

ANATOMÍA DE PLANTAS VASCULARES

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La anatomía de plantas es aquella disciplina científica, una de las más antiguas en la botánica que estudia las estructuras de las plantas a una escala microscópica.

Debe visualizarse como un estudio de procesos dinámicos de las células, tejidos y órganos de la planta, como resultante de la interacción del metabolismo de la misma con su entorno.

Se relaciona con otras disciplinas de la botánica como:

Evolución

Taxonomía y sistemática

Genética

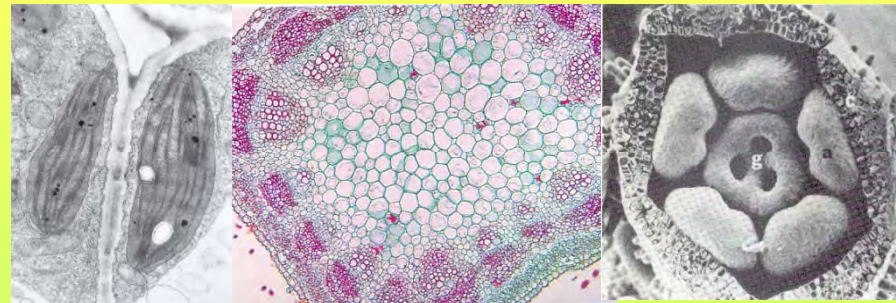
Citología

Bioquímica y biofísica

Fisiología

Biomecánica

Ecología



Anatomía Vegetal

Programa

- La célula vegetal
- Tejidos: origen, tejidos fundamentales, características y funciones
- Tejidos meristemáticos primarios y secundarios: características, origen, localización e importancia
- Organografía
- Anatomía fisiocológica

ANATOMÍA DE LA CÉLULA VEGETAL

ANATOMÍA DE LA CÉLULA VEGETAL, SU ORIGEN Y ESPECIALIZACIÓN

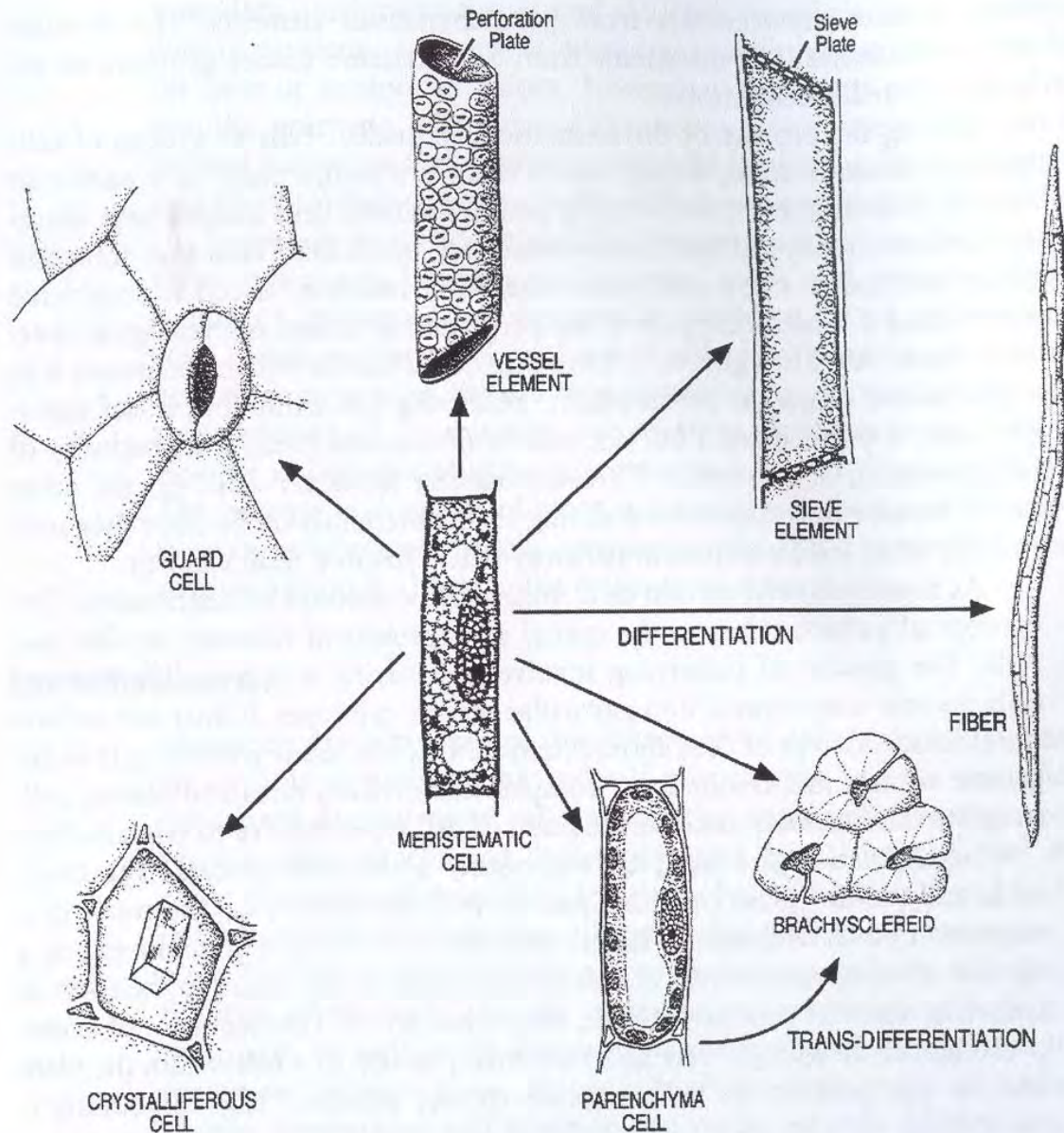


FIGURE 1.3 Representative end products of plant cell differentiation from a meristematic cell. The parenchyma cell retains a living protoplast and is able to transdifferentiate into another cell type, such as a sclereid, that becomes devoid of living contents at maturity.

LA CÉLULA VEGETAL tiene los siguientes organelos o componentes presentes, potenciales o no expresados:

- Pared Celular**
- Membrana o Plasmalema**
- Plasmodesmos o intercomunicadores**
- Hialoplasma o Citosol**
- Núcleo y nucleolo**
- Ribosomas**
- Retículo endoplásmico**
- Microtúbulos o citoesqueleto**
- Vacuola y su membrana (tonoplasto)**
- Plastidios**
- Mitocondrias**
- Dictiosomas o Aparato de Golgi**
- Microcuerpos: peroxisomas y glicoxisomas**
- Sustancias ergásticas.**

Célula vegetal

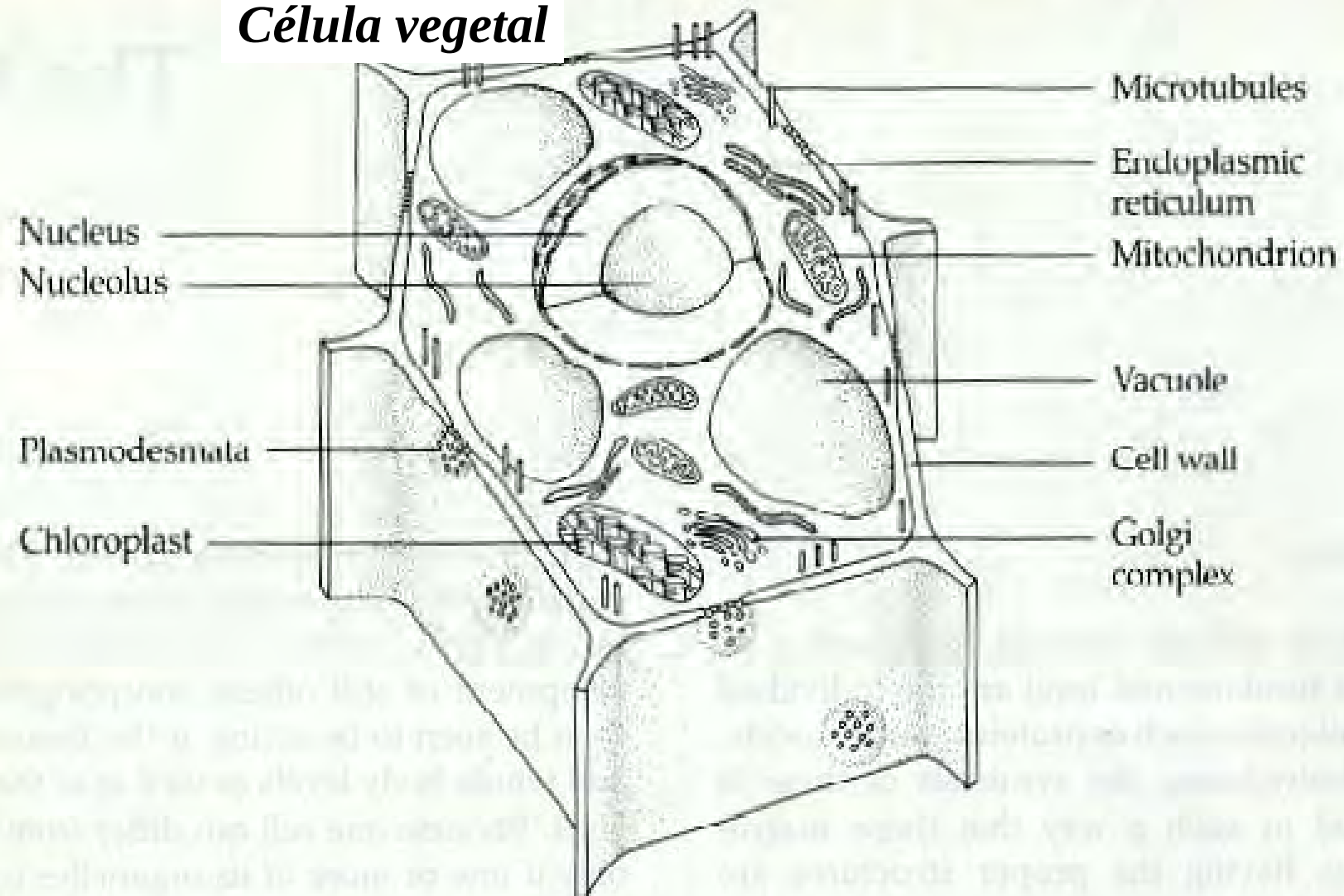
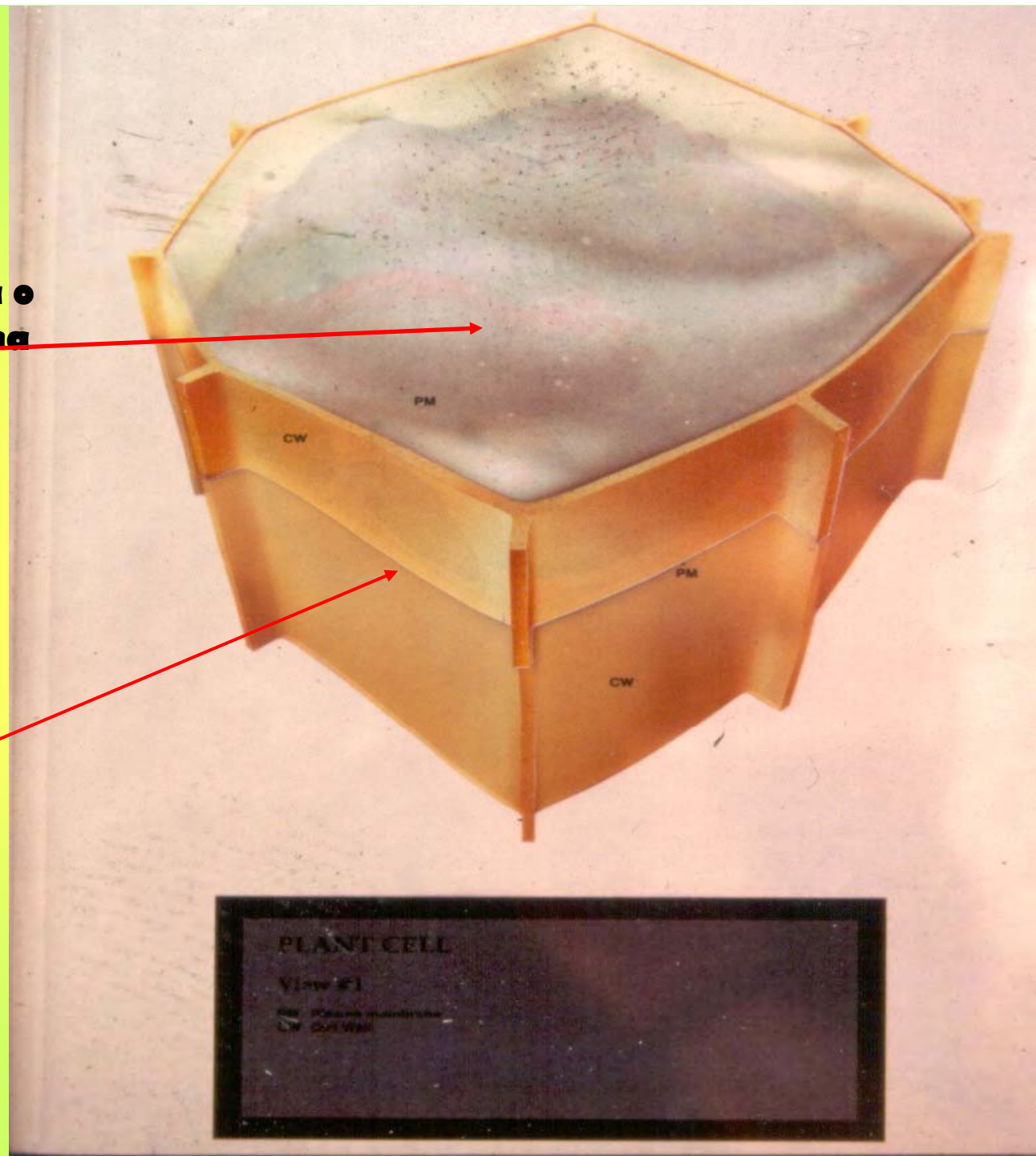


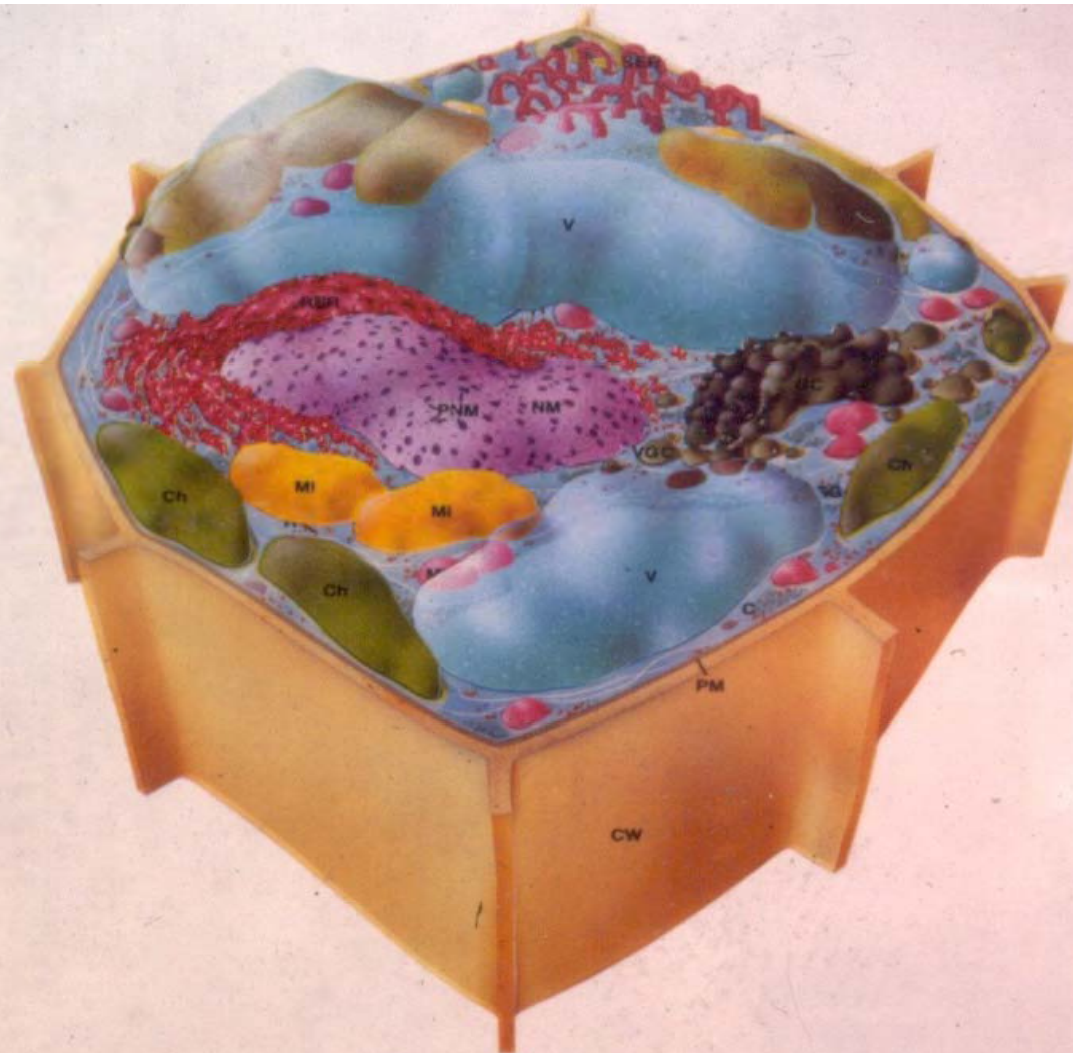
Figure 2.1

This is a diagrammatic representation of a plant cell and the organelles that might be found in it.

**Membrana o
plasmalema**

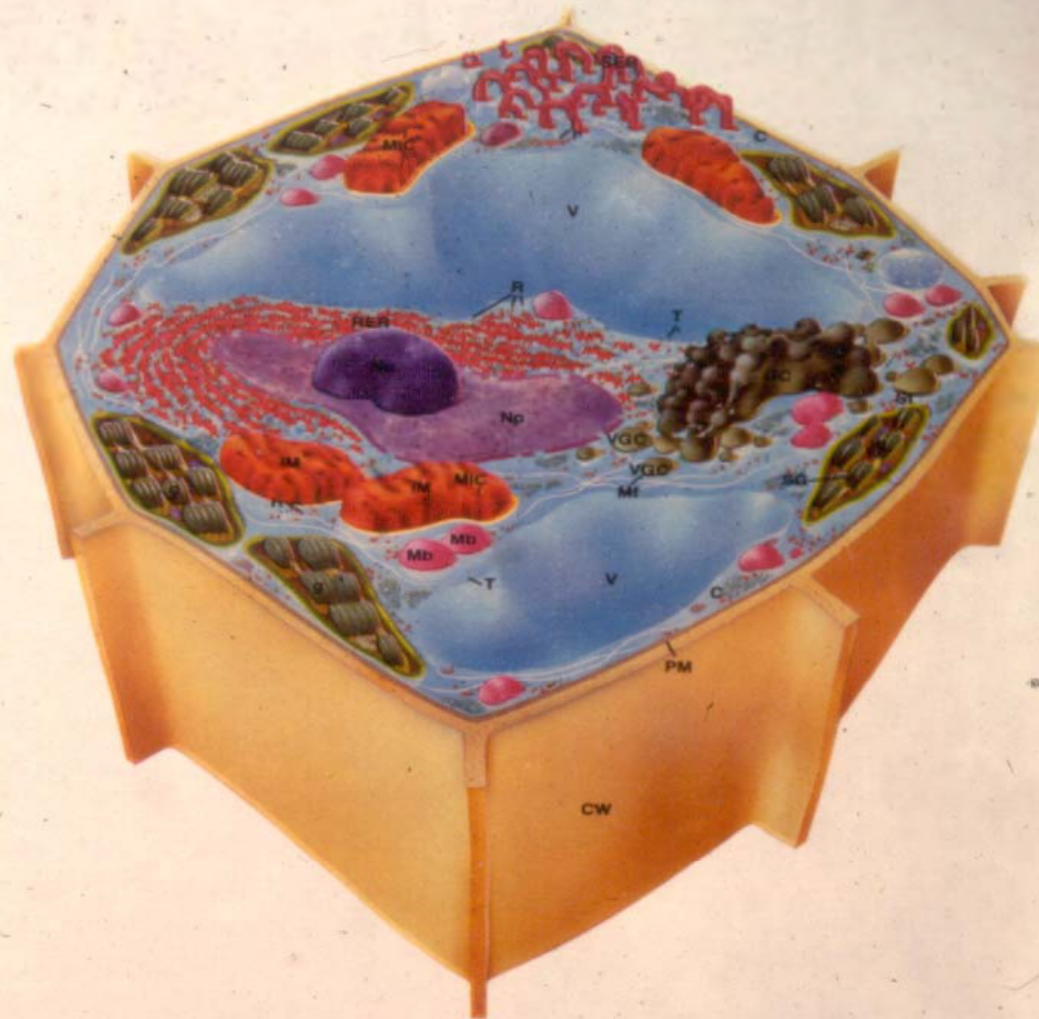
Pared celular





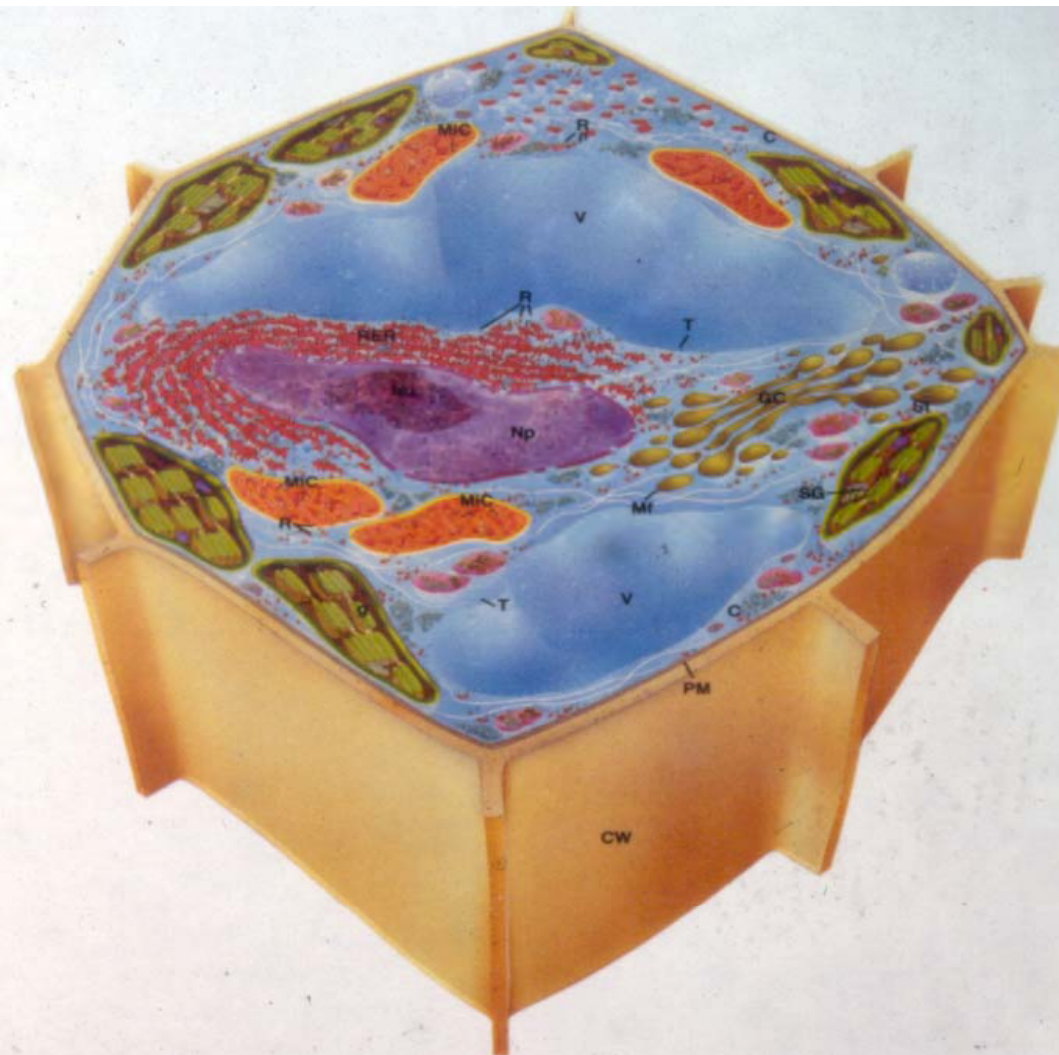
View #2

PM	Plasma membrane	Mb	Microbodies
C	Cytoplasm	GC	Golgi complex
CW	Cell wall	VOC	Vesicles of the golgi complex
Ch	Chloroplast	R	Ribosomes
V	Vacuole	SER	Smooth endoplasmic reticulum
Mi	Mitochondrion	MF	Microfilaments
RER	Rough endoplasmic reticulum		
NM	Nuclear membrane		
PNM	Pores of the nuclear membrane		



View #3

PM	Plasma membrane	MIC	Mitochondrial cristae
C	Cytoplasm	g	Grana of the chloroplast
CW	Cell wall	GC	Golgi complex
RER	Rough endoplasmic reticulum	VGC	Vesicles of the golgi complex
Np	Nucleoplasm	Mb	Microbodies
SER	Smooth endoplasmic reticulum	V	Vacuole
Nu	Nucleolus	R	Ribosomes
Mf	Inner membrane of the mitochondrion	Mf	Microfilaments



Key	
CW	Cell wall
PM	Plasma membrane
C	Cytoplasm
Ch	Chloroplast
T	Tonoplast (vacuole membrane)
GR	Golgi apparatus
G	Grains of the chloroplast
Np	Nucleus
R	Rough endoplasmic reticulum
SER	Smooth endoplasmic reticulum
Mt	Mitochondrion
MIC	Mitochondrial cristae
V	Vacuole
SG	Starch granule

LA MEMBRANA

La membrana en anatomía e histología vegetal también se denomina plasmalema.

Está formada por una doble capa de lípidos y por una conjunto de proteínas. Intercomunican a la célula con otras y con el exterior del tejido.

Cada célula se conecta con otra a través de orificios en las membranas, a manera de placas que se denominan plasmodesmos.

El concepto de simplasto precisamente abarca el paso de información a través de las células por medio de los plasmodesmos.

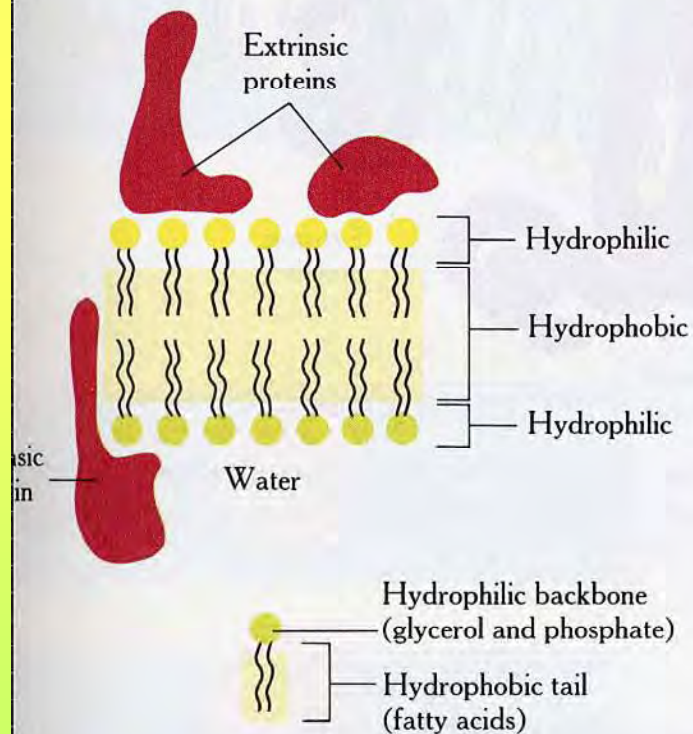
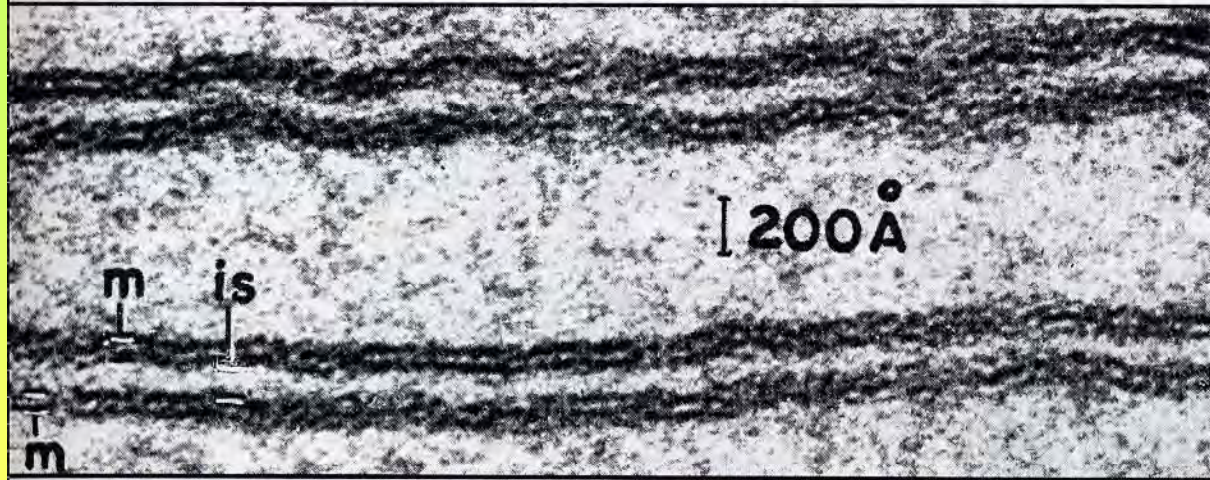


Figure 3.6

(a) In electron micrographs, membranes appear as two dark lines (proteins) separated by a light region (composed mostly of lipids ($\times 600,000$)). (b) Pictures such as (a) led scientists to believe that membranes consist of two layers of lipids with proteins located only on the surface. However, there are many proteins that fit partly into the lipid bilayer or pass all the way through it. (c) A phospholipid has three parts: (1) two fatty acids, (2) a backbone of glycerol, and (3) a phosphate group.

Just as important are cellular interactions by which cells not only sense if they are part of a larger organism but also identify which part they are and how they should differentiate. In a developing embryo, the proper cells must be instructed to begin forming an embryonic shoot while other cells are induced to form an embryonic root, vascular tissues, seed leaves, and so on. This requires extensive sophisticated intercellular communication.

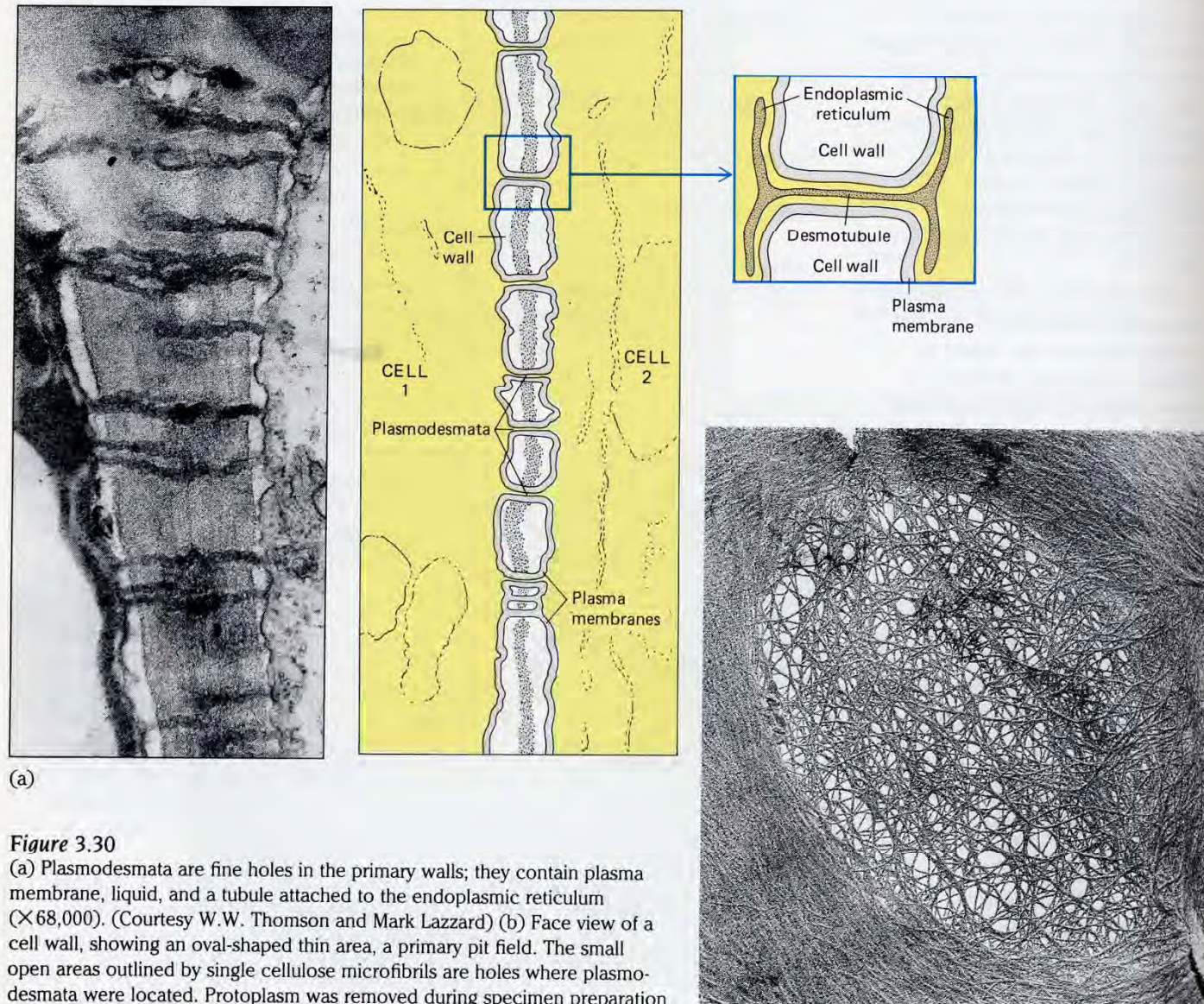


Figure 3.30

(a) Plasmodesmata are fine holes in the primary walls; they contain plasma membrane, liquid, and a tubule attached to the endoplasmic reticulum ($\times 68,000$). (Courtesy W.W. Thomson and Mark Lazzard) (b) Face view of a cell wall, showing an oval-shaped thin area, a primary pit field. The small open areas outlined by single cellulose microfibrils are holes where plasmodesmata were located. Protoplasm was removed during specimen preparation.



Figure 2.5

This cell (from the plasmalemma of *Pteris tremula*) was frozen in liquid nitrogen, then fractured; the break passes through the middle of membranes, revealing the protein particles embedded in them. The large ridges are areas where the membrane is pressed against cellulose fibrils in the wall below. $\times 10,000$. Micrograph generously provided by A. Koller and E. Roberts.

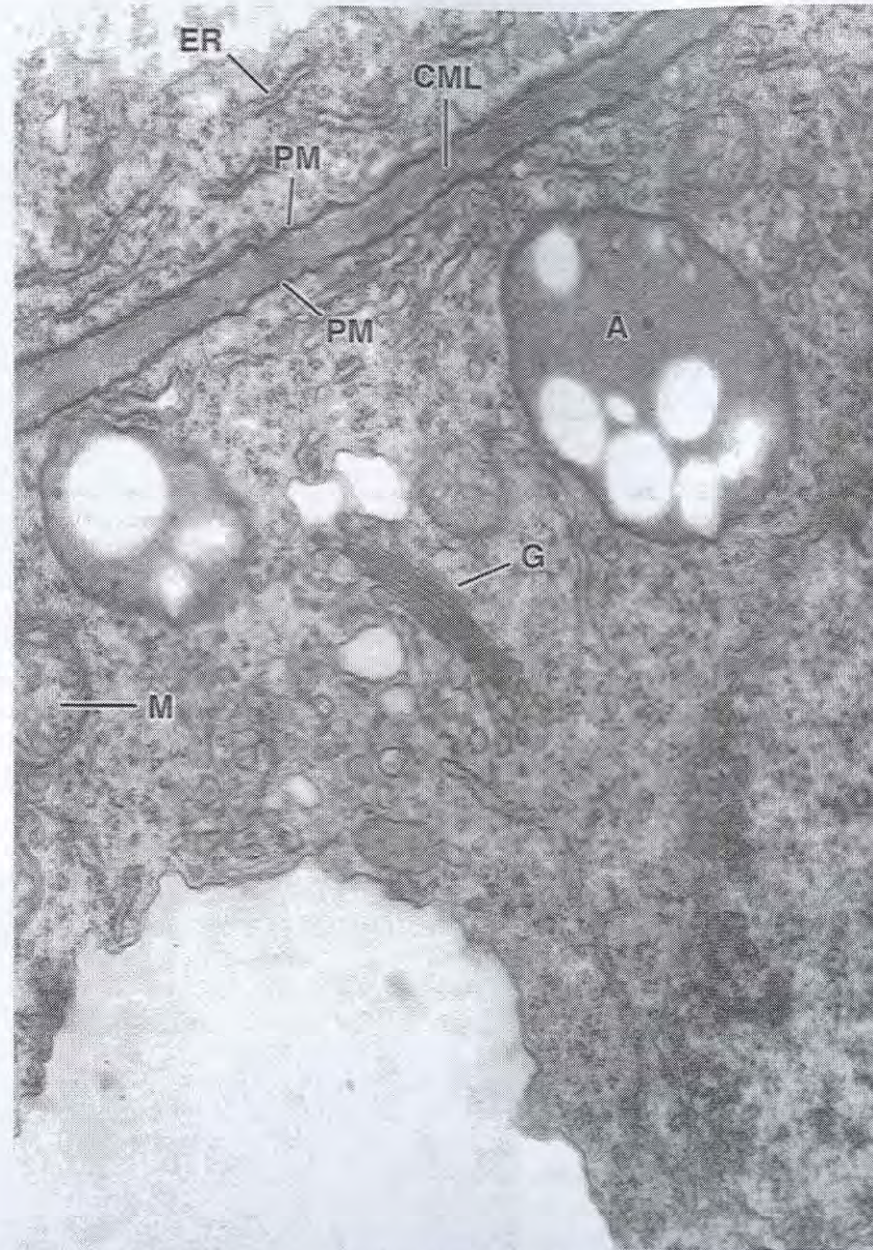


FIGURE 1.26 EM of pea (*Pisum*) root cells showing plasma membranes of adjacent cells positioned against the compound middle lamella. Abbreviations: A, amyloplast; CML, compound middle lamella; ER, endoplasmic reticulum with associated ribosomes; G, Golgi; M, mitochondrion; PM, plasma membrane. Courtesy of T. Perdue.

membranas

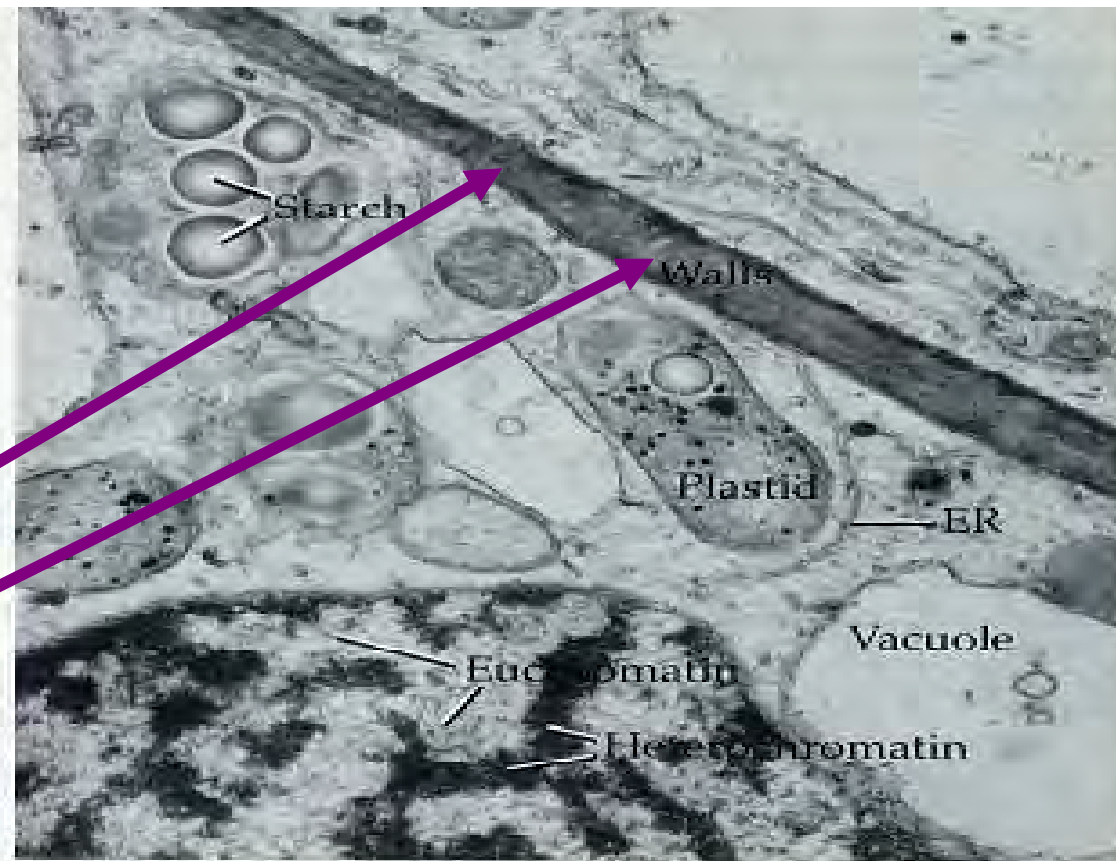


Figure 2.6

It is extremely common for the nucleus to be located near a wall like this, although they can sometimes be found suspended in the center of a cell. This nucleus contains patches of euchromatin (light color) and heterochromatin (dark color). The two membranes of the nuclear envelope are also visible, but the magnification is too low to show nuclear pores. Four plastids are present, and they are so undeveloped that they would be considered proplastids; three contain starch deposits. Mitochondria and endoplasmic reticulum are also visible. The walls between the two cells are extremely thin. $\times 750$.

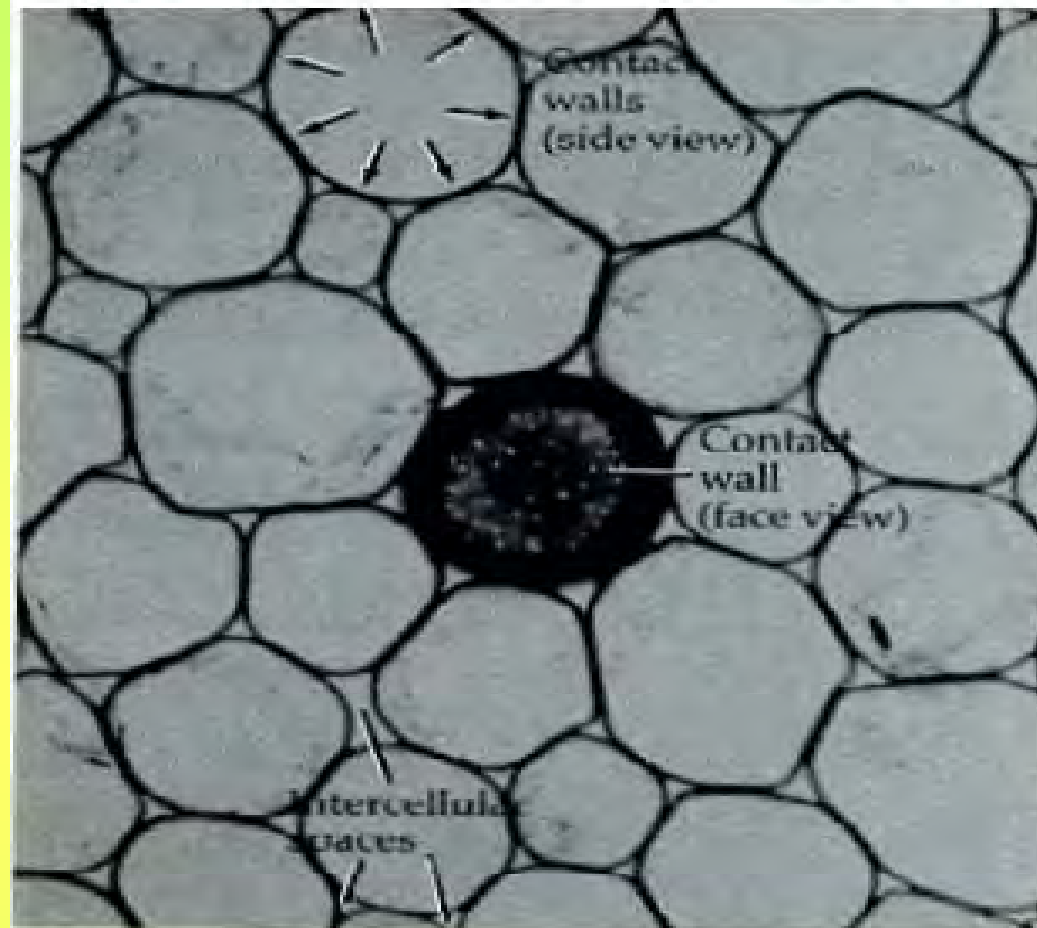
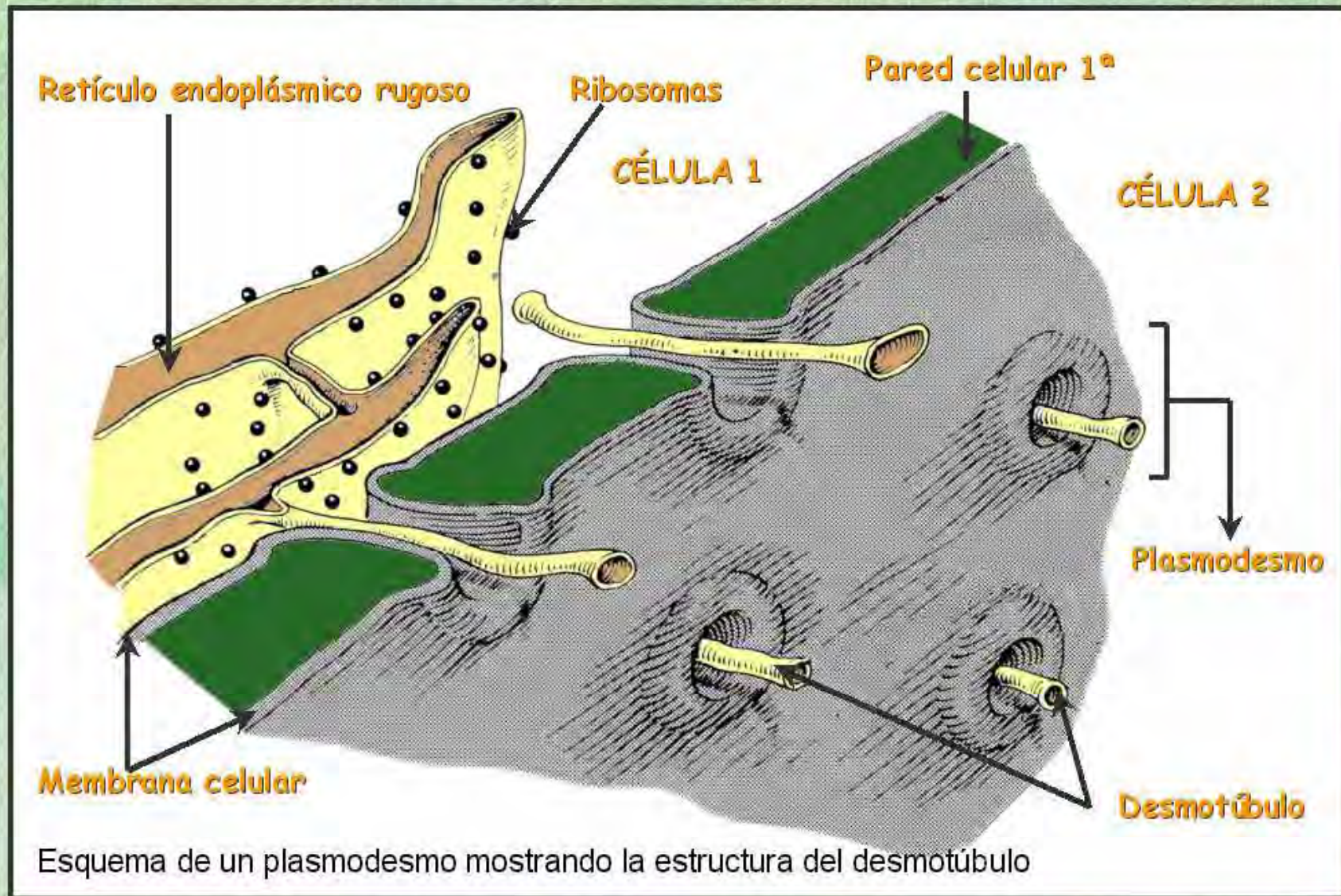


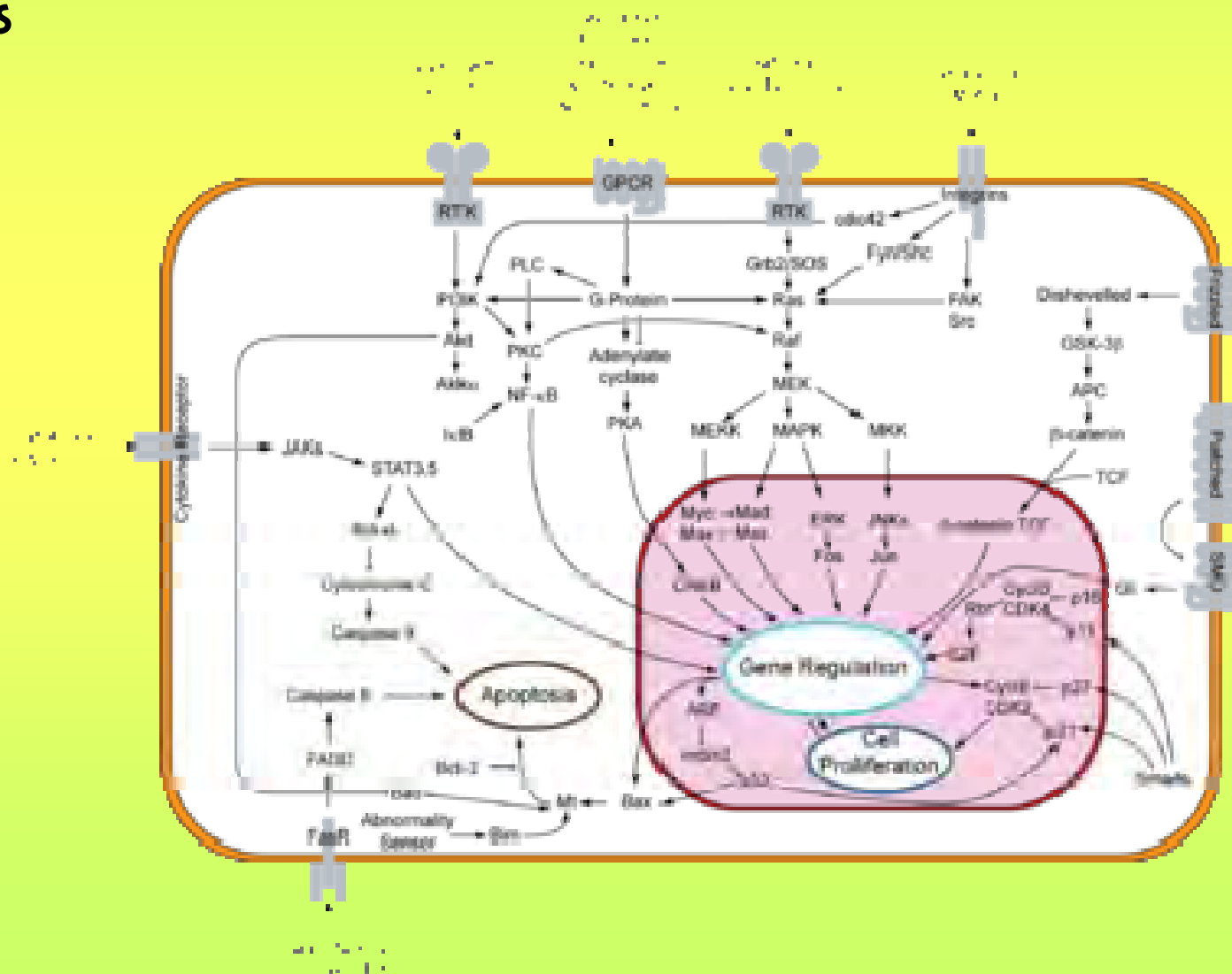
Figure 2.3

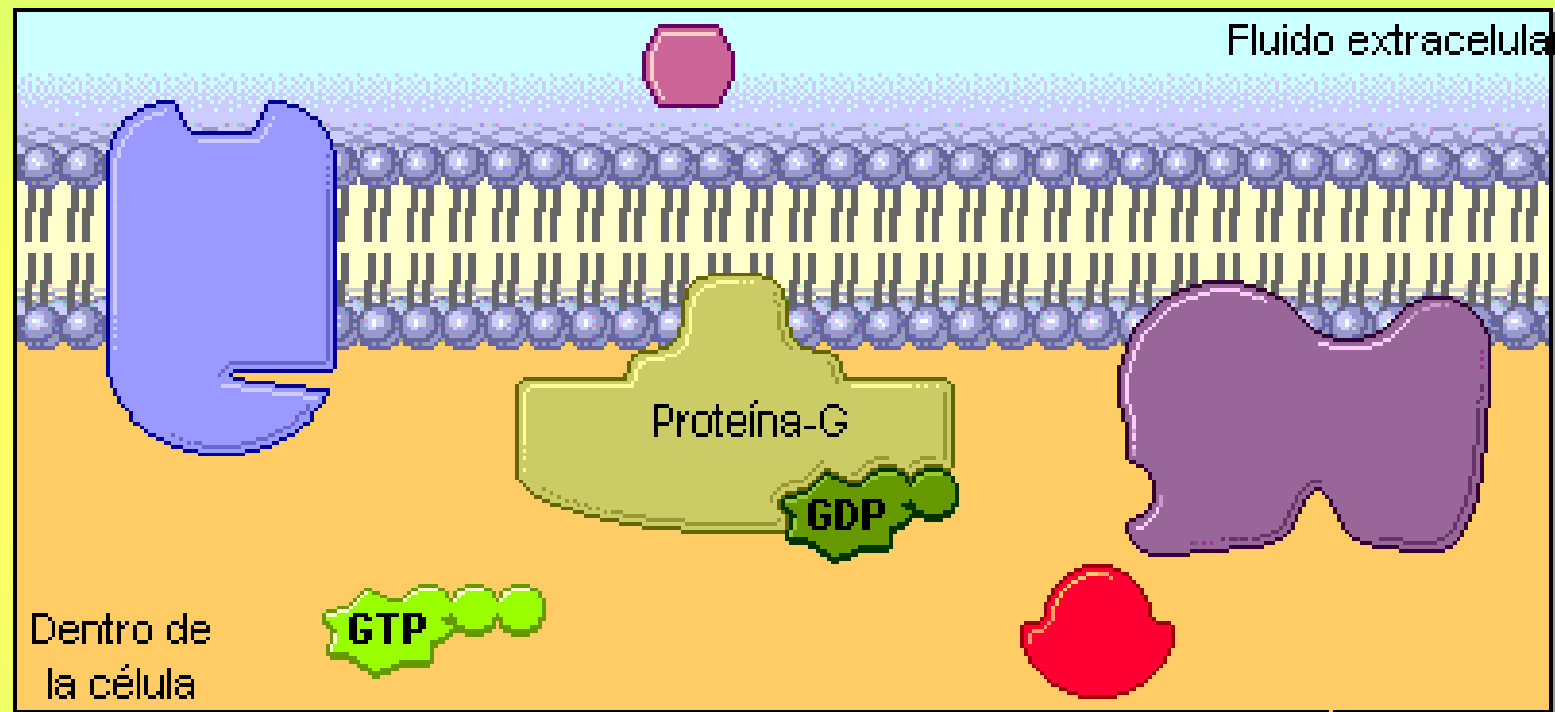
These are cells in the stem of *Ranunculus*; they appear empty because the vacuoles constitute almost all of the protoplasm. The stem was cut in such thin sections that both the front wall and the back wall were removed from every cell. The dark circular plate in the center of the photo is a wall between two cells that was not cut away. It appears to have holes in it, but those are thin areas (primary pit fields). $\times 100$.

Plasmodesmos: el desmotúbulo



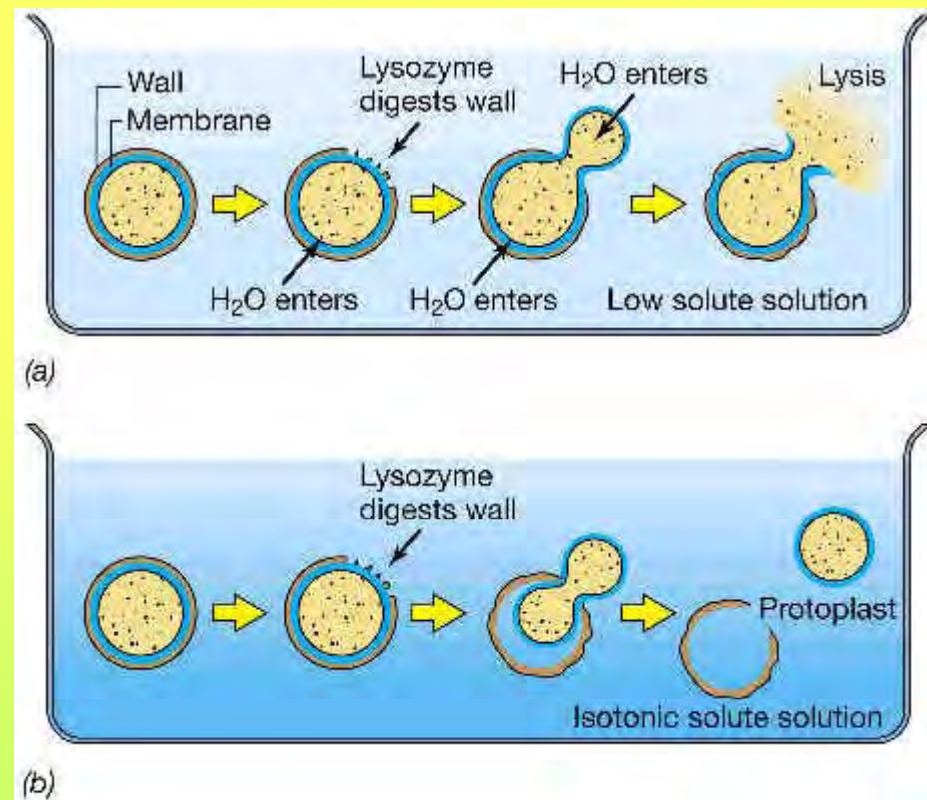
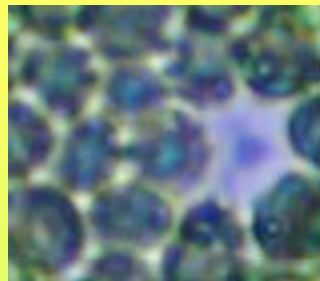
La célula vegetal se comunica con otras células a través de la membrana y por medio de señales bioquímicas las que se denominan señales de transducción o transducción de señales





Protoplasto

Se define como la célula vegetal aislada de pared celular



PARED CELULAR

Toda célula vegetal tiene pared celular.

Algunas células tienen una sola pared primaria, otras tienen doble pared (primaria y secundaria).

Los constituyentes de la pared celular son:

- Celulosa - glucosa polimerizada a través de puentes β 1,4***
- Proteínas ricas en hidroxiprolina, serina***
- Hemicelulosa***
- Pectina***
- Lignina***

SÍNTESIS DE LA PARED CELULAR

La pared celular está formada por un entretejido de microfibrillas de celulosa.

La celulosa se sintetiza en la agrupación de enzimas que forman estructuras denominadas rosetas que se localizan en el plasmalema.

Las microfibrillas son agrupaciones de 40 -70 cadenas que se aglomeran en las rosetas.

El concepto de apoplasto es el paso de información a través de las células por vía de la pared celular.

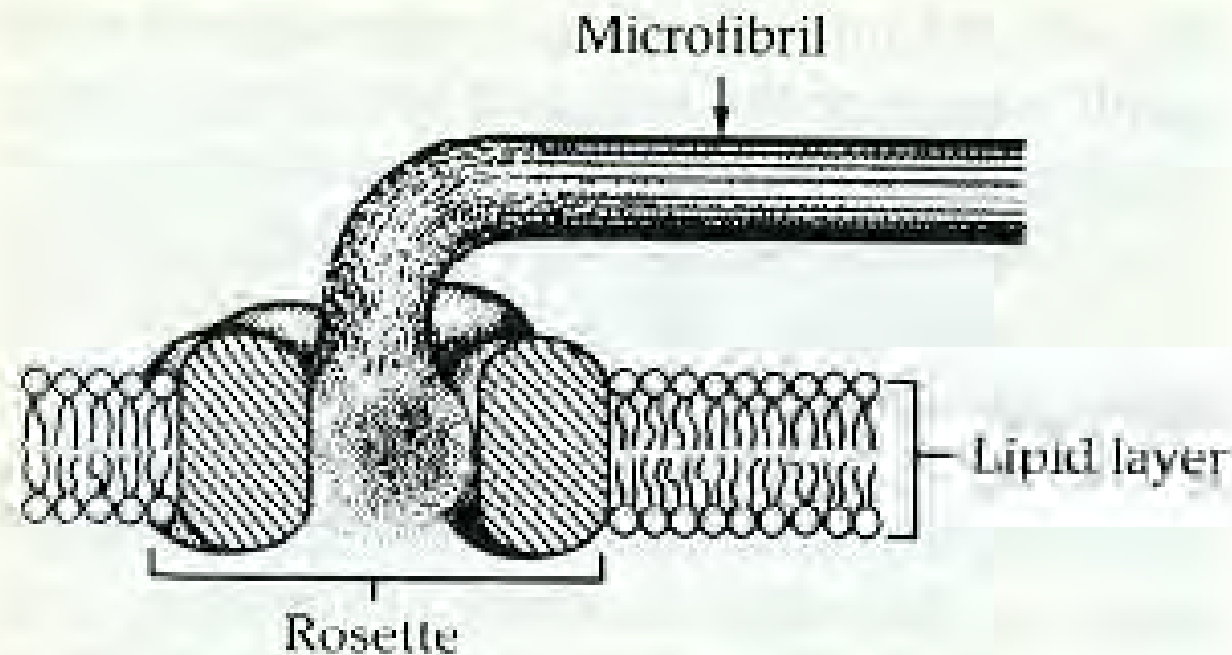


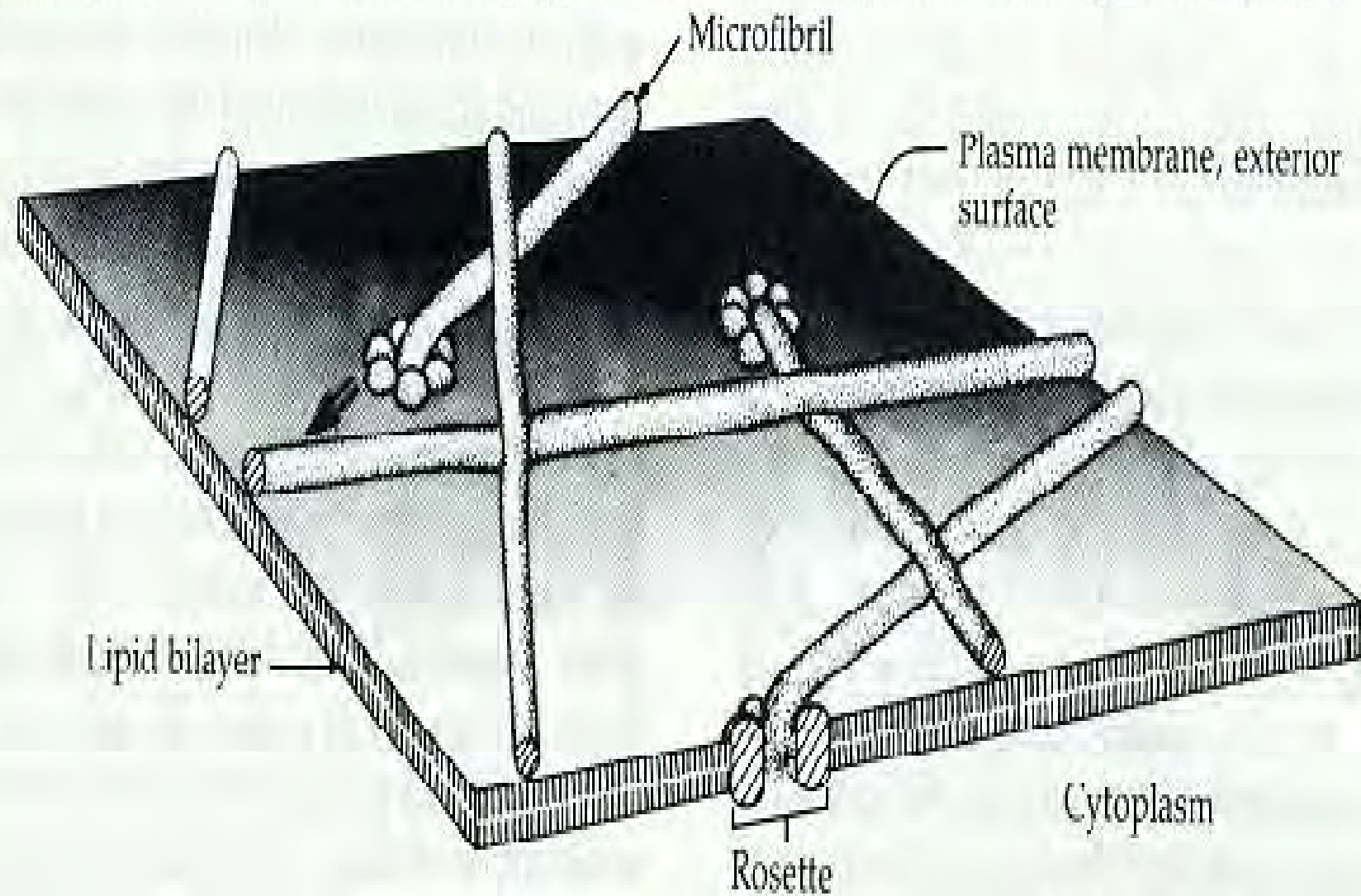
Figure 2.16

This diagram represents a membrane with a cellulose-synthesizing rosette embedded in it. The rosette extends completely through the membrane, so precursors can be absorbed on the cytoplasm side and the cellulose polymer (the microfibril) extruded on the other side. Diagram generously provided by T. H. Giddings, Jr. Reproduced from *The Journal of Cell Biology*, 1987, vol. 84:327, by copyright permission of The Rockefeller University Press.



Figure 2.18

This micrograph shows several hexagonal arrays of rosettes. The entire array moves forward as a unit, and, as each rosette produces a microfibril, that microfibril reacts and crystallizes with the adjacent, aligned microfibrils. $\times 10,000$. Micrograph generously provided by T. H. Giddings, Jr. Reproduced from *The Journal of Cell Biology*, 1987, vol. 84:327, by copyright permission of The Rockefeller University Press.



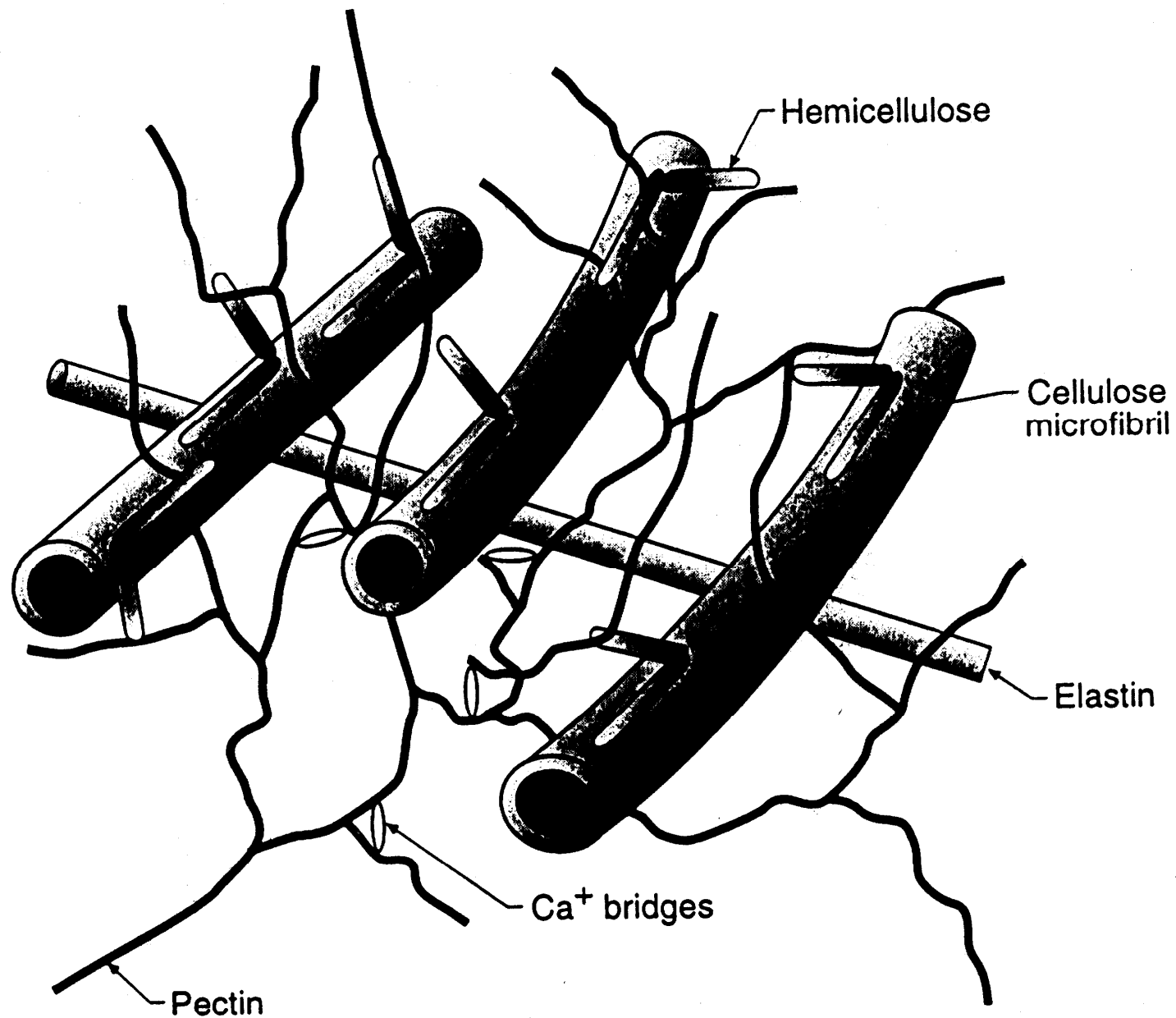
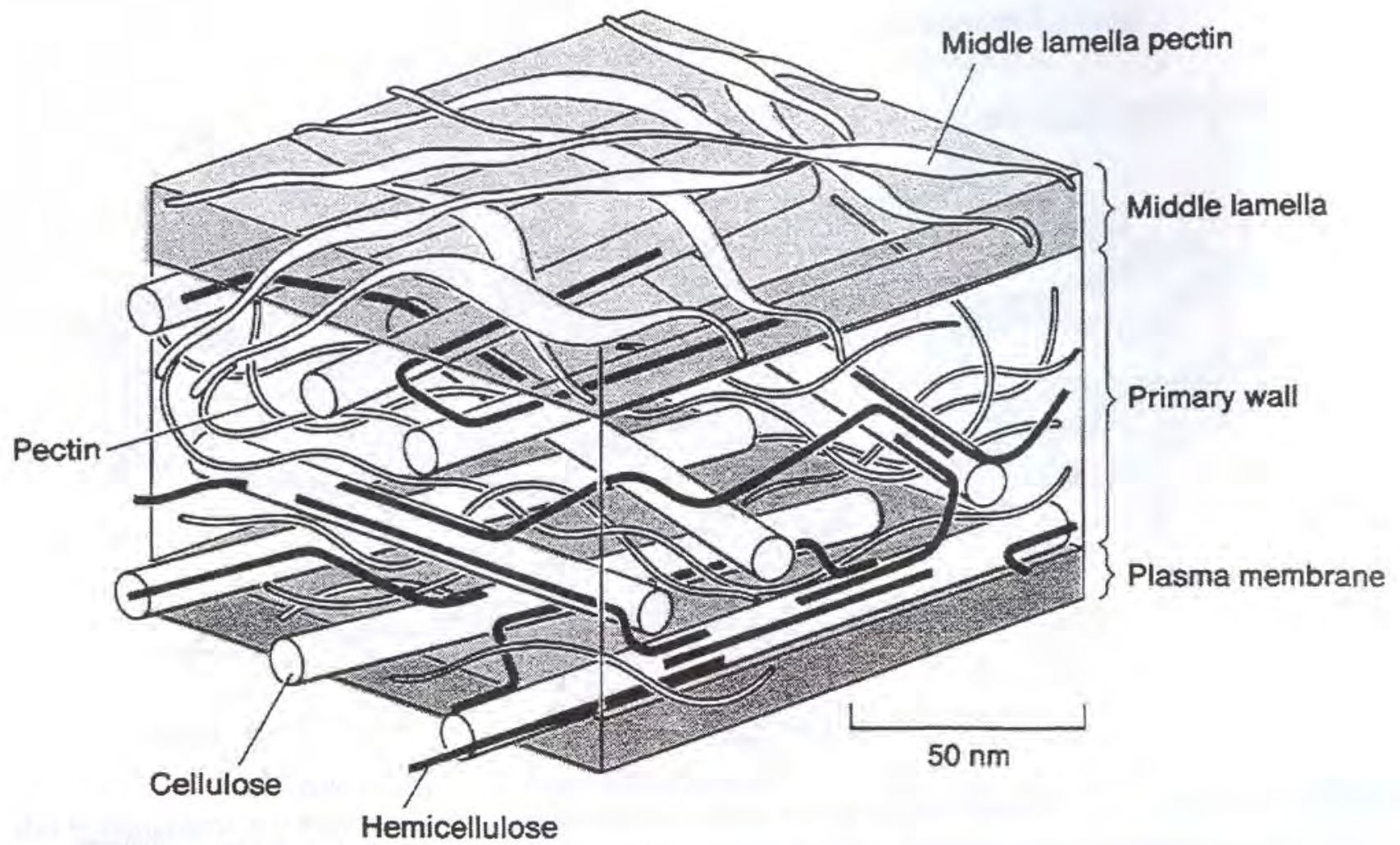


Figure 2.5 Diagrammatic representation of the main components of the cell wall and their structural interrelationship. (Modified from Taiz and Zeiger 1991.)



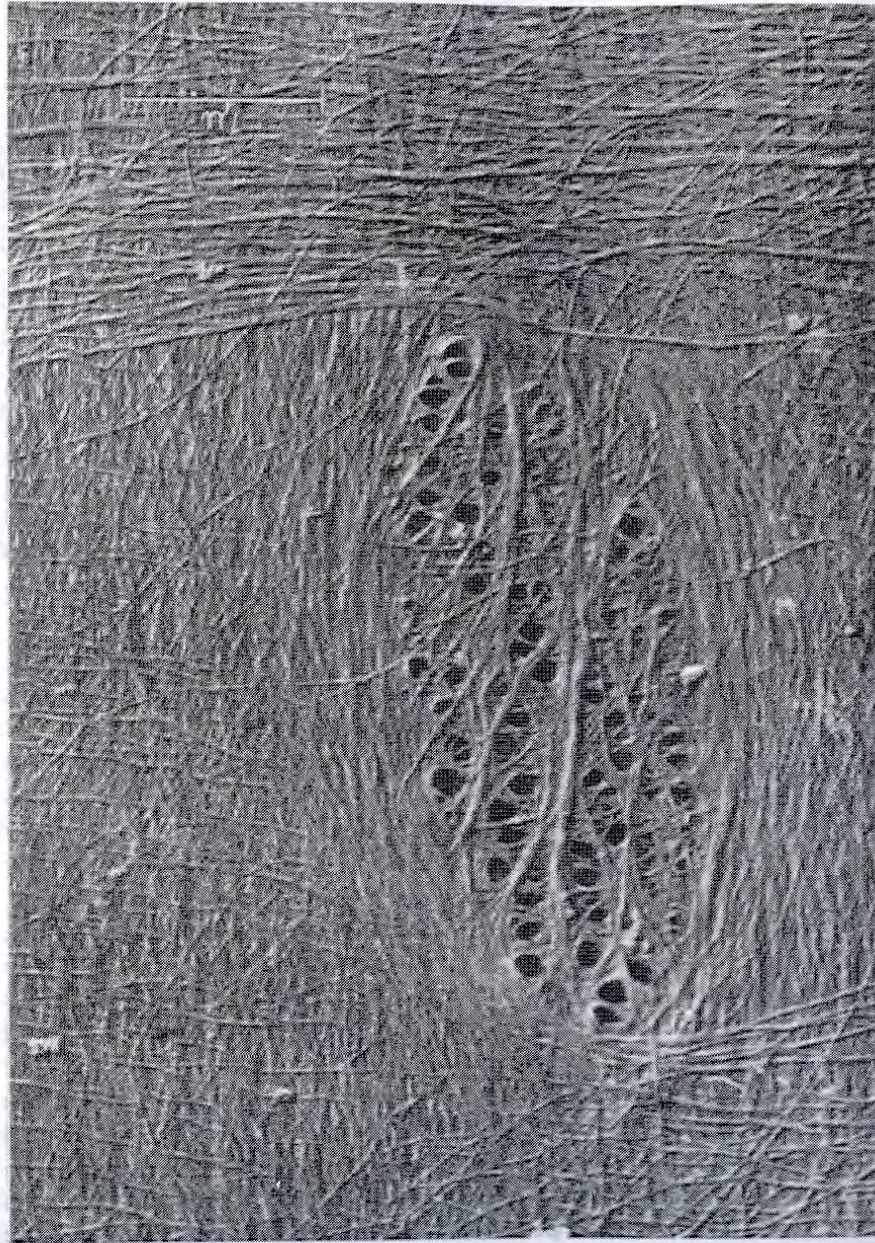


FIGURE 1.13 Electron micrograph of primary wall of a parenchyma cell from oat, *A* (Gramineae), coleoptile. The parallel-oriented microfibrils at top occurred in one of the angles of cell. Other microfibrils show a random orientation. Plasmodesmatal pores are clustered in a primary field, $\times 26,000$. Reprinted with permission from Böhmer (1958), *Planta* **50**, 461–497.

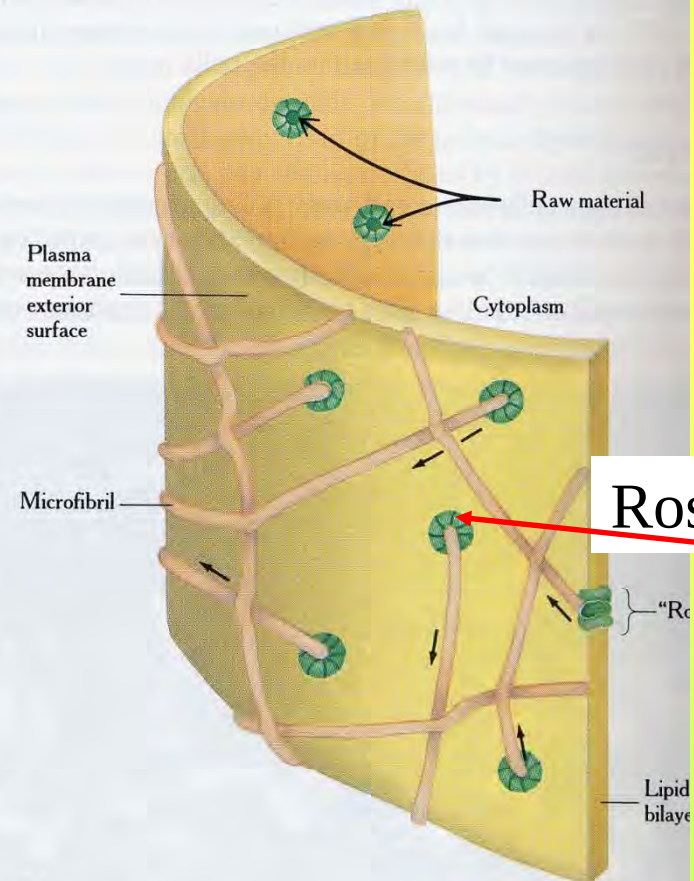
Figure 3.28

(a) Two layers of cellulose microfibrils are visible; other layers are present deeper in the wall. Each layer provides strength in the direction parallel to the microfibrils. Other wall components have been dissolved away to reveal the cellulose ($\times 5000$). (Courtesy Dr. Shun Mizuta, Kochi University, Japan) (b) Cellulose-synthesizing enzymes are large proteins embedded in the plasma membrane; several proteins form a cluster called a rosette. Sugar monomers are absorbed by the enzymes of the membrane inner face, then passed through (in the direction of the arrows) and polymerized into cellulose on the outer face. The growing microfibril extends out from the rosette and lays against microfibrils already in place. Because the microfibril cannot push into the wall, the rosette is pushed through the membrane (opposite direction of the arrows) as the microfibril grows.



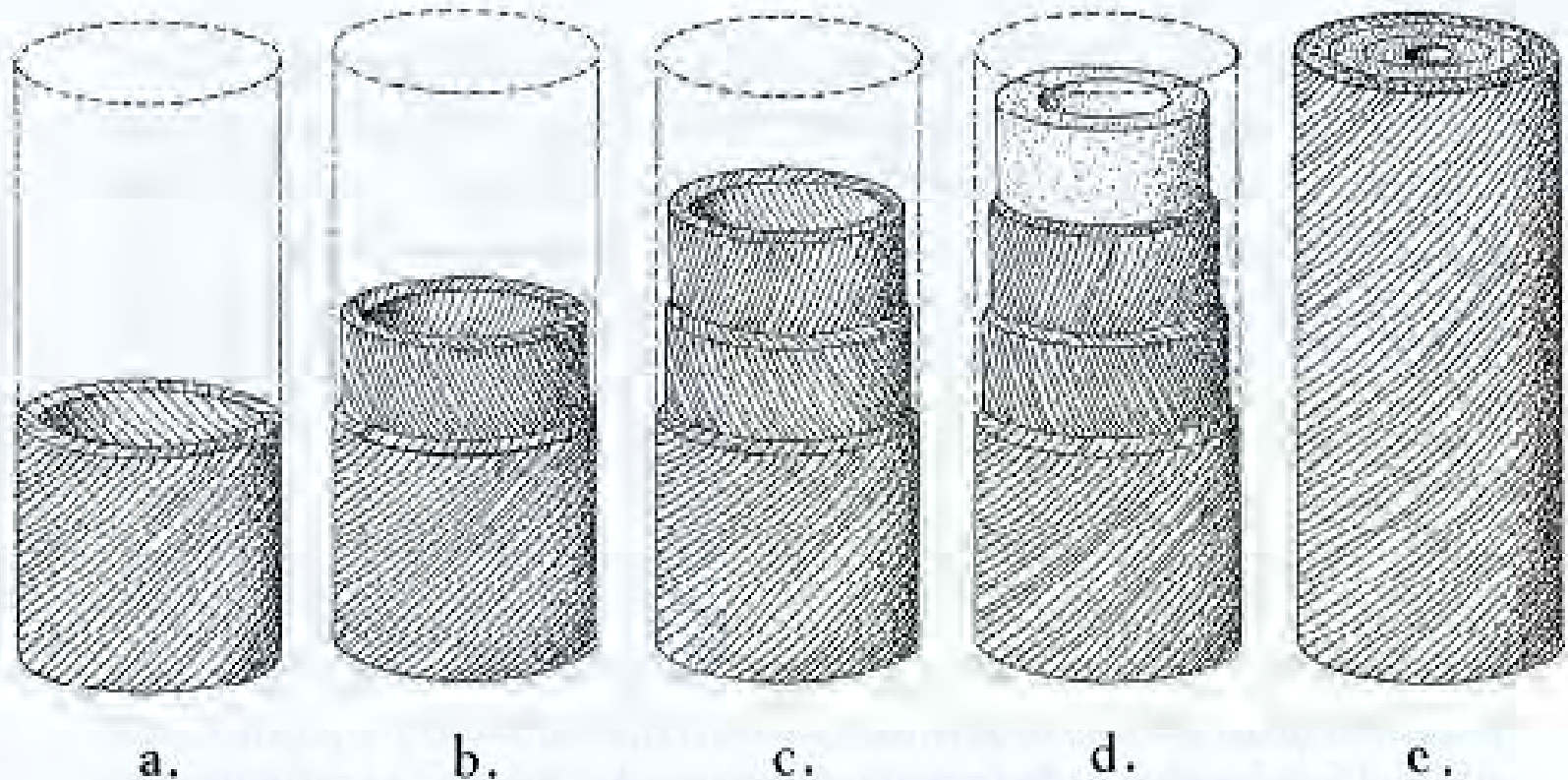
(a)

The cell wall contains a considerable amount of the polysaccharide cellulose (Figs. 3.5b and 3.28a). Adjacent, parallel cellulose molecules crystallize into extremely strong **microfibril** 10 to 25 nm wide. Numerous microfibrils wound around the cell, completely covering the plasma membrane. Each cellulose polymer grows only at one end, where a complex of enzymes adds glucose residues, one molecule at a time (Fig. 3.28b). The enzymes are intrinsic proteins of the plasma membrane, and as they add new sugars to the chain, they float forward in the membrane (the chain is too heavy to be pushed backward). New cellulose molecules can be added only on the inner side of the wall, adjacent to the plasma membrane.



(b)

Formación de la pared secundaria



Thickening of a plant cell wall. a. Cellulose microfibrils of the primary cell wall. The cavity at the center is occupied by the protoplasm (not shown). b. and c. Secondary wall thickening begins with additional layers of cellulose, each layer is laid down in a different direction. d. A layer of lignin is added. e. With the addition of another lignin layer, wall thickening is complete. The shrunken protoplasm soon dies.

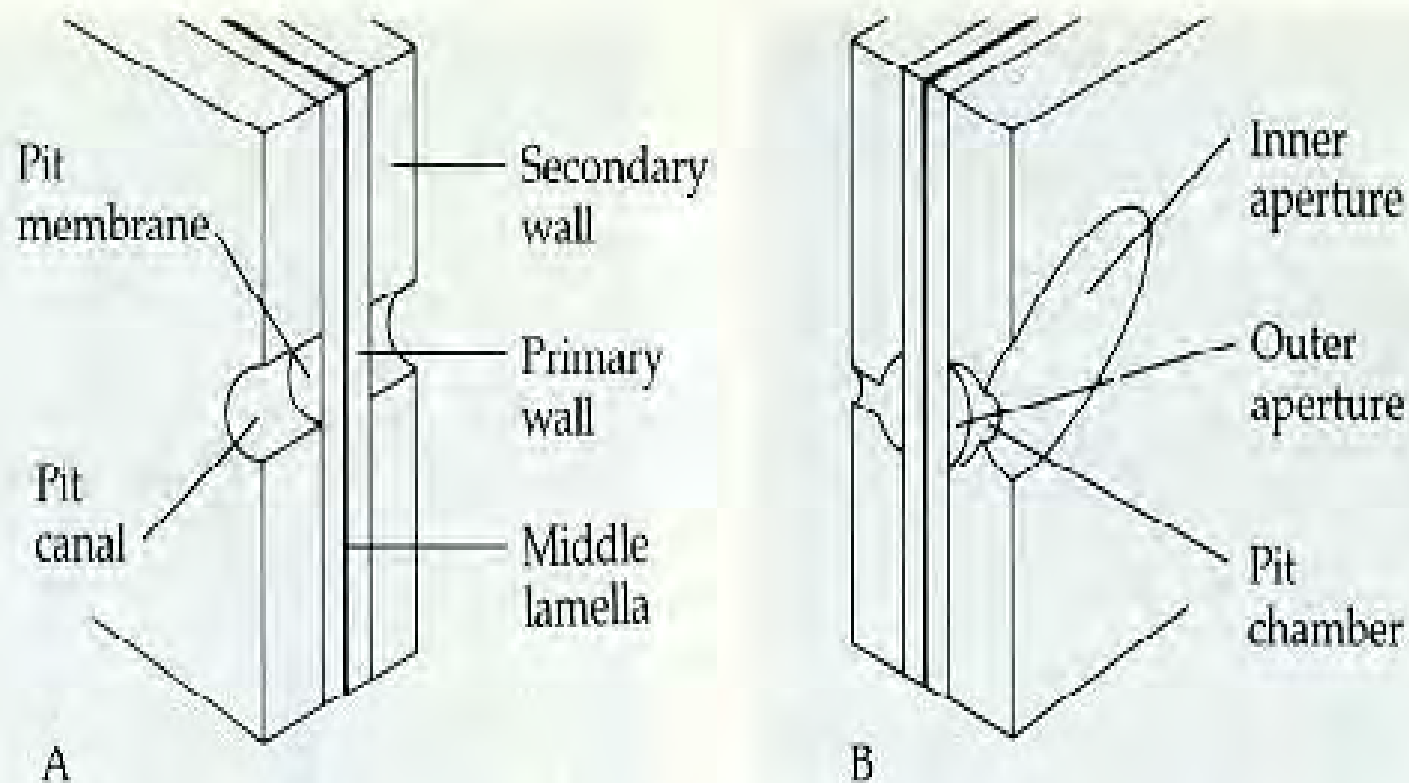


Figure 5.5

These diagrams show the structure of pits; in (A) is a pair of simple pits. These have been drawn with an intermediate depth, but they could have been deeper or shallower, narrower or wider. The significant feature is that the sides are more or less parallel to each other. The pit is merely the absence of secondary wall: initially the cell has only a primary wall, and pits are areas where no secondary wall is deposited. A slightly more complex pit is shown in (B): as the wall is deposited the aperture does not remain round but instead gradually shifts to oval.

RETÍCULO ENDOPLÁSMICO

Organelo en forma de red , localizado en el citosol u endoplasmo.

Está formado por túbulos , vesículas y cisternas; interconectado a la membrana nuclear y forma estructuras en forma de copa alrededor de los plastidios y mitocondrias.

Tiene dos fases: la RER o rugosa que se asocia a los ribosomas y se asocia al la síntesis de proteínas.

La RES o suave se asocia a la síntesis de lípidos.



Figura 1-10 Sección a través de dos células adyacentes de un fruto en desarrollo de bolsa de pastor (*Capsella*), con un extenso retículo endoplásmico (RE) rugoso en la célula superior. (Cortesía de Patricia Schulz.)



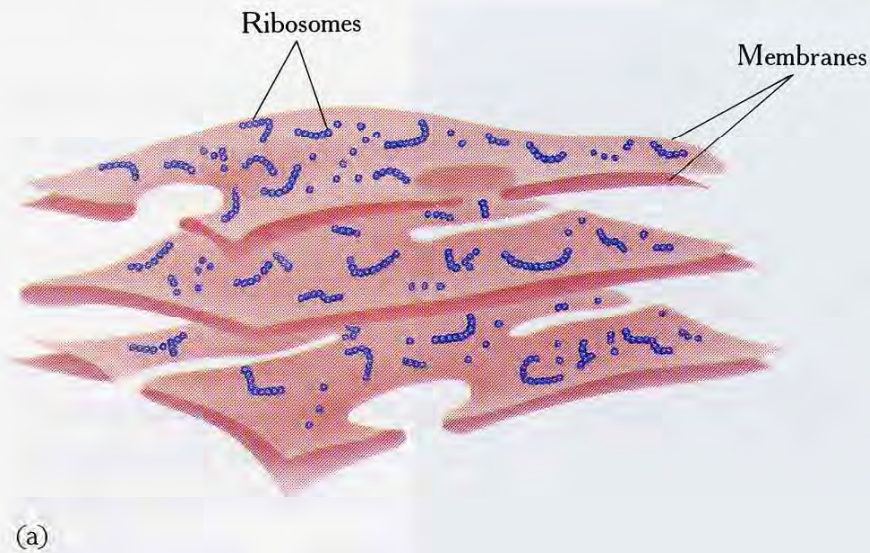
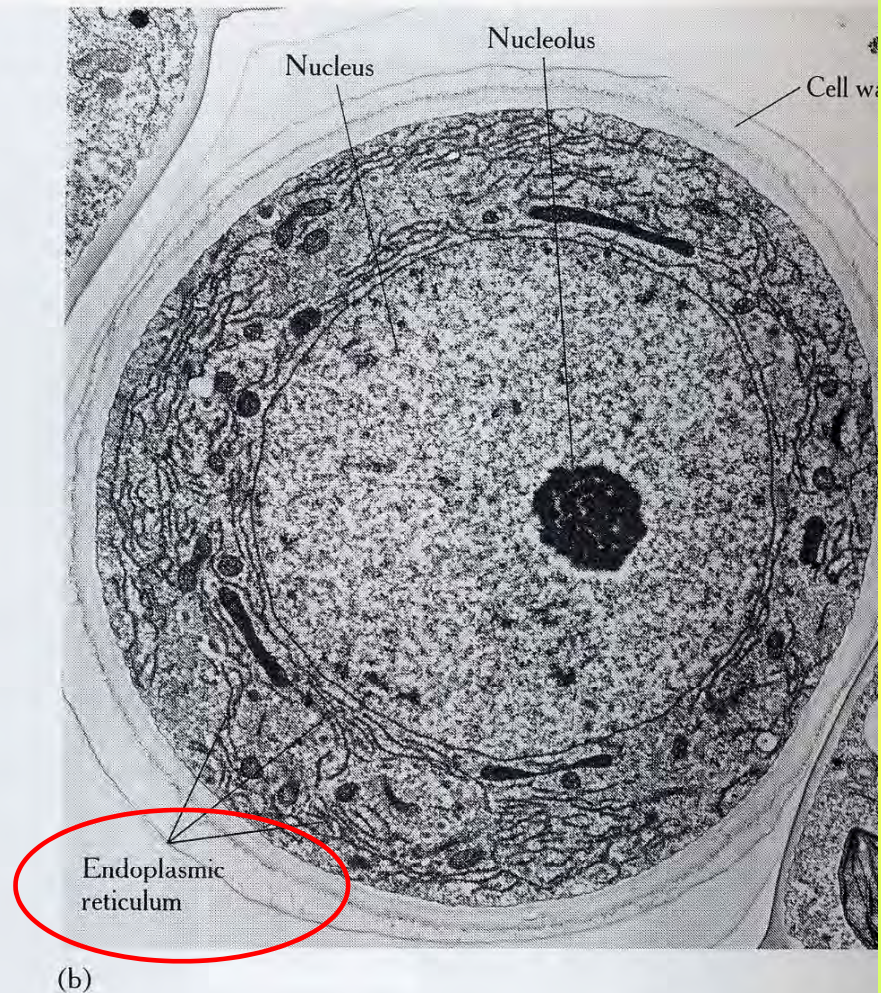


Figure 3.16

(a) Diagram showing location of ribosomes and membranes. (b) The electron micrograph is a cross section of a hair cell that secretes mucilage. The mucilage is synthesized in the endoplasmic reticulum, which is unusually abundant for a plant cell ($\times 3000$). (Courtesy of R. Fulginiti)

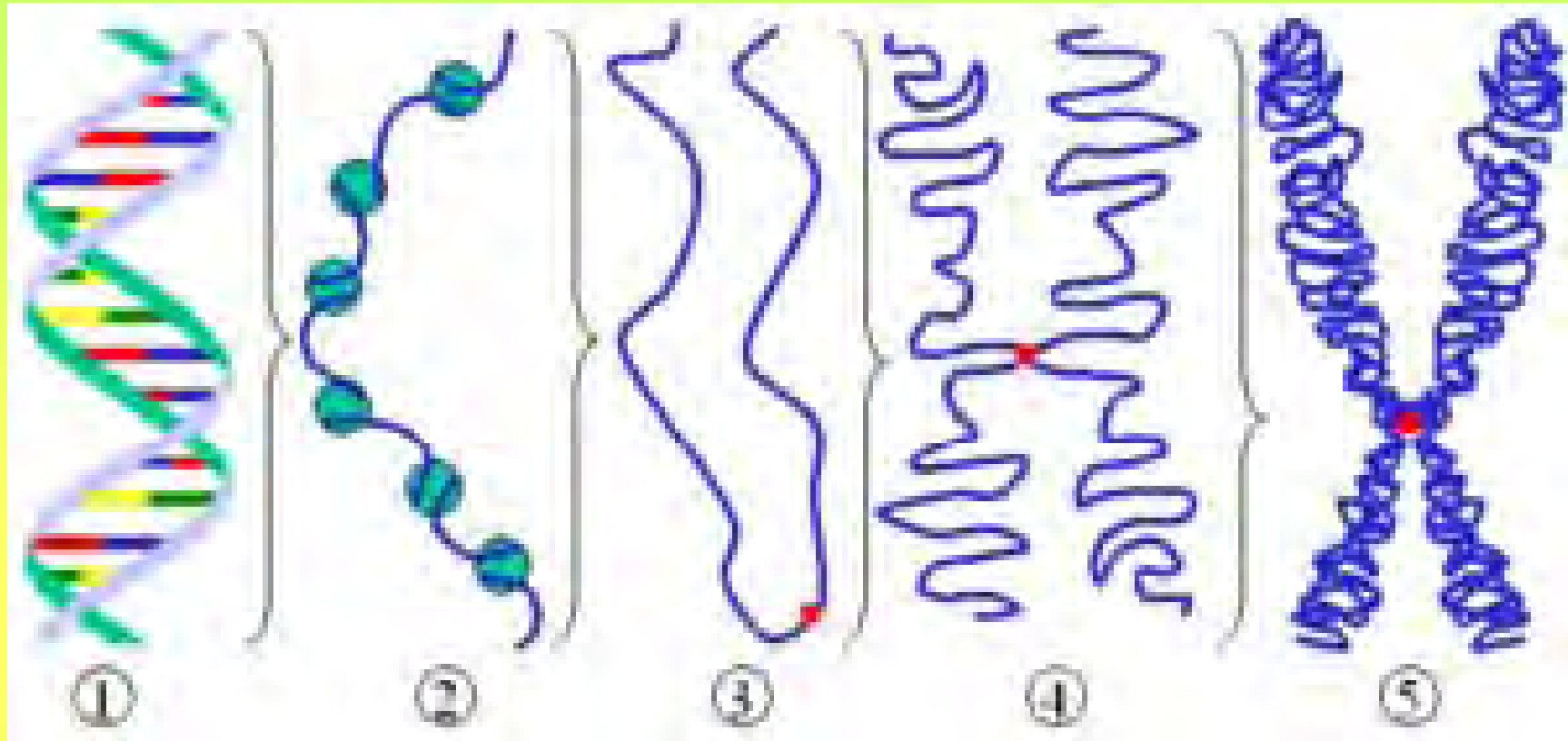


Núcleo

- Núcleo: lugar de almacenamiento de la información genética.
- Se “traducen” áreas específicas del ADN en forma de ARN mensajero.
- La membrana nuclear presenta poros, que participan en el transporte de materiales hacia afuera y hacia adentro del núcleo.
- El nucleoplasma es una asociación compleja de enzimas, proteínas (histonas y no histonas), ADN, ARN y agua.

