots, taproots, root hairs, adventitious roots
 - Dermal, vascular, and ground tissues
 - Monocot leaves and eudicot leaves
 - Parenchyma, collenchyma, sclerenchyma, water-conducting cells of the xylem, and sugar-conducting cells of the phloem
 - Sieve-tube element and companion cell.

2. Explain the phenomenon of apical dominance.
3. Distinguish between determinate and indeterminate growth.
4. Describe in detail the primary and secondary growth of the tissues of roots and shoots.
5. Describe the composition of wood and bark.

6. Distinguish between morphogenesis, differentiation, and growth.
7. Explain how a vegetative shoot tip changes into a floral meristem.

GRAMINEAE/ POACEAE:

1. *Oryza sativa*
2. *Zea mays*
3. *Imperata cylindrica*
4. *Saccharum officinarum*
5. *Paspalum conjugatum*
6. *Cyperus rotundus*
7. *Cynodon dactylon*
8. *Sorghum bicolor*
9. *Triticum durum*
10. *Bambusa bamboo*
11. *Eleusine indica*
12. *Bambusa balcoa*

PALMAE:

1. *Cocos nucifera*
2. *Elaeis guineensis*
3. *Zalacca edulis*
4. *Phoenix dactylifera*
5. *Areca catecu*
6. *Actinorhytis calapparis*
7. *Adonidia merrillii*
8. *Aiphanes horrida*
9. *Archontophoenyx alexandrae*
10. *Archontophoenyx maxima.*

Cari masing-masing lima nama latin tanaman dari Famili:

- 1. Brassicaceae**
- 2. Cucurbitaceae**
- 3. Solanaceae**
- 4. Myrtaceae**
- 5. Musaceae**
- 6. Rutaceae**
- 7. Euphorbiaceae**
- 8. Rosaceae**
- 9. Pinaceae**
- 10. Labiatae (Lamiaceae)**
- 11. Apiaceae (Umbelliferae)**

Cari masing-masing lima nama latin tanaman dari Famili:

12. Dioscoreaceae

13. Anacardiaceae

14. Convolvulaceae

15. Piperaceae

16. Vitaceae

17. Lauraceae

18. Moraceae

19. Oleaceae

20. Meliaceae