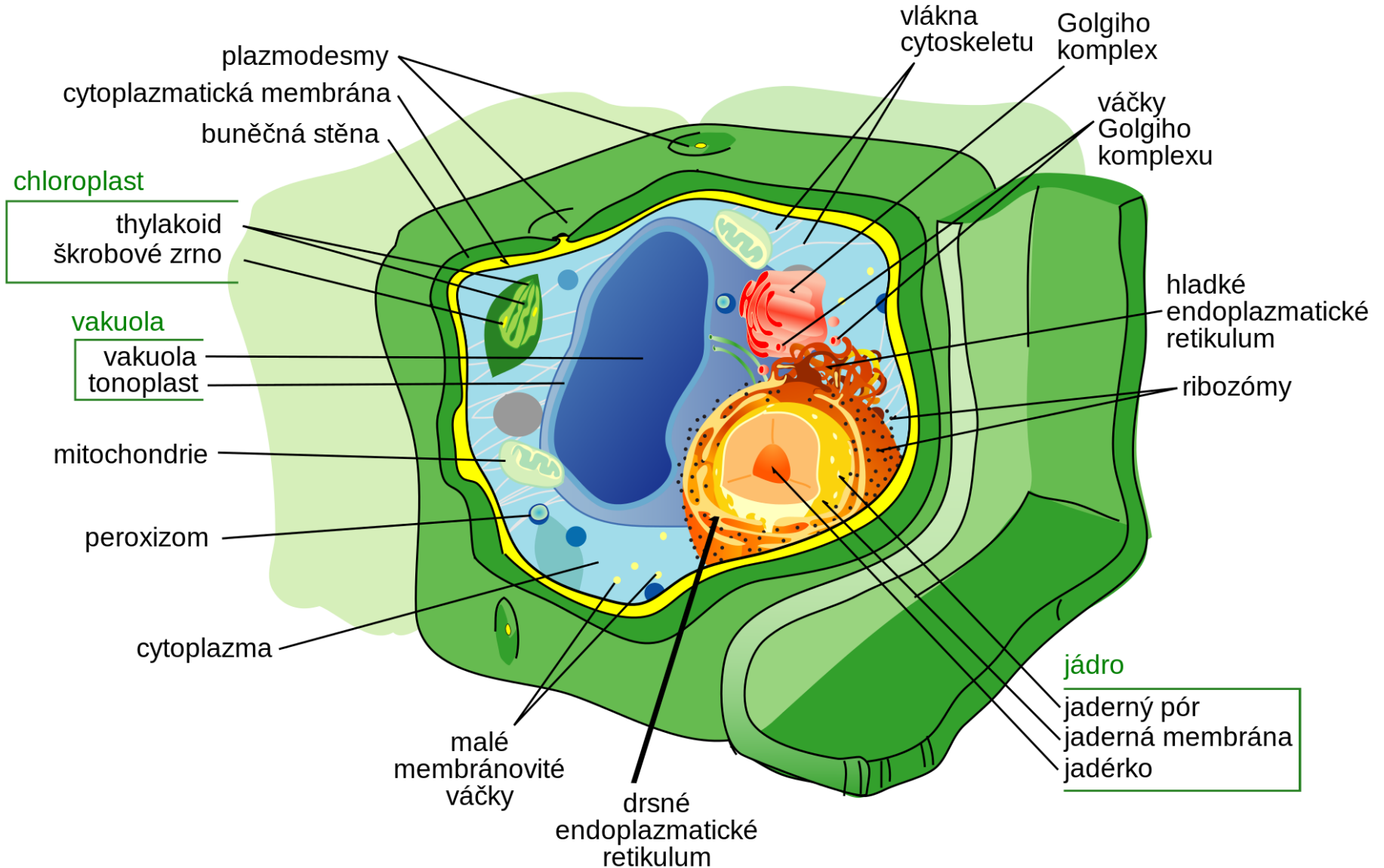
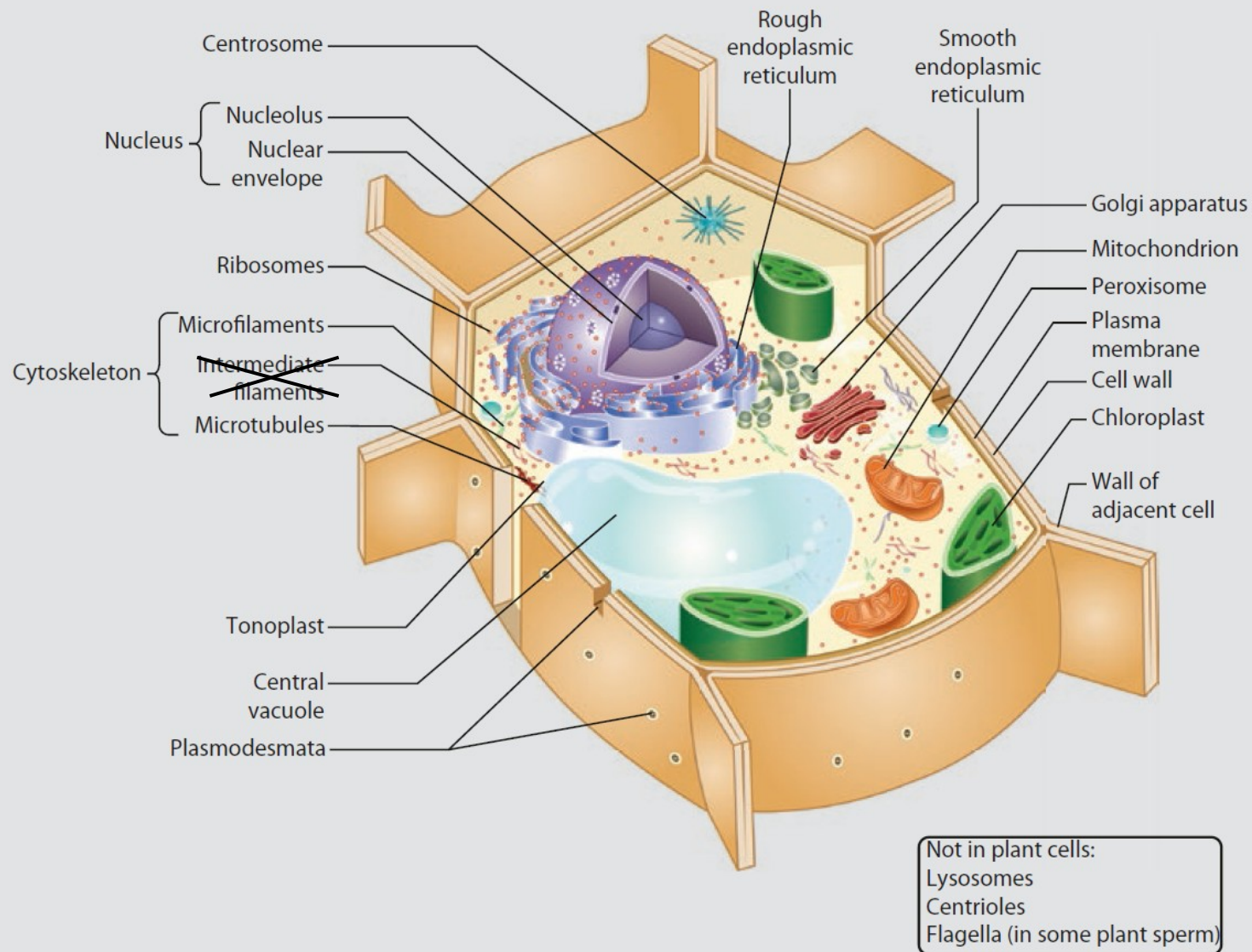


# Rostlinná buňka

[https://cs.wikipedia.org/wiki/Rostlinná\\_buňka](https://cs.wikipedia.org/wiki/Rostlinná_buňka)



# Rostlinná buňka



■ Fig. 3.2 Basic components of a plant cell. The individual organelles are discussed throughout this chapter (Redrawn from Wikipedia)