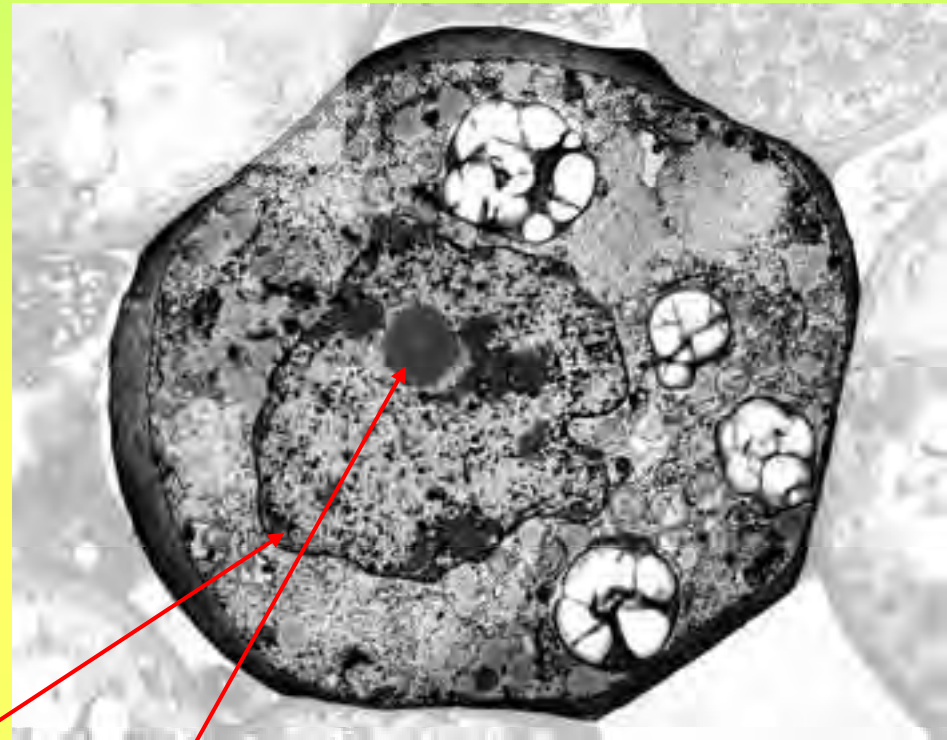
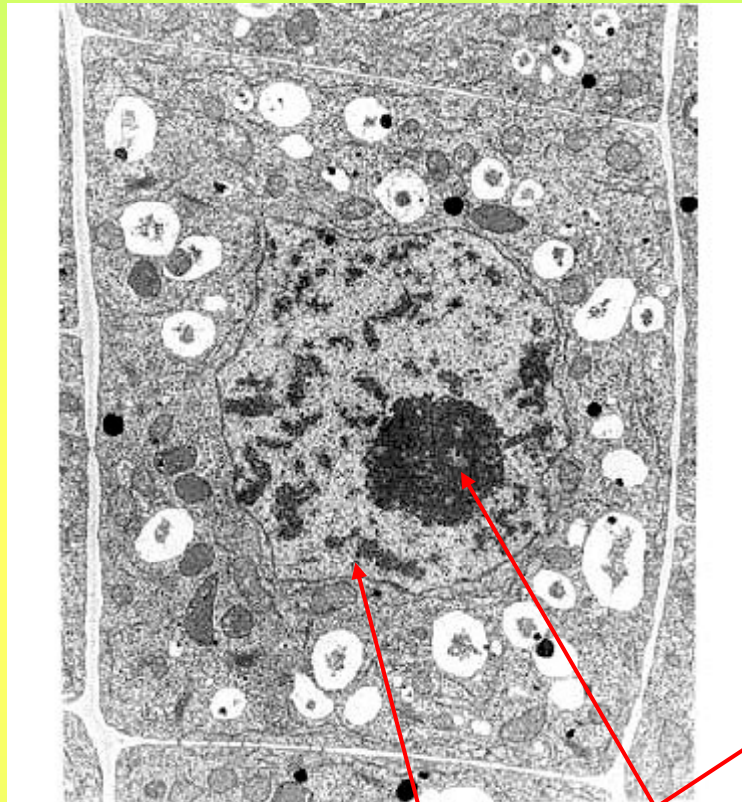
Nucleolo

- Sitio donde se sintetizan los componentes de los ribosomas y donde son parcialmente ensamblados.
- Pueden existir en números de 1, 2 ó varios.



Diferentes niveles de condensación de ADN.

- 1 Cadena simple de ADN.**
- 2 Cadena de cromatina (ADN con histonas, "cuenta de collar").**
- 3 Cromatina durante la interfase con centrómero.**
- 4 Cromatina condensada durante la profase (2 copias de ADN están presentes).**
- 5 Cromosoma durante la metafase.**



núcleo

nucleolo



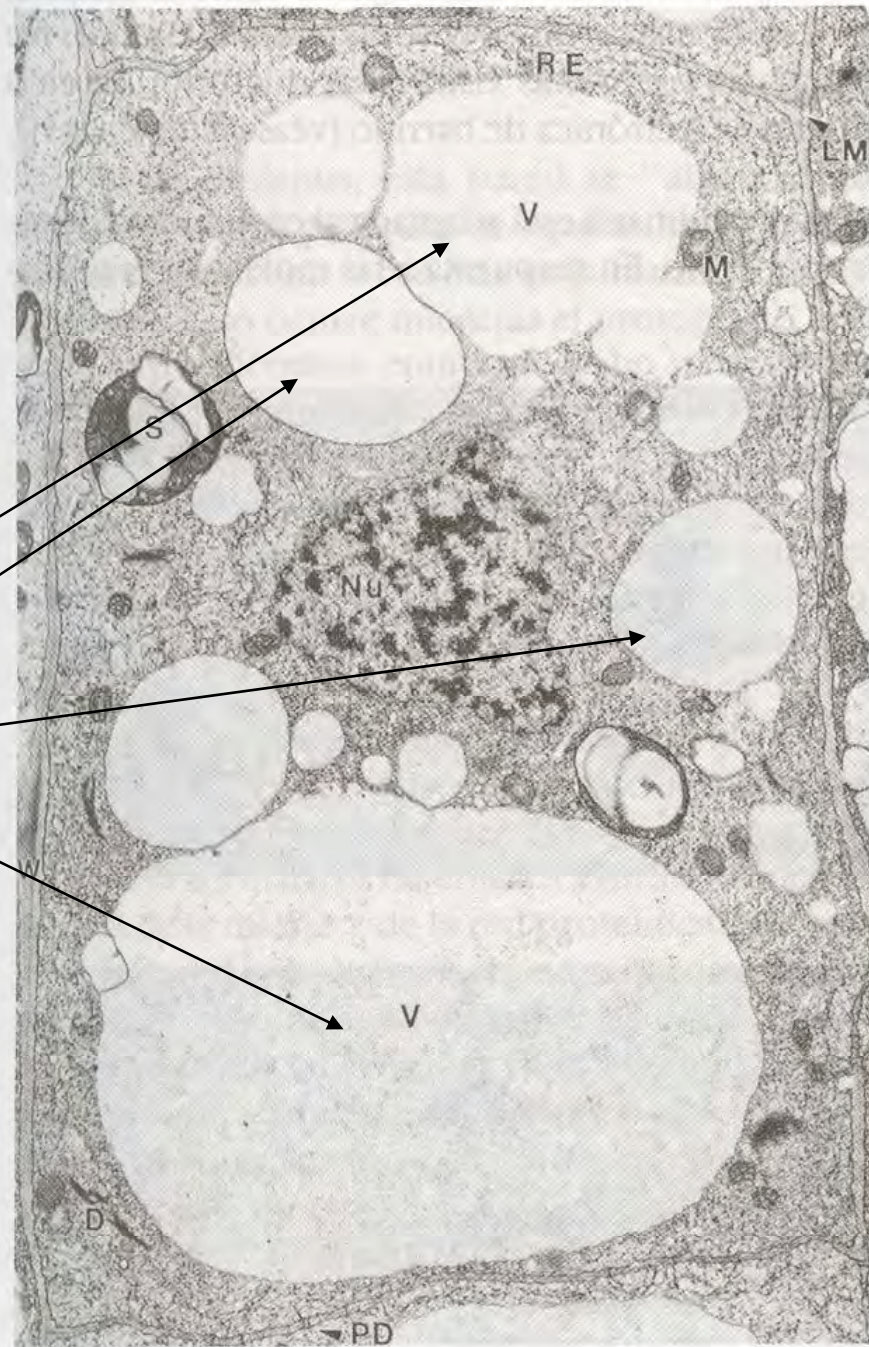
Figure 2.6

It is extremely common for the nucleus to be located near a wall like this, although they can sometimes be found suspended in the center of a cell. This nucleus contains patches of euchromatin (light color) and heterochromatin (dark color). The two membranes of the nuclear envelope are also visible, but the magnification is too low to show nuclear pores. Four plastids are present, and they are so undeveloped that they would be considered proplastids; three contain starch deposits. Mitochondria and endoplasmic reticulum are also visible. The walls between the two cells are extremely thin. $\times 750$.

VACUOLA

- Es el organelo más voluminoso de la célula vegetal.
- La membrana vacuolar se denomina tonoplasto
- La función vacuolar es regular el potencial hídrico de la célula (presión de turgencia) y el almacenamiento de ciertas sustancias.
- Algunas vacuolas actúan como lisosomas, digiriendo y renovando sustancias en el citosol.

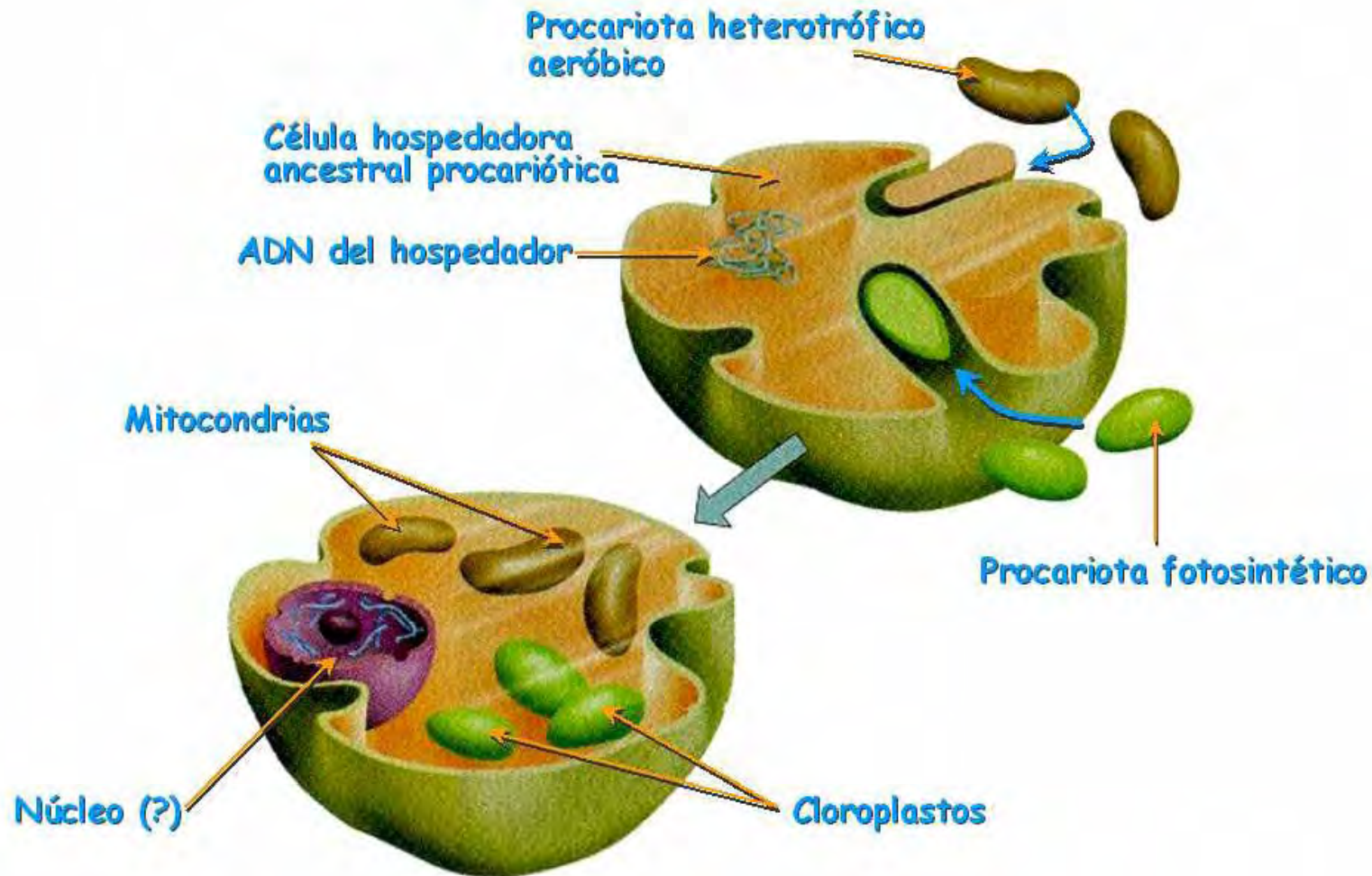
vacuolas



c



organelos con ADN, su posible origen



Teoría endosimbiótica sobre el origen de las mitocondrias y de los cloroplastos

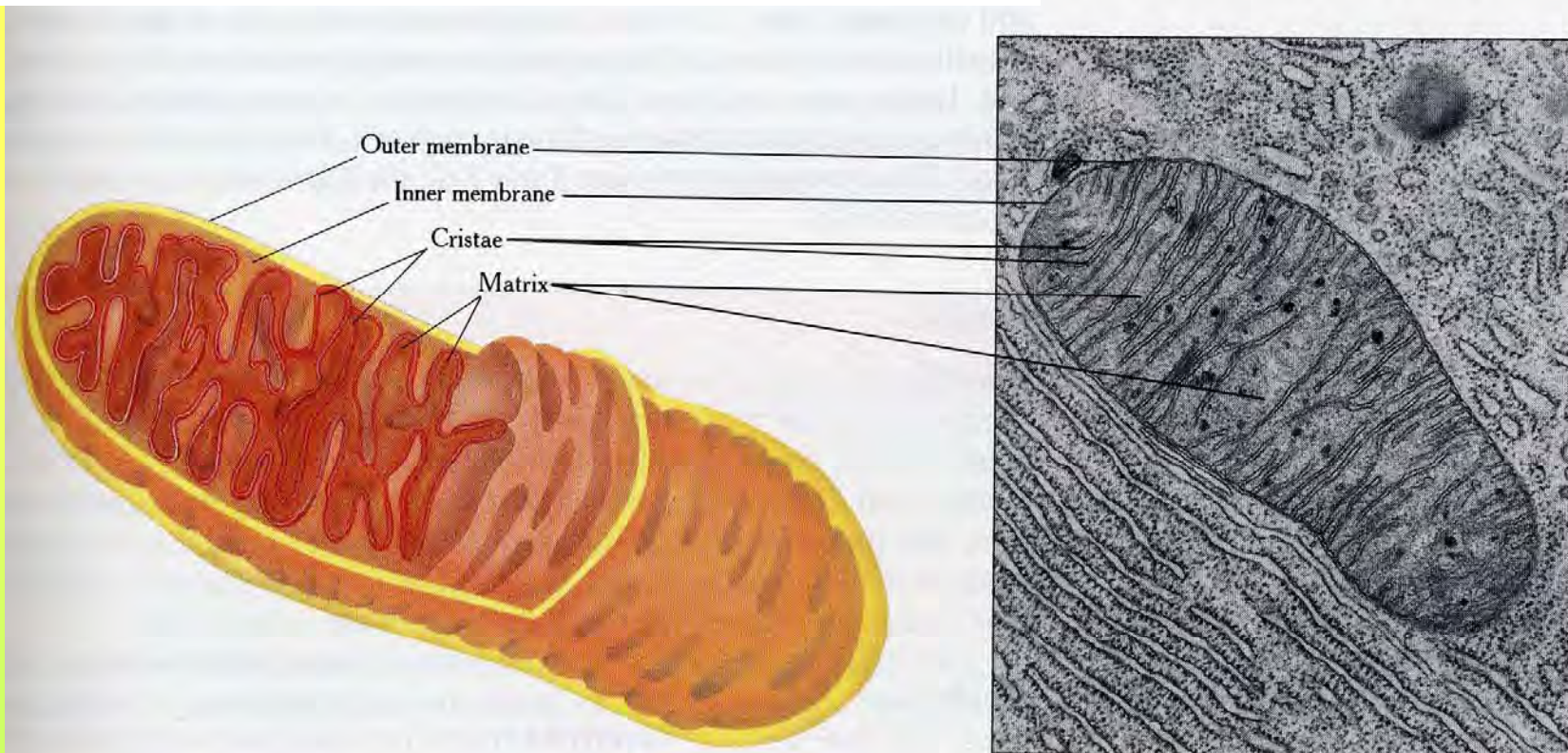
Mitocondria:

Organelo responsable de la respiración aeróbica. Es el más abundante en las células vegetales.

Posee doble membrana y ADN autónomo. En este se lleva a cabo el ciclo de Krebs. En una sola célula pueden encontrarse de 200 a 3000.

Figure 3.12

The inner mitochondrial membrane is folded into platelike cristae, giving it a large surface area; many respiratory enzymes are intrinsic proteins embedded in the cristae membrane. The large surface area makes it possible to contain many copies of each enzyme, and more reactions can occur simultaneously.



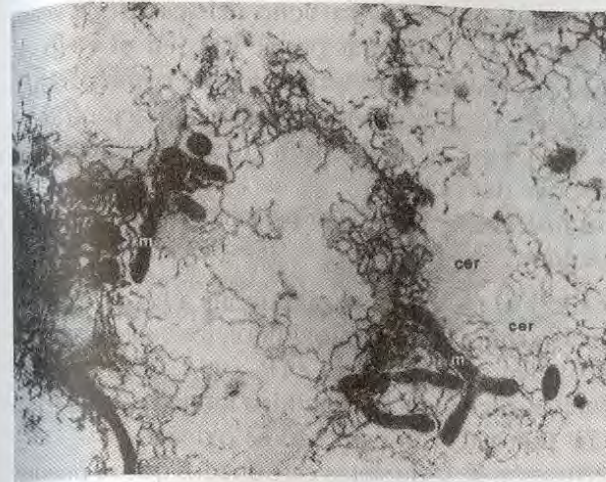


Figura 13-7 Diversas vistas de mitocondrias. **(a)** Micrografía electrónica de transmisión a alto voltaje de mitocondrias polimorfas en células de cotiledón de alubia (*Vigna radiata*). **(b)** Micrografía electrónica de transmisión de mitocondrias vegetales aisladas. Las crestas aparecen como áreas claras, mientras que la matriz corresponde a las regiones oscuras. (Tomado de Smith, 1977; fotografía cortesía de W. D. Bonner, Jr.) **(c)** Interpretación esquemática de una mitocondria aislada. (Modificado de Malone *et al.*, 1974.)

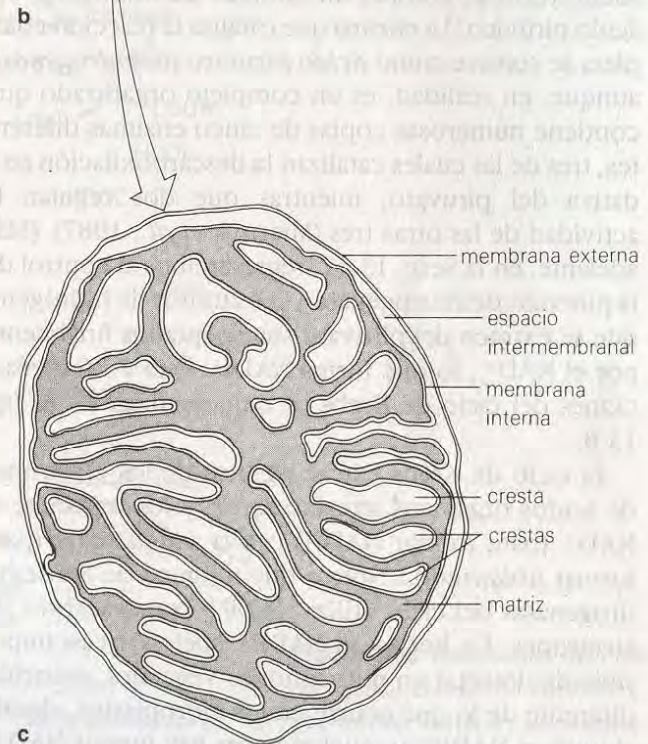
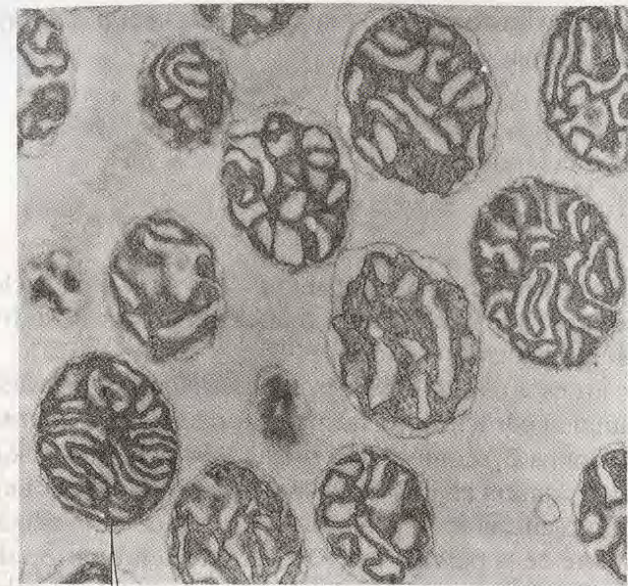




Figure 2.2

This is a parenchyma cell of *Echinocereus engelmannii*; the nucleus dominates this section of the photograph. Several small chloroplasts are visible, as are vacuoles and mitochondria. The cell walls are prominent, and plasmodesmata can be seen. $\times 1000$.

Plastidios

Son organelos muy dinámicos. Tienen doble membrana y ADN autónomo. Todas las células vegetales tienen plastidios ; las células embrionarias PROPLASTIDIOS.

- CLOROPLASTOS son los plastidios más importantes al ser fotosintéticos.

PLASTIDIOS de almacenamiento de sustancias son:

AMILOPLASTOS- almidón

ELAIOPLASTOS- lípidos

CROMOPLASTOS- pigmentos varios (betalaína, carotenoides)

Las plantas etioladas poseen ETIOPLASTOS, que tienen la estructura parecida a un cloroplasto pero sin clorofila y sí algo de carotenoides

CLOROPLASTO

Tiene doble membrana y ADN autónomo

Pigmentos: clorofila a, clorofila b, carotenos, xantofilas

Fase amorfa se denomina estroma, con enzimas que convierten el CO₂ en carbohidratos. FASE OSCURA O CICLO DE CALVIN

Fase sólida se denomina tilacoides, que forma una red de canales y apilamientos de granos (grana), donde están los pigmentos fotosintéticos. FASE LUMINOSA. Aquí se lleva la oxidación del agua y la obtención de ATP y NADPH.

CLOROPLASTOS



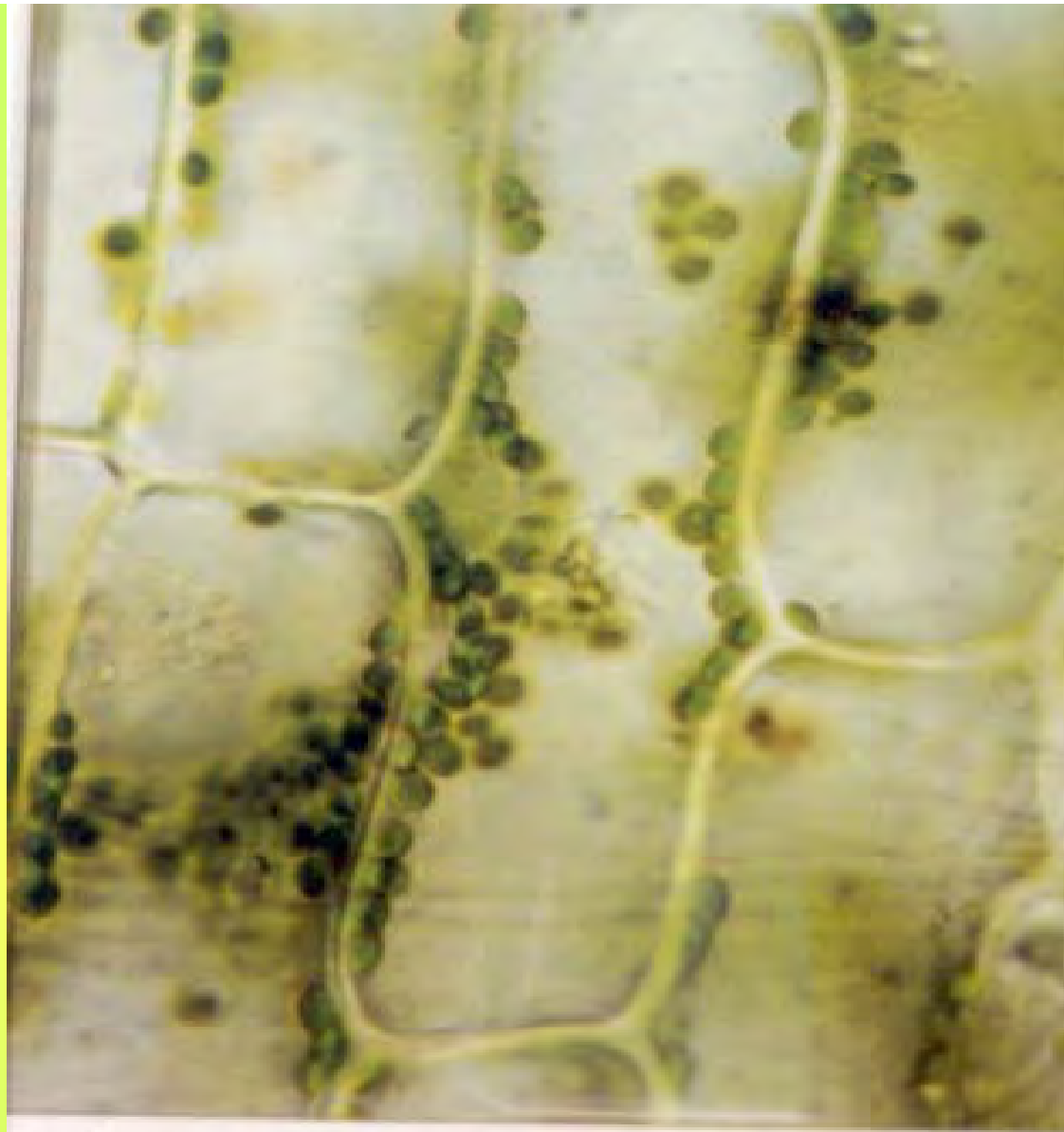


FIGURE 32-11 Some parenchyma cells contain chloroplasts. The primary function of these cells is photosynthesis.

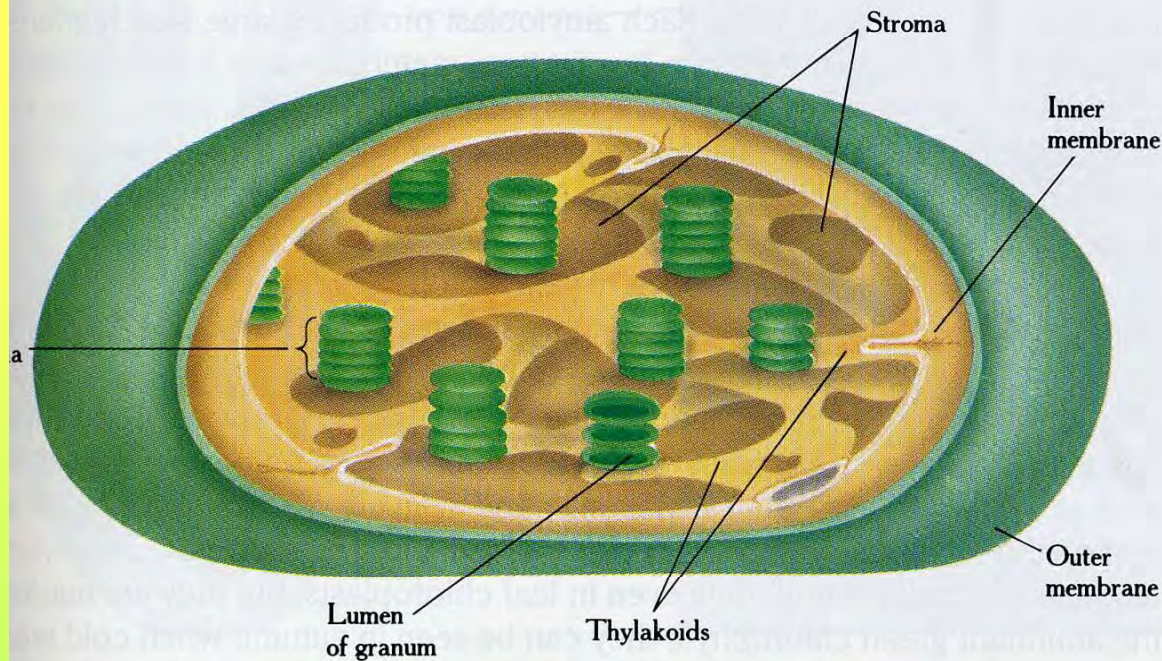
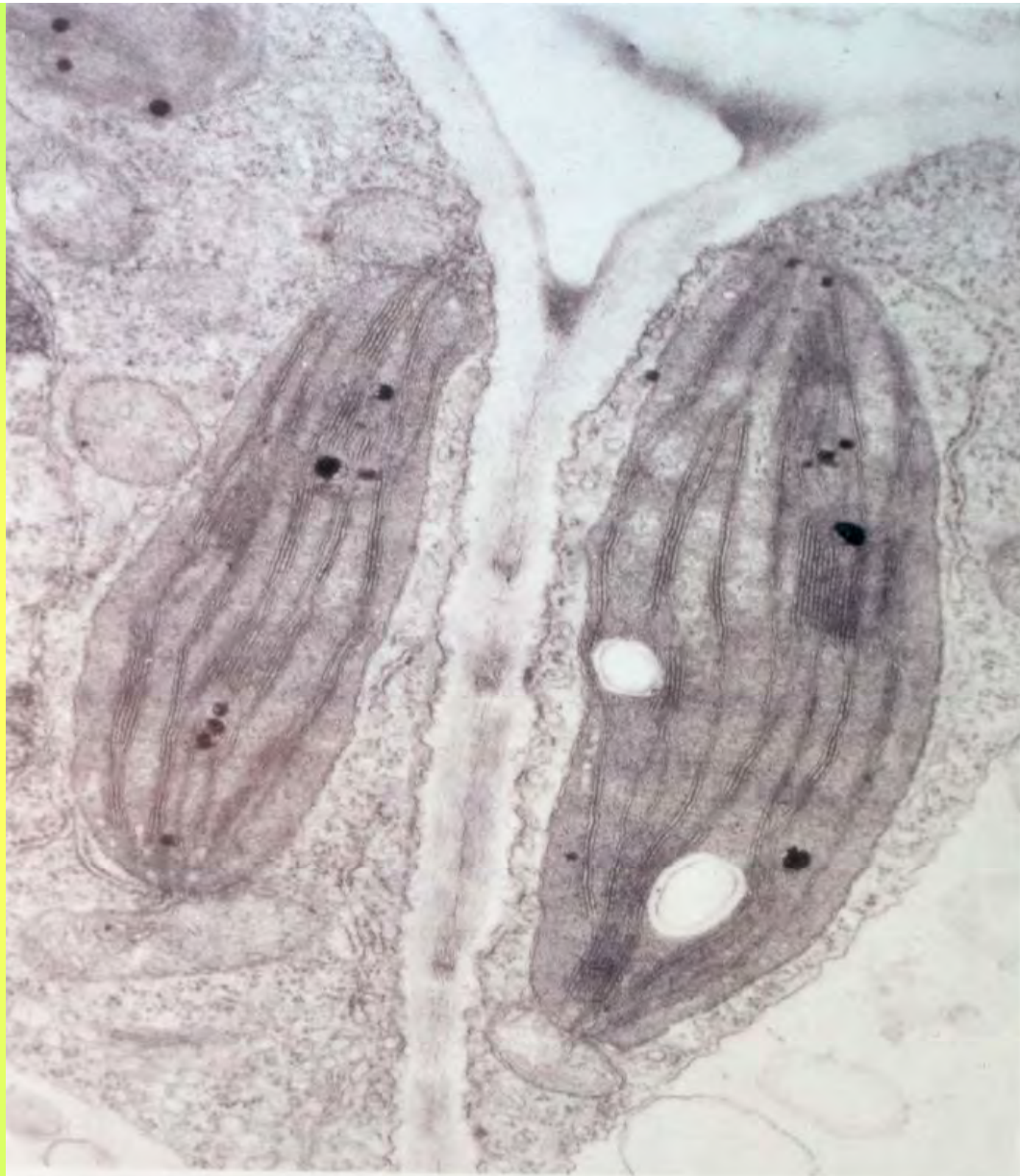


Figure 3.14

(a) All plastids have an outer and an inner membrane, but in chloroplasts the inner membrane is extensive and highly folded. The single membranes are thylakoids, and the multiple membranes are actually stacks of flattened vesicles, the grana. Like mitochondrial cristae, the extra surface area of the inner membrane provides room for many copies of each enzyme. The photosynthetic pigment chlorophyll is part of the membrane lipid layer (approx. $\times 30,000$). (Courtesy of E.T. Weir) (b) Each granum is part of a thylakoid.



Magnified 36,800 times their actual size, two chloroplasts are separated by the walls of adjacent cells. Each chloroplast contains long, parallel, membranous structures connecting short membrane stacks, called grana. Chlorophyll and other pigments are concentrated in the grana. The right-hand chloroplast contains two starch bodies (light areas). The oval and elongated organelles, near the chloroplasts, are mitochondria—sites of cellular respiration. At bottom right, a portion of the cell's vacuole.



Figure 2.9

One of the easiest tests to be certain that particles such as those in Figure 2.8 are really starch is to view them with polarized light. Starch will always appear bright with a dark cross. Notice that these are the same cells and amyloplasts as in Figure 2.8. $\times 100$.

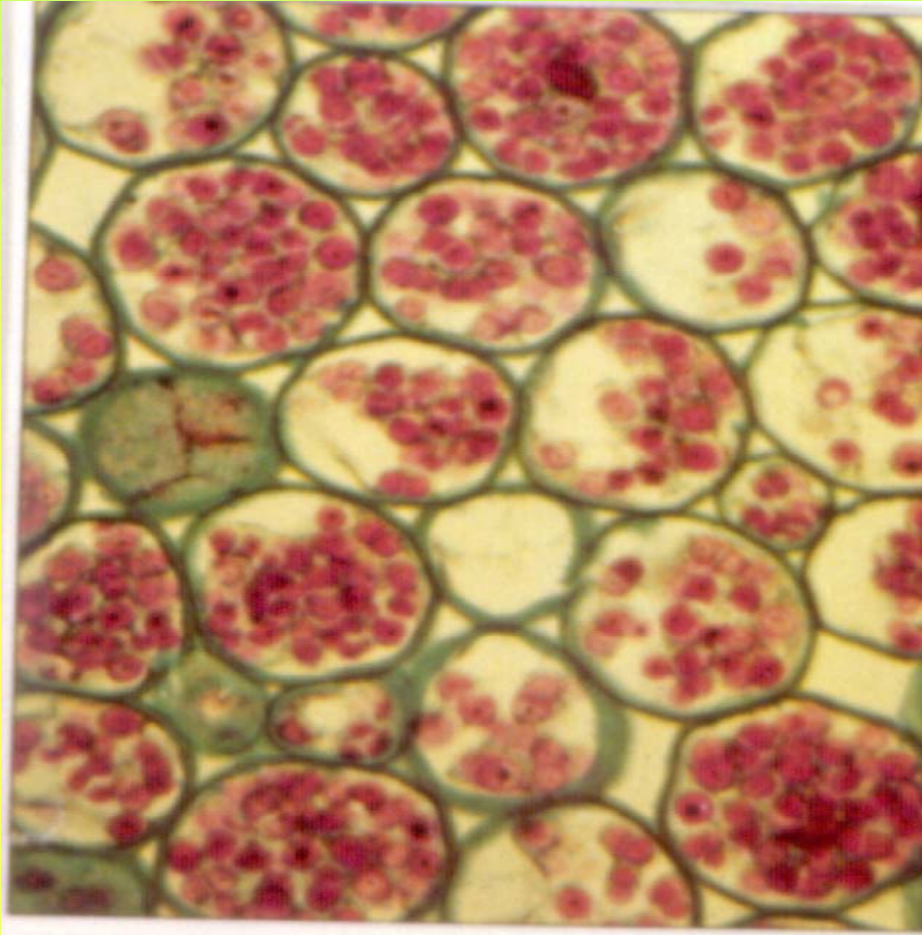
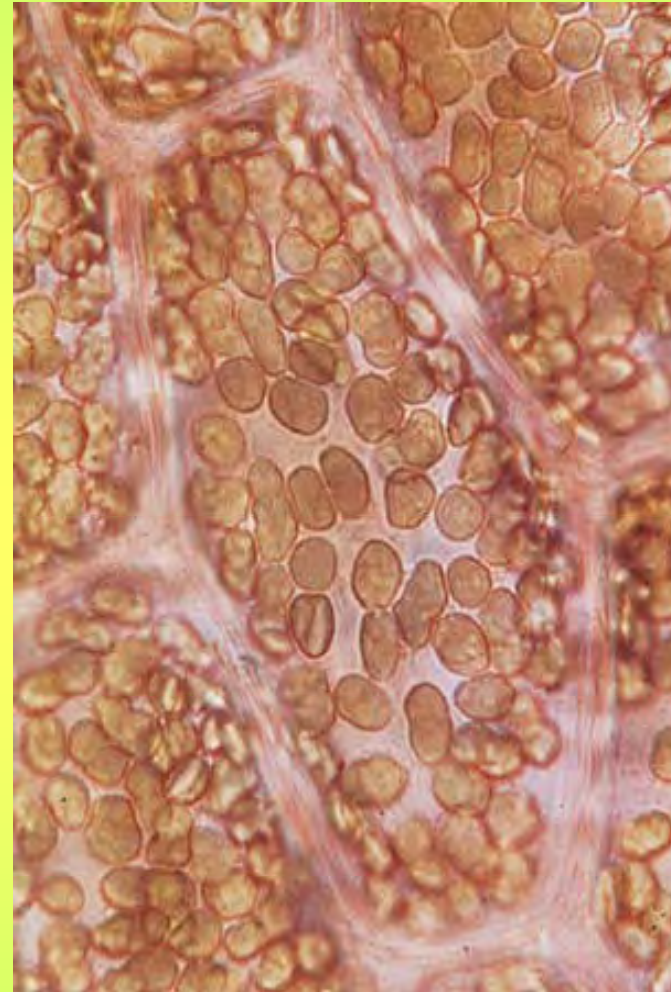
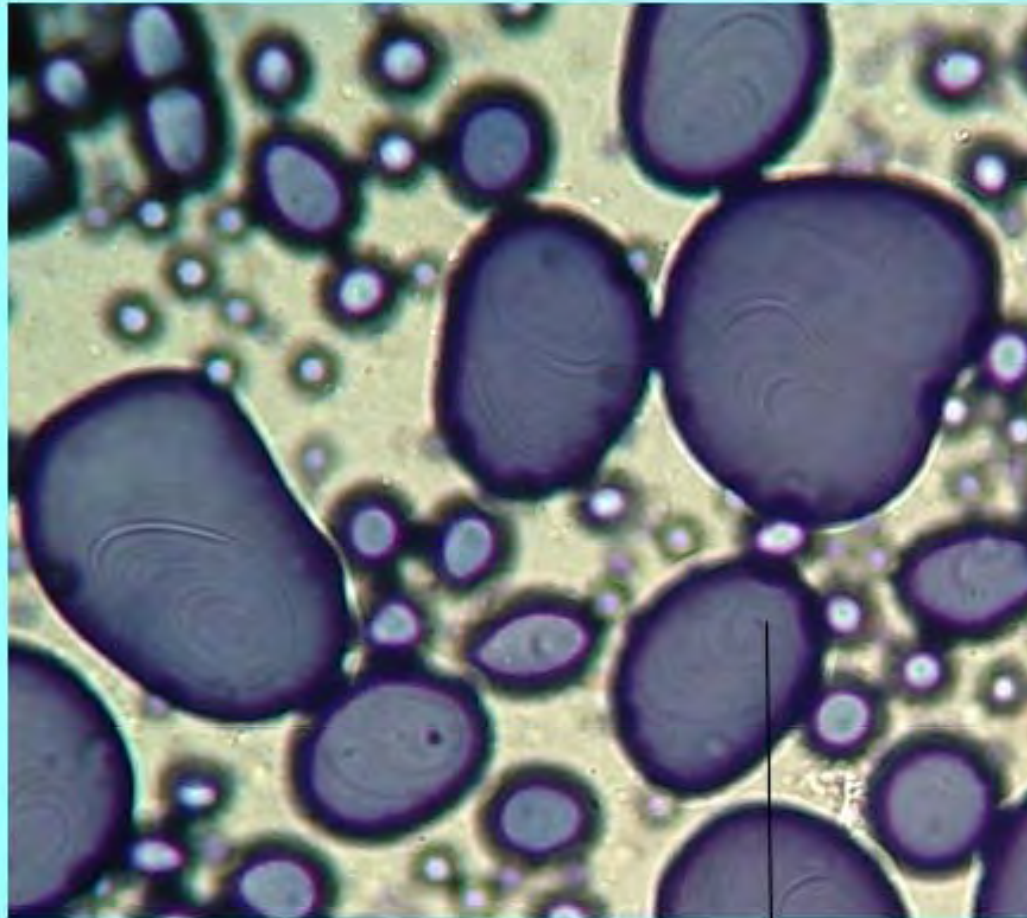


FIGURE 32-12 Parenchyma cells often function in storage. These parenchyma cells are from the cortex of a *Ranunculus* root. Note the starch grains filling the cells.



Amiloplastos o leucoplastos



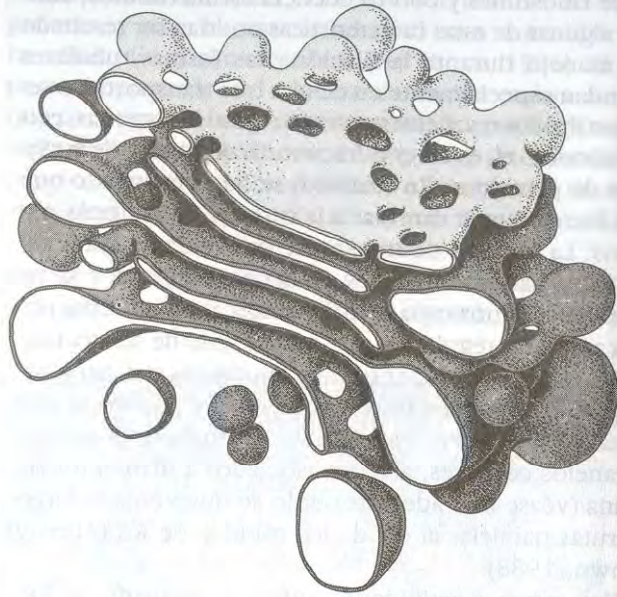
Hilo excéntrico

DICTIOSOMAS

Son organelos en forma de vesículas, algunas veces derivado del retículo endoplásmico.

Su función es la secreción de carbohidratos, mucílago o complejos de glicoproteínas.

Este organelo es equivalente al complejo o aparato de Golgi, con la diferencia que en las células animales son agrupaciones de vesículas y en plantas son solitarias aunque a veces intercomunicados por túbulos.



b



Figura 1-13 Micrografía electrónica de una célula apical de raíz, en la que se aprecian fusión de productos de secreción (P) y dictiosomas comprimidos (D). También se ven la membrana y la pared celulares (PC). (De D. J. Morré *et al.*, 1967.)

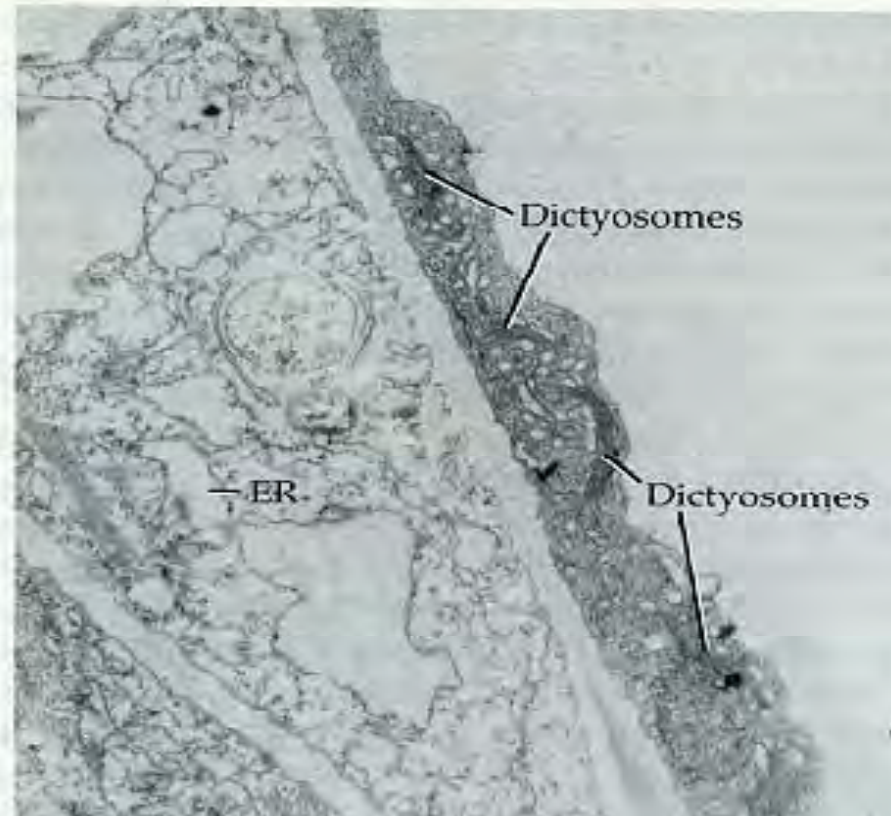


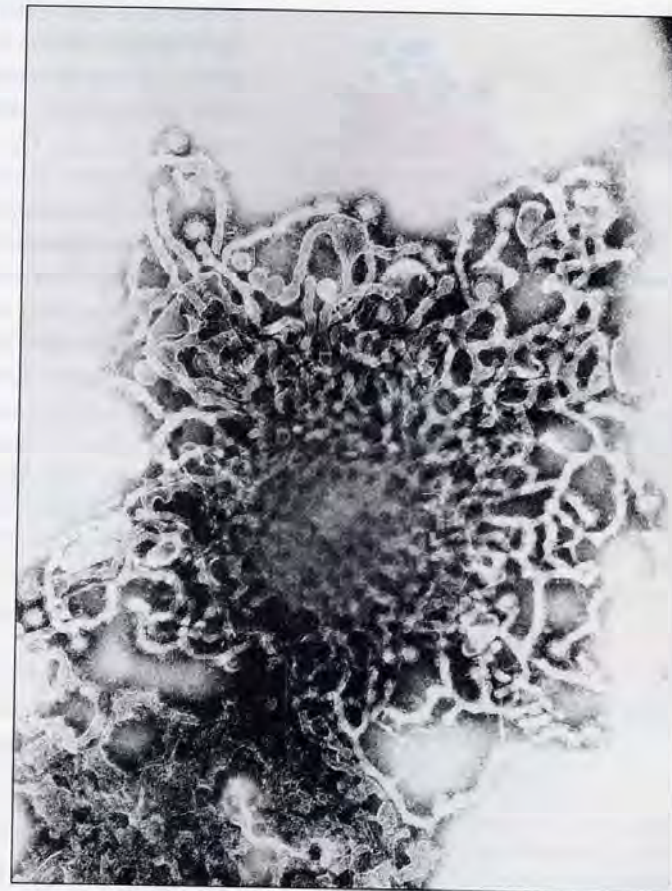
Figure 2.10

These three cells were beginning to differentiate as fiber cells when they were fixed; the predominant activities would have been elongation of the cell and the deposition of extremely thick walls. In one cell, four prominent dictyosomes are visible; the vesicles that they were producing were carrying material for wall construction. In the middle cell, there are numerous irregular vesicles interconnected by short tubes; these are all part of the endoplasmic reticulum (ER). $\times 1000$.



Figure 3.17

(a) Dictyosomes are stacks of flattened vesicles; the edges form a network of tubules and small vesicles. (b) With rapid dictyosome activity, as in these mucilage-secreting cells, the cytoplasm may almost fill with dictyosome vesicles, and fusion of vesicles with the plasma membrane is so abundant that the plasma membrane appears scalloped ($\times 12,000$). (c) Face view of dictyosome isolated from a plant cell; the network of peripheral tubules is visible ($\times 60,000$). (b and c courtesy of H. Mollenhauer)



(c)

Citoesqueleto

El Citoesqueleto está constituido por proteínas del citoplasma que polimerizan en estructuras filamentosas.

Este es responsable de la forma de la célula y del movimiento de la célula en su conjunto y del movimiento de orgánulos en el citoplasma.

Se subdividen en microtúbulos y filamentos intermedios.

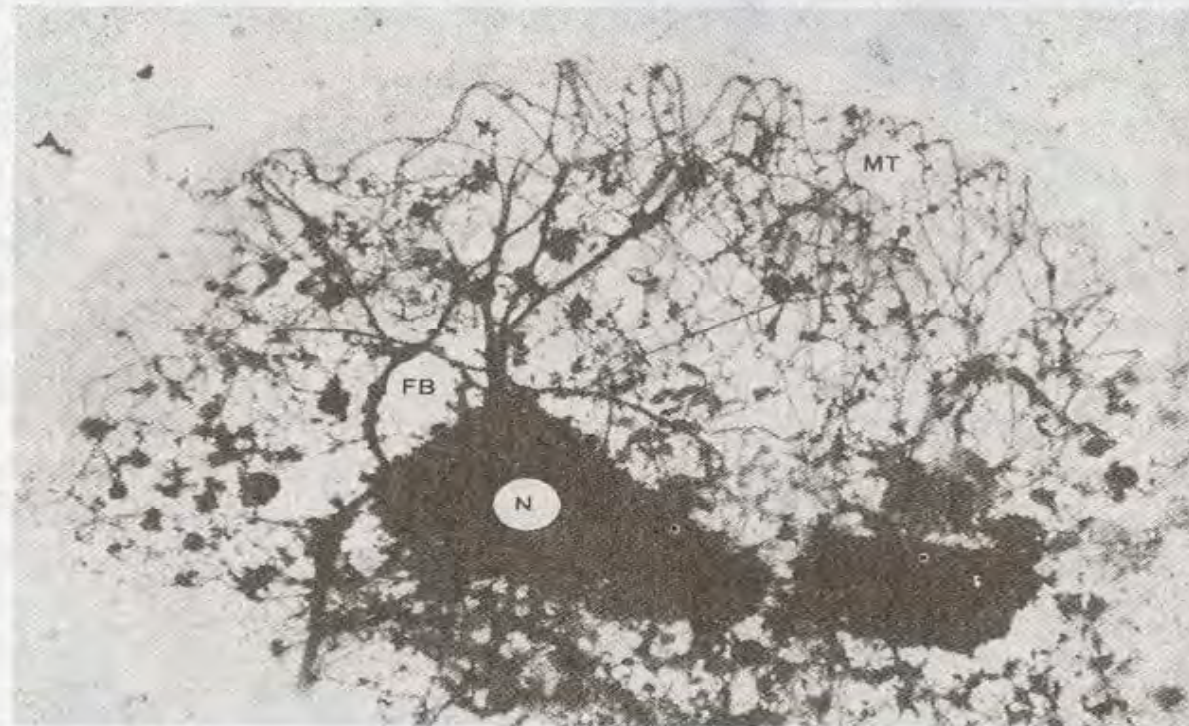
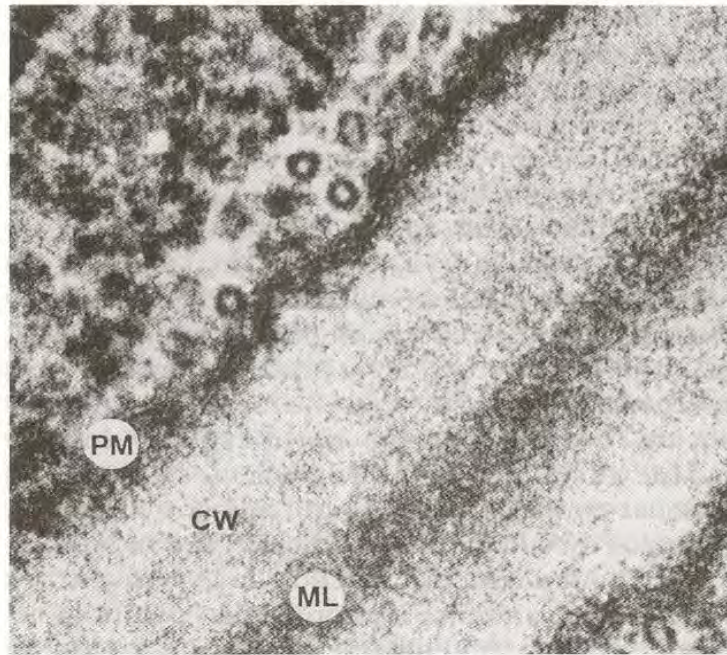
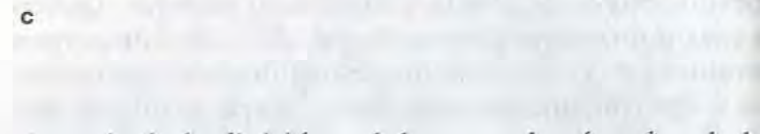
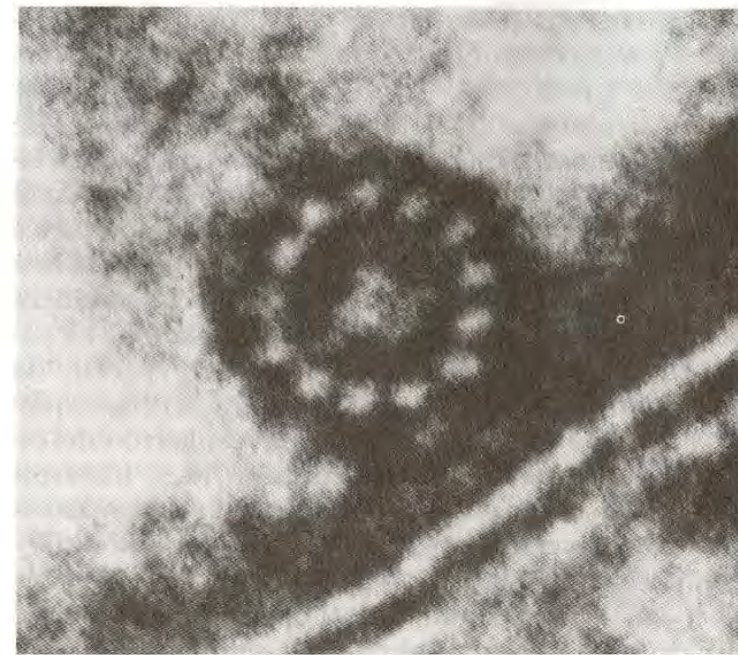


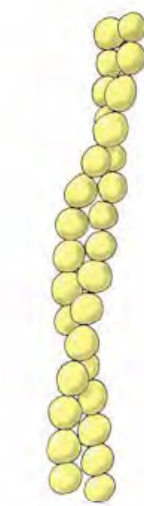
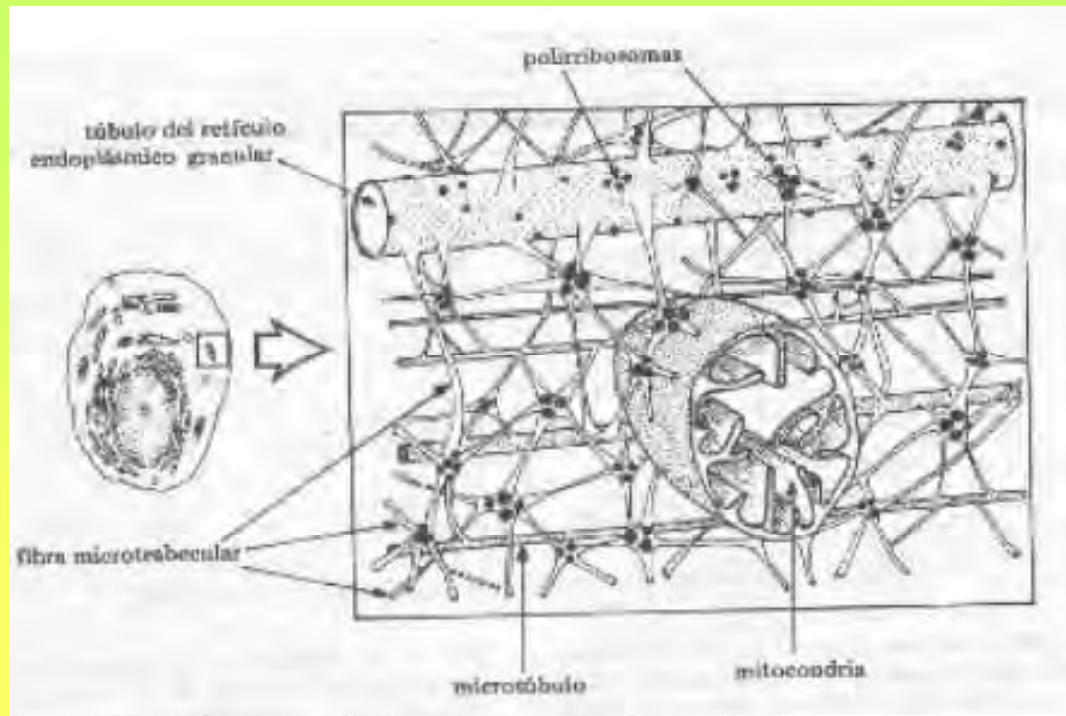
Figura 1-14 Preparación completa de citoesqueleto, con tinción negativa, de protoplasto de célula de zanahoria cultivado en suspensión. Cuando estas células se extraen en solución amortiguada isoosmótica estabilizadora de los microtúbulos que contiene detergente, permanece la parte citoesquelética, que es insoluble en el detergente. Con la tinción negativa se observa que los citoesqueletos están compuestos de microtúbulos corticales (MT), vistos como asas bajo la periferia celular, y de haces de fibrillas (FB) de 7 nm, que parecen unirse al núcleo (N) y a la corteza celulares. Se descubrió que este último elemento citoesquelético no está compuesto de la proteína *actina*. (Micrografía cortesía de Clive Lloyd; véase Powell *et al.*, 1982.)



Los microtúbulos están constituidos por dímeros de tubulina. Son unos polímeros que tienen forma cilíndrica y que están huecos, como una tubería.

Así es que la sección transversal del microtúbulo es circular y tubular cuando se cortan longitudinalmente.

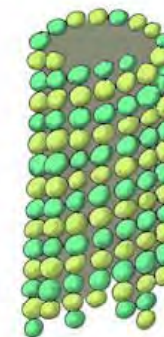




Microfilamento



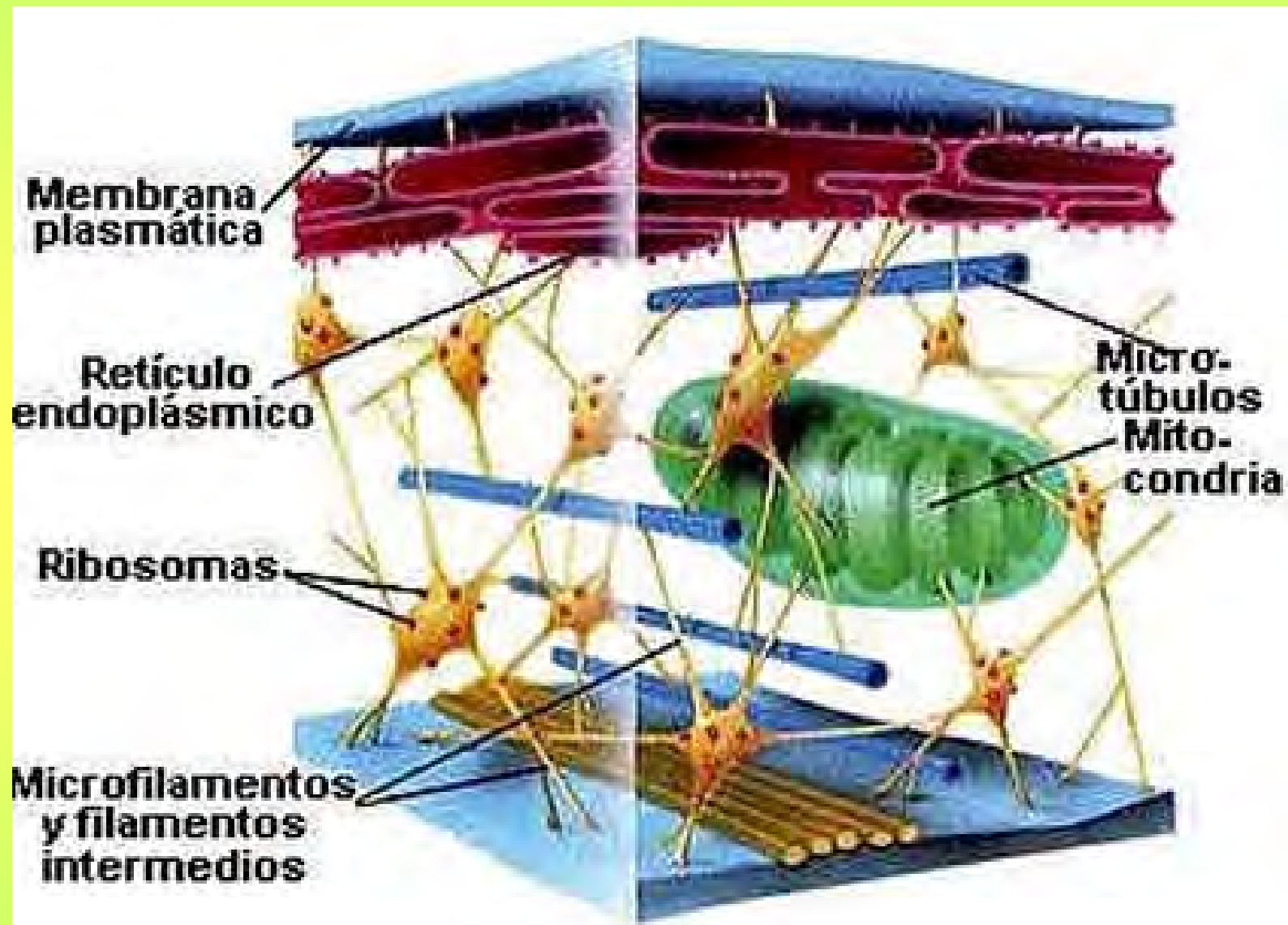
Filamento intermedio



Microtúbulo



Tubulina



Corpúsculos o microcuerpos

Existen al menos de dos tipos:

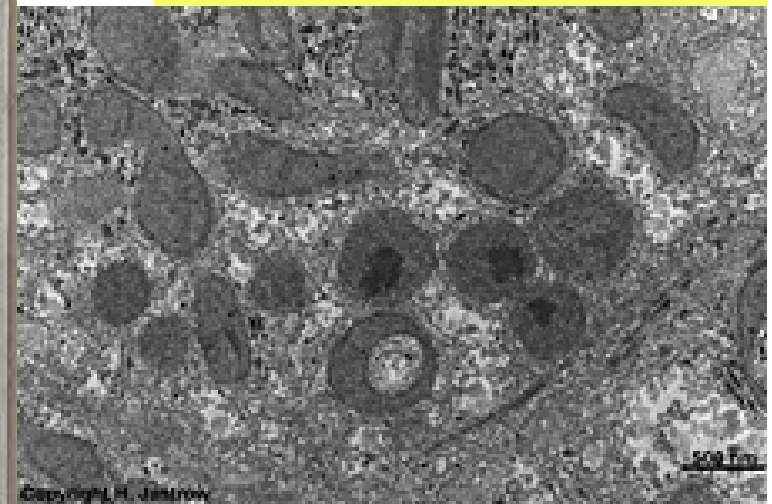
PEROXISOMAS- Asociados a los cloroplastos y en estos se acumula el ácido glicólico que se oxida con peróxido durante la fotorrespiración.

GLIOXISOMAS- Corpúsculos en los que se acumula AcetilCoA producida durante la movilización de las reservas de lípidos, especialmente en la germinación de semillas oleaginosas.

peroxisoma



Figura 11-8 Asociación estrecha de cloroplastos, peroxisomas (P) y mitocondrias (M) en una célula foliar. La matriz, de apariencia cristalina en estos peroxisomas, se debe a la enzima catalasa, aunque muchos peroxisomas que contienen catalasa no presentan esta matriz. (Cortesía de Eugene Vigil.)



Glioxisoma:

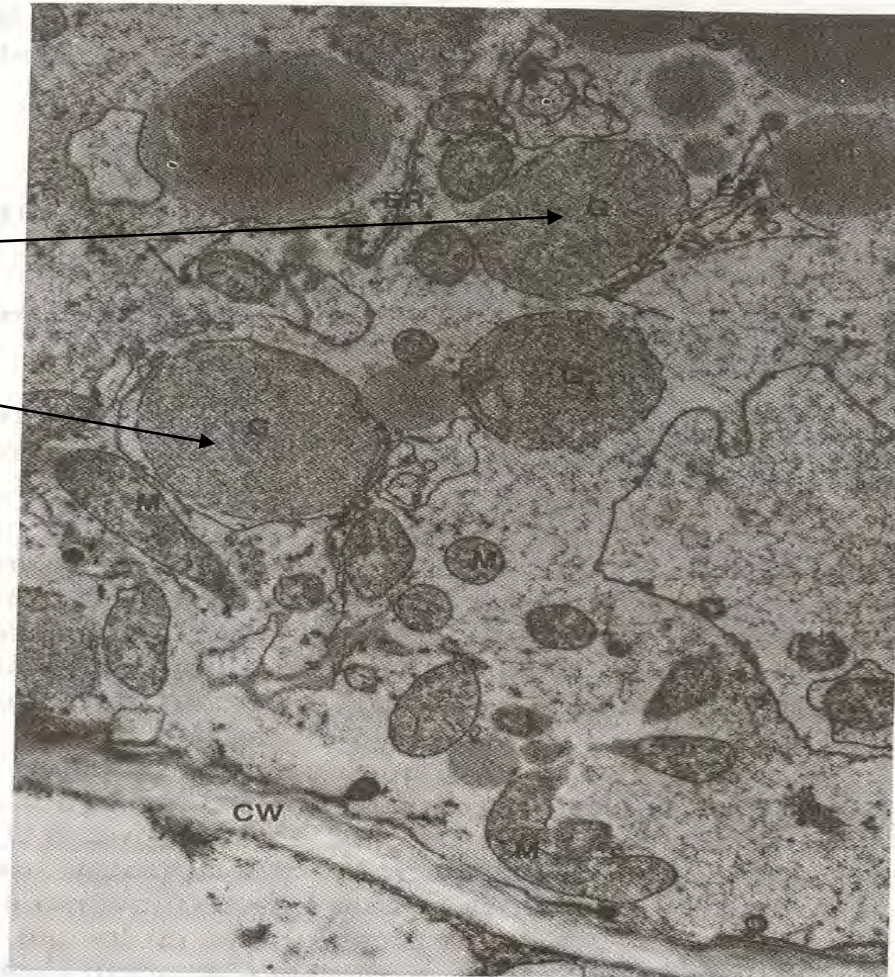


Figura 15-3 Parte de una célula acumuladora de grasa en el megagametofito de una semilla de pino ponderosa con siete días de germinación; pueden apreciarse glioxisomas (G), oleosomas para almacenamiento de grasa (O), retículo endoplásmico (ER) y mitocondrias (M). La mayor parte de la grasa se ha transformado en azúcares. Algunos de los glioxisomas parecen estar conectados al retículo endoplásmico, del que se originan; nótese la flecha. (Tomado de Ching, 1970.)

ORGANELOS SIN MEMBRANAS, CUERPOS Ó SUSTANCIAS ERGÁSTICAS:

Se refiere a todas aquellas sustancias que están en forma de cristales o englobadas en vacuolas u otros organelos dentro de la célula vegetal.

Almidón: en amiloplastos y cloroplastos.

Lípidos: en los elaeoplastos (oleoplastos)

Taninos: en vacuolas de células especializadas o idioblastos.

Cristales: con formas geométricas: drusas, rafidios, estiloides

Cuerpos silíceos y stegmata: depósito de dióxido de silicio.

Cuerpos proteicos y mucilaginosos: depósitos amorfos

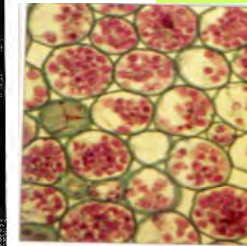
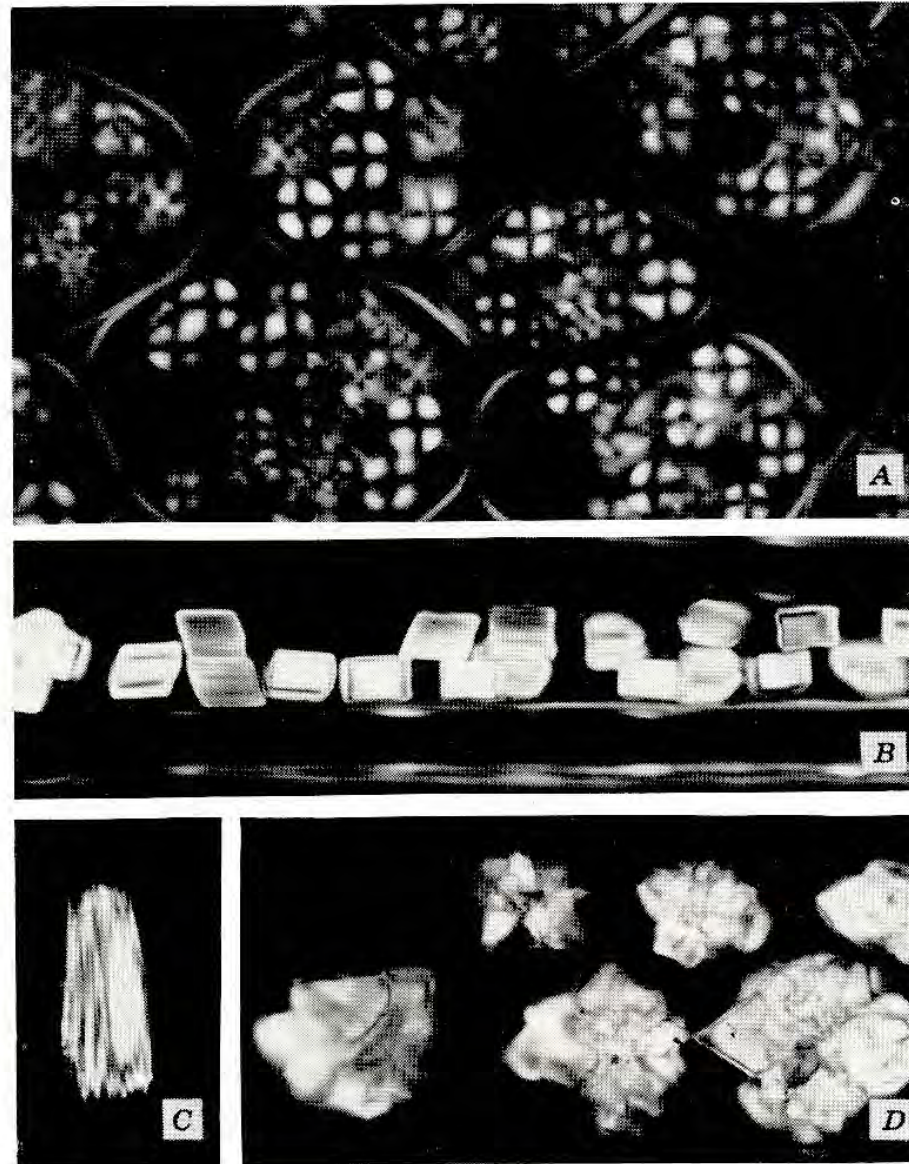


FIGURE 32-12 Parenchyma cells often function in storage. These parenchyma cells are from the cortex of a *Ranunculus* root. Note the starch grains filling the cells.

Lámina 6. Cuerpos ergásticos birrefringentes vistos con luz polarizada. A, granos de almidón en células de una raíz de *Convolvulus*, mostrando la característica cruz oscura. B, cristales prismáticos en el parénquima del floema de una raíz de *Abies*. C, rafidios de la hoja de *Vitis*. D, drusas en el córtex del tallo de *Tilia*. En A y B se observa también la doble refracción de las membranas celulares.
(A, C y D, $\times 750$; B, $\times 500$.)



Figura 13-1 Micrografía electrónica de barrido de gránulos de almidón en amiloplastos de una célula parenquimatosa en un tallo de arroz. Muchos de los amiloplastos en estas células contienen cuatro gránulos de almidón. (Cortesía de P. Dayanandan.)

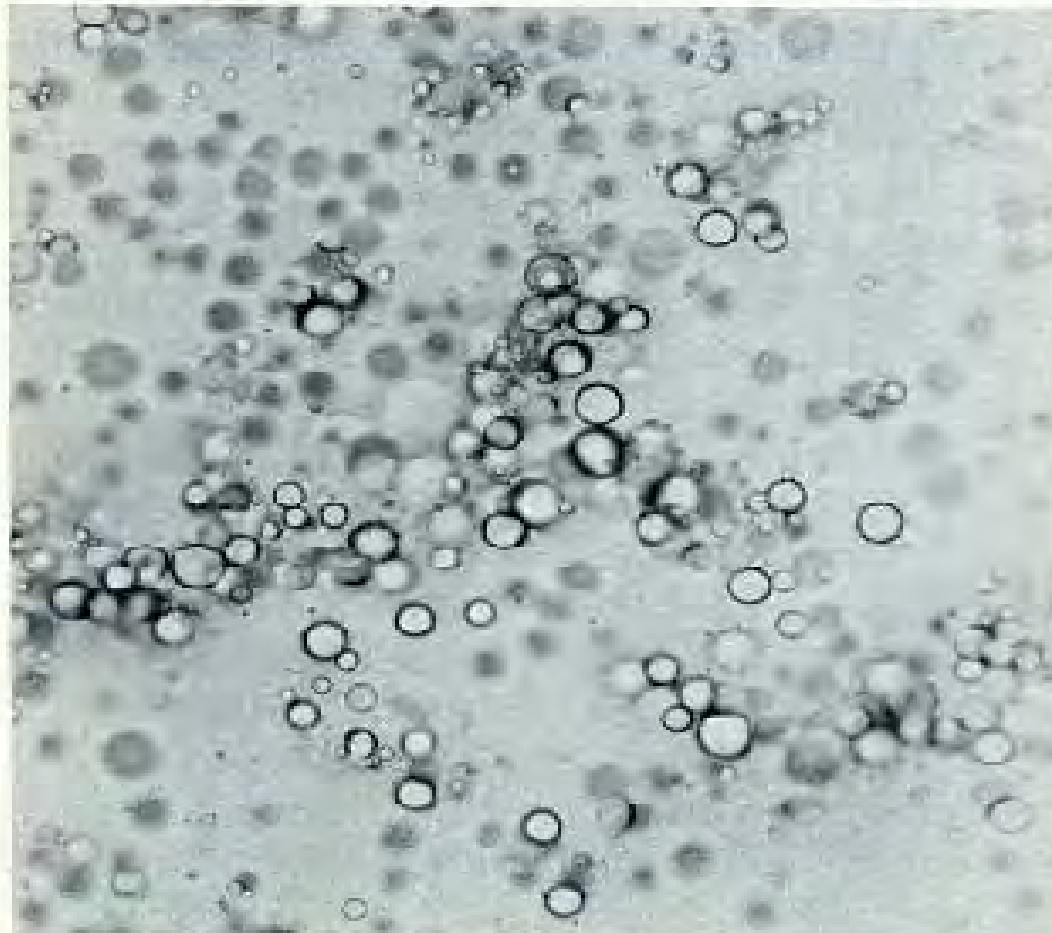


Figure 2.11

These are the fat bodies or elaioplasts from an avocado fruit. Notice that they are round, which is often a good indication that the particle is soft and is held together by a membrane; solid particles are frequently angular. $\times 200$.

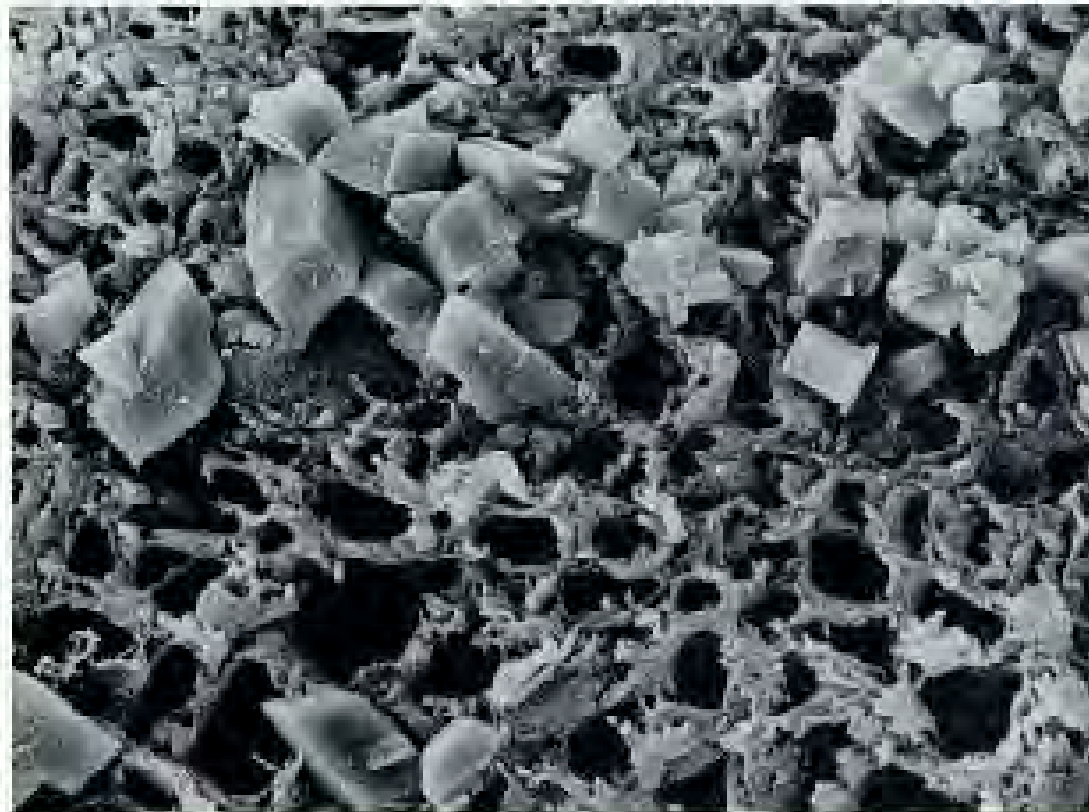


Figure 2.12

These are crystals from the wood of *Crinodendron patagense*. The shape and location of crystals are important characters for both taxonomists and physiologists. Although each crystal appears to be free, each had formed within a cell, $\times 1000$. Micrograph generously provided by G. Montenegro.



Figure 2.13

Star-shaped crystals such as these are druses, and they are extremely common. They can be abundant in some tissues, occurring in virtually every cell. $\times 500$. Material prepared by J. Menard.



Figure 2.14

These two cells contain packets of raphide crystals in the leaves of taro (*Colocasia esculenta*); each crystal is needle-shaped. Raphides always occur in bundles like this. $\times 400$. Micrograph generously provided by L. A. Sunell and P. L. Healey.



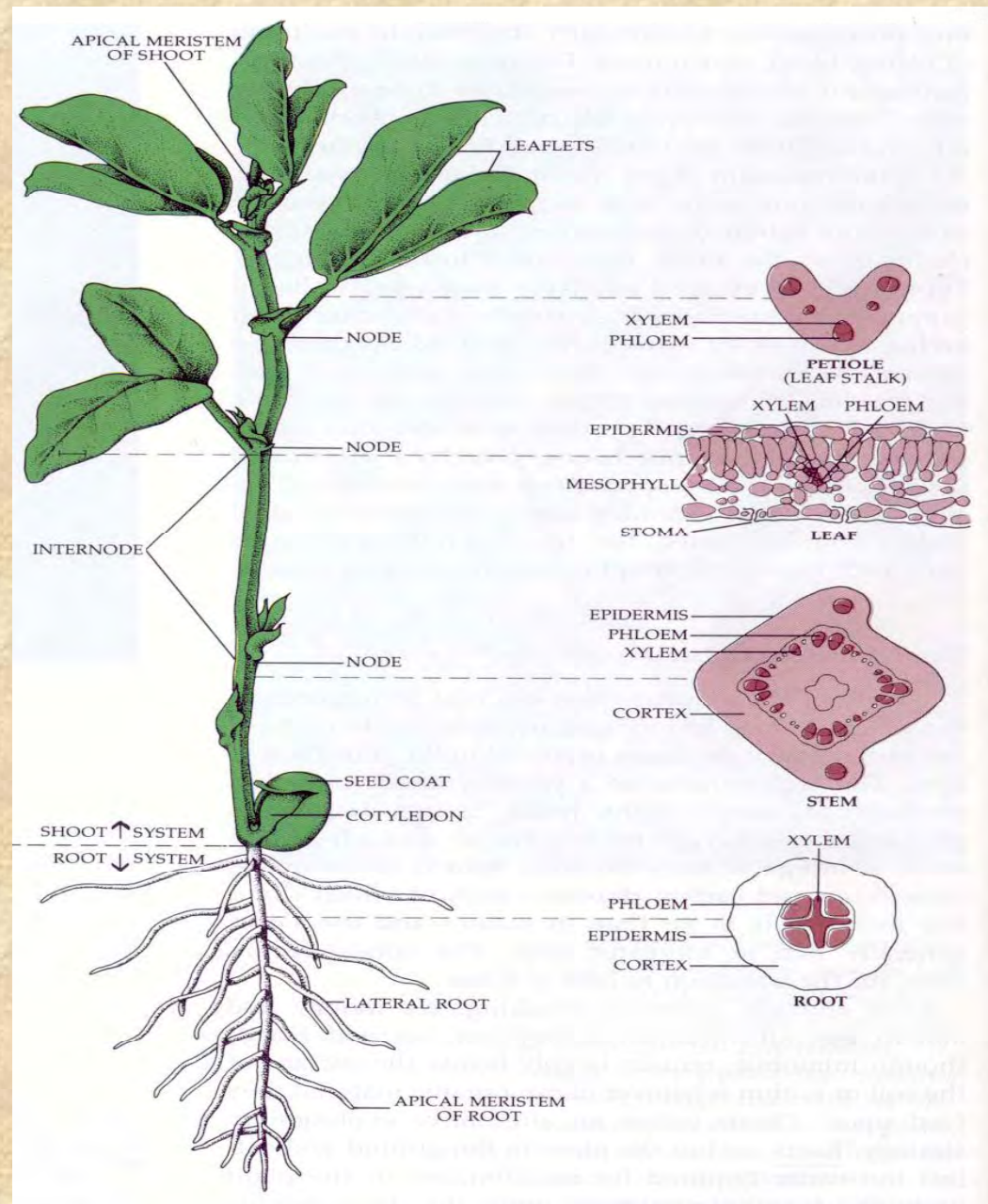
Figure 2.15
Protein bodies from the cotyledons of a sunflower seed. $\times 1000$. Micrograph generously provided by R. D. Allen.

ANATOMÍA VEGETAL:

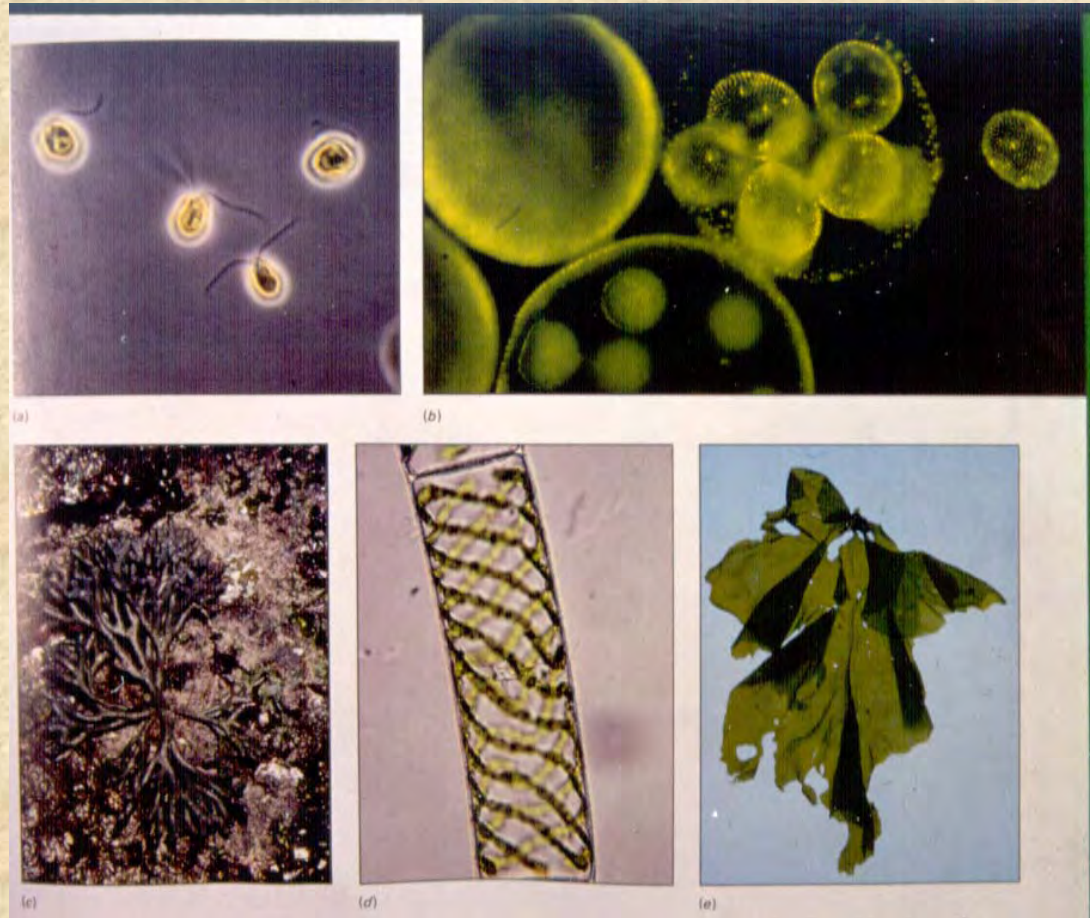
TEJIDOS FUNDAMENTALES

Morfología y anatomía

El estudio de las plantas ha conducido a que los estudios de la forma y función se lleve antes con los estudios de morfología y anatomía:
Ambas disciplinas se complementan.

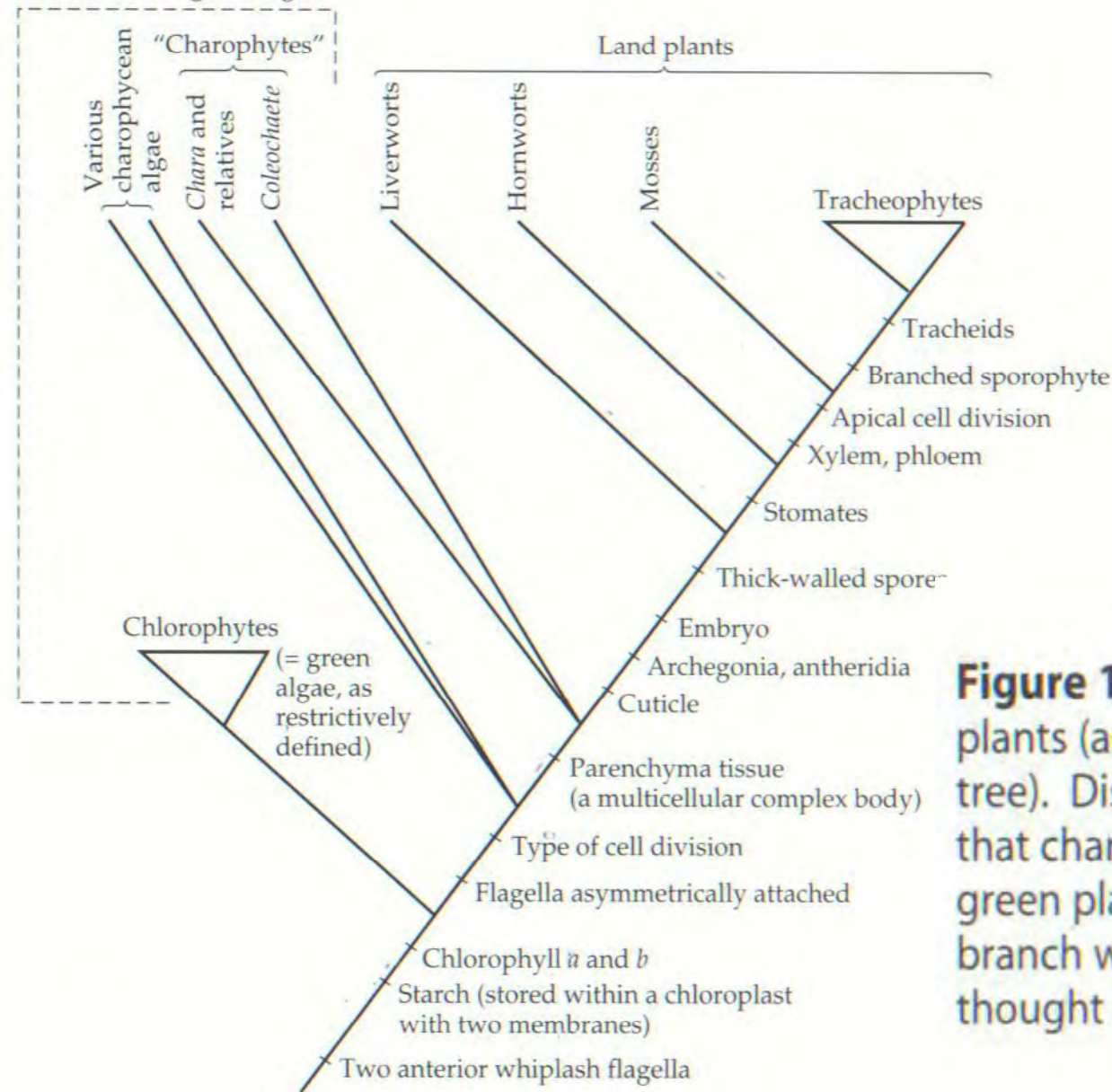


Origen y evolución de los tejidos fundamentales



La algas verdes dieron origen a las plantas vasculares. El talo o cuerpo de las clorofitas está constituido solamente por el tejido más sencillo en cuyas células se presenta una sola pared celular sencilla. Los tejidos de sostén y conducción aparecen posteriormente en las primeras plantas terrestres.

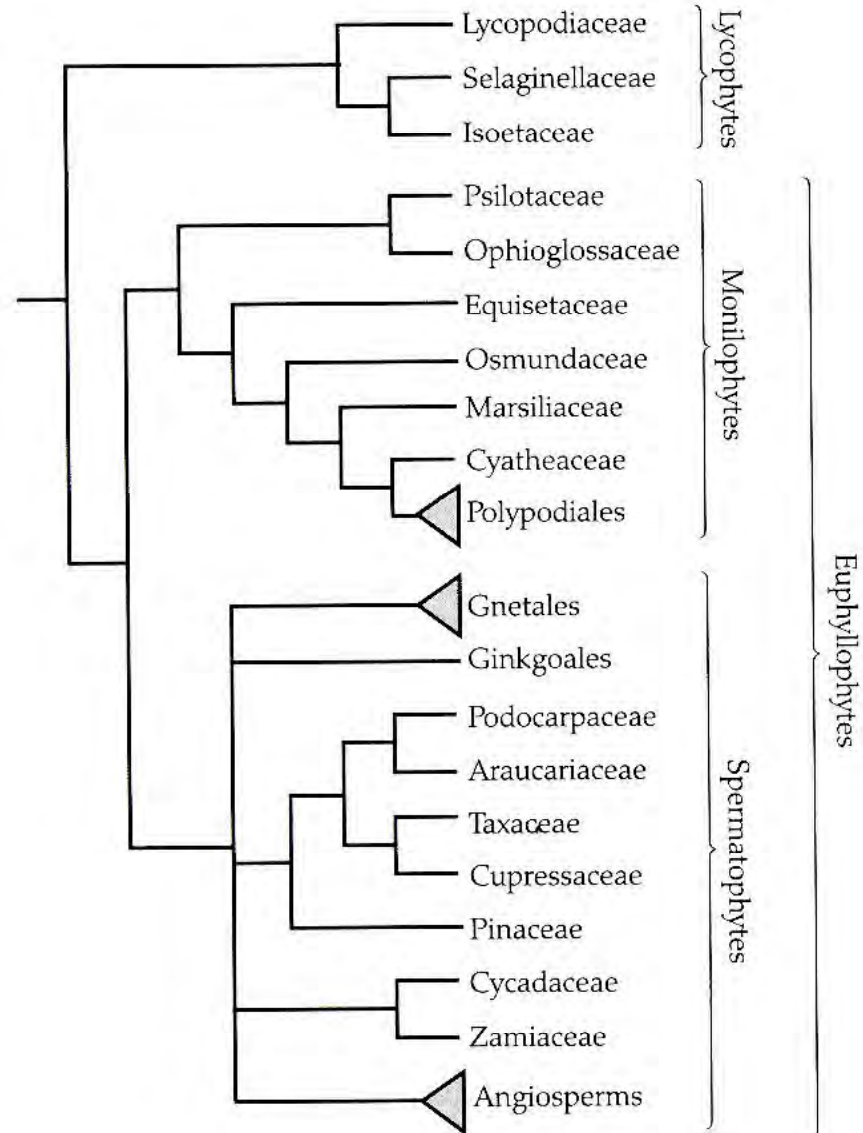
Often all these groups are considered as "green algae"



El talo equivale al tejido de plantas vasculares denominado "parénquima"

Figure 1.1 A phylogeny of green plants (as pictured in a phylogenetic tree). Distinctive structural features that characterize various groups of green plants are indicated on the branch where the characteristic is thought to have evolved.