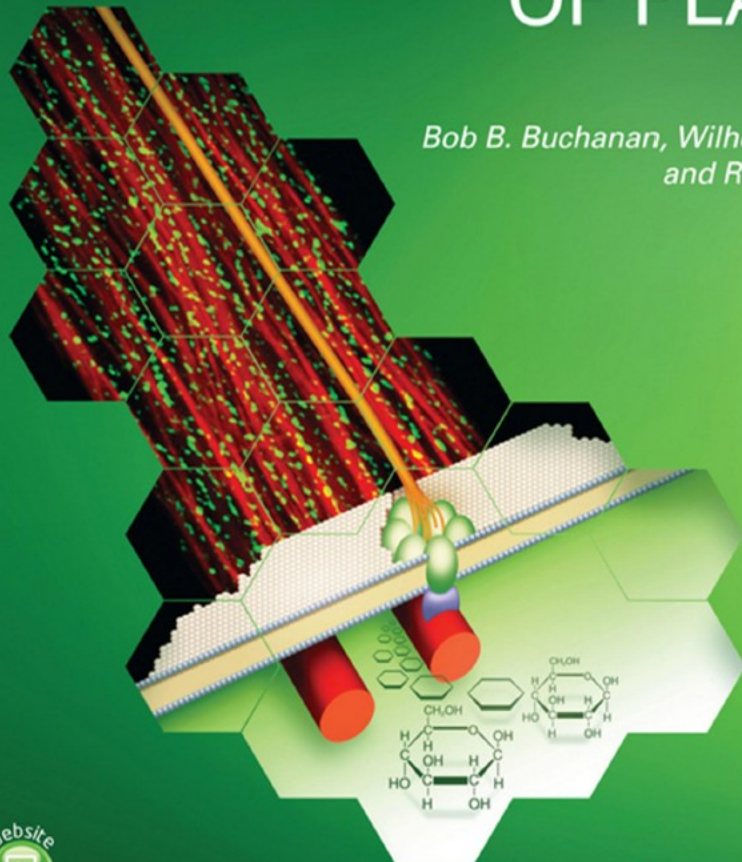
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SECOND EDITION

# BIOCHEMISTRY & MOLECULAR BIOLOGY OF PLANTS

EDITED BY

*Bob B. Buchanan, Wilhelm Grissem,  
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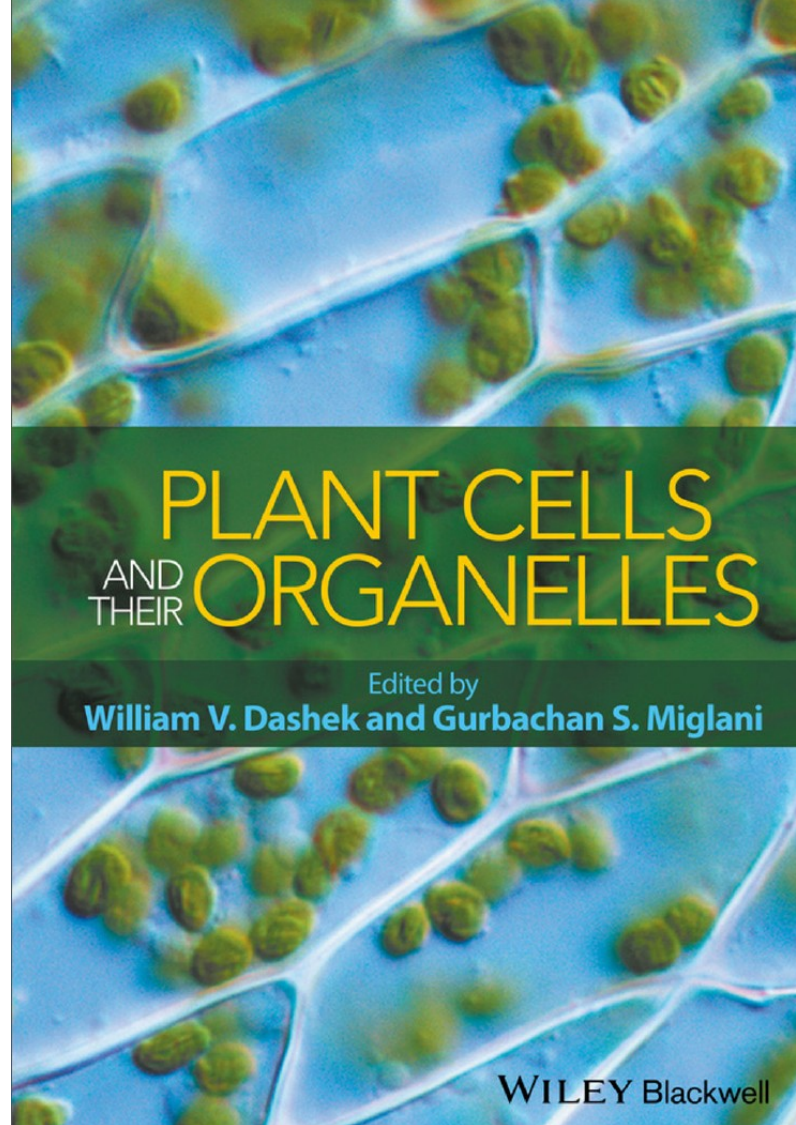
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# PLANT CELLS AND THEIR ORGANELLES

Edited by  
**William V. Dashek and Gurbachan S. Miglani**

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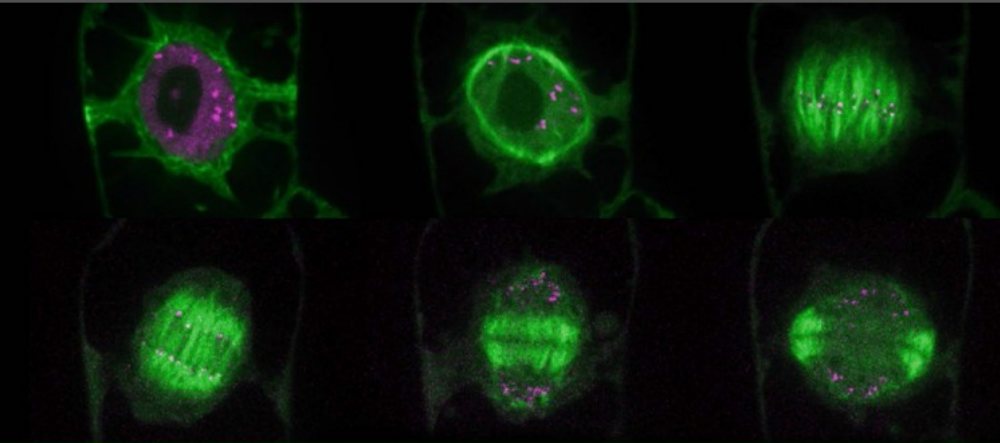
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Tetsuko Noguchi · Shigeyuki Kawano · Hirokazu Tsukaya · Sachihiko Matsunaga  
Atsushi Sakai · Ichirou Karahara · Yasuko Hayashi *Editors*

# Atlas of Plant Cell Structure



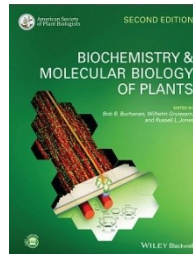
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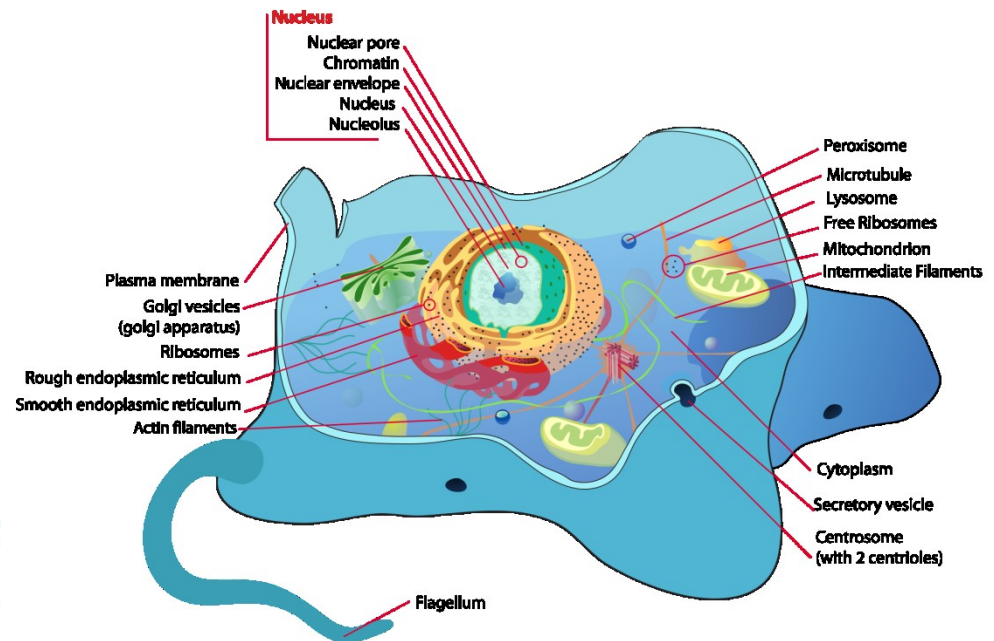
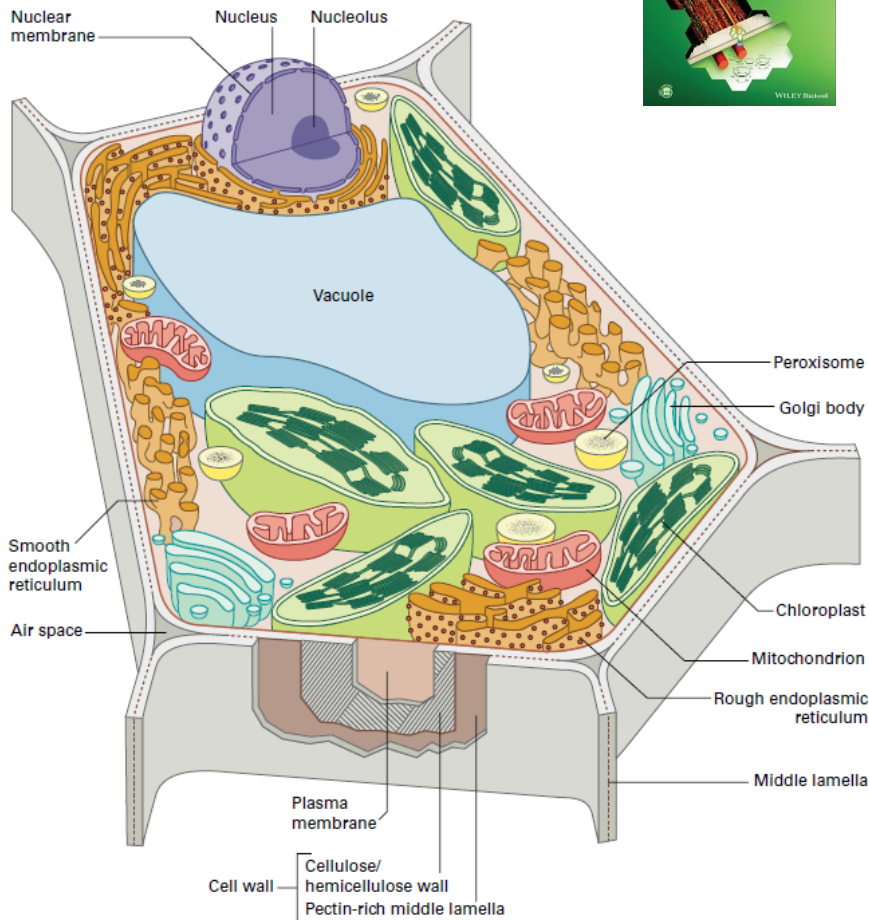
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# Rostlinná vs. živočišná buňka

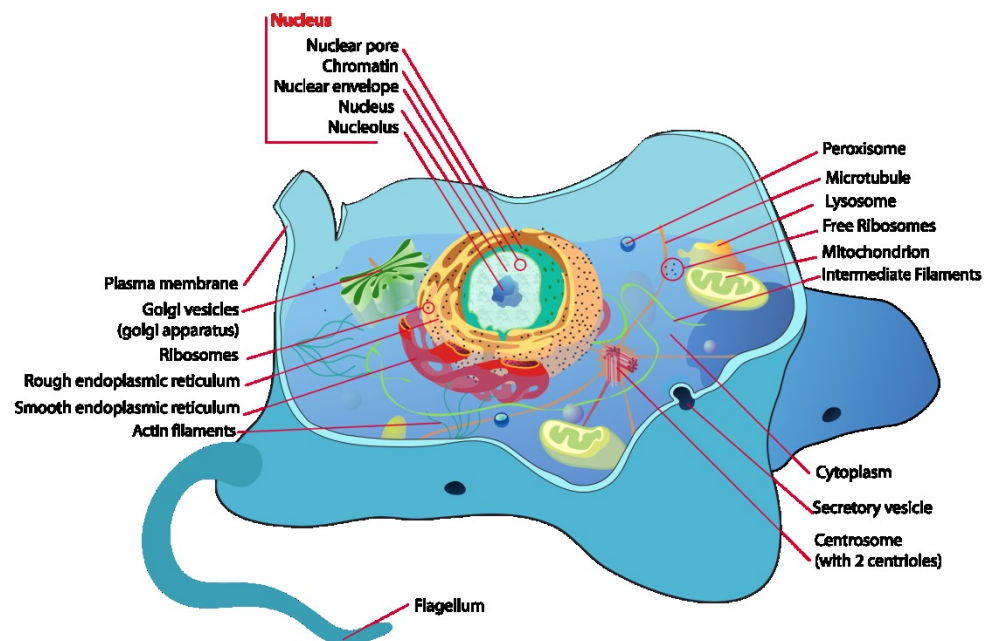
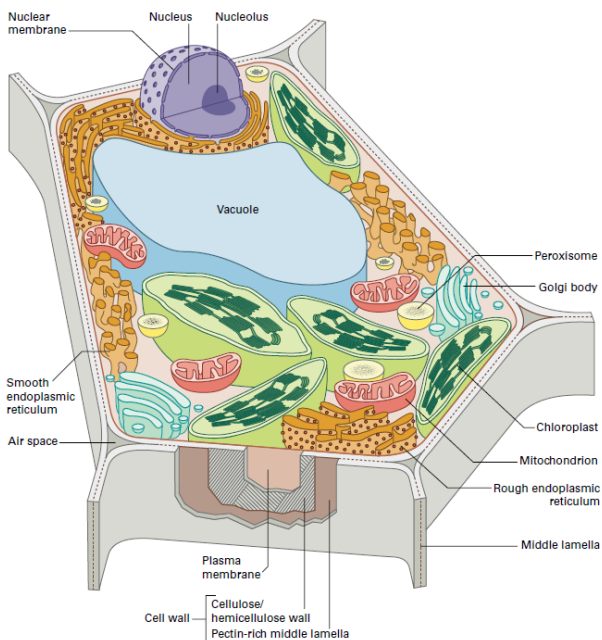


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# Rostlinná vs. živočišná buňka



1. Buněčná stěna (+ vs. -)
2. Lytické vakuoly vs. lysozomy
3. Plastidy (+ vs. -)
4. Centriola/centrozom (- vs. +)
5. Bičíky a brvy (výjimečně + vs. hojněji +)
6. Specifické formování struktur: PPB v mitóze rostlinných buněk (+ vs. -)
7. Cytokineze (fragmoplast a buněčná deska vs. zaškrvení)
8. Zásobní látky (škrob vs. glykogén)
9. Intermediární filamenta (- vs. +)
10. Plazmodezmata (+ vs. -, resp. vodivé, syn. [mezerové spoje](#))
11. Totipotence buněk (+ vs. -)

# Rostlinná buňka

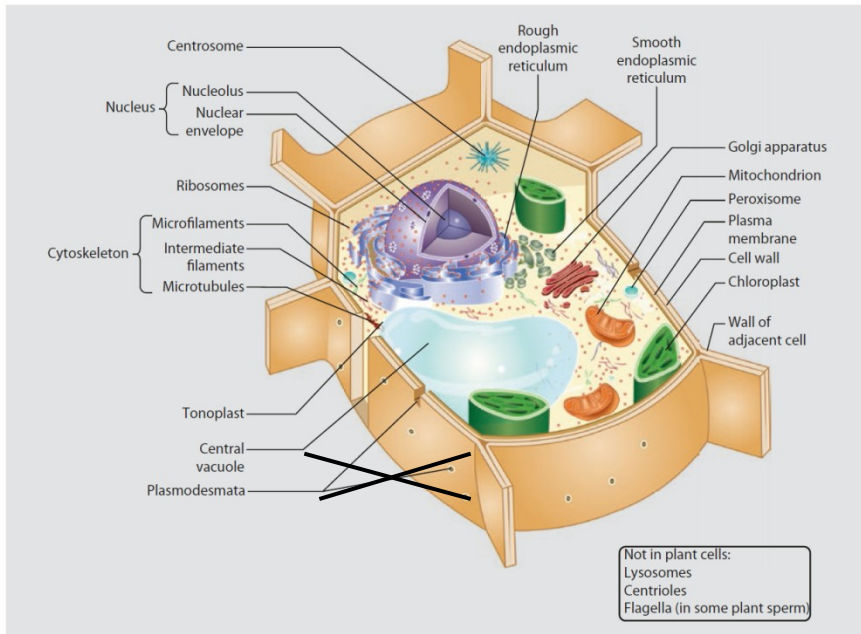
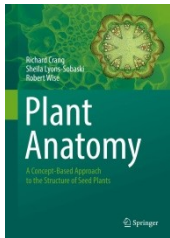