TRACHEOPHYTES

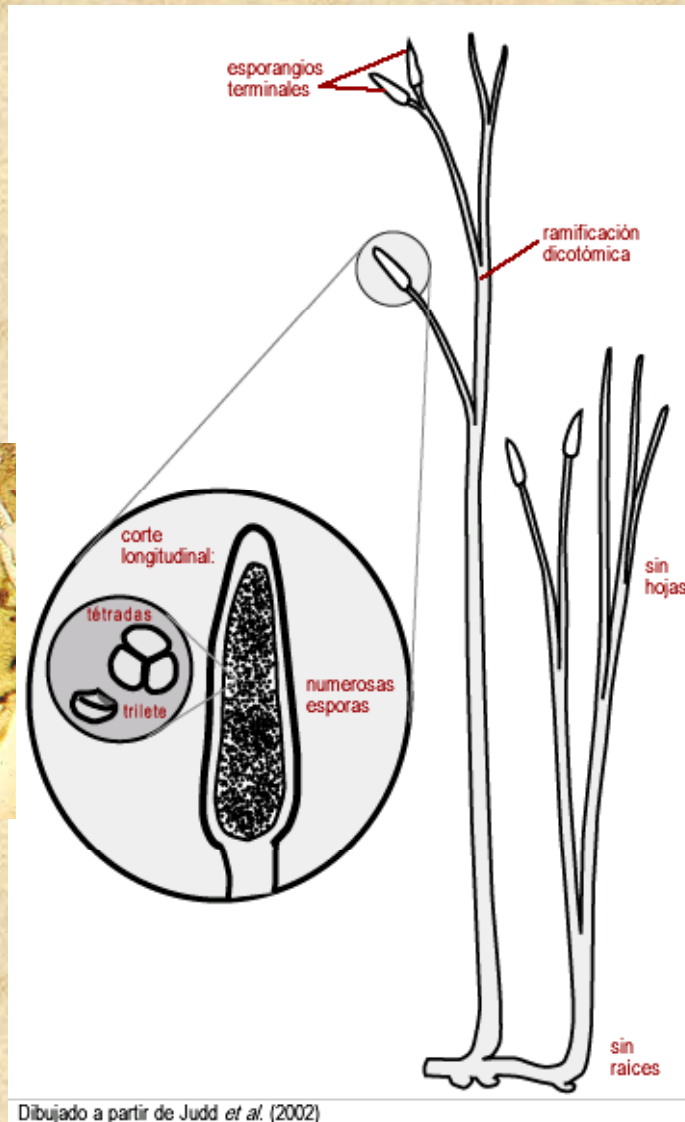
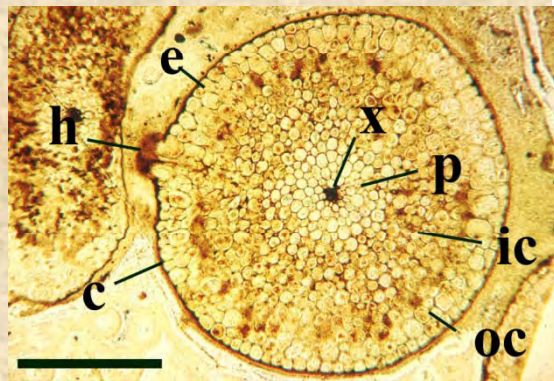


FILOGENIA DE LAS TRAQUEOFITAS

(JUDD ET AL., 2008)

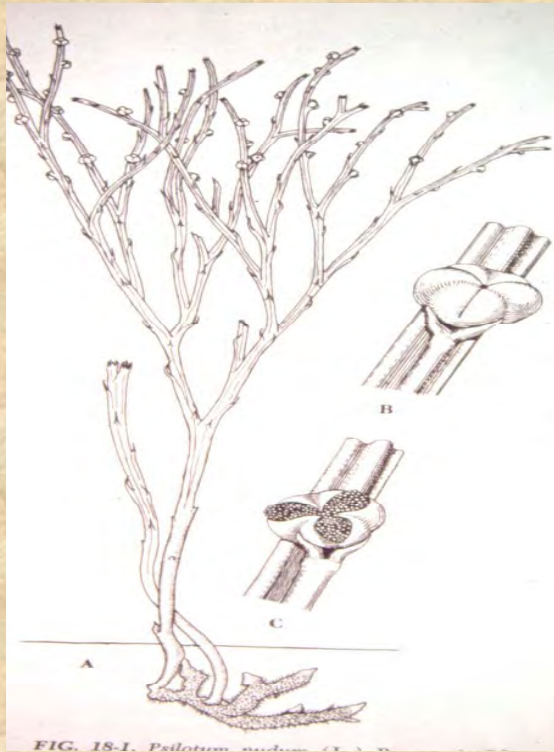
CAUSAS DE LA COLONIZACIÓN AL MEDIO TERRESTRE Y ASÍ POSIBLE ORIGEN DE LAS PLANTAS VASCULARES.

- 1. El medio acuático está limitado en CO₂, por lo que había competencia por este gas.**
- 2. El medio terrestres es más abundante en CO₂.**
- 3. La atmósfera ya contaba con un filtro contra rayos de onda corta, es decir, la capa de ozono, fabricada previamente por las cianobacterias.**
- 4. Sin embargo en el medio terrestre hubo fuerte limitación de agua.**
- 5. Las plantas entonces evolucionaron en la producción de cortezas, epidermis gruesas y sistemas de conducción del agua.**
- 6. Hubo pues una diferenciación del talo que derivó en un gran número de tejidos.**
- 7. Hubo una evolución concomitante con radiaciones evolutivas.**



Dibujado a partir de Judd *et al.* (2002)

Esquema de *Rhynia*, primera planta terrestre de hace aprox. 600 millones de años



Psilotum nudum, planta terrestre muy primitiva que aún carece de tejidos de conducción diferenciados su cuerpo o talo está formado casi exclusivamente de tejidos parenquimatosos o talo. Es la planta terrestre que más se parece a *Rhynia*.



FIG. 24-27. A. *Lepidodendron obovatum* Sternb. B. *Sigillaria* sp. C. *Lepidodendron* sp. $\times 0.003$. (A, B. After Hirmer from Smith, C. After Eggert.)

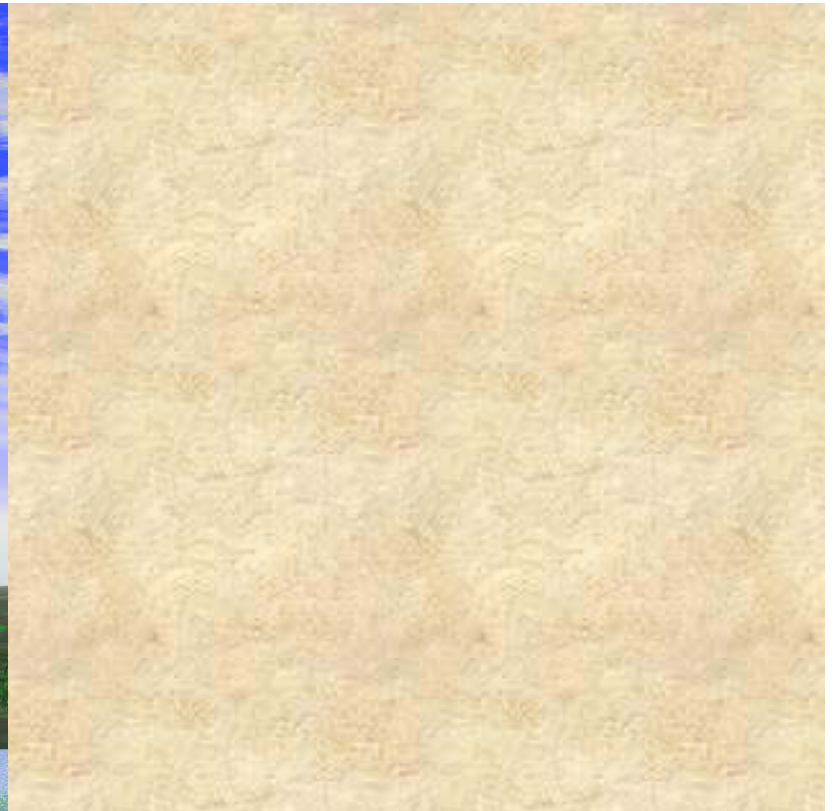


A



C

Ejemplos de plantas vasculares muy primitivas del Carbonífero, en las que hay ya manifestaciones de diferenciación de tejidos



Calamites sp.



En las plantas vasculares hay tres sistemas de tejidos

- **Tejidos fundamentales o básicos**
- **Tejidos vasculares**
- **Tejidos dérmicos**

Cada uno opera de acuerdo a las funciones específicas en la planta

LOS SISTEMAS DE TEJIDOS

Se agrupan de acuerdo a similitudes en su origen, función, continuidad topográfica, etc.

Son originados en el desarrollo del embrión en el que se desarrollan:

- Tejido fundamental (a partir de meristemo fundamental)
- Tejido vascular (*procambium*)
- Tejido dérmico (*protodermis*)

LOS ORGANISMOS VEGETALES SIEMPRE TENDRÁN TEJIDO EMBRIONARIO EN SU CUERPO, ESTE ES EL MERISTEMO QUE ES TOTIPOTENCIAL

TEJIDOS BÁSICOS.

Los tejidos básicos o fundamentales son:

Parénquima. Las células tienen pared celular sencilla y son los más abundantes y con funciones de todo tipo en la planta, excepto sostén.

Colénquima. Sus células con pared celular engrosada de forma irregular y son de sostén.

Esclerénquima. Células con doble pared celular. Con doble función: sostén y conducción.

SISTEMAS DE TEJIDOS...

También pueden agruparse de acuerdo a su complejidad:

- **Sistemas de tejidos simples: formados por un tipo de célula, i.e., parénquima, colénquima.**
- **Sistemas de tejidos complejos: formados por mas de un tipo de célula: xilema, floema, epidermis.**

SISTEMAS DE TEJIDOS...

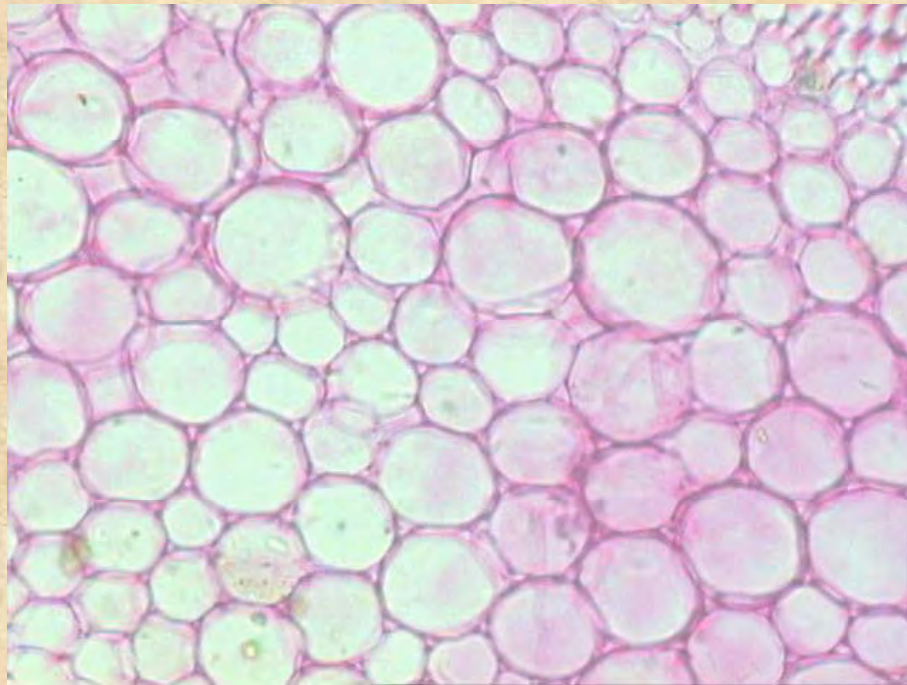
- **Tejidos fundamentales: parénquima, colénquima y esclerénquima**
- **Tejido vascular : xilema y floema**
- **Tejido dérmico : epidermis y peridermis**

TEJIDOS FUNDAMENTALES

Proviene del meristemo fundamental y son:

- **Parénquima**
- **Colénquima**
- **Esclerénquima**

PARÉNQUIMA



PARÉNQUIMA

Tejido fundamental y el más abundante en las plantas. Se caracteriza por tener una sola pared celular delgada o sencilla. Las células embrionarias que son parenquimáticas (meristemos) pueden generar los otros dos tipos de tejidos.

Características:

- Progenitor de todos los demás tejidos
- Forma celular variable
- Pared celular primaria presente
- Vivas y activas en la madurez

El parénquima se divide en los siguientes tipos:

Sintético: meristemático, fotosintético y secretor

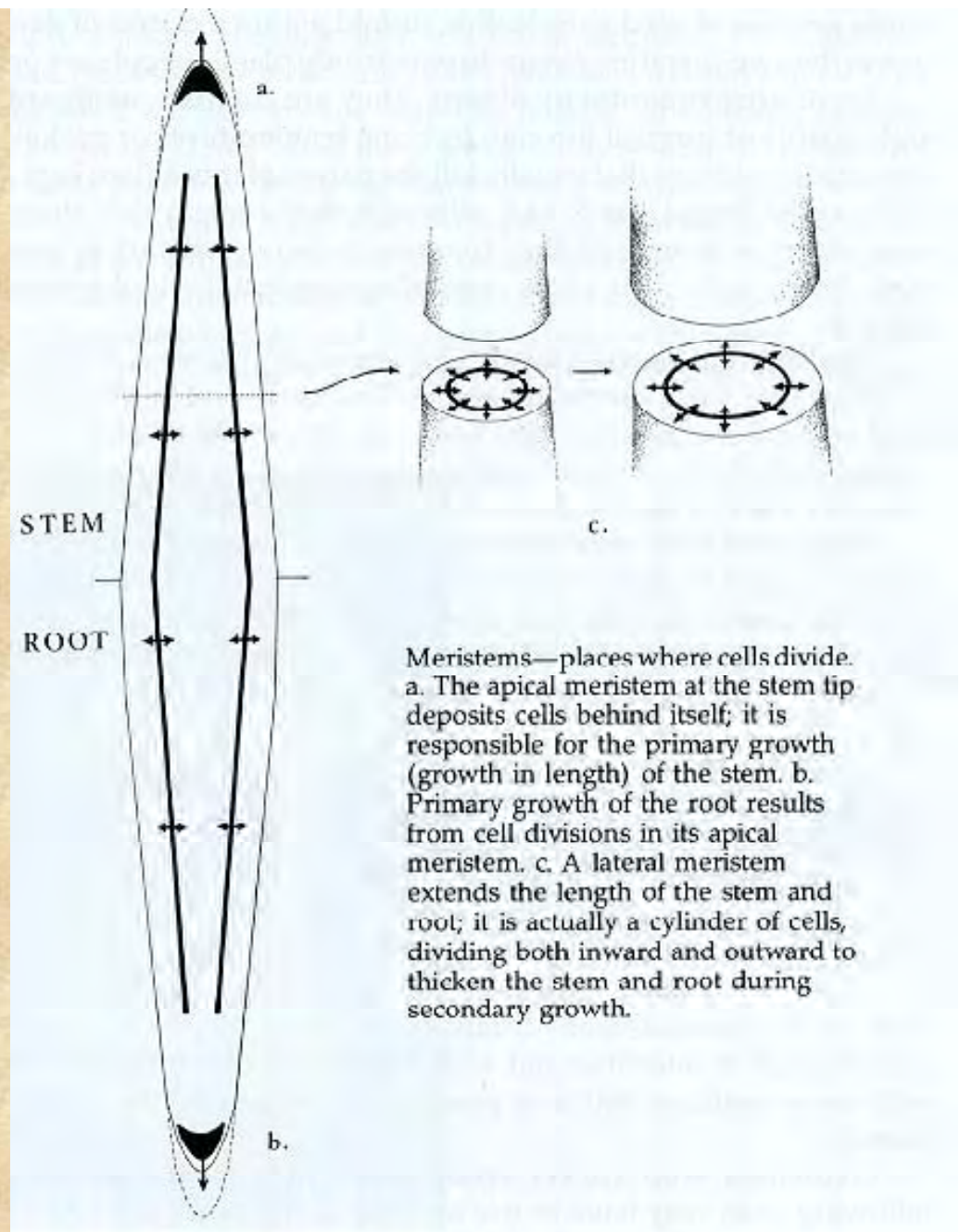
Estructural : parénquima fundamental, aerénquima

Limítrofe: epidermis, endodermis

Transportador: floema o elementos cribosos, de transferencia, de transmisión de la luz

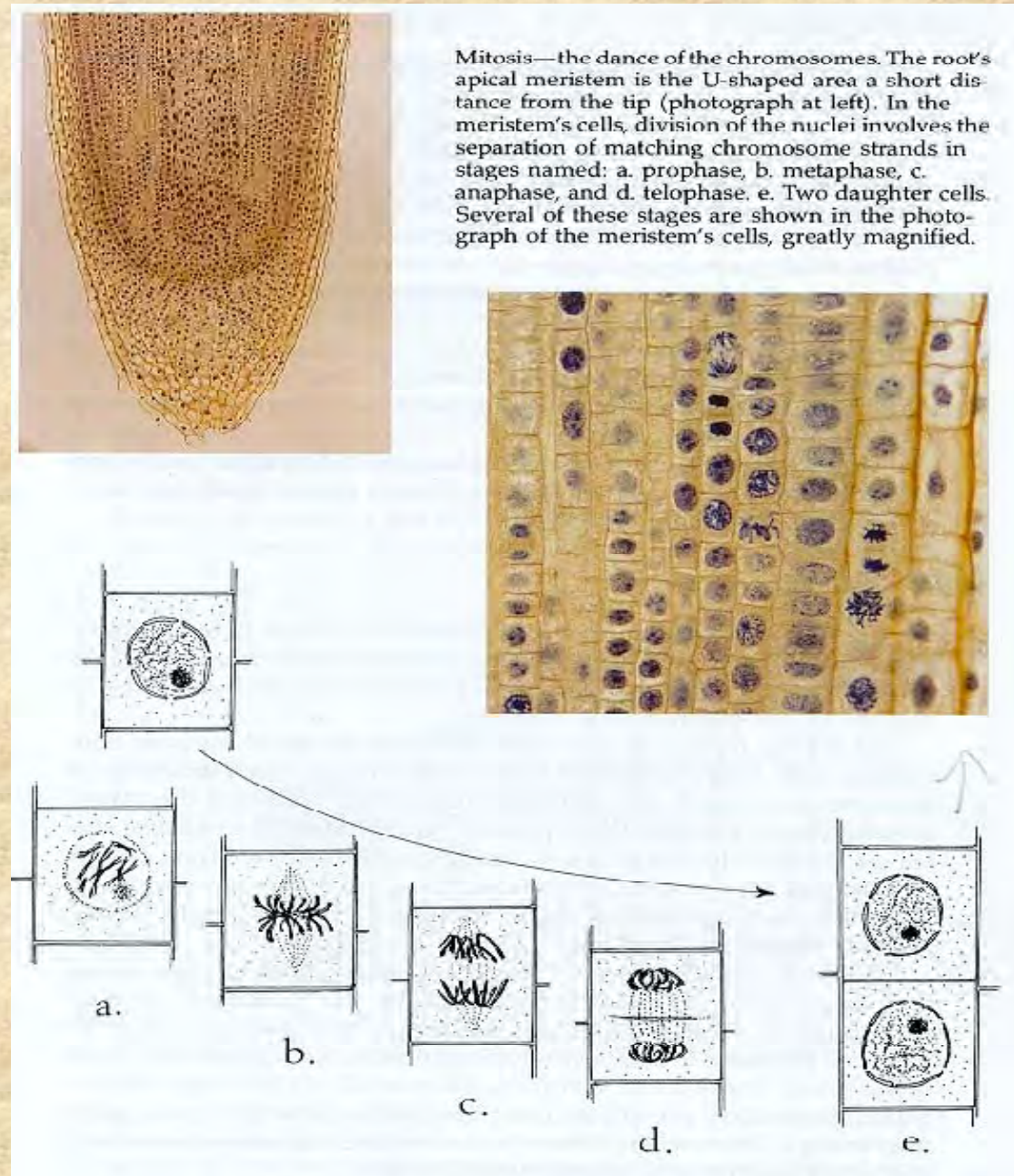
Almacenador: parénquima almidonoso

PARÉNQUIMA SINTÉTICO:
El meristemo o tejido
embrionario es el primero en
aparecer.



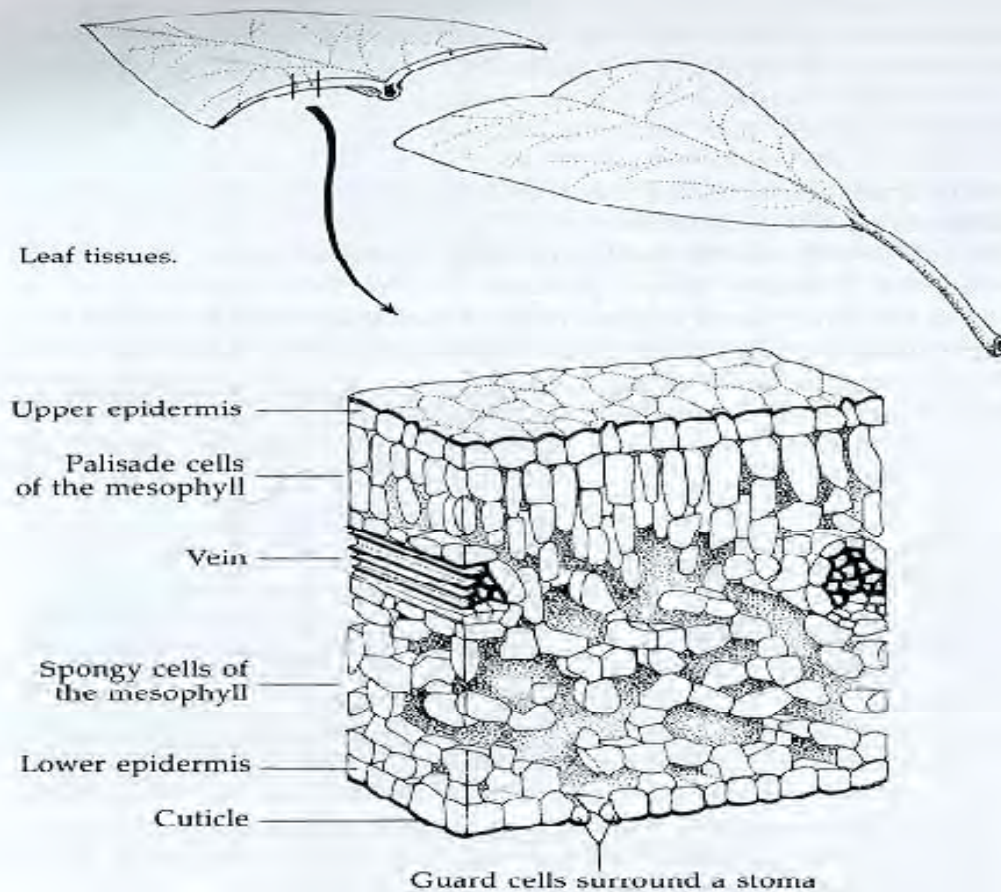
Parénquima

Sintético: meristemo en la zona de crecimiento de la raíz

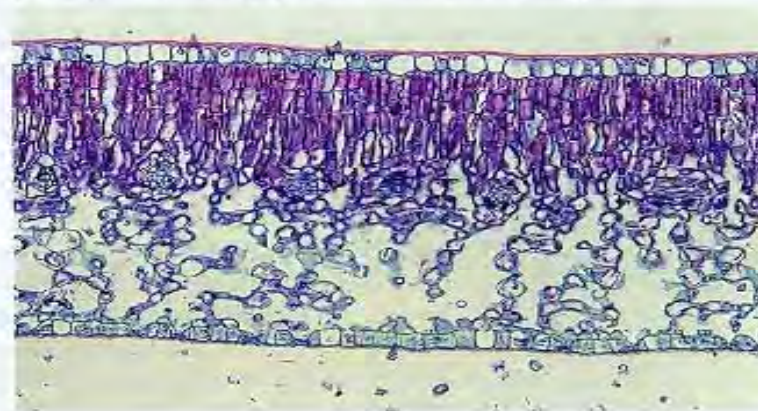


Parénquima sintético:

células del mesófilo
en empalizada y
esponjoso



The anatomy of a leaf. Tissues may be identified by comparing the photograph with the above diagram.



Parénquima sintético:

células del mesófilo
en empalizada y
esponjoso

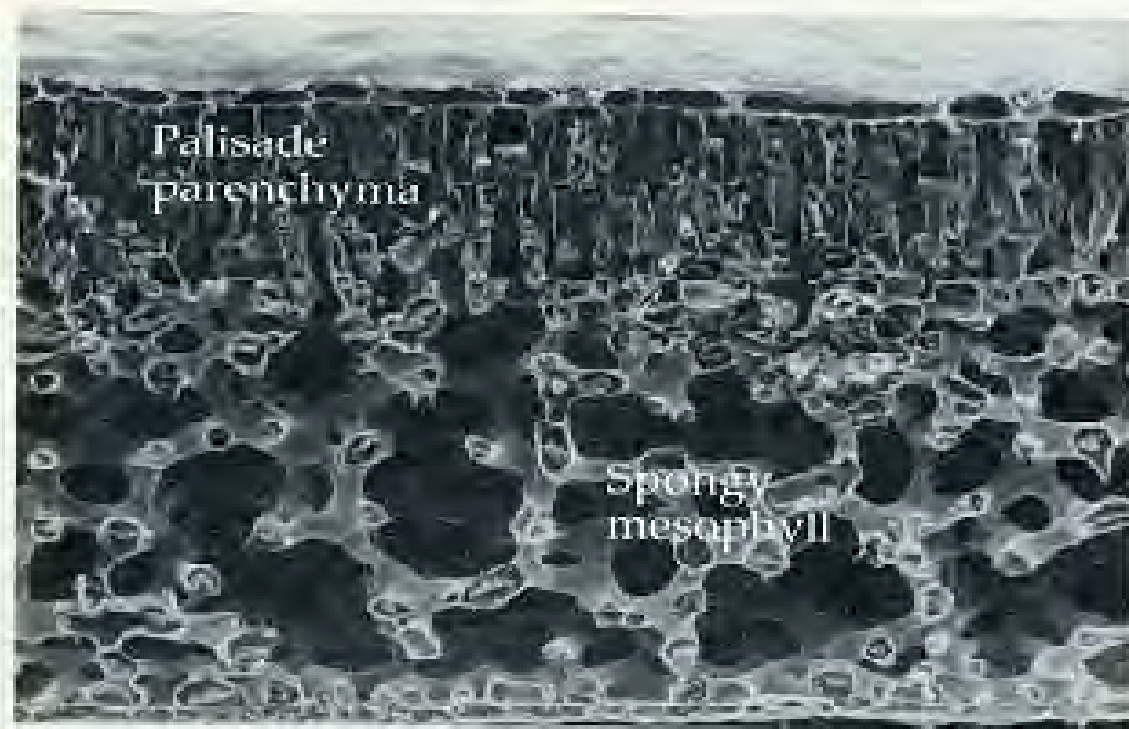


Figure 3.3

Cross section through a leaf of *Laurelia philippiana*. The uppermost layer (the epidermis) has no intercellular spaces; the next two layers (of palisade parenchyma) have small intercellular spaces. But in the lowest layers, the intercellular spaces constitute over half the volume. Imagine how freely the carbon dioxide can circulate once it enters through a stoma in the lower epidermis. $\times 100$. Micrograph generously provided by G. Montenegro.

Parénquima
sintético:
tejido secretor

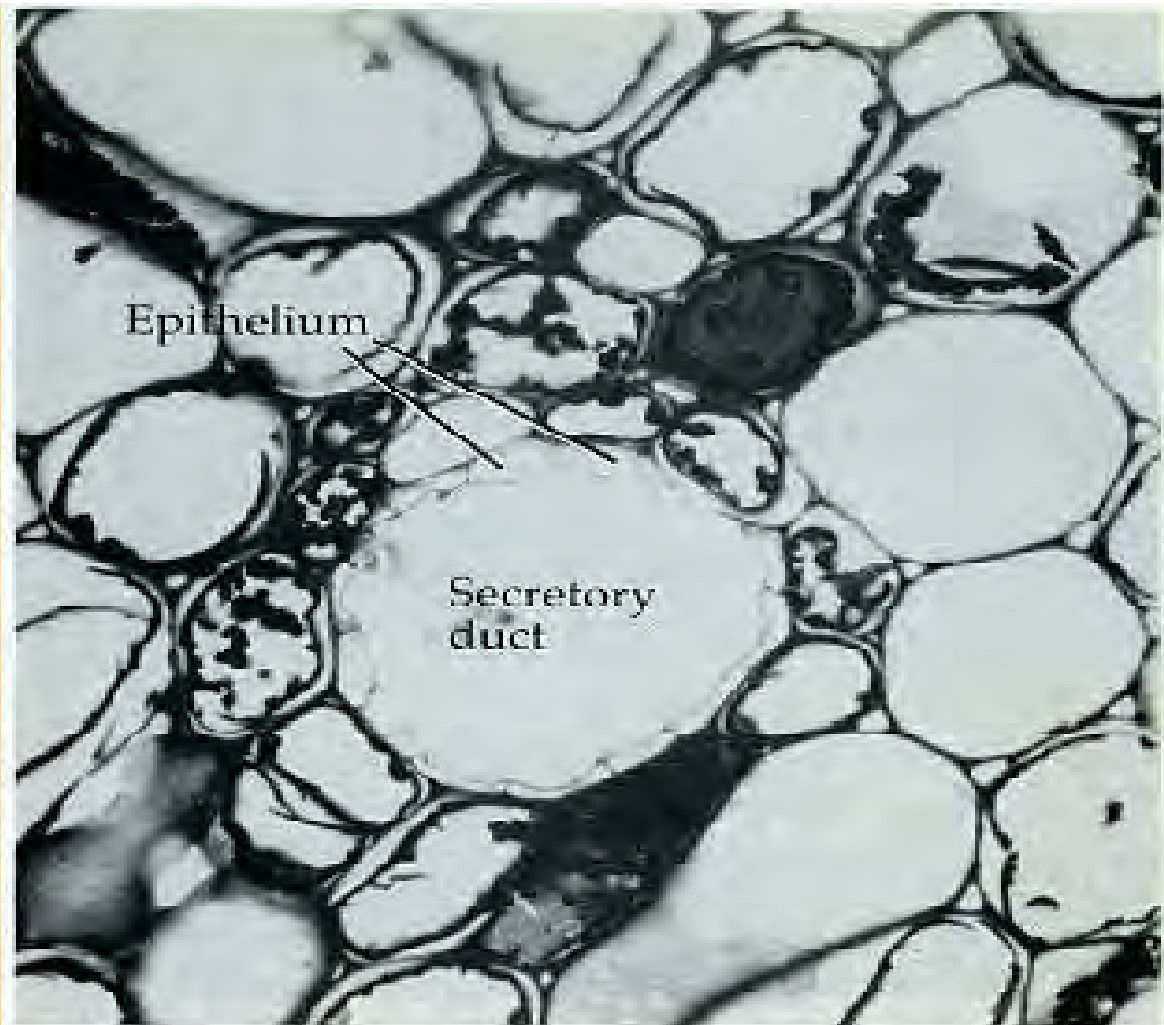


Figure 3.2

This is a secretory duct in the root of *Clusia*; it has a lining (epithelium) of parenchyma cells. Such parenchymatic linings often have the dual function of producing the secretion and of keeping it isolated from the rest of the plant. The surrounding cells are other parenchyma cells of the cortex; some have produced tannins. $\times 200$.

PARÉNQUIMA ESTRUCTURAL;

AERÉNQUIMA

***Es aquél parénquima que
por causas adaptativas
conserva espacios aéreos
de forma simétrica***



Figure 3.4

Stem of *Ludwigia terrestris*: the cortex is almost pure aerenchyma, formed when large regions of one layer of cells separated from the next layer. These channels provide an excellent means for gas circulation and permit the construction of a large stem using almost no building material. $\times 100$. Micrograph generously provided by G. Montenegro.

AERÉNQUIMA

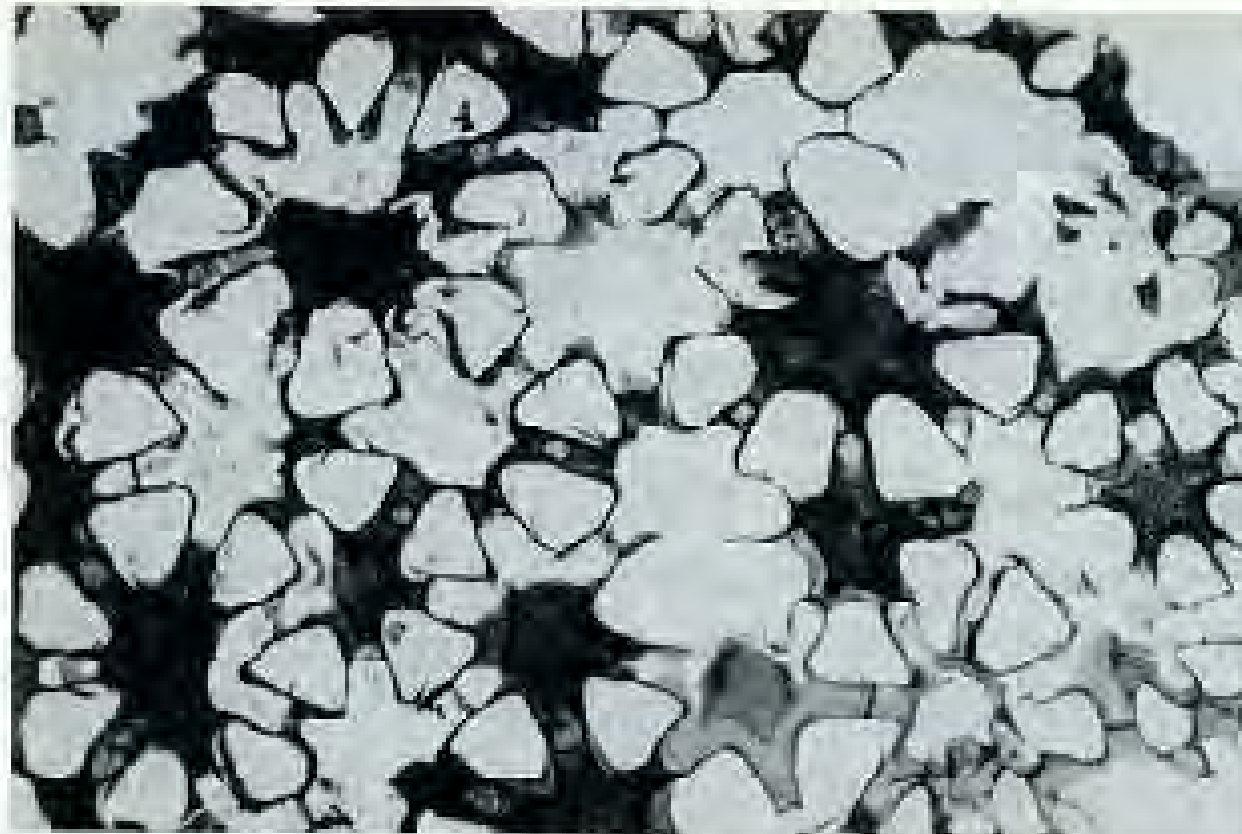


Figure 3.5

This is the aerenchyma from the interior of a leaf of banana (*Musa*). This construction permits the leaf to be flexible, an important quality for leaves as large as these (two or three meters long). $\times 100$.

***PARÉNQUIMA
ESTRUCTURAL:***

***PARÉNQUIMA
FUNDAMENTAL
DE TALLO FORMADOR
DE MÉDULA***

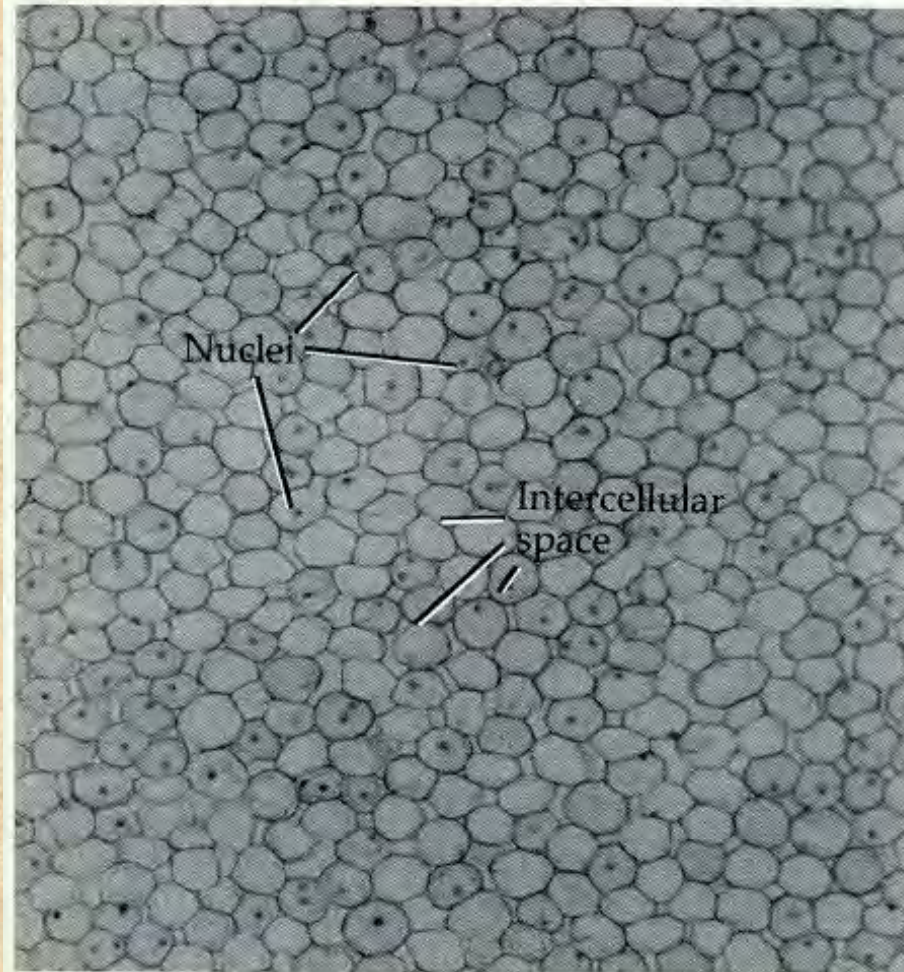
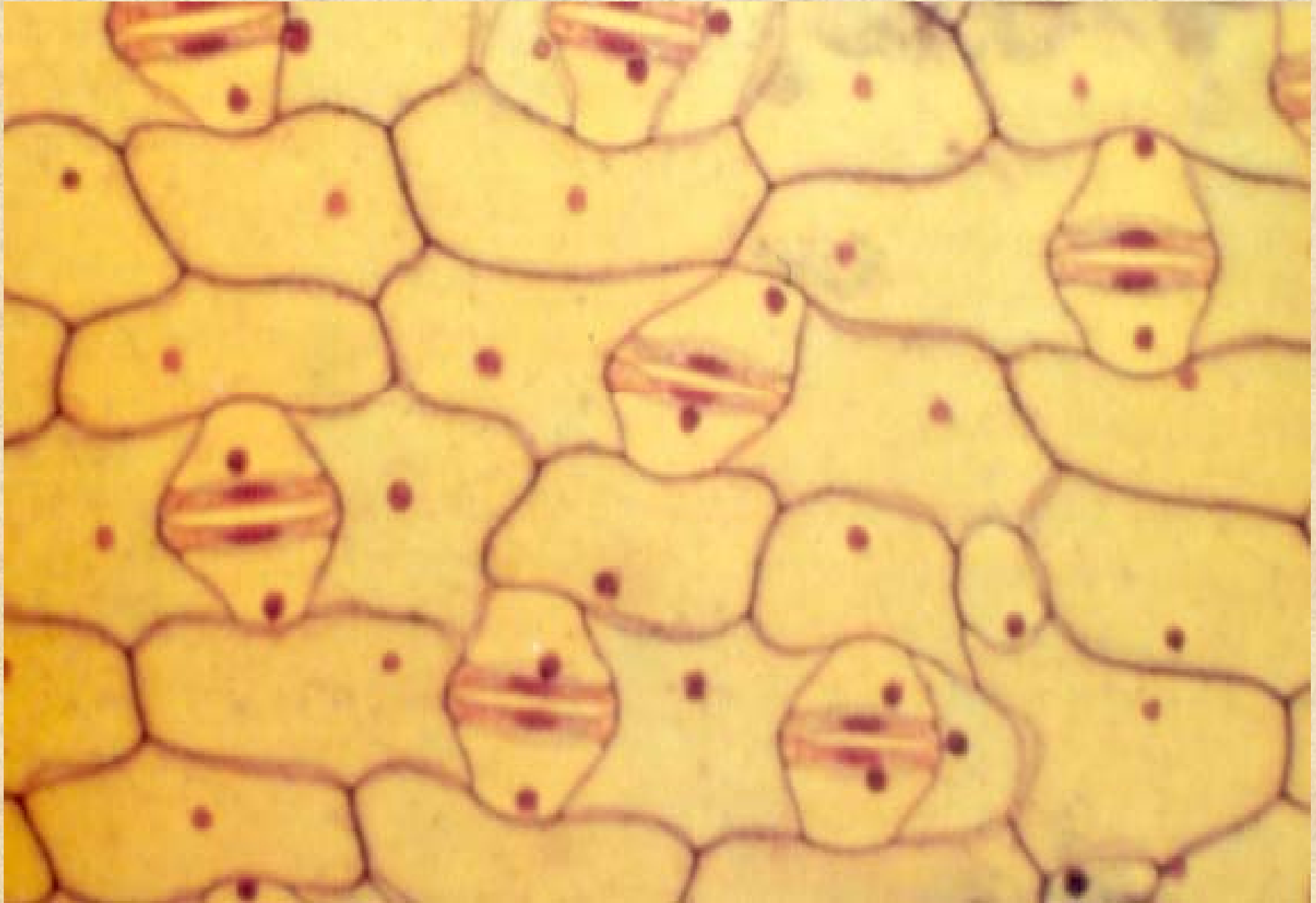
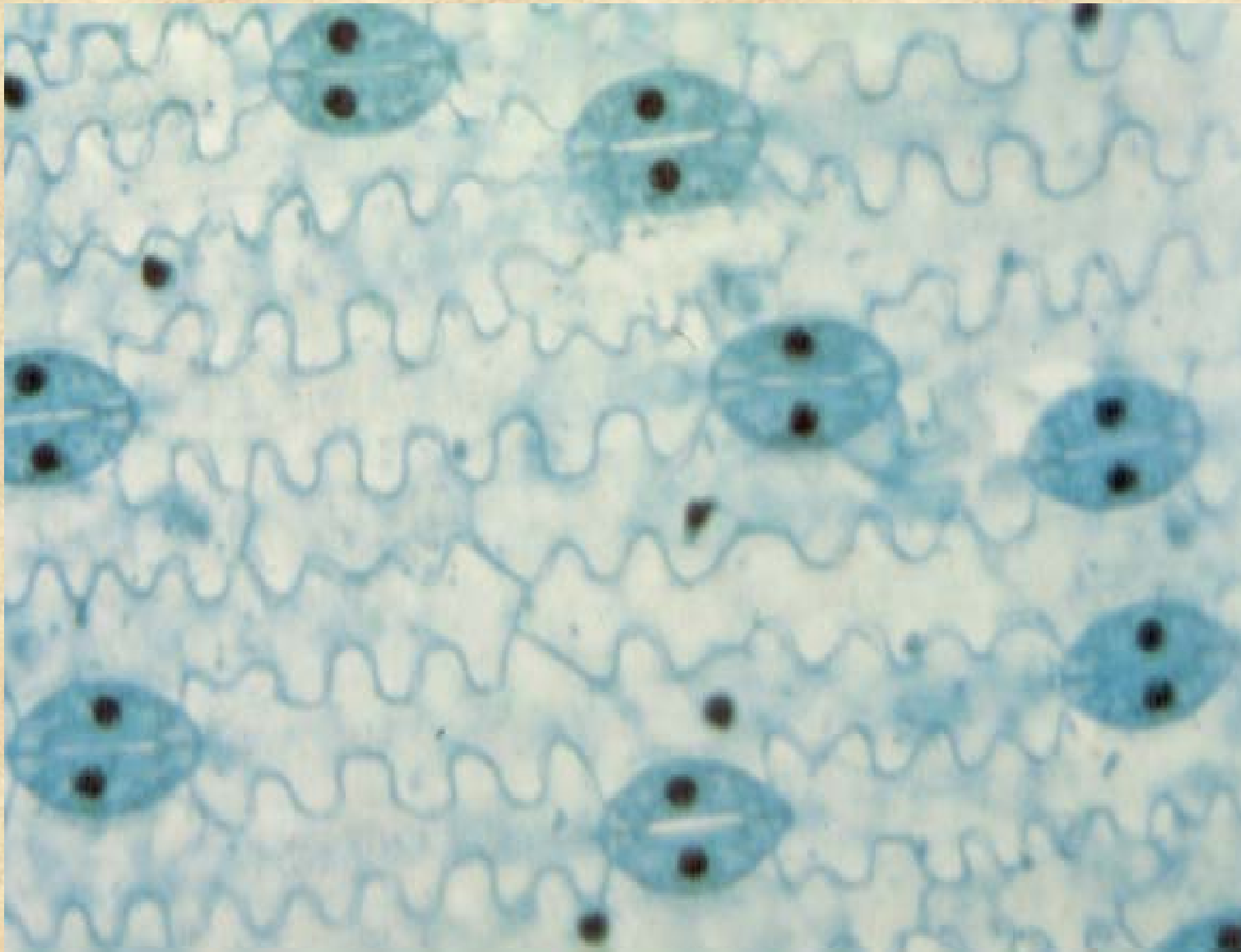


Figure 3.1

This is a mass of pure parenchyma from the body of *Homalocephala texensis*; it is probably the type of tissue that most people envision when they think of parenchyma: the cells are large, have thin walls, and do not appear specialized. $\times 100$.

Parénquima limítrofe. En este caso es epidermis foliar





Epidermis foliar. Nótese las células guarda de los estomas



***Cutícula con tricomas.
Este tejido también es parenquimático limítrofe***



Figure 3.9

This is a longitudinal section through a leaf of *Frithia pulchra*. Notice that the center is translucent and the sides chlorophyllous. Try to imagine this buried up to its upper surface, the central parenchyma conducting light and the peripheral chlorenchyma carrying out subterranean photosynthesis. $\times 8$. Photograph generously provided by L. Simpson and R. Moore.

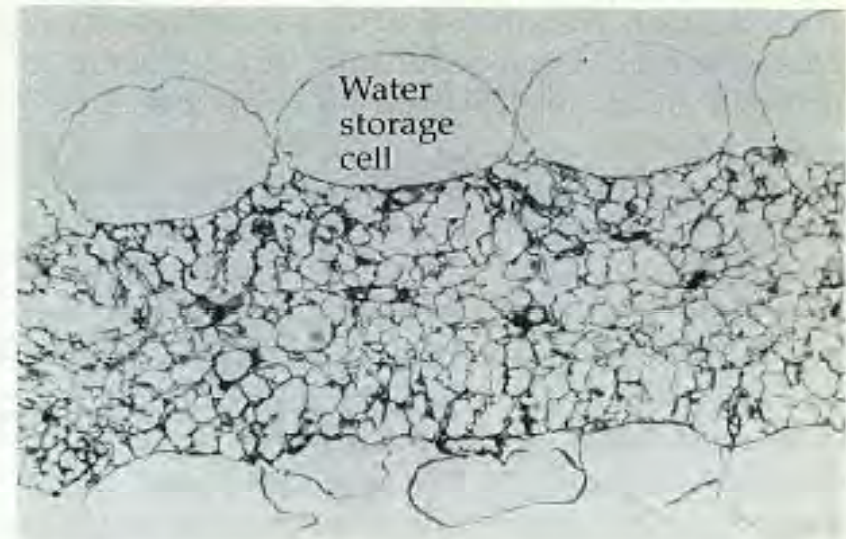
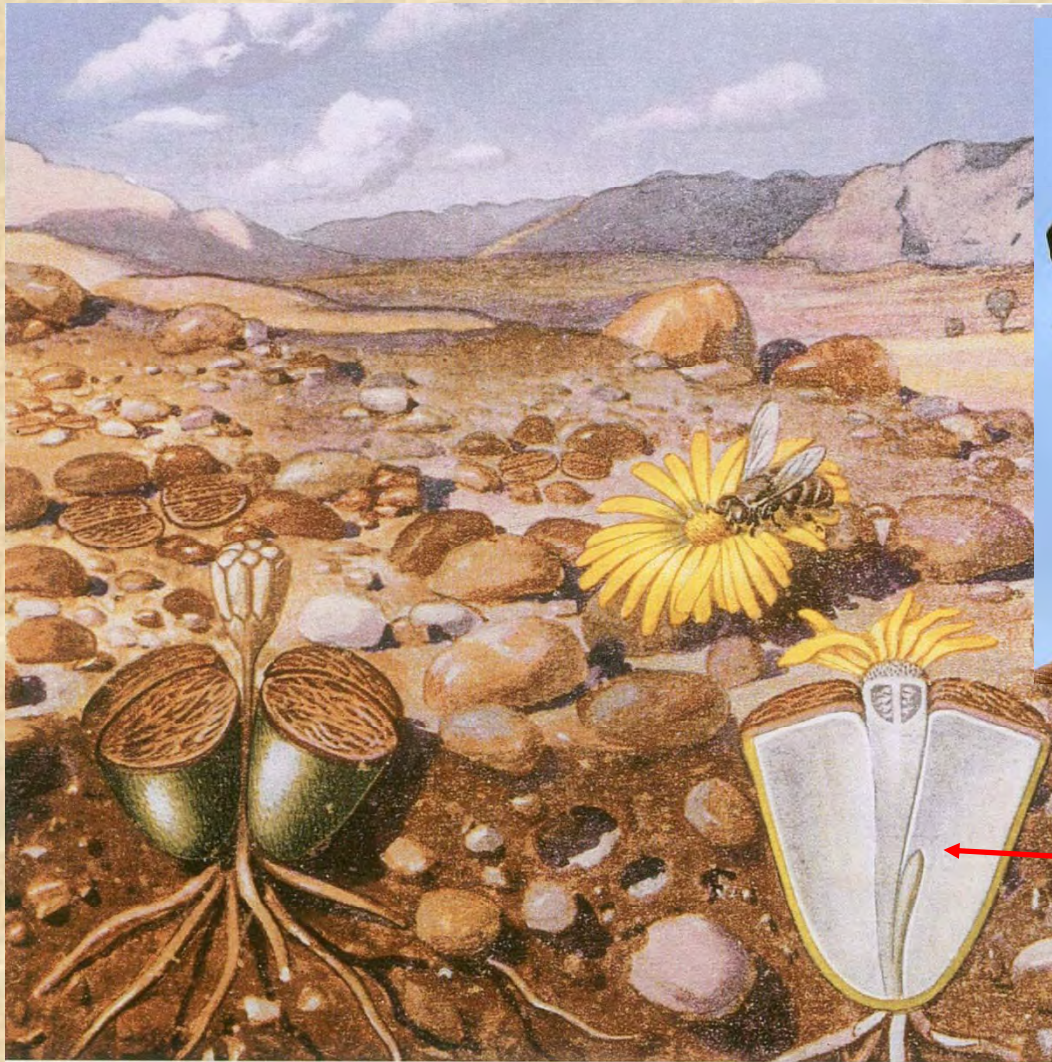


Figure 3.10

Cross section of a leaf of *Carpobrotus* (ice plant); although some of the epidermal cells are small (as in Figure 3.3), many become enormous, filled with water. These plants are leaf succulents of semi-arid regions. $\times 50$.

Parénquima transportador o de transferencia. En este caso se transmite la luz.



PARÉNQUIMA DE
TRANSFERENCIA

Lithops sp

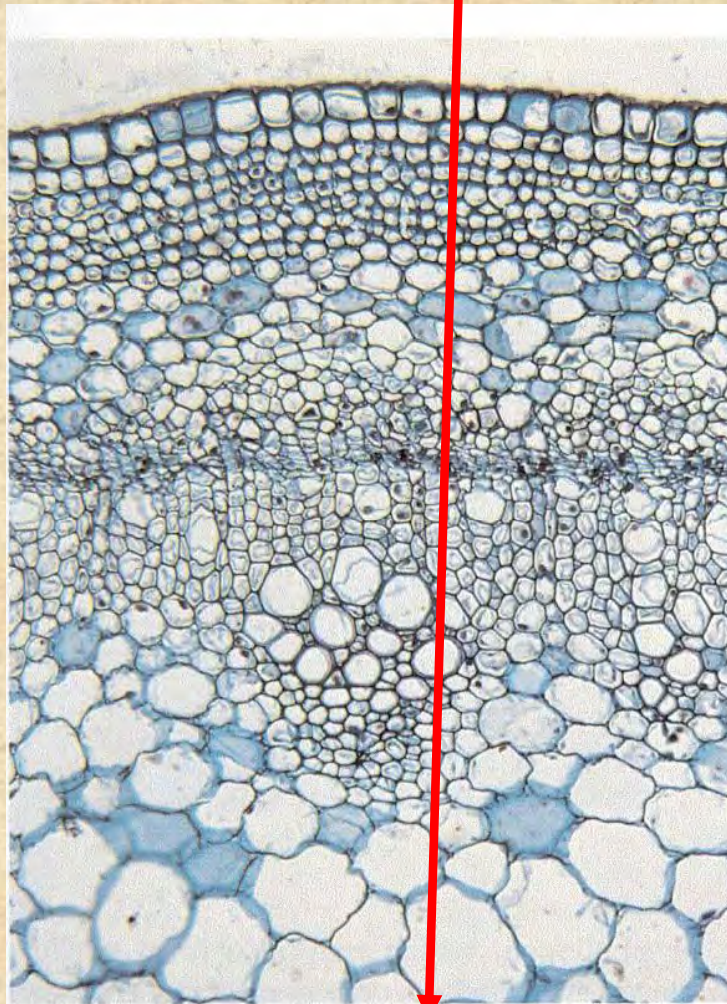
PARÉNQUIMA DE TRANSFERENCIA O TRANSPORTADOR



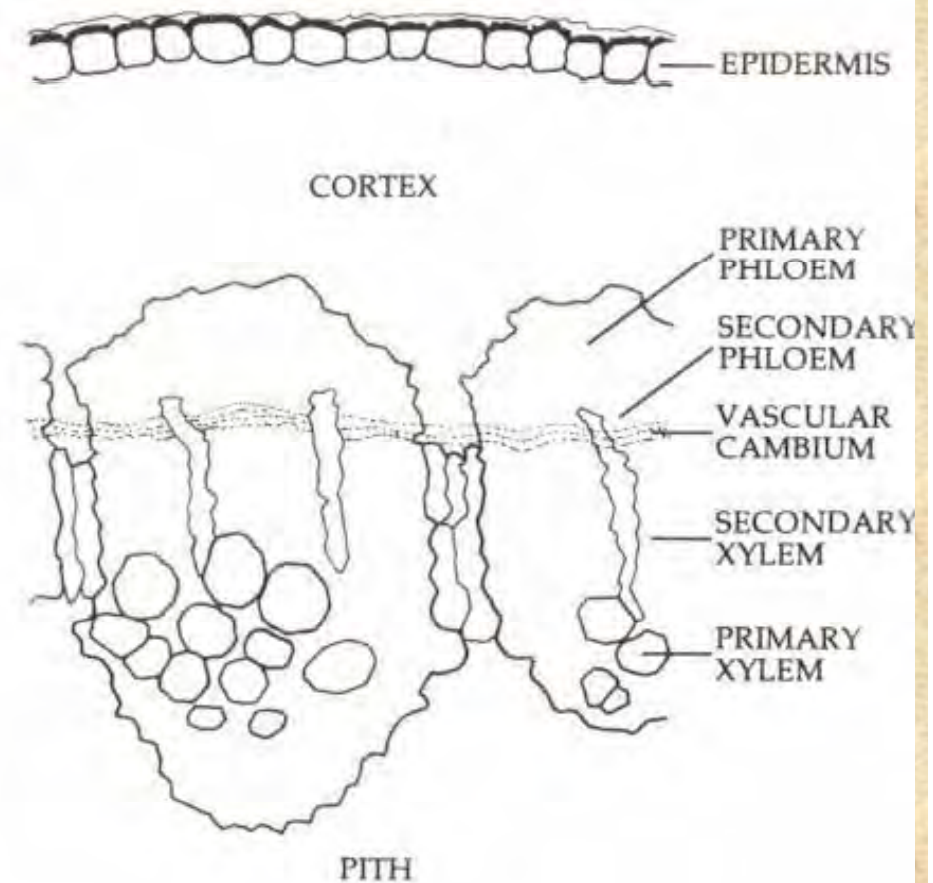
Figure 3.7

Labyrinthine walls in two root cells of the orchid *Sobralia macrantha*. $\times 4000$. Micrograph generously provided by D. H. Benzing, D. W. Ott, and W. E. Friedman.

Parénquima en tallo o médula

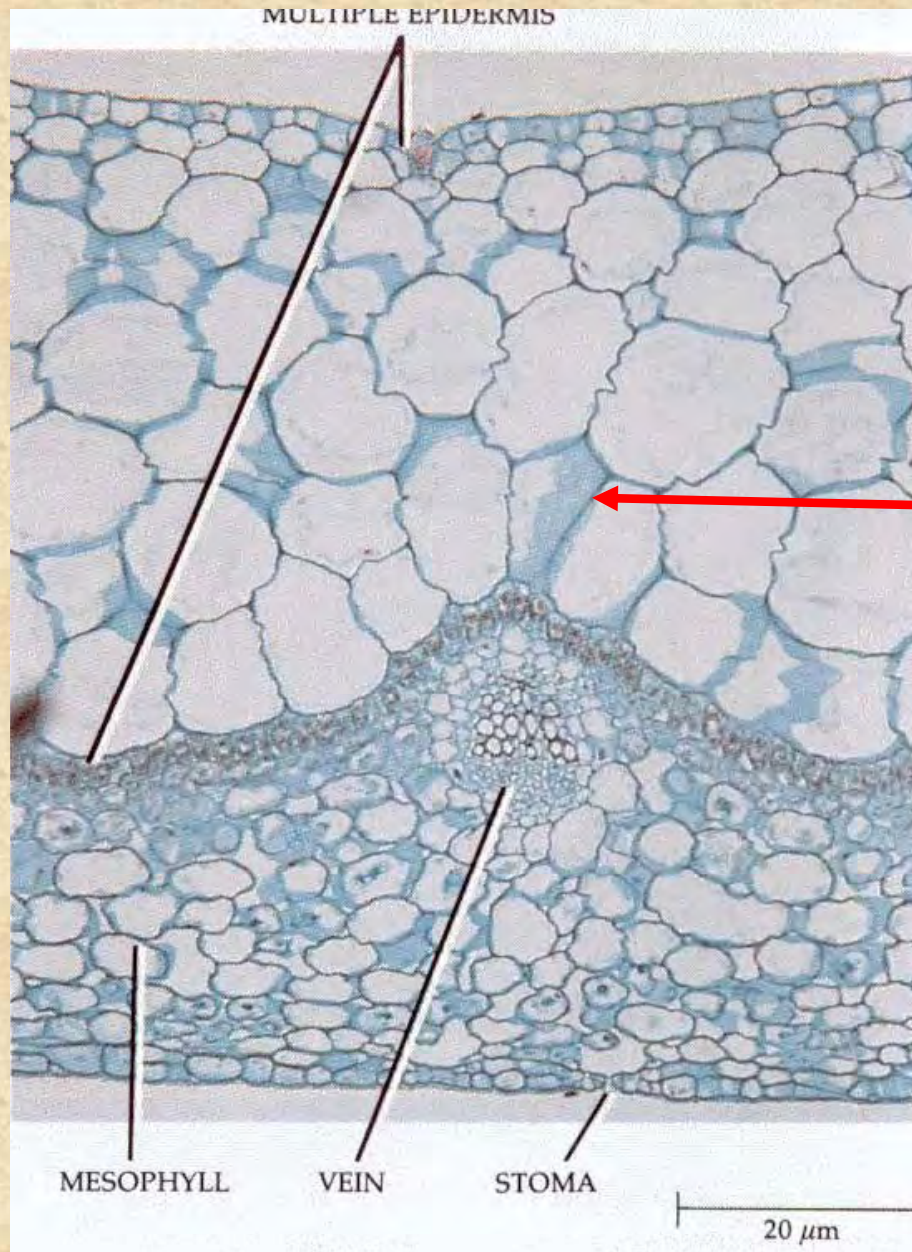


200 μm



23-8

Transverse section of an elderberry (Sambucus canadensis) stem in which a small amount of secondary growth has taken place. A cork cambium has not yet been formed.



Localización de
parénquima en
hojas (esponjoso)

22-43

Transverse section of leaf blade of Peperomia. The very thick multiple epidermis, visible on its upper surface, presumably functions as water-storage tissue.

Parénquima transportador:

Células cribosas de gimnospermas:

- **Alargadas y adelgazándose en los extremos**
- **Pared celular: primaria en muchas especies con áreas cribosas en toda la superficie de la célula, callosa usualmente asociada con las paredes y los poros**
- **Células albuminosas asociadas**
- **Vivas en la madurez, carecen de distinción las vacuolas y el citoplasma**

Floema de gimnospermas: células albuminosas asociadas a las células cribosas

Características:

Generalmente alargadas

- **Pared celular primaria**
- **Vivas en la madurez, asociadas con células cribosas pero generalmente no derivadas de la misma célula madre del elemento criboso.**
- **Se cree que toman parte en el movimiento de nutrimentos hacia dentro y fuera de la célula cribosa (numerosas conexiones con la célula cribosa)**

Presente en gimnospermas y algunas angiospermas primitivas.

PARÉNQUIMA TRANSPORTADOR EN ANGIOSPERMAS

FLOEMA..

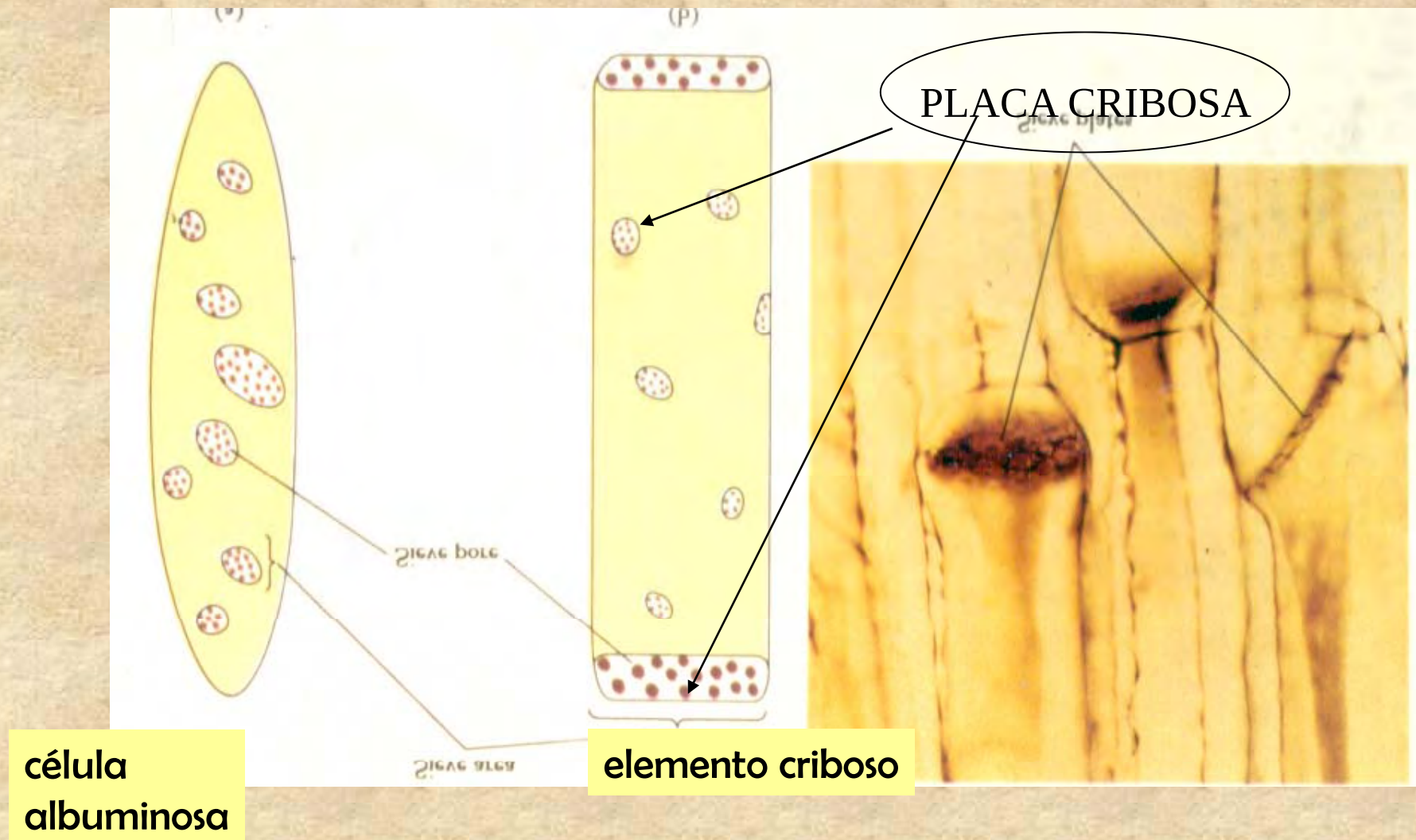
- Formado por células cortas y anchas, aplanándose en los extremos.
- Contiene placas cribosas, además de los plasmodesmos que posee en las paredes laterales.
- Vivas en la madurez, carecen o contienen remanentes de núcleo en la madurez, carecen de distinción las vacuolas y el citoplasma.
- Células acompañantes asociadas

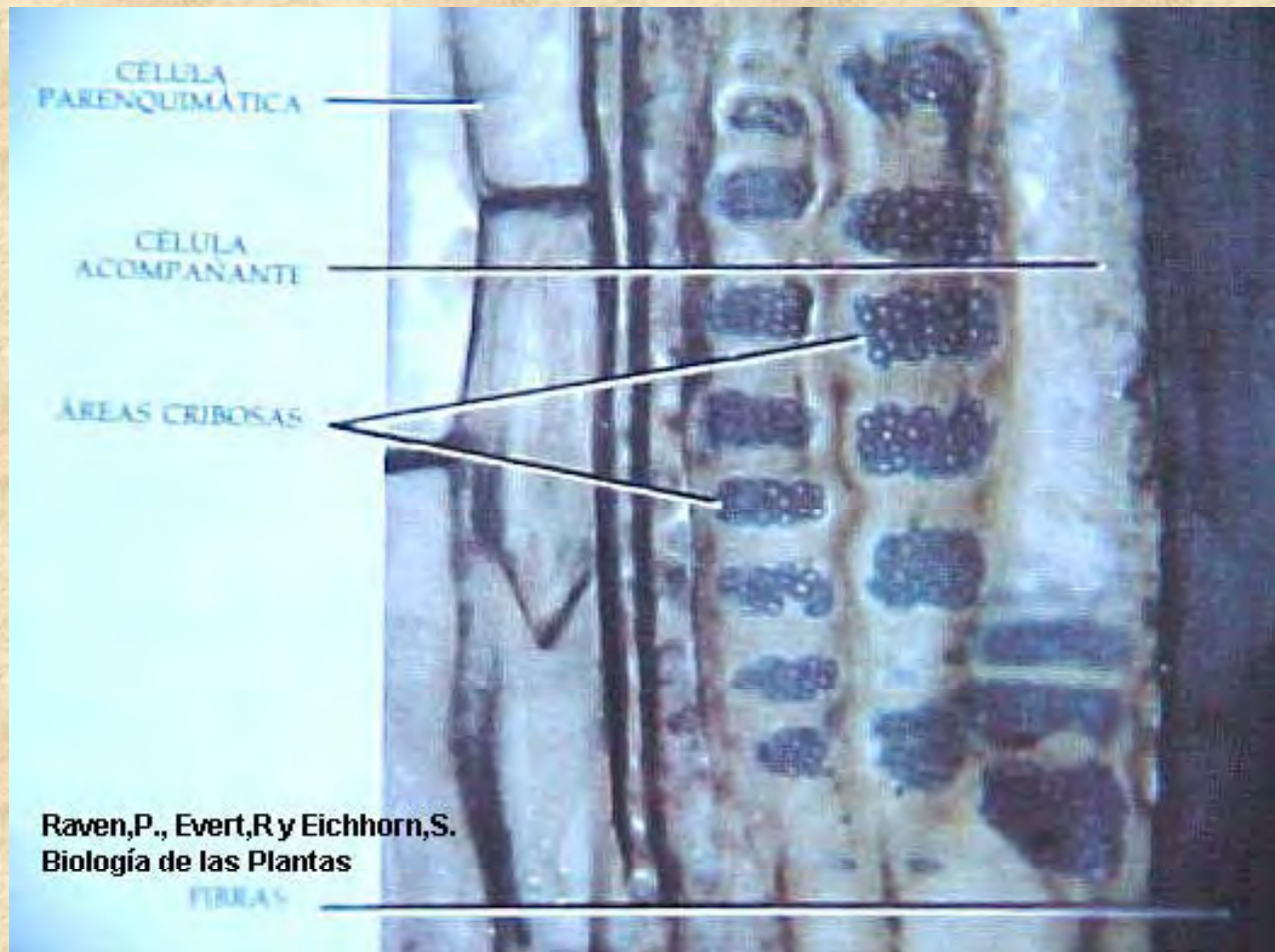
Células acompañantes

- **Más pequeñas que las células conductoras o elementos cribosos**
- **Núcleo prominente**
- **Citoplasma denso, con ribosomas**
- **Transportadores de azúcares a los miembros del tubo criboso**
- **Se origina de la misma célula que se origina el tubo criboso**

PARÉNQUIMA DE TRANSFERENCIA:

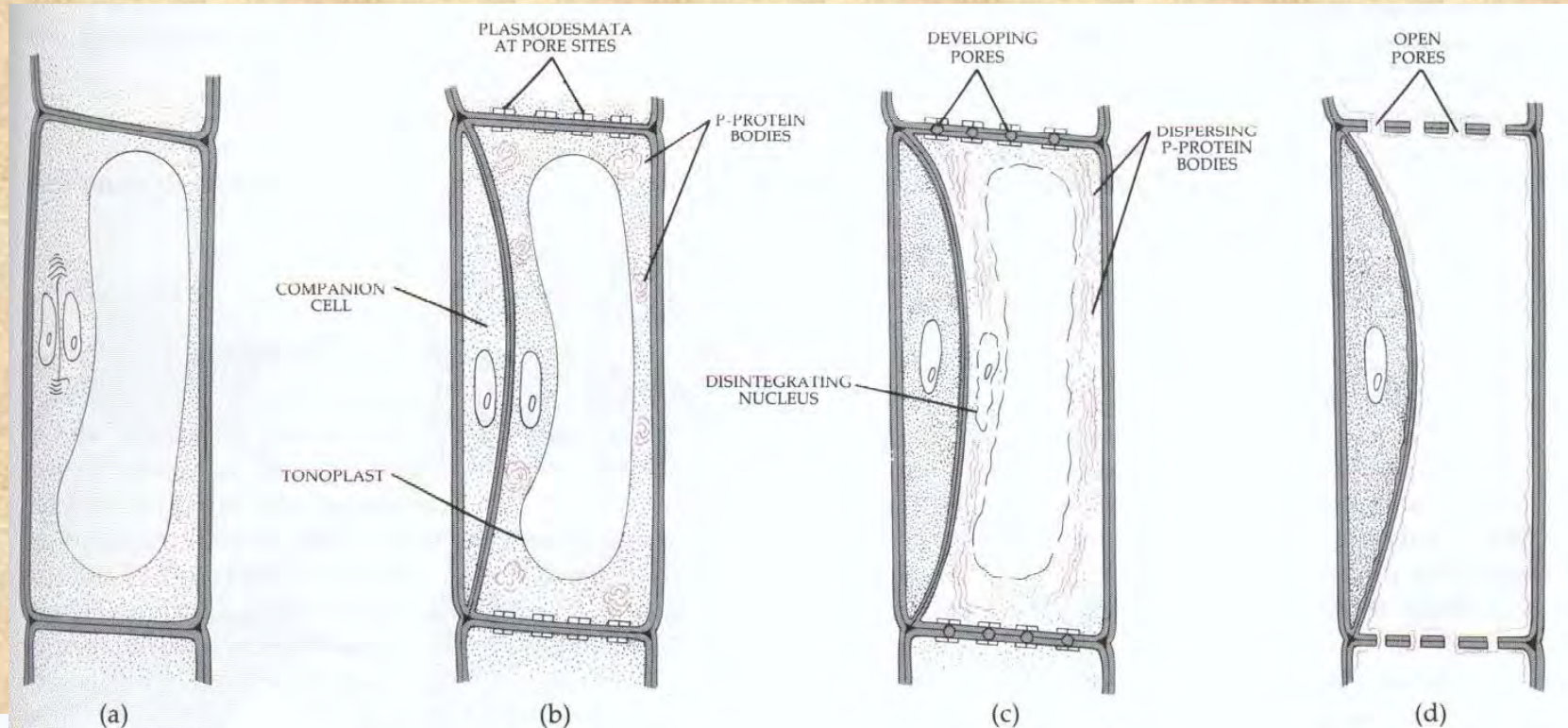
TEJIDO FLOEMÁTICO COMPUESTO DE TUBOS CRIBOSOS





Raven, P., Evert, R y Eichhorn, S.
Biología de las Plantas

Tubo criboso y célula acompañante



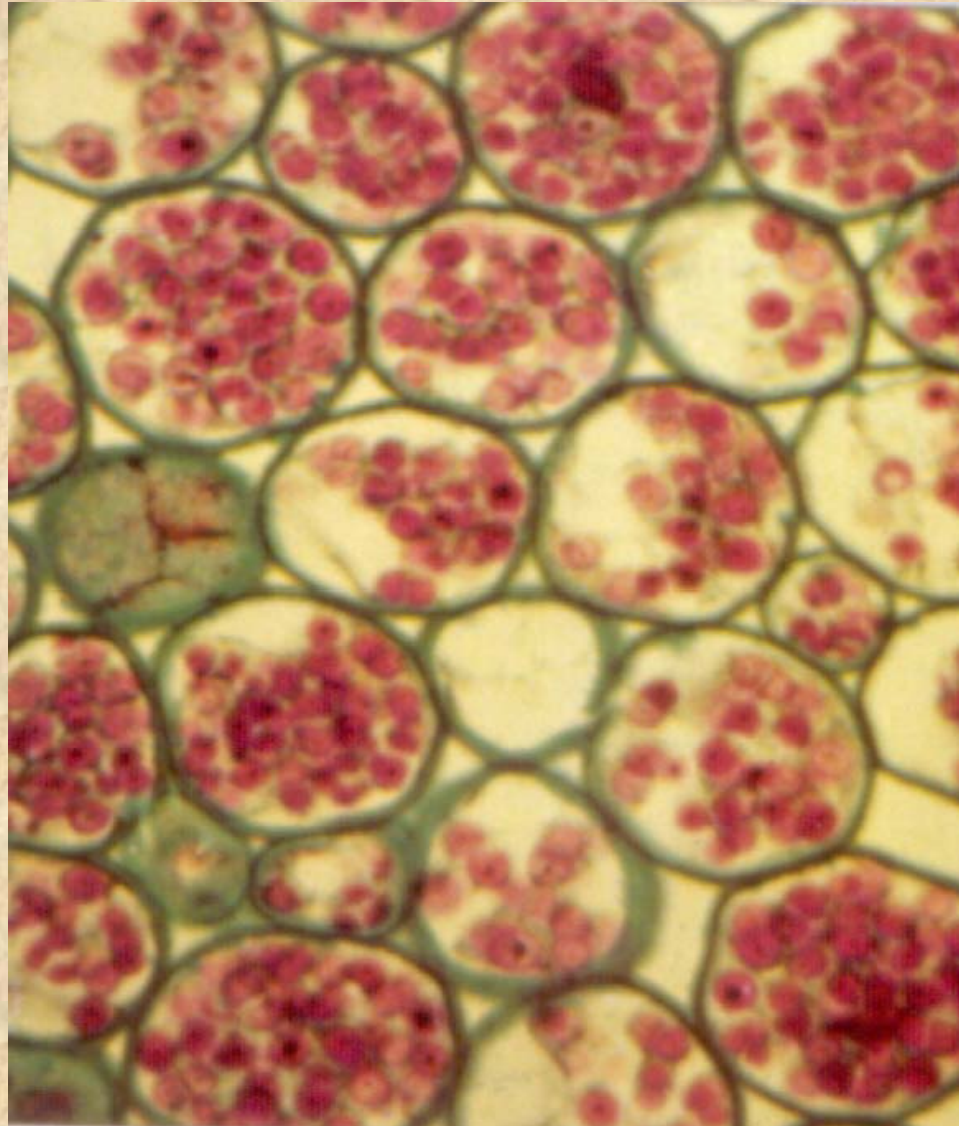
20-18

Diagram illustrating differentiation of a sieve-tube member. (a) The mother cell of the sieve-tube member undergoing division. (b) Division has resulted in formation of a young sieve-tube member and a companion cell. After division, one or more P-protein bodies arise in the cytoplasm, which is separated from the

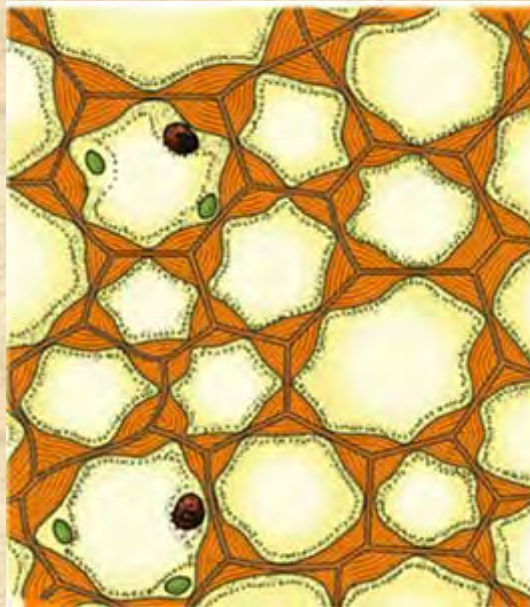
vacuole by a tonoplast. The wall of the young sieve-tube member has thickened, and the sites of the future sieve-plate pores are represented by plasmodesmata. (c) The nucleus is degenerating, the tonoplast is breaking down, and the P-protein bodies are dispersing in the cytoplasm lining the wall; concomitantly,

the plasmodesmata of the developing sieve plates are beginning to widen into pores. (d) At maturity, the sieve-tube member lacks a nucleus and a vacuole. All of the remaining protoplasmic components, including the P-protein, line the walls, and the sieve-plate pores are open.

PARÉNQUIMA DE ALMACENAMIENTO:
EN ESTE CASO SE TRATA DE PARÉNQUIMA QUE ALMACENA
GRANOS DE ALMIDÓN



COLÉNQUIMA



COLÉNQUIMA

Tejidos cuyas células tienen una sola pared, pero engrosada irregularmente. Son tejidos de sostén y resistencia. Se presentan con frecuencia en cactáceas.

Los tipos de colénquima son:

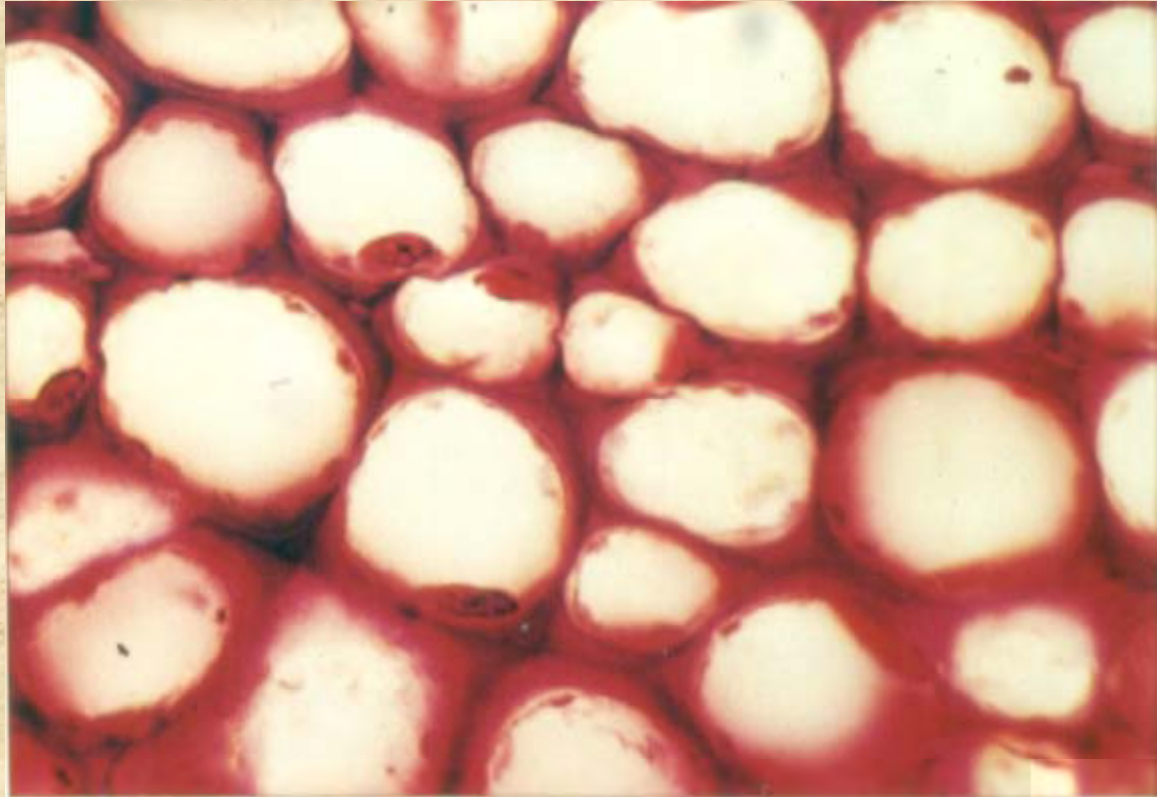
ANGULAR En bordes de tejidos

LAMINAR Se agrupa en capas

LAGUNAR. Se agrupa en capas en torno a una cavidad

ANULAR. Parecido al anterior, pero algunas células tienen lumen.

COLÉNQUIMA ANGULAR



COLÉNQUIMA ANGULAR

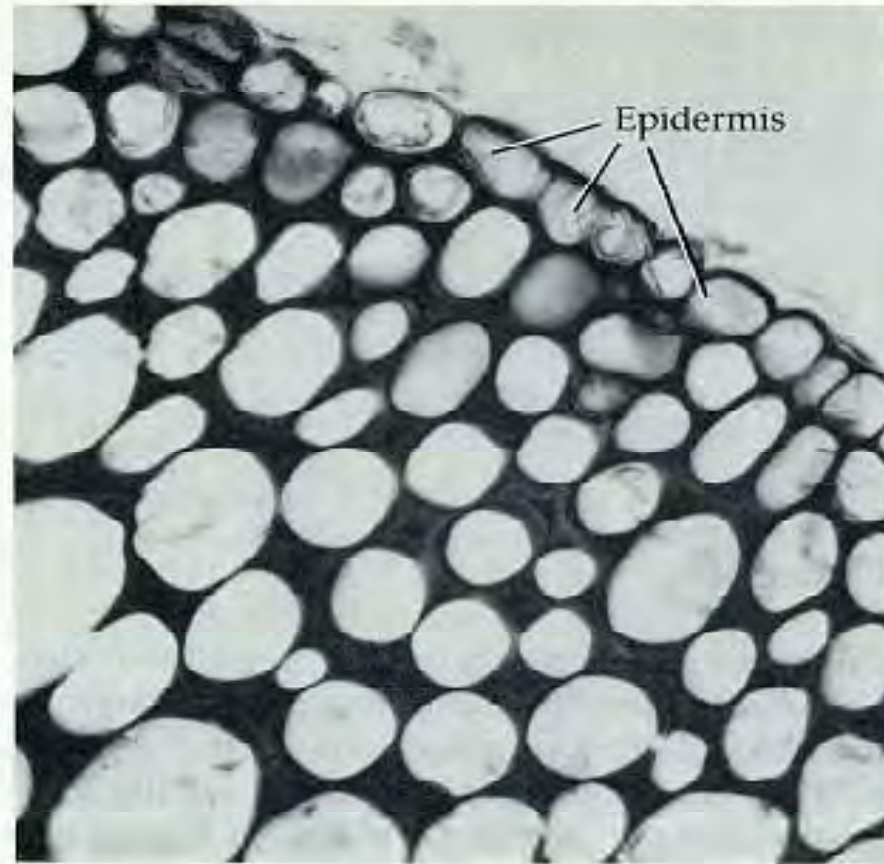


Figure 4.2

The collenchyma cells of this water lily petiole are more fully developed than the cells of Figure 4.1: their walls are much thicker, and the cell lumen appears round. $\times 90$.

COLÉNQUIMA LAMINAR

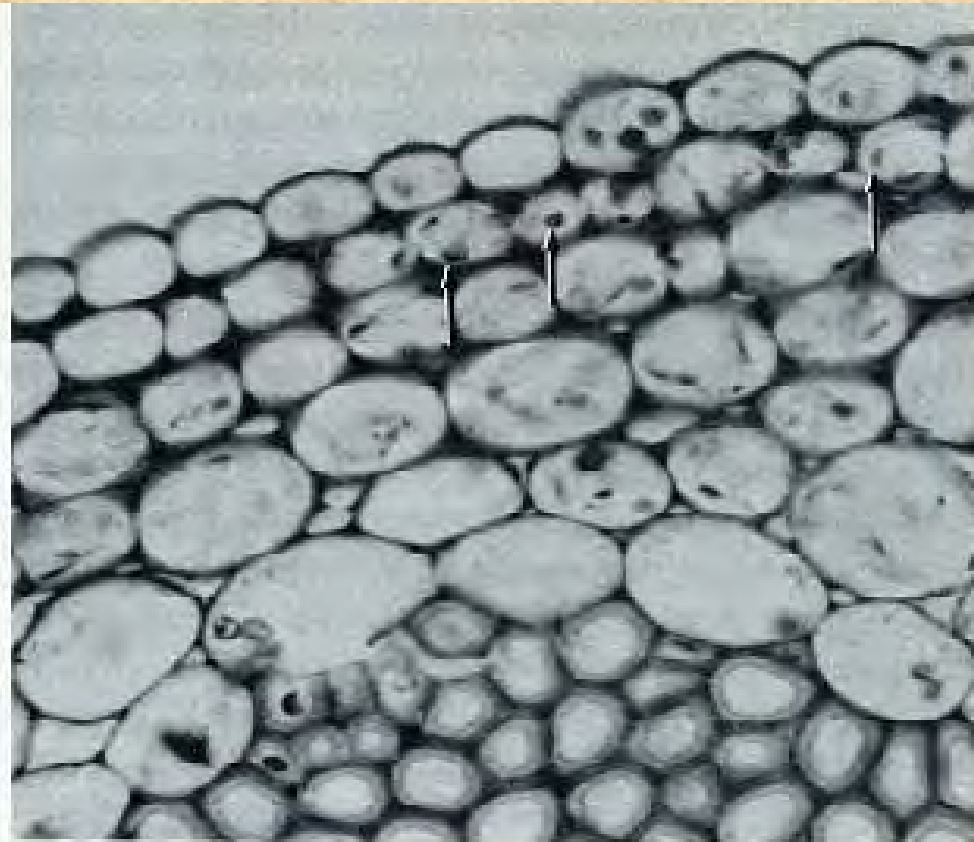
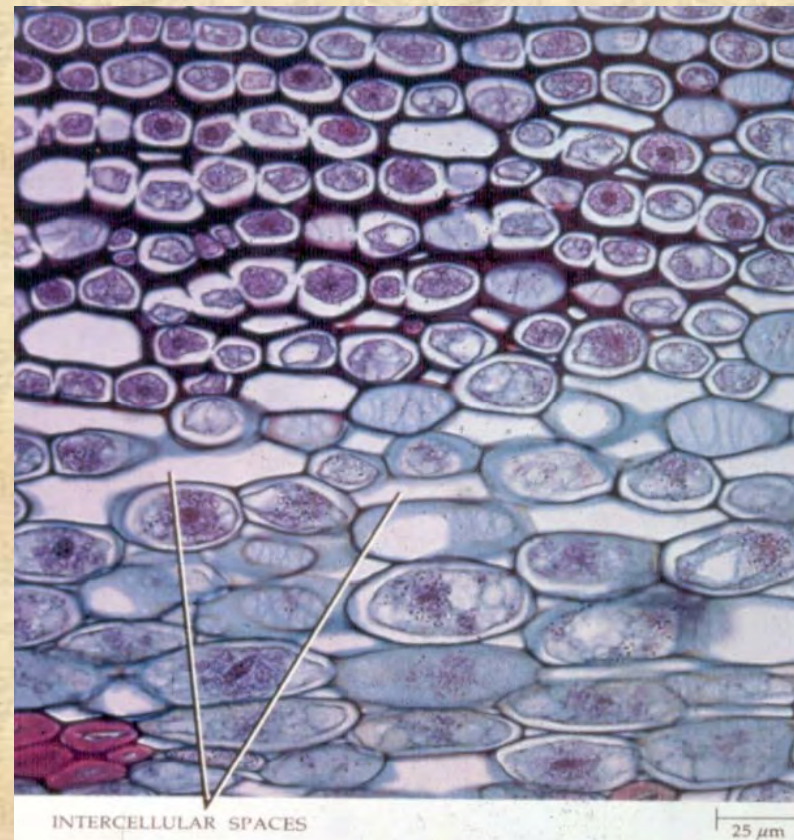


Figure 4.3

This stem has lamellar collenchyma. The inner wall of each epidermis cell is collenchymatous, as are the tangential walls of the second, third, and fourth layers. Chloroplasts can be seen in most of the collenchyma cells (arrows). $\times 75$.

Colénquima laminar



INTERCELLULAR SPACES

25 μm

20-2

Transverse section of the cortex of an elderberry (*Sambucus canadensis*) stem, showing collenchyma cells with unevenly thickened walls (above) and parenchyma cells (below). Clear areas between the cells are intercellular spaces. In some of the parenchyma cells, a meshwork of lines is visible in the facing walls. The light areas within the meshwork are primary pit-fields, thin areas in the walls.

COLÉNQUIMA ANULAR

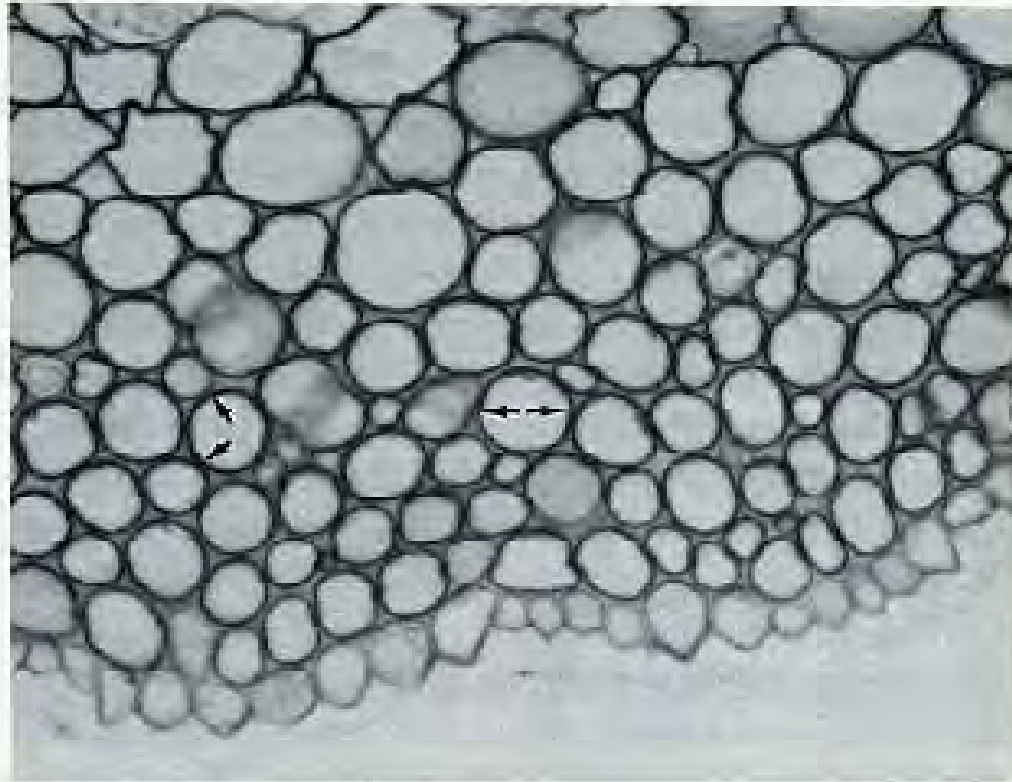


Figure 4.4

These collenchyma cells in the midrib of a *Nerium* leaf have a thin, dark layer of lignin on their inner surface (arrows). $\times 75$.

COLÉNQUIMA ANULAR

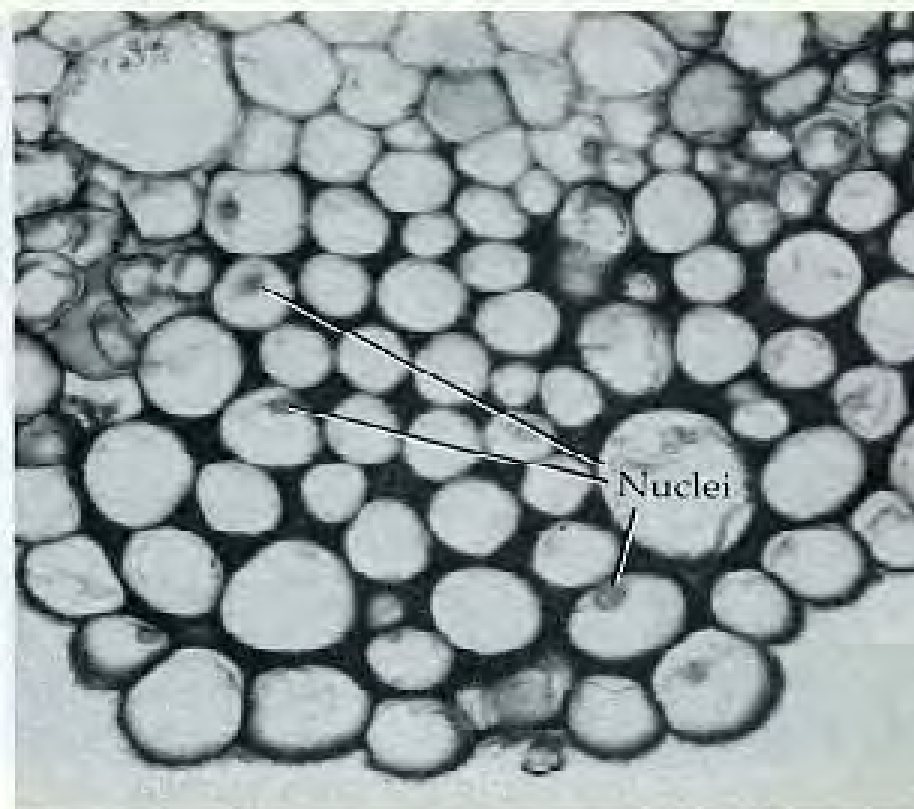


Figure 4.5

This micrograph of the midrib of a leaf of *Sambucus canadensis* shows how localized collenchyma tissue can be: it is restricted to the area just below the midrib and does not extend out into the thin blade region. Nuclei are visible in several cells. $\times 75$.