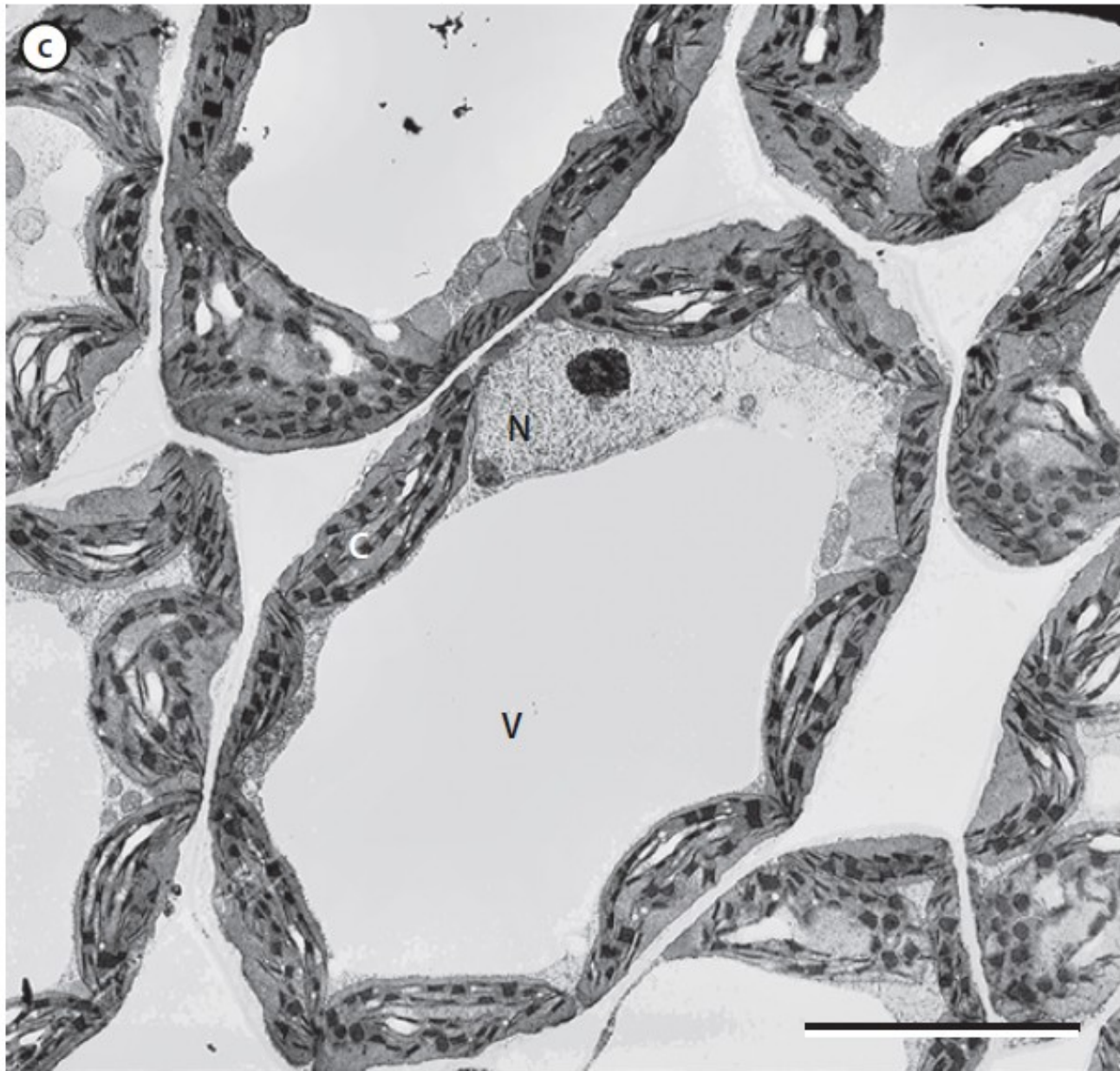
Fig. 3.2 Basic components of a plant cell. The individual organelles are discussed throughout this chapter (Redrawn from Wikipedia)



## Termíny:

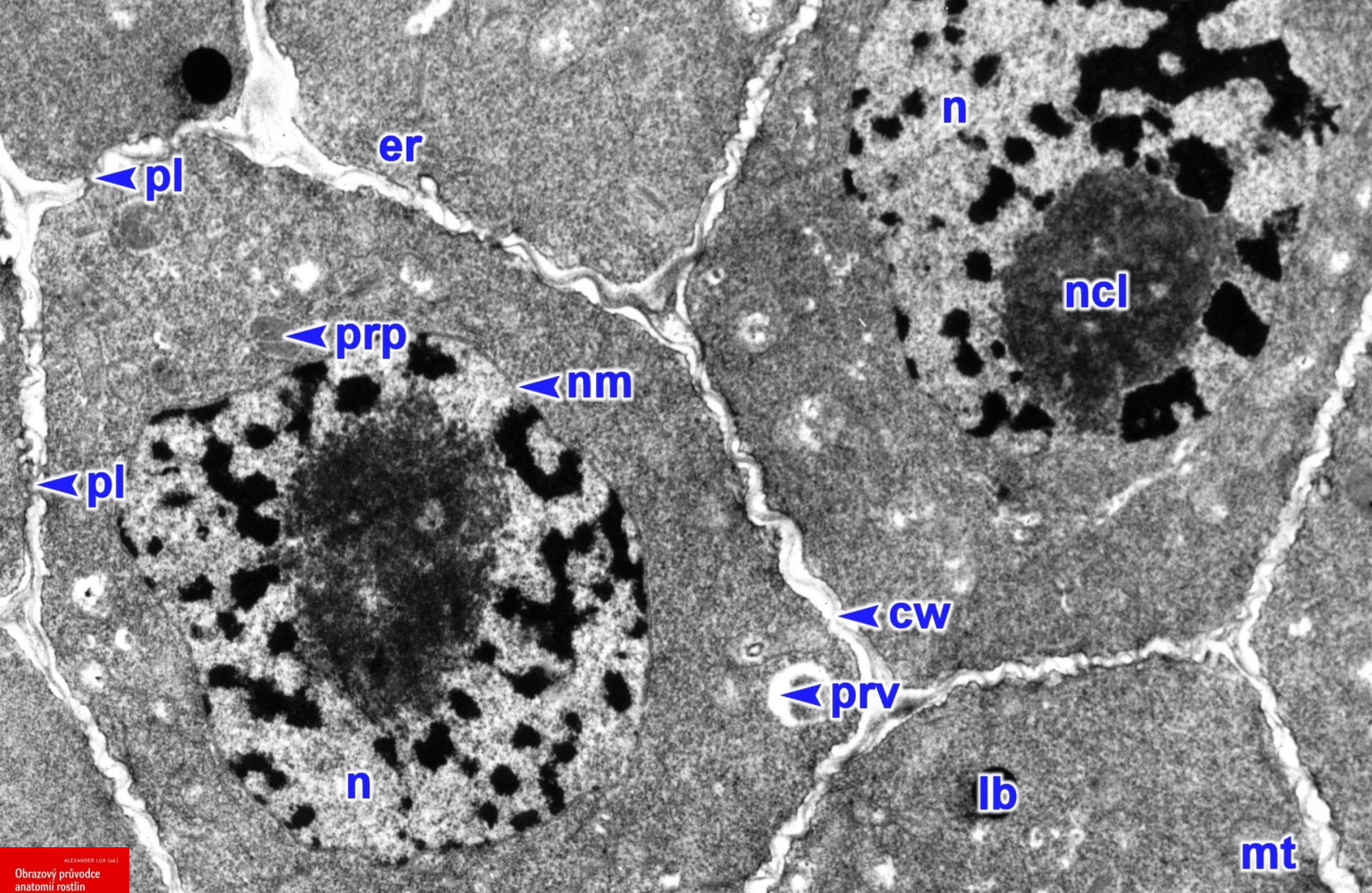
- Protoplasma (= cytoplazma + karyoplazma)
- Protoplast
- Cytosol
- Apoplast
- Symplast (symplazmický prostor)





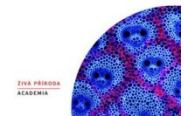
■ Fig. 2.11 c Transmission electron micrograph of a cucumber (*Cucumis sativus*) leaf cell. Note vacuole (V), nucleus (N) and chloroplasts (C). Scale bar = 20  $\mu\text{m}$  (RR Wise)





Buňka apikálního meristému kořene ječmene setého (*Hordeum vulgare* L.).

**n** jádro; **ncl** jadérko; **nm** jaderná membrána; **mt** mitochondrie; **prv** provakuola; **er** endoplazmatické retikulum; **prp** proplastid; **lb** lipidové tělísko; **cw** buněčná stěna; **pl** plazmodezmus.



# Osnova přednášky

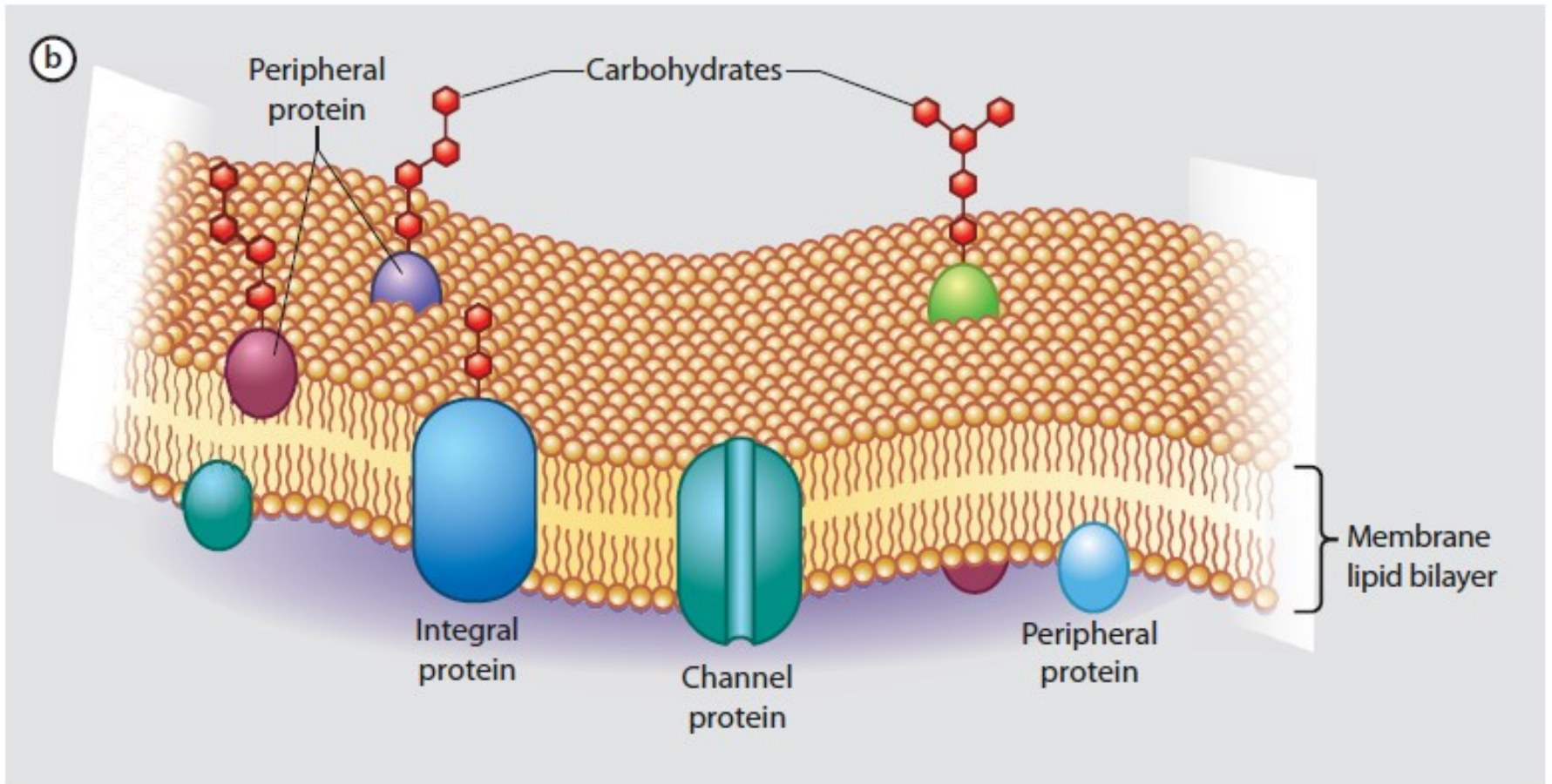
## **Buněčné membránové struktury**

- vlastnosti membrán, model fluidní mozaiky
- cytoplazmatická membrána
- endoplazmatické retikulum
- Golgiho aparát
- vakuola
- jádro
- peroxizómy, glyoxyzómy
- plastidy
- mitochondrie



# Biologické membrány

- s výjimkou cytoskeletu a ribozómů ohraničují všechny orgány i buňku jako takovou - kompartmentace buňky
- cytoplazmatická membrána, jaderná membrána, ER, tonoplast, membrána plastidů, Golgiho aparát...
- **bariéra difúze polárních (ve vodě rozpustných) látek**
- umožňují odlišná elektrochemická prostředí v jednotlivých organelách
- **lipidická dvouvrstva s proteiny, model fluidní mozaiky**
- **složení:** lipidy (*fosfolipidy, galaktosylglyceridy, glukocerebrosidy, steroly + další lipidy - chlorofyly, karotenoidy*), glykoproteiny, proteiny (*až 85% hmotnosti membrány!; transportní molekuly, přenašeče signálu, enzymatická aktivita - lipidy, glykoproteiny, polysacharidy*), sacharidy; typicky 2:2:1
- formuje se ve vodním prostředí spontánně (self-assembly)
- jednoduché nebo dvoujednotkové (dvojitě) membrány



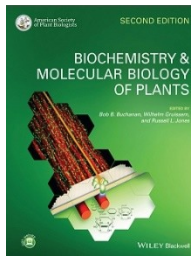
■ Fig. 3.3 b Basic components of a plant cell membrane. The amphipathic lipids face each other creating two hydrophilic surfaces and a hydrophobic interior. Different proteins may be on the surface of, or embedded within, the membrane (Redrawn from Crang and Vassilyev 2003)

**TABLE 1.1** Membrane types found in plant cells.

Plasma membrane
Nuclear envelope membranes (inner/outer)
Endoplasmic reticulum
Golgi cisternae ( <i>cis</i> , medial, <i>trans</i> types)
<i>Trans</i> -Golgi network/early endosome membranes
Clathrin-coated, COPIa/Ib*, COPII*, secretory and retromer vesicle membranes
Autophagic vacuole membrane
Multivesicular body/late endosome membranes
Tonoplast membranes (lytic/storage vacuoles)
Peroxisomal membrane
Glyoxysomal membrane
Chloroplast envelope membranes (inner/ outer)
Thylakoid membrane
Mitochondrial membranes (inner/outer)

\*COP, coat protein.

- cca 20 různých membránových systémů
- po jejich zformování, předávány následným generacím buněk (v mitóze) ve funkčně aktivní formě!
- nové membrány: růstem a splýváním stávajících membrán





# Amfipatická povaha lipidických látek

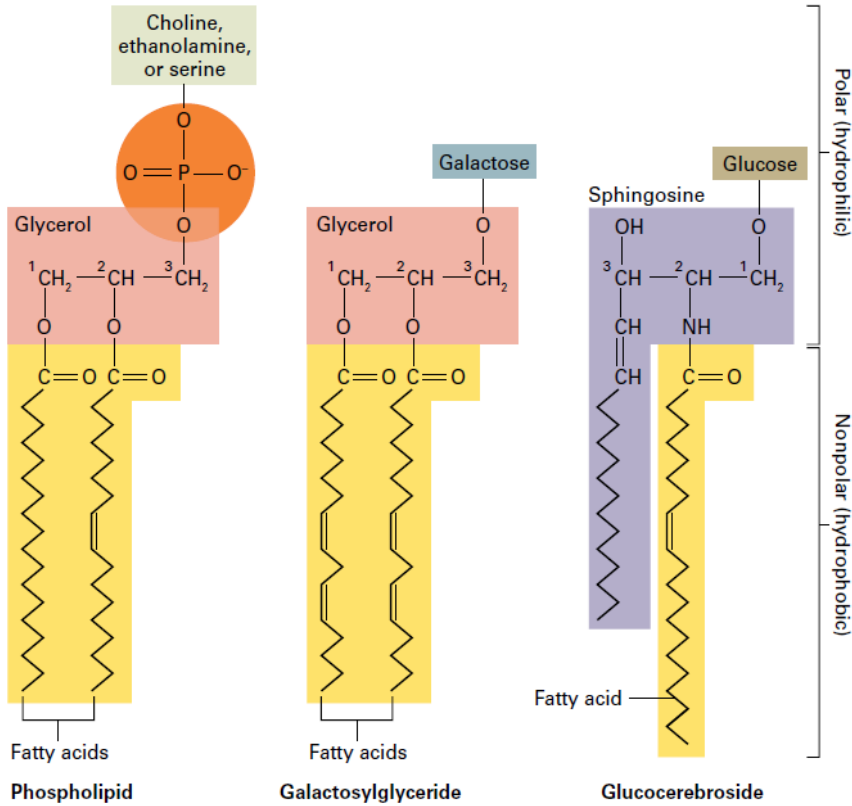


FIGURE 1.3 Plant membrane lipids.

ve vodném prostředí:  
samoorganizace do micel a  
dvojvrstevné membrány

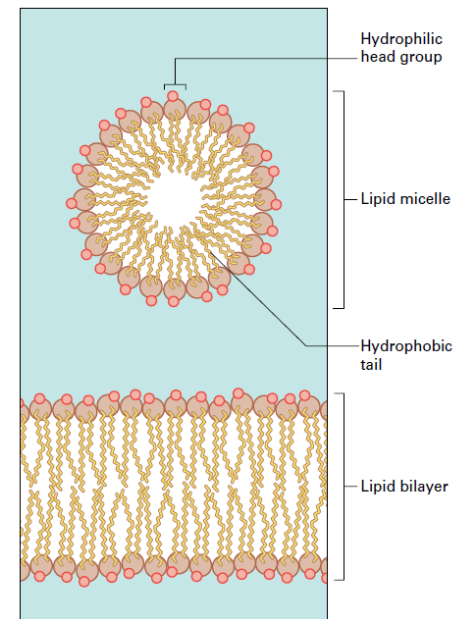


FIGURE 1.2 Cross-sectional views of a lipid micelle and a lipid bilayer in aqueous solution.