COLÉNQUIMA ANULAR RADIAL

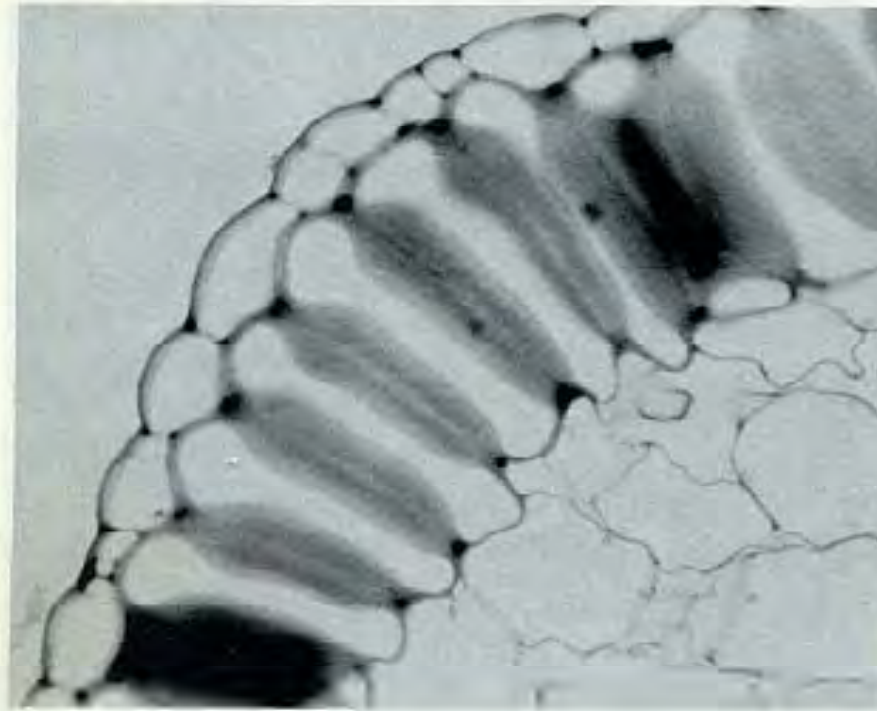
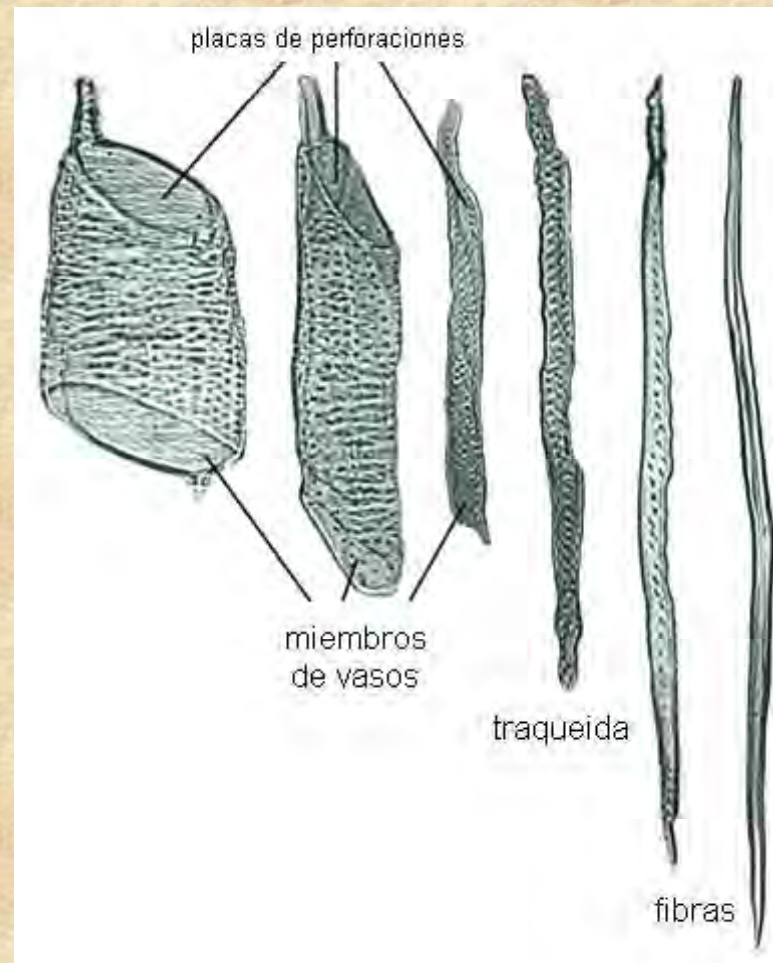
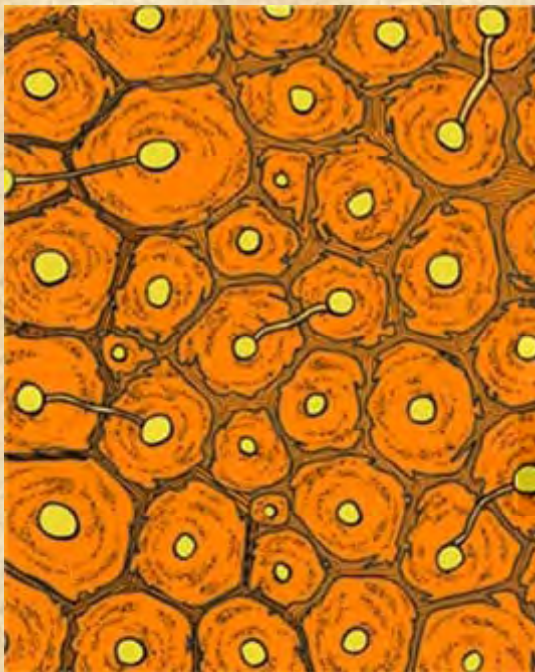


Figure 4.6

The radial walls of these collenchyma cells in *Mammillaria magnimamma* are the ones that are the thickest, whereas the tangential walls are thin. Notice that only one single cell layer is collenchymatous: the next layer inward has no sign of wall thickening, and the inner wall of the epidermis has only a trace of extra wall material. $\times 100$.

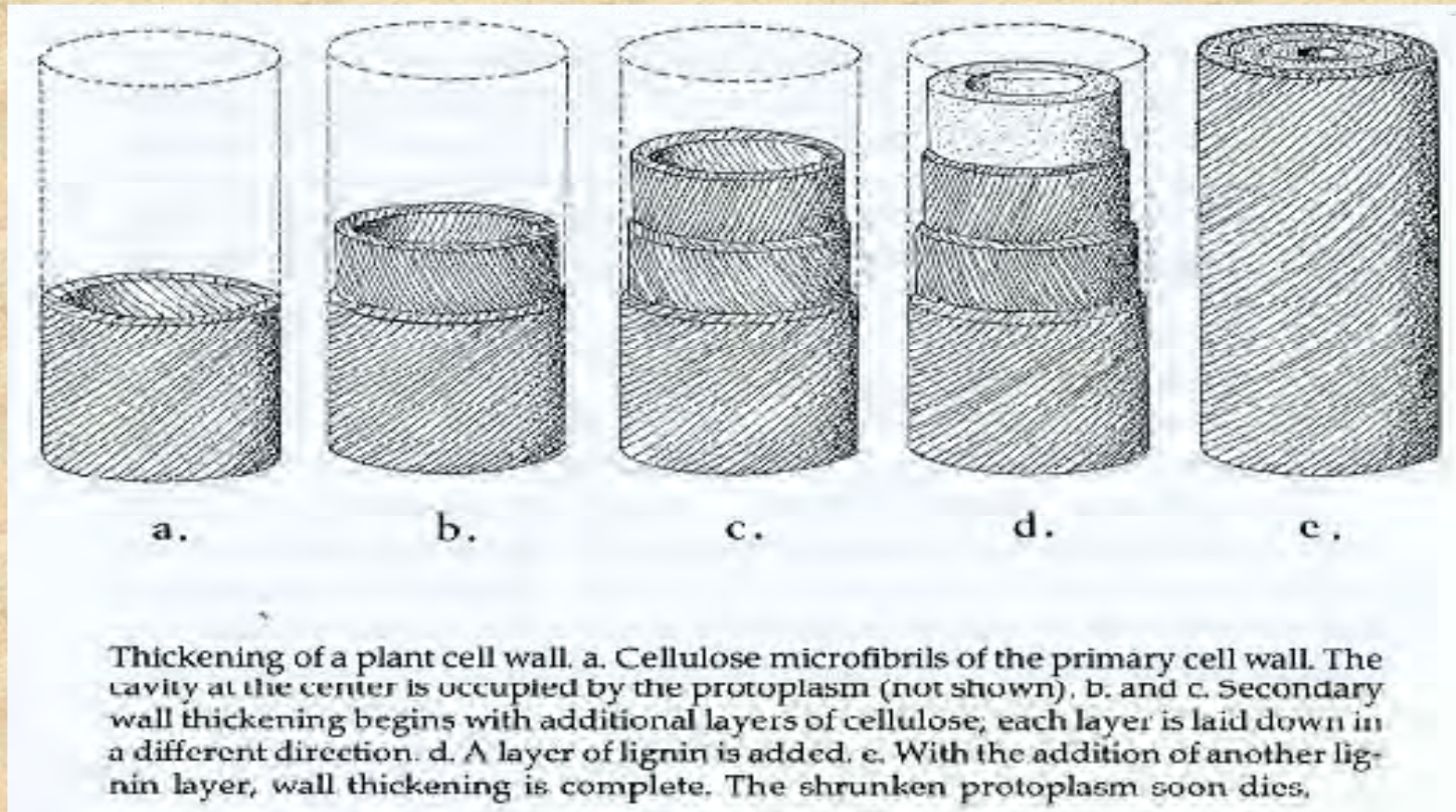
ESCLÉRENQUIMA



ESCLERÉNQUIMA

Tejidos que pueden ser de sostén y de conducción(xilema).

Tiene doble pared celular con la segunda con tres capas:
S1, S2, S3.



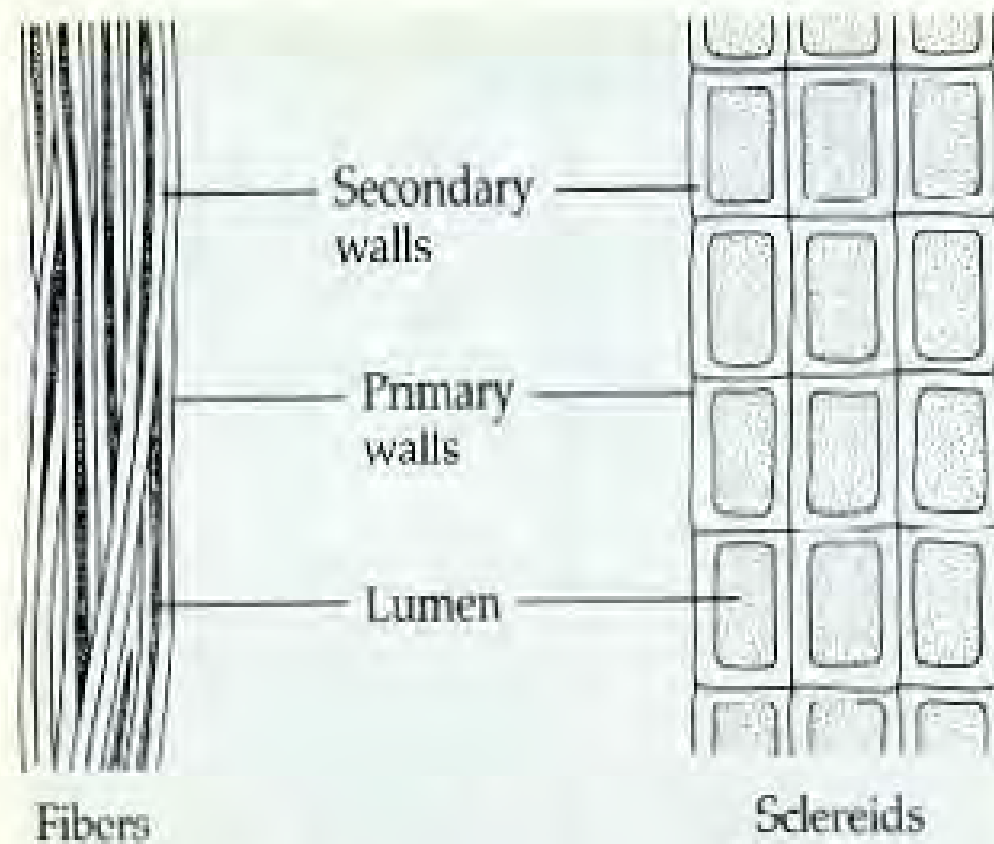


Figure 5.10

A mass of fibers can flex and twist, but it resists stretching. A mass of sclereids, because of the cross walls, resists motion in all directions.

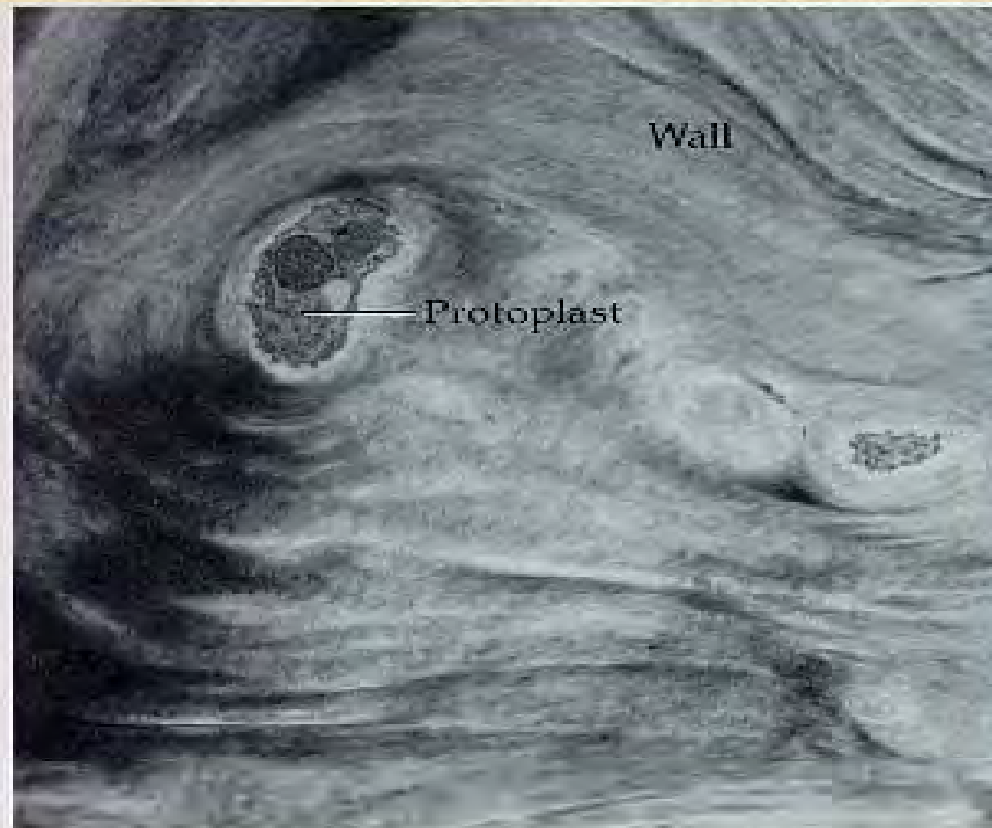


Figure 5.3

This is an electron micrograph of a sclerenchyma cell, showing the very thick, prominent secondary wall. $\times 1000$. Micrograph generously provided by W. M. Harris.

TIPO DE CÉLULAS DEL ESCLERÉNQUIMA:

- a) ESCLEREIDAS- AMORFAS CON LUMEN MUY CERRADO Y SON DE SOSTÉN EXCLUSIVAMENTE, YA QUE DAN RIGIDEZ.
- b) FIBRAS- SON FUSIFORMES MUY GRANDES, CON POCO LUMEN Y SON EXCLUSIVAMENTE DE SOSTÉN
- c) TRAQUEIDAS- ELEMENTOS DE CONDUCCIÓN PRIMITIVOS CON LUMEN Y PUNTEADURAS
- d) FIBROTRAQUEIDAS- MÁS LUMEN QUE LA ANTERIOR
- e) FIBRAS LIBRIFORMES VASOS- VASOS ALARGADOS
- f) ELEMENTOS DE VASO- VASOS CORTOS CON PLACAS DE PERFORACIÓN Y PUNTEADURAS

ESCLEREIDAS

Tipos:

Braquiesclereidas- células pétreas, son isodiamétricas.

Macroesclereidas- en forma de bastones y forman capas

Astroesclereidas- con ramificaciones y diamétricas

Osteoesclereidas- alargadas y engrosadas en los extremos

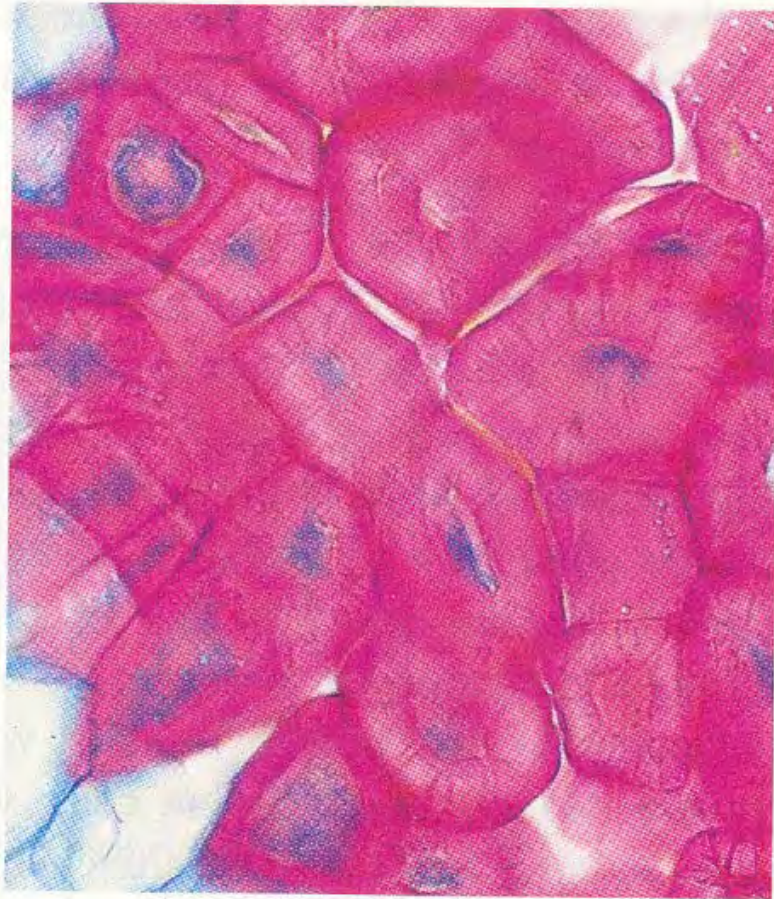
Tricoesclereidas- muy alargadas y delgadas, difieren de las fibras en que se ramifican.

braquiesclereida



Figure 5.8

These are sclereids in the leaf of *Hedyosmum bonplandianum*. It is possible that the presence of such cells makes the leaf inedible (see Fig. 5.12), or possibly they act as water reservoirs. Two types of sclereids are present: in the center of the cluster are isodiametric brachysclereids; the outer ones are macrosclereids. These cells are part of a leaf clearing; the leaf was treated with bleach to make it transparent, then the lignin was stained with the dye basic fuchsin. Material generously provided by C. Todzia. $\times 150$.



10 μm

macroesclereidas



Figure 5.1

These sclereids in the shell of a coconut (*Cocos nucifera*) show how thick the secondary wall can become; the small black oval in the center of each is the lumen of the cell. The wall is much more voluminous than the protoplast. In several cells, the walls show numerous striations, indicating the many fine layers that contribute to the wall. The pits (the dark lines radiating away from each lumen) are elongate and most are branched. At the arrow, the surface of a cell is visible, and the pits are seen to be rather circular in cross section. $\times 100$.

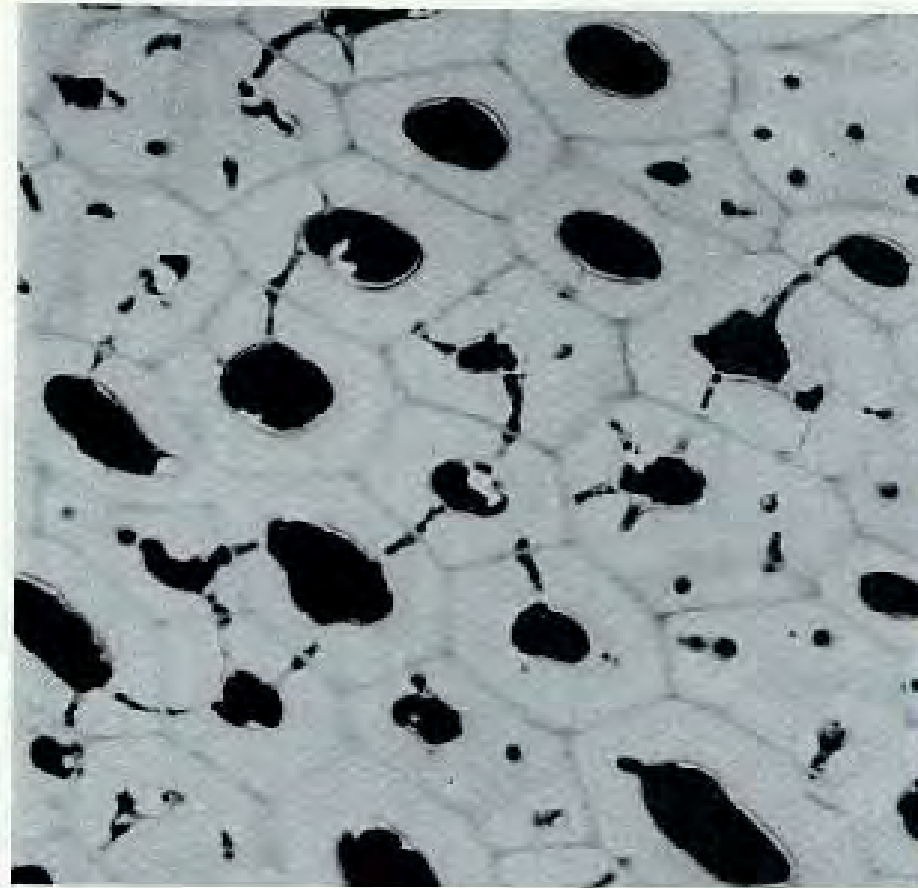


Figure 5.4

These sclereids of *Diospyros* (persimmon) endosperm have fewer but wider pits than do those of Figure 5.1, and it is possible to see that a pit of one cell meets a pit in neighboring cells. The primary walls and middle lamellas are visible as a dark line; where they cross the pit pairs they are known as a pit membrane. $\times 100$.

macroesclereidas

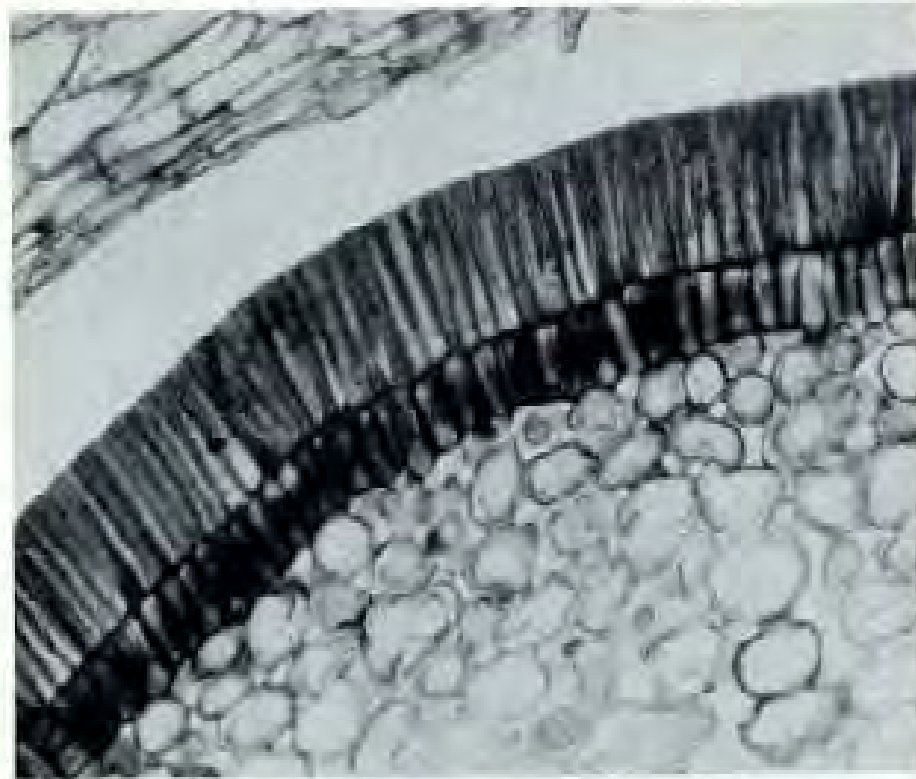


Figure 5.11

This is the seed coat of bean, consisting of an outer layer of macroscleireids and an inner layer of developing osteosclereids. $\times 90$.

Astroesclereida

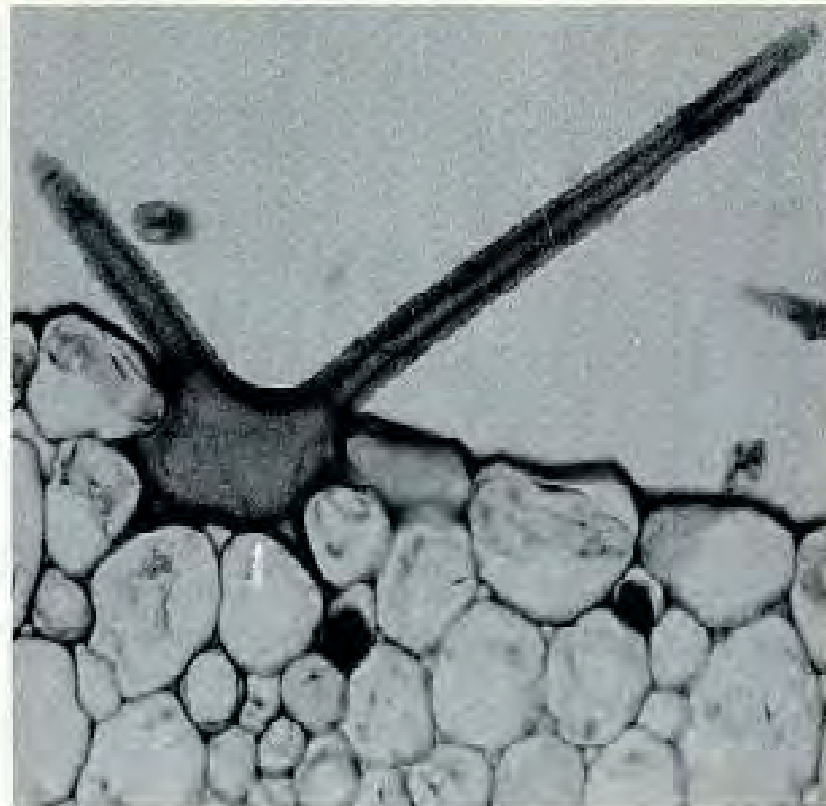


Figure 5.13.

This is only a small part of an astroclereid, showing part of two arms that project into a large intercellular space in a water lily petiole. $\times 100$.

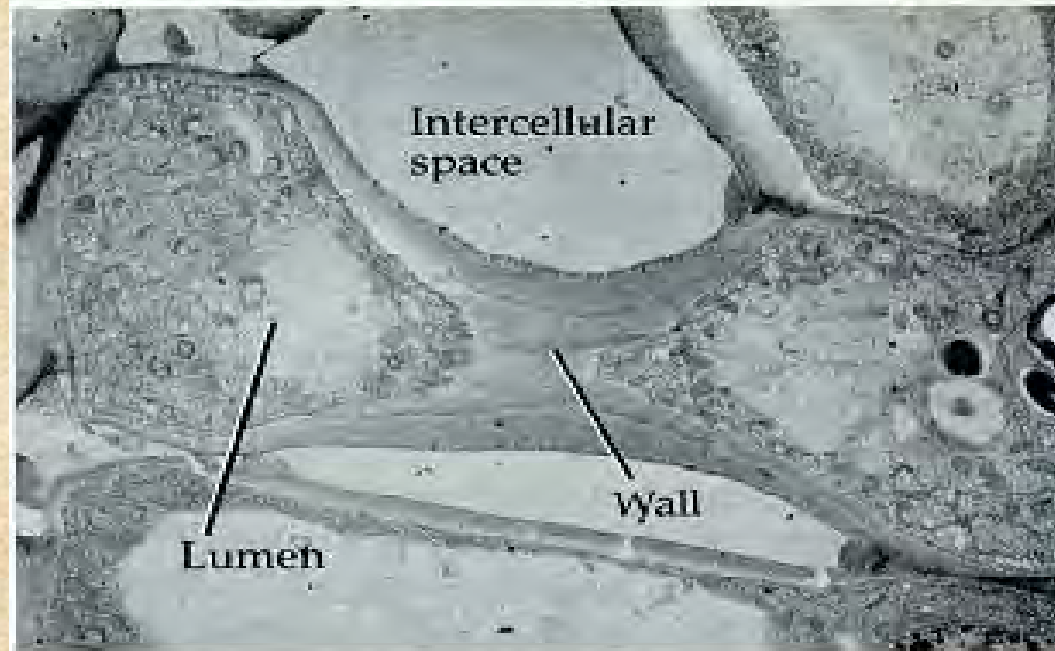
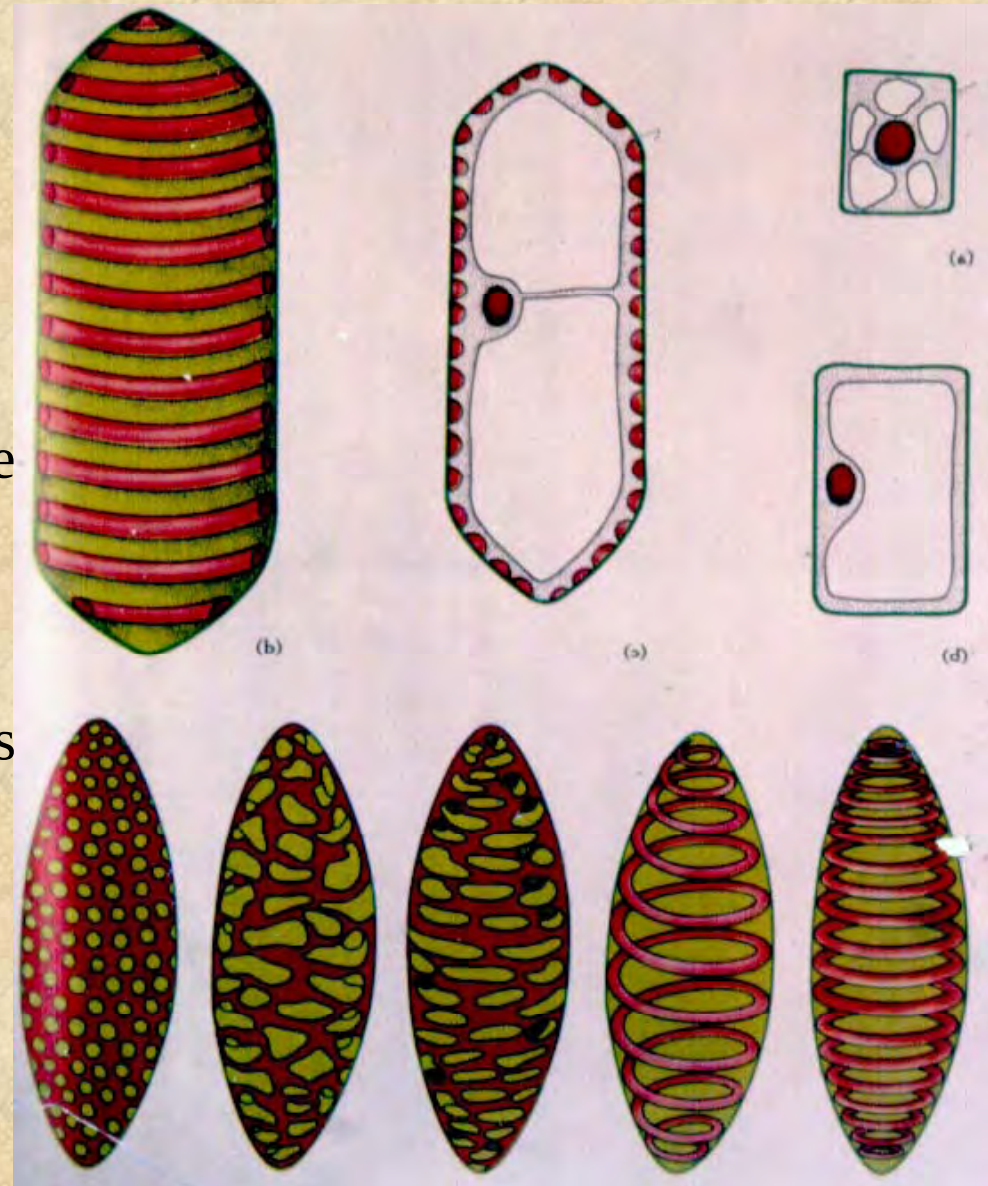


Figure 5.14

An early stage in the development of an osteosclereid. The cell lumen was originally cylindrical, but then wall deposition in the midregions prevented further enlargement. At the time the specimen was fixed, turgor pressure was causing the ends to swell, establishing the bonelike shape. Micrograph generously provided by W. M. Harris. $\times 1000$.

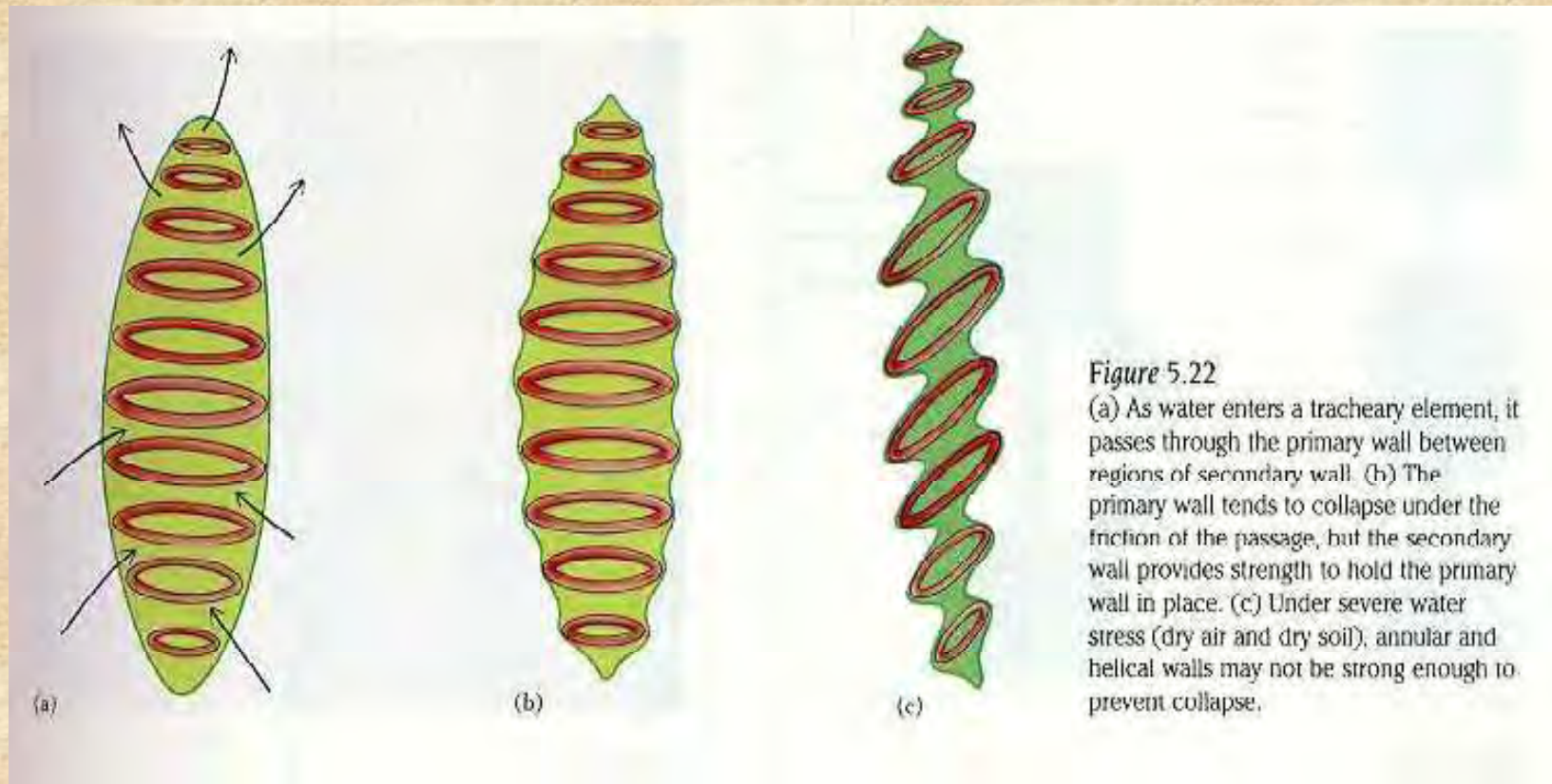
Osteosclereida

Las traqueidas son elementos de conducción primitivos y se caracterizan por carecer de perforaciones en la primera pared células largas, imperforadas en sus extremos, con depositación de pared secundaria en forma **escaleriforme o punteada**, que mueren en la madurez. Se comunican a través de los campos de puntuaciones primarias o a través de las puntuaciones.



TIPOS DE TRAQUEIDAS

Pared secundaria: función



Las fibras son elementos de sostén.

Son células muy alargadas (a veces de varios cm de longitud) que tienen como función principal el sostén de la planta.

Hay varios tipos de fibras:

Extraxilarias- localizadas fuera del xilema.

Xilarias- Localizadas en el xilema y de múltiples formas.

Gelatinosas o mucilaginosas- localizadas en la madera y cuyas paredes absorben agua y se hinchan.

Septadas- aquellas que se dividen y forman paredes delgadas

De sustitución- células alargadas y que pueden ser consideradas parenquimatosas.



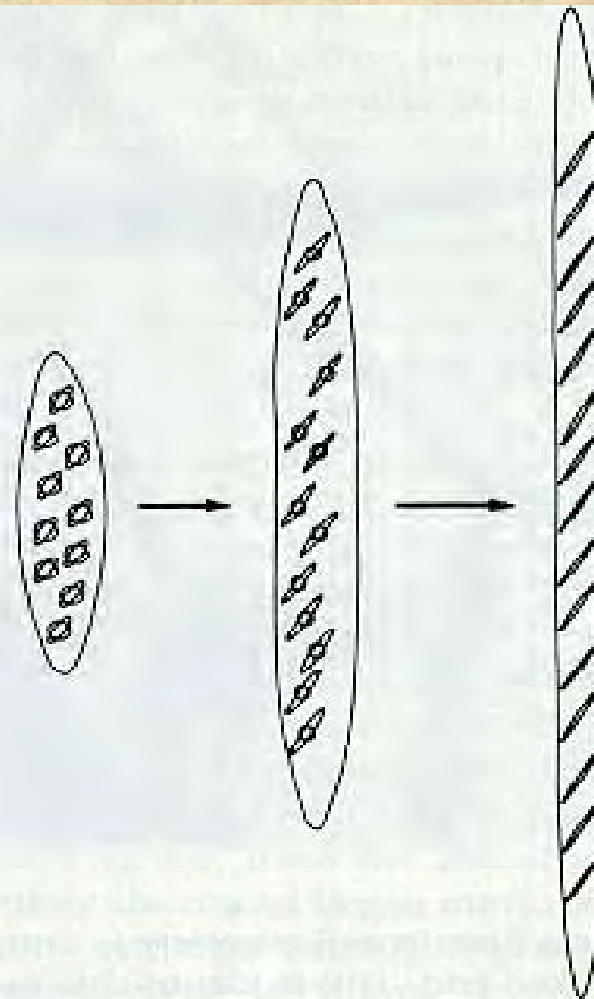


Figure 5.15

This diagram represents the presumed evolution of tracheids into fiber-tracheids, then into libriform fibers. The cells increased in length, the walls became thicker, and the pits became narrower and simpler.

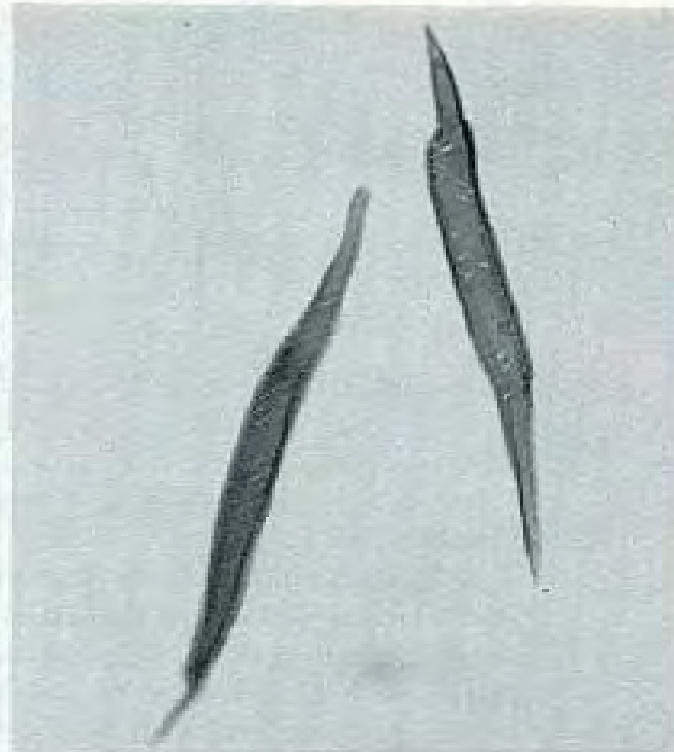


Figure 5.7

These fiber-tracheids of *Weingartia westii* are rather short for fibers, but they have pits with elongate inner apertures. The centers of several pits are bright and rather circular, indicating that there are small chambers, making these fiber-tracheids. Note that in each cell the inner apertures of some pits are elongate in one direction and that the apertures of others are perpendicular. This is because both the front and back wall are visible, and the two sets of pits appear superimposed. These cells were prepared by maceration: they were treated with acid until the middle lamella dissolved. $\times 250$.



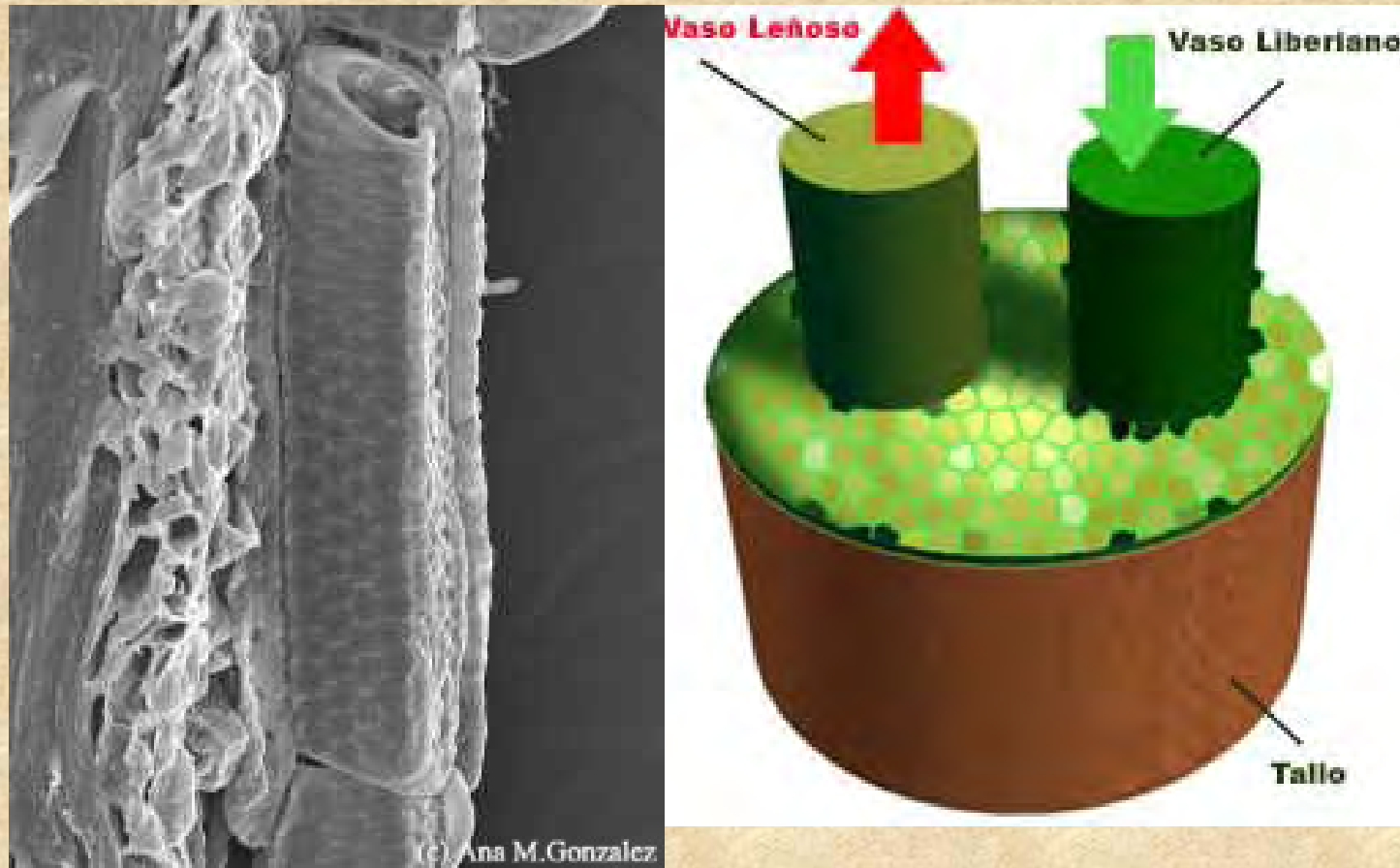
Figure 5.16

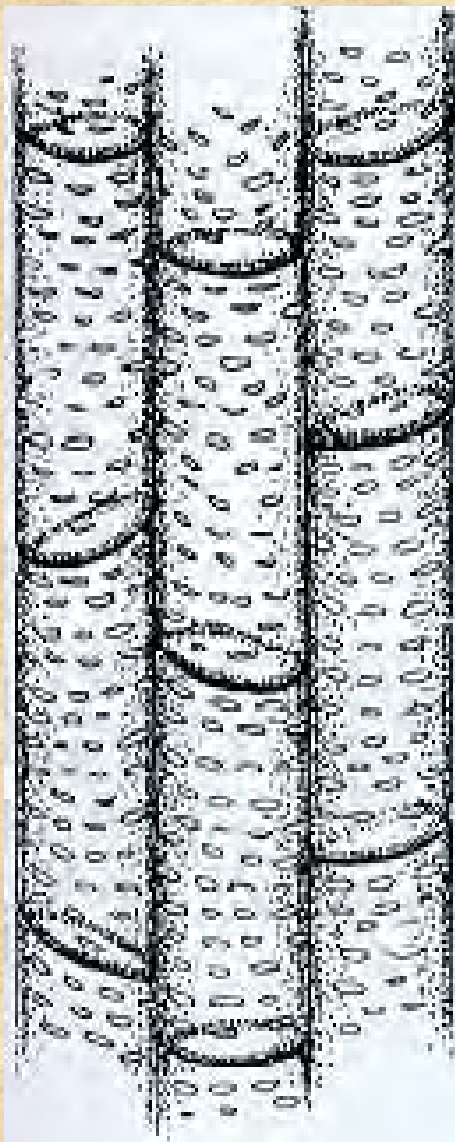
This libriform fiber from *Leptocereus* is unusual in having a forked end. This is identifiable as a libriform fiber (rather than a fiber-tracheid) because the pits are small and without a pit chamber. $\times 300$.



FIBRAS Y FIBROTRAQUEIDAS

Vasos y elementos de vasos en el xilema





a.

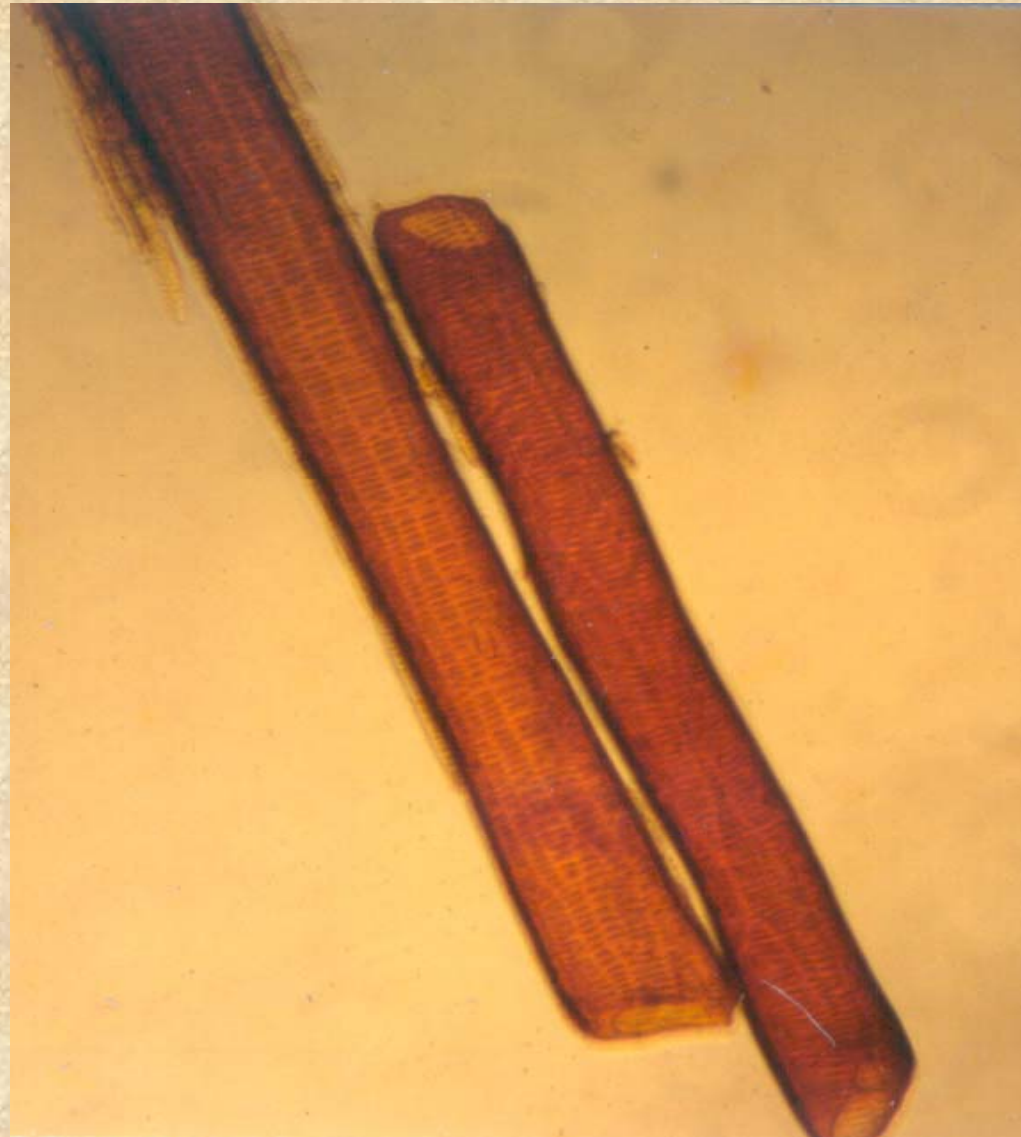


b.

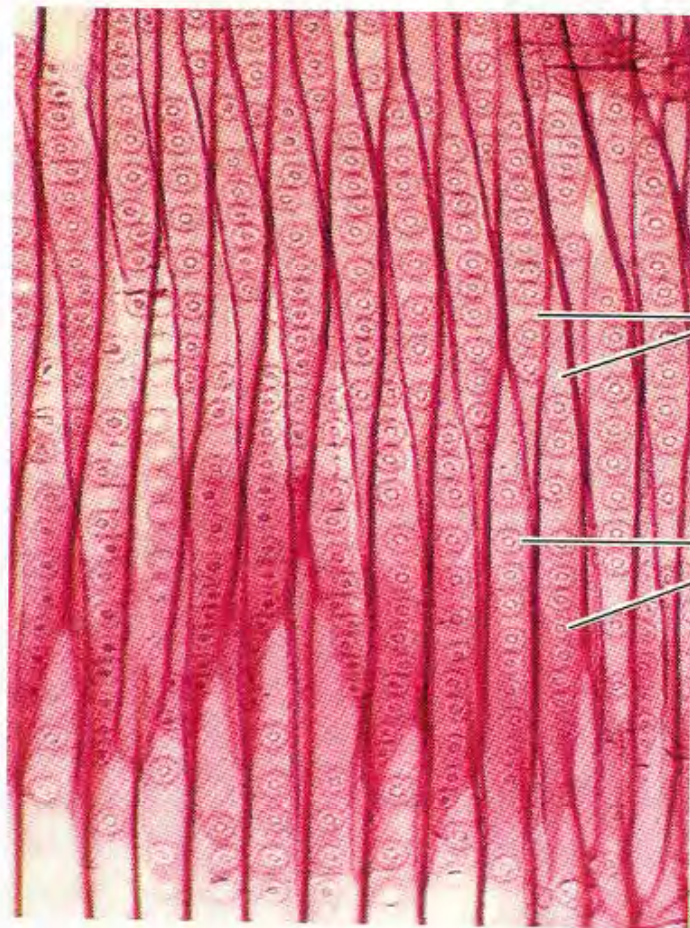
Water- and food-conducting cells.
a. Columns of vessel cells in the xylem. Numerous pits perforate the side walls; end walls and protoplasm are missing. b. Sieve tubes (large cells) and companion cells (small cells) in the phloem. End walls of the sieve tubes are called sieve plates; living cytoplasm connects the cells. Companion cells contain the nuclei that control the activities of both cell types.



Elementos de vaso



ELEMENTOS DE VASO

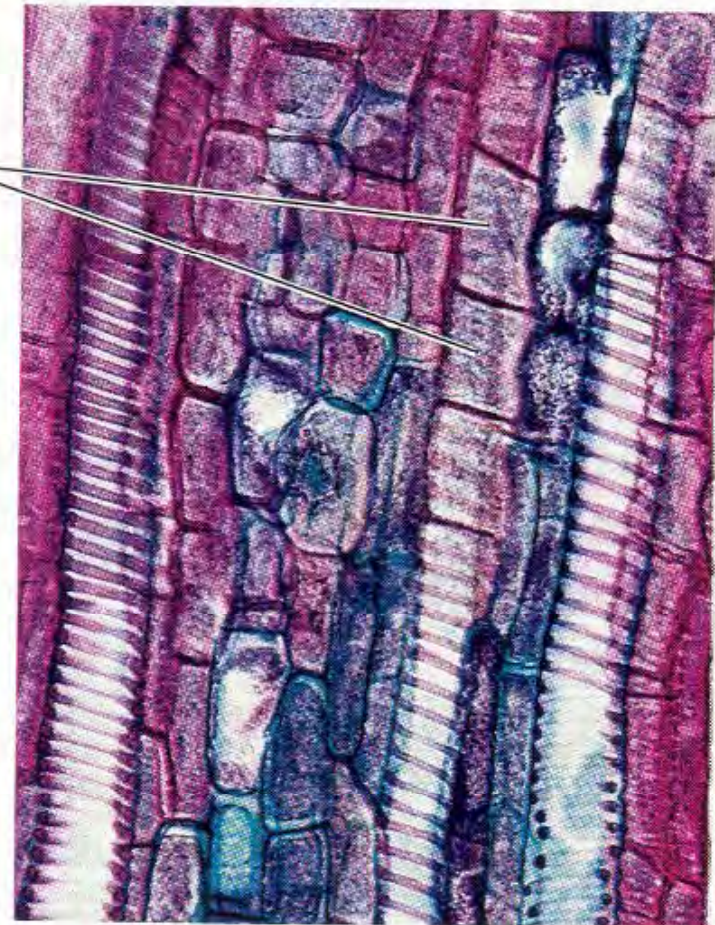


50 μm

Vessel
elements

Tracheids

Pits



50 μm

(c) Xylem showing tracheids (left) and vessel elements (right)
in longitudinal sections

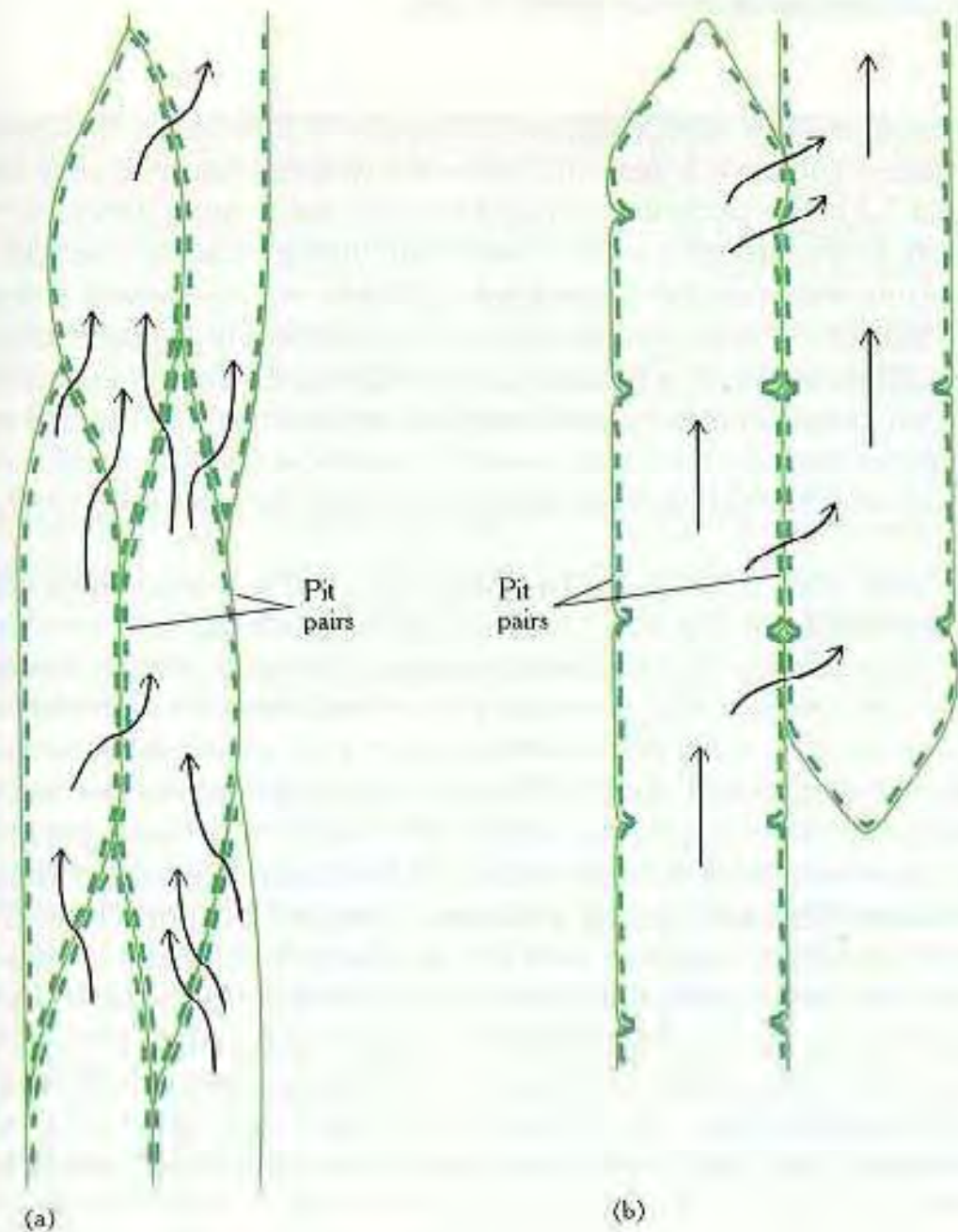
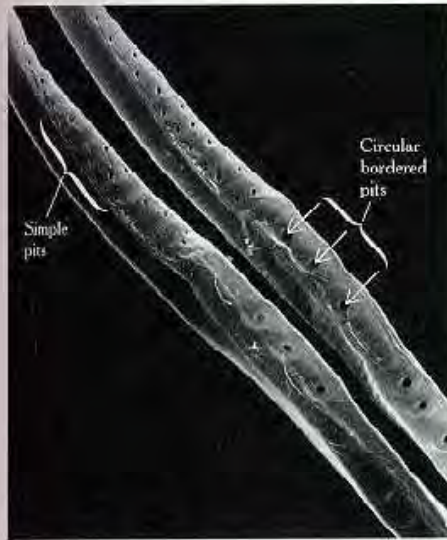


Figure 5.25

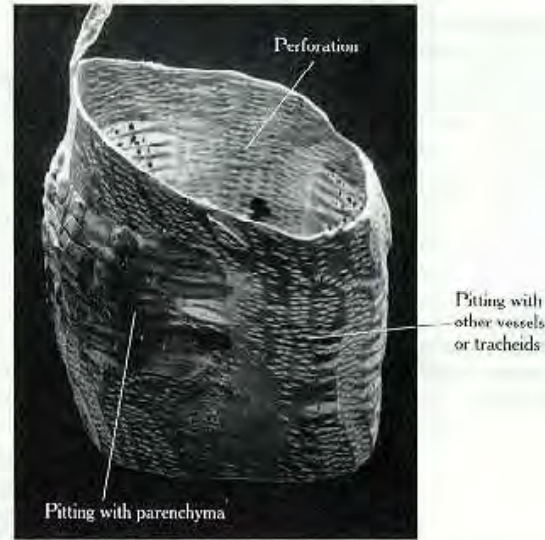
(a) Water can pass between tracheids only through pit-pairs. (b) Water can pass between vessel elements through perforations, but it can pass between vessels only through pit-pairs.

Figure 5.20

Tracheary elements. (a) and (c) Tracheids are long cells with tapered ends. The primary wall is complete over the whole surface, and in (c) it is so thin the inner, spiral secondary wall is visible. In (a), the primary wall tore during specimen preparation, permitting views of circular bordered pits and simple pits. (b) and (d) Vessels tend to be wider and shorter than tracheids, but the most important feature is the perforation, the large hole at each end. (a) $\times 600$; (b) $\times 270$; (c) $\times 100$; (d) $\times 200$. (a and b courtesy of W.A. Côté, Jr.)



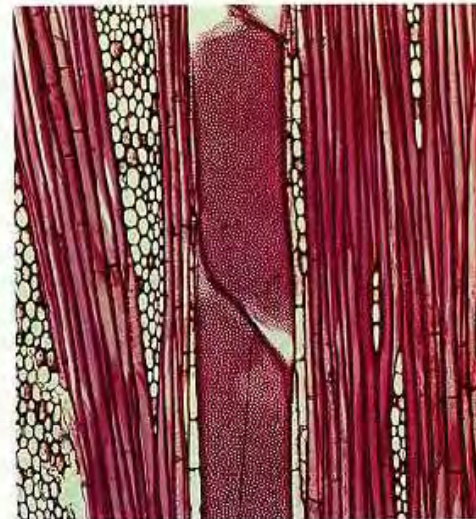
(a)



(b)



(c)



(d)

Traqueidas y elementos de los vasos



Figure 5.19

These are septate libriform fibers in the wood of *Triomma malaccensis*. Note how dark the septa are but that the dark staining does not extend into or along the secondary walls of the original mother cell. In several cells you can see at least two septa, and many more would be visible if entire cells were shown. $\times 75$.

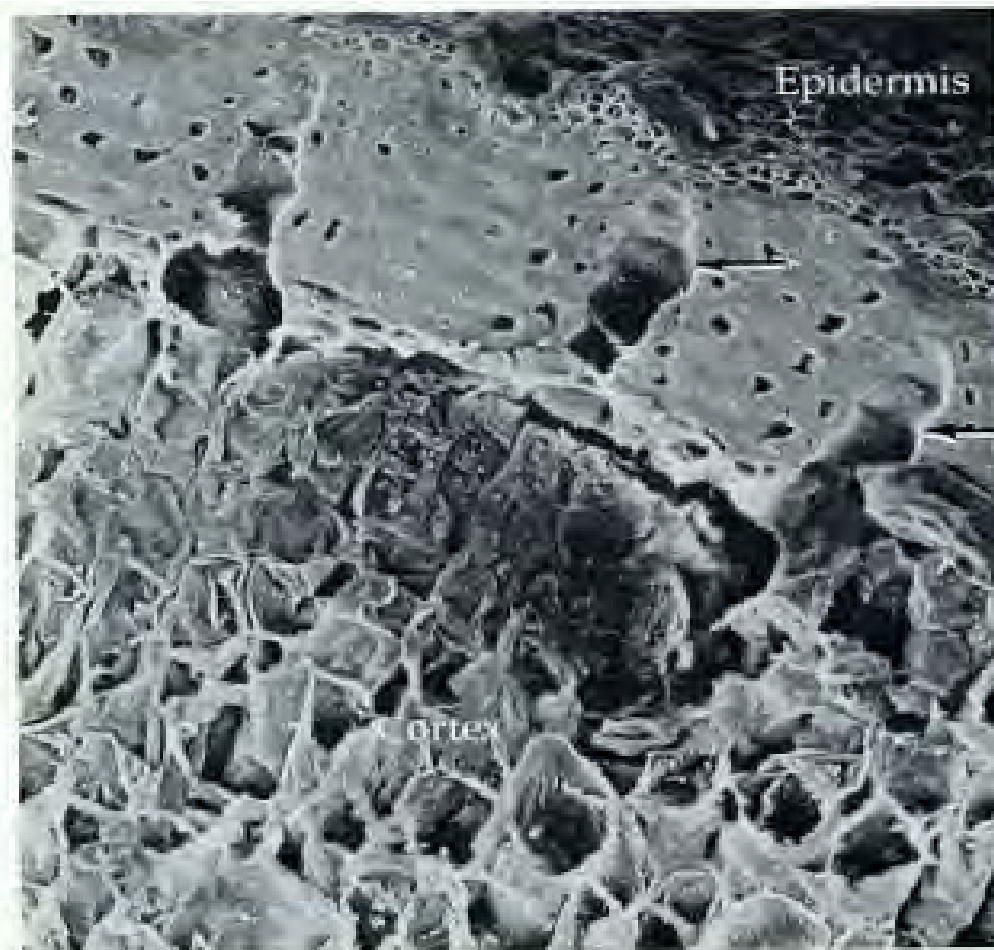
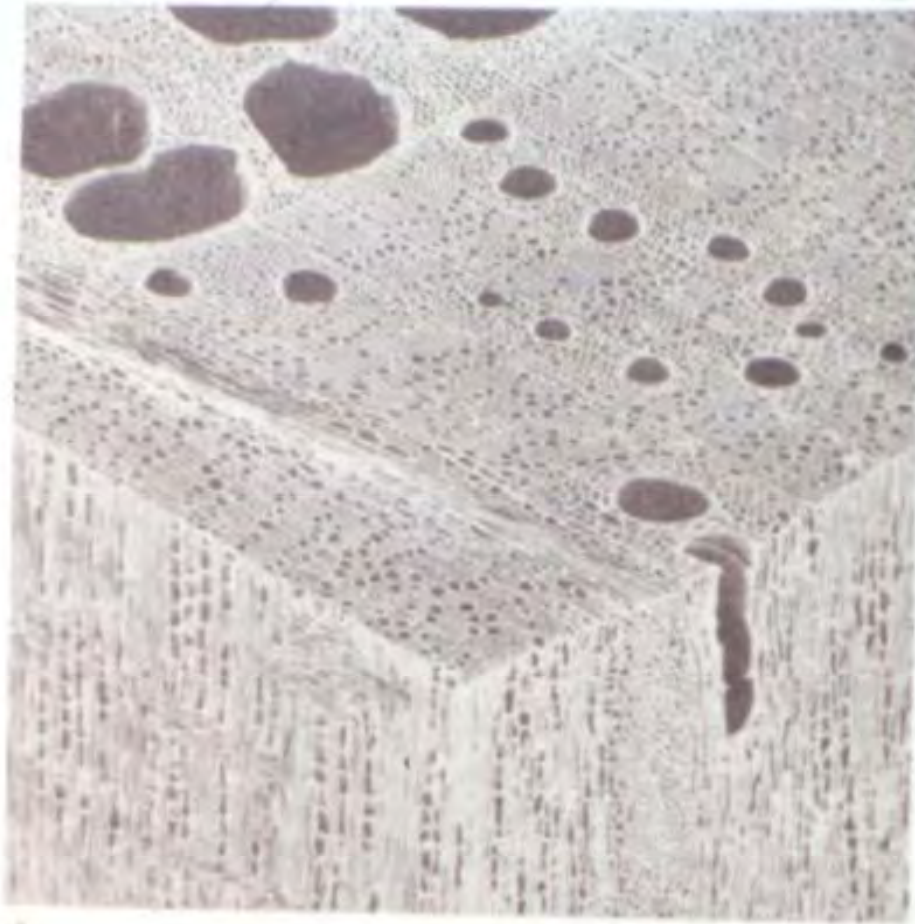


Figure 5.2

This scanning electron micrograph shows the surface of a large cactus, *Trichocereus chilensis*. The epidermis has thin walls, but the next six or seven layers are sclereids with extremely thick walls, which protect the plant from animals and fungi and help conserve water. The three canallike regions (arrows) are located below stomata and permit carbon dioxide to pass through the sclerenchyma layer. $\times 75$.



A

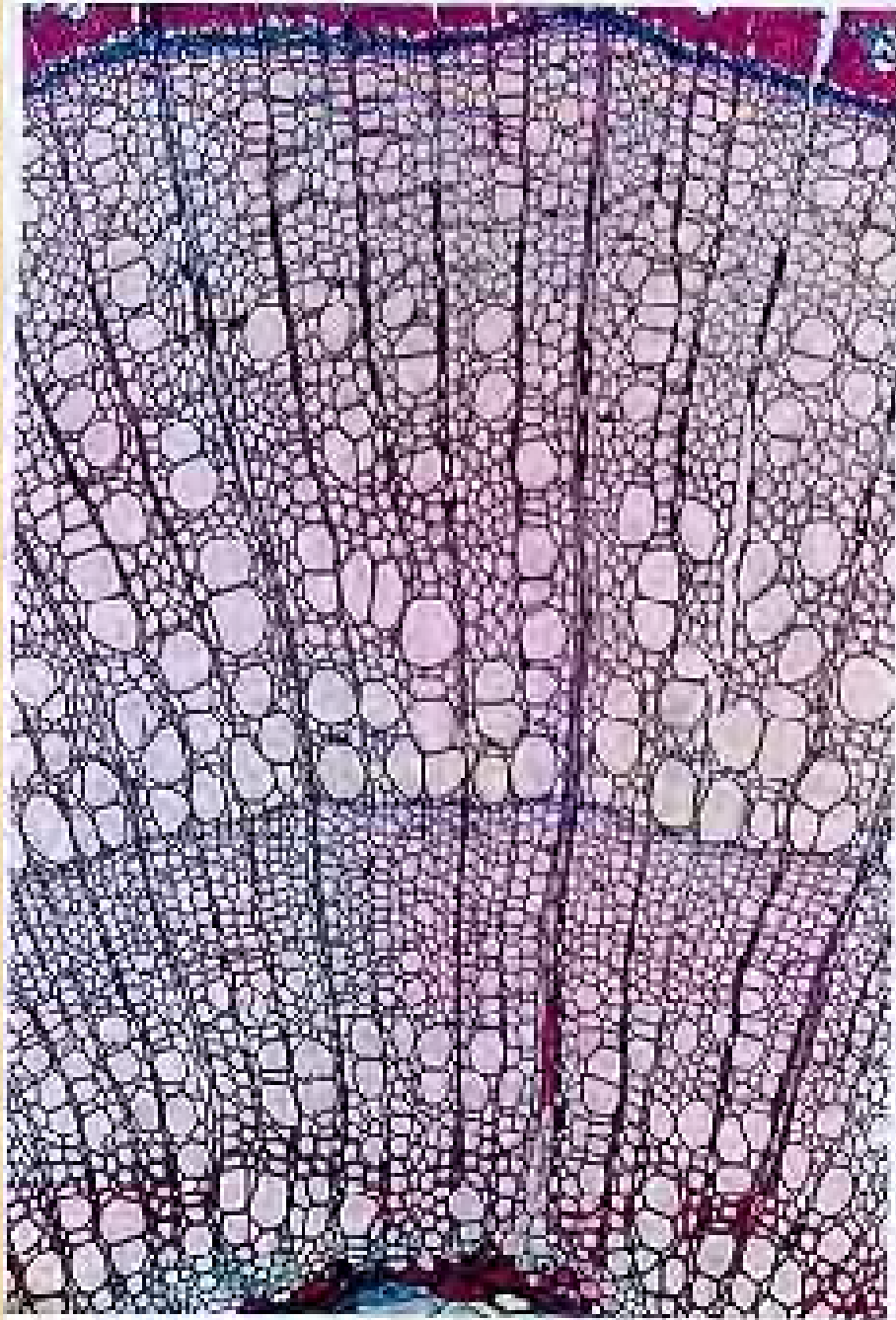


B

Figure 15.10

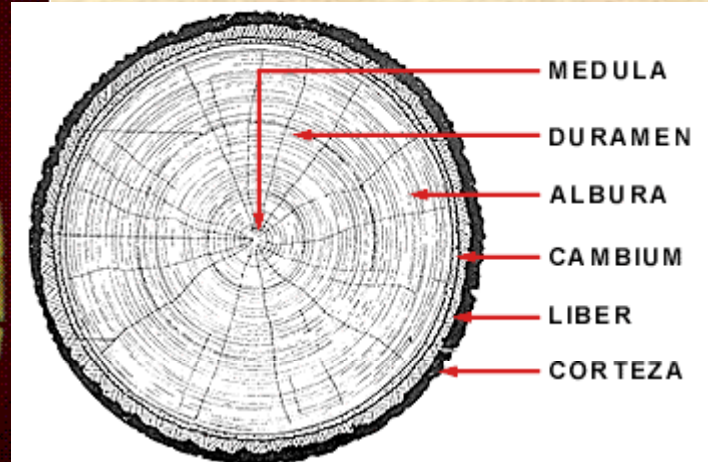
(A) This scanning electron micrograph shows the three-dimensional relationships of the wood elements in red oak. In cross section are visible the vessels of springwood and summerwood, paratracheal parenchyma, and fibers. The radial longitudinal face (left) and the tangential face (right) show the structure of the rays. $\times 120$. (B) This magnification of the vessels shows the regions of crossfield pitting (large pits) and intervacular pitting (small pits). $\times 100$. Both micrographs generously provided by W. A. Côté, N. C. Brown Center for Ultrastructure Studies.

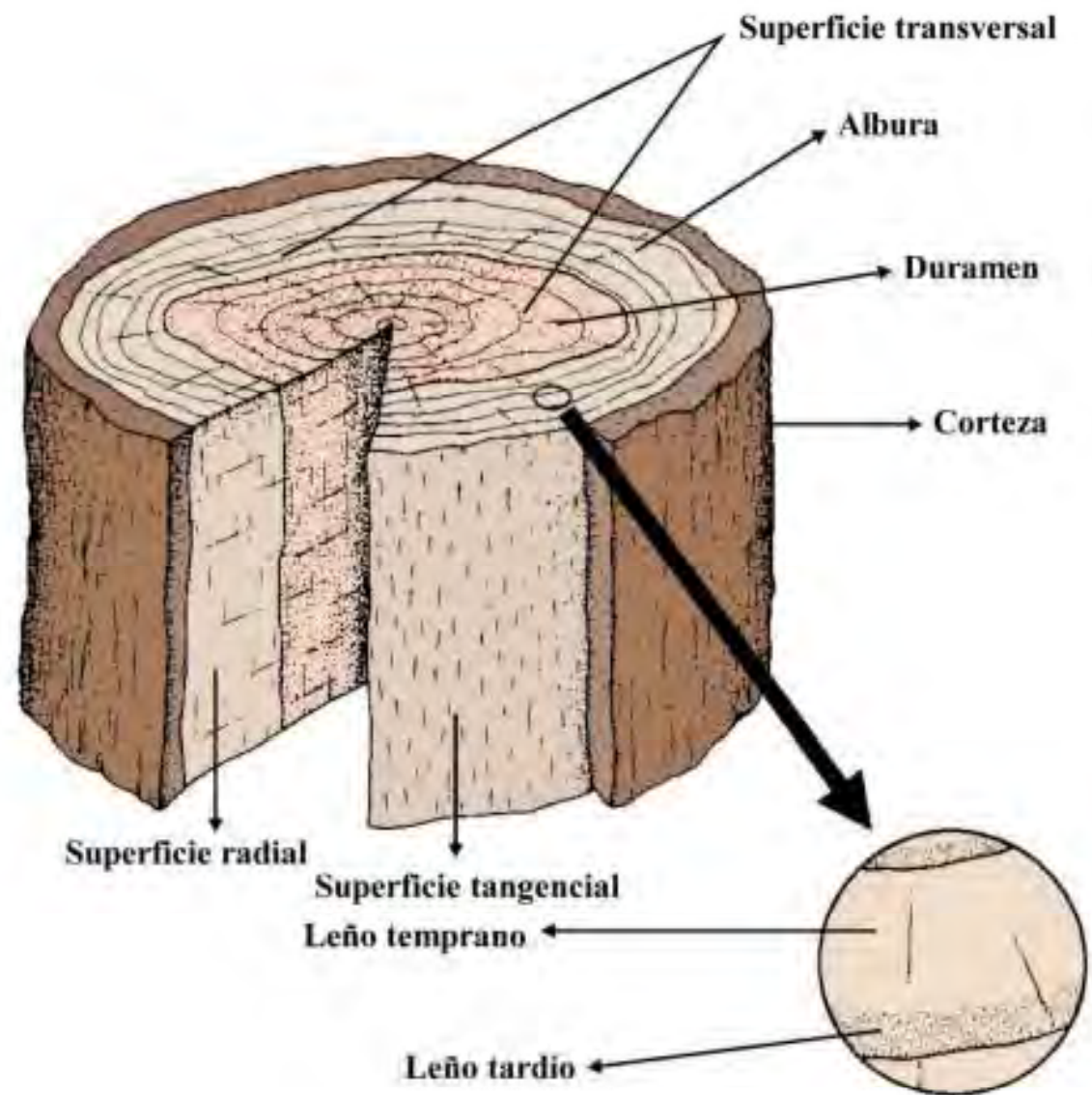




Secondary xylem (wood) is traversed by vascular rays—narrow rows of cells that transport waste materials from living cells in the bark to the inner tissues of the heartwood. Here the wood is divided into two annual rings, in each of which large xylem cells of the springwood merge with smaller cells of summerwood.

Anillos de crecimiento de la madera



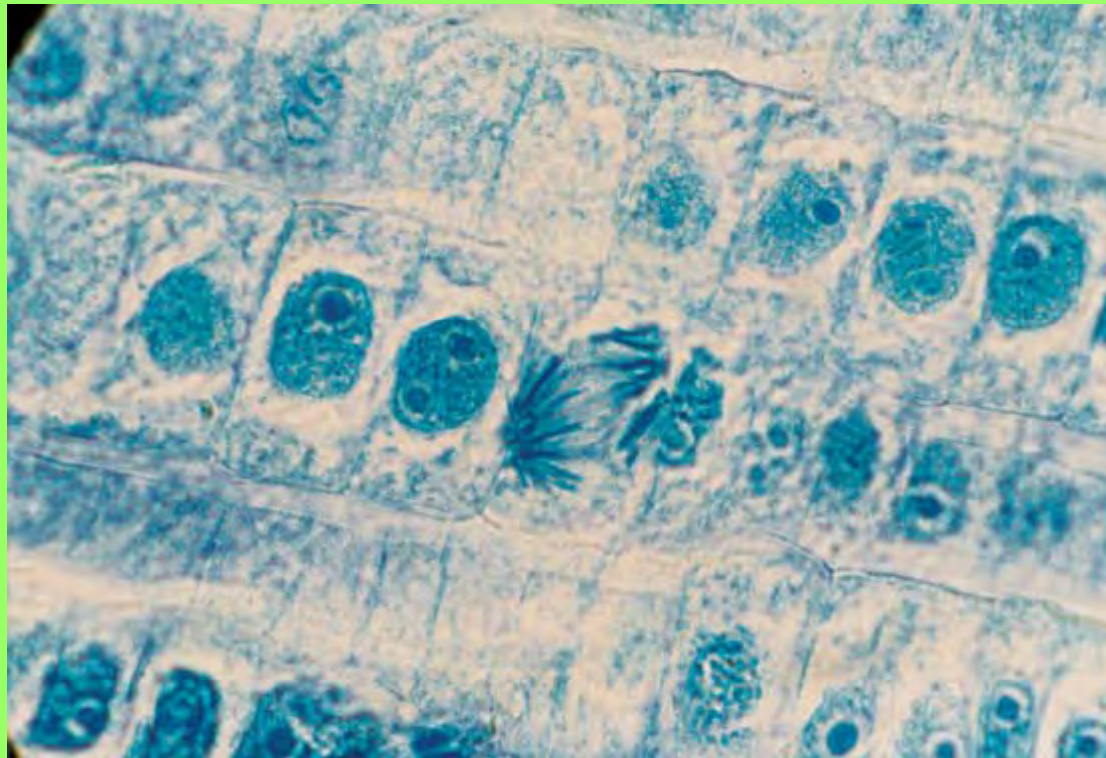


Tejidos meristemáticos primarios y secundarios

Características, origen, localización e importancia.

Las células embrionarias, las que se dividen en el cuerpo de la planta se denominan **MERISTEMOS**

El meristemo primario es el que se localiza en el embrión.
el meristemo secundario es el que se localiza en el cuerpo de la planta en crecimiento.



Tejidos que originan los meristemas

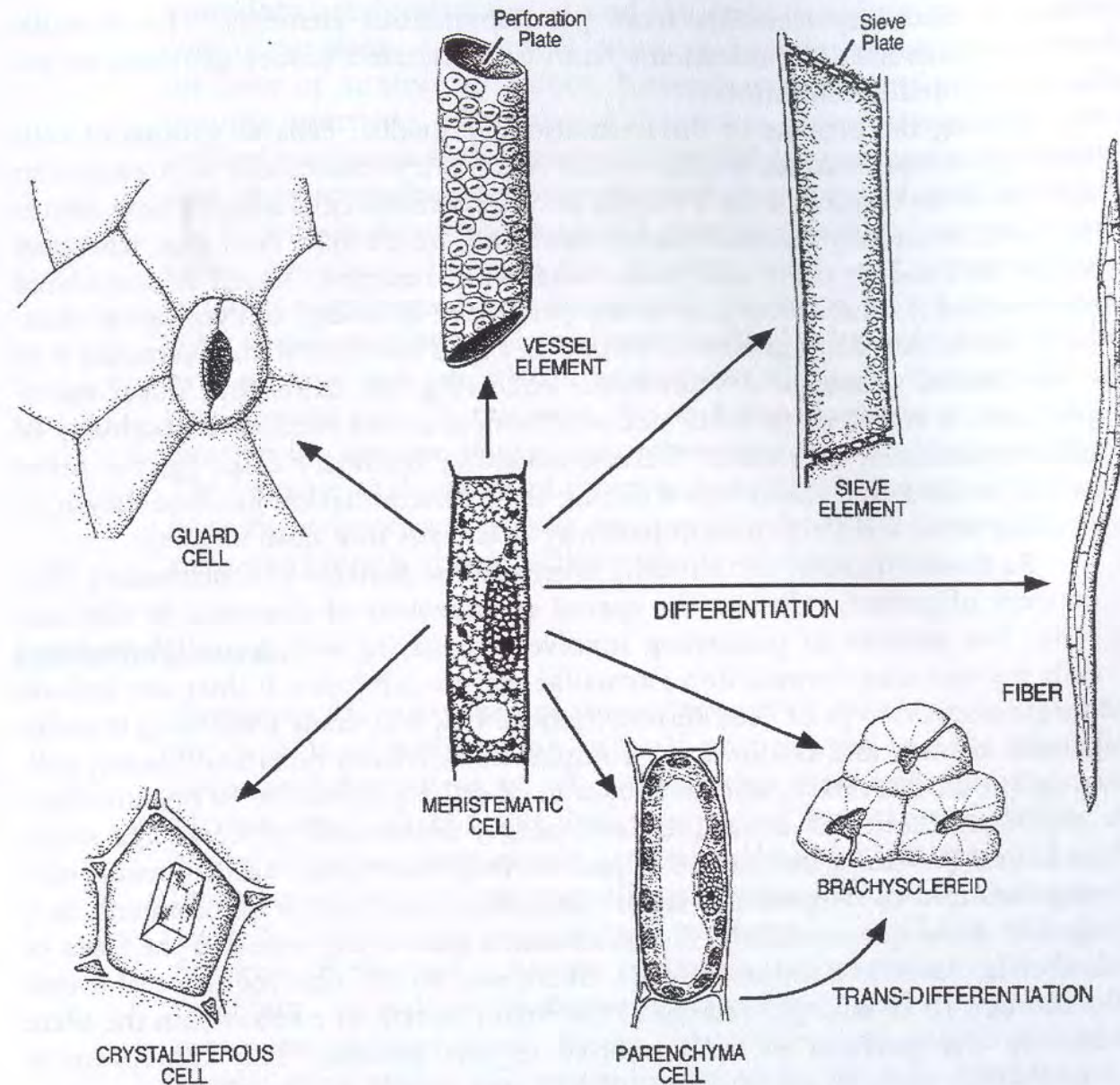
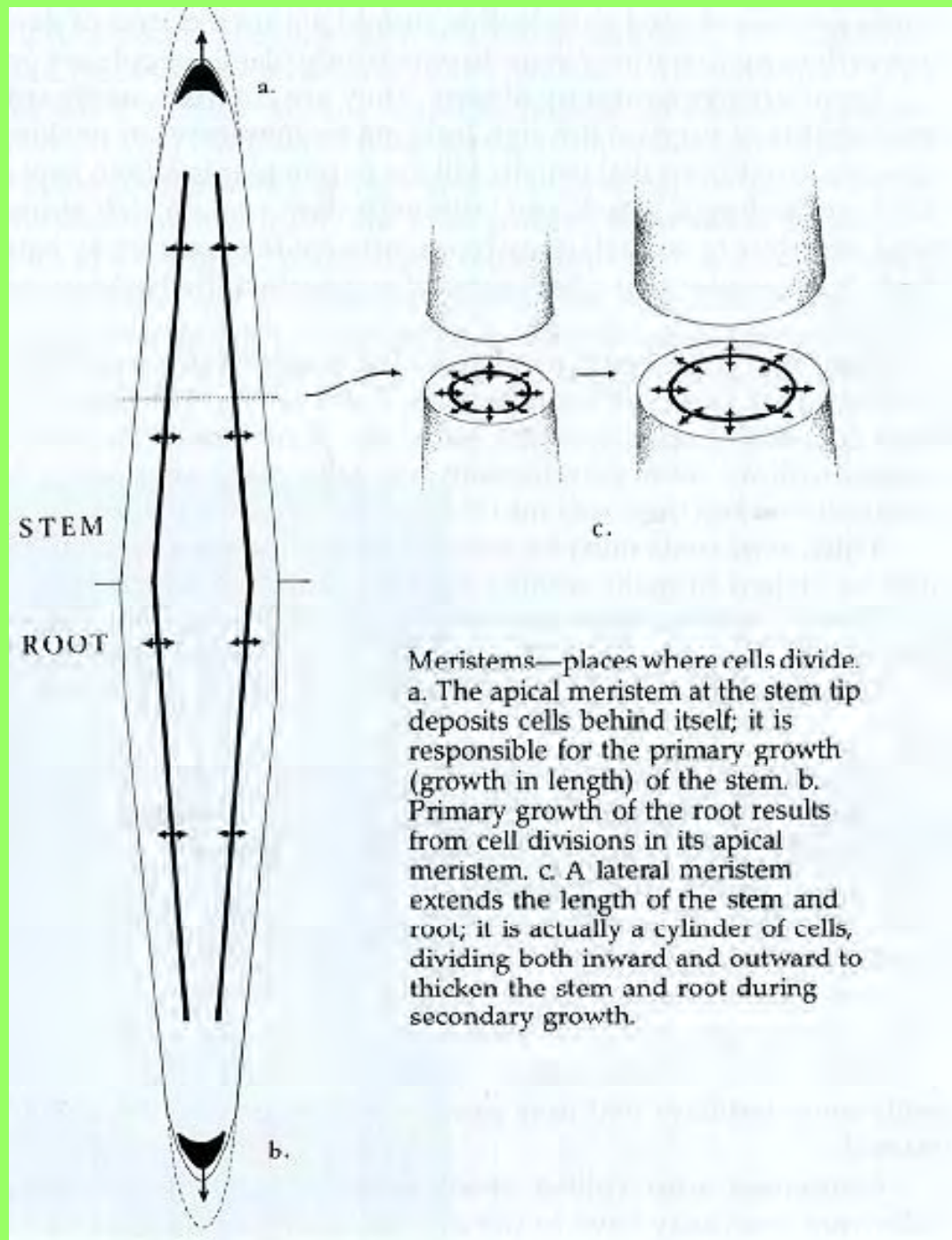
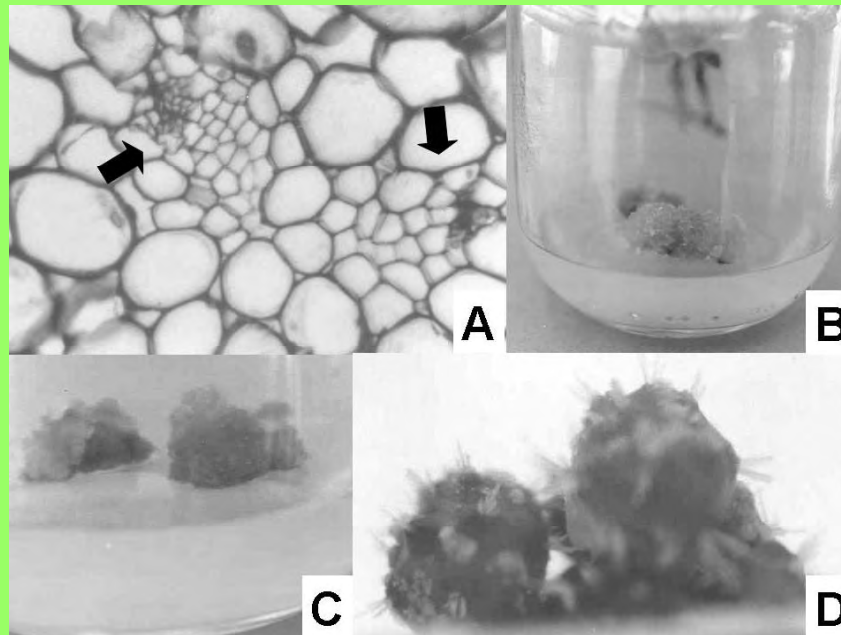


FIGURE 1.3 Representative end products of plant cell differentiation from a meristematic cell. The parenchyma cell retains a living protoplast and is able to transdifferentiate into another cell type, such as a sclereid, that becomes devoid of living contents at maturity.



En la zona meristemática apical, ocurre la mitosis y se depositan células a ambos lados de la región meristemática

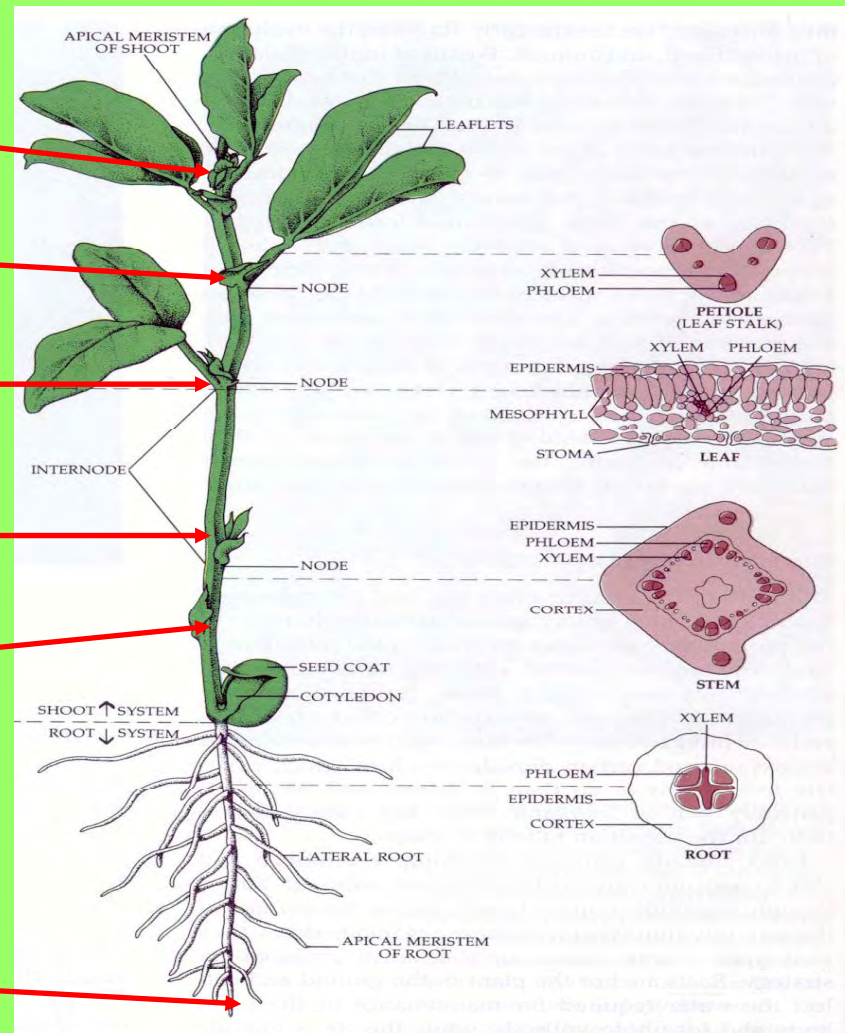
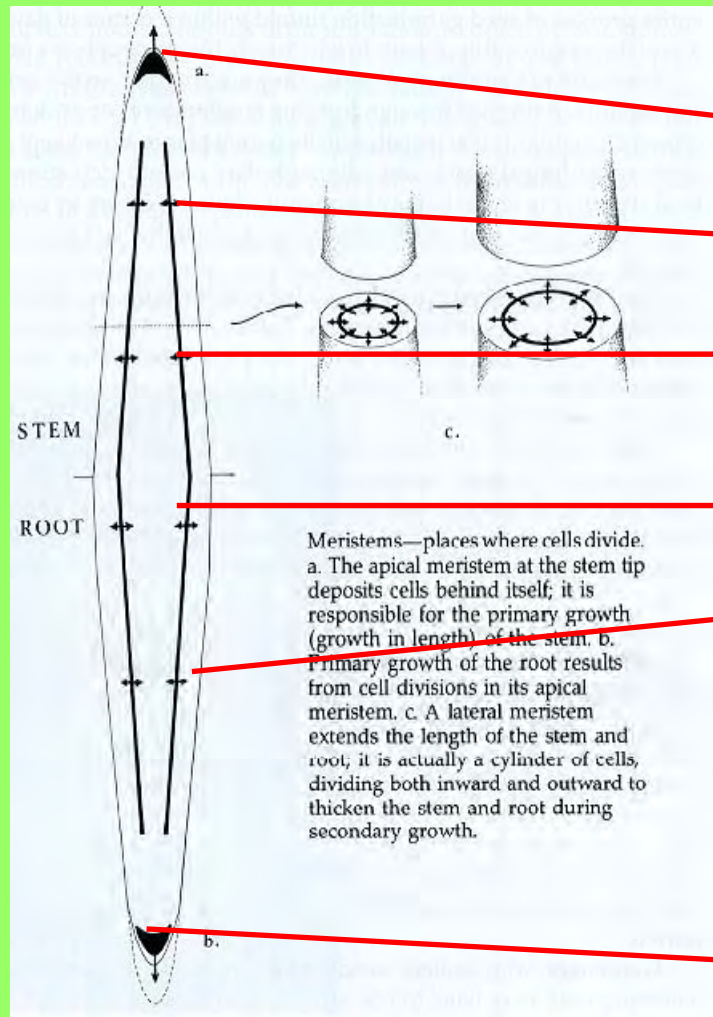
- 1.El tejido meristemático es considerado como totipotencial
2. El crecimiento de las plantas puede ser continuo e indeterminado.
3. Son excepcionales las plantas que tienen un “programa” de muerte meristemática.



Tipos de meristemos:

- **Apicales.** Localizados en el ápice del órgano (vástago, raíz)
- **Basales.** Localizados en la base del órgano
- **Intercalares.** Entre los tejidos que origina o sus derivados
- **Laterales.** Localizados en la periferia de sus derivados
- **Axilares.** son los meristemos apicales de los brotes laterales

MORFOLOGÍA Y ANATOMÍA



Localización
de los
meristemos
primarios

Tipos de derivados producidos directamente por los meristemas

Procambium- produce los tejidos vasculares primarios

Promeristemos- que da lugar a otro tipo de meristemas por posición en la planta

Protoderms- origina células epidérmicas

Meristemo fundamental- produce tejidos masivos como la médula o la corteza o masas de fibras esclerenquimáticas

Diferencias básicas entre las dicotiledóneas y las monocotiledóneas en cuanto a la producción de los sistemas de conducción.

- Monocotiledóneas no tienen crecimiento secundario (solo tienen *procambium*)
- Dicotiledóneas sí tienen crecimiento secundario (*procambium* en la fase embrionaria y *cambium* en el crecimiento secundario)

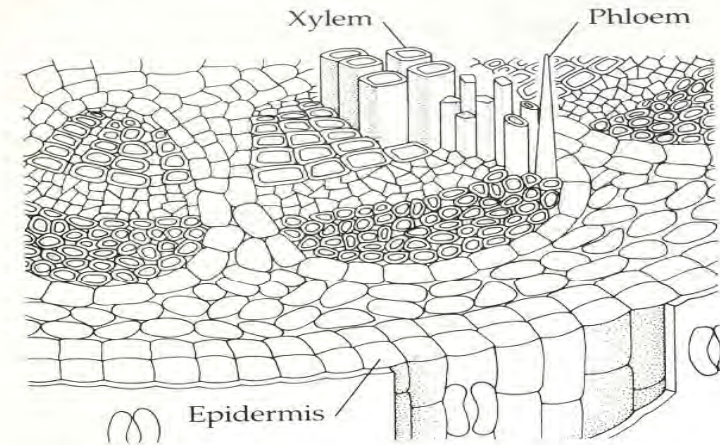


Figure 1.3

In most dicot stems, there is a ring of vascular bundles, each containing xylem and phloem. Inside the ring is pith; outside are cortex and an epidermis.