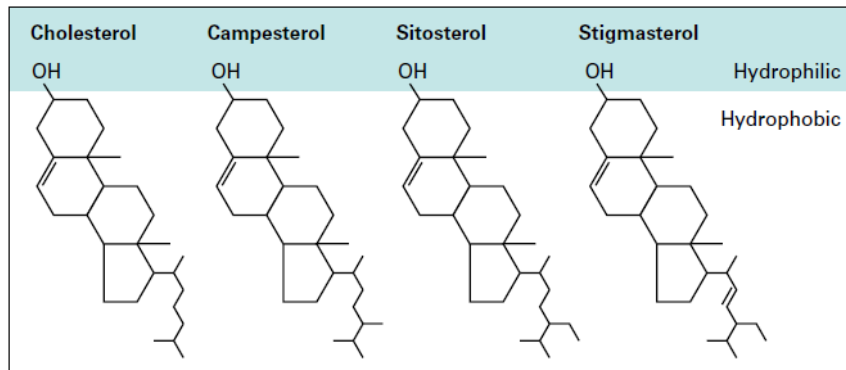
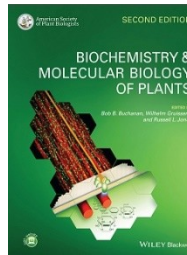


FIGURE 1.4 Sterols found in plant plasma membranes.

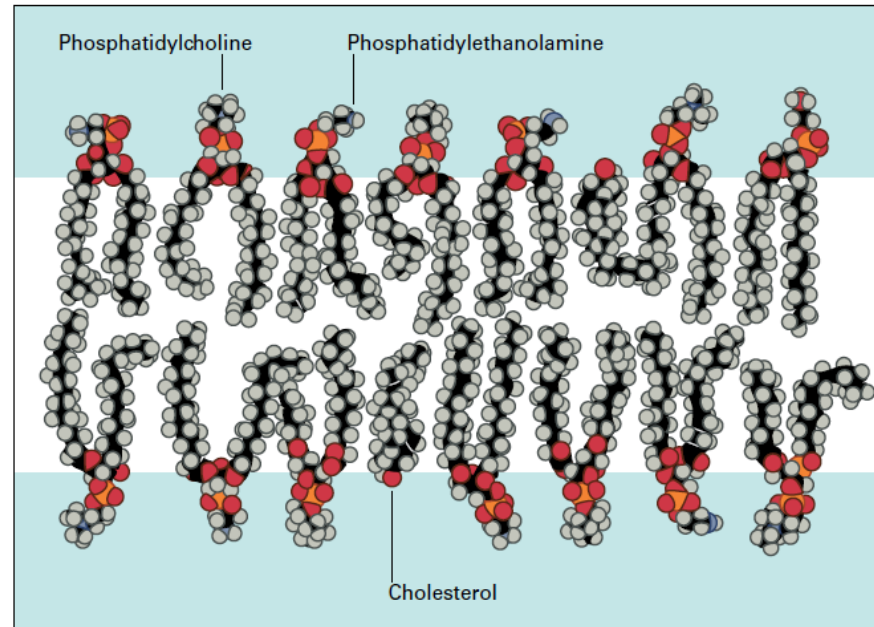
Fytosteroly



# Amfipatická povaha lipidických látek

**FIGURE 1.5** Organization of amphipathic lipid molecules in a bilayer.

- flip-flop
- flippáza

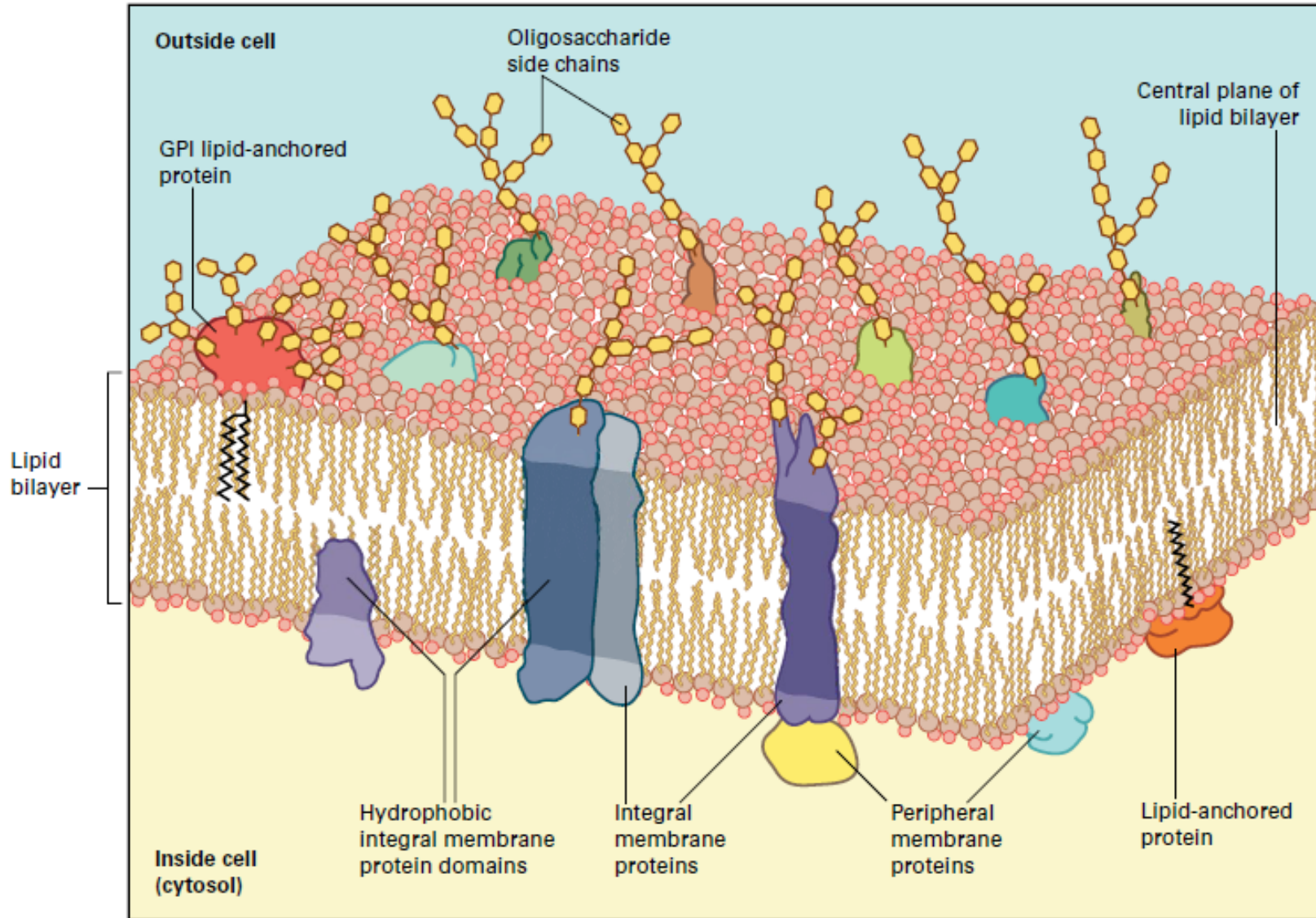


**TABLE 1.2** The effects of fatty acid chain length and double bonds on the temperature of melting ( $T_m$ ) of some defined phospholipids. **fázový přechod: semikrystalinní gel - tekutina**

Types of chains*	$T_m$ (°C)		
	Phosphatidylcholine	Phosphatidyl-ethanolamine	Phosphatidic acid
Two $C_{14:0}$	24	51	
Two $C_{16:0}$	42	63	67
Two $C_{18:0}$	55	82	
Two $C_{18:1}$ ( <i>cis</i> )	-22	15	8

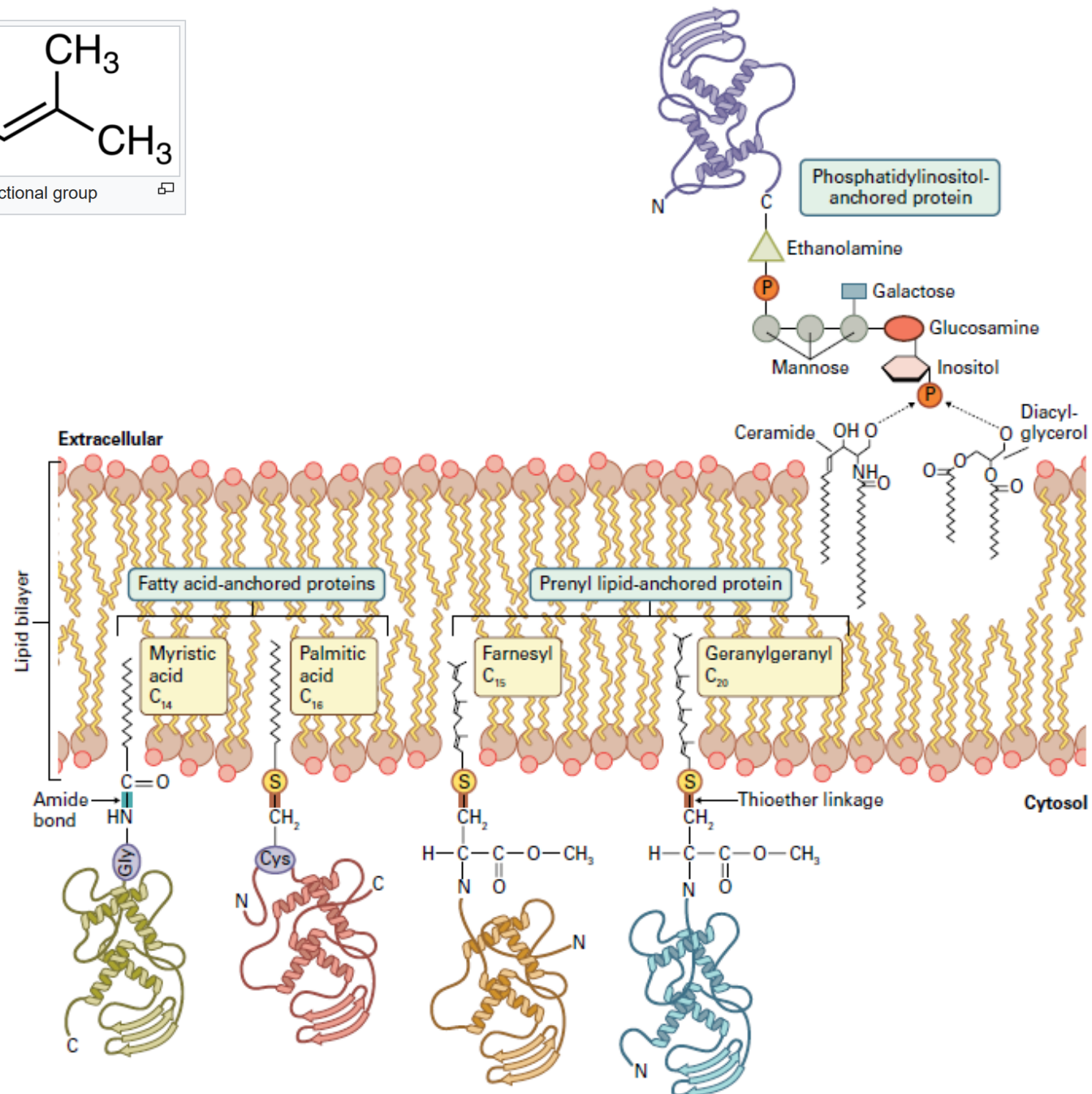
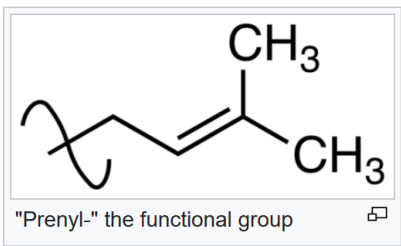
\*The shorthand nomenclature for the fatty acyl chains denotes how many carbon atoms (first number) and double bonds (second number) they contain.

# Periferní, integrální a lipidy ukotvené proteiny

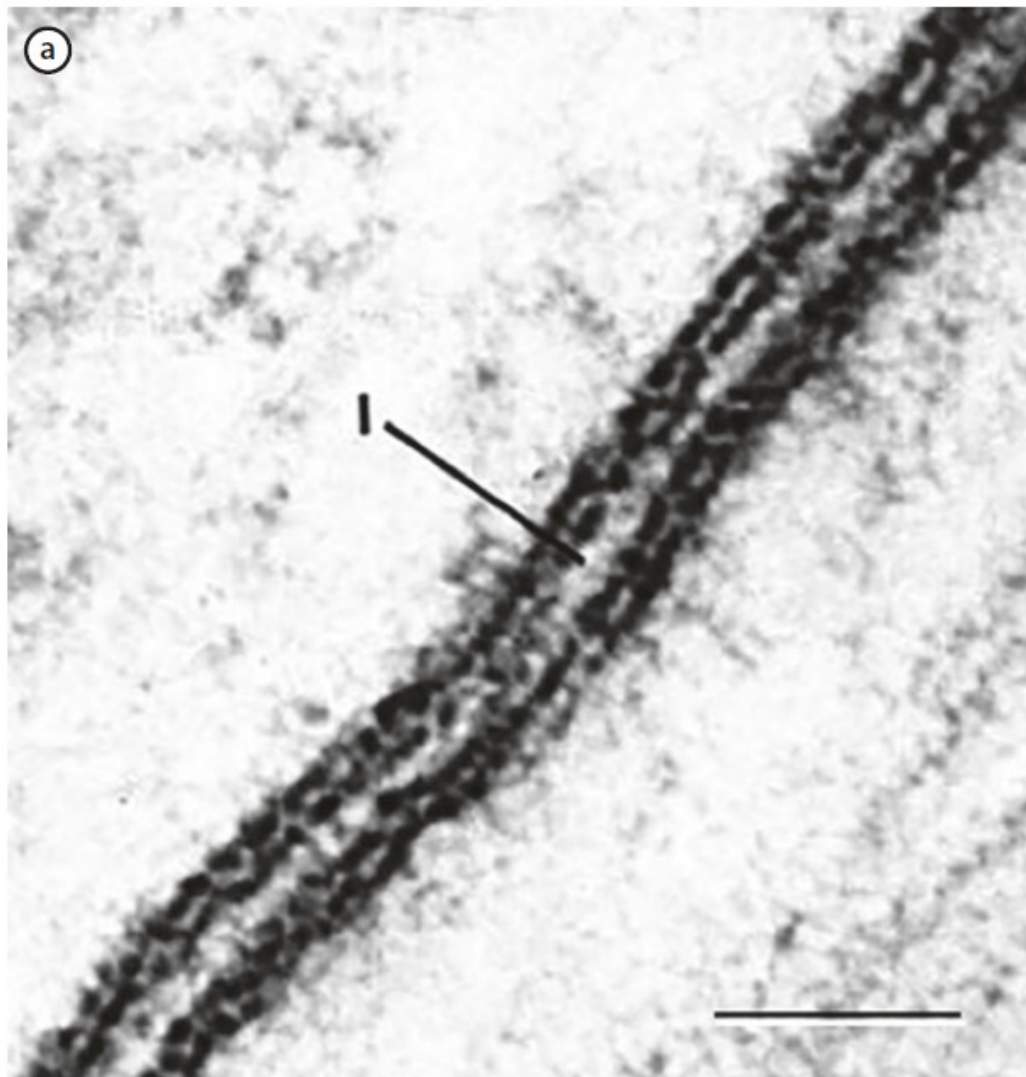


**FIGURE 1.9** A modern version of the fluid-mosaic membrane model, depicting integral, peripheral, and lipid-anchored membrane proteins. Not drawn to scale.





**FIGURE 1.10** Fatty acid-anchored, prenyl lipid-anchored, and glycosylphosphatidylinositol (GPI)-anchored proteins.



**Fig. 3.3 a** Unit membrane structure of nuclear envelope observed with very high-resolution transmission electron microscopy. Two unit membranes are found closely opposed to each other, with an intervening space (l), which is similar to the nuclear envelope or outer double membrane of chloroplasts. The magnification of this micrograph is close to 350,000 $\times$ , and the thickness of each membrane is approximately 10 nm (i.e., 100 Å). Scale bar = 50 nm. (Image from Macleod (1973) *Cytology: The Cell and Its Nucleus*, The Upjohn Co, with permission)

# Plazmalema

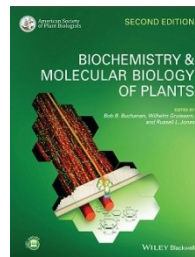
- = cytoplazmatická membrána (plasma membrane)
- jednotková membrána
- hranice mezi apoplastem a symplastem
- tvorba plazmodezmat (spolu s ER)
- prominentní proteiny: transportní (PM H<sup>+</sup>-ATPase; akvaporiny...); receptory signálů; proteiny související se syntézou a funkcemi BS (celulózasyntáza, kalózasyntáza)
- kontrolovaná výměna látek mezi buňkou a jejím okolním prostředím
- turgor – plazmalema působící tlakem na BS
- signální uzel pro růstové a vývojové procesy a pro biotické i abiotické stresory
- kotvící místo pro cytoskeleton