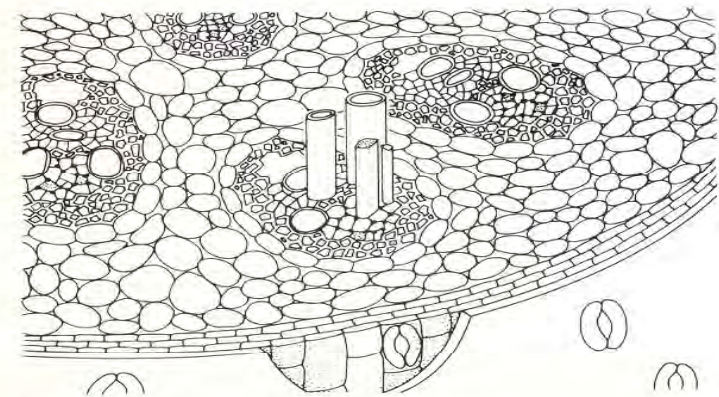
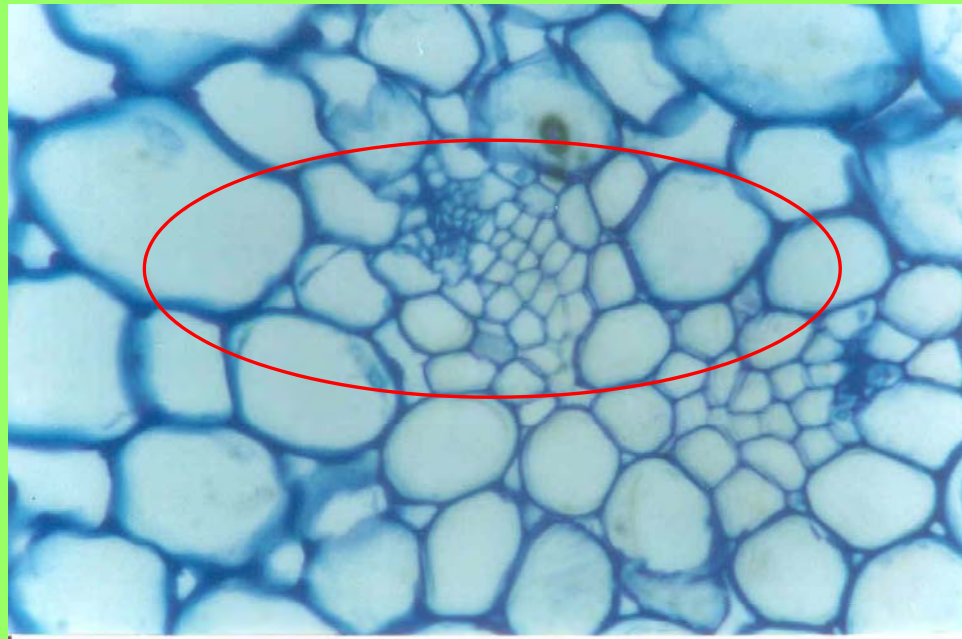


Figure 1.4

A monocot stem also contains vascular bundles but usually in a more complex pattern.

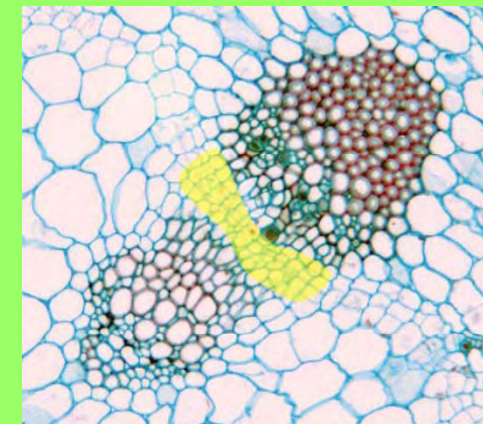
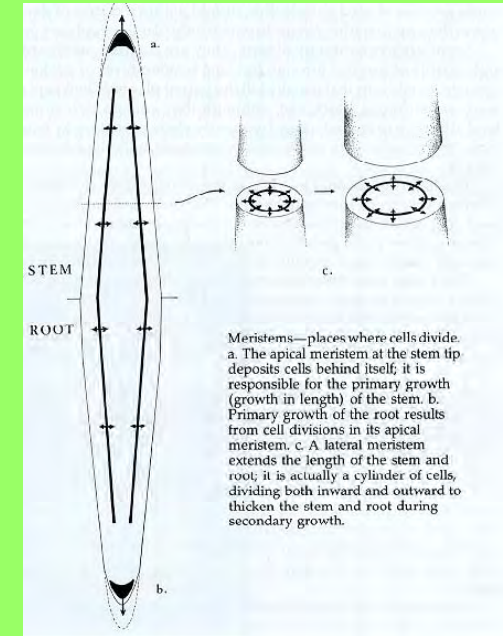
Meristemos primarios: apicales y radicales.



Secuencia de formación de meristemos

1. Primarios son aquellos presentes en la zona de crecimiento del vástago y raíz del embrión. Produce los tejidos primarios.

2. Secundarios aquellos que producen los tejidos secundarios como el *cambium* vascular y *cambium* del corcho

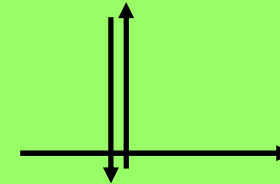


Formas de división celular de los meristemos:

Periclinal o paralelo al plano



Anticlinal perpendicular al plano



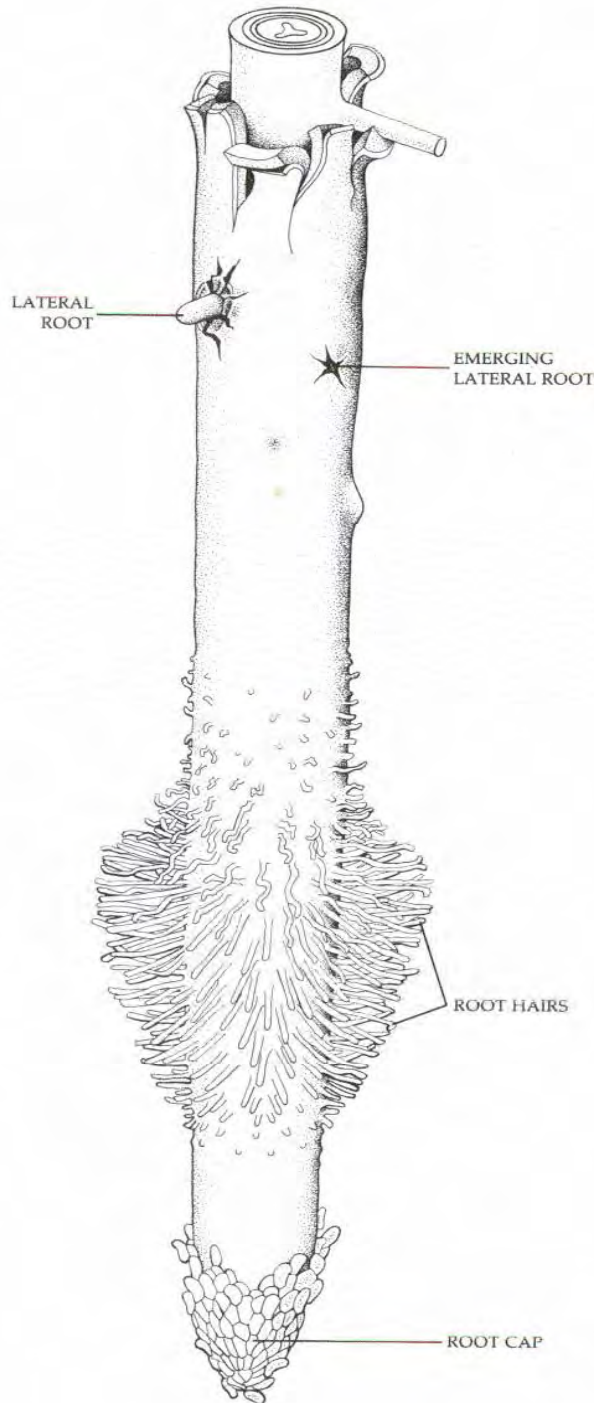
Meristemos apicales de la raíz

- La raíz primaria se origina del embrión
- En dicotiledóneas y gimnospermas: la raíz se convierte en “raíz pivotante” y da origen a las raíces laterales, formando un sistema con predominio de una raíz líder.
- En monocotiledóneas: se forman raíces adventicias que se inician en el tallo, formando un sistema fibroso; el tallo está muy reducido, son en general plantas acaules (sin tallo).

Meristemas radicales primarios

- Contribuyen a la elongación del cuerpo de la planta por debajo del suelo
- Región de división, elongación y maduración
- En la región de maduración, hay formación de raíces laterales (del periciclo)
- Protección (cofia o caliptra), responsable de la respuesta al geotropismo, ayuda en el proceso de penetración de la raíz en el suelo.

Raíz



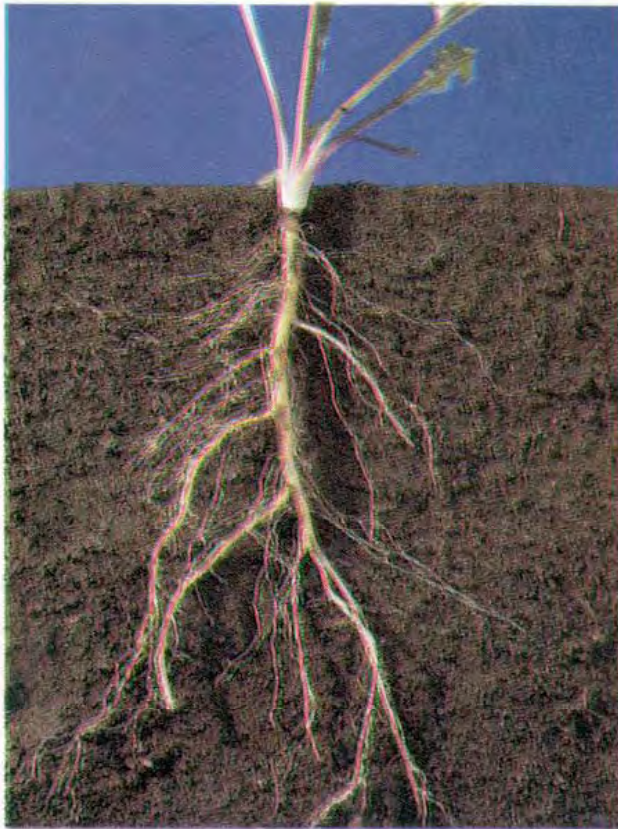
Porción de una raíz de “dicotiledónea” mostrando la relación espacial entre la cofia o caliptra de la raíz, región de los pelos radicales y cerca de la parte de arriba, la zona de origen de las raíces laterales, las cuales se originan de la parte interna, del periciclo. Nuevos pelos radicales se originan por debajo de la región de elongación, casi a la misma tasa que los viejos van muriendo.

Tipos de sistemas de raíces

Dos tipos de sistemas radicales

a) Raíz pivotante de *Taraxacum officinale*.

b) Sistema fibroso de una gramínea.



(a)



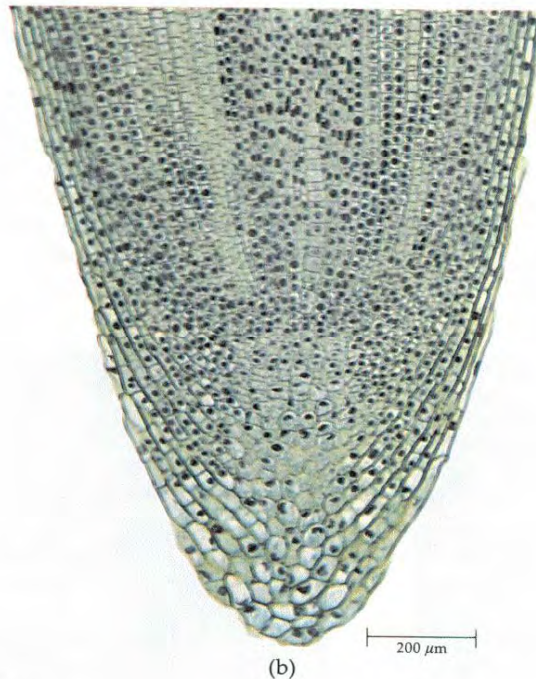
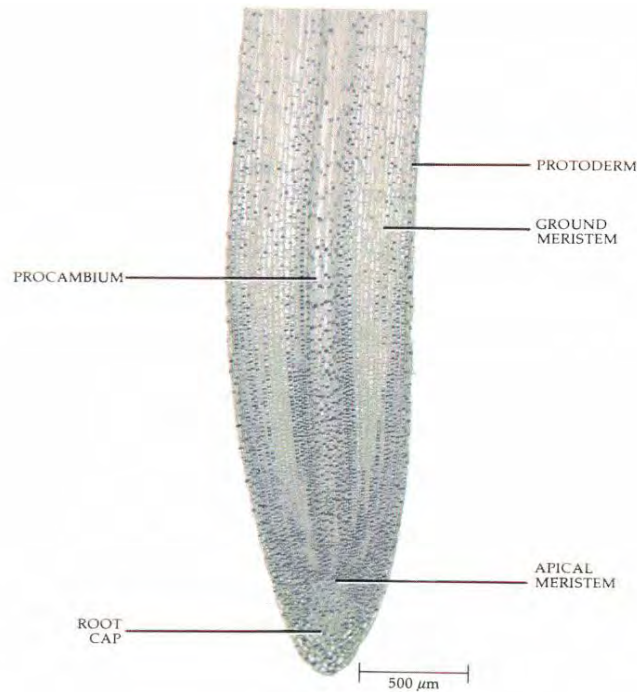
(b)

Raíz

Sección longitudinal de raíz de cebolla (*Allium cepa*).

(a) Meristemas primarios se distinguen en la región apical de la raíz

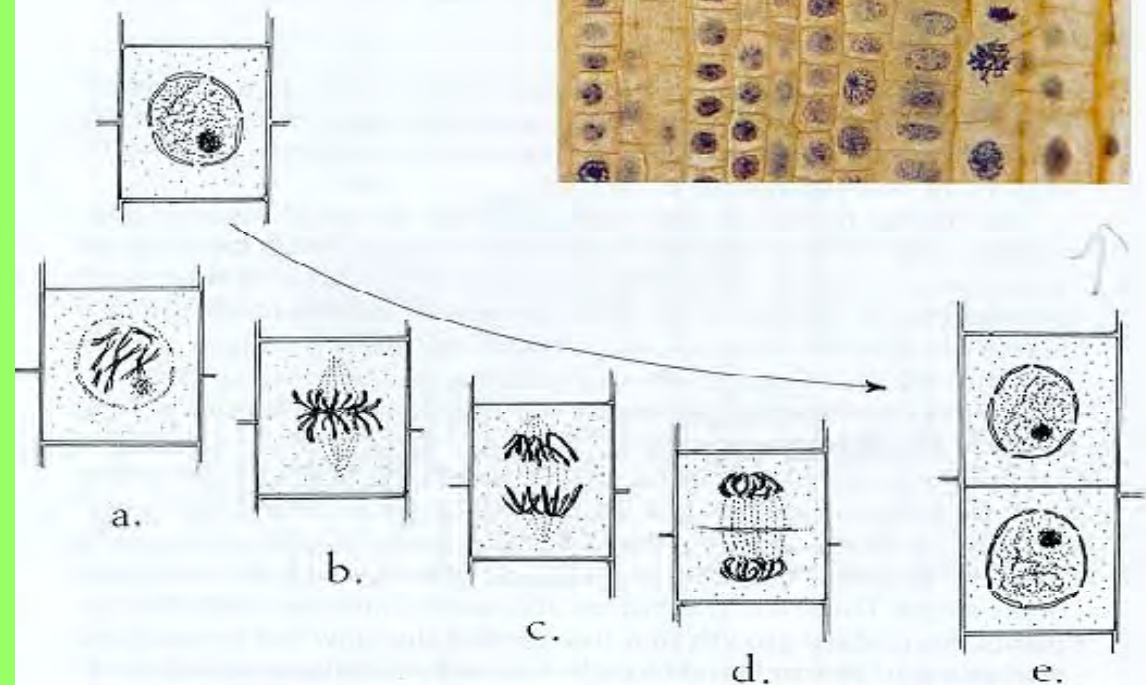
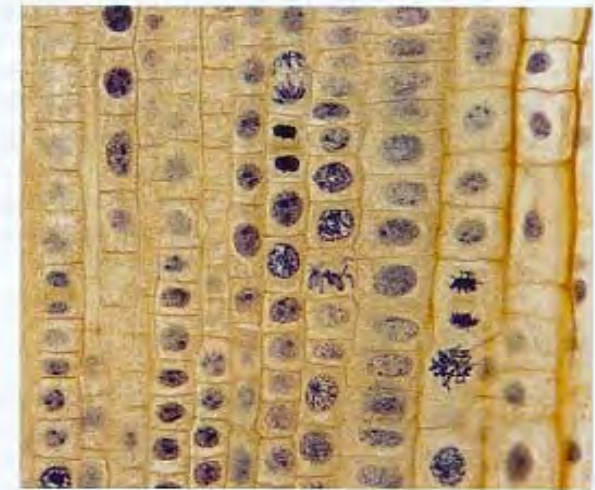
(b) Detalle del meristemo apical.



**Mitosis en la región
del meristemo
primario de la raíz.
Se observan las
diferentes fases de la
mitosis.**



Mitosis—the dance of the chromosomes. The root's apical meristem is the U-shaped area a short distance from the tip (photograph at left). In the meristem's cells, division of the nuclei involves the separation of matching chromosome strands in stages named: a. prophase, b. metaphase, c. anaphase, and d. telophase. e. Two daughter cells. Several of these stages are shown in the photograph of the meristem's cells, greatly magnified.



Raíz

Diagrama de un corte longitudinal y dos transversales de la raíz, donde se muestran los estadios primarios del desarrollo de la raíz. Se distingue el periciclo que es la zona meristemática que genera las raíces secundarias

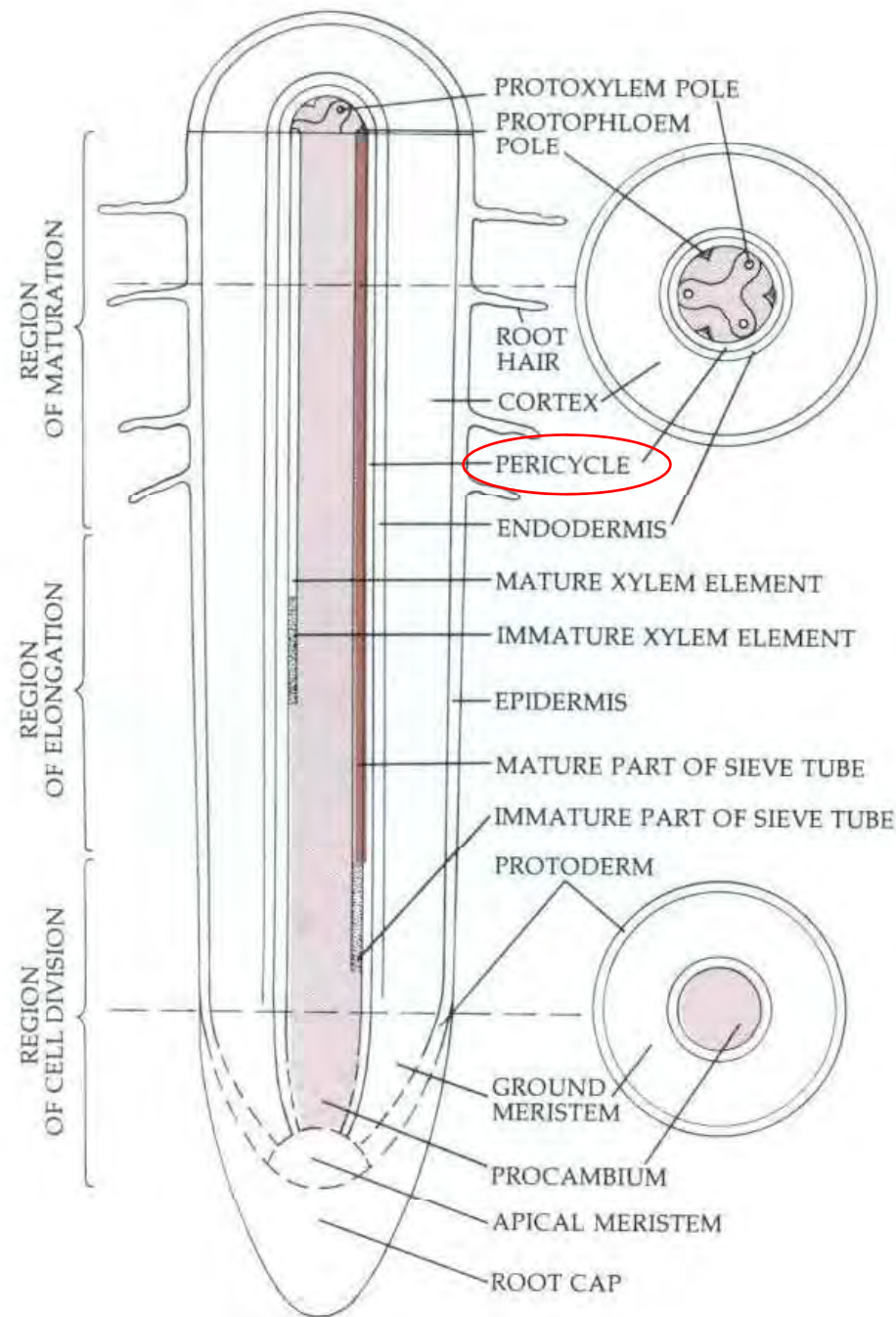
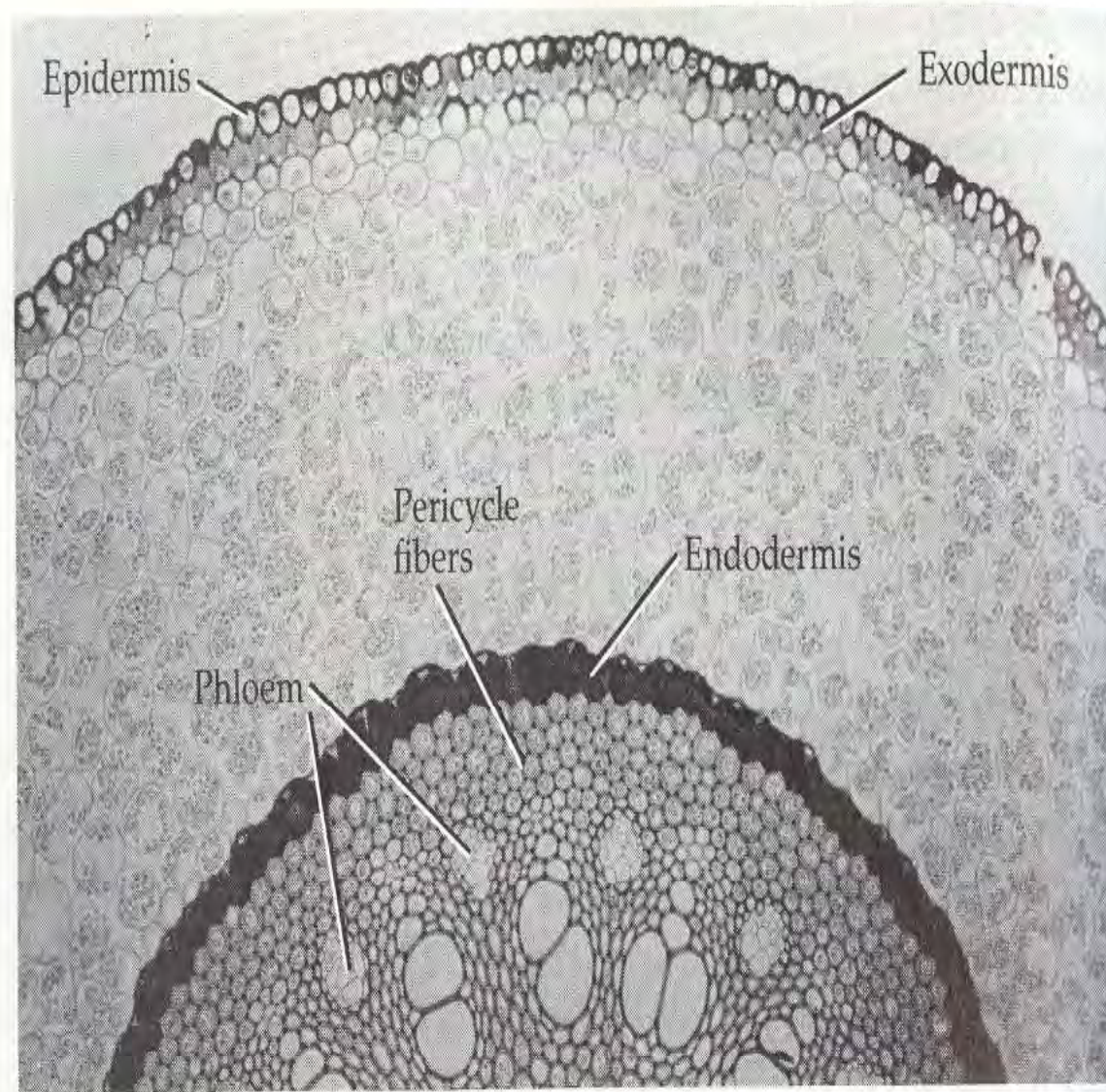


Figure 13.8

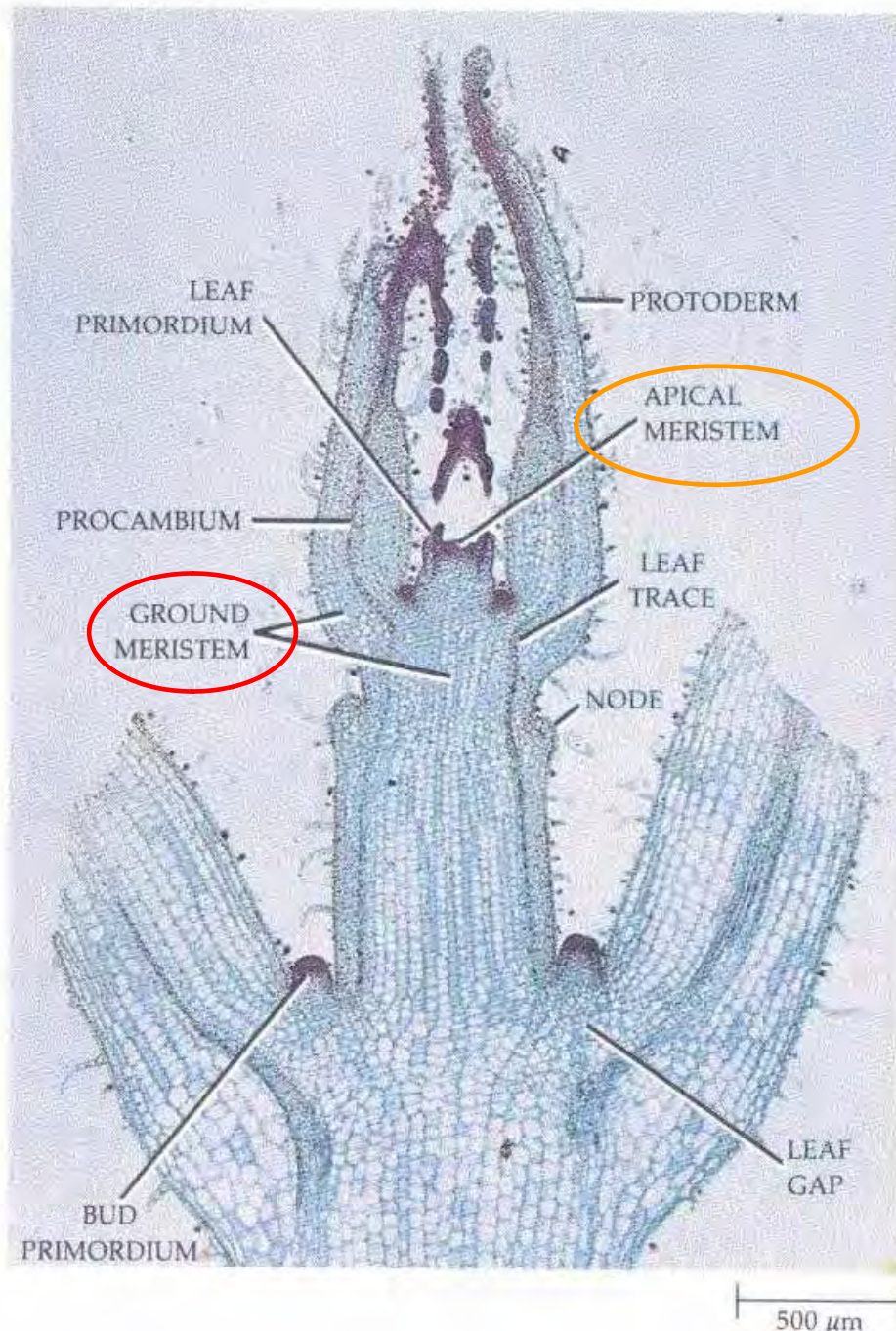
In this cross section of a root of *Smilax* (greenbriar), all tissues are easily recognizable. The exodermis and the endodermis both have extremely thickened walls on the radial sides and either the outer tangential wall (exodermis) or the inner one (endodermis). $\times 100$.



Meristemos apicales del tallo

- Contribuyen a la elongación del cuerpo de la planta.
- No hay región de división, elongación y maduración como en las raíces.
- Carencia de protección (no hay cofia) solamente en algunos casos se presenta una bráctea denominada estípula .

Meristemo apical



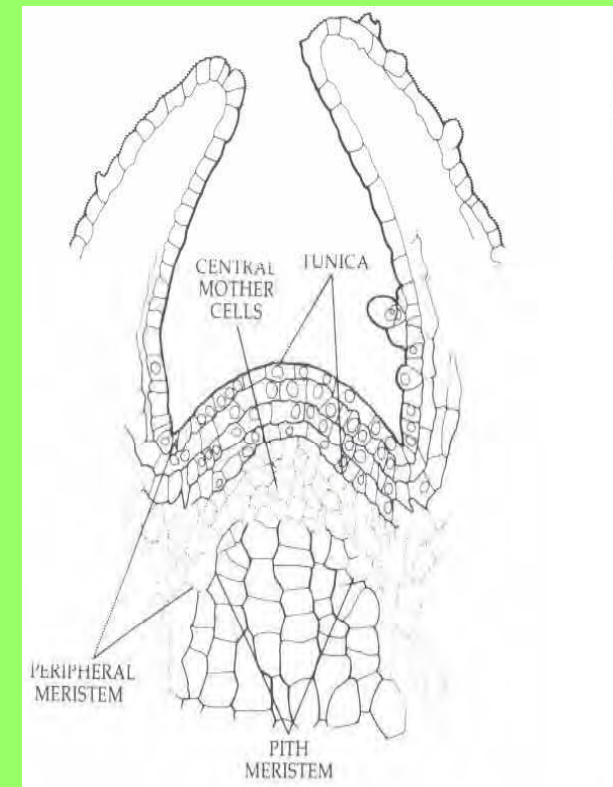
Sección longitudinal del ápice de un tallo de *Coleus blumei*, una “dicotiledónea”. Las hojas son opuestas, cada par sucesivo en angulo recto al par previo.

REGIÓN MERISTEMÁTICA DEL TALLO

- Tiene células iniciales y derivativas.
- Las células iniciales sufren mitosis, de manera que de cada inicial se origina una “célula derivativa” la cual se diferenciará en otro tipo de célula, quedando la inicial sin diferenciarse y con capacidad de división.
- Estas células iniciales son reserva para futuro crecimiento.

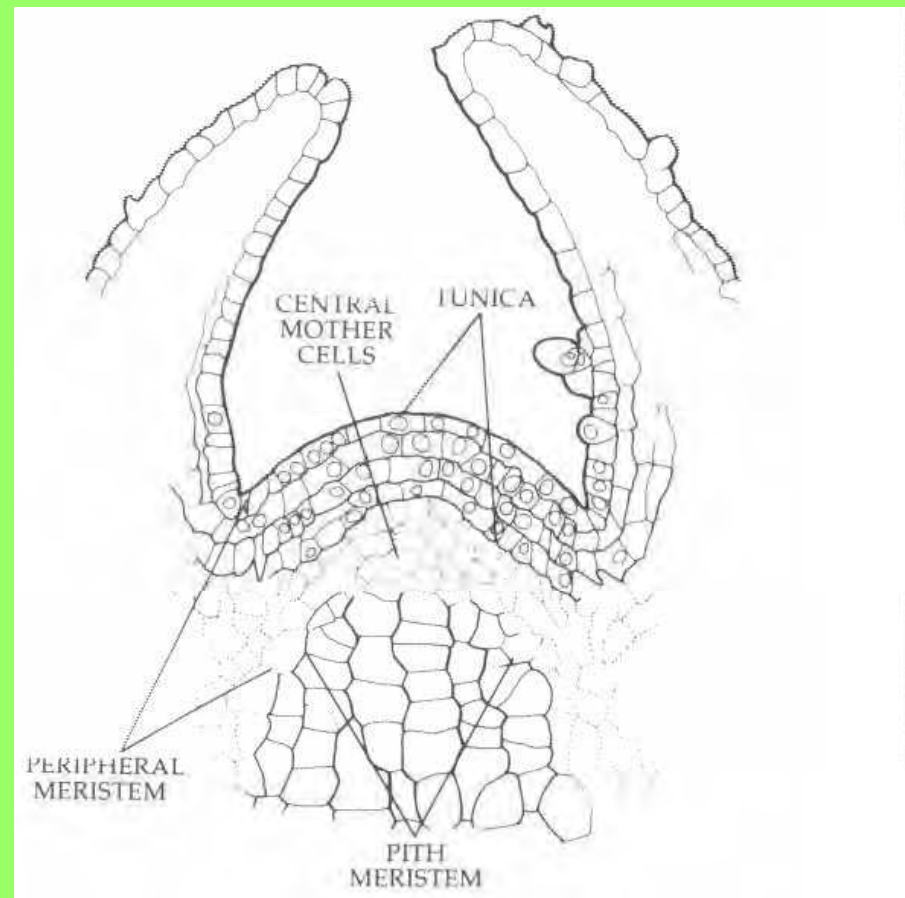
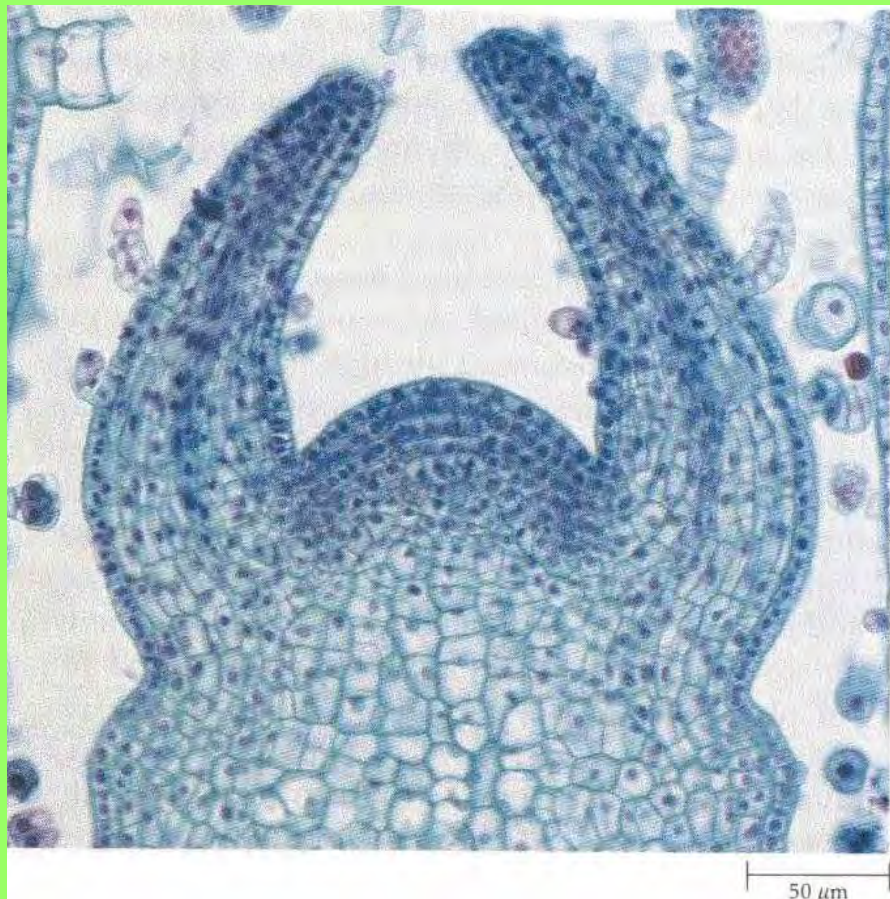
ORGANIZACIÓN *CORPUS*- TÚNICA

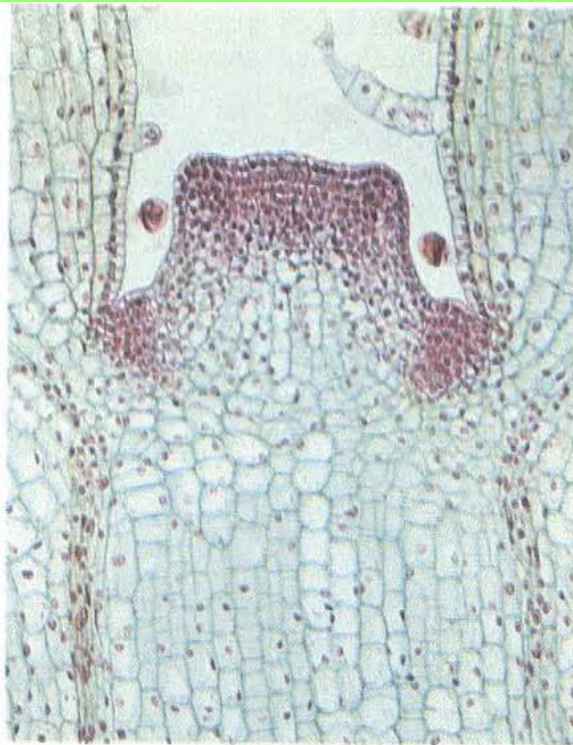
- La TÚNICA es la región de células más externas, las que se dividen en el plano perpendicular a la superficie del meristemo (divisiones anticlinales) y contribuye al crecimiento de la superficie.
- El *CORPUS* (o células madres centrales) consiste de células que se dividen en varios planos y añaden volumen al cuerpo del tallo.
- El meristemo periférico es el más activo mitóticamente y se origina parcialmente del *corpus* y parcialmente de la túnica.
- Cada uno tiene sus células iniciales.



Tallo

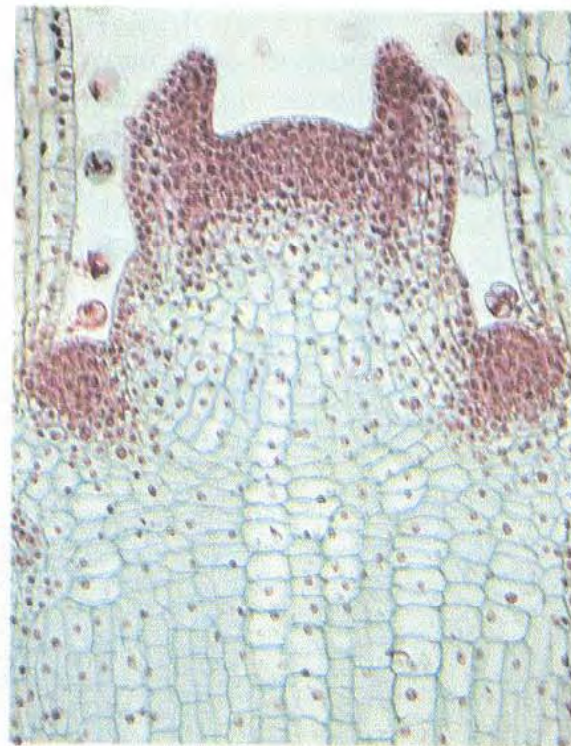
Detalle del ápice del tallo de *Coleus blumei*, mostrando la organización de las dos zonas meristemáticas: túnica - corpus .





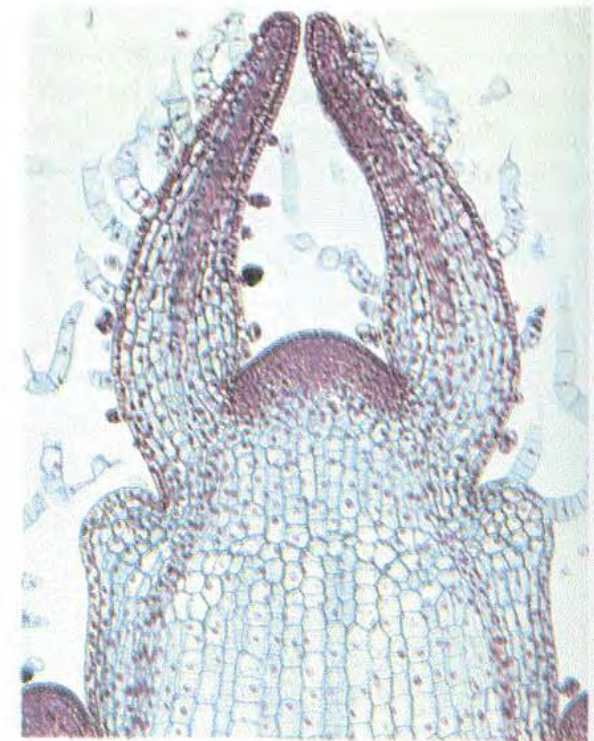
(a)

80 μm



(b)

80 μm



(c)

180 μm

22-28

Some early stages of leaf development in *Coleus blumei*, as seen in longitudinal sections of the shoot tip. The leaves in *Coleus* occur in pairs, opposite one another at the nodes (see Figure 22-2). (a) Two small bulges, or leaf buttresses, can be seen opposite one another on the flanks of the apical meristem. In

addition, a bud primordium can be seen arising in the axil of each of the two young leaves, below. (b) Two erect, peg-like leaf primordia have developed from the leaf buttresses. Notice the procambial strands extending upward into the leaf primordia. The bud primordia, below, are further along in development than those

in (a). As the leaf primordia elongate (c), the procambial strands, which are continuous with the vascular bundles in the stem, continue to develop into the leaves. Trichomes, or epidermal hairs, develop from certain protodermal cells very early, long before the protoderm matures to become the epidermis.

**Meristemas secundarios:
cambium vascular y felógeno.**

MERISTEMO APICAL EN EMBRIONES

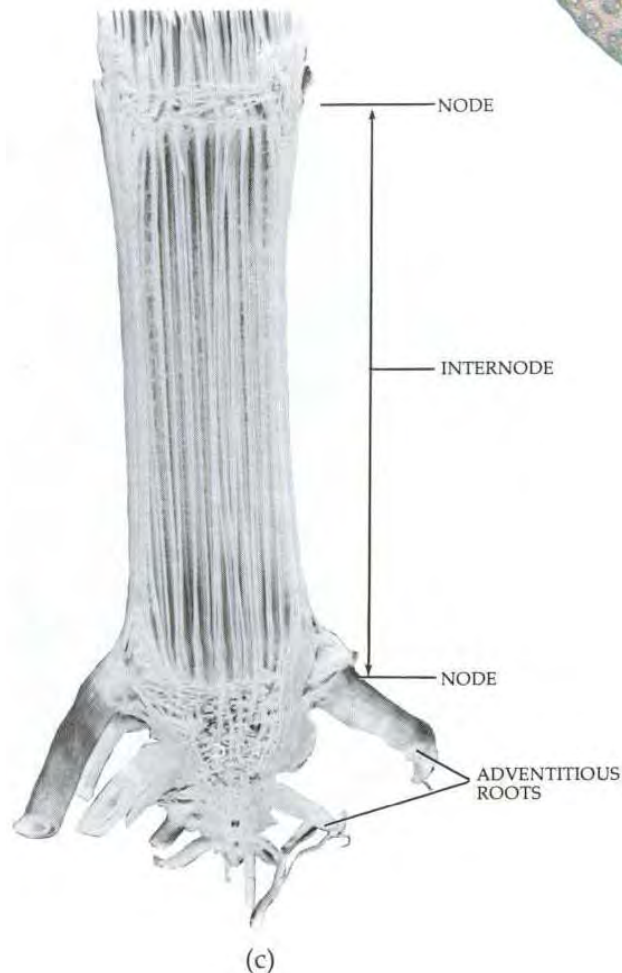
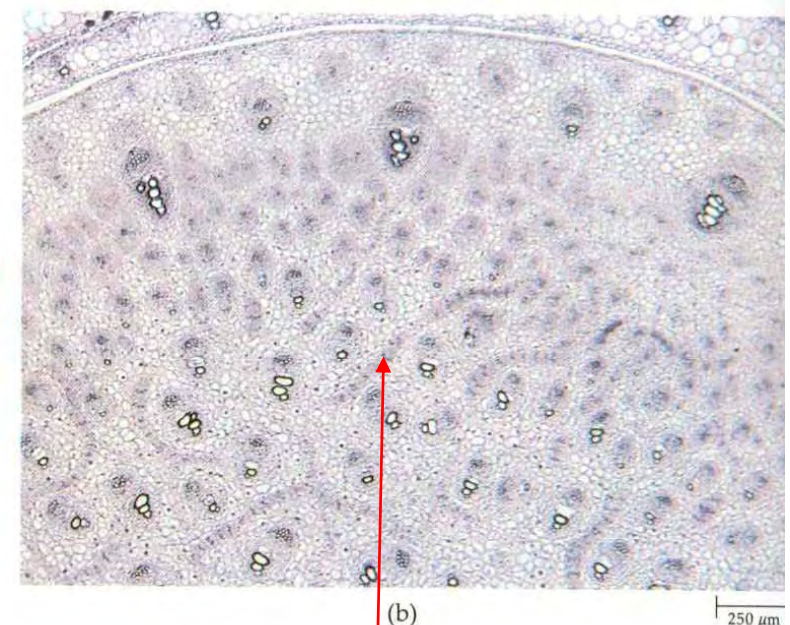
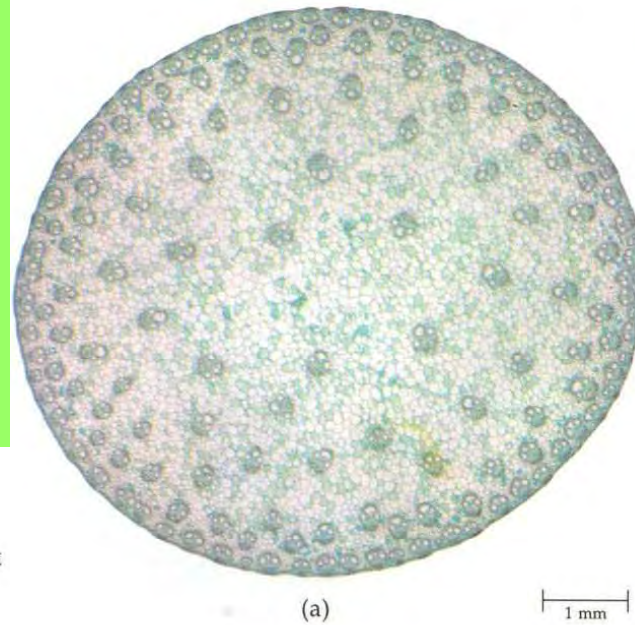
- La PROTODERMIS se origina de la capa más externa de la túnica.
- El PROCAMBIUM y el tejido fundamental se originan del meristemo periférico.
- La MÉDULA (del tallo) se forma del meristemo de la médula.

Tejidos secundarios

Se originan por vía de dos tipos de meristemos:

- Cambium vascular: forman xilema y floema secundario
- Cambium del corcho o felógeno (cork cambium): forma corcho

Tallo



Tallo de maíz (*Zea mays*). (a) Sección transversal de la región internodal, mostrando numerosos haces vasculares dispersos en todo el tejido. (b) Sección transversal de la región nodal de un tallo joven de maíz, mostrando bandas horizontales de *procambium* que interconectan con haces verticales. (c) Una vista longitudinal de un tallo maduro; el tejido fundamental ha sido removido para mostrar el sistema vascular.

Tejidos secundarios...

- Cambium vascular: divisiones periclinales y anticlinales
 - Cambium fascicular (que se forma dentro de los fascículos vasculares)
 - Cambium interfascicular: células parenquimatosas entre los fascículos vasculares se dividen y se conecta (el *cambium*) con el *cambium* fascicular
 - Presentes en raíces, tallos y ramas

Cambium vascular

- Iniciales como células fusiformes: producen por un lado traqueidas, elementos de los vasos, y por otro células o elementos de los tubos cribosos, parénquima y fibras
- Iniciales de los rayos: parénquima (almacenamiento) y en gimnospermas, células albuminosas

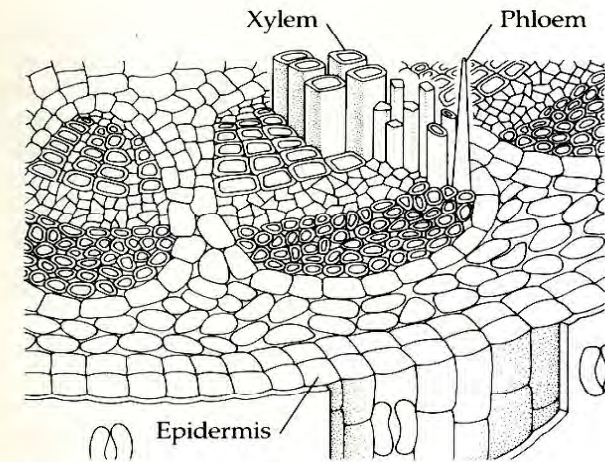


Figure 1.3

In most dicot stems, there is a ring of vascular bundles, each containing xylem and phloem. Inside the ring is pith; outside are cortex and an epidermis.

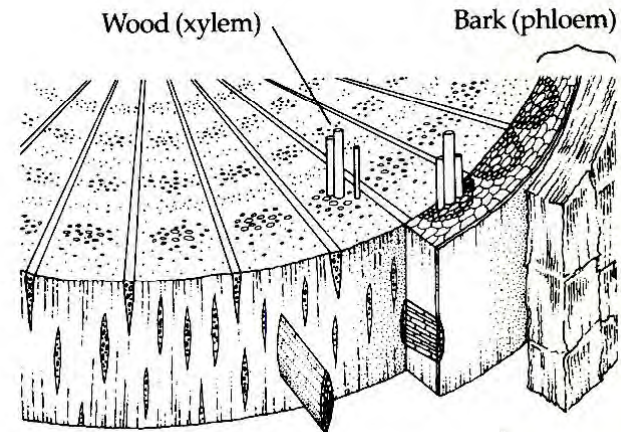


Figure 1.6

Some plants are able to become woody; that is, they undergo secondary growth, as shown in this cross section of a tree trunk. They produce both wood and bark; plants that do not are herbs.

Cambium vascular: forma de las células

- Iniciales fusiformes: parenquimatosas, largas, adelgazándose hacia los extremos; división celular longitudinal, producen 2 células, una continúa siendo inicial, la otra se diferencia en xilema o floema
- Iniciales de los rayos: Cortas y cuboidales

Cambium vascular

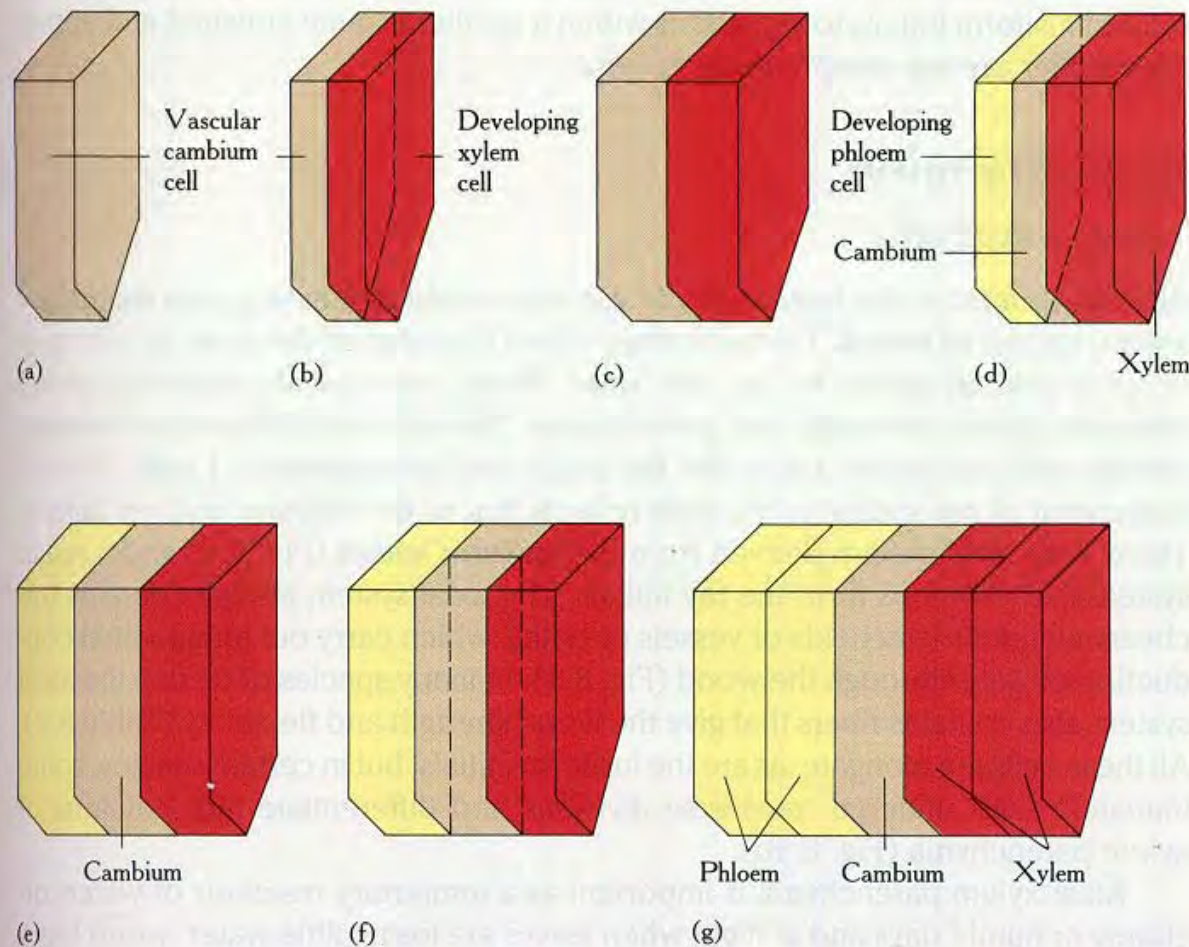


Figure 8.6

(a) The lower half of a fusiform initial before division. (b) Division by a periclinal wall results in two thin cells; the outer one remains a fusiform initial and the inner cell develops into secondary xylem. (c) Both cells enlarge to the size of the original cell. (d) The fusiform initial divides again; this time the outer cell matures as secondary phloem while the inner one remains a fusiform initial. (e) The cells grow back to the original size. (f) The fusiform initial divides by an anticlinal wall, resulting in two fusiform initials. (g) After the radial division in (f), a new row of cells is initiated in the secondary xylem and phloem.

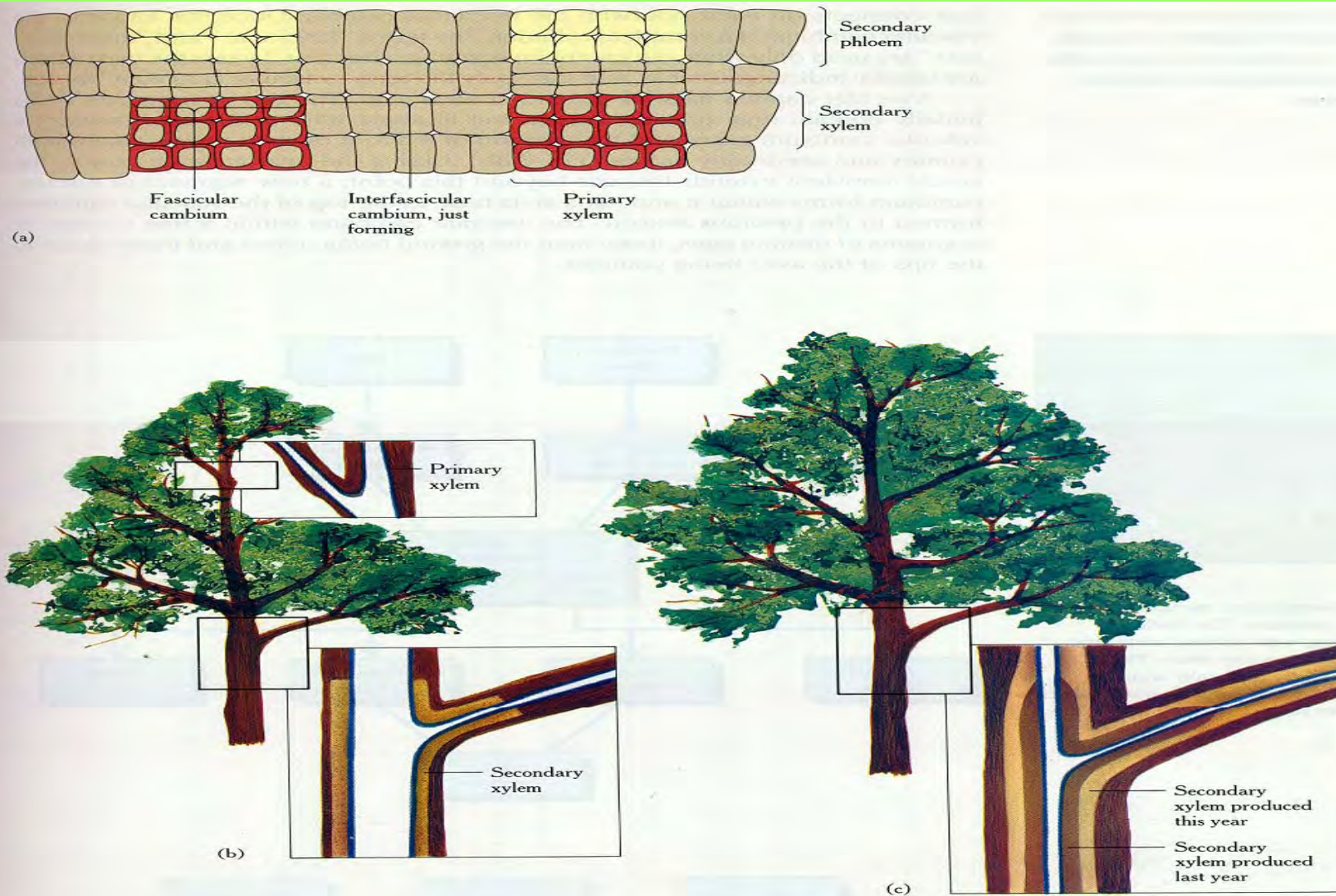
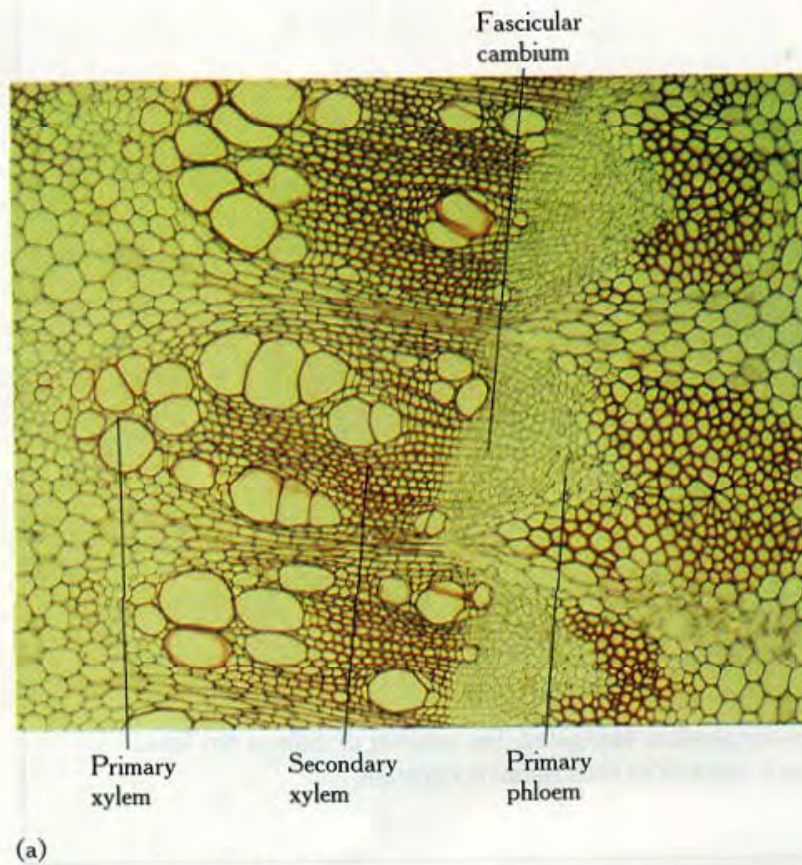


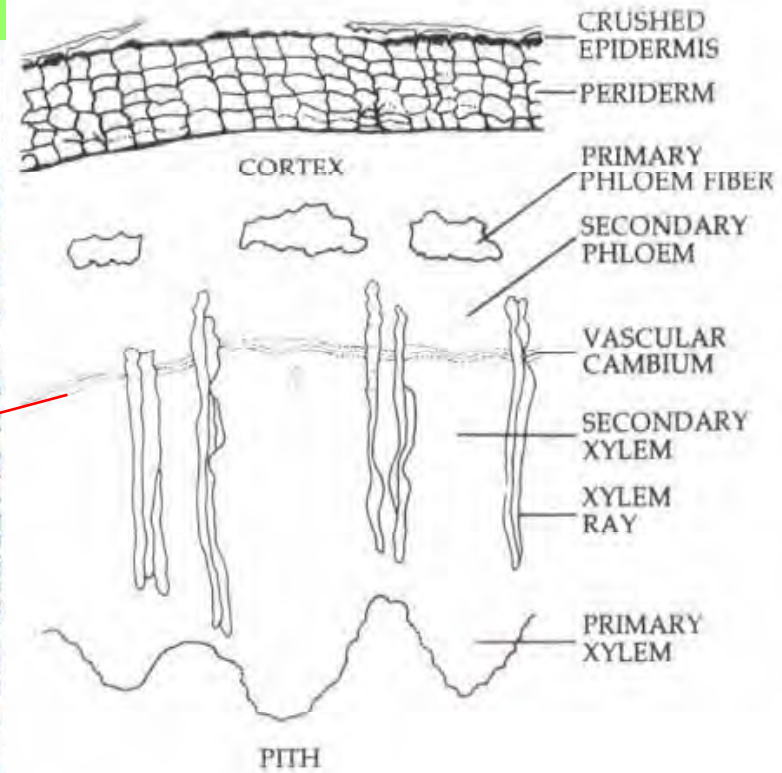
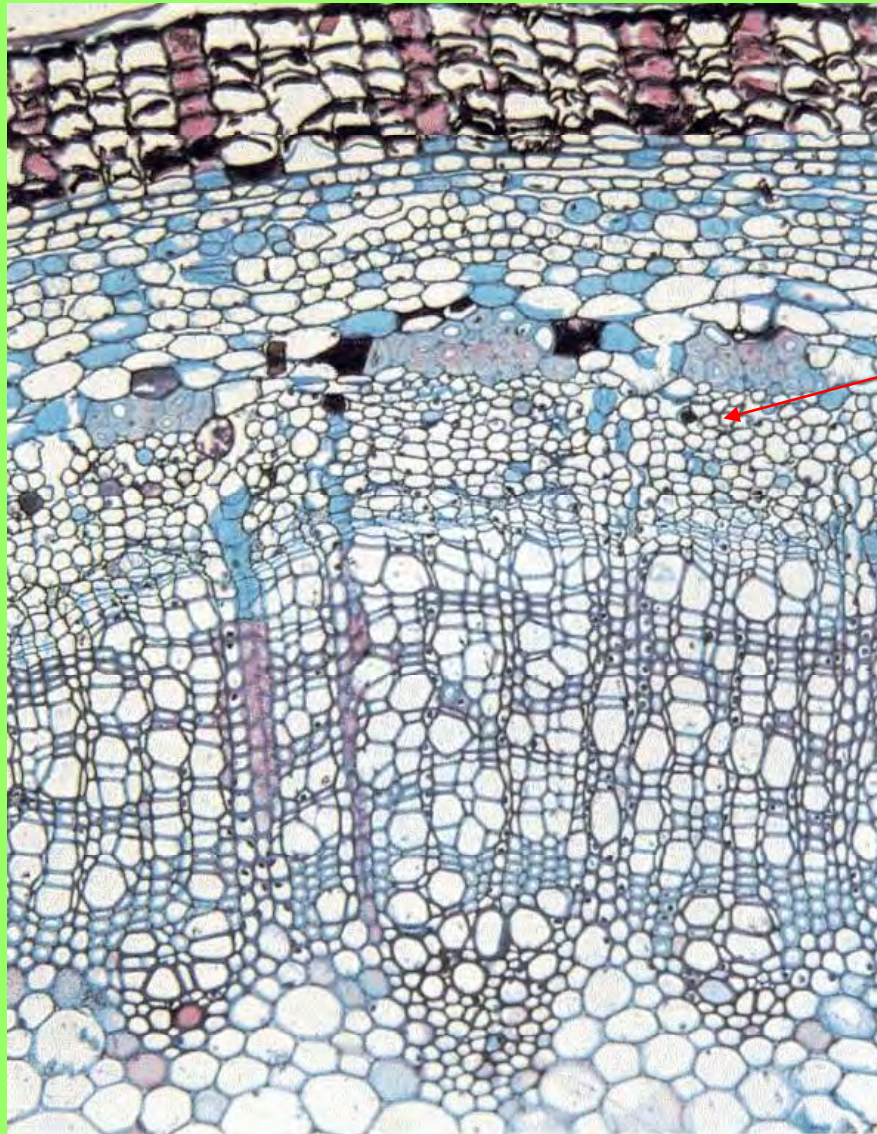
Figure 8.3

(a) Two vascular bundles and the parenchyma located between them; some of the parenchyma cells have begun renewed cell division and constitute an interfascicular cambium. This zone of renewed mitotic activity is located between two fascicular cambia, so one full cambial zone will result. (b) The vascular cambium usually does not form until after a portion of shoot or root is many months old, so these tips have only primary growth. (c) As the stem or root elongates, more provascular tissue transforms into vascular cambium, and the cambium also becomes longer. At the tips, it produces the first annual ring for the region; lower in the stem, the cambium is in its second year and is producing the second annual ring for that region, and so on. A twig is younger and has fewer annual rings than a branch has, and the base of the trunk has the most.

Figure 8.2

(a) The cambium has recently formed in this *Bocconia* stem. The fascicular cambia are rather obvious, but the interfascicular cambia are difficult to see. They have produced more secondary xylem than secondary phloem ($\times 180$). (b) This cambium has only recently formed; there are about eleven layers of secondary xylem and five of secondary phloem. Five groups of primary xylem are visible, so you can tell where fascicular and interfascicular cambia arose; but at this stage, the two are identical and we use the term "vascular cambium" ($\times 220$).

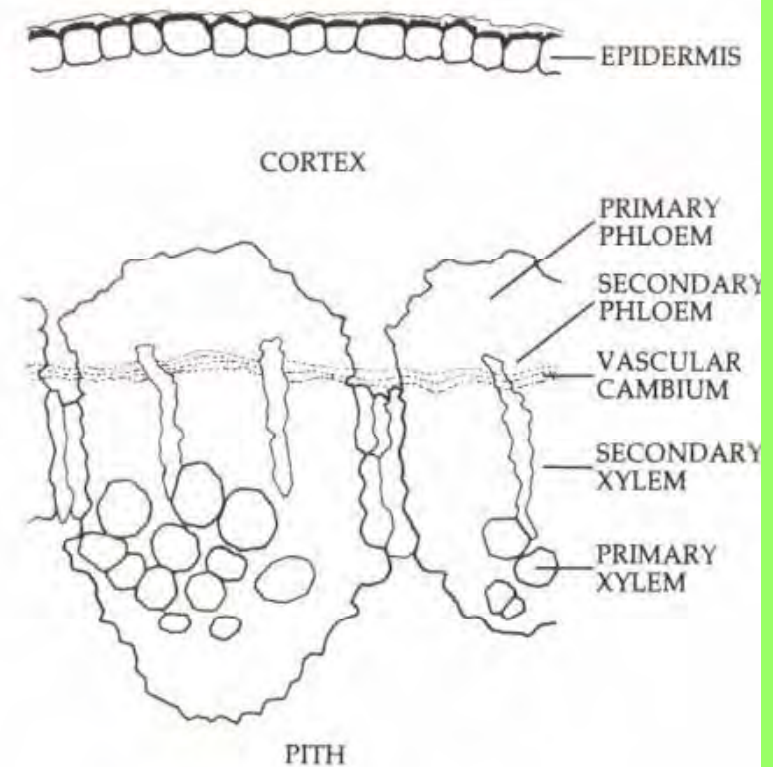
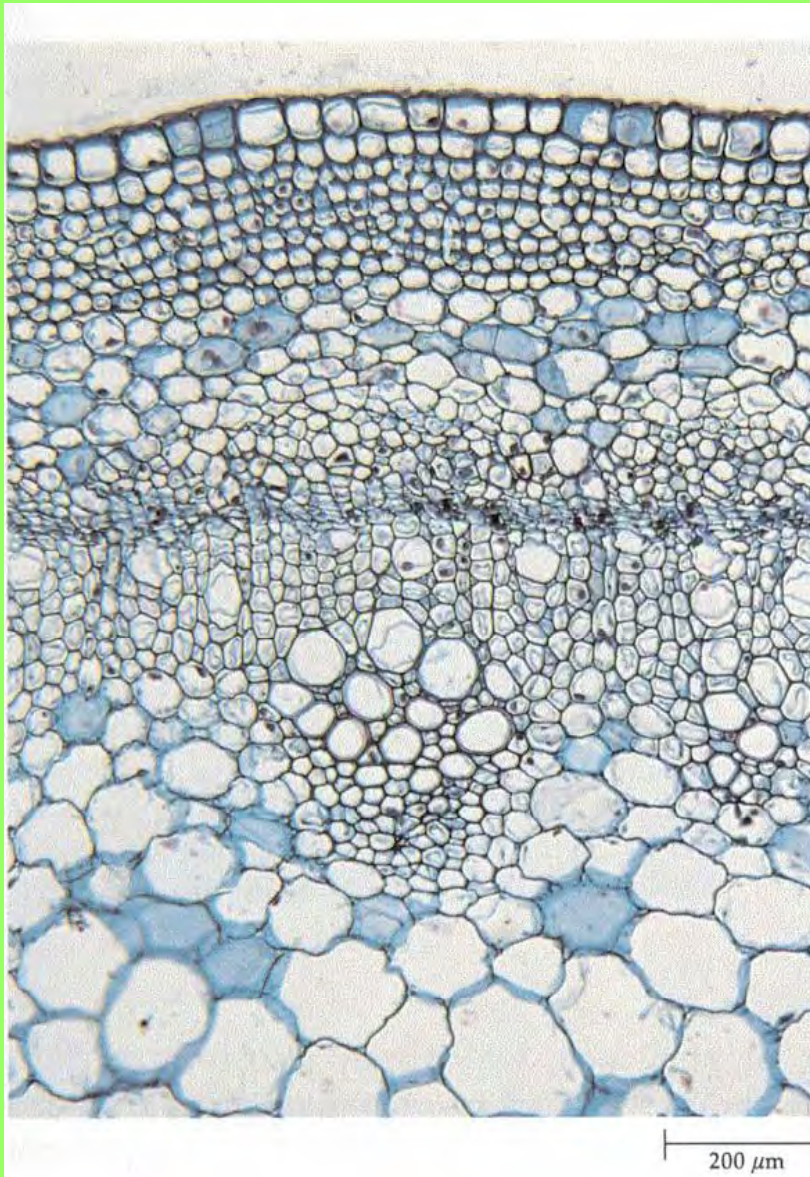




23-9

Transverse section of an elderberry (Sambucus canadensis) stem at the end of first year's growth.

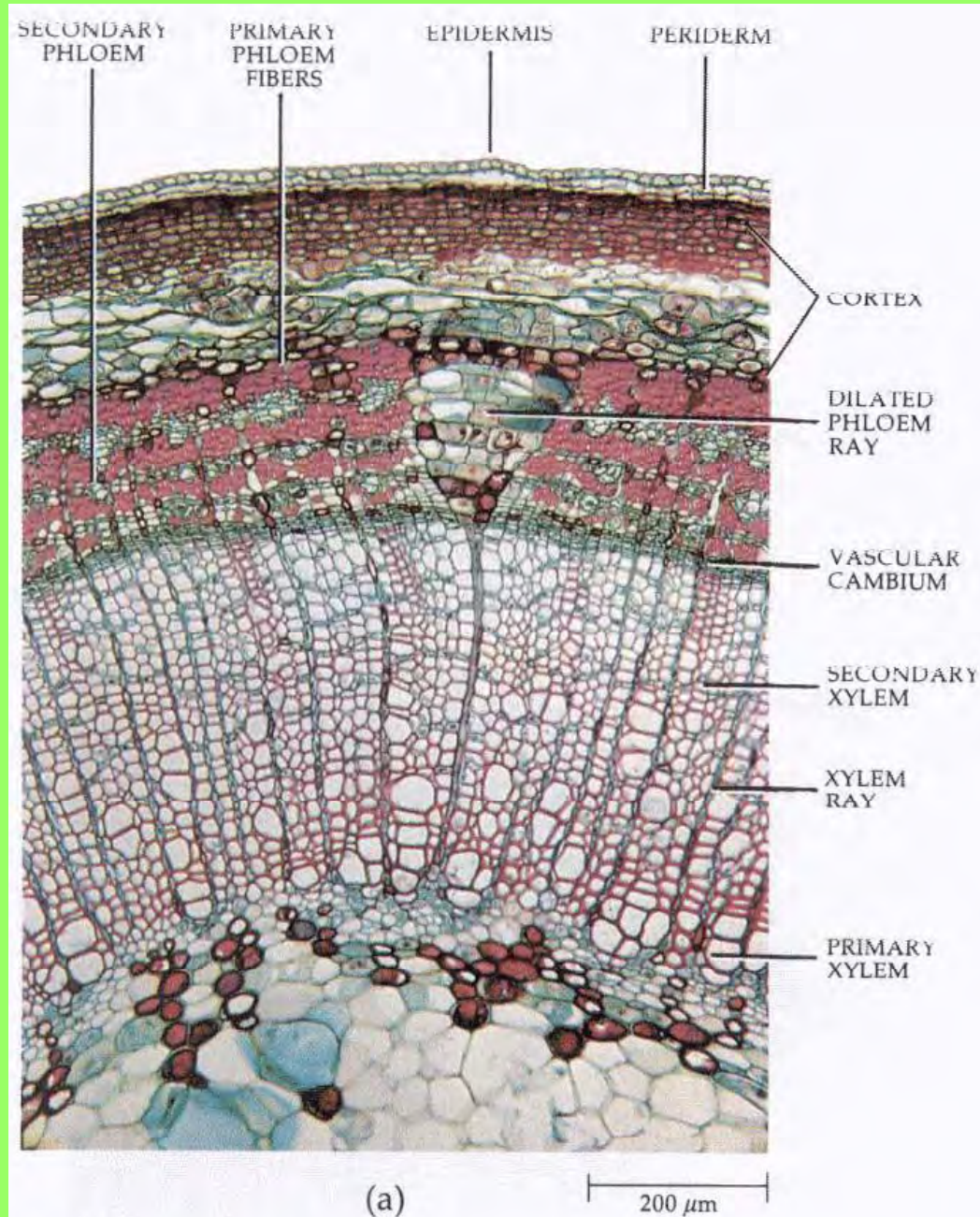
200 μ m



23-8

Transverse section of an elderberry (Sambucus canadensis) stem in which a small amount of secondary growth has taken place. A cork cambium has not yet been formed.

Tallos



23-10

Transverse sections of linden (Tilia americana) tree stems. (a) One-year-old stem. (b) Two-year-old stem. (c) Three-year-old stem. Numbers indicate growth rings in the secondary xylem.

Tallos

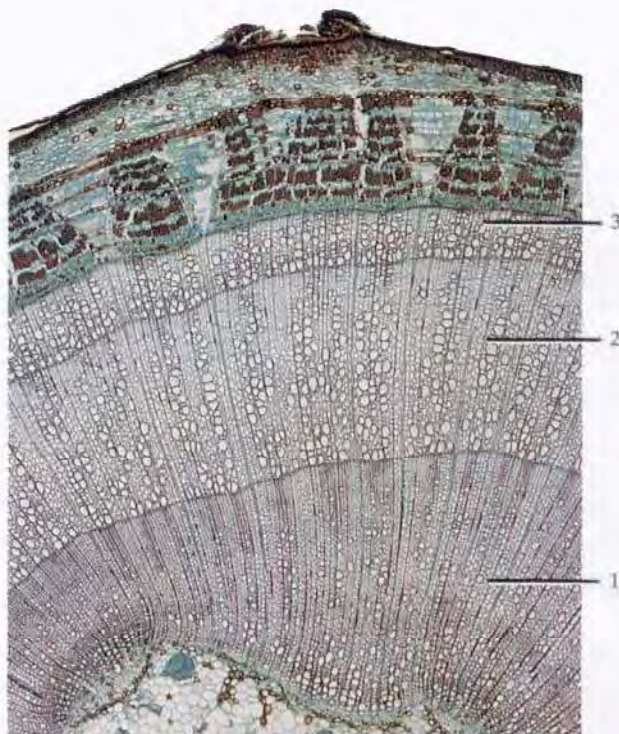
23-10

Transverse sections of linden (Tilia americana) tree stems. (a) One-year-old stem. (b) Two-year-old stem. (c) Three-year-old stem. Numbers indicate growth rings in the secondary xylem.



(b)

1 mm

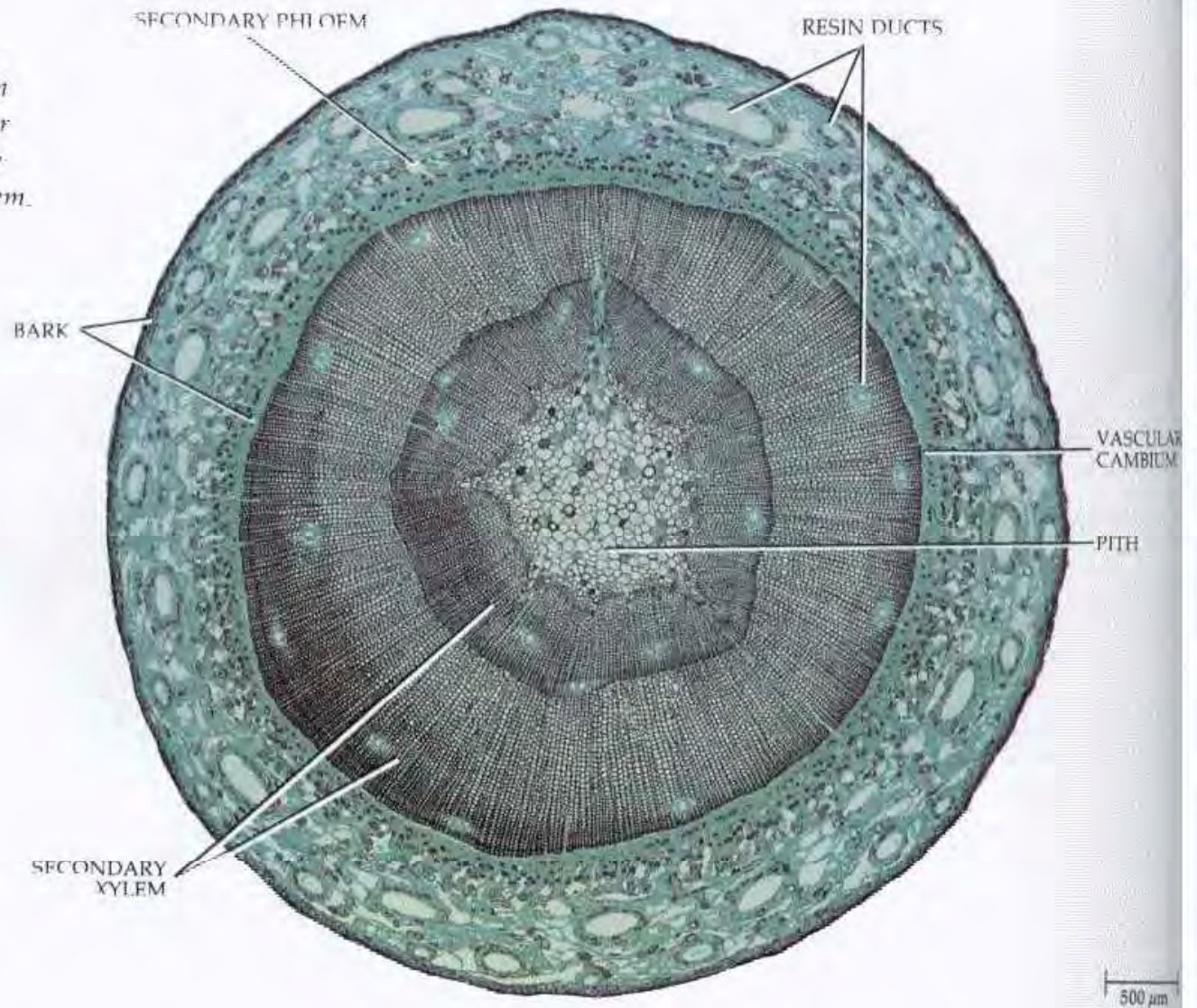


(c)

1 mm

18-14

Pinus. Cross section of stem, showing secondary xylem and secondary phloem separated from one another by vascular cambium. All of the tissues outside the vascular cambium, including the phloem, comprise the bark.



Cambium del corcho

- **Células cuboidales, las células del corcho tienen pared con suberina, mueren en la madurez a diferencia de las que produce el cambium vascular.**

Cambium del corcho

- Localizado por encima de la epidermis, tiene iniciales que dan origen a dos células, una del corcho y otra permanece inicial.
- En algunas especies, este cambium produce 1-2 células hacia adentro las cuales maduran en una capa denominada felodermis.
- Cambium del corcho + células del corcho + felodermis = peridermo.

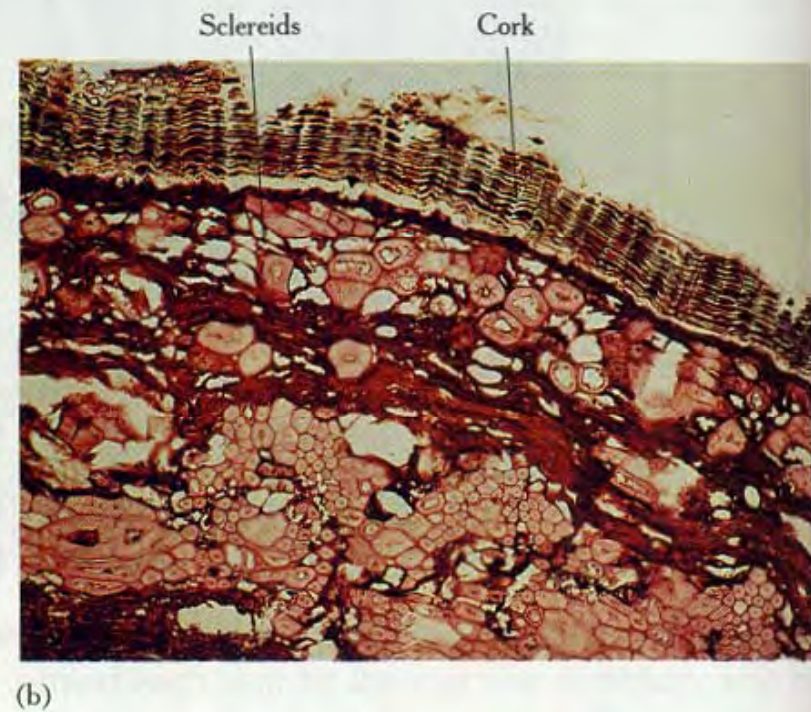
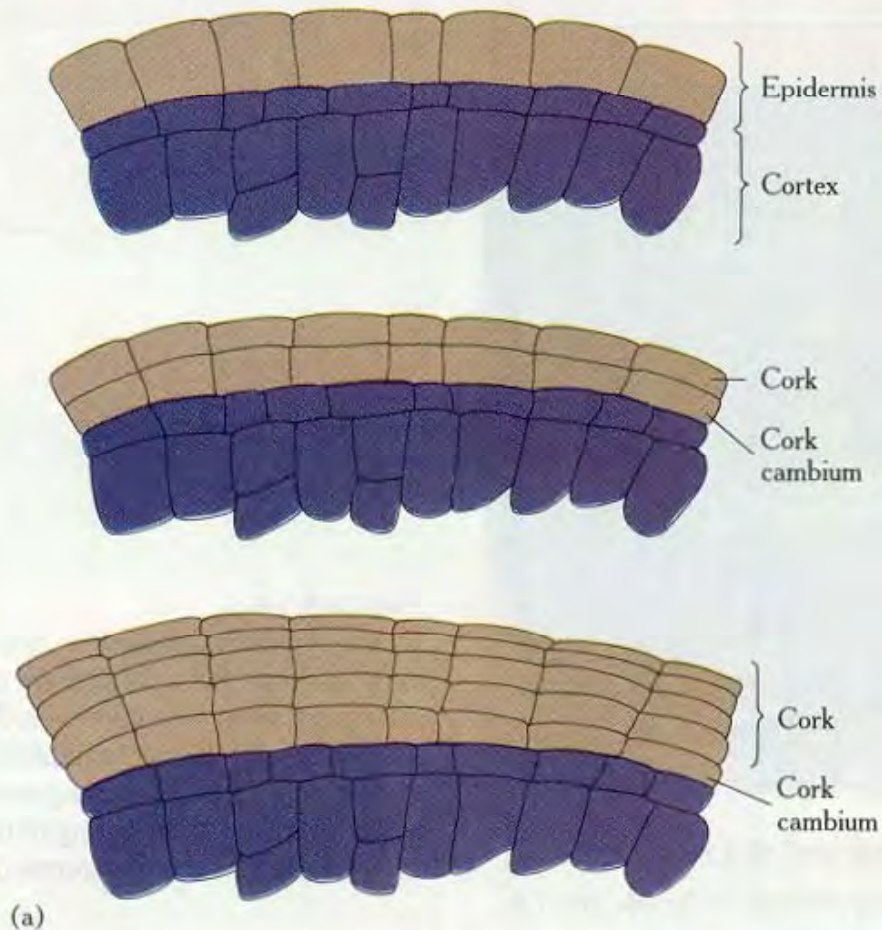


Figure 8.16

(a) The first cork cambium may form as epidermal cells resume mitotic activity. All cell divisions are by periclinal walls, and the inner cell continues as cork cambium while the outer cell differentiates into cork. (b) A thick layer of cork is present on this stem of *Balanops*. Many parenchyma cells in the cortex and secondary phloem have converted to sclereids, making the bark stronger and more protective. The next cork cambium will form deep in the secondary phloem, where there are numerous parenchyma cells capable of becoming mitotically active again; the sclereids cannot resume cell division ($\times 160$).

Tallo

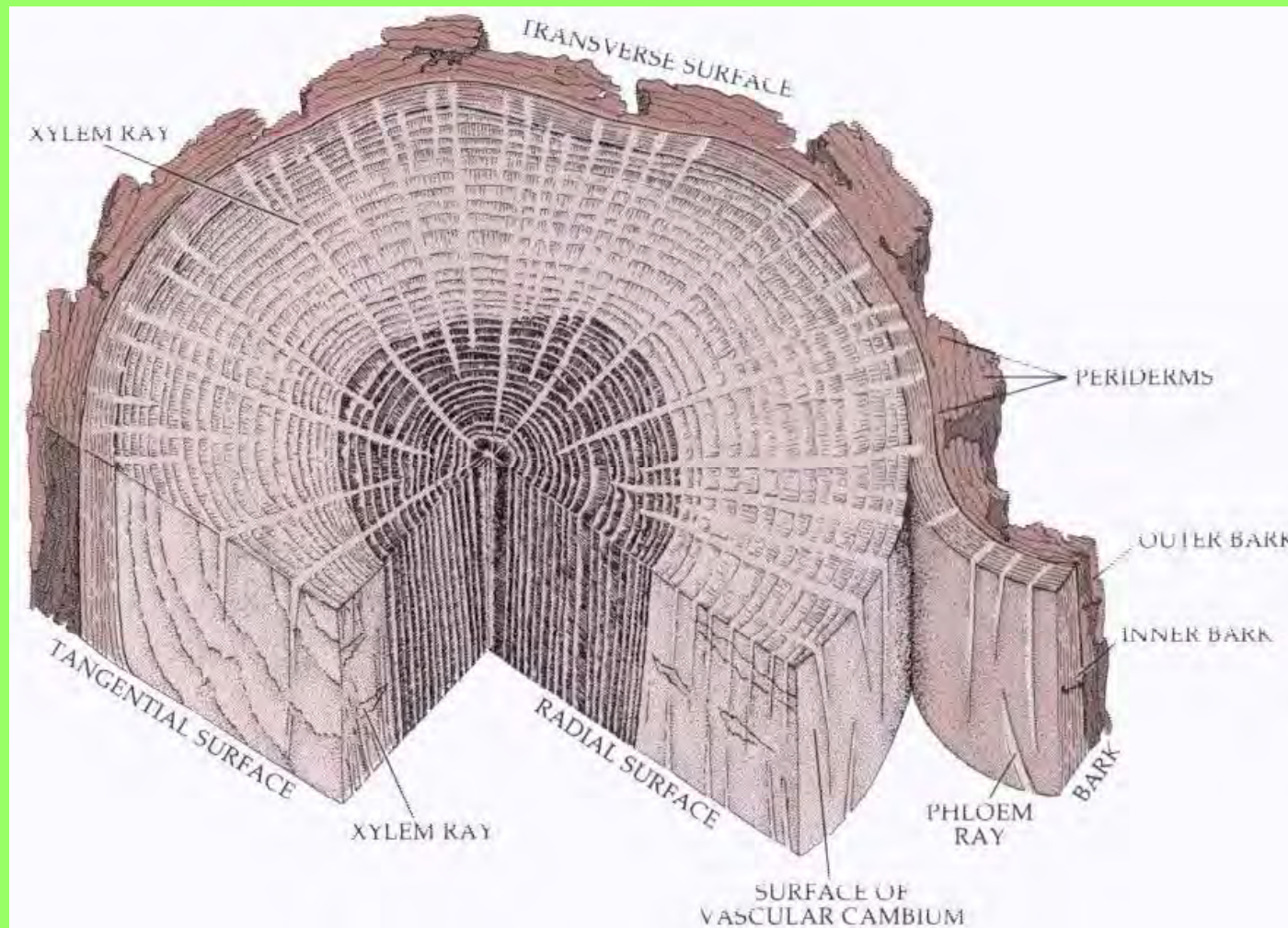
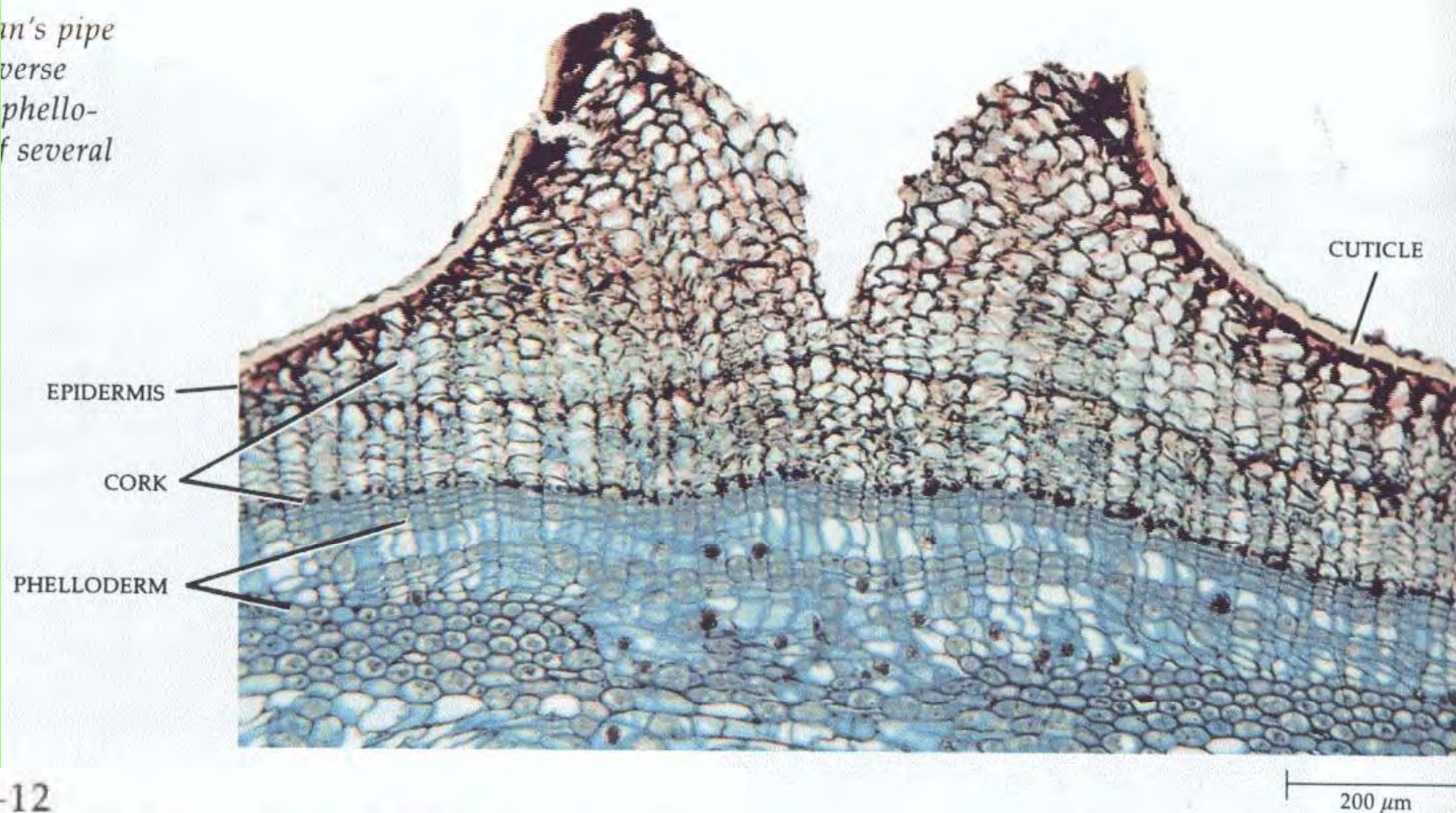


Diagrama de parte de la madera del tallo de encino rojo (*Quercus rubra*), donde se observan secciones transversales, tangenciales y radiales. El área oscura del centro es madera duramen, la mas clara es conocida como albura.

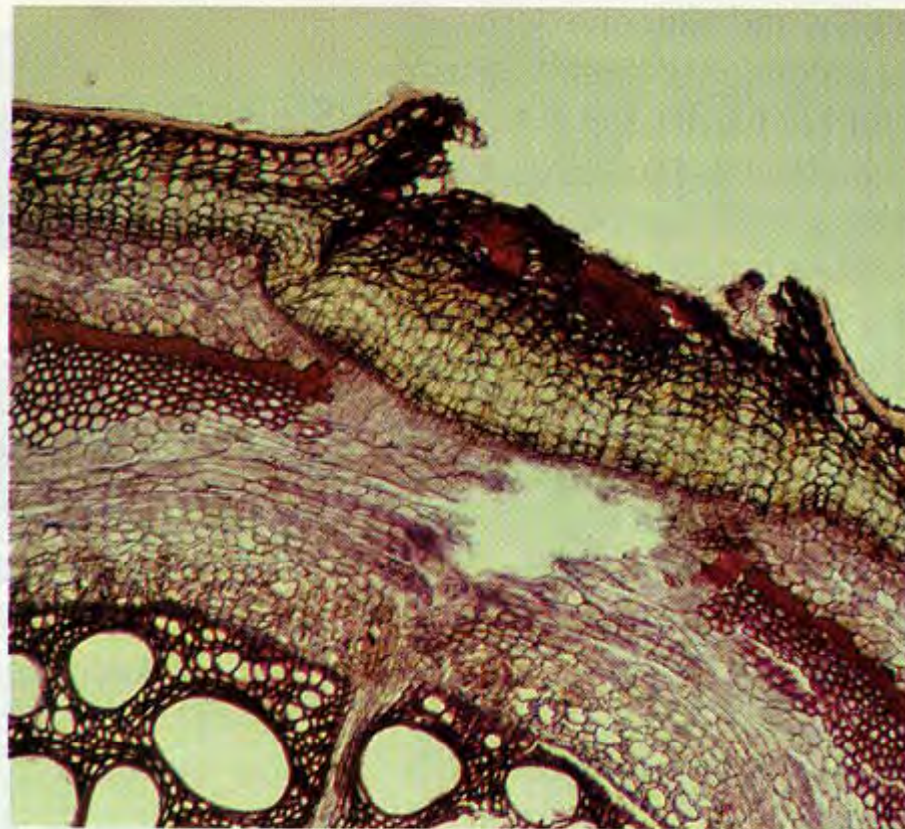
an's pipe
verse
phello-
f several



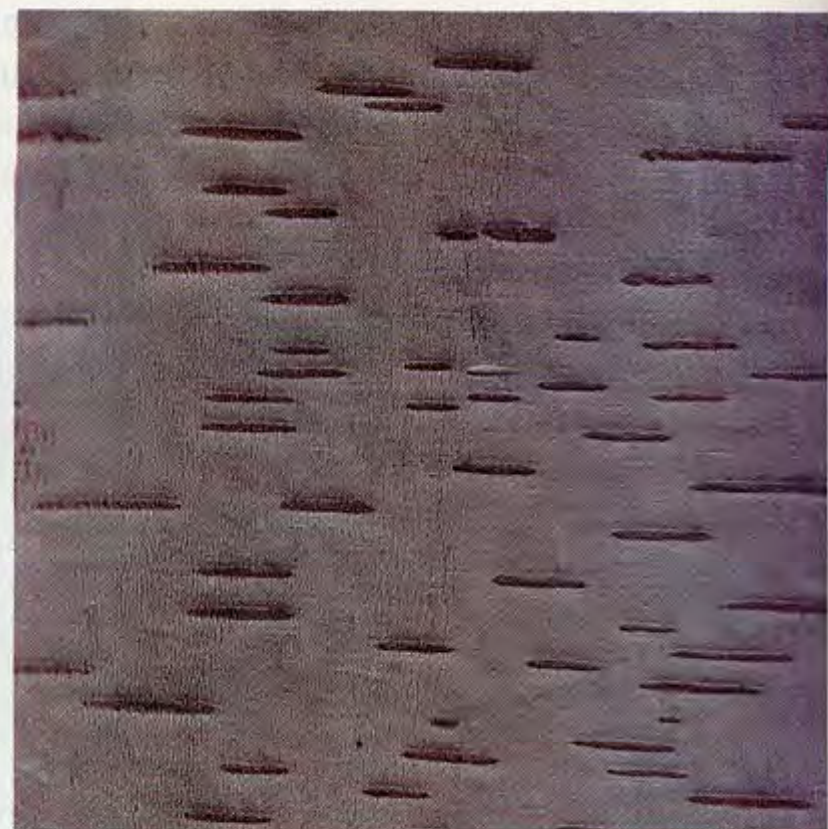
23-12

Lenticel of the stem of Dutchman's pipe (Aristolochia), as seen in transverse section. Unlike Sambucus, the phelloderm of Aristolochia consists of several layers of cells.

Lenticelas



(a)

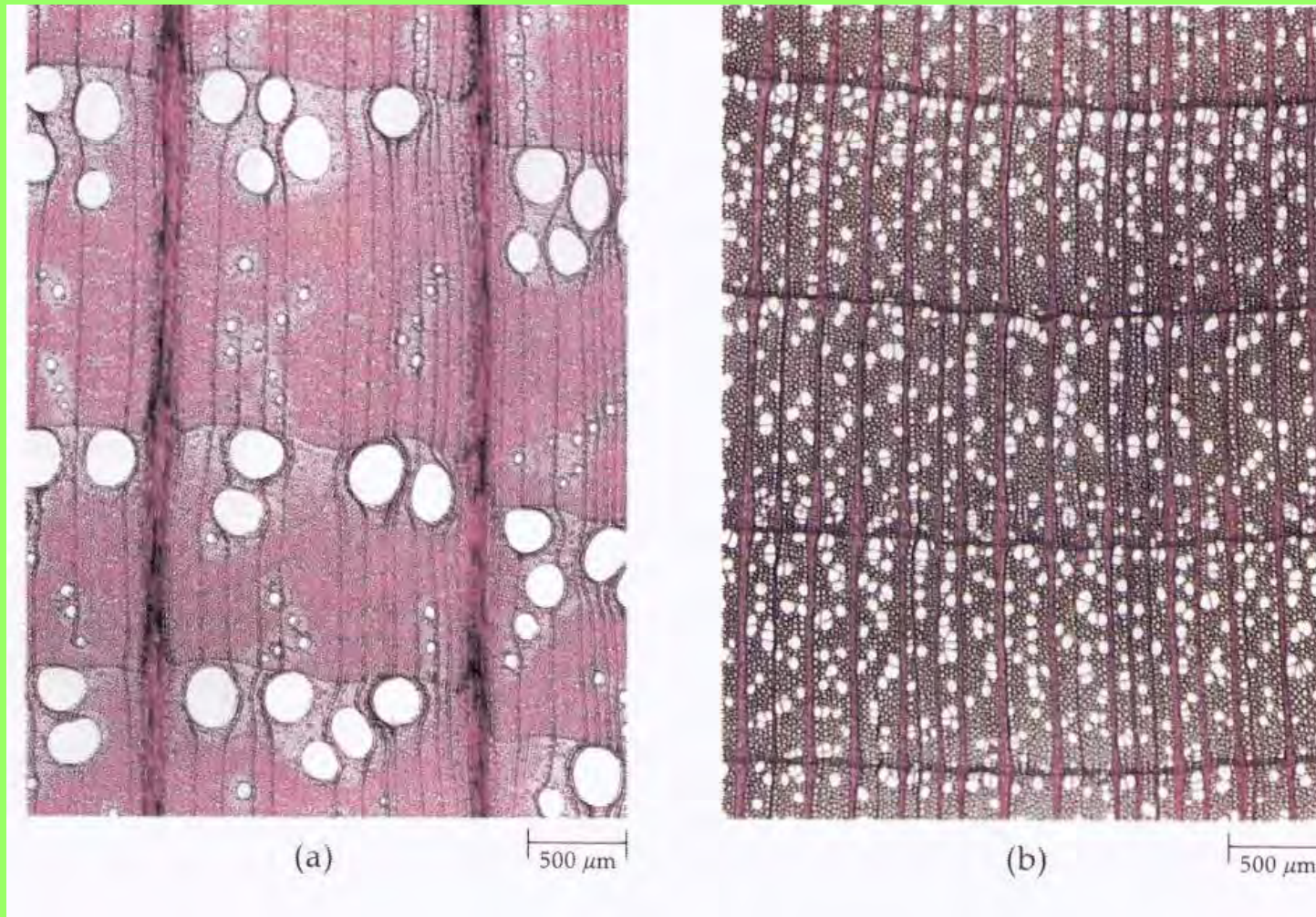


(b)

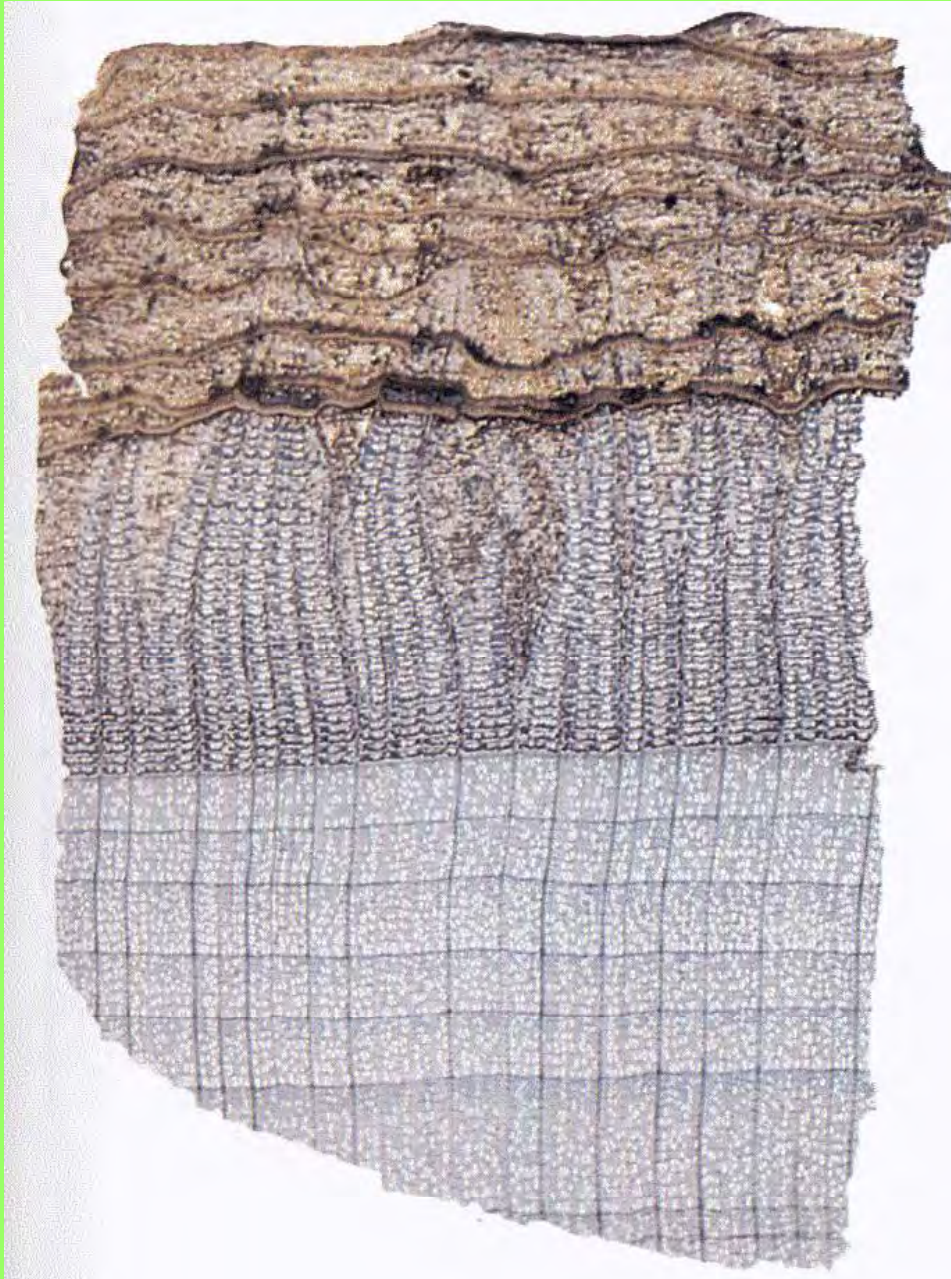
Figure 8.18

(a) The rapid production of cork cells in the lenticel causes the epidermis to rupture. Although they are difficult to see here, small intercellular spaces exist which allow oxygen to diffuse through the lenticel into the trunk or root ($\times 100$). (b) The lenticels of birch (*Betula*) become wider as the trunk increases in circumference. Occasionally they divide into two lenticels when the central cork cambium cells begin producing compact cork instead of aerenchymatous cork. .

Sección transversal de madera, mostrando capas de crecimiento (a) encino rojo (*Quercus rubra*). Los grandes vasos de madera de anillos porosos en madera joven. Las líneas verticales oscuras son rayos. (b) Árbol tulipán (*Liriodendron tulipifera*). Una madera de poros difusos.



Vasos del
xilema y
anillos de
crecimiento



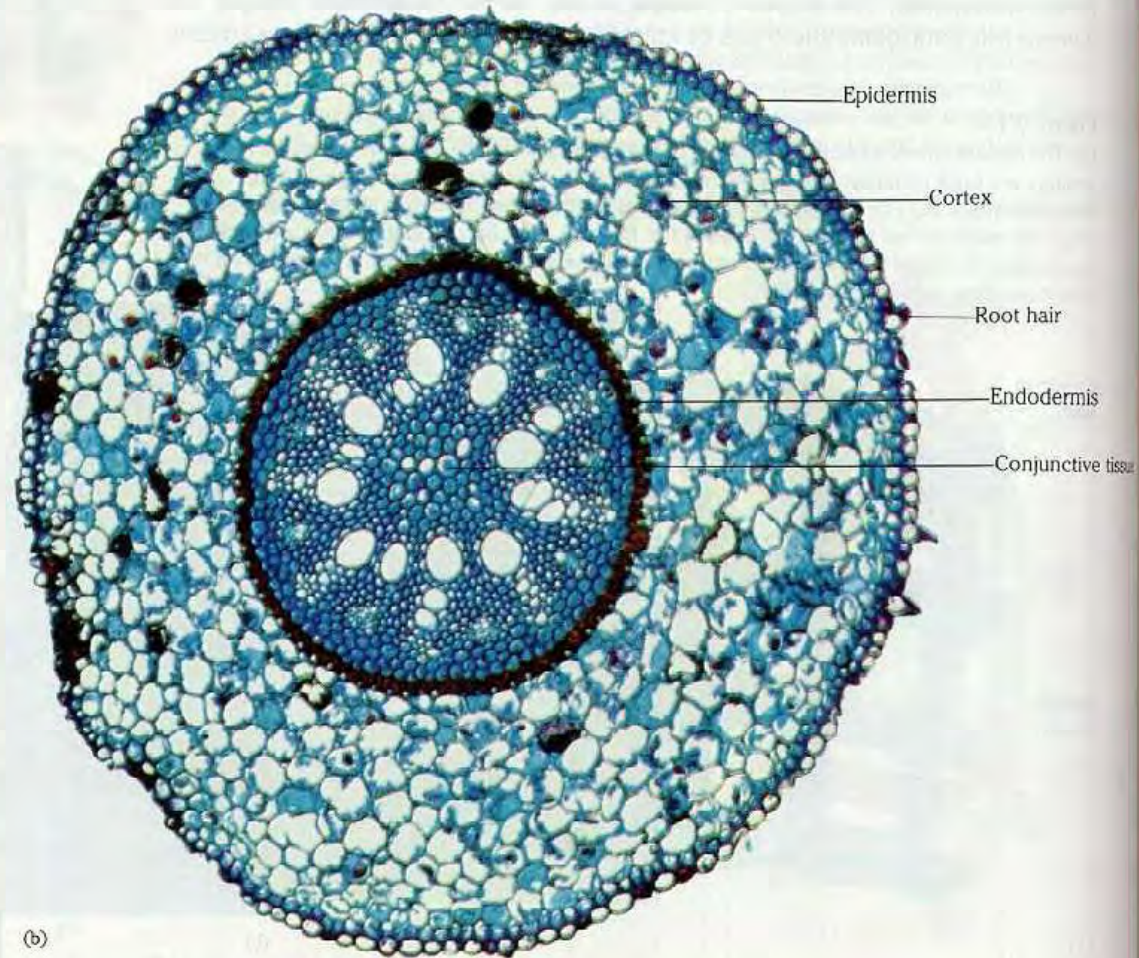
Tallo:

Peridermis y madera

Sección transversal de la madera y xilema secundario de tallo viejo (*Tilia americana*). Varias peridermis son vistas atravesando la madera marrón clara en la parte de arriba. Debajo de la madera mas externa está la madera interna, la cual es diferente en apariencia del xilema mas teñido en la parte basal del corte.

Figure 7.14

(a) Cross-section of a root of buttercup, *Ranunculus*; the xylem has four sets of protoxylem, the narrow cells at the tips of the arms. The central, larger xylem cells are metaxylem. There are four masses of phloem also; this is a tetrarch root. The endodermis is visible, but Casparian strips are difficult to see at this low magnification. The pericycle is the set of cells between the endodermis and the vascular cells ($\times 140$). (b) The vascular tissue of many monocot roots consists of numerous large vessels or collateral bundles surrounded by a set of alternating strands of xylem and phloem. (Carolina Biological Supply Company)



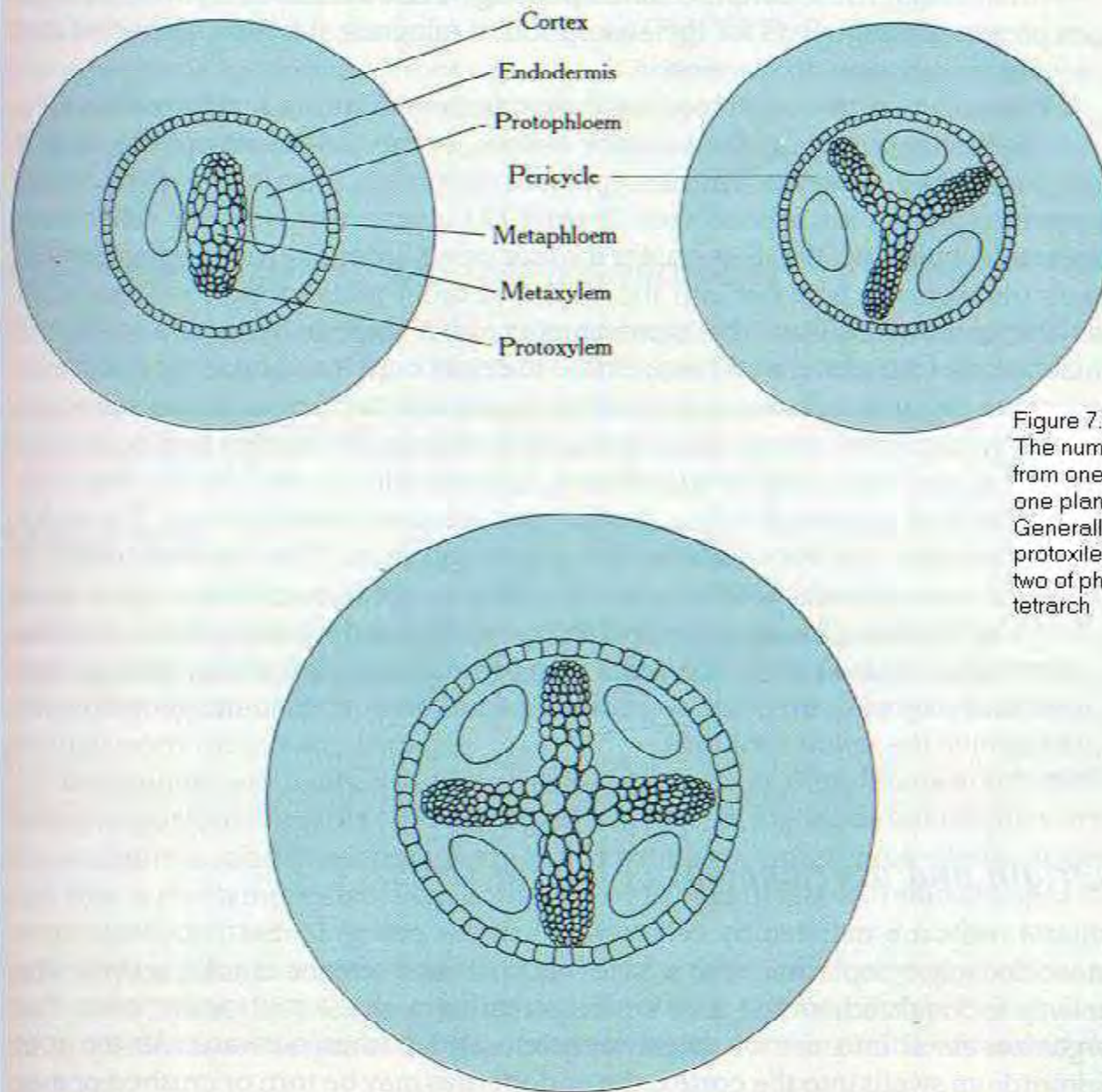
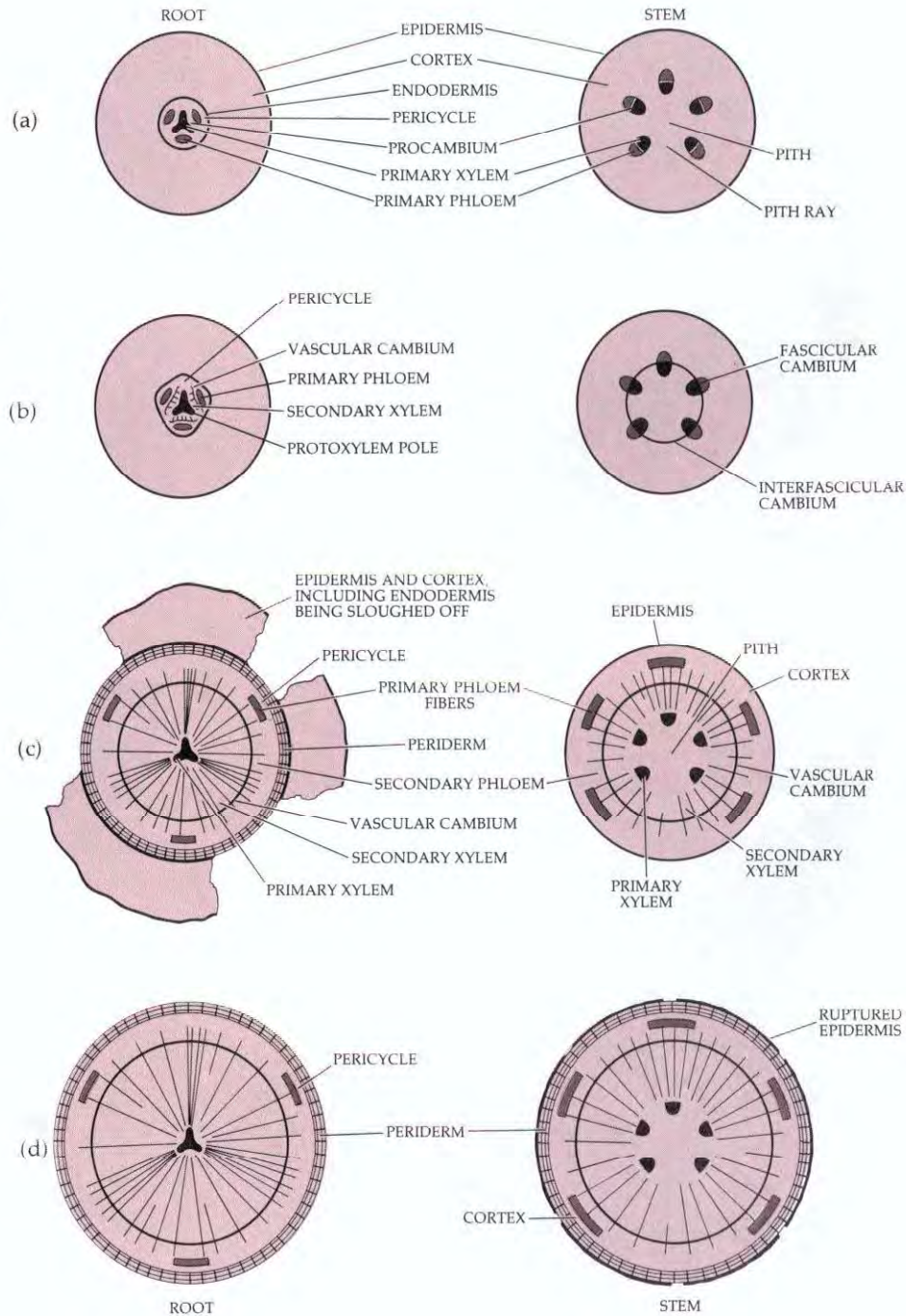


Figure 7.15

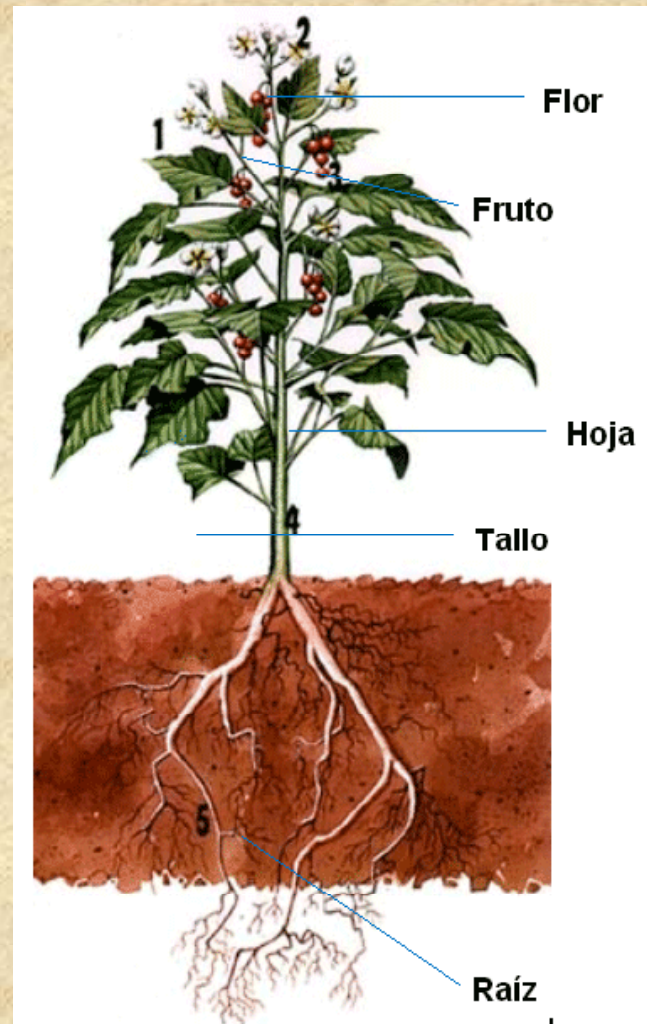
The number of strands of protoxylem in root varies from one species to another and among the roots of one plant.

Generally, wider, more robust roots have more protoxylem masses. Two masses of protoxylem (and two of phloem) is diarch; three is triarch; and four is tetrarch.

Comparison of primary and secondary structure in root and stem of a woody dicot. (a) Root and stem at completion of primary growth. In the triarch root represented here, cambial activity has been initiated in three independent regions from procambium between the three primary phloem strands and the primary xylem. (b) Origin of vascular cambium. The pericyclic cells opposite the three protoxylem poles will also contribute to the vascular cambium. Some secondary xylem has already been produced by the newly formed vascular cambium of procambial origin. (c) After formation of some secondary xylem and secondary phloem in root and stem, and periderm formation in root. (d) At end of first year's growth, showing the effect of secondary growth—including periderm formation—on the primary plant body. In (c) and (d), the radiating lines represent rays.



ORGANOGRAFÍA de plantas



TEMÁTICA

Localización y características de los tejidos primarios y secundarios en diferentes órganos vegetales en diversos grupos de plantas.

Tallo: Anatomía primaria y secundaria- Estele.

Raíz: Anatomía primaria y secundaria.

Hoja: Anatomía de diferentes tipos de hojas.

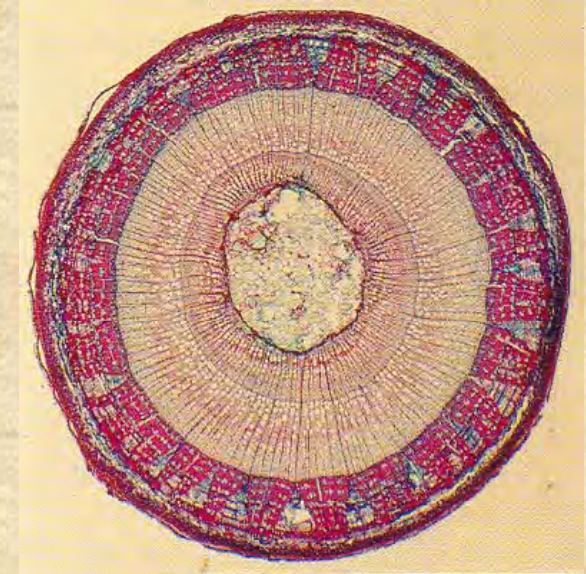
Flor: Estructura y algunos aspectos.

Fruto: Algunos aspectos de la anatomía.

Semilla: Anatomía.

Concepto de estele o estela

Este es el cilindro o columna central que abarca la red vascular de xilema y floema desde la raíz hasta la punta del tallo.



En raíces está muy bien definido por estar rodeado por el periciclo y todos los tejidos del interior.

En tallos el límite es menos preciso ya que se considera estele a todos los tejidos a partir del floema hacia el interior.

Este es un concepto controvertido que algunos anatomistas han decidido abandonarlo. Ha sido tomado en estudios de evolución de plantas vasculares

Tipos de esteles :

De acuerdo al desarrollo de la médula y posiciones de los paquetes vasculares)

Protostele (sin médula):

Haplostele

Actinosteale

Plectosteale

Sifonosteale (tubular):

Sifonosteale anfifloemático

Sifonosteale ectofloemático

Eustele

Atactosteale

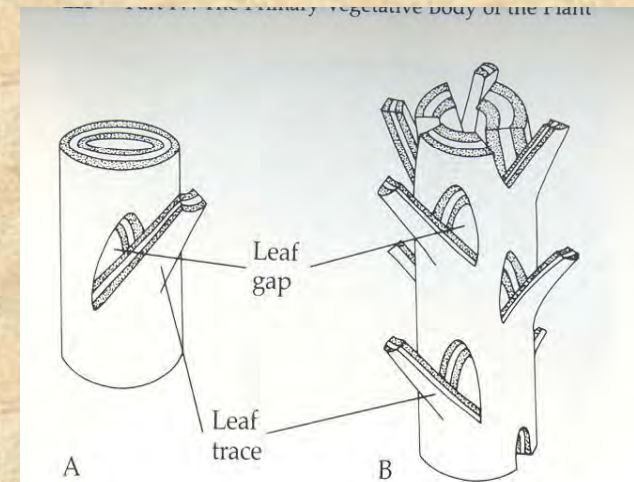


Figure 11.39

If leaf gaps are rare (A), the stele is mostly a cylinder, but as leaf gaps become more common, the stele begins to appear to consist of interconnected bundles (B).

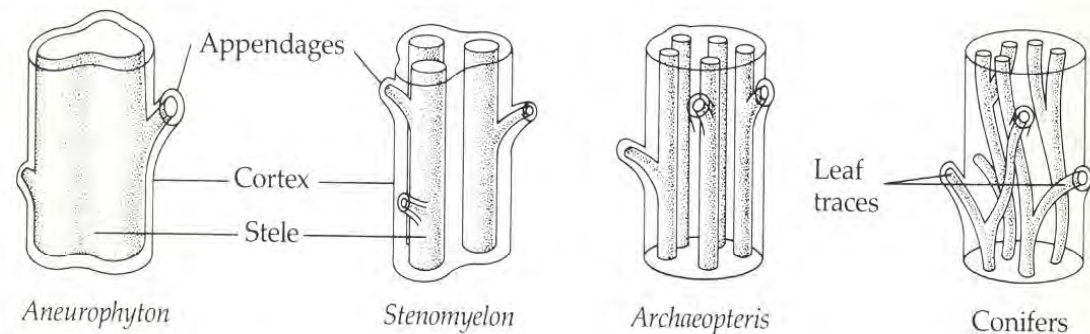
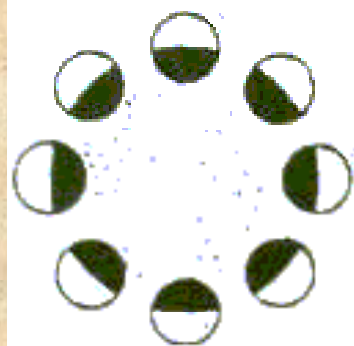
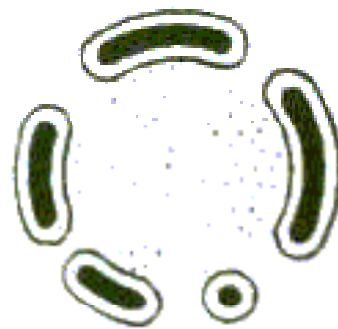


Figure 11.40

This diagram represents a hypothesis about the origin of the siphonostele in seed plants: the original condition was a haplostele; as leaf traces came off, the margins became undulate (an actinosteale); with deeper undulations, the protosteale edges became separated, forming a siphonostele. Based on the information and ideas presented by Namboodiri and Beck (1968a, b).



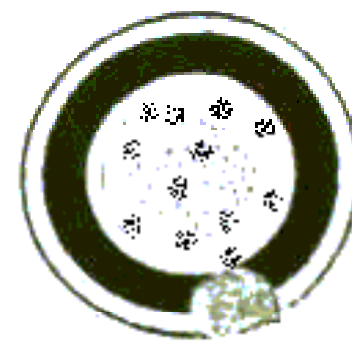
Eustela



Dictiostela



sifonostela
antifloica



sifonostela
ectofloica



Eustela



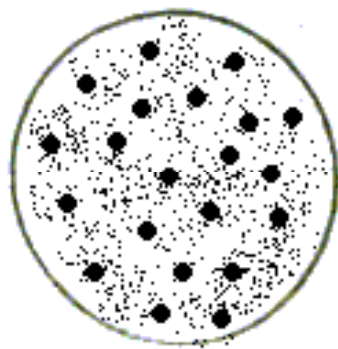
haplostela



protostela



actinostela



atactostela (negro xilema,
blanco floema y médula
punteado)



atactostela

**Distintos tipos de
estelas**

PROTOSTELES (SIN MÉDULA)

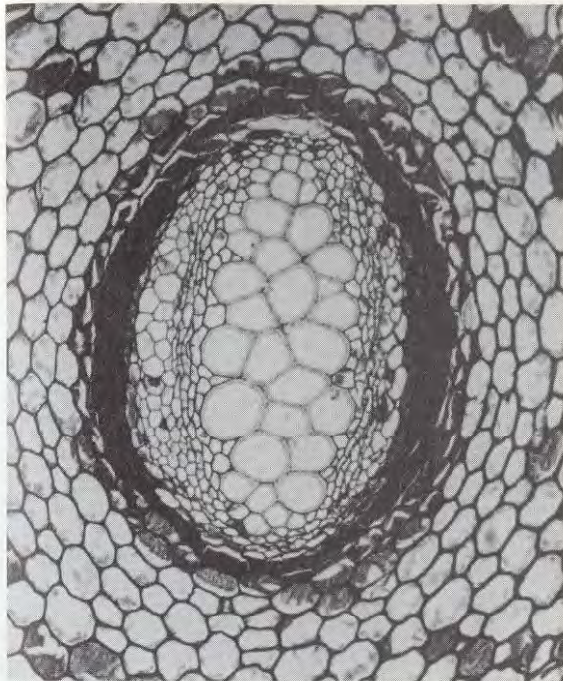


Figure 11.34
This is a haplostele of *Osmunda*. It is a protosteles with a solid mass of xylem that is more or less circular. $\times 160$.

haplostele

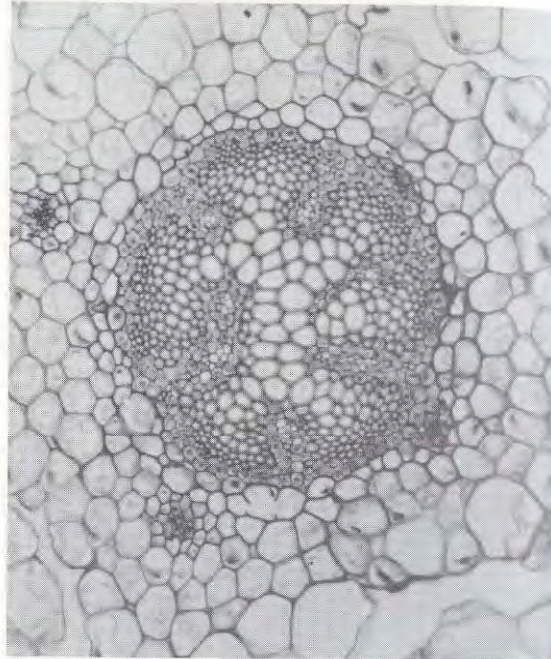


Figure 11.36
Because this protosteles (no pith) of *Lycopodium* (club moss) has a star-shaped mass of xylem, it is an actinosteles. Notice that this steles, as well as those in Figures 11.34 and 11.37, has the protoxylem on the exterior of the xylem mass and the metaxylem located in the center. $\times 160$.

actinosteles



Figure 11.37
The tissue between the plates of xylem is phloem, not pith, so this is a protosteles; because the xylem consists of plates, it is a plectosteles. Look carefully at the phloem and you can see several large sieve cells. They are not usually so easily visible. *Lycopodium annotinum*. $\times 100$.

plectosteles

F
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SIFONOSTELES

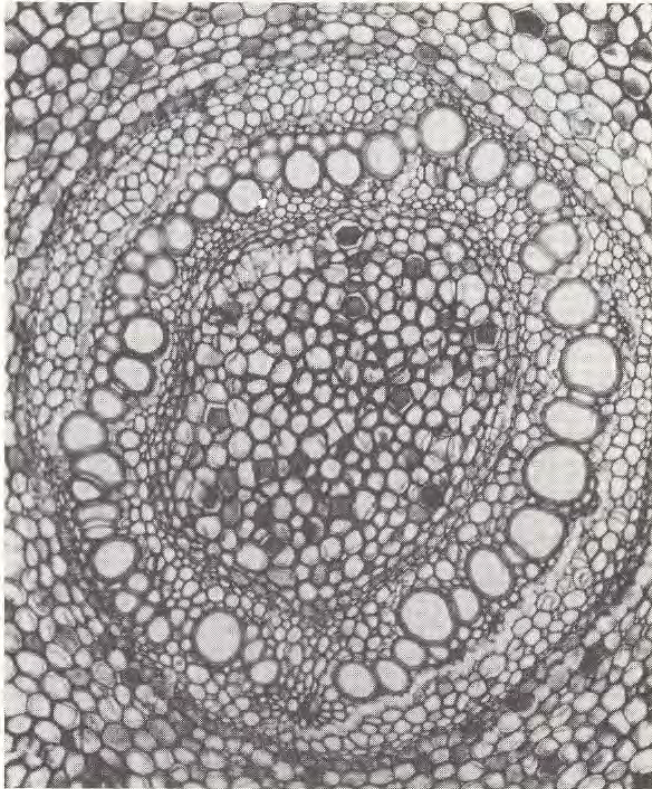


Figure 11.35

An amphiphloic siphonostele. It is amphiphloic because there is phloem on both sides of the xylem, and a siphonostele because there is a pith in the center. Because there are no leaf gaps visible, they must be scarce, so this is a solenostele. *Marsilea*. $\times 160$.

anfifloemático

FIGURE 11.3 The Primary Vegetative Body of the Plant

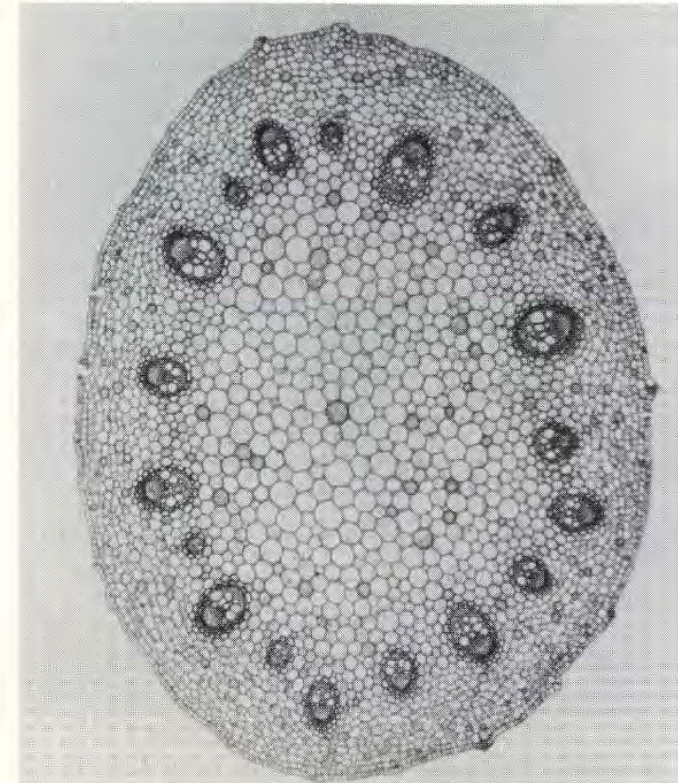
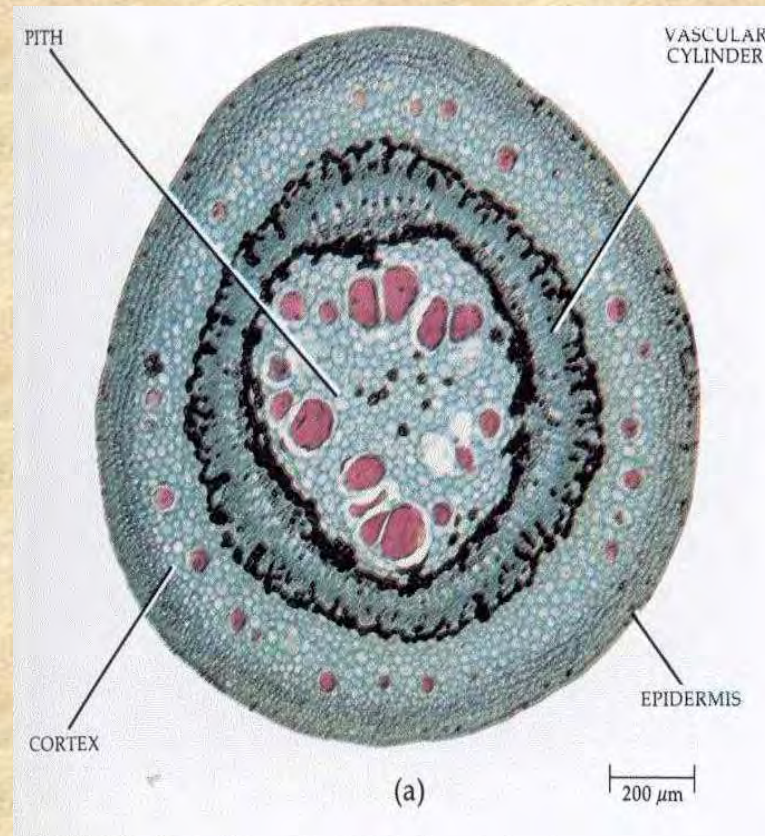


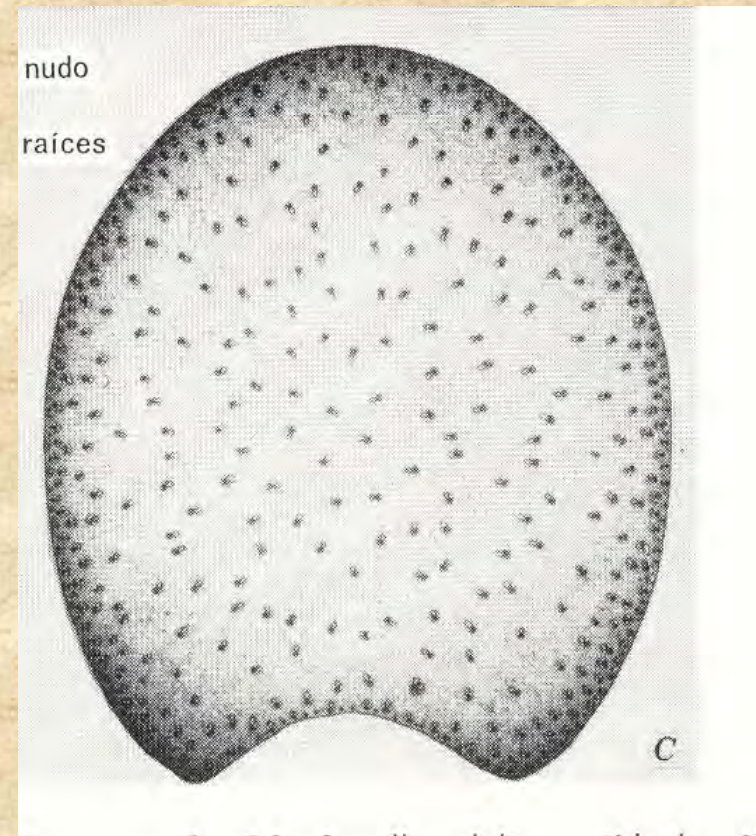
Figure 11.3

This cross section of a stem of *Ranunculus* (buttercup) shows the arrangement of the tissues. From outside to inside: epidermis, cortex, vascular bundles, pith. The parenchyma between the vascular bundles is called a medullary ray. $\times 40$.

ectofloemático



Euestele



Atactostele

Anatomía de tallo

TALLO

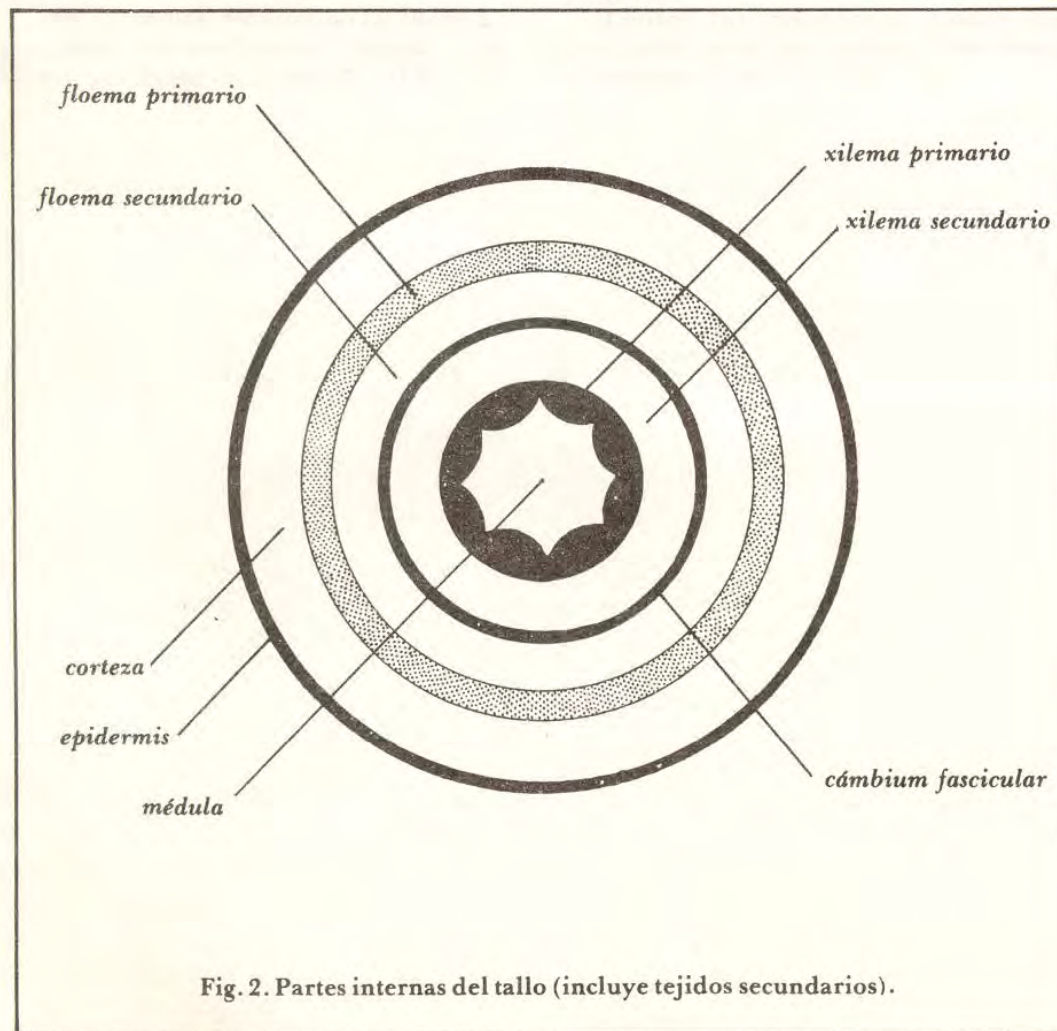
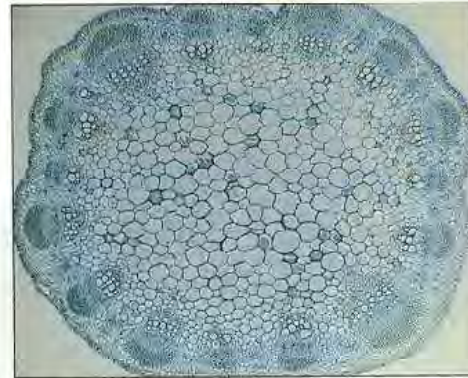


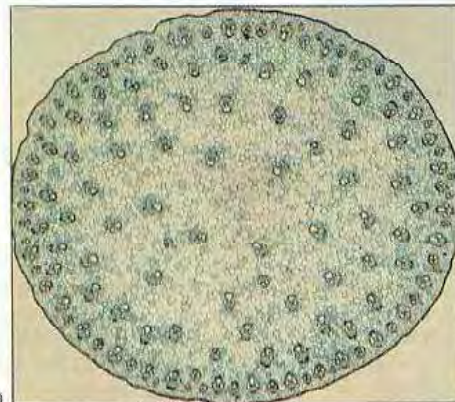
Figure 5.34

(a) The stem of most dicots contains one ring of collateral bundles located between the cortex and pith. (Ed Reschke) (b) The stem of most monocots contains numerous bundles arranged in a complex network in the conjunctive tissue. (b, left, Carolina Biological Supply Company; right, Ed Reschke).

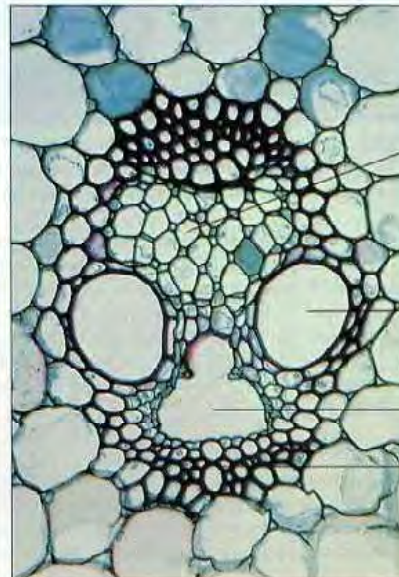


Phloem
fiber
cap
Phloem
Vascular
cambium
Xylem

(a)



(b)



Phloem
Xylem
Air space
Bundle sheath

Diferencias básicas entre las dicotiledóneas y las monocotiledóneas

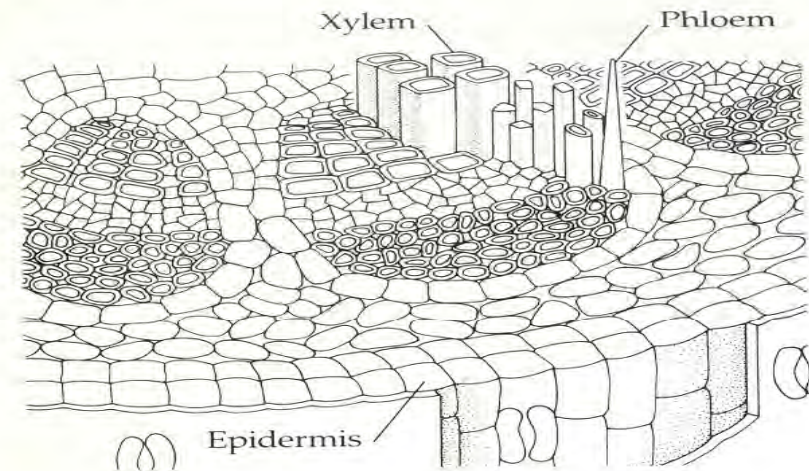


Figure 1.3
In most dicot stems, there is a ring of vascular bundles, each containing xylem and phloem. Inside the ring is pith; outside are cortex and an epidermis.

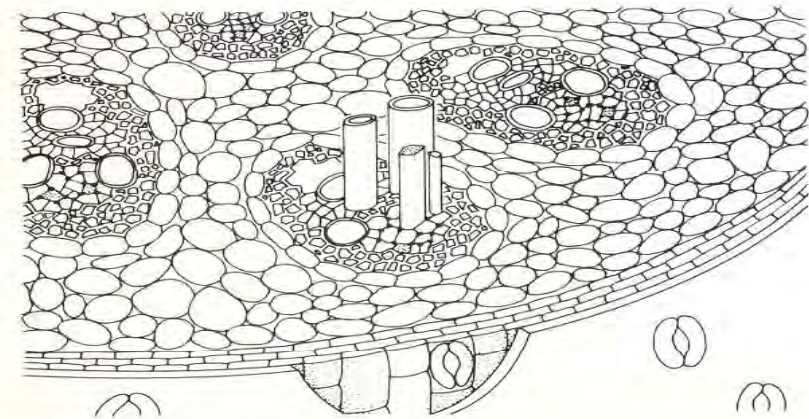
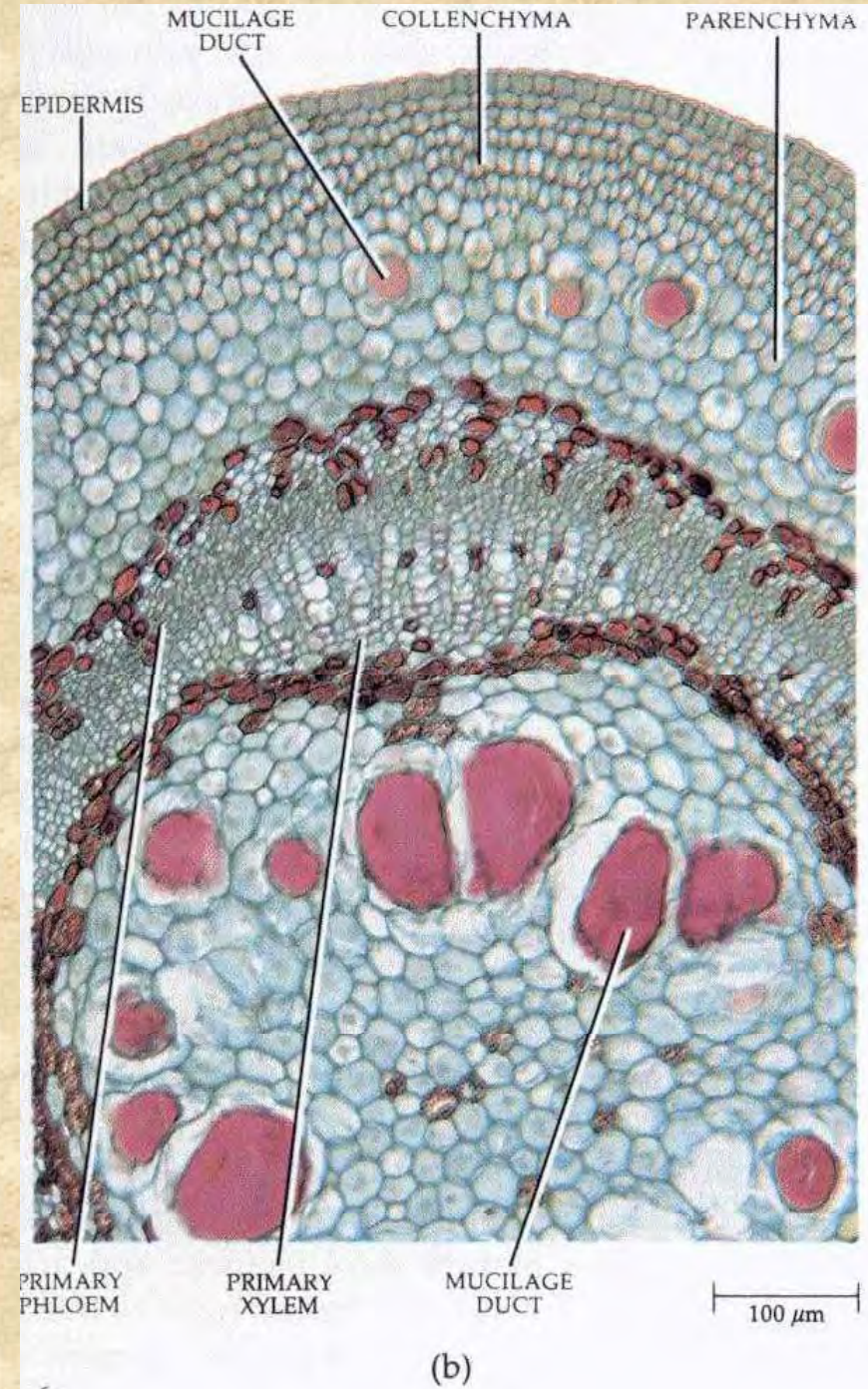
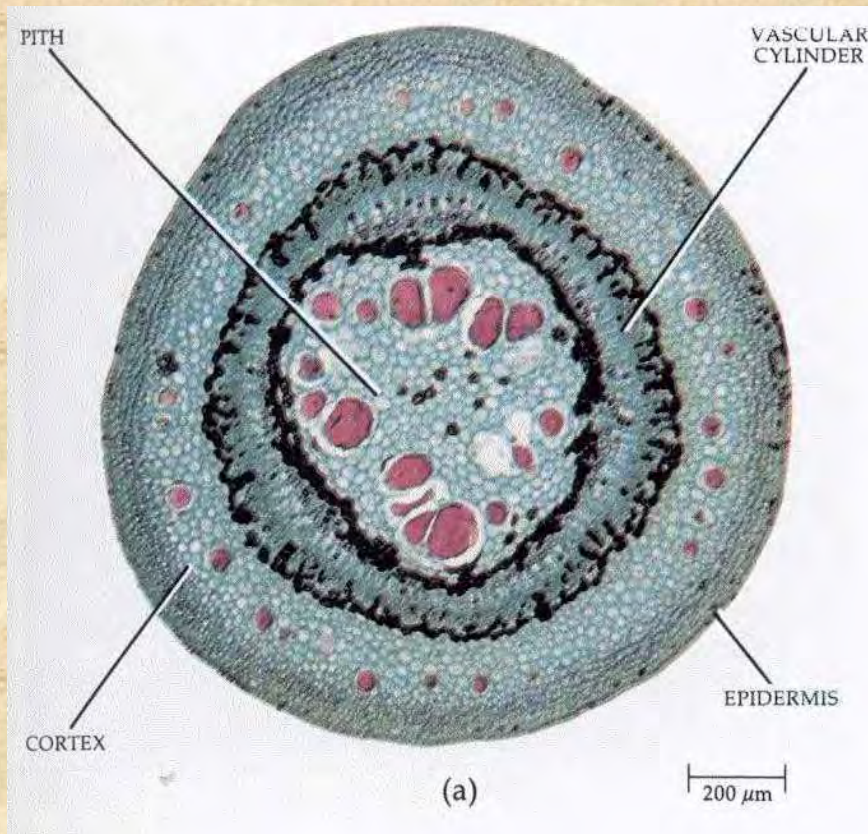


Figure 1.4
A monocot stem also contains vascular bundles but usually in a more complex pattern.

into one or many bundles in both roots and shoots. If several bundles are present, then they are arranged into a ring which surrounds the pith in all seed plants except the monocots; in these latter plants the bundles are organized

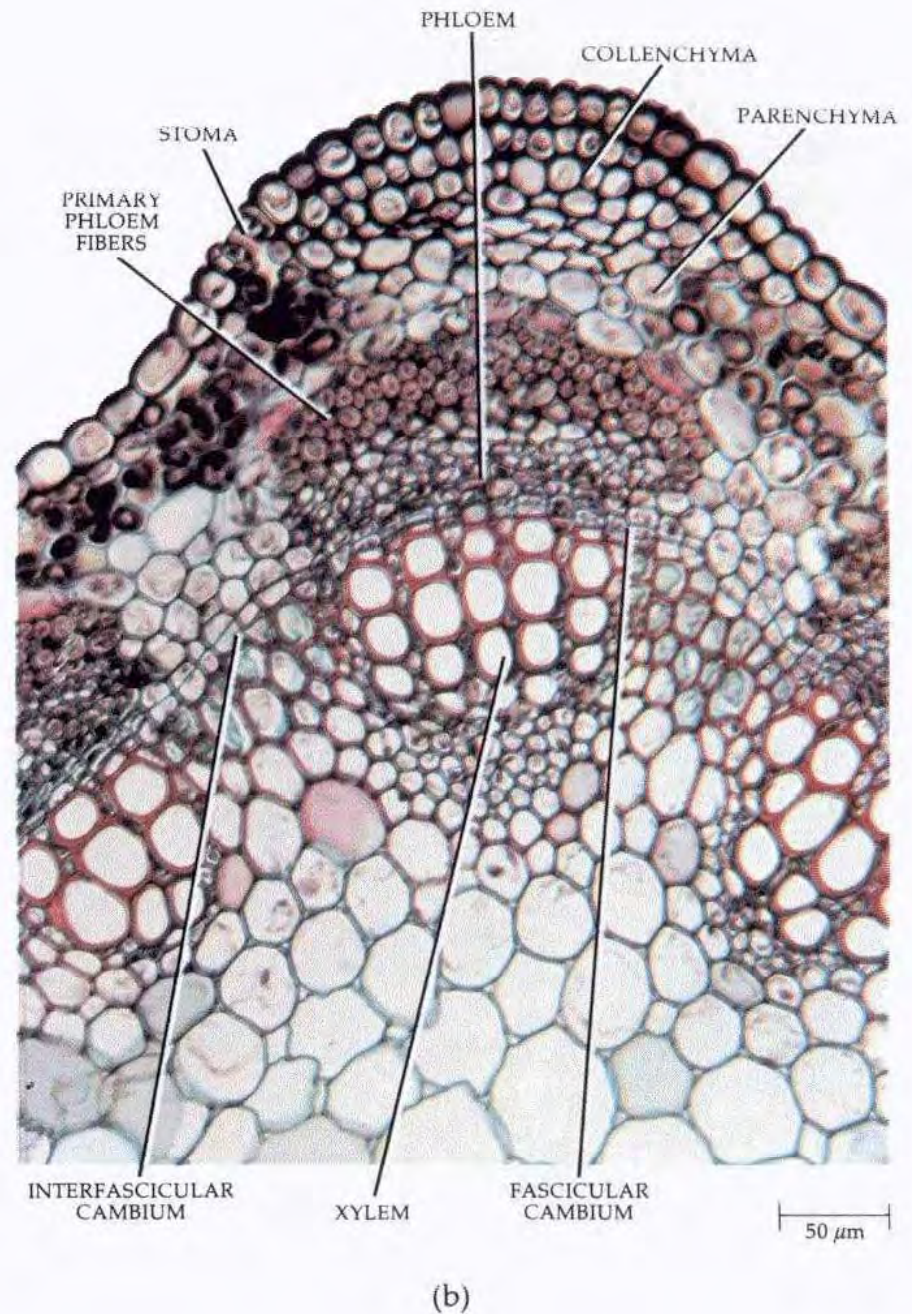
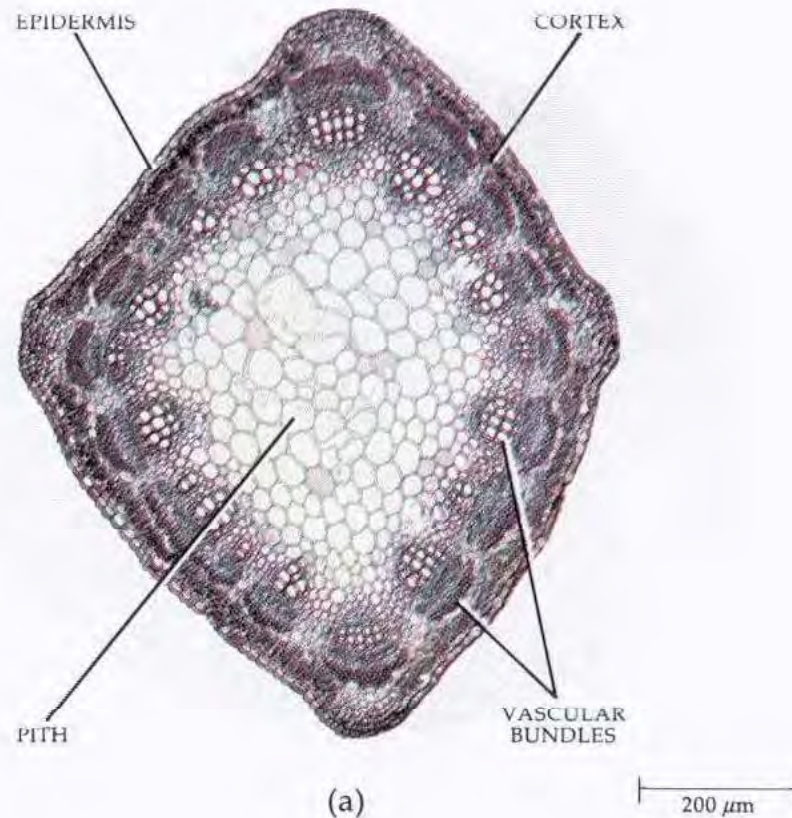
Tallo

(a) Sección transversal de tallo de *Tilia americana* en desarrollo temprano. El tejido vascular aparece como un cilindro hueco que divide el tejido fundamental en médula interna y corteza externa (b) Detalle de una porción del mismo tallo.



Tallo

Sección transversal de tallo de alfalfa (*Medicago sativa*), una dicotiledónea con haces vasculares discretos (b) Detalle de una porción del mismo tallo.



Anatomía de raíz

Epidermis- Tejido uniestratificado con células alargadas y pelos absorbentes

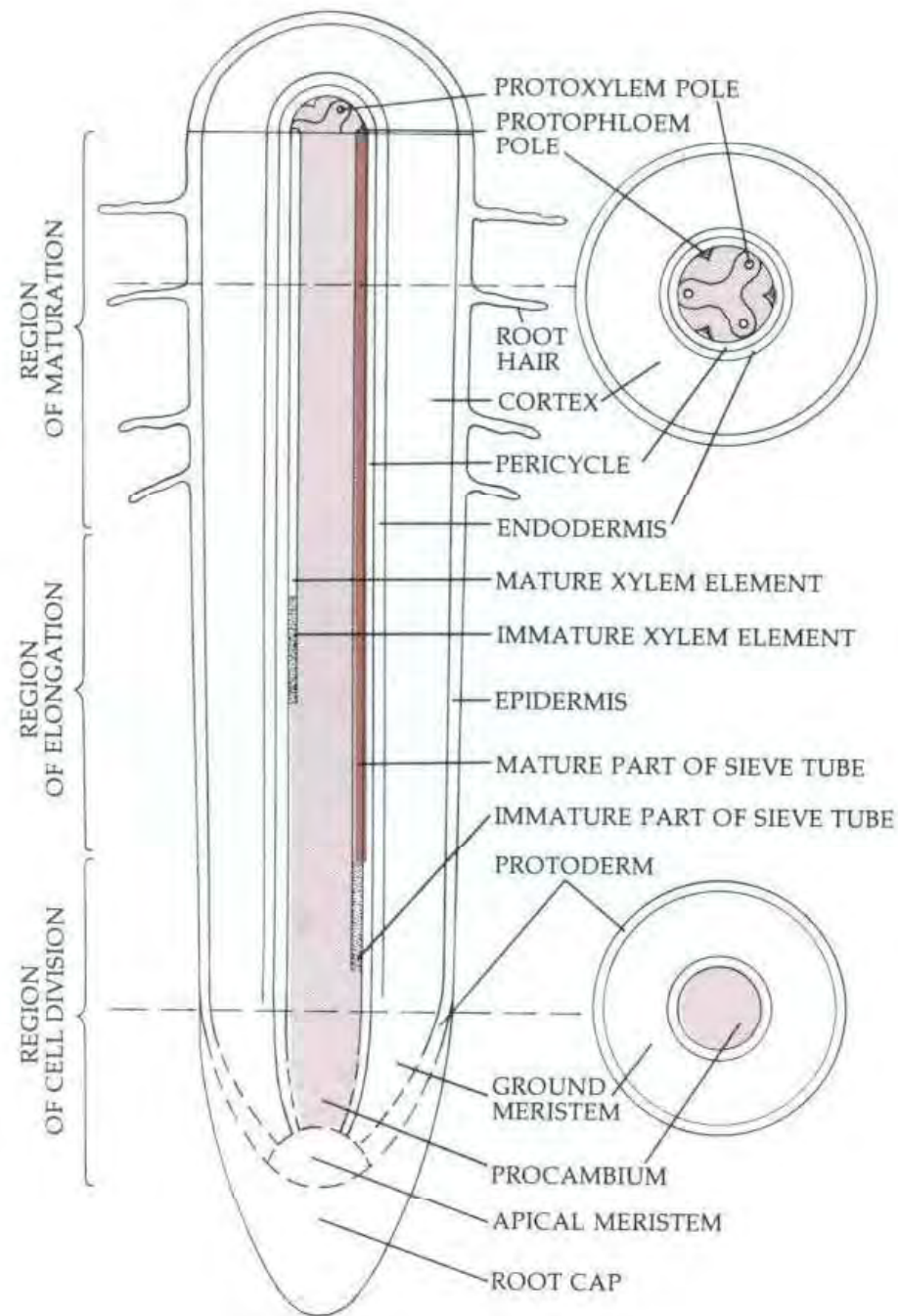
Caliptra o cofia- tejido parenquimático con células que se desprenden y mucílago

Cortex o corteza- Exodermis (células parenquimáticas suberizadas parcialmente)
- Parénquima fundamental

Endodermis, células con banda de Caspary, hidrofóbica de suberina

Periciclo, meristemo que da lugar a raíces secundarias

Cilindro vascular (estele) : periciclo meristemático
sistema vascular (xilema y floema)



Raíz:

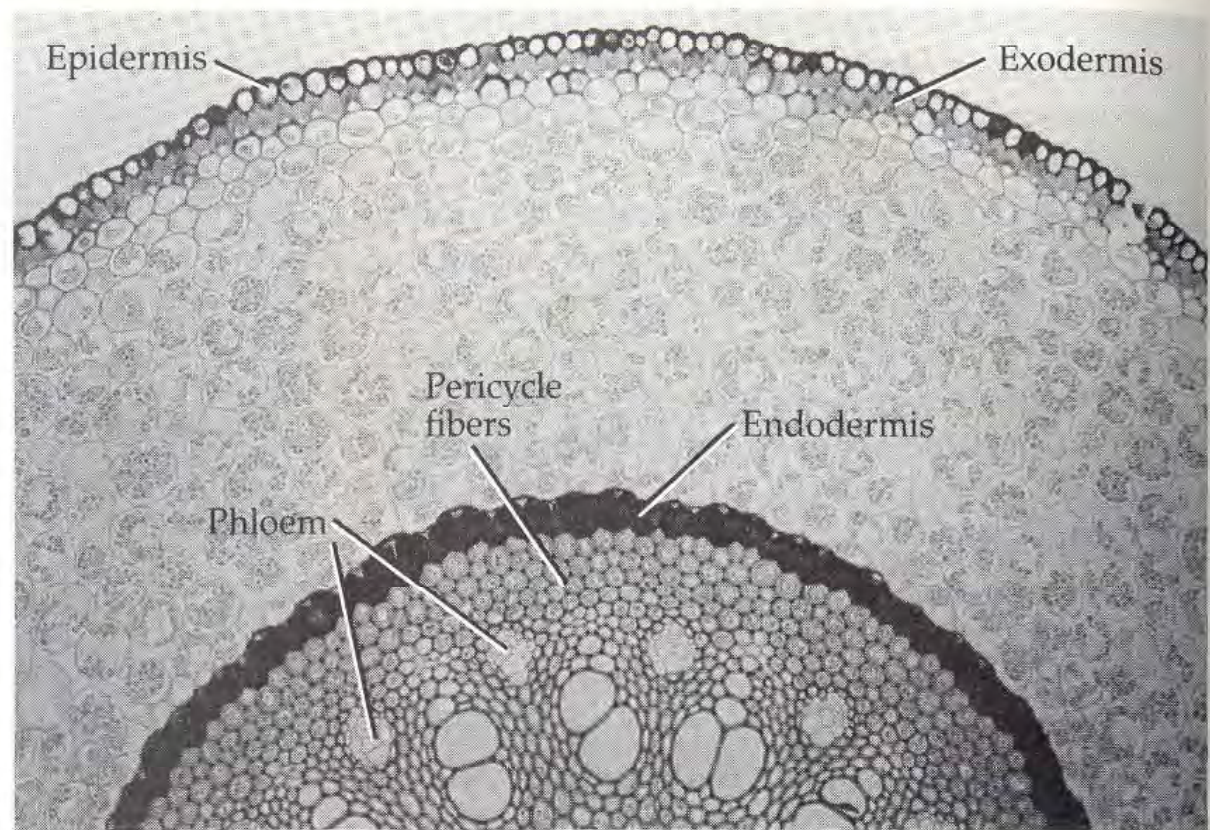
tiene tres zonas diferenciadas: de división, de elongación, de maduración

Diagrama ilustrando estadios tempranos en el desarrollo primario del ápice de la raíz.

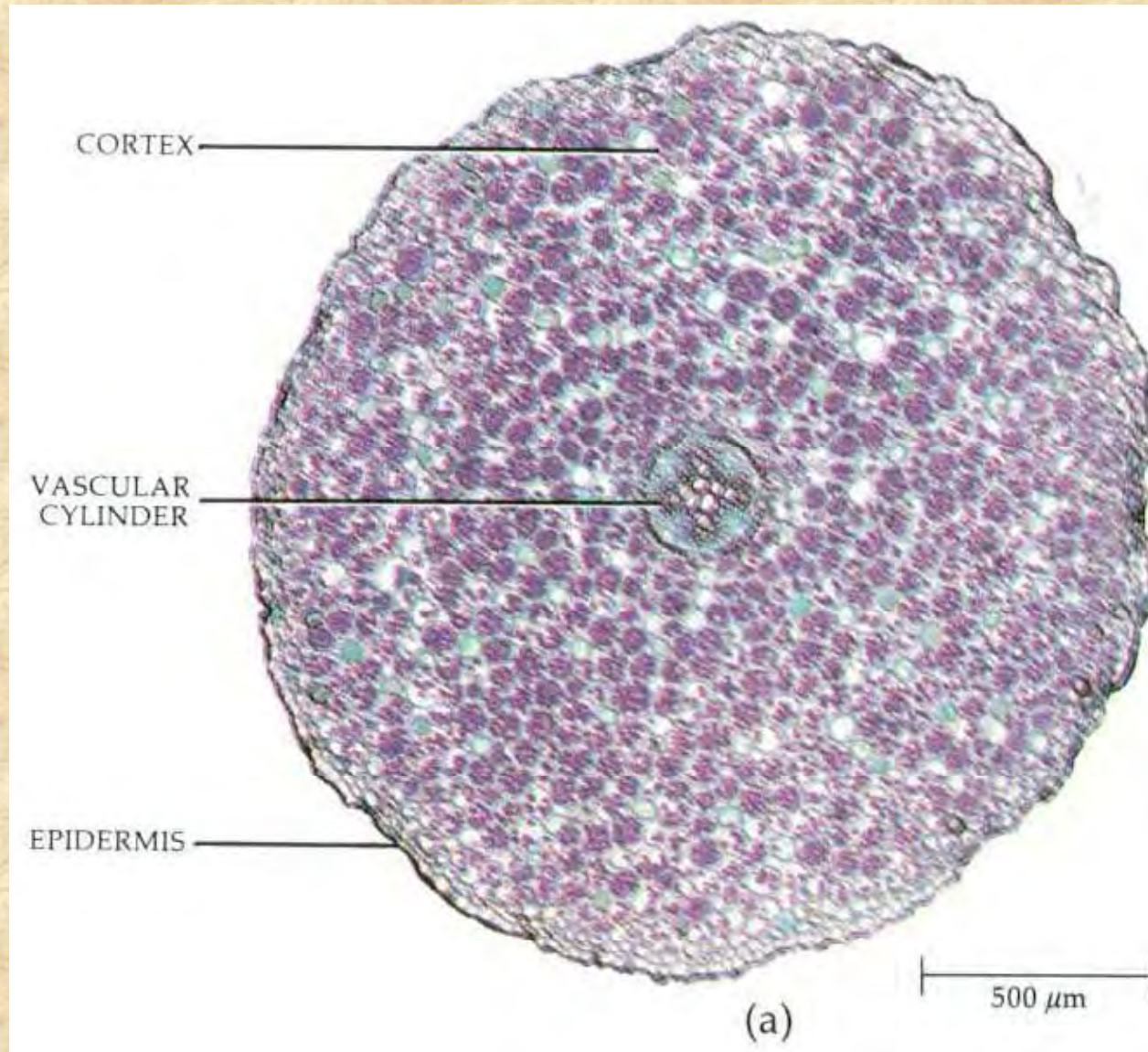
Raíz de monocotiledónea

Figure 13.8

In this cross section of a root of *Smilax* (greenbriar), all tissues are easily recognizable. The exodermis and the endodermis both have extremely thickened walls on the radial sides and either the outer tangential wall (exodermis) or the inner one (endodermis). $\times 100$.

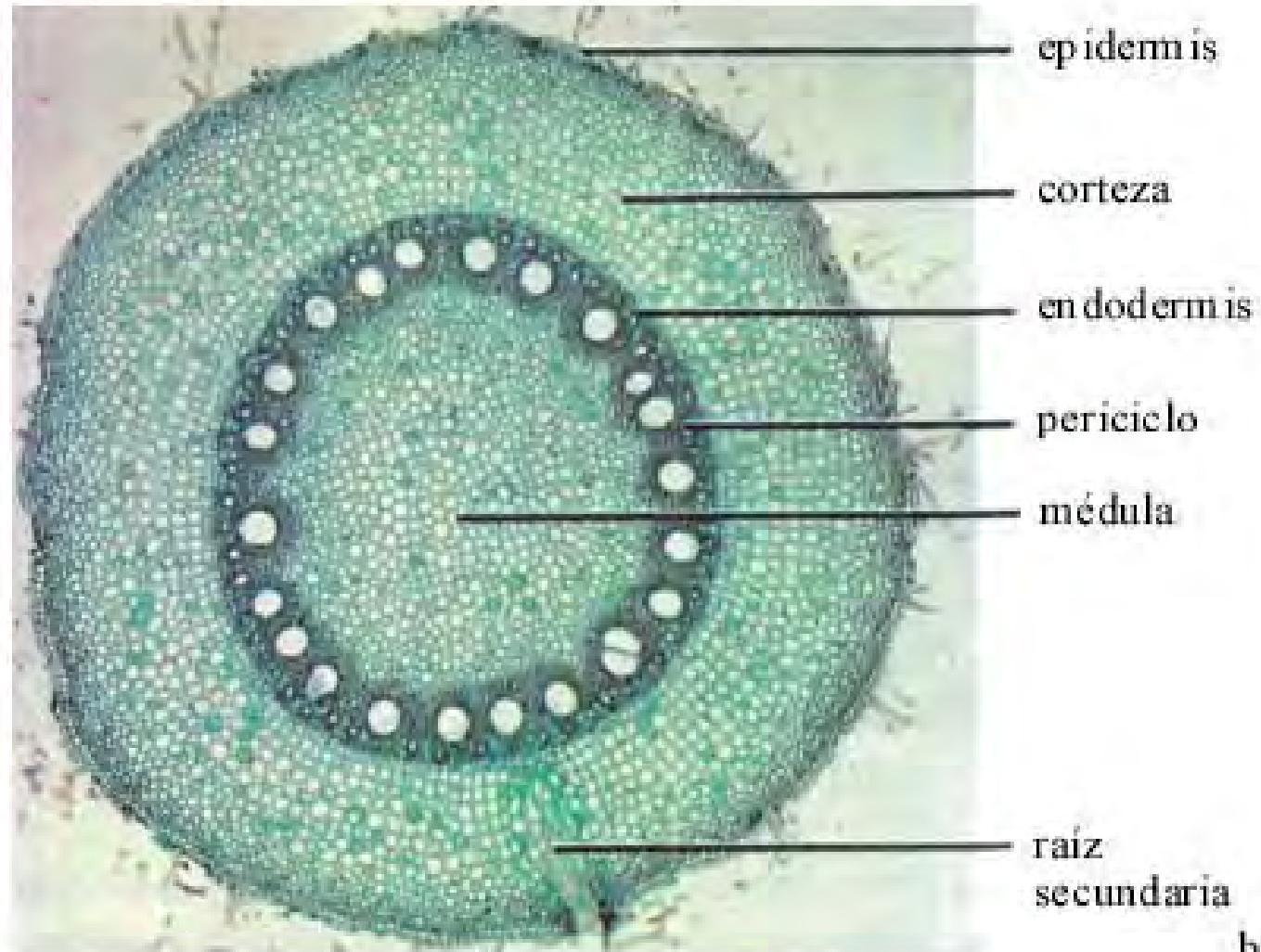


Raíz de paleohierba



Sección transversal
de una raíz de
Ranunculus.

Raíz de herbácea



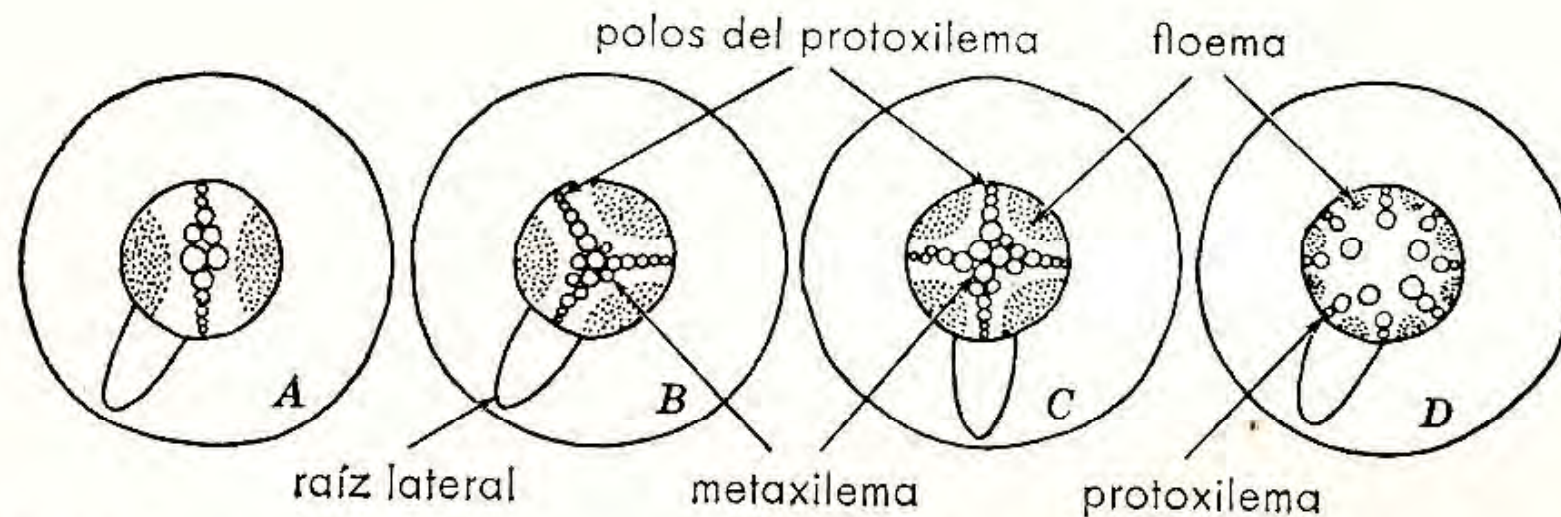


Fig. 17-6. Disposición de los tejidos vasculares primarios y orientación de las raíces laterales. En relación con el número de cordones xilemáticos dispuestos radialmente, las raíces son diarcas (A), triarcas (B), tetrarcas (C) y poliarcas (D). A-C representan la disposición más frecuente en las dicotiledóneas y D en las monocotiledóneas. Las raíces laterales se señalan como habiéndose formado frente al polo del protoxilema (B y C), entre los polos del xilema y del floema (A) y frente al floema (D).

Tipos de raíz dependiendo de los polos de xilema y floema

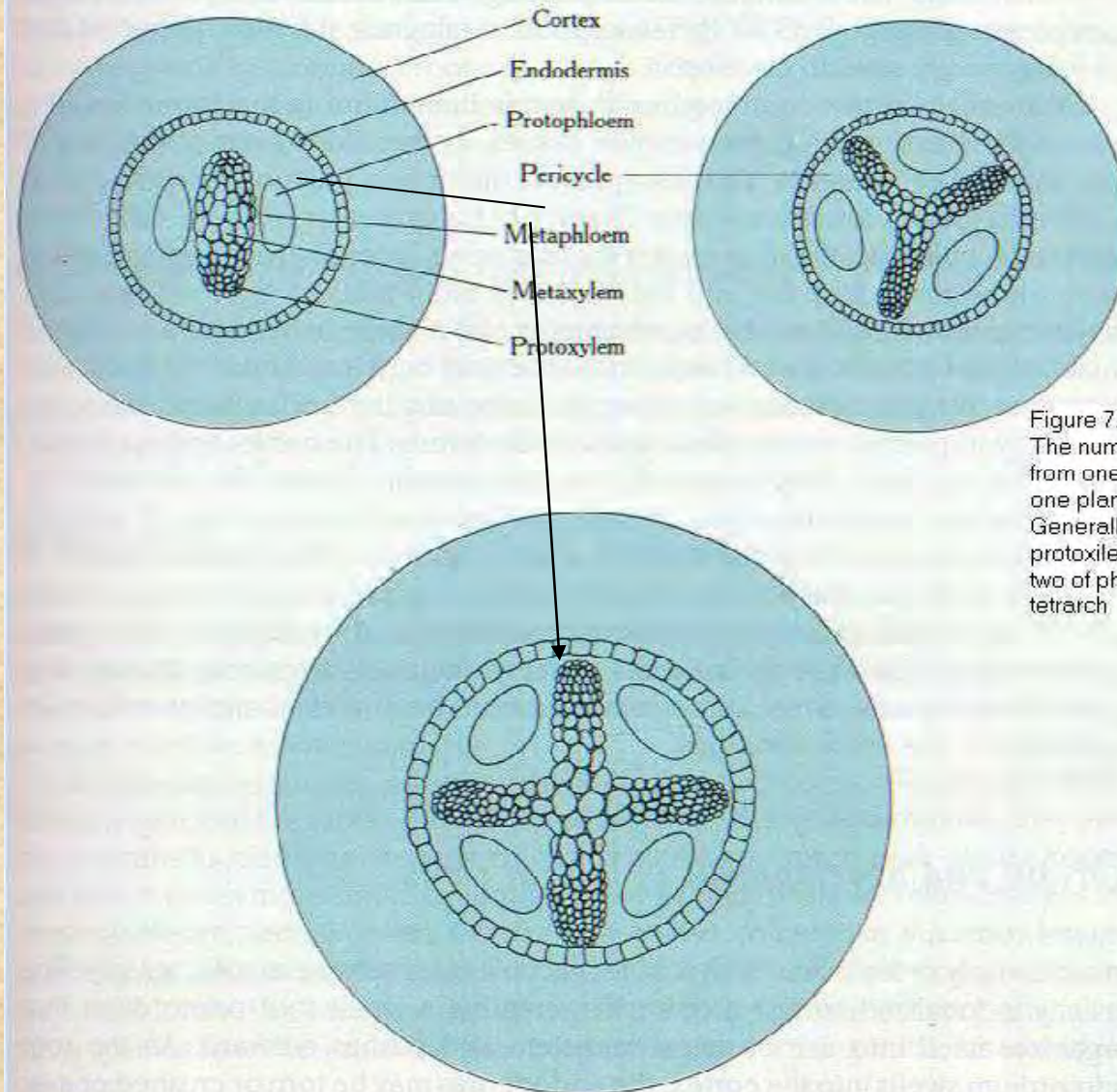


Figure 7.15

The number of strands of protoxylem in root varies from one species to another and among the roots of one plant.

Generally, wider, more robust roots have more protoxylem masses. Two masses of protoxylem (and two of phloem) is diarch; three is triarch; and four is tetrarch.

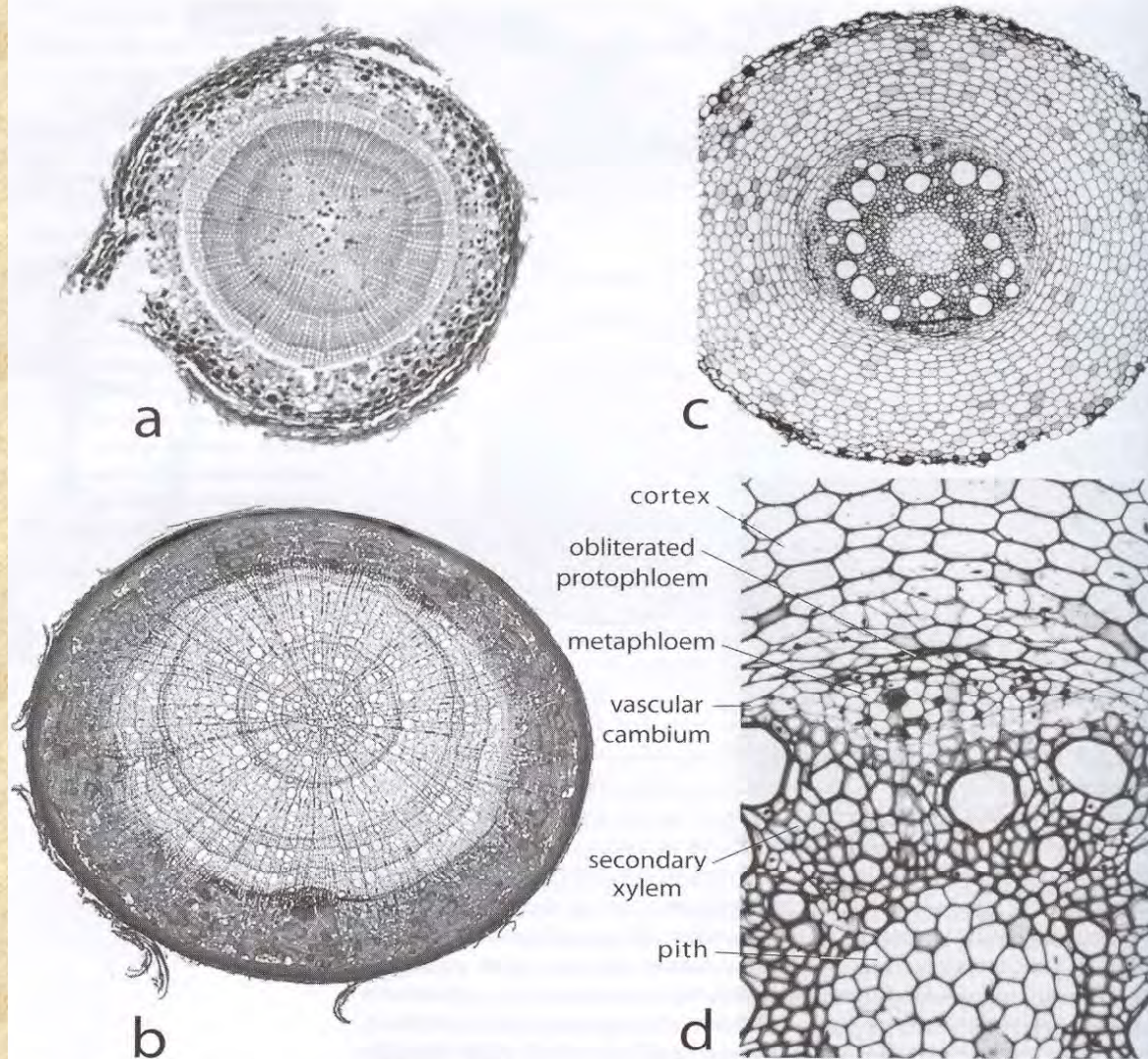
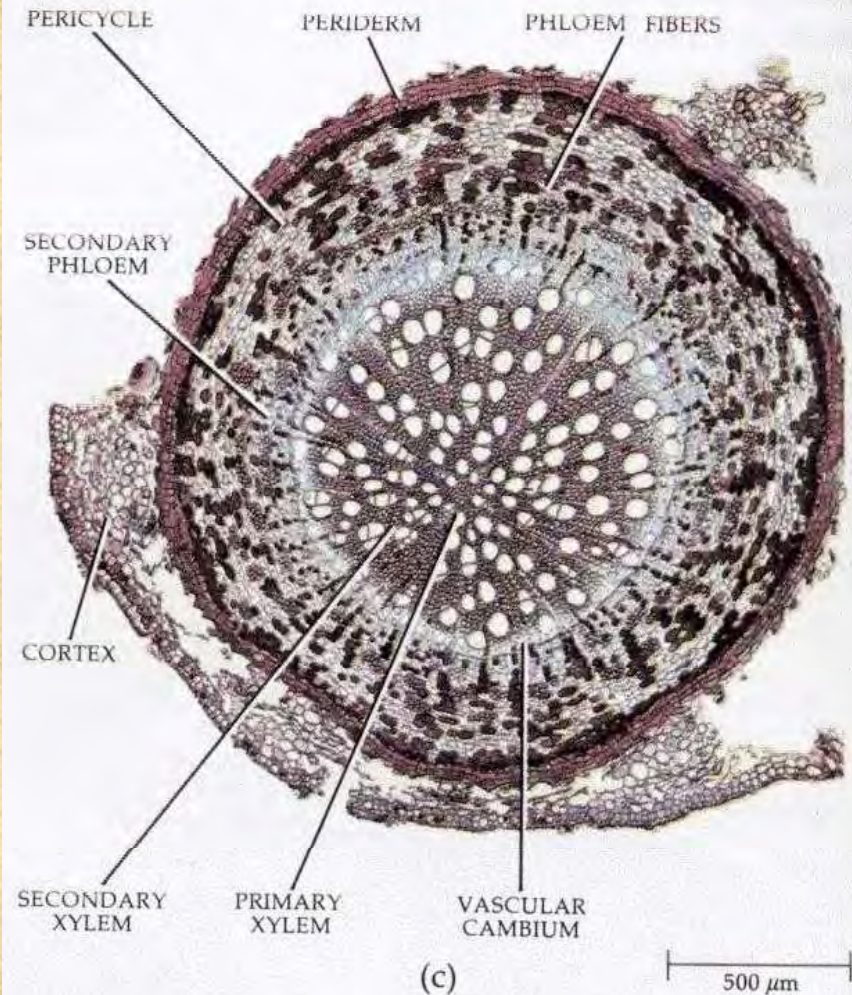
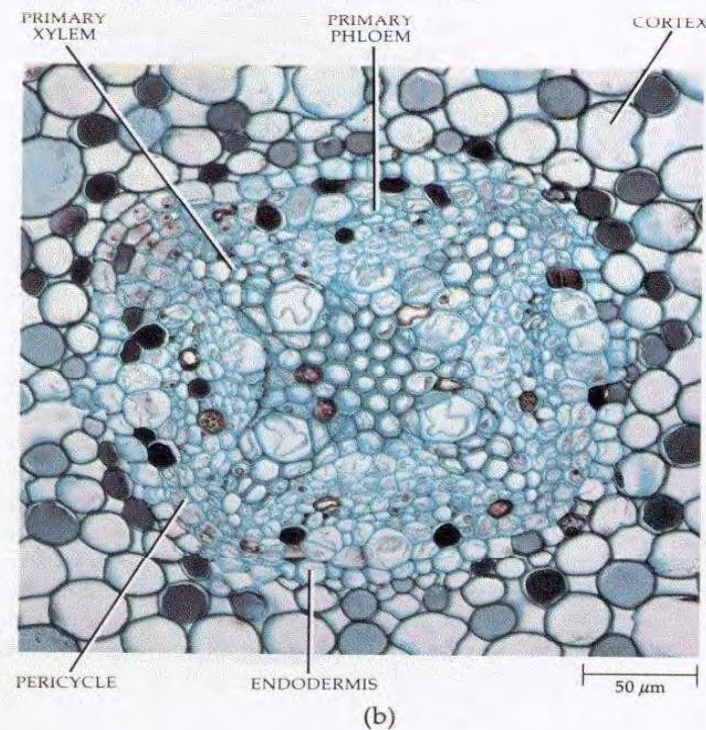
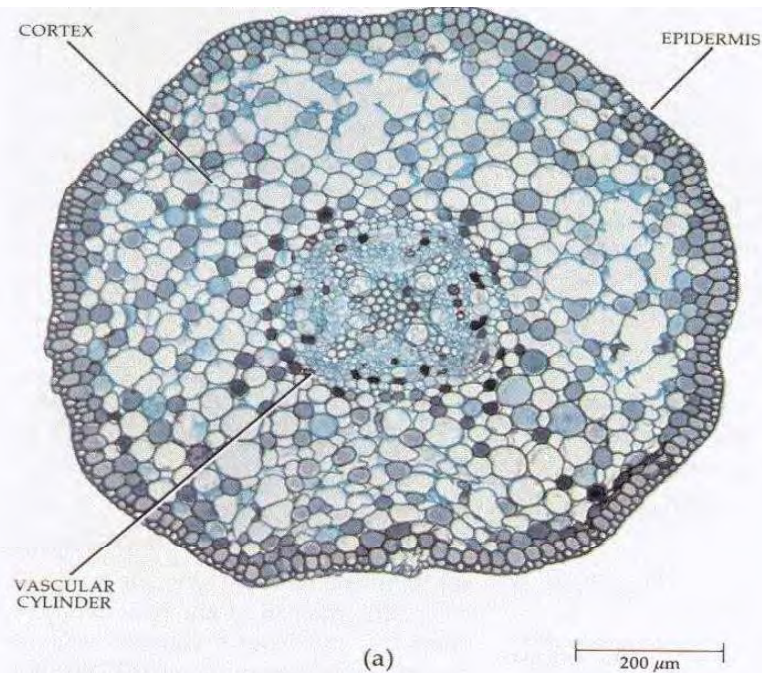


Figure 16.18 Transverse sections of roots with secondary tissues. (a) A root of *Cedrus deodara* with tetrarch primary xylem. Note that the vascular cambium was not continuous around the ends of the primary xylem ribs until near the end of the first growing season. Periderm is in contact with the secondary phloem. The cortex and epidermis have sloughed off. Magnification $\times 43$. (b) A root of *Tilia americana*. The secondary xylem contains numerous rays and very large vessels. Note the periderm in contact with the secondary phloem. Magnification $\times 24$. (c, d) Root of *Pelargonium*. Note the pith, the cortex, and the large vessels in the secondary xylem. (d) The vascular cambium produces little or no secondary phloem, and the metaphloem functions as the major conduit for the transport of hormones and photosynthate for the life of the plant. Note the compressed and obliterated protophloem. Magnification (c) $\times 50$, (d) $\times 185$.



23-7

Transverse sections of the willow (Salix) root, which becomes woody. (a) Overall view of root near completion of primary growth. (b) Detail of primary vascular cylinder. (c) Overall view of root at end of first year's growth, showing effect of secondary growth on primary plant body.

Endodermis de la raíz

- Compuesto de suberina y algunas veces lignificada
- Todo lo que entra y deja el cilindro vascular pasa a través de la endodermis
- Barrera del paso de sustancias

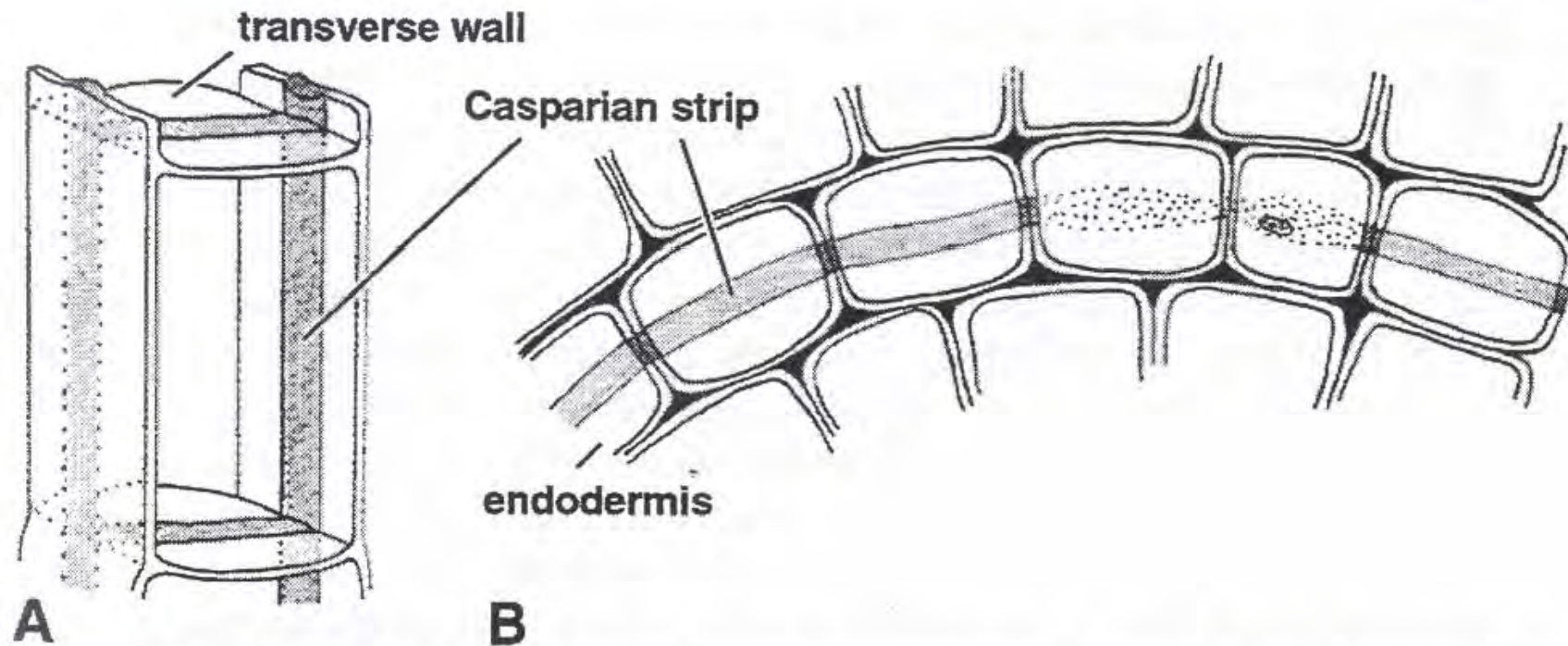
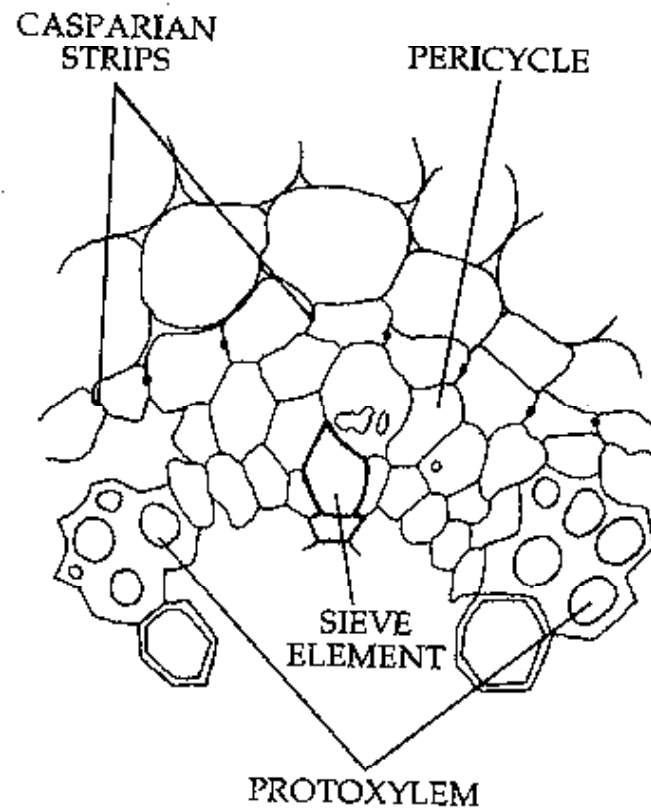


FIGURE 3.23 Structure of the primary endodermis of roots. (A) Three-dimensional view of endodermal cell showing Casparian strip. (B) Transverse section of endodermis showing Casparian strips. Drawing courtesy of P. G. Mahlberg.



Endodermis y localización de la banda de Caspary en las paredes anticlinales (perpendiculares a la superficie de la raíz)

High-magnification view of a portion of an immature buttercup (Ranunculus) root, showing Casparian strips in the endodermal cells. Notice that the plasmolyzed protoplasts of the endodermal cells cling to the strips.

Figure 16.8 Endodermis

illustrating Casparian bands.

(a) Endodermis in the stem of *Acorus calamus*. Note Casparian bands in surface and sectional views. (b) Three-dimensional diagram of an endodermal cell showing the Casparian band in radial and transverse walls.

(c) Sectional view showing that the suberized Casparian band extends through the walls of contiguous cells. Note that the plasmalemma of each cell is tightly attached to the Casparian band. Upon plasmolysis, the plasmalemma pulls away from the walls except in the region of the Casparian band.

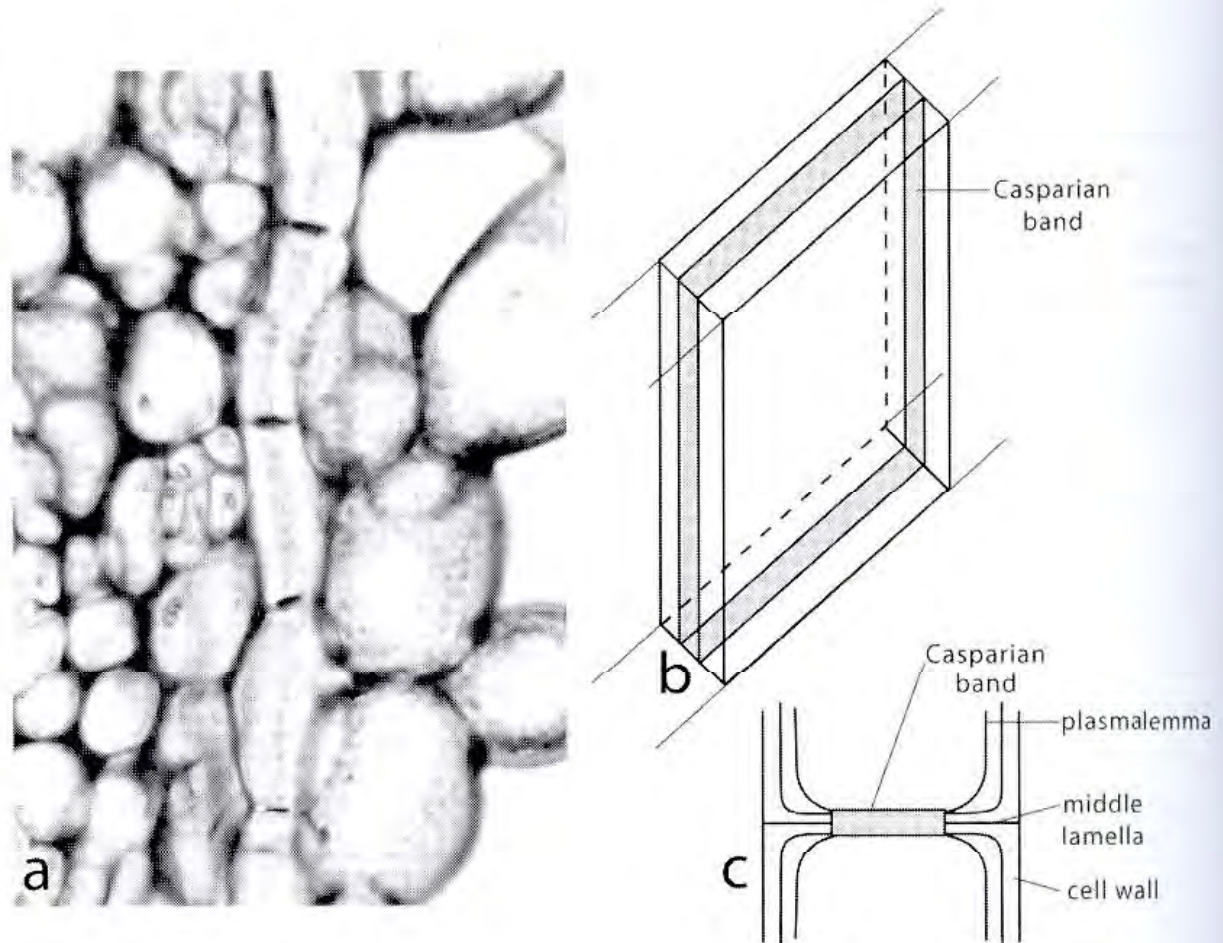
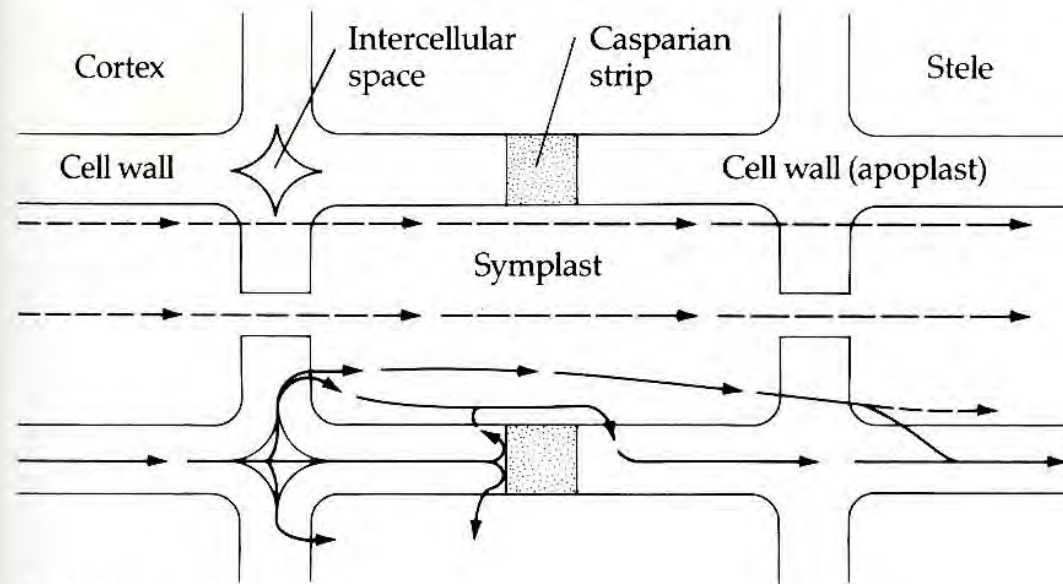
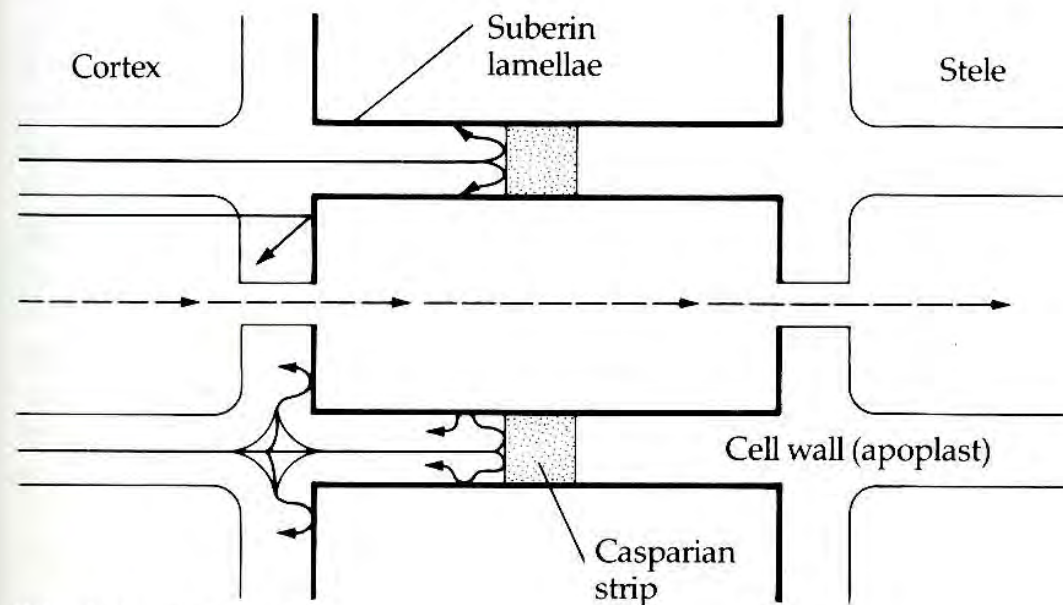




Figure 16.9 Casparian bands as seen in sectional views (at arrow heads) in the exodermis of the root of *Allium*. The layer of cells on the right is the epidermis. Bar = 50 μm . From Peterson (1988). Used by permission of Blackwell Publishing Ltd.



A. Endodermis state 1



B. Endodermis state 2

Figure 13.9

The top portion of this diagram represents an endodermis in State I, having only Casparian strips on its walls. In the lower portion of the diagram, the endodermal cell is in State II, and now solutes can cross the endodermis only if they are in the cortical symplast. The endodermal plasmalemma is completely covered.

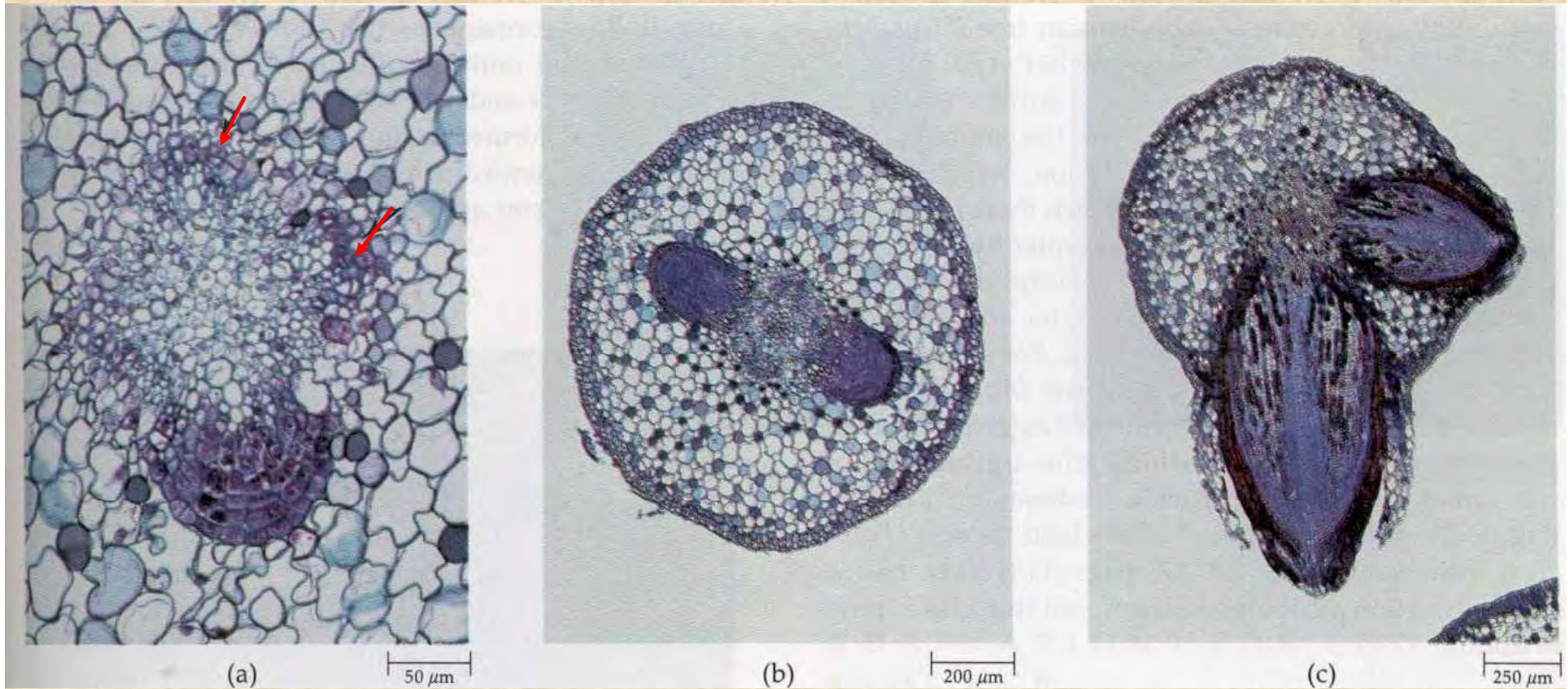
Origen de raíz lateral a partir del periciclo y protección a la entrada de patógenos



Figure 7.17

This young lateral root of willow (*Salix*) was initiated in the pericycle, next to a mass of protoxylem; its growth caused considerable damage to the parent root cortex, and it broke the surface open. Entry of pathogens will be prevented by formation of wound bark around the tear it caused ($\times 50$).

Raíz: origen de raíces laterales



Tres estadios en el origen de las raíces laterales en el sauce (*Salix*). (a) Un primordio radical está presente y otros dos se están originando en el periciclo (ver flechas). El cilindro vascular es aun joven. (b) Dos primordios radicales penetrando la corteza. (c) Una raíz lateral ha llegado afuera, y la otra apenas lo hace.

Anatomía de hojas

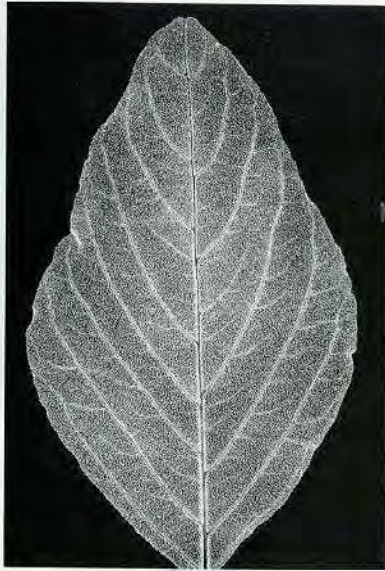


Figure 6.11
A leaf of *Amaranthus retroflexus* treated to remove all tissues except vascular bundles. The extensive reticulate venation is obvious in this dicot leaf; no part of the leaf is without veins. (Courtesy of D. Fisher)



Figure 6.12
High magnification of a leaf clearing of *Acalypha*, a dicot. Fine vein endings are visible, as are numerous crystals within the leaf and the trichomes located on the leaf surface. The veins are so close together that no leaf cell is far from one (X80).



Figure 6.13
Cattails (*Typha latifolia*) have long, straplike leaves common in monocots. Vascular bundles run parallel to each other from leaf base to tip.

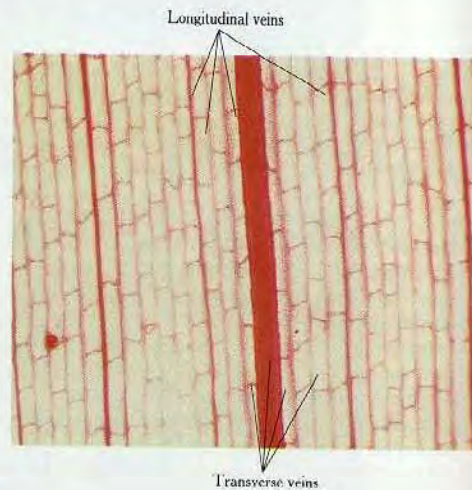
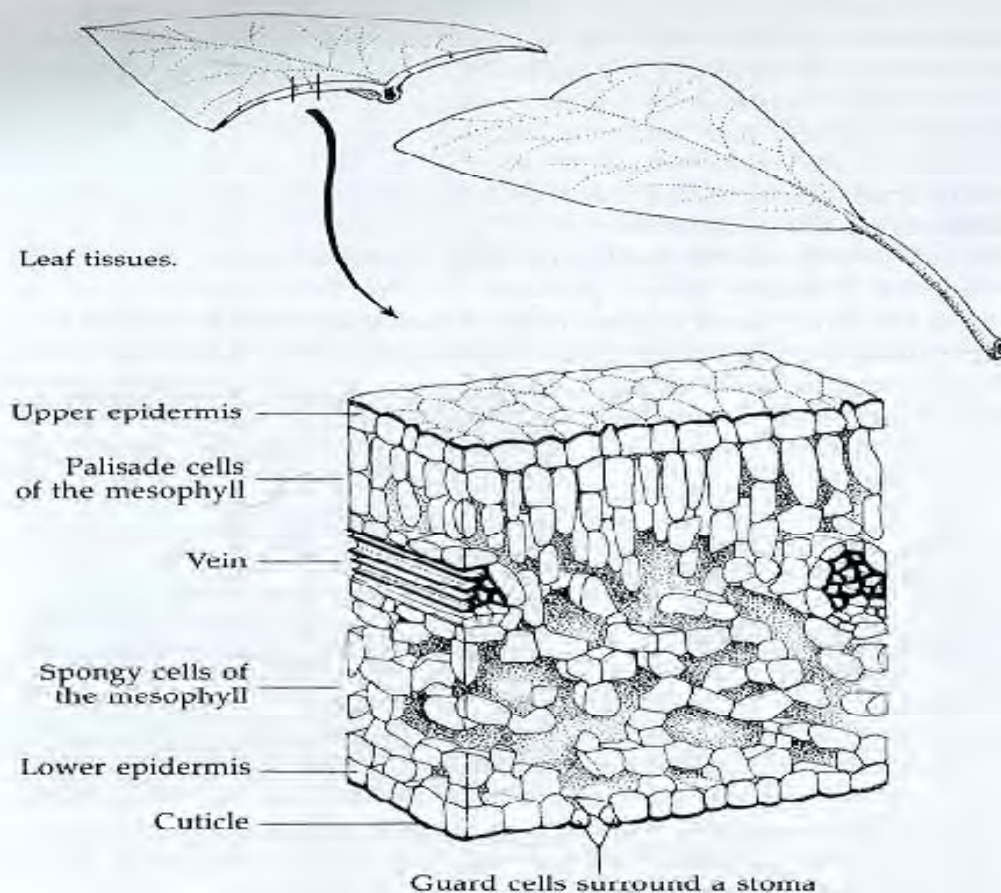
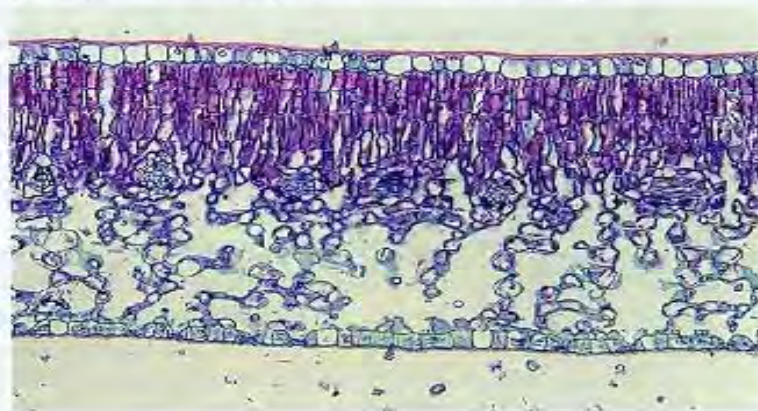


Figure 6.14
High magnification of a leaf clearing of corn (*Zea*), a monocot. There are several sizes of longitudinal veins; if a longitudinal vein is broken by insect damage or any other problem, conduction can detour around the site by means of the fine transverse veins (X120).

**Diferencias
morfológicas y
anatómicas entre
“dicotiledóneas”
venación reticulada
(en red) y
monocotiledóneas
(venación paralela)**

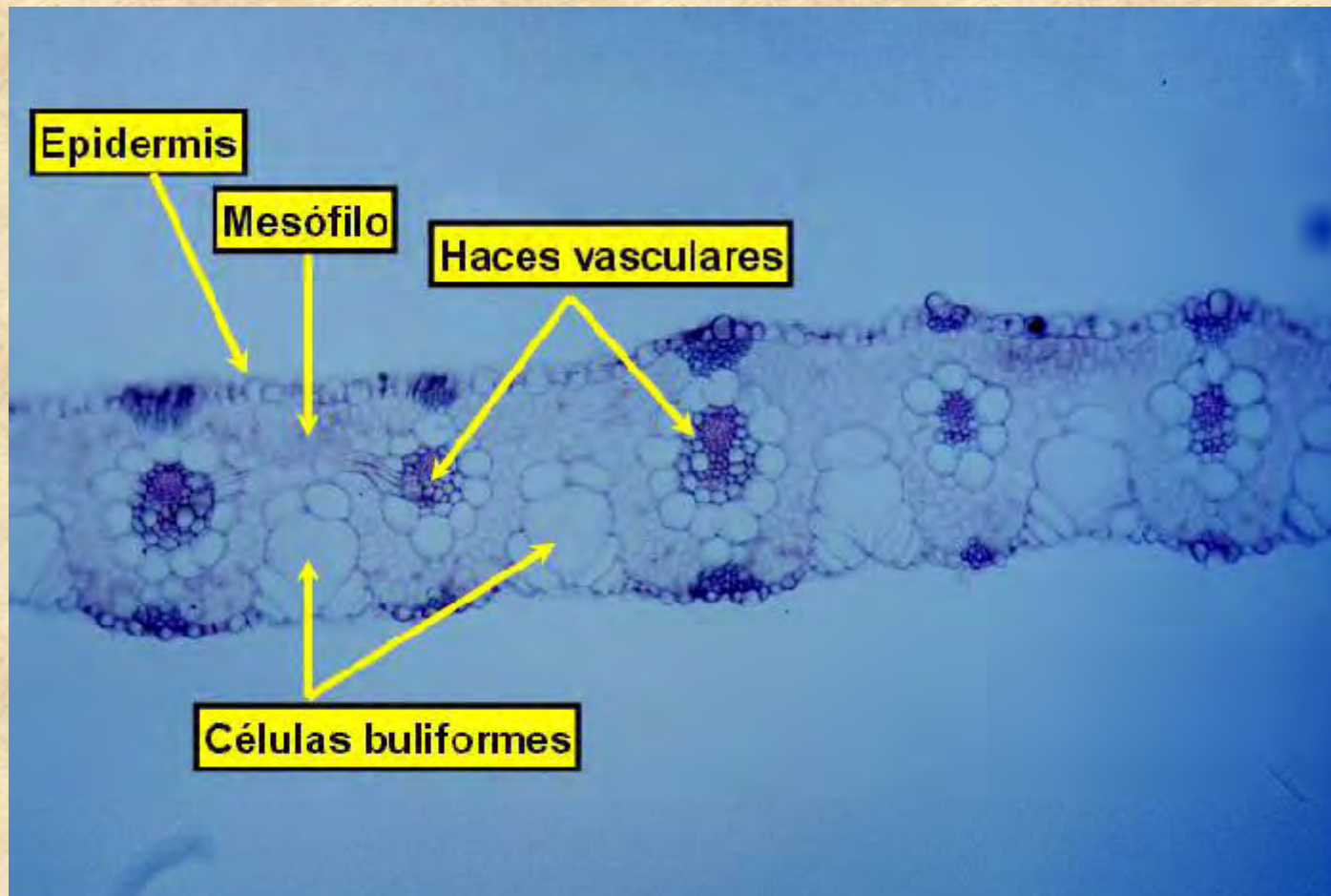


The anatomy of a leaf. Tissues may be identified by comparing the photograph with the above diagram.



Corte transversal de hoja de “dicotiledónea” mostrando la organización de los diferentes tejidos: epidermis y mesófilo.

Hoja de monocotiledónea



Hojas de monocotiledóneas

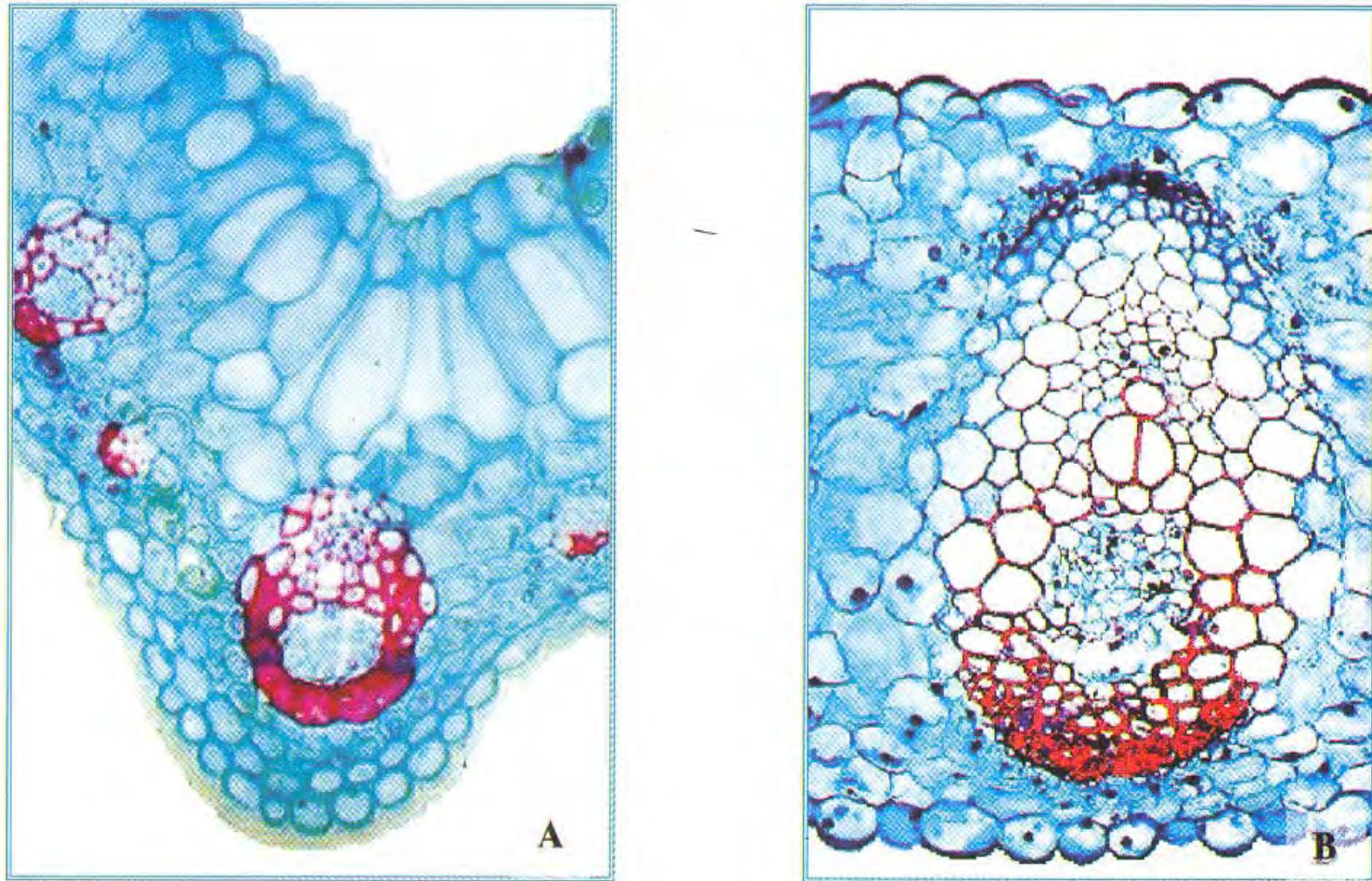
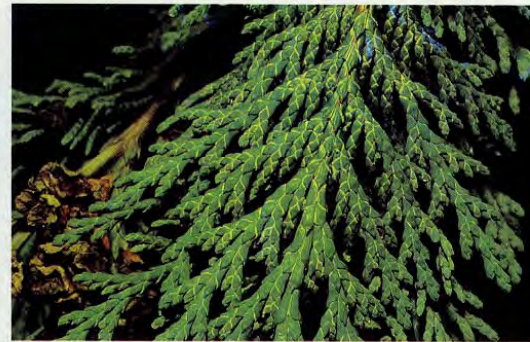


Fig. 47. Coloración obtenida con safranina "O" - verde rápido FCF. A. *Cuitlauzina candida*, Orchidaceae. Sección transversal de hoja, vena media, X400 B. *Rossioglossum grande*, Orchidaceae. Sección transversal de hoja, vena secundaria, X200.



(a)



(b)



(c)



(d)

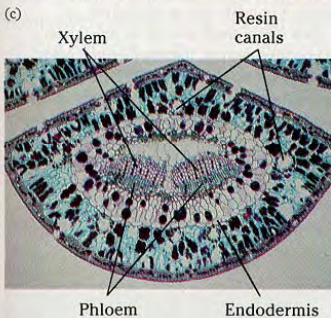
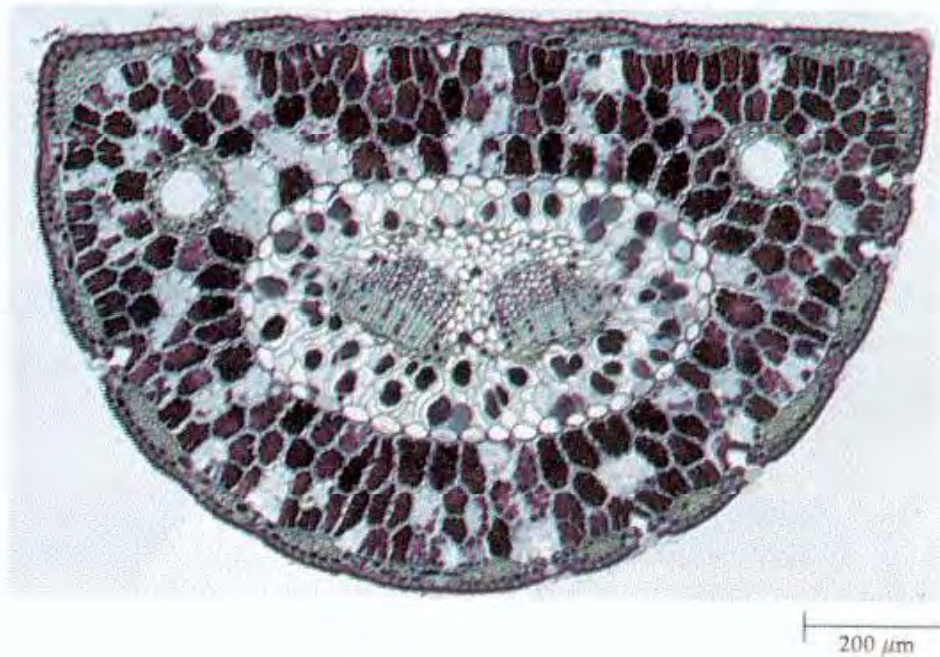
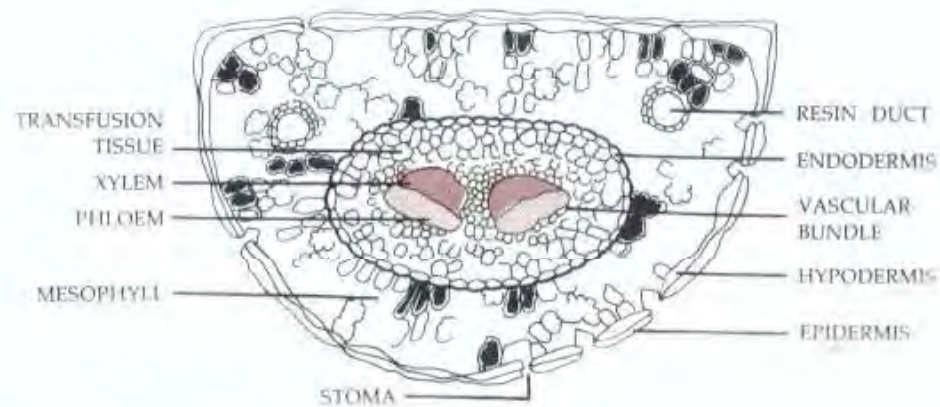


Figure 24.10

Conifer leaves are never compound. They are always simple and leathery, needle-like in some, scalelike in others. (a) In eastern or Canadian hemlock (*Tsuga canadensis*), each leaf has two white bands where stomata are located. (Grant Heilman). (b) Scalelike leaves of *Chamaecyparis lawsoniana*. (William E. Ferguson). (c) Short scale leaves of Norfolk Island pine (*Araucaria heterophylla*). (Robert and Linda Mitchell). (d) Pines have two types of leaves — small, papery brown scales on the long shoots (visible on the expanding new branch) and the long needles borne by the short shoots located in the axils of the papery scale leaves. The long needles were produced last year; this year's needles are just becoming visible near each scale leaf. White pine (*Pinus strobus*). (Runk/Schoenberger from Grant Heilman). (e) Conifer leaves have numerous xeromorphic characters. The cylindrical shape of needles has a low surface-to-volume ratio, and the epidermis is composed of thick-walled cells with a dense cuticle and sunken stomata. Chlorenchyma consists of lobed cells rich in chloroplasts and traversed by resin canals. Two vascular bundles are surrounded by an endodermis, which is rare in leaves of flowering plants but common in conifers (X25). (Robert and Linda Mitchell)

Coníferas: Hoja usualmente acicular (aguja)



18-13

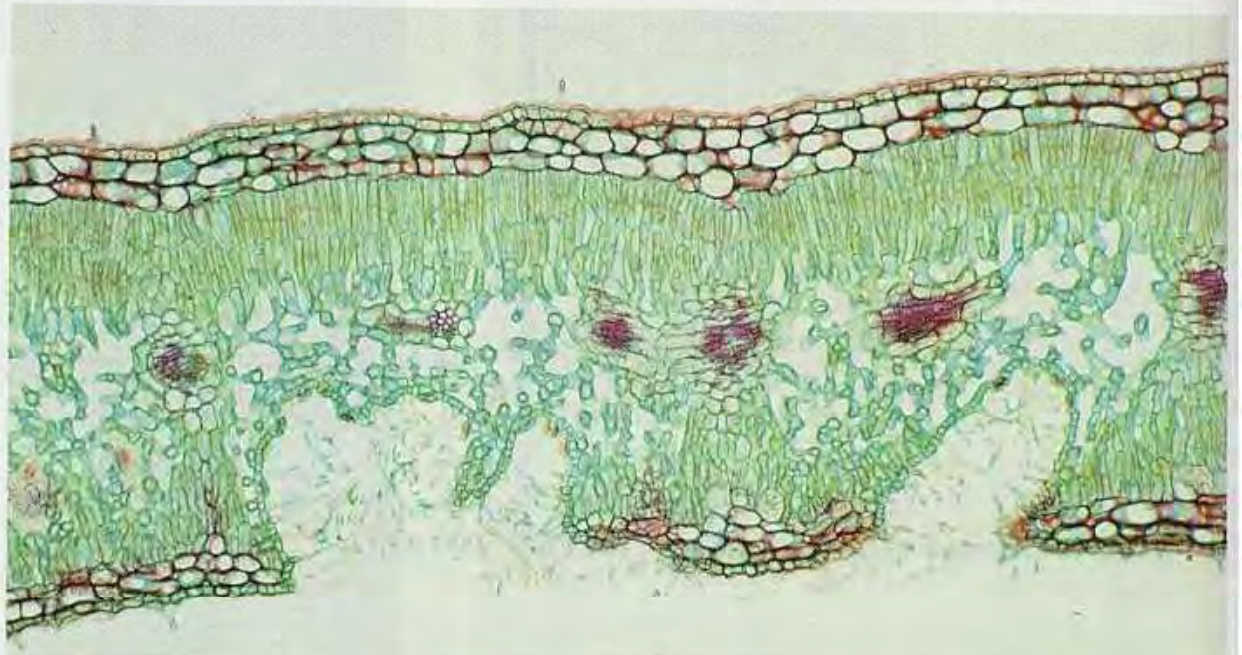
Pinus. Transverse section of needle, showing mature tissues.

**Anatomía de
hojas aciculares
(Coníferas).
Presencia de
una endodermis**

Hoja: estomas y tricomas en criptas. plantas de sitios secos

Figure 6.16

Oleander (*Nerium oleander*) leaves have stomatal crypts filled with trichomes and stomata. Crypts occur only in the lower surface ($\times 80$).



Arreglo celular que permite difusión de gases

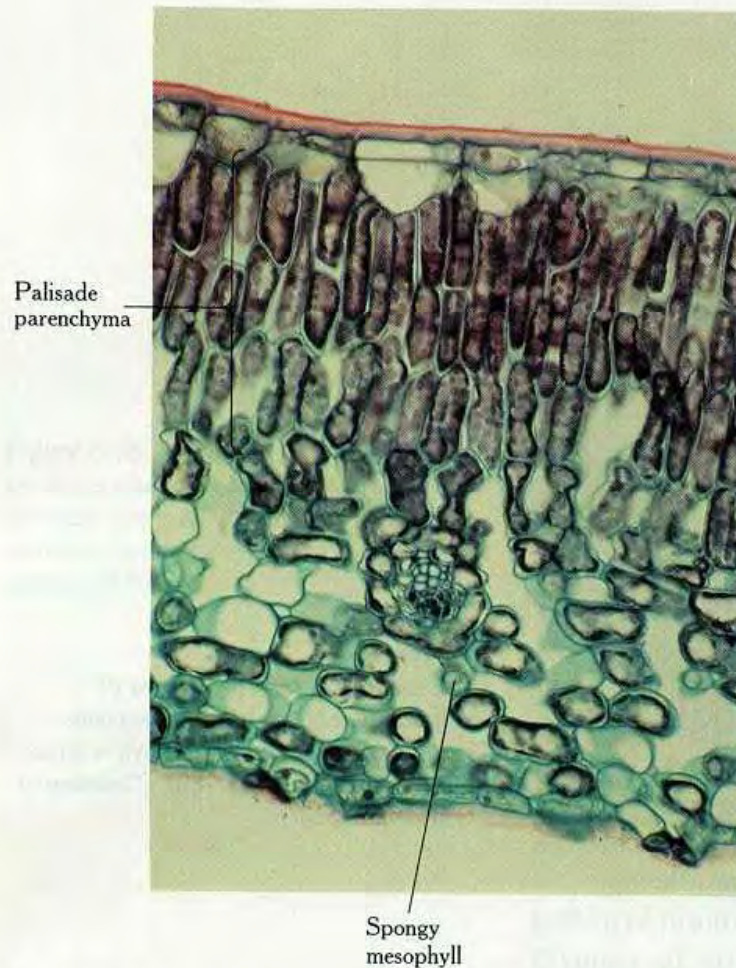


Figure 6.19

Leaves of holly (*Ilex*) have an extremely thick palisade parenchyma consisting of at least three layers of columnar cells. Cells of the lowest palisade layer are relatively widely separated, permitting rapid diffusion of CO_2 from the spongy mesophyll to the upper palisade ($\times 220$).

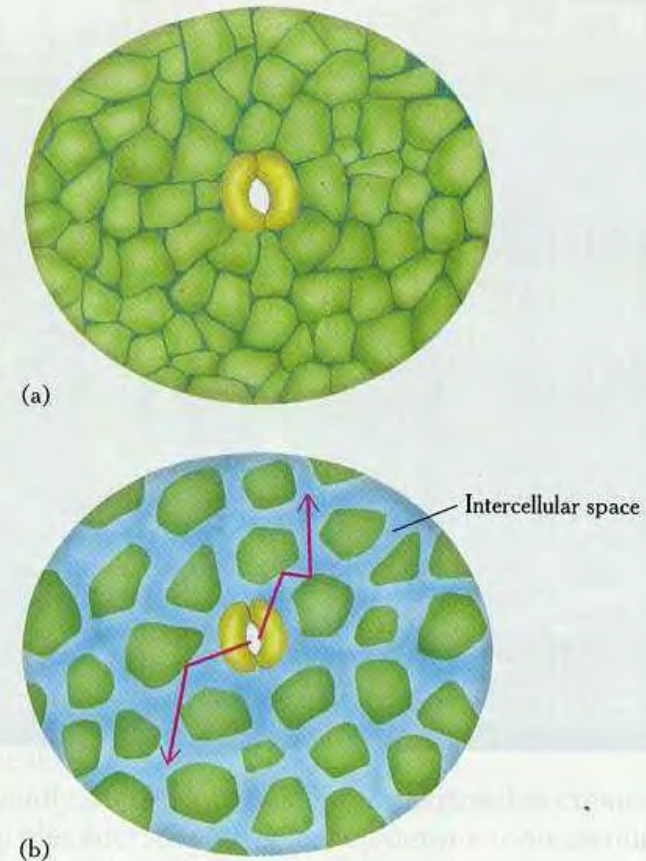


Figure 6.20

(a) If cells are compactly arranged near a stomatal pore, carbon dioxide molecules that enter the pore may bounce off the cells and back out of the pore. (b) Aerenchyma around a pore makes it possible for carbon dioxide molecules to diffuse deep into the leaf away from the stoma.

*Diferencias en la vaina
envolvente del paquete
Vascular en hojas tipo
C₃ y C₄*

***En las C₄ se denomina
"Kranz" (guirnalda en
Aleman)***

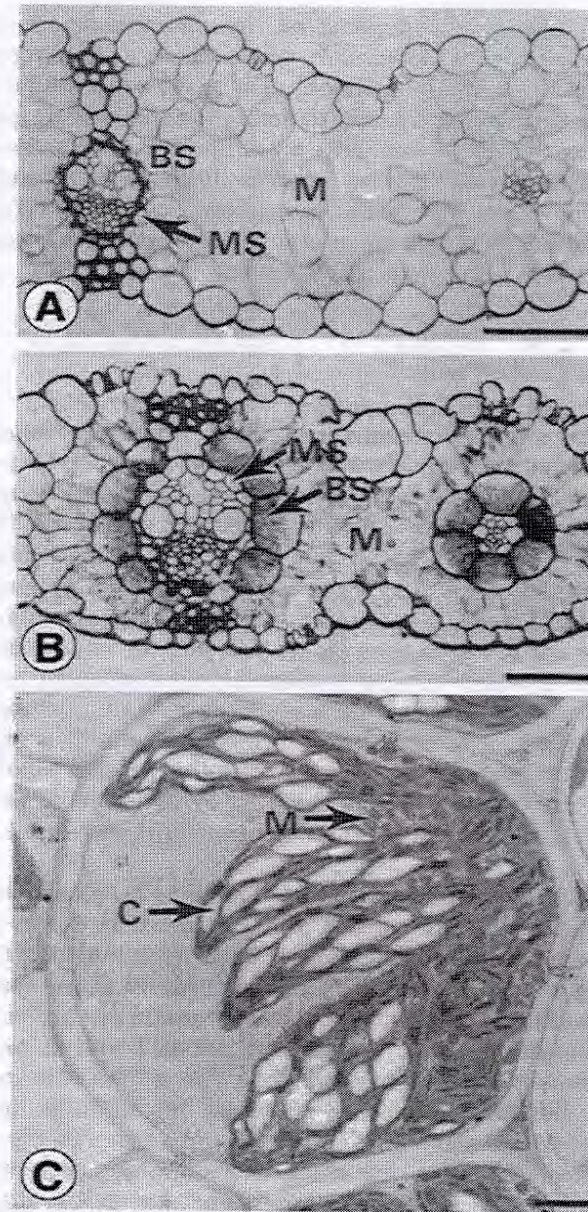
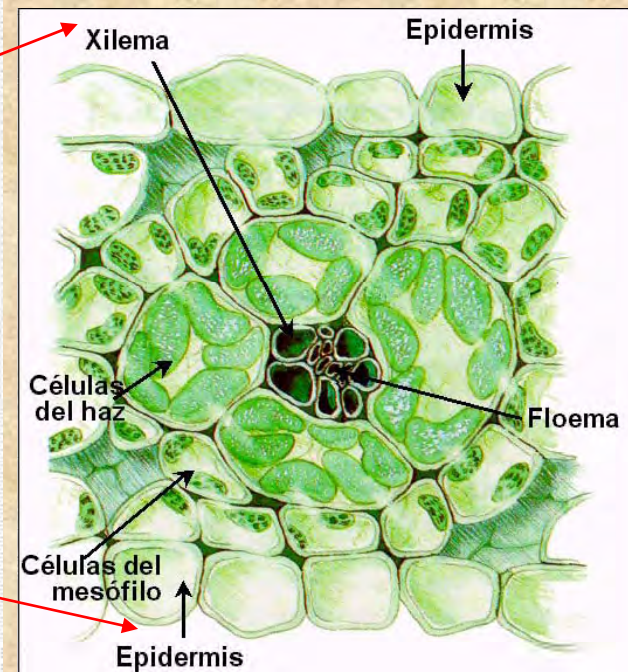
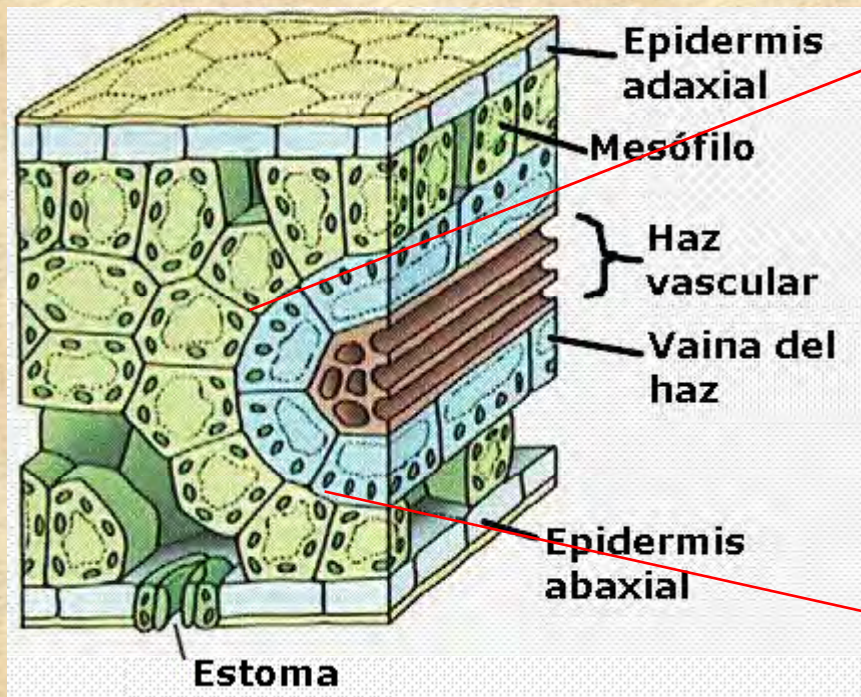


FIGURE 7.9 Leaf cross sections of C₃ and C₄ grasses. (A) *Bromus tectorum*, a C₃ plant. (B) *Zea mays*, a C₄ plant. (C) Ultrastructure of bundle sheath cell of *Panicum effusum*, a C₄ plant. Note centripetal position of chloroplasts and mitochondria. Scale bar = 50 μ m in A and B; scale bar = 2 μ m in C. Abbreviations: BS, bundle sheath; C, chloroplast; M in A and B, mesophyll; M in C, mitochondrion; MS, mesophyll sheath. Reprinted with permission from Nelson and Dengler (1992). *Int. J. Plant Sci.* 153, S93–S105. Published by the University of Chicago Press.



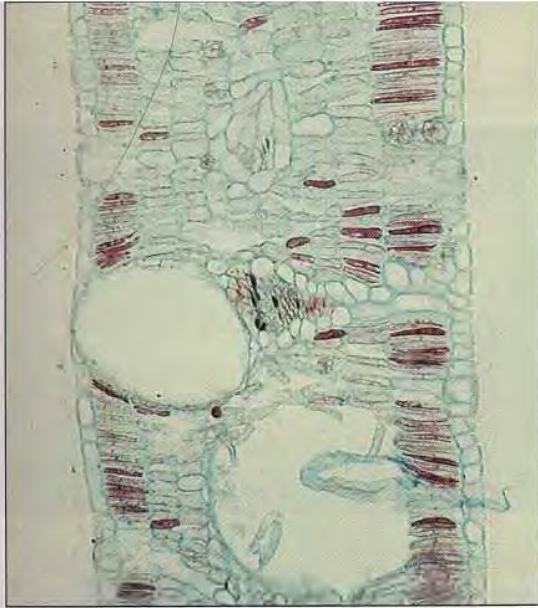


Figure 6.21
Eucalyptus leaves are pendant and have palisade parenchyma along both surfaces; it is also several cell-layers deep on both sides of the leaf. The little spongy mesophyll present is located in the center of the leaf. ($\times 80$).

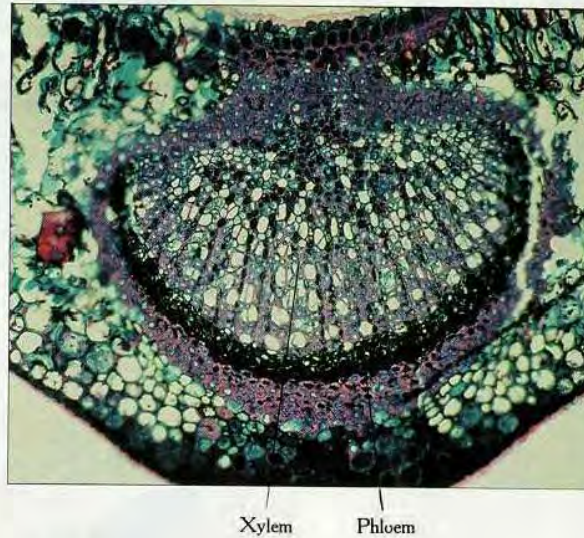
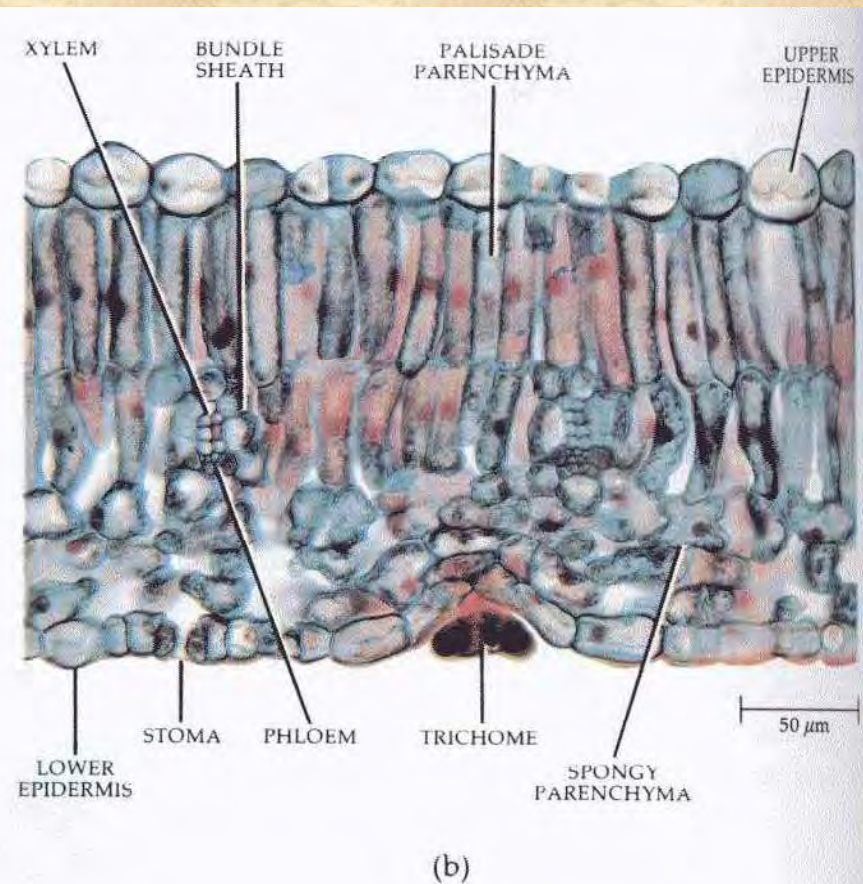
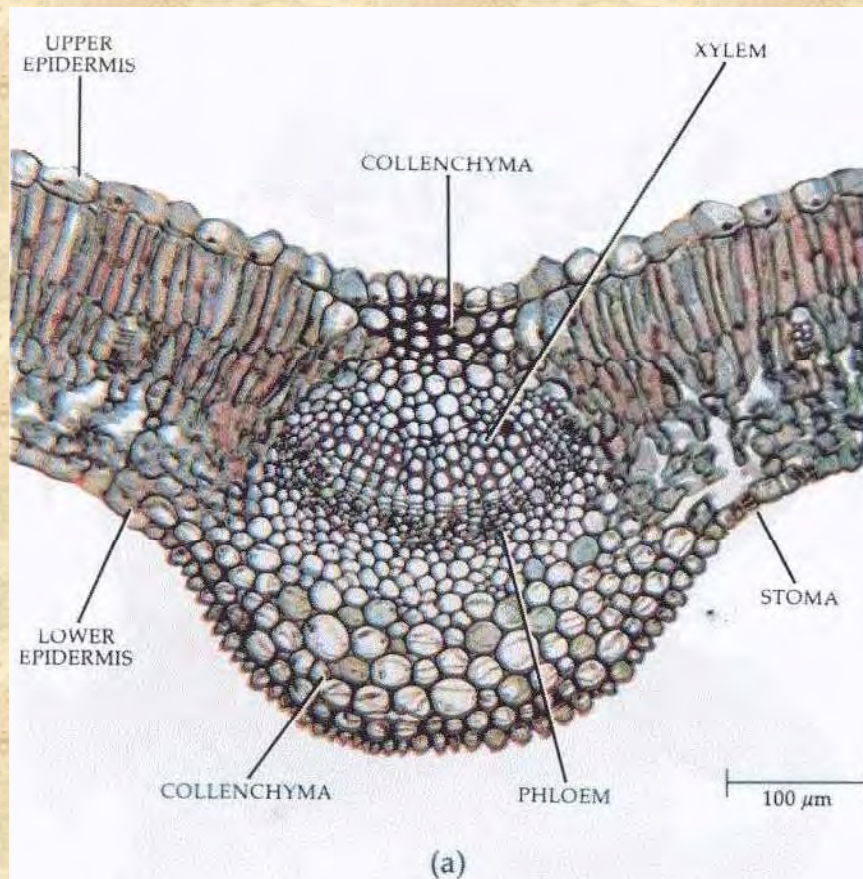


Figure 6.22
 Cross-section through a leaf midrib, showing the xylem, the phloem, and the large number of fibers. Numerous tannin cells are present here ($\times 150$).

Hojas de
Eucalyptus
 sp. son
 péndulas y
 hay mesófilo
 en
 empalizada
 en ambas
 caras

Hoja: mesófilo esponjoso, en empalizada, estomas, colénquima, estomas, tricomas

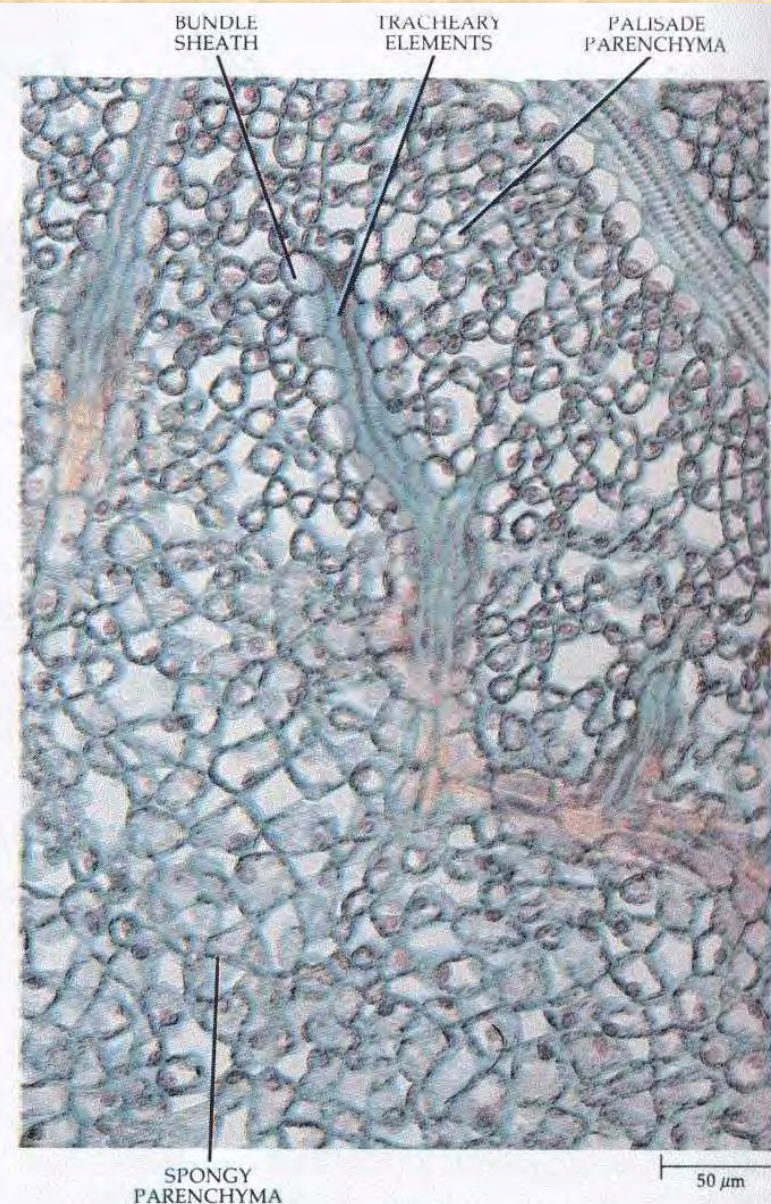


Corte tangencial de una hoja: elementos conductores, mesófilo, etc.



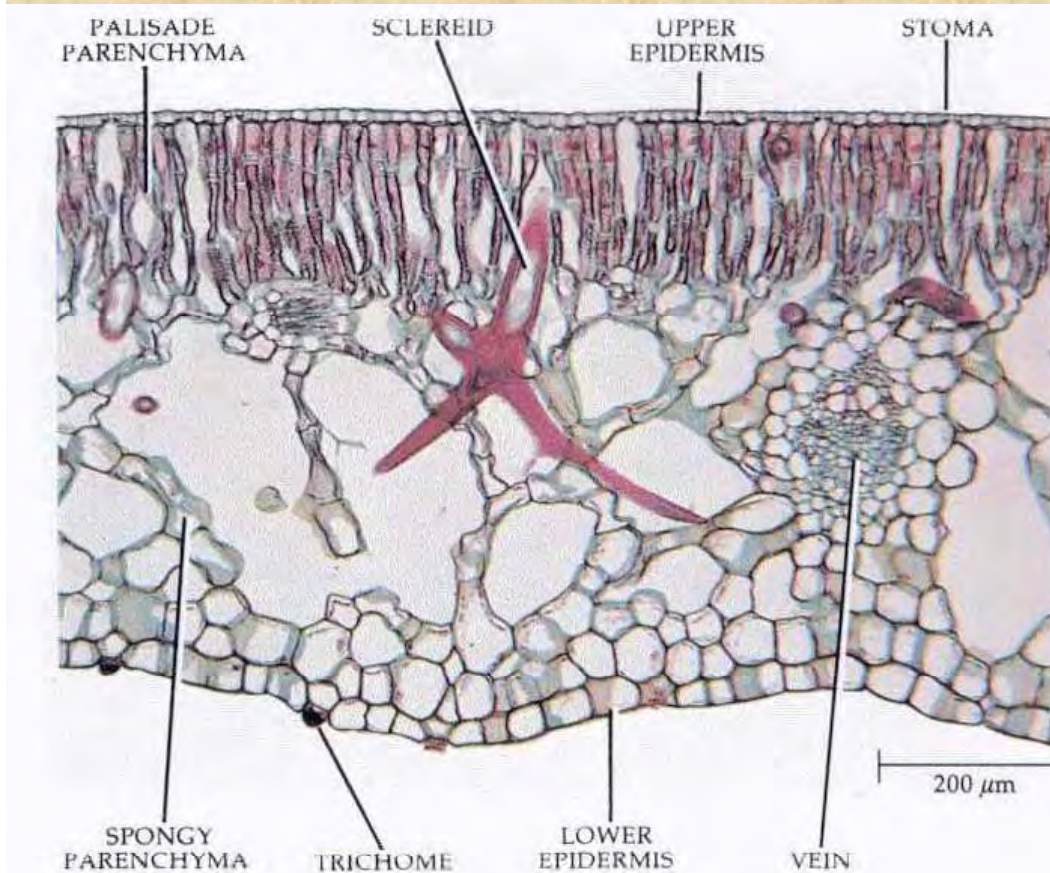
(c)

Leaf



(d)

Hoja: posición del aerénquima en hoja flotante, mesófilo y proporción del xilema en *Nymphaea*



22-19

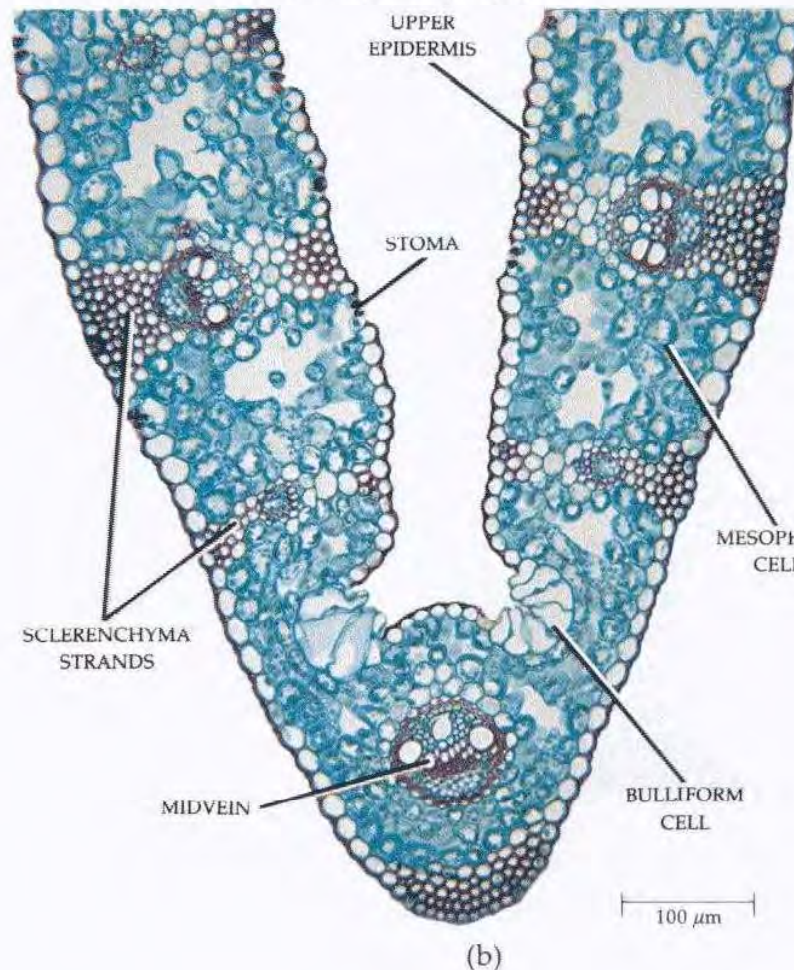
Transverse section of the water lily (*Nymphaea odorata*) leaf, which floats on the surface of the water and has stomata in the upper epidermis only. As is typical of hydrophytes, the vascular tissue in the *Nymphaea* leaf is much reduced, especially the xylem. The palisade parenchyma consists of several layers of cells above the spongy parenchyma.

22-27

Transverse sections of annual bluegrass (*Poa annua*, a C_3 grass) leaf. (a) Overall view of leaf. (b) Enlargement of portion of leaf including midvein. In the grass leaf, the mesophyll is not differentiated as palisade and spongy parenchyma.

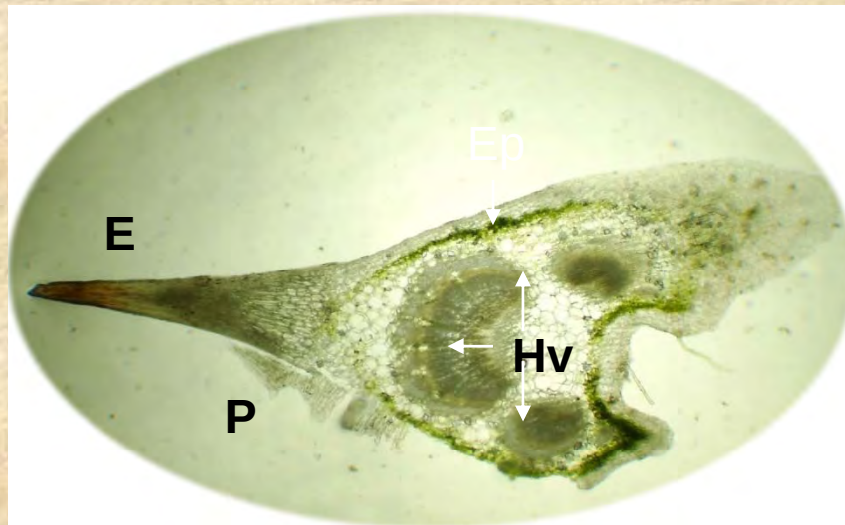
Strands of sclerenchyma cells commonly occur above and below the veins. The epidermis of the grass leaf contains bulliform cells—large epidermal cells thought to play a part in the rolling and unrolling (folding and unfolding) of grass

leaves. In the *Poa* leaf shown here, the bulliform cells are partly collapsed and the leaf is folded. An increase in turgor in the bulliform cells would presumably cause the leaf to unfold.

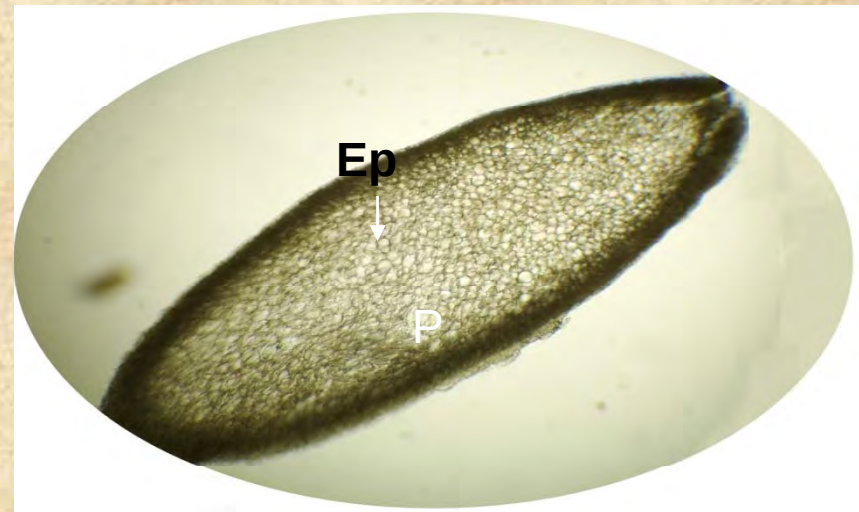


Hojas de gramíneas:
Un solo tipo de mesófilo, esclerenquima abundante y células buliformes

Espinas



Corte transversal de un tronco de rosal (4X).



Corte transversal de una espina de rosa (4X)

Espina (E), Epidermis (Ep), Haz vascular (Hv), Parénquima (P).

**DESARROLLO DE ÓRGANOS REPRODUCTORES:
ESTRÓBILOS
FLORES E INFLORESECENCIAS**



APARATO REPRODUCTOR: inflorescencias femeninas (estróbilos)

Tipos de estróbilos o piñas



Disposición de las piñas en una rama de pino



Pinus



Cedrus



Abies



- A. Gámbula de Cupressus sempervirens. B. Gámbula de C. macrocarpa.
C. Aróstita de Juniperus communis. D. Aróstita de J. oxycedrus (sección longitudinal).

ESCAMAS SEMINÍFERAS



1



2



3



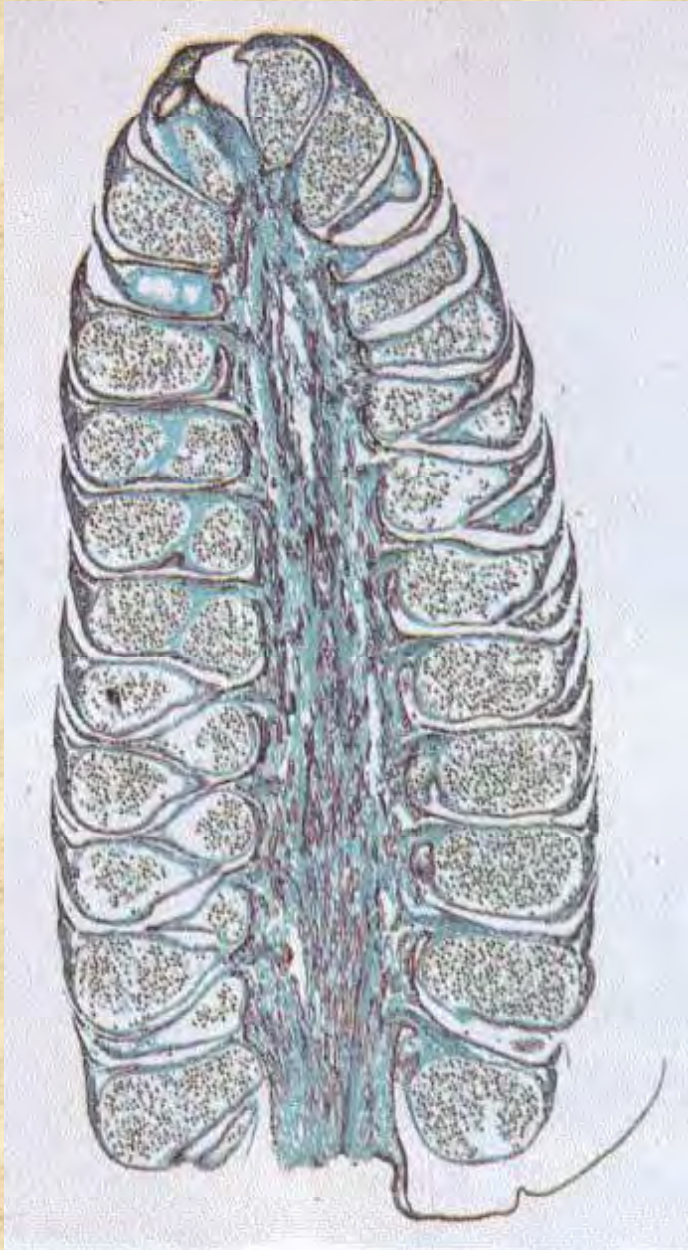
4



5

1. Joven inflorescencia masculina de Pinus.
2. Escama seminífera (es) y su bráctea tectriz (bt).
3. Escama seminífera presentando la cara superior ventral con dos óvulos (o).
4. Cara dorsal de la escama seminífera que permite ver la bráctea tectriz que la soporta (bt).
5. Bráctea adulta después de la fecundación, cuya escama ovulífera (es) soporta dos semillas (s) con un ala cada una.

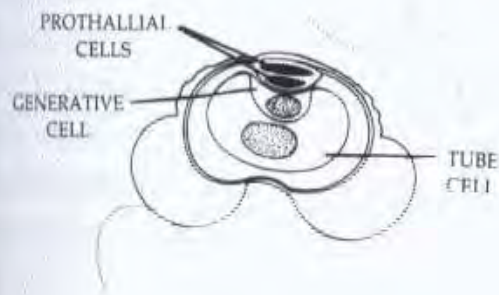
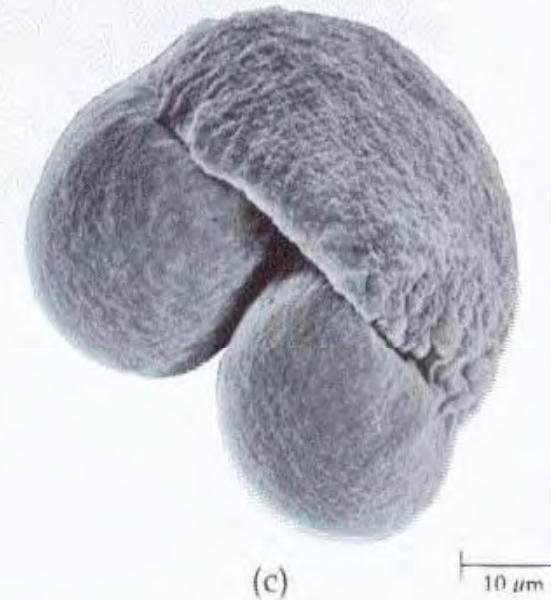
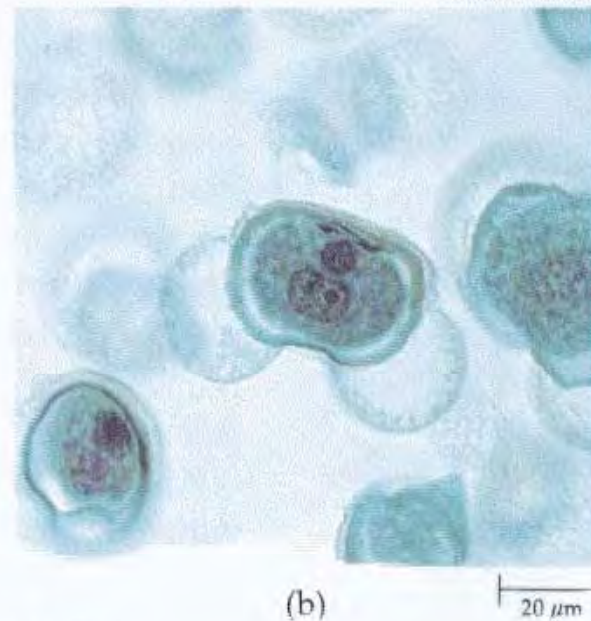
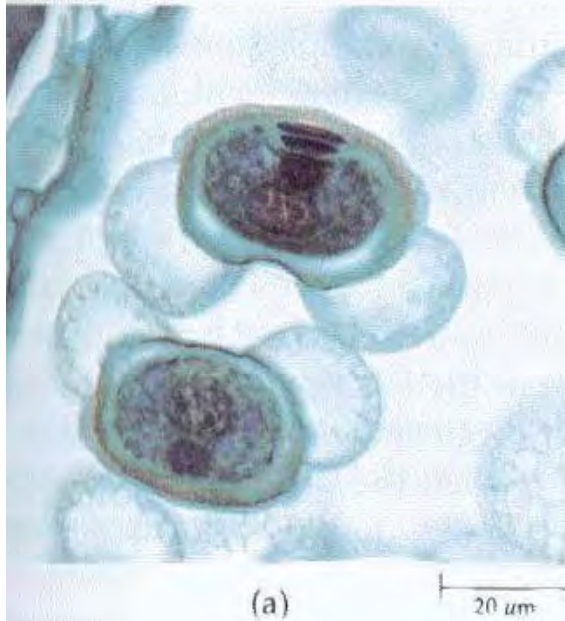
REINO METAFITAS: ESPERMATOFITAS (Gimnospermas)



Cono masculino de pino con polen maduro

18.16. *Pinus*. Vista longitudinal de un cono productor de polen, mostrando microsporófilos y microesporangios conteniendo granos maduros de polen.

Polen de gimnospermas



18-17

Pinus. (a) Pollen grains with enclosed immature male gametophytes. Each gametophyte consists of two prothallial cells, a relatively small generative cell, and a relatively large tube cell. (b) A somewhat older pollen grain than that shown in (a). Here the prothallial cells,

which have no apparent function, have degenerated. (c) Scanning electron micrograph of a pine pollen grain, with its two bladder-shaped wings. When the pollen grain germinates, the pollen tube emerges from the lower end of the grain between the wings.

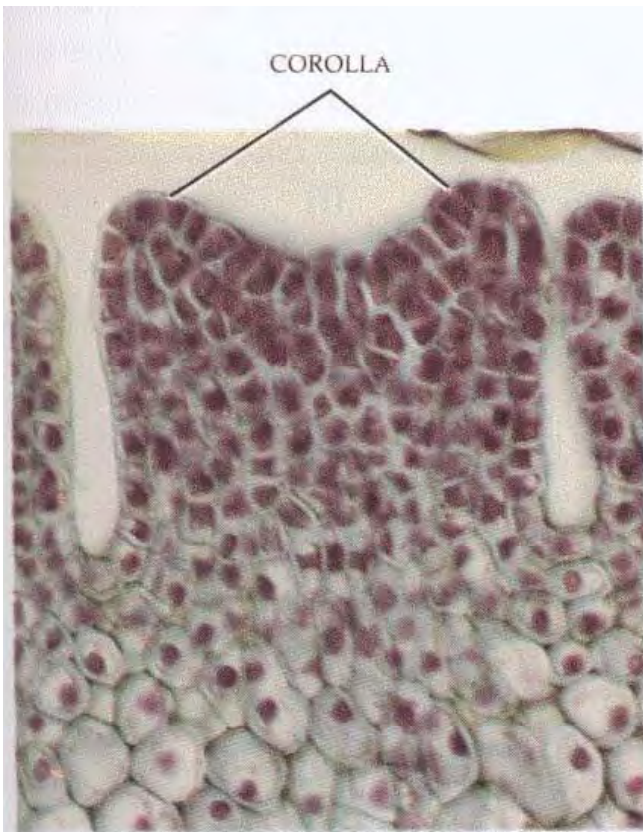


Polen

18-15. Monterey Pine, *Pinus radiata*. Conos microsporángicos que liberan polen, que es dispersado por el viento. Alguna cantidad de este alcanza la vecindad de los óvulos en los conos ovulados y germinan produciendo tubos polínicos y eventualmente fertilizan.

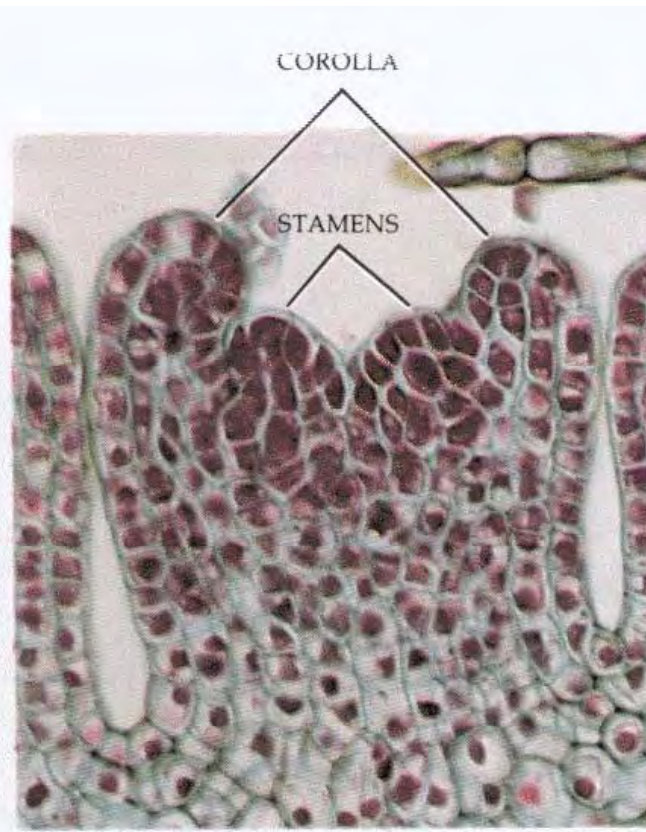
origen y desarrollo de flores

Las inflorescencias se originan a partir de una zona meristemática similar a la que originaria un tallo y hojas, es decir de la estructura de meristemas en *tunica y corpus*



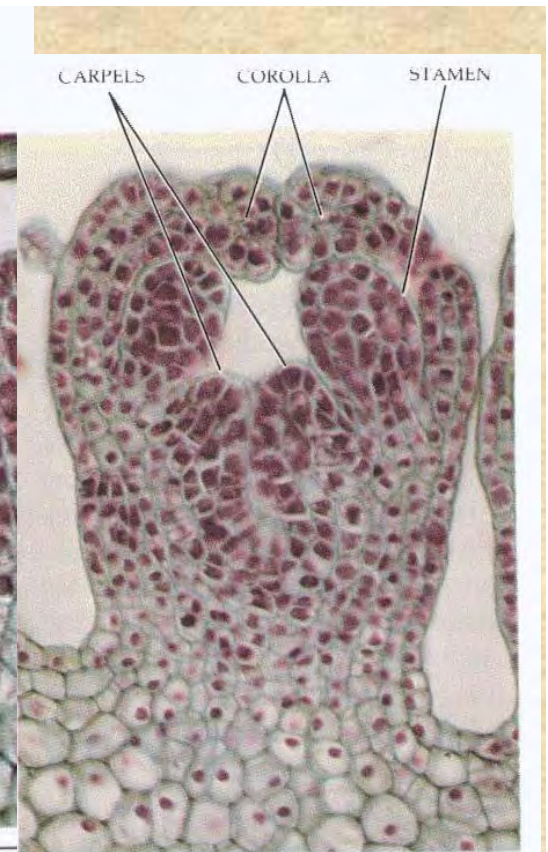
(a)

50 μm



(b)

50 μm



22-36

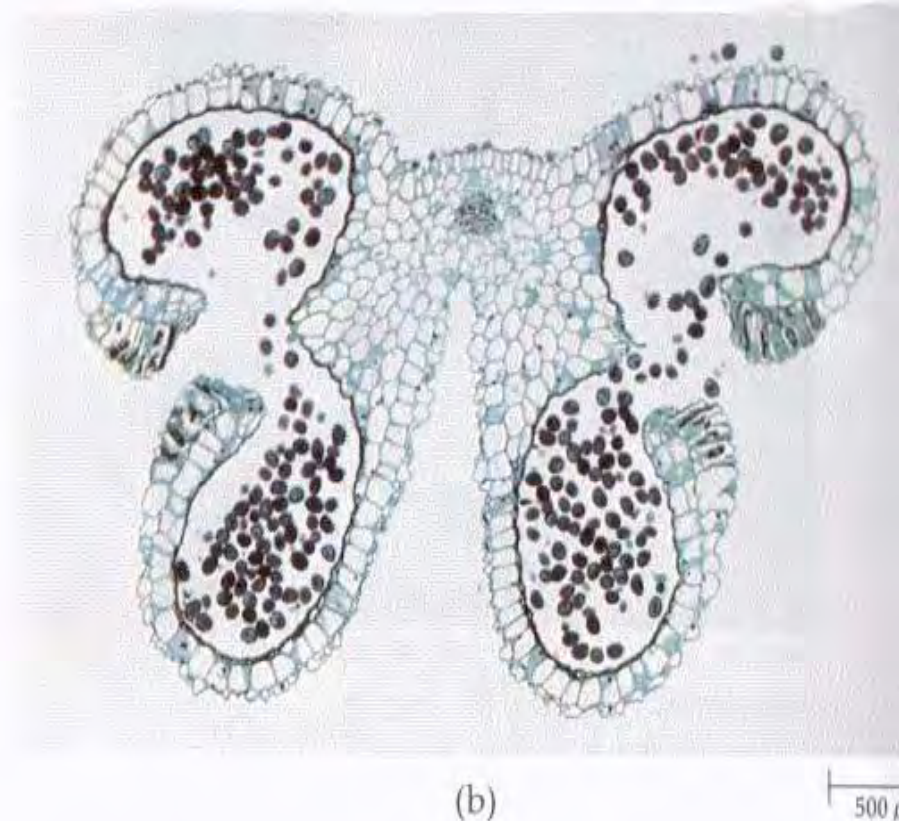
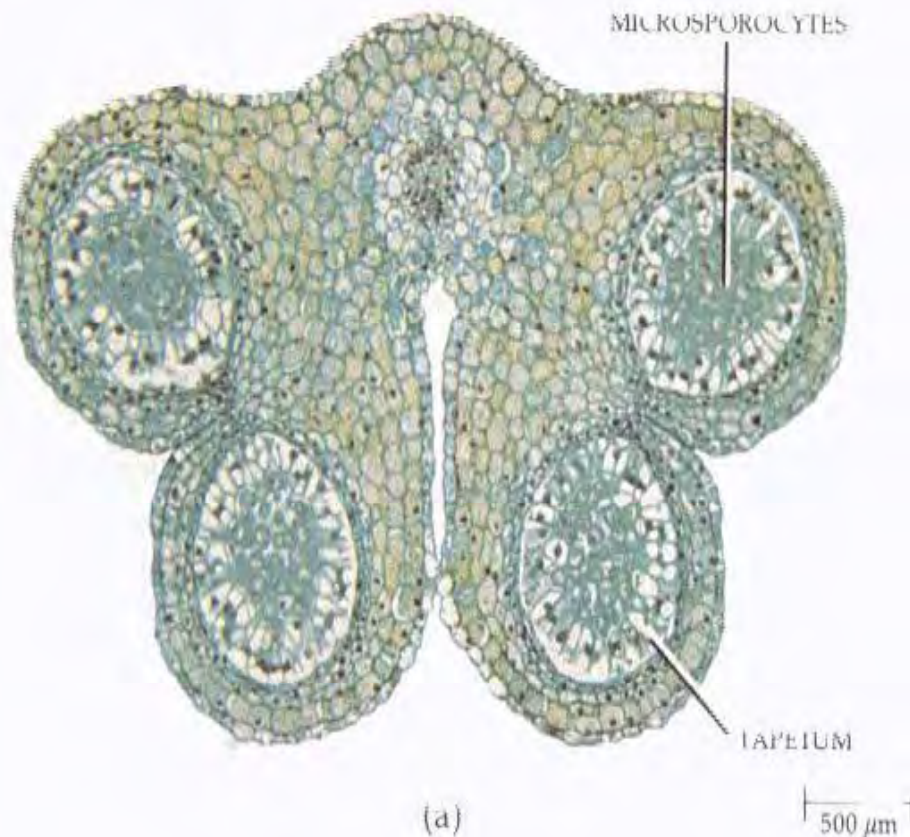
Stages in development of the fleabane (*Erigeron*) flower, as seen in longitudinal sections. (a) Flower primordium with developing corolla. (b) Initiation of

stamens, which are adnate to the corolla. (c) Flower with developing corolla, stamens, and carpels. (Continued on next page.)

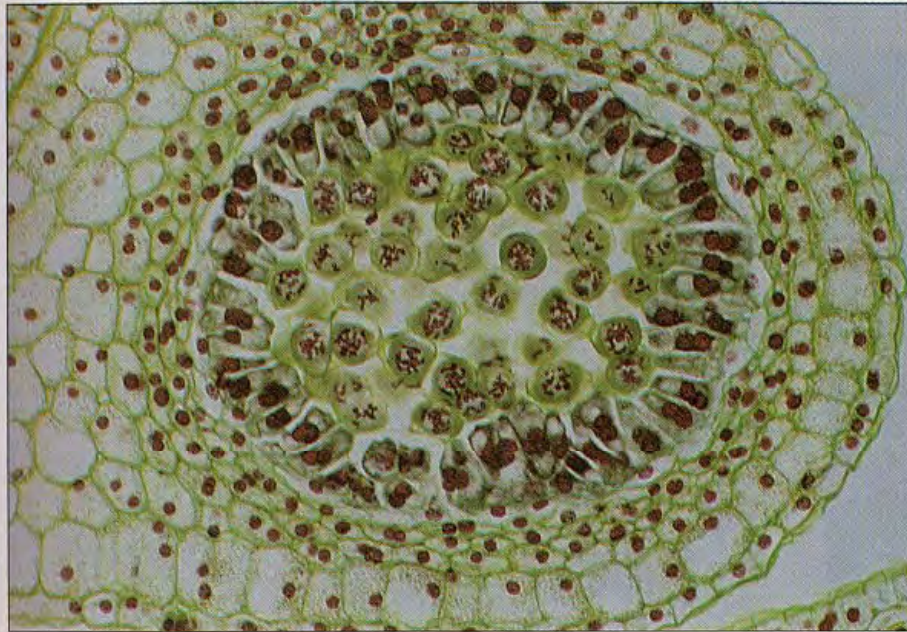
Flor: meristemo floral:
secuencia de órganos florales

Corte transversal de anteras: deshicencia-liberación de polen-

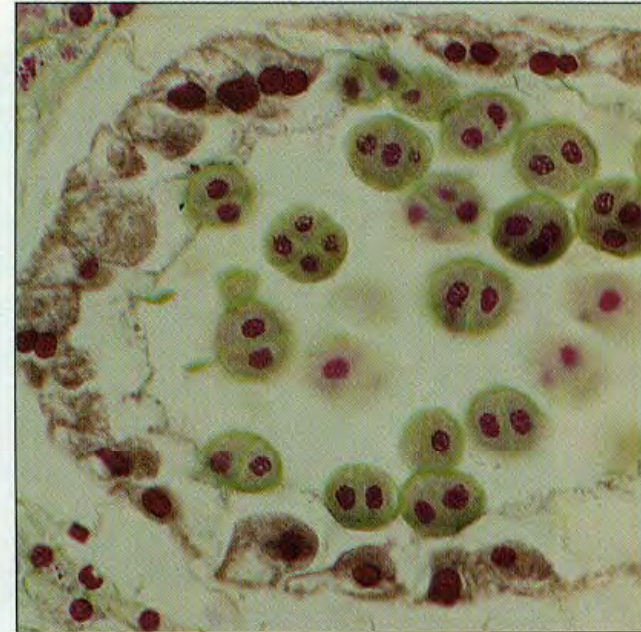
Dos secciones transversales del lirio (*Lilium*) anteras, (a) antera inmadura, mostrando los cuatro sacos polínicos que contienen los microsporocitos rodeados por el *tapetum*. (b) Antera madura conteniendo los granos de polen. Las particiones entre los sacos polínicos se rompen antes de la dehiscencia, como se muestra.



Anteras con granos de polen (meiosis y granos de polen)



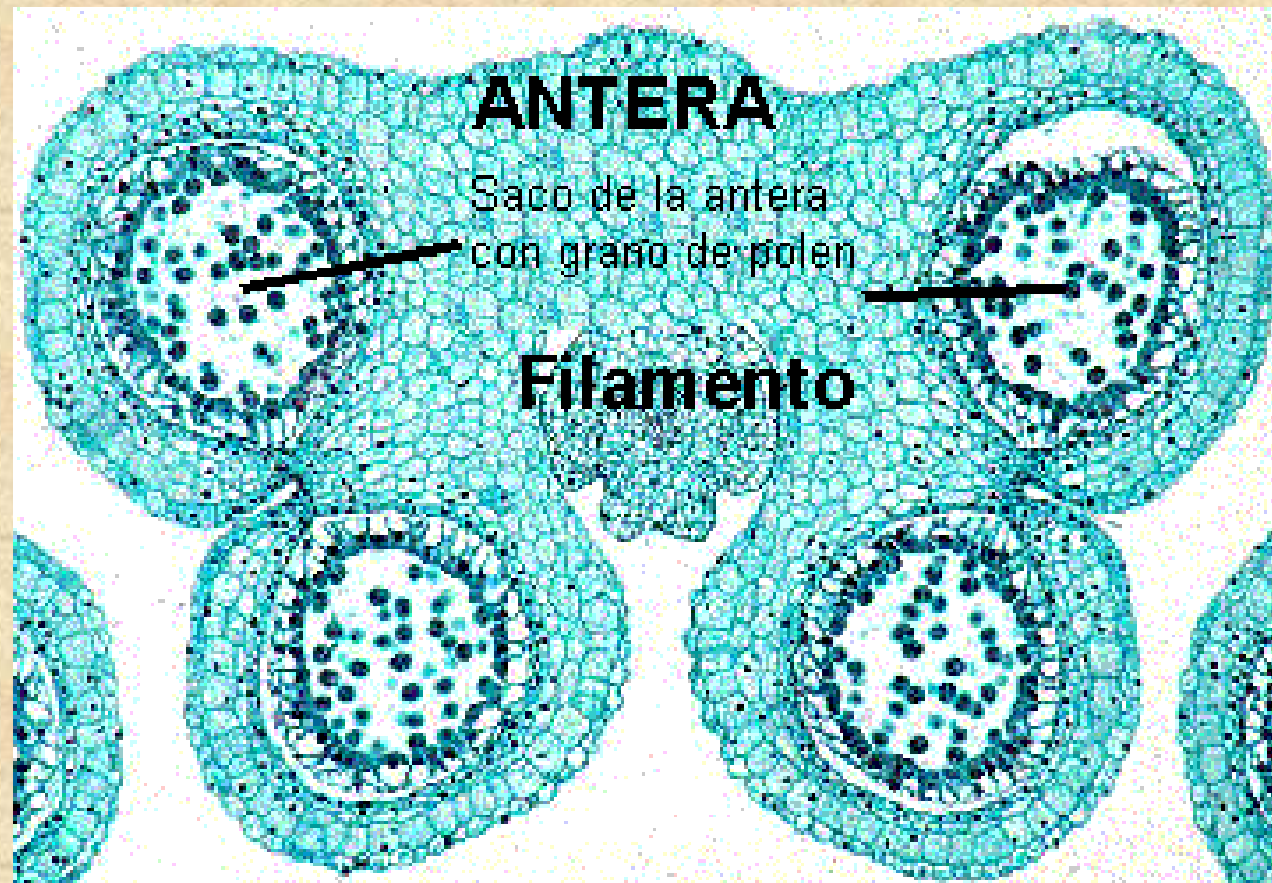
(a)



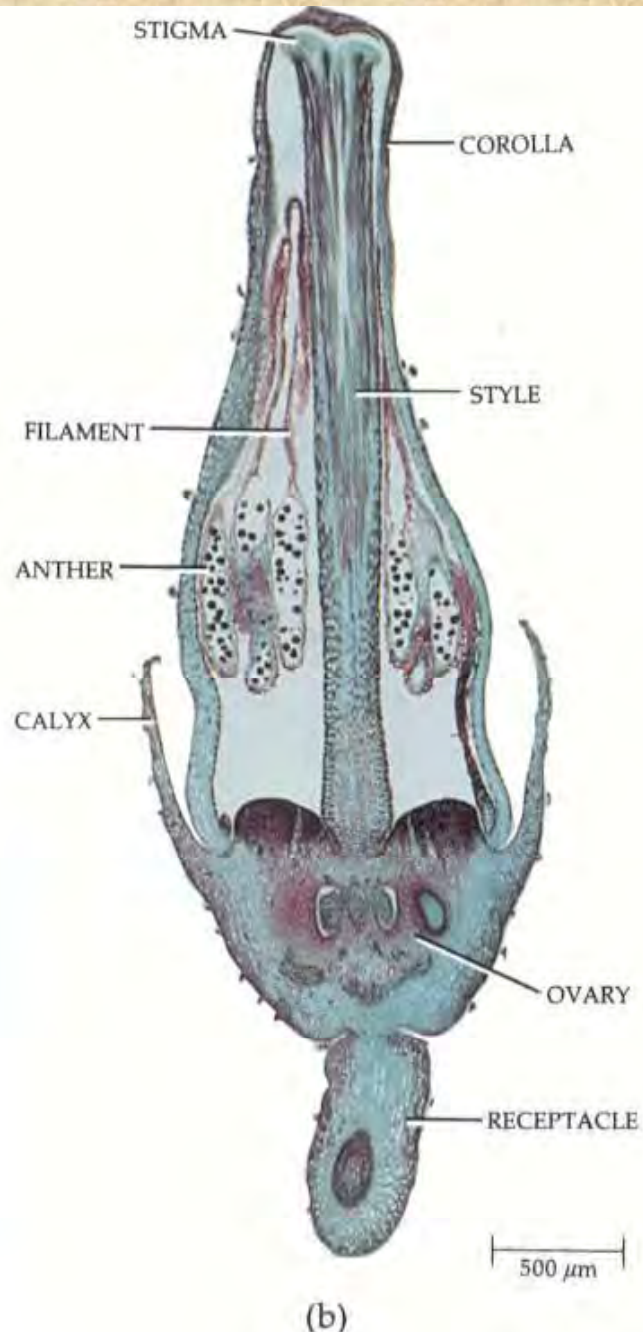
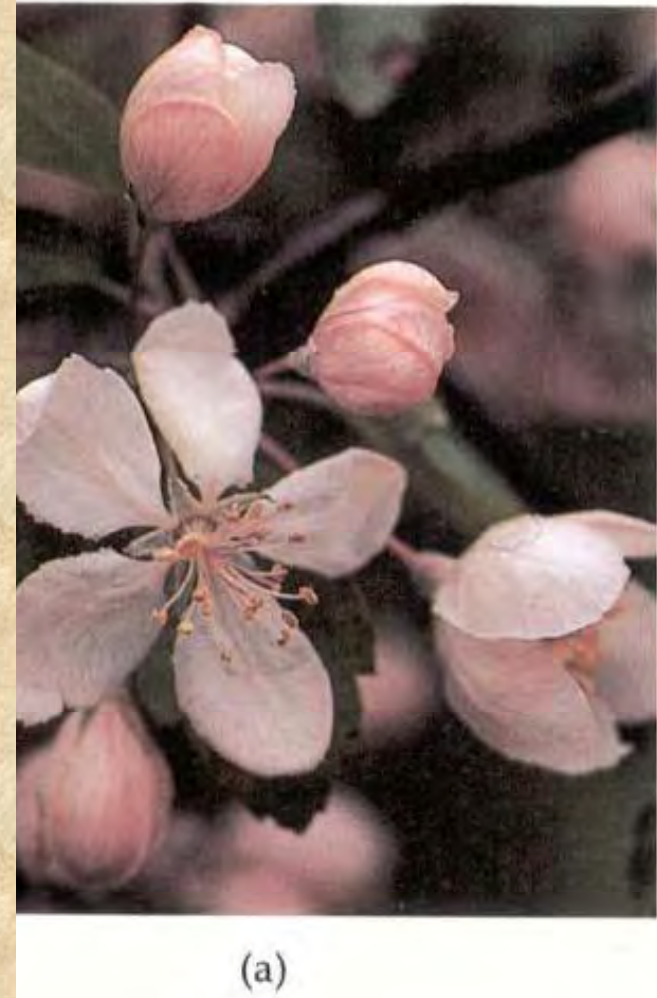
(b)

Figure 9.11

(a) Transverse section through an anther of a lily, showing the microsporocytes in prophase of the first meiotic division that will produce haploid microspores. The surrounding cells do not undergo meiosis and are described as sterile tissue ($\times 200$) (G. I. Bernard/Earth Scenes). (b) After meiosis, the four microspores remain together temporarily, but as they develop their specialized pollen cell wall, they usually separate from each other ($\times 500$).



Flores



Manzana (*Malus sylvestris*) cuyas flores exhiben con segmentos florales insertados por encima del ovario (flores epíginas). Obsérvese la alta proporción de tejido parenquimático.

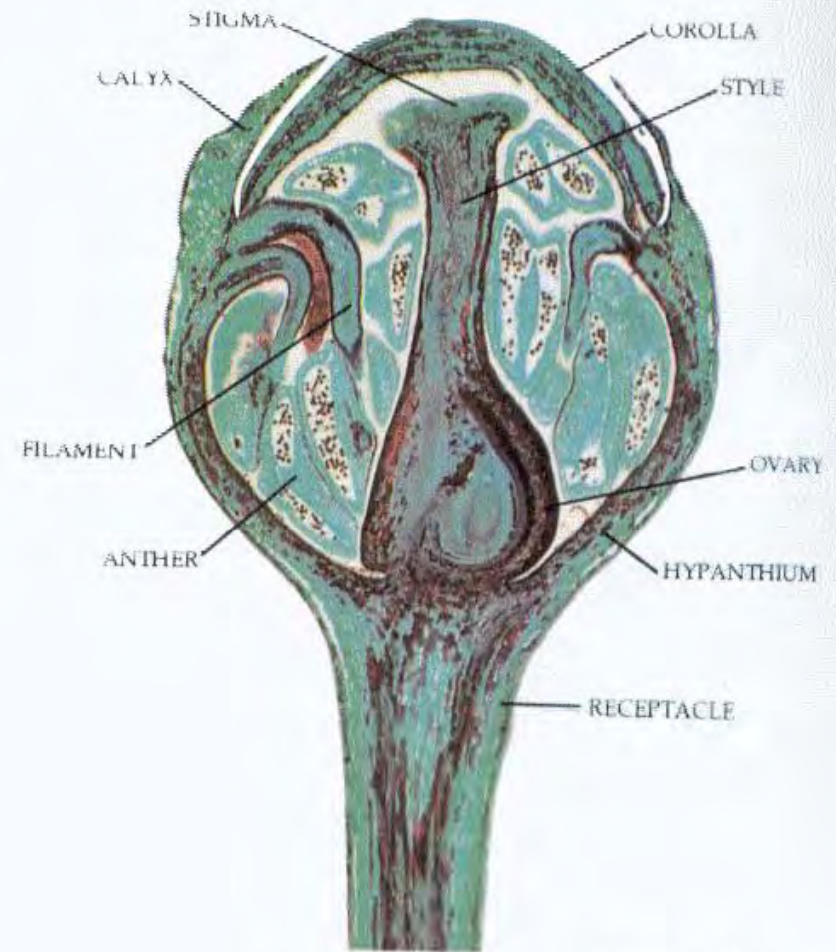
Flores de cereza: presencia de hipantio, disco alrededor del ovario



(a)

18-47

(a) and (b) Cherry (*Prunus*) flowers exhibit perigyny—their sepals, petals, and stamens are attached to a hypanthium (a cup-shaped extension of the receptacle). In (b) the stamens are crowded in the hypanthium because the flower has not yet opened.

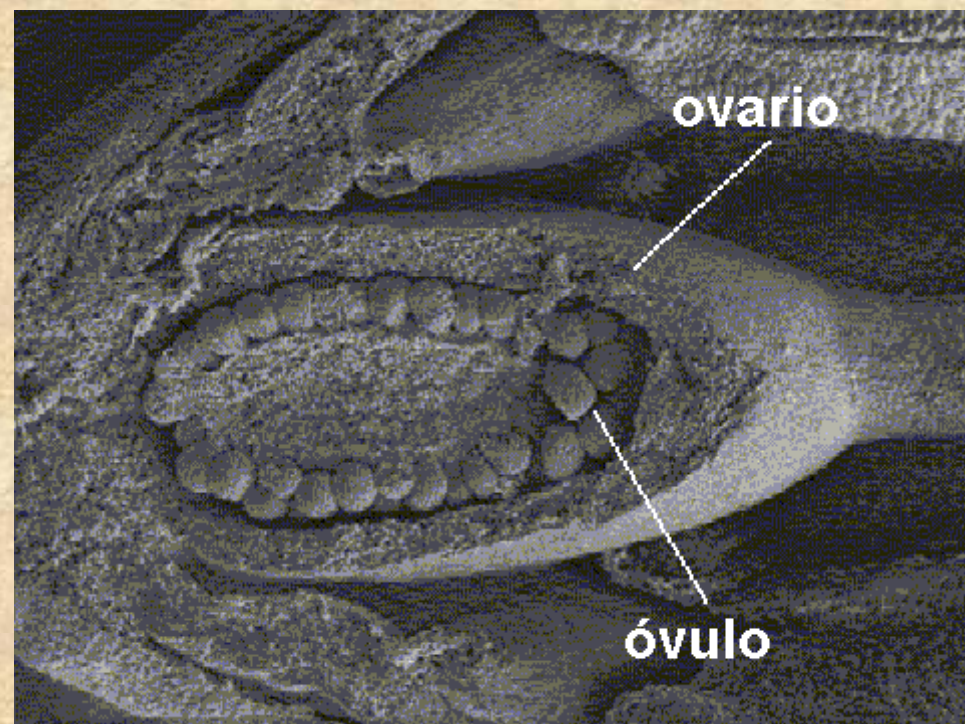


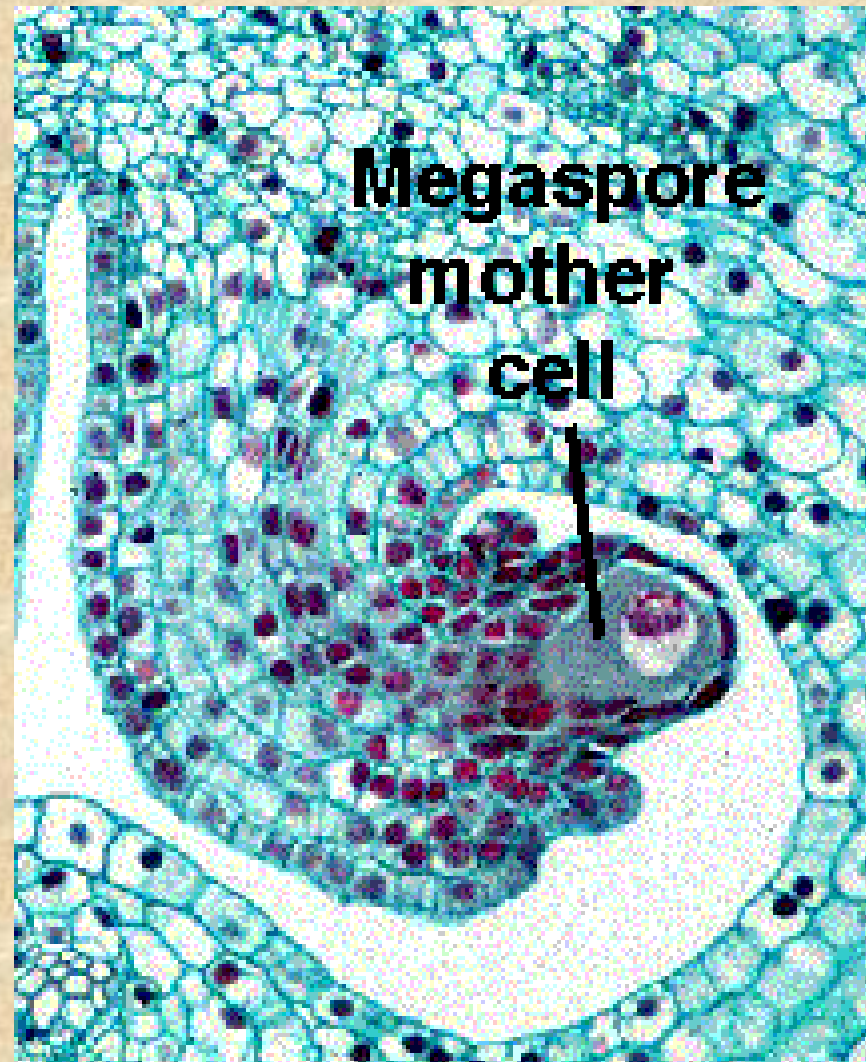
(b)

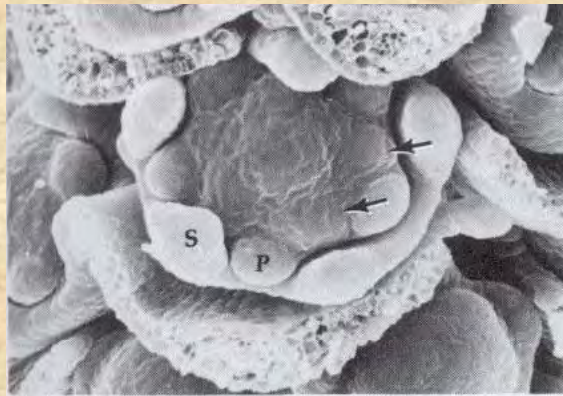
500 μm



Corte transversal de ovario tricarpetar







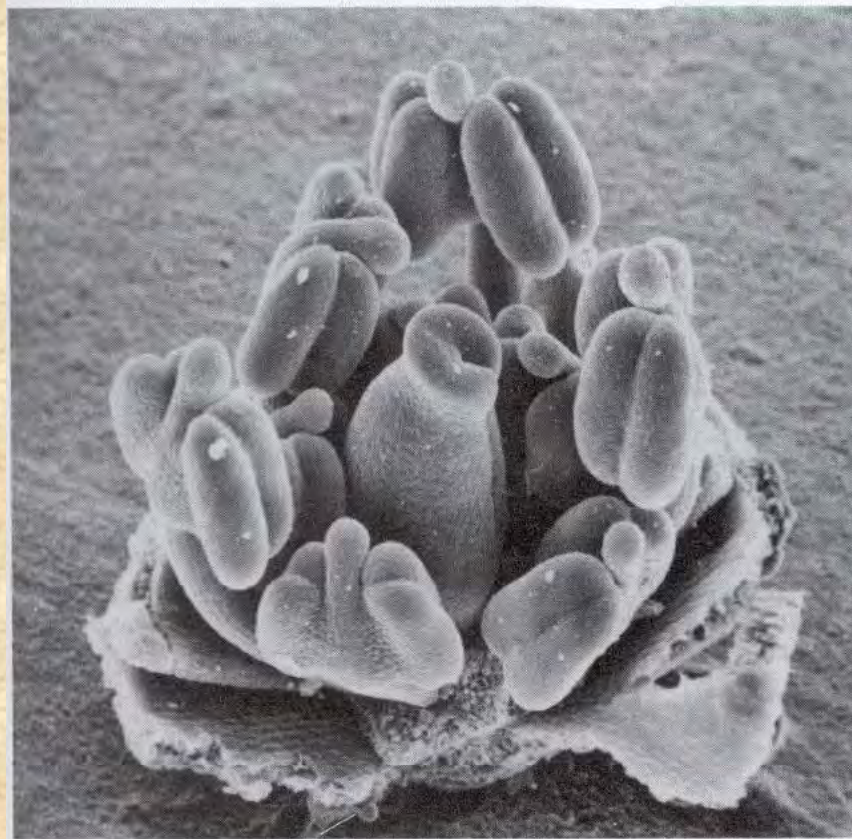
(d)

50 μm



22-35

Longitudinal section of young inflorescence of fleabane (*Erigeron*), a member of the Asteraceae. The inflorescence contains numerous flower primordia. The older flower primordia are on the periphery of the inflorescence, the younger in the center.

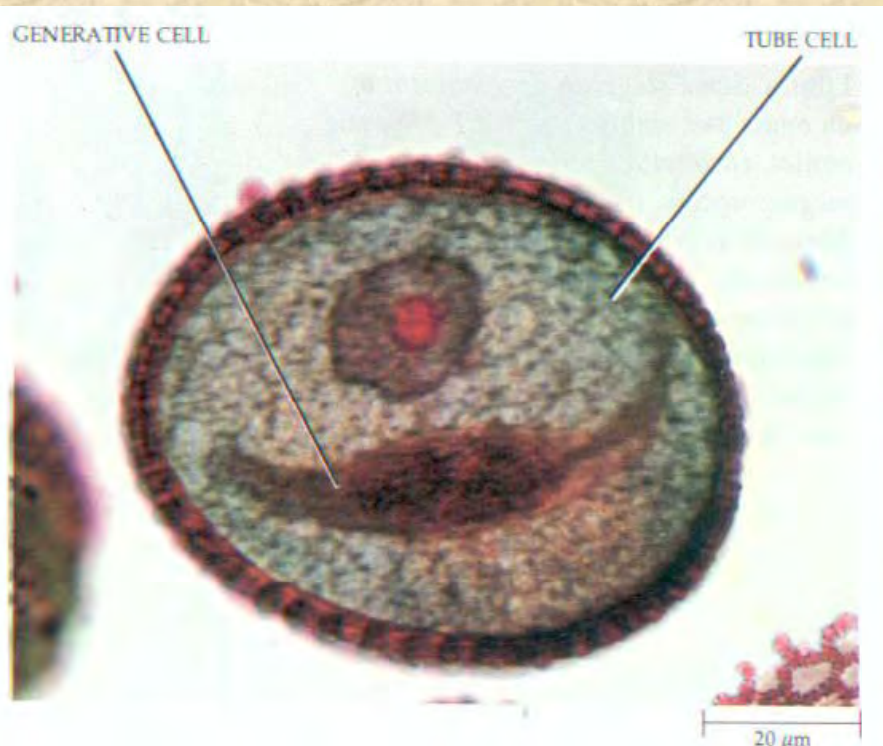


(g)

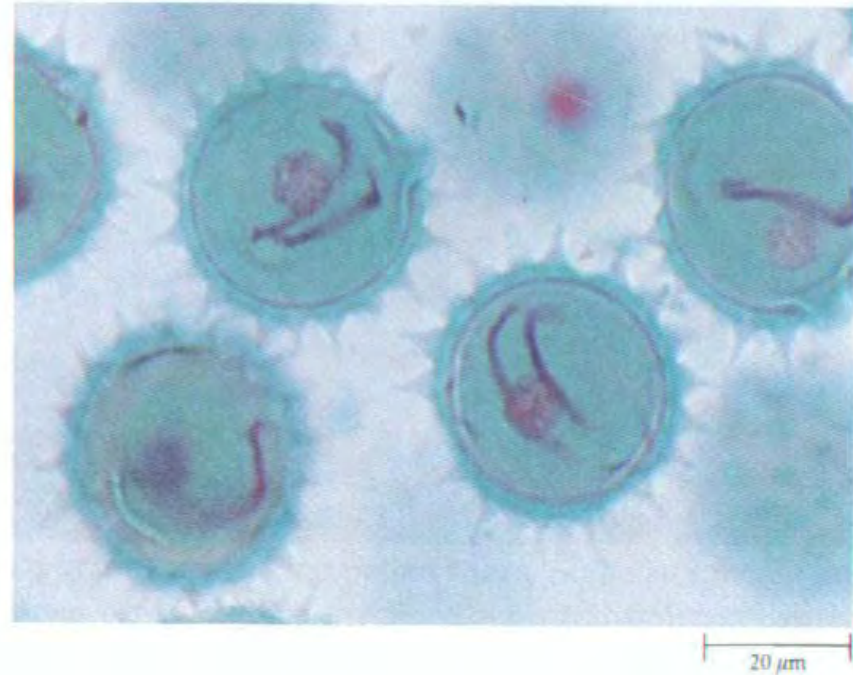
100 μm

Anteras y estigma, inflorescencia

Polen de Angiosperma

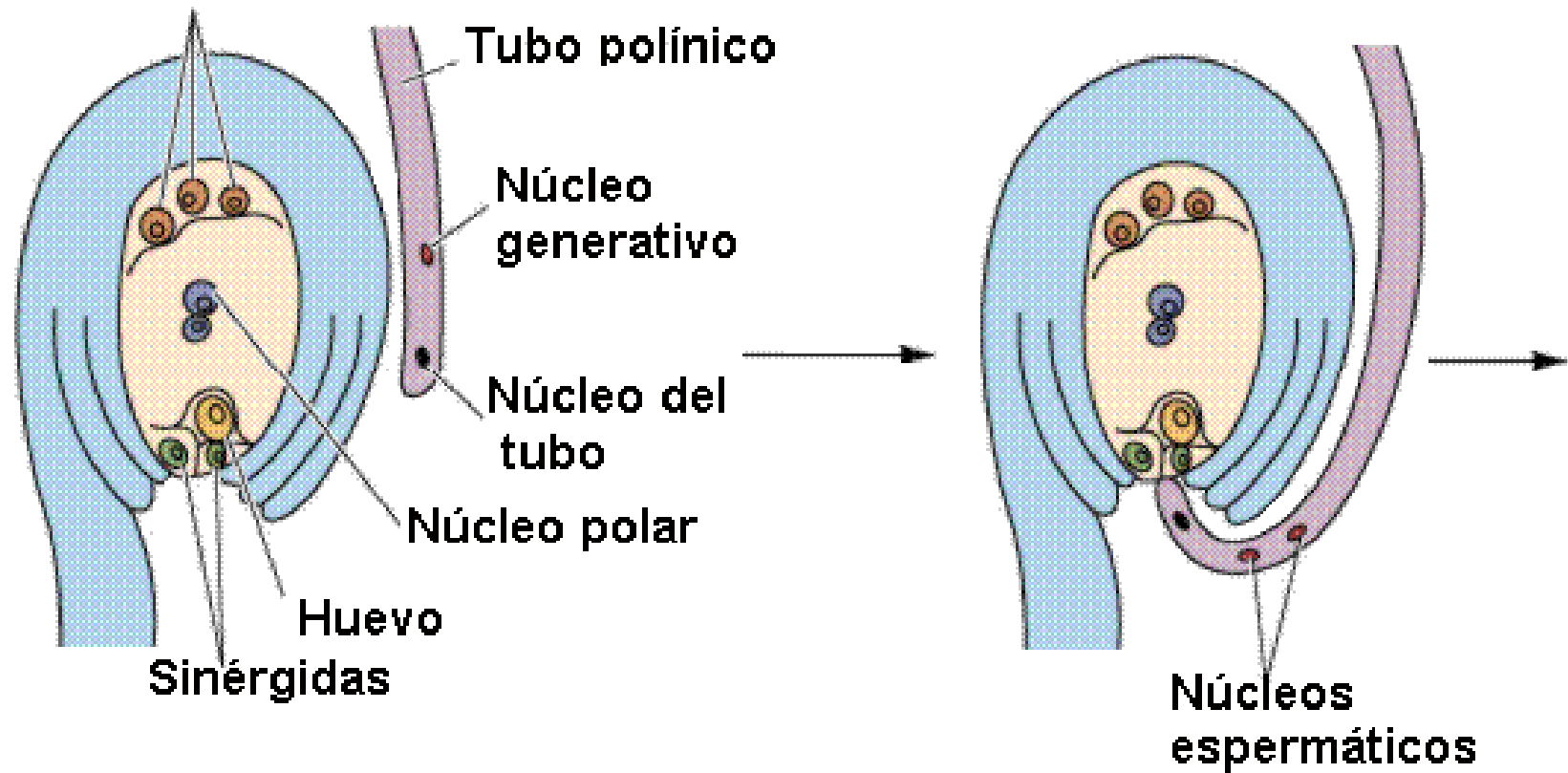


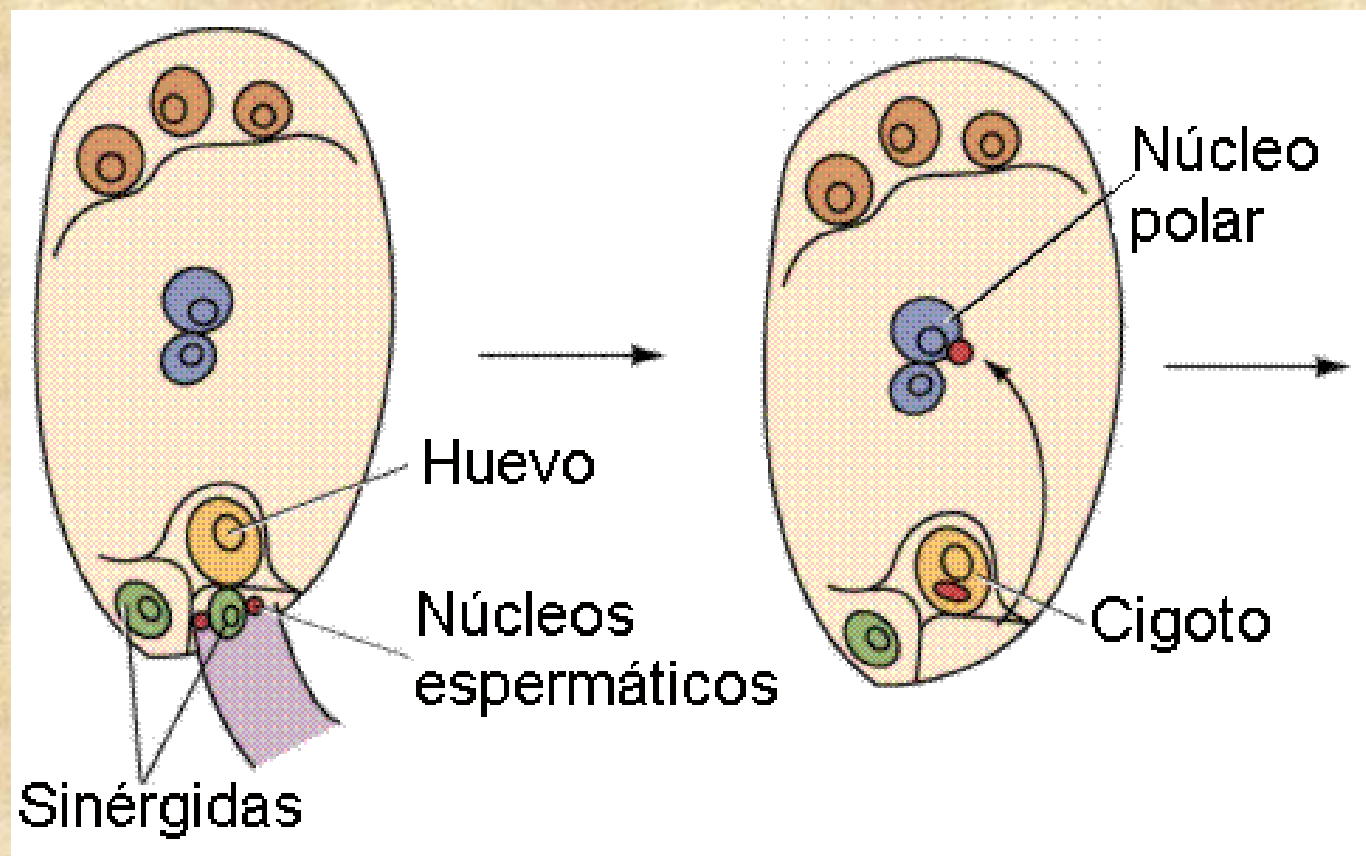
Polen maduro de *Lilium* (Liliaceae), con el gametofito de 2 células. La célula generativa se dividirá mitóticamente, dando origen a dos células espermáticas; la célula del tubo formara el tubo polínico.

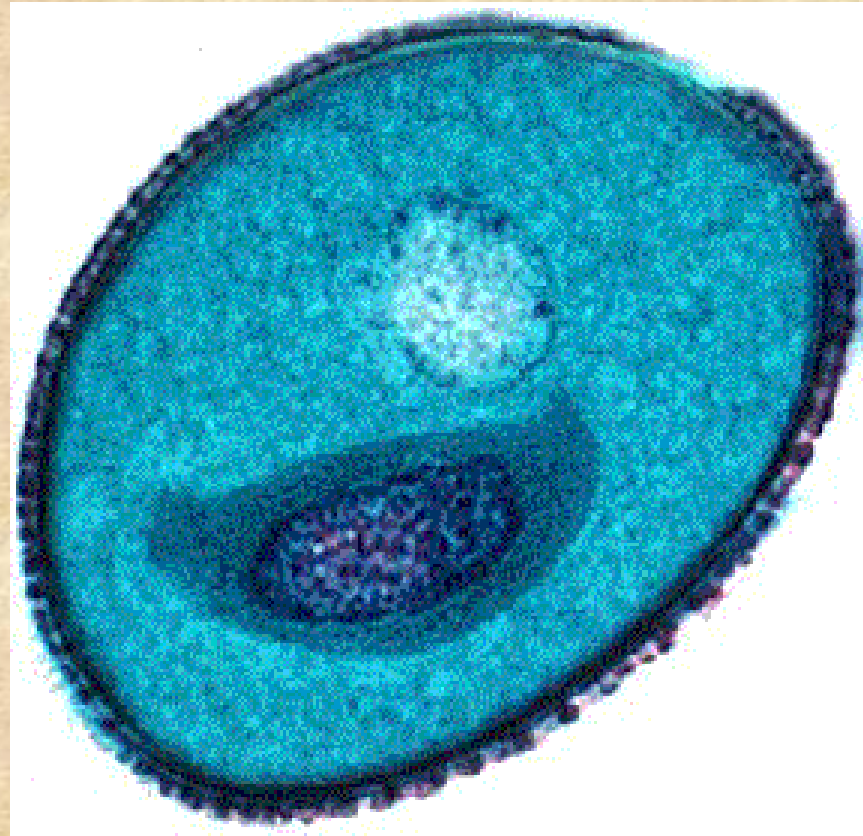


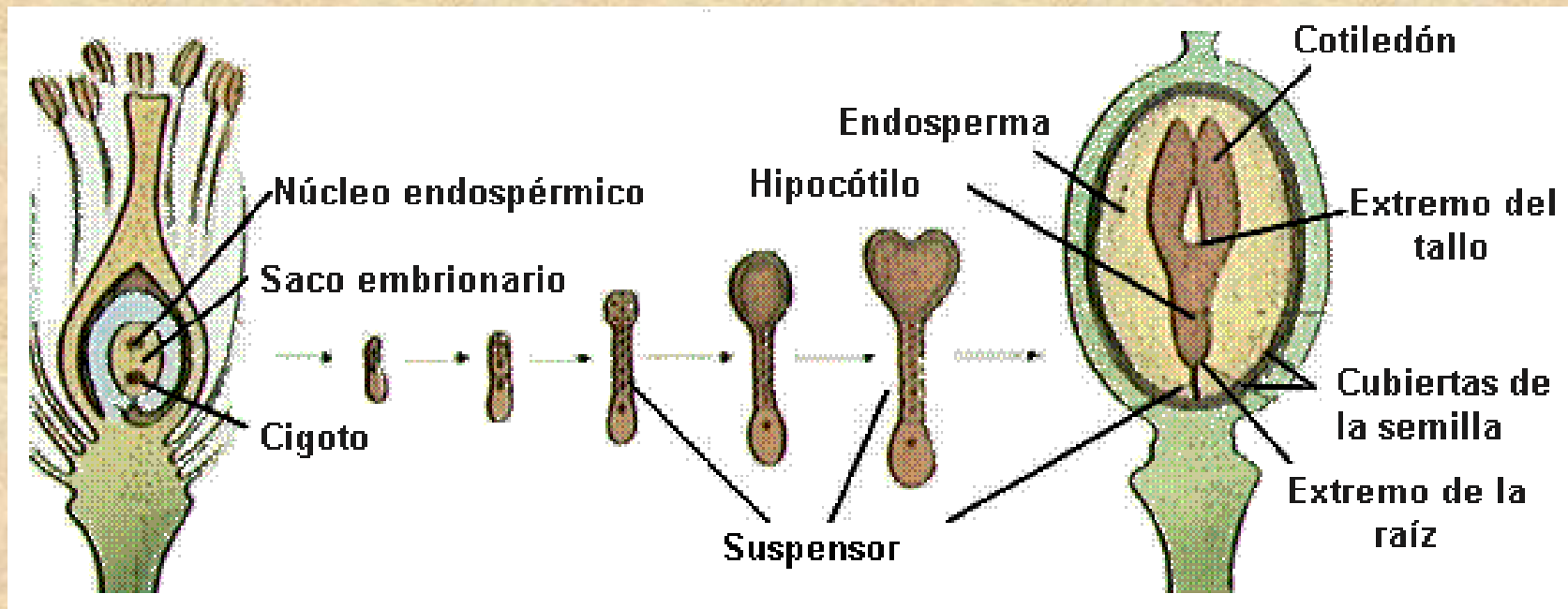
Polen maduro con gametofitos de 3 células en *Silphium* (Asteraceae). Antes de la polinización, cada grano de polen contiene dos células espermáticas filamentosas, las cuales están suspendidas en el citoplasma de la célula del tubo. En otras palabras, el polen de *Silphium* se libera en estado tri celular, mientras que el de *Lilium*, se libera en estado de 2 células.

Tres células antípodas

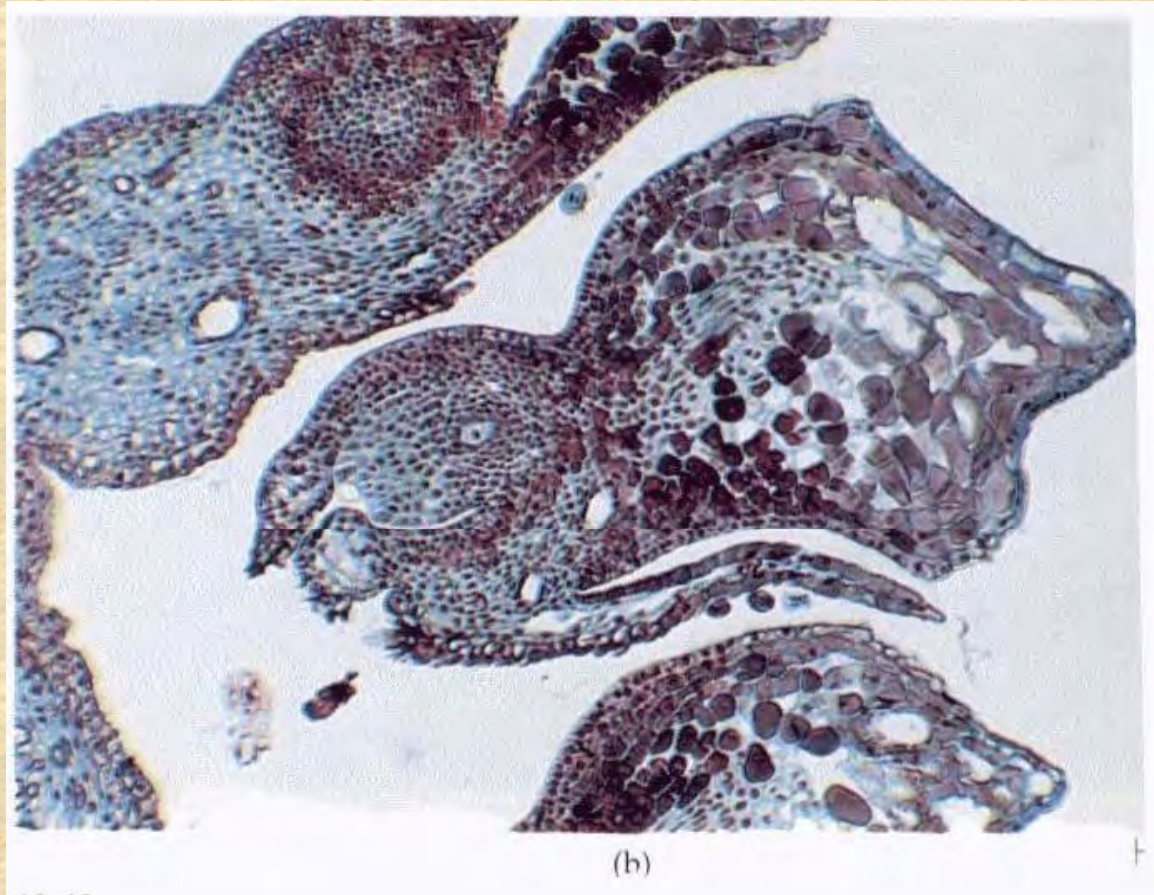
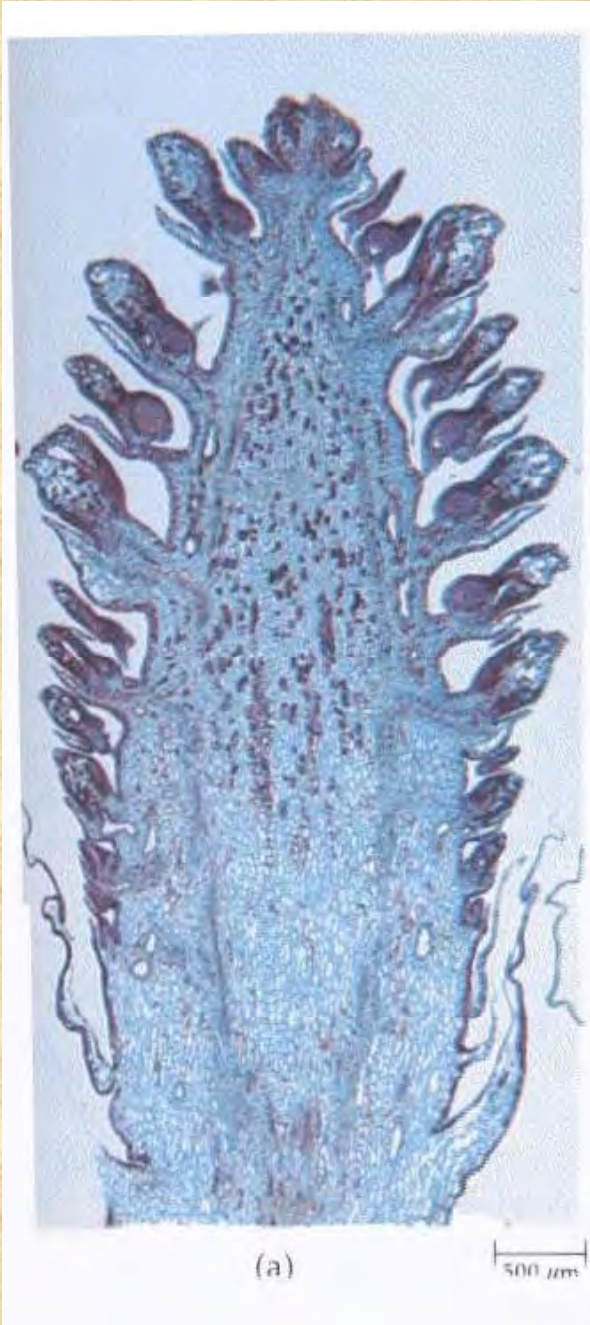




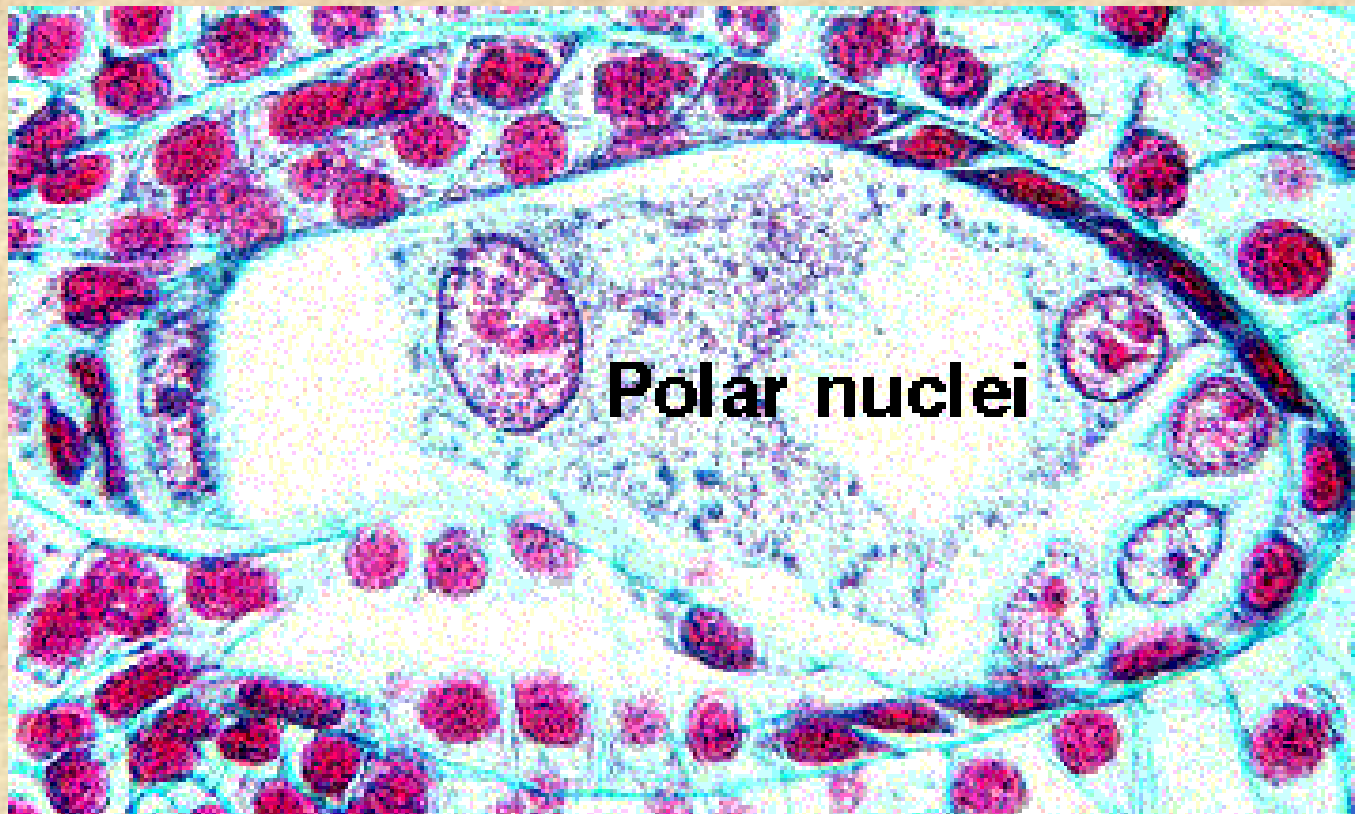




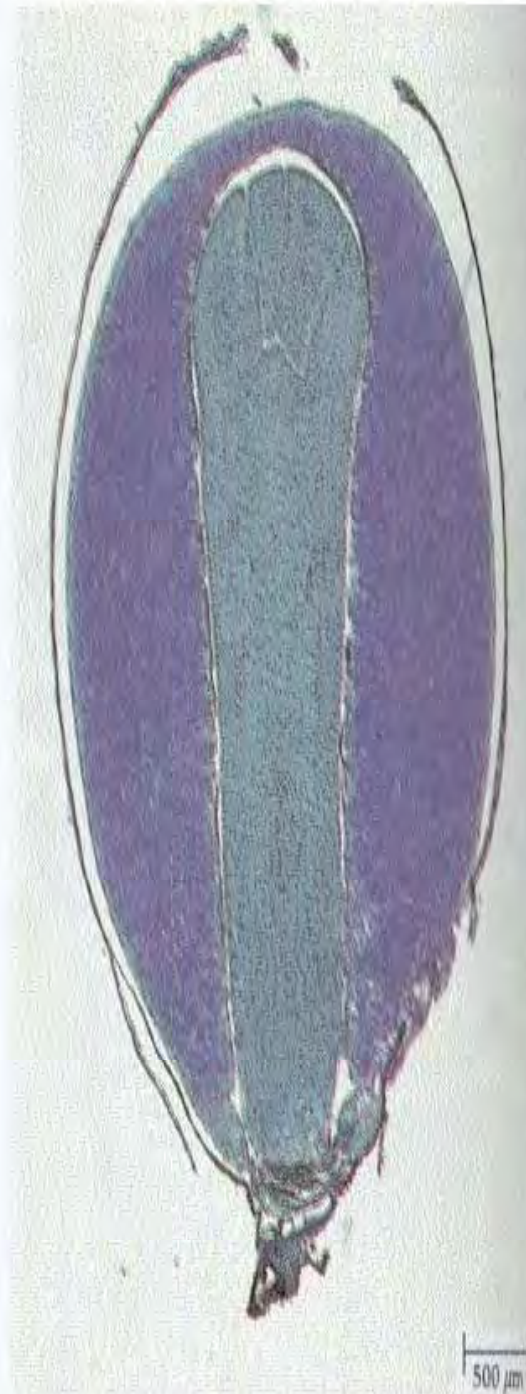
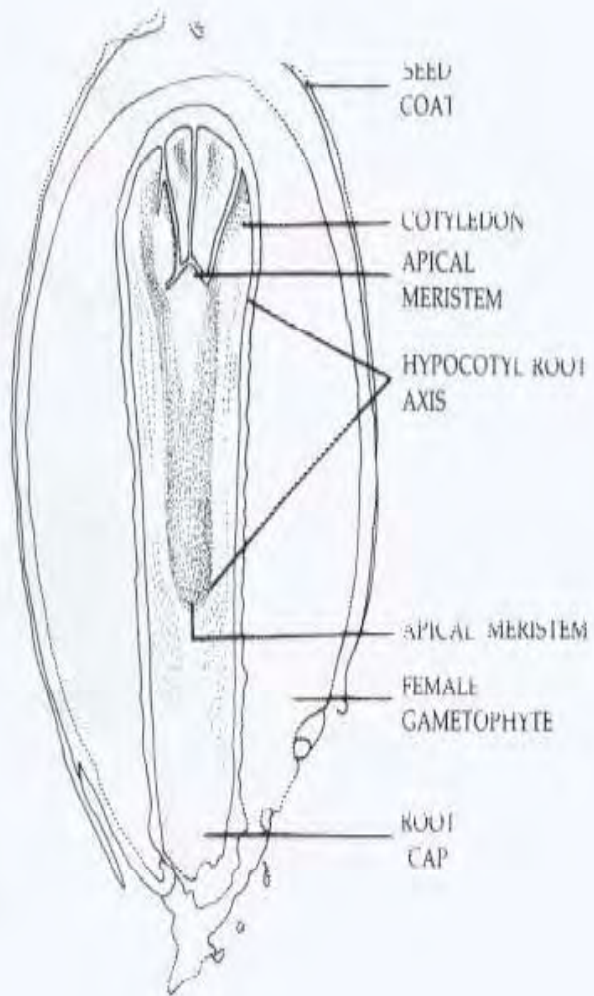
Cono femenino de pino con óvulos



18-19. *Pinus* (a) Vista longitudinal de un cono con gametofito joven , o estróbilo, mostrando su compleja estructura. (b) Detalle de la porción del estróbilo. Note el magasporocito (célula madre de la megaspora) rodeada por el nucelo.



Anatomía de semilla



Semilla:
corte
longitudinal
y embrión
con las
diferentes
zonas de
origen de
los tejidos

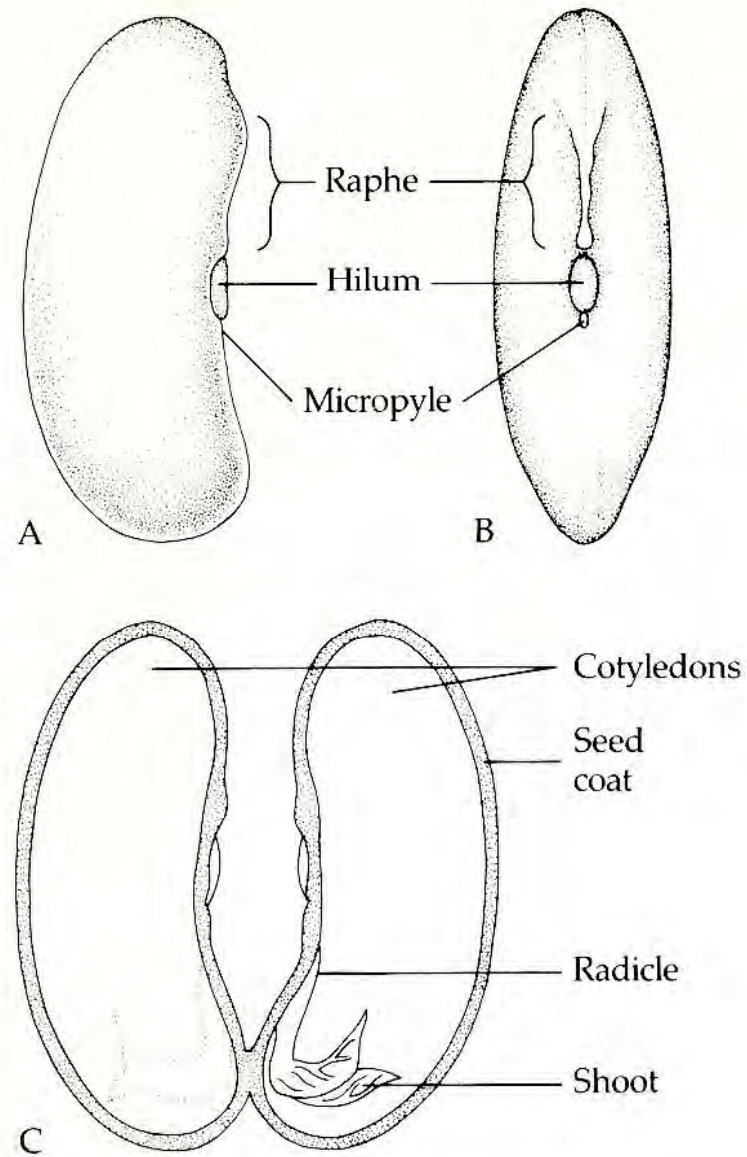
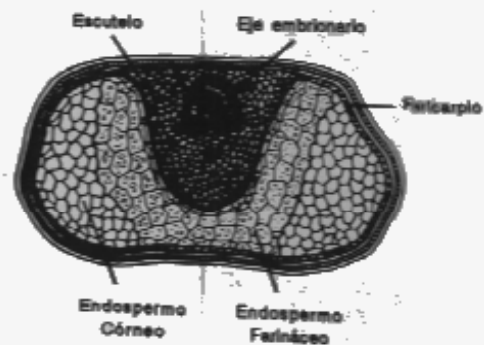
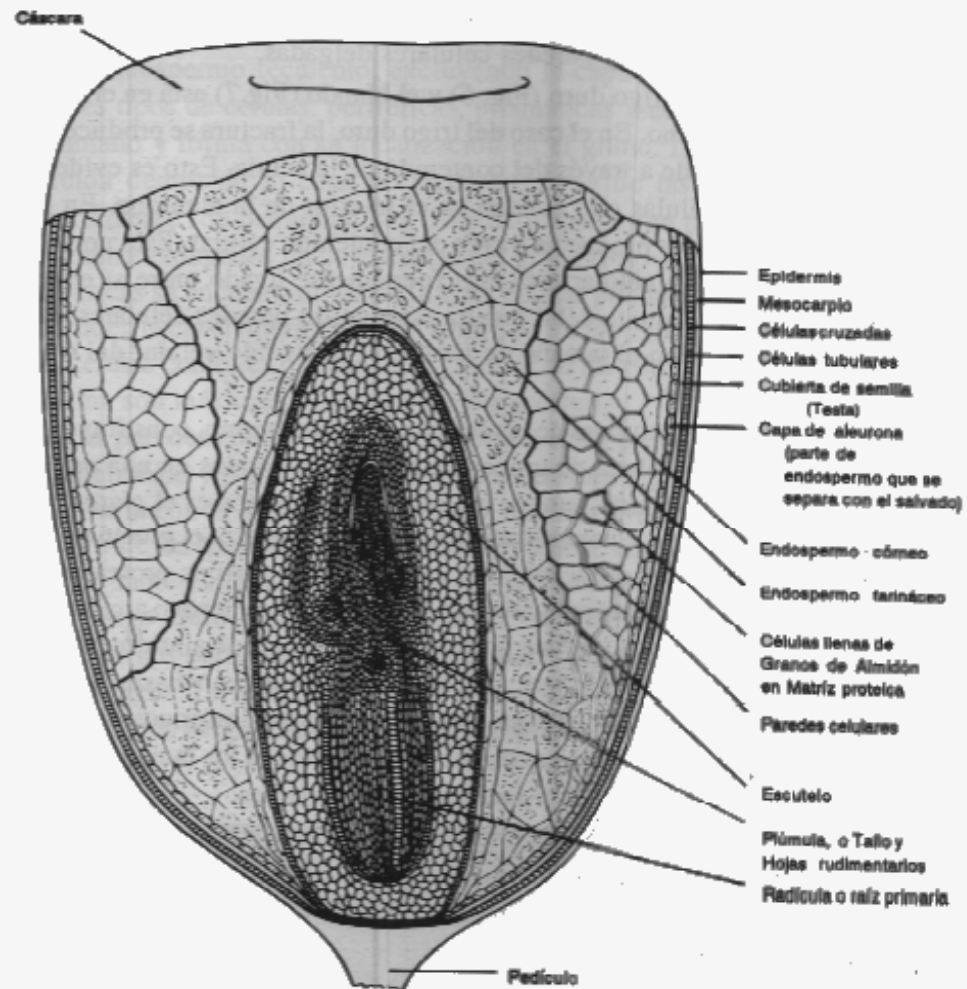
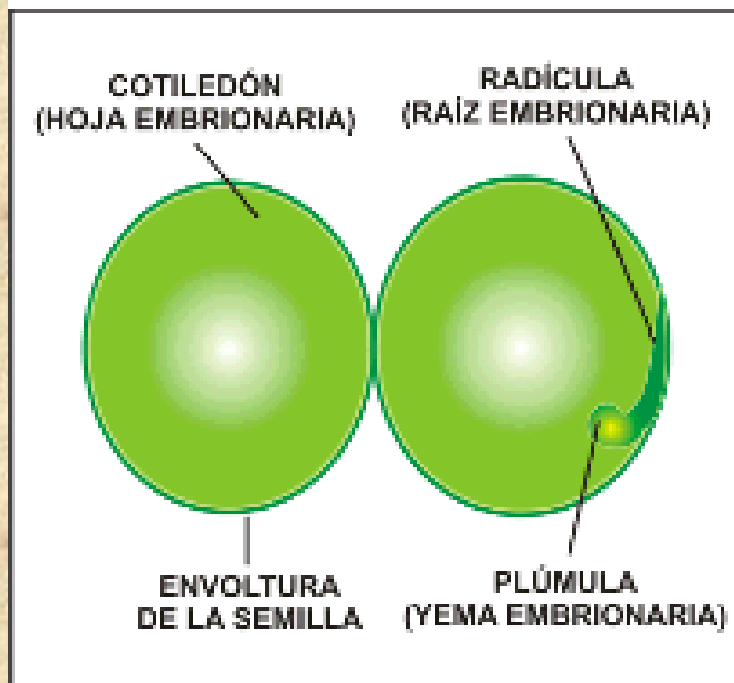
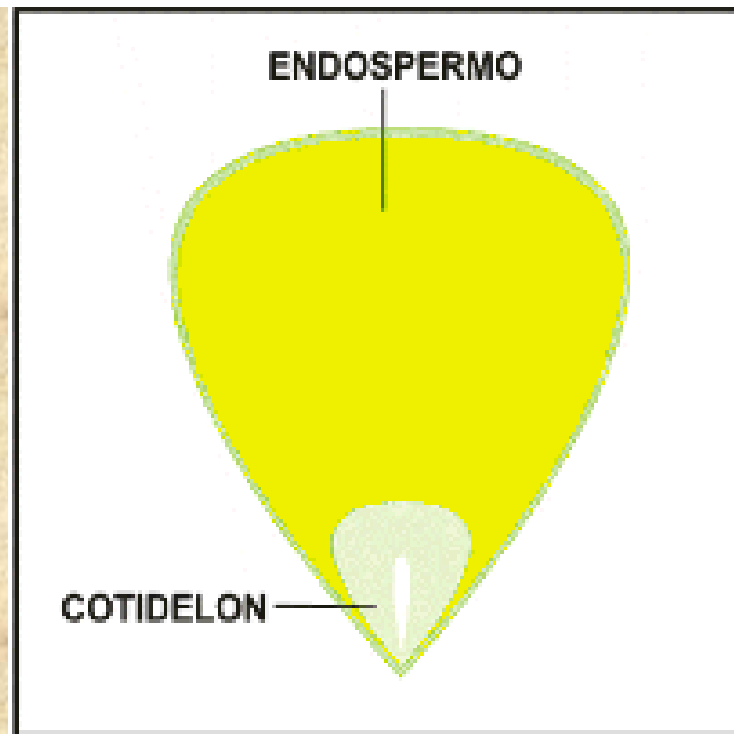
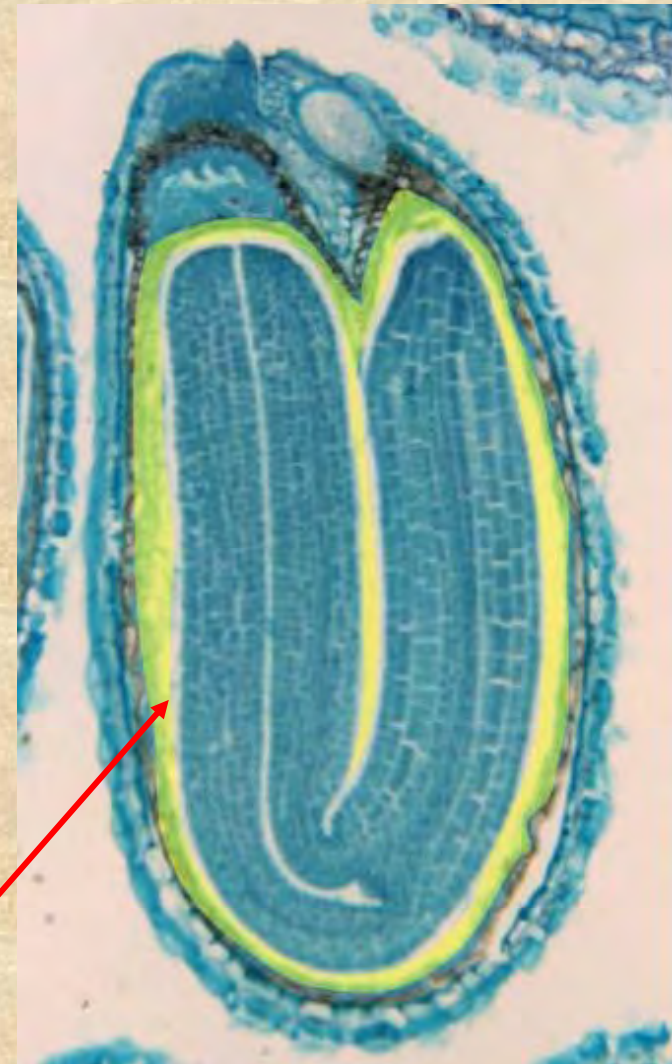
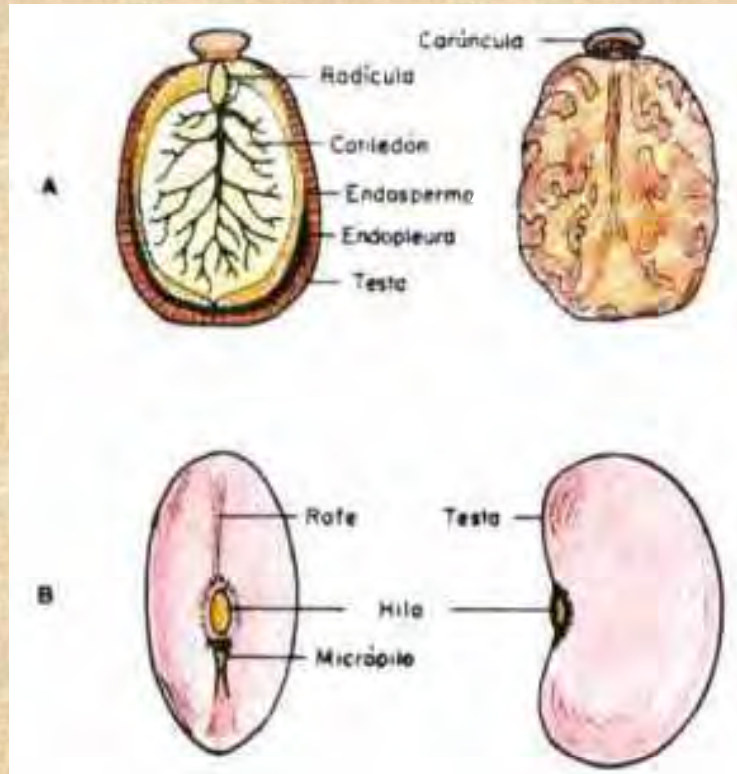


Figure 20.20

This diagram shows the various parts that are commonly present in seeds.

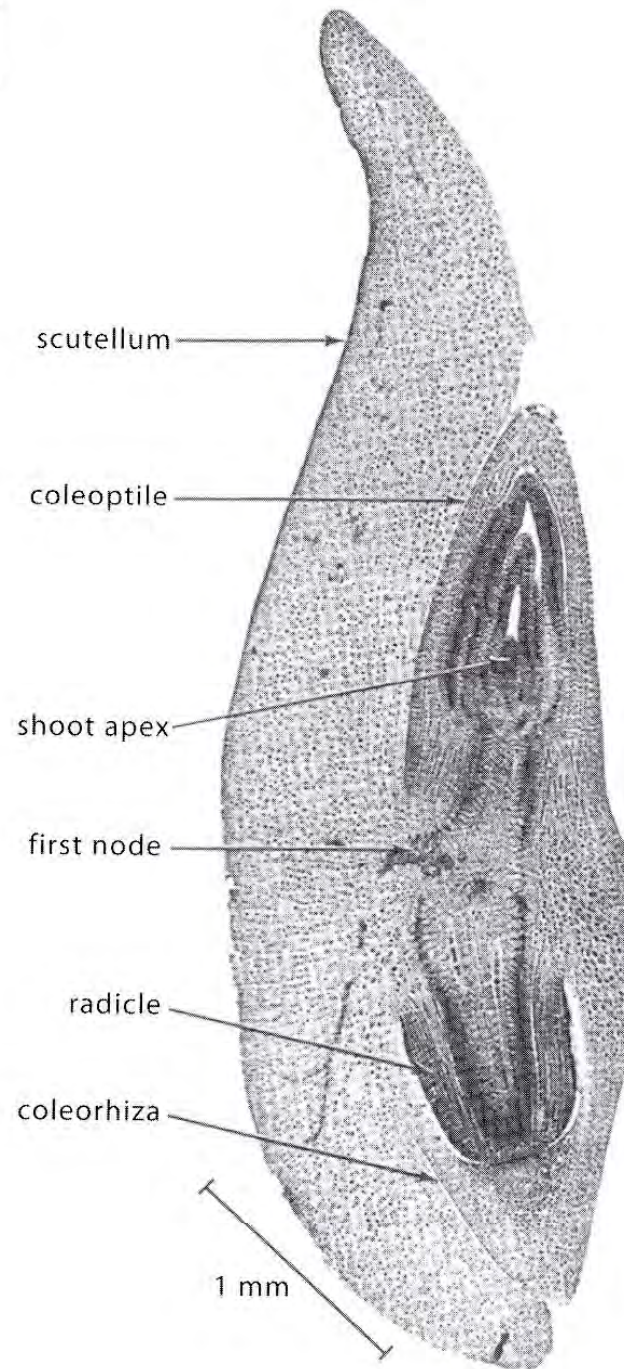






endospermo

Figure 18.16 The embryo of *Zea mays*.



el escutelo es el
cotiledón

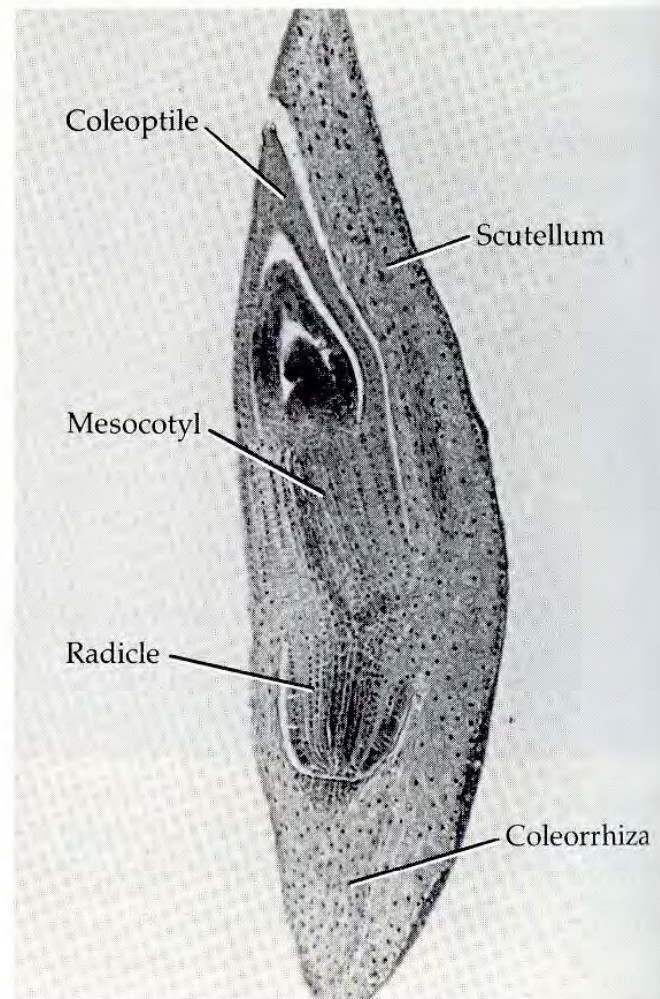


Figure 20.15

This is an embryo of *Panicum maximum*, a grass. On the right is the large scutellum; on the left are the embryo axis and leaves. The radicle and shoot apex are visible; notice that the radicle is encased by the coleorrhiza and that the large outermost leaf is the coleoptile. The point where the scutellum attaches to the rest of the embryo is the mesocotyl. The epiblast is not visible. $\times 78$. Micrograph generously provided by C.-Y. Lu and I. K. Vasil.

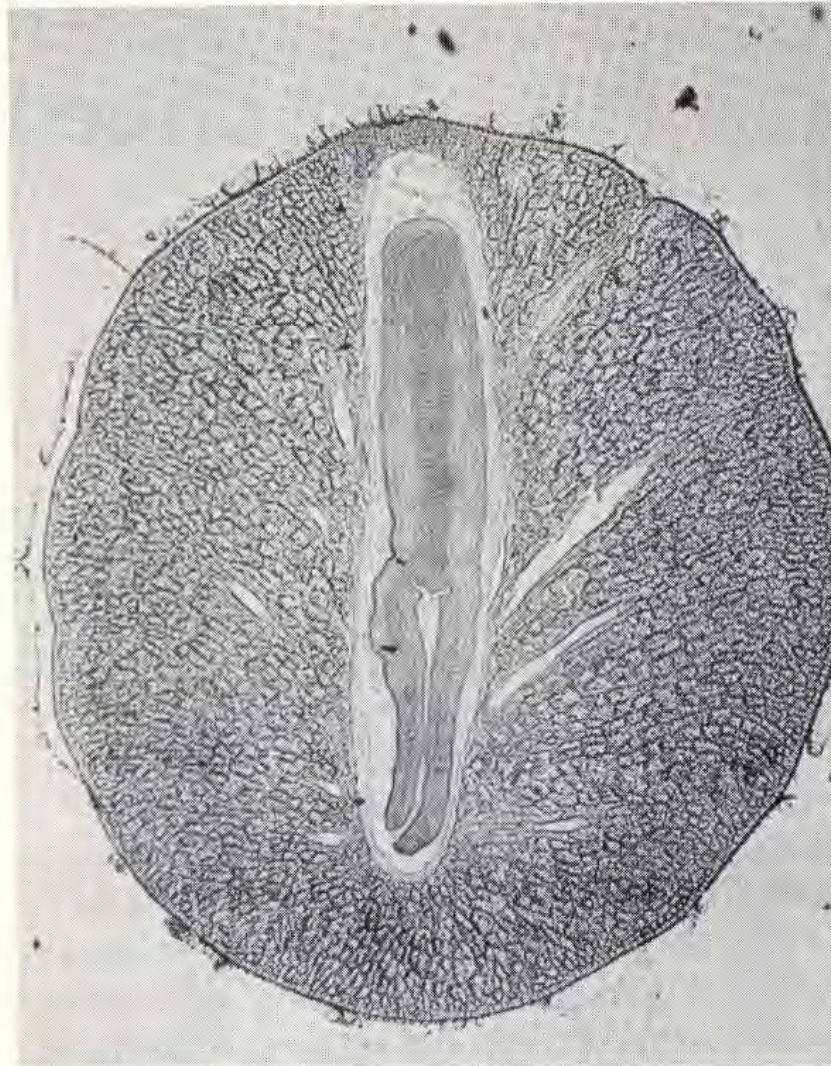


Figure 20.1

This longitudinal section of a whole seed of *Pholistoma* shows all the seed parts: the thin outermost seed coat, thick endosperm, and embryo with prominent cotyledons, hypocotyl, and radicle. $\times 25$. Micrograph generously provided by R. Y. Berg.

QUINTA CLASE

Adaptaciones a diferentes condiciones ambientales observadas en diferentes órganos y/o tejidos vegetales

- Raíces fotosintéticas: Orchidaceae.
- Tallos fotosintéticos: Cactaceae.
- Velamen: Raíces aéreas de Orchidaceae y Araceae.
- Tricomas foliares absorbentes: Bromeliaceae.
- Cutículas engrosadas: plantas xerófitas y su lucha por el agua.
- Hojas modificadas: ¿menor superficie?

¿Estructuras fotosintéticas?
No solo las hojas



¿Estructuras fotosintéticas?

Figure 5.3

This orchid plant of the genus *Polyradi-
clon lindenii* is composed almost
completely of photosynthetic roots; only a
small portion of shoot remains. Unlike
most roots, these occur above ground and
are green, being rich in chloroplasts.

Harrisela

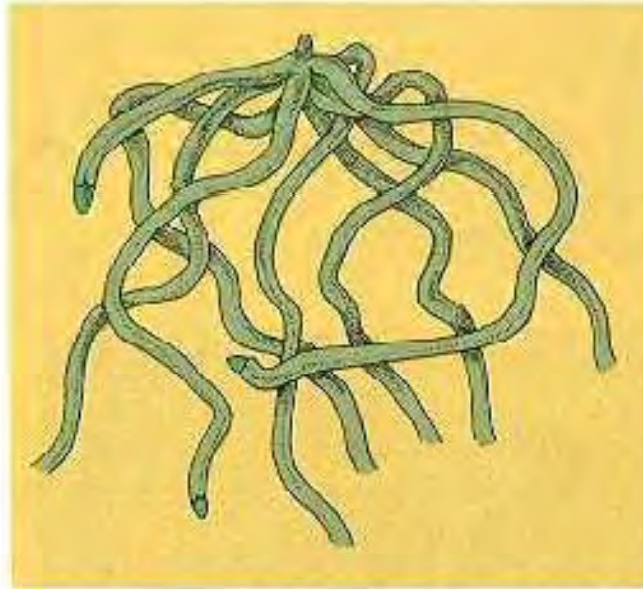


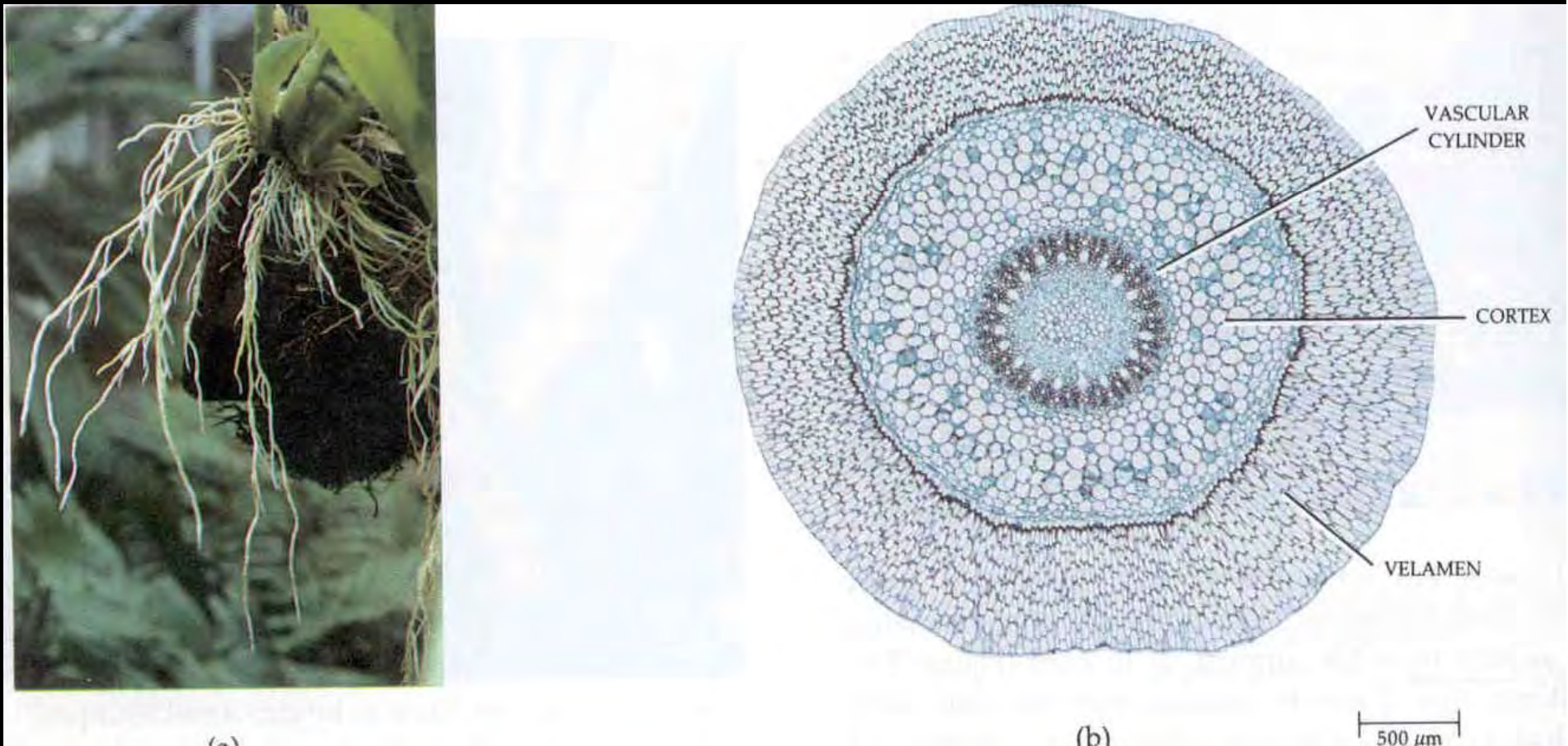
Figure 5.4

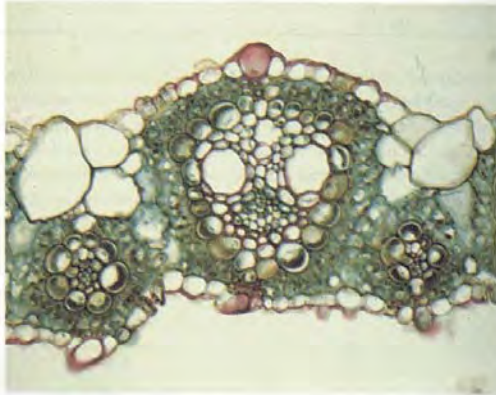
Most epiphytic orchids, like this *Dendrobium*, resist
the stresses of temporary drying because their
shoots are fibrous and have a thick cuticle
composed of cutin and wax.



Velamen de la raíz: Epidermis múltiple cubriendo raíces;
toma rápida de agua, lenta pérdida de la misma y protección
de la corteza especialmente en órganos fotosintéticos

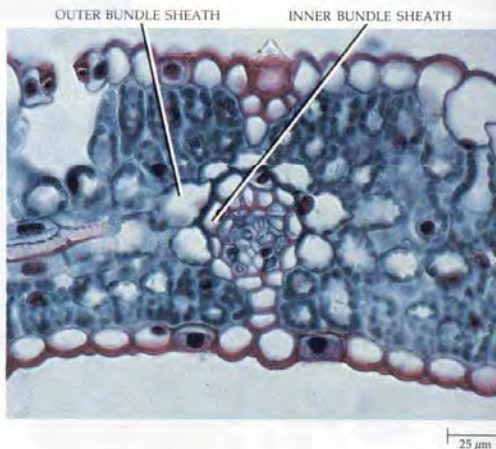
21-17. (a) Aerial roots of an orchid (*Oncidium sphacellatum*). (b) transverse section of an orchid root, showing the multiple epidermis, or velamen.





22-25

Transverse section of sugarcane (*Saccharum officinarum*) leaf. As is typical of C_4 grasses, the mesophyll cells are radially arranged around the bundle sheaths consisting of large chlorophyllous cells.



22-26

Transverse section of wheat (*Triticum aestivum*) leaf. As is typical of C_3 grasses, the mesophyll cells are not radially arranged around the bundle sheaths. The bundle sheaths in the wheat leaf consist of two layers of cells, an outer sheath of relatively thin-walled parenchyma cells and an inner sheath, the mesophyll sheath, of thick-walled cells.

Hoja:

anatomía de plantas C_4

Caña de azúcar (arriba) con células del mesófilo radialmente arregladas alrededor de la vaina de esclerenquima (Anatomía de Cranz), y con abundante clorofila.

Trigo (abajo) una típica C_3

Hojas con gran proporción de fibras: duración y protección



Figure 6.32

The leaves of barberry (*Berberis*) are tough and hard; it is difficult for insects to bite into them or lay eggs in them. However, the plant must invest considerable glucose to make the sclerenchyma cells, so the leaves must photosynthesize longer before they reach the breakeven point.



Vascular bundles

Fibers

Figure 6.33

Yucca leaves are excellent examples of sclerophylls; they are tough and fibrous, and the cuticle is thick. These features reduce the amount of light reaching the chlorenchyma, but plant growth is probably limited by scarcity of water rather than reduced photosynthesis. These leaves may function for 5 to 10 years or more ($\times 120$).

Plantas parásitas



- ¿Cómo obtienen sus nutrimentos?

A través del
Establecimiento
de un haustorio

Hifas de hongos:

¿Por dónde penetran a la planta?

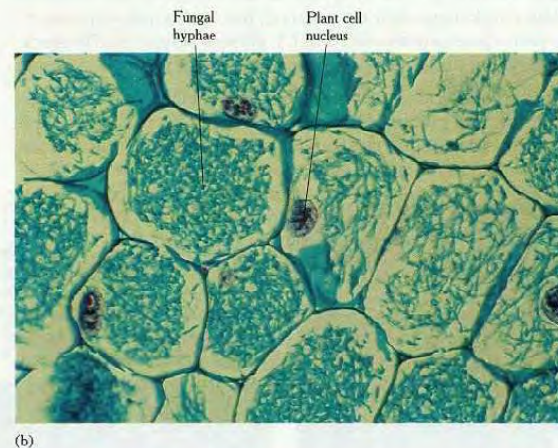
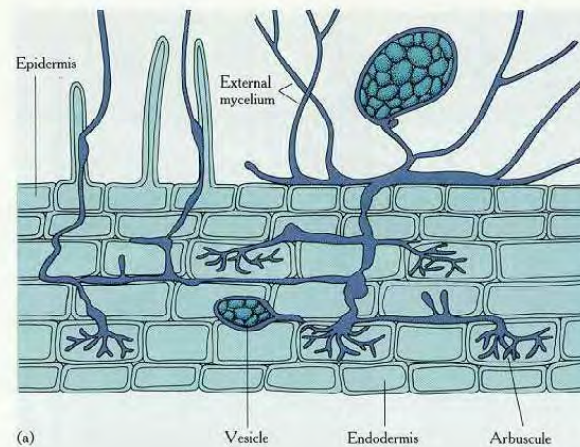


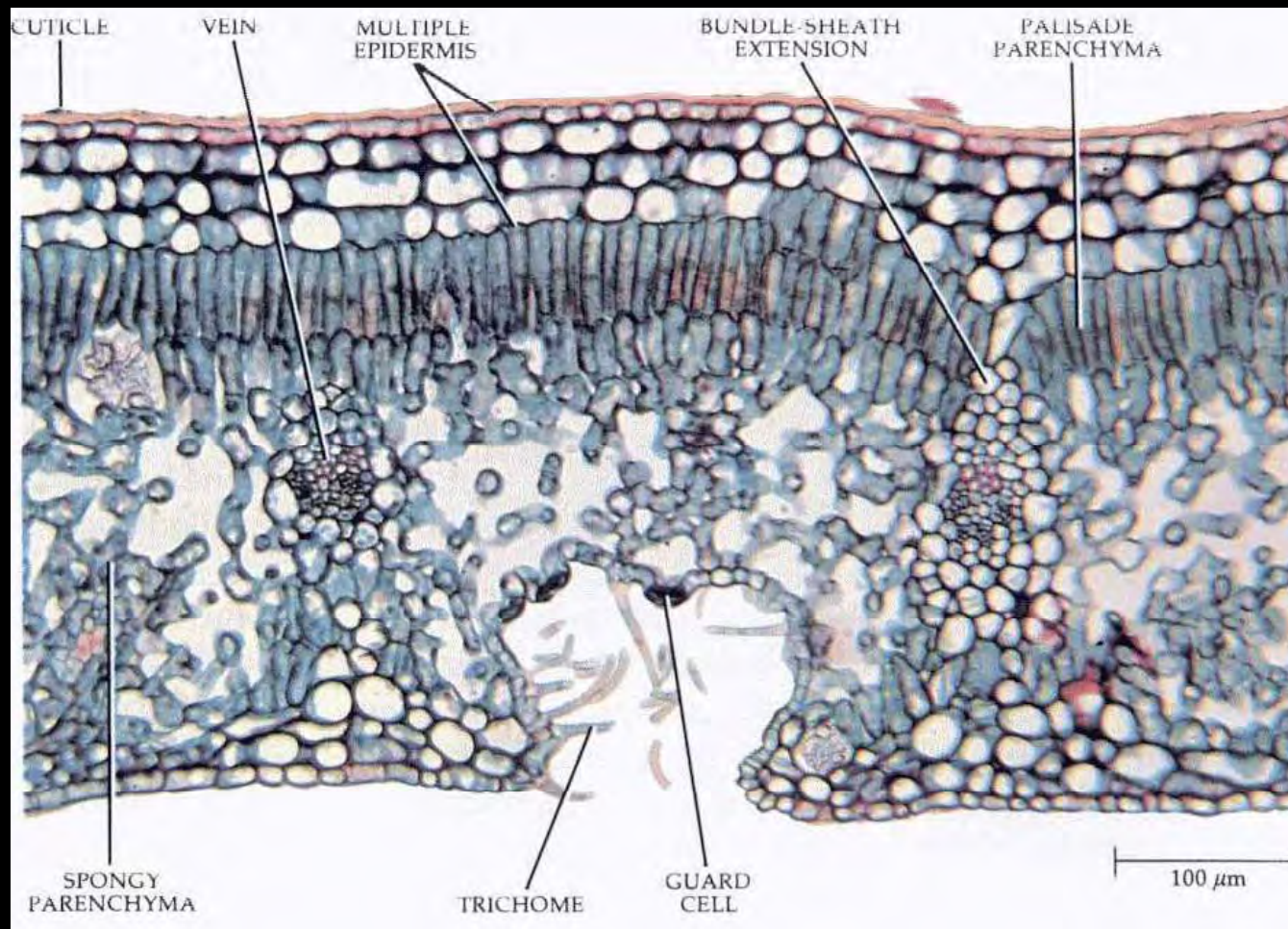
Figure 7.20

(a) Diagram of endomycorrhizae showing hyphae penetrating the root cortex and forming arbuscules and vesicles. (b) Root cells filled with fungal hyphae in the form of arbuscules. You can tell that this is a symbiotic fungus rather than a pathogenic one because the plant cells are healthy, with large normal nuclei ($\times 220$).

**Penetran por la raíz,
a atraviesan la
corteza y forman
vesículas.
Puede verse el
tejido vivo infectado
de hifas
(relación simbiótica)**

Hoja: estomas crípticos y cutícula gruesa en plantas de sitios secos

- Sección transversal de hoja de adelfa (*Nerium oleander*). La adelfa es xerófita y esto se refleja en la estructura de la hoja. Nótese la cutícula muy gruesa que cubriendo la epidermis multiestratificada en las superficies adaxial y abaxial de la hoja. Los estomas y tricomas están restringidos por porciones invaginadas de la epidermis abaxial denominada cripta.





- Adaptaciones en sitios secos o xéricos:
- Cutícula
- Suculencia por tejido almacenador de agua
- Modificación de hojas en espinas



Suculencia



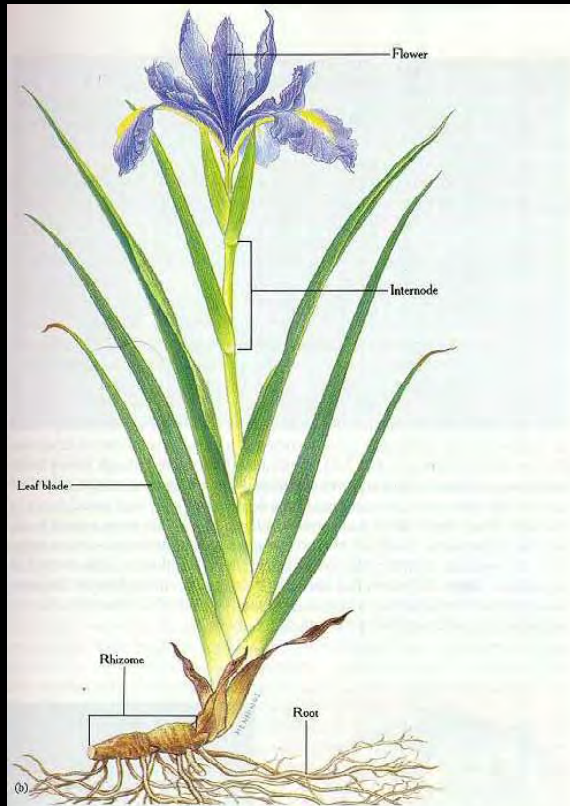


Figure 5.2

This *Opuntia* shows that one plant can have two types of shoot: the "pad" is the main shoot and the spine clusters are highly modified branch shoots. Four of the spine-bearing branches have been stimulated to develop into the first type of shoot and will become the earlike branches. The plant also has two types of leaves, small fleshy leaves on the young buds and spines on the axillary branches.

Hojas modificadas en espinas





Cactaceae:
Hojas y espinas
(hojas
modificadas)



- ¿Cuáles adaptaciones a nivel anatómico y fisiológico se observan en plantas que habitan en sustratos rocosos o con suelos poco profundos, altas temperaturas y alta exposición solar?



- ¿Qué tipo de tejido será abundante en los órganos de ésta planta?
- ¿Porqué?



Utricularia reniformis is an insectivorous plant that can live in bromeliad tanks. Along the length of its very fine rhizomes, utricles develop to imprison insect larvae that live in the tank-water.

- Adaptaciones para la absorción foliar y "carnivorismo". ¿qué estructura absorbe?



Fig. 1.3 The author's wife, Elizabeth, modeling the latest in decorative *Tillandsia* wigs.

- Epifitismo extremo:
- Ausencia de raíces, cuya función es llevada a cabo por tricomas foliares



Plantas "aéreas"
¿cómo obtienen
agua y
nutrimentos?

Tricomas Foliales Bromeliaceae

The schematic figure illustrates a longitudinal cross section of a trichome. It resembles a flat thumbtack. Its head consists of four central cells, and the cap- and wing-cells. Water absorbing cells located within the head are attached to base cells.

Due to the alternating hydration and dehydration of the water absorbing cells, a sort of pump effect is created drawing water from outside the tissues.

The trichomes are located above coarse, water storing tissue which is protected from drying by a layer of cutin.

The dense arrangement of trichomes protects the cutin layer from intense sunlight which can result in burns.

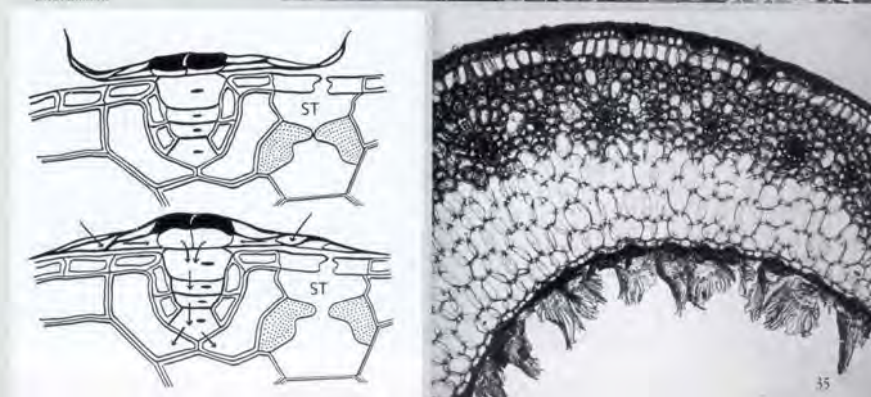
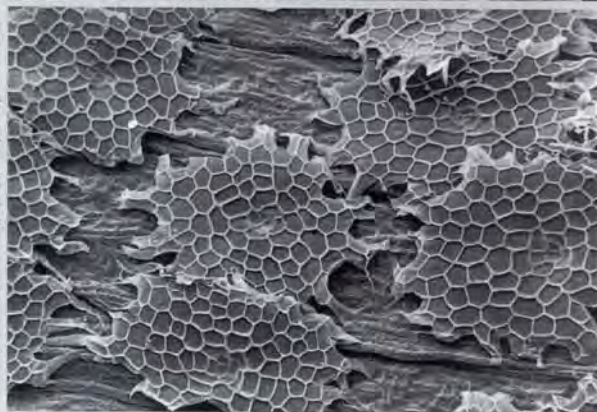
The stomata located on the undersurface of the leaves are often covered by trichomes providing especially effective protection from excess transpiration.

ST: Stoma (plural stomata), pores on the underside of bromeliads leaves, bracts and on stems.

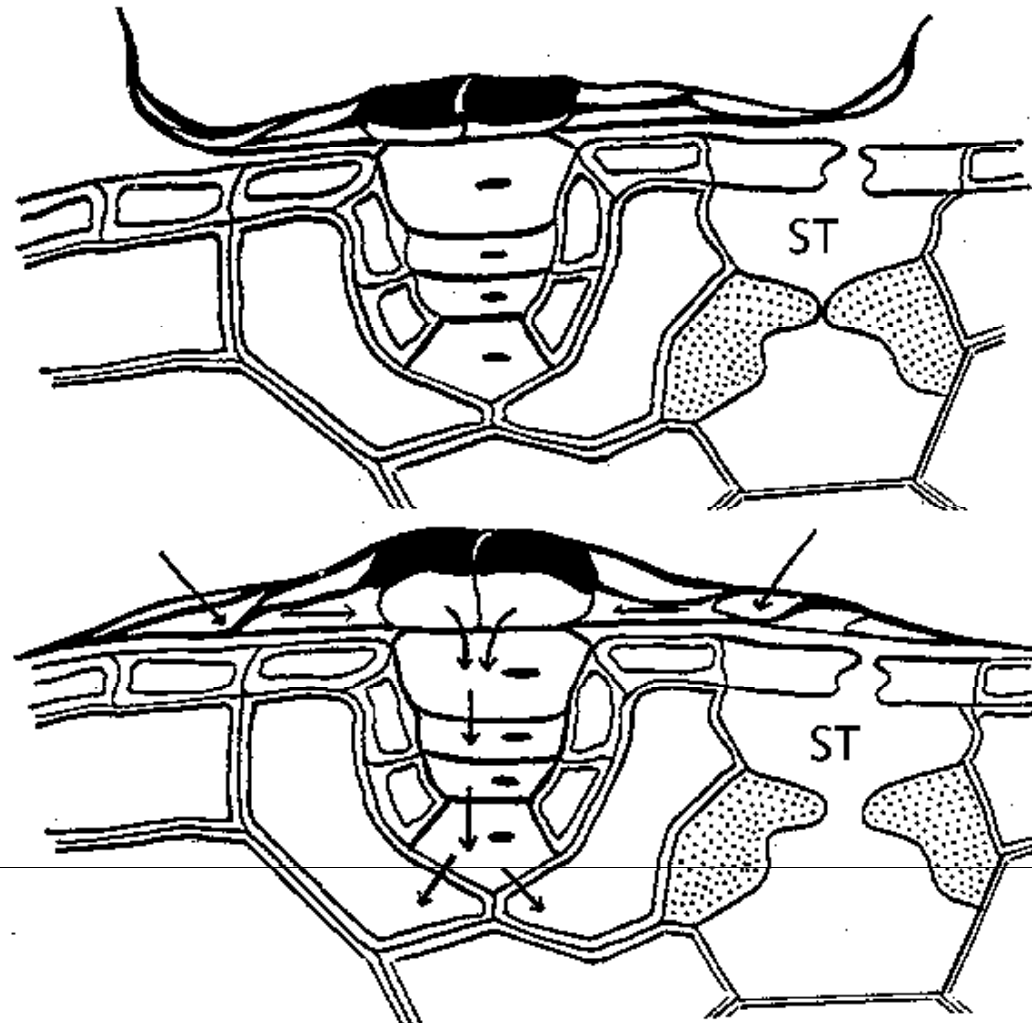
The upper photograph shows trichomes of *Tillandsia caput-medusae*, the picture in the middle is of *Puya graffii*. Both photos are enlarged approximately 200 times. The photograph on the bottom shows a leaf cross section of *Tillandsia butzii* with trichomes on the undersurface of the leaf, and coarse water storing tissue. Photo is enlarged approximately 50 times.

We gratefully acknowledge the following for their electron microscope photographs:

- (1) Christine DANNENBAUM
- (2) Elvira GROSS,
both Heidelberg,
- (3) C. ALBRECHT, from Karl ZIMMER:
BROMELIEN.



Funcionamiento del tricoma foliar en BROMELIACEAE:
el ala está elevada en condición de sequía, se extiende y deja pasar agua cuando hay humedad en el aire o llueve. Nótese la protección de los estomas por los tricomas en el diagrama superior.



Parásitas Loranthaceae



Flores efímeras: mayor proporción de tejido parenquimatoso y cutícula delgada



Tejidos florales

(de corta duración)