**TABLE 1.3** Lipid composition of plasma membranes from various non-cold-acclimated species and tissues (mole %).

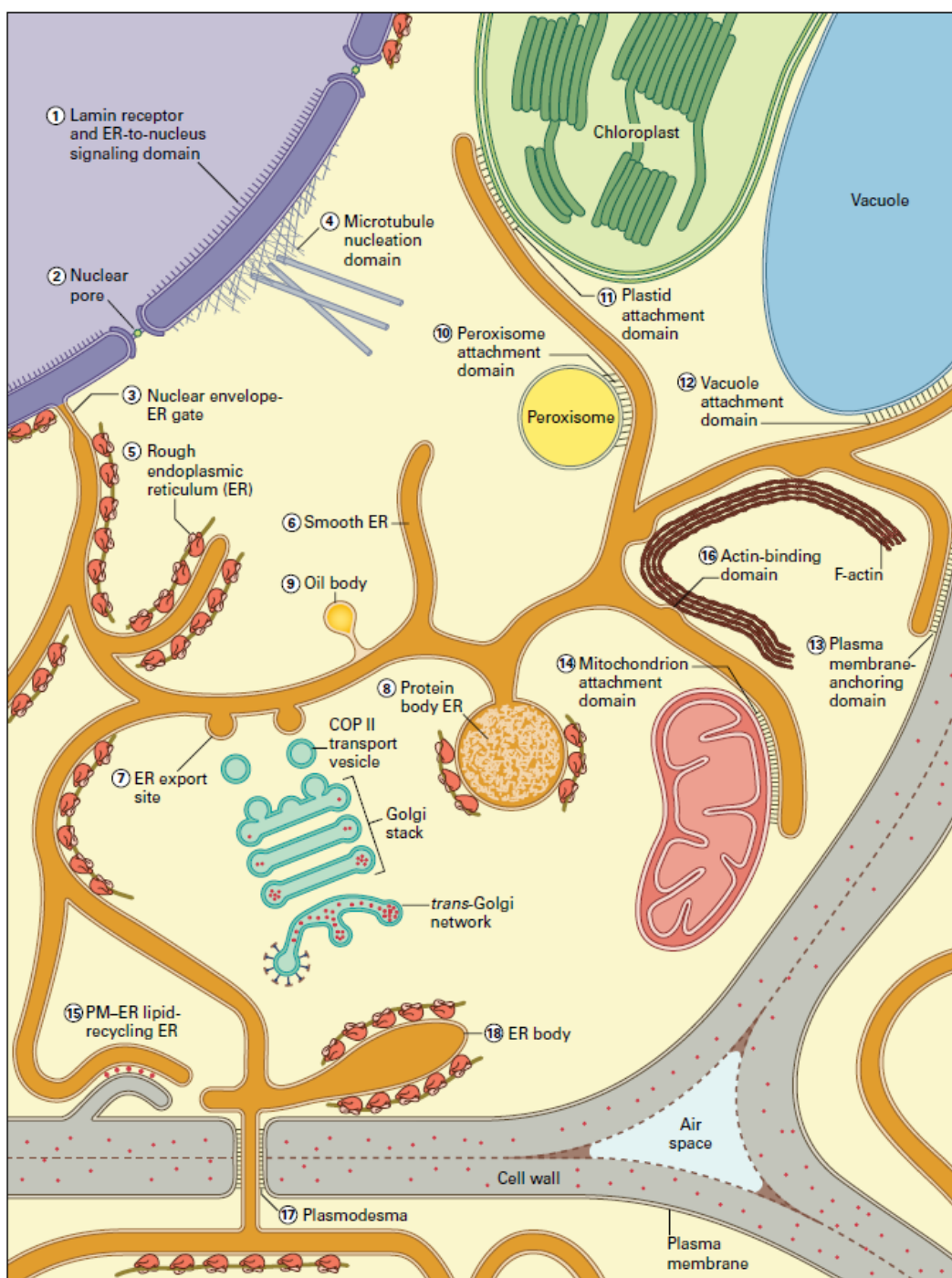
Lipid type	Barley root	Barley leaf	<i>Arabidopsis</i> leaf	Spinach leaf
Phospholipids	26	44	47	64
Free sterols	57	35	38	7
Steryl glucosides	7	–	5	–
Acylated steryl glycosides	–	–	3	13
Glucocerebrosides	9	16	7	14

- výrazné změny složení při aklimaci na nízké teploty (zvýšení podílu fosfolipidů – zejména se dvěma nenasycenými řetězci; snížení podílu glukocerebrosidů)



# Endoplazmatické retikulum

- nejrozsáhlejší, velmi adaptabilní organela eukaryotních buněk s mnoha funkcemi
- propojený 3D systém tubulů a váčků v cytoplazmě
- vnitřní prostor ohraničen jednotkovou membránou
- syntéza lipidů (hladké - SER) či proteinů (drsné - RER, asociovány ribozómy) a jaderná membrána; součást endomembránového systému
- korové ER: kotvící místa pro aktinová filamenta – proudění cytoplazmy
- reguluje koncentraci  $\text{Ca}^{2+}$  v cytosolu (např. formování buněčné desky v cytokinezi, gravipercepce ve sloupku v apexu kořene); homeostáze auxinu
- drsné ER: proteiny začleněny do membrány, či vtlačeny do lumen ER
- hladké ER: semena olejnin, nektárie, sekreční trichomy, buňky napadené bakteriemi (kalóza)

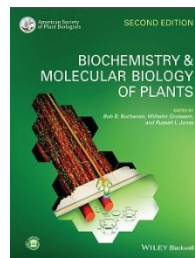


hladké, drsné ER a  
jaderná membrána

vs.

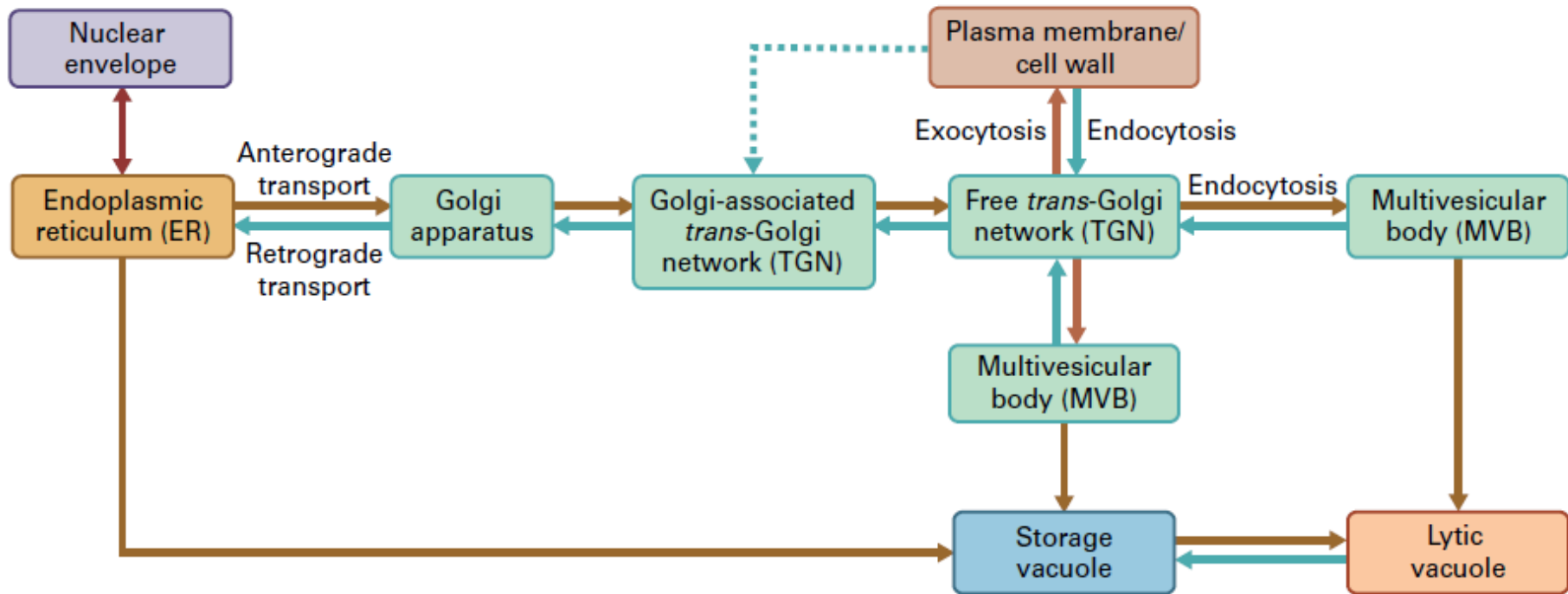
18 funkčních domén ER

FIGURE 1.14 Diagram illustrating 18 functional domains of the plant ER system.

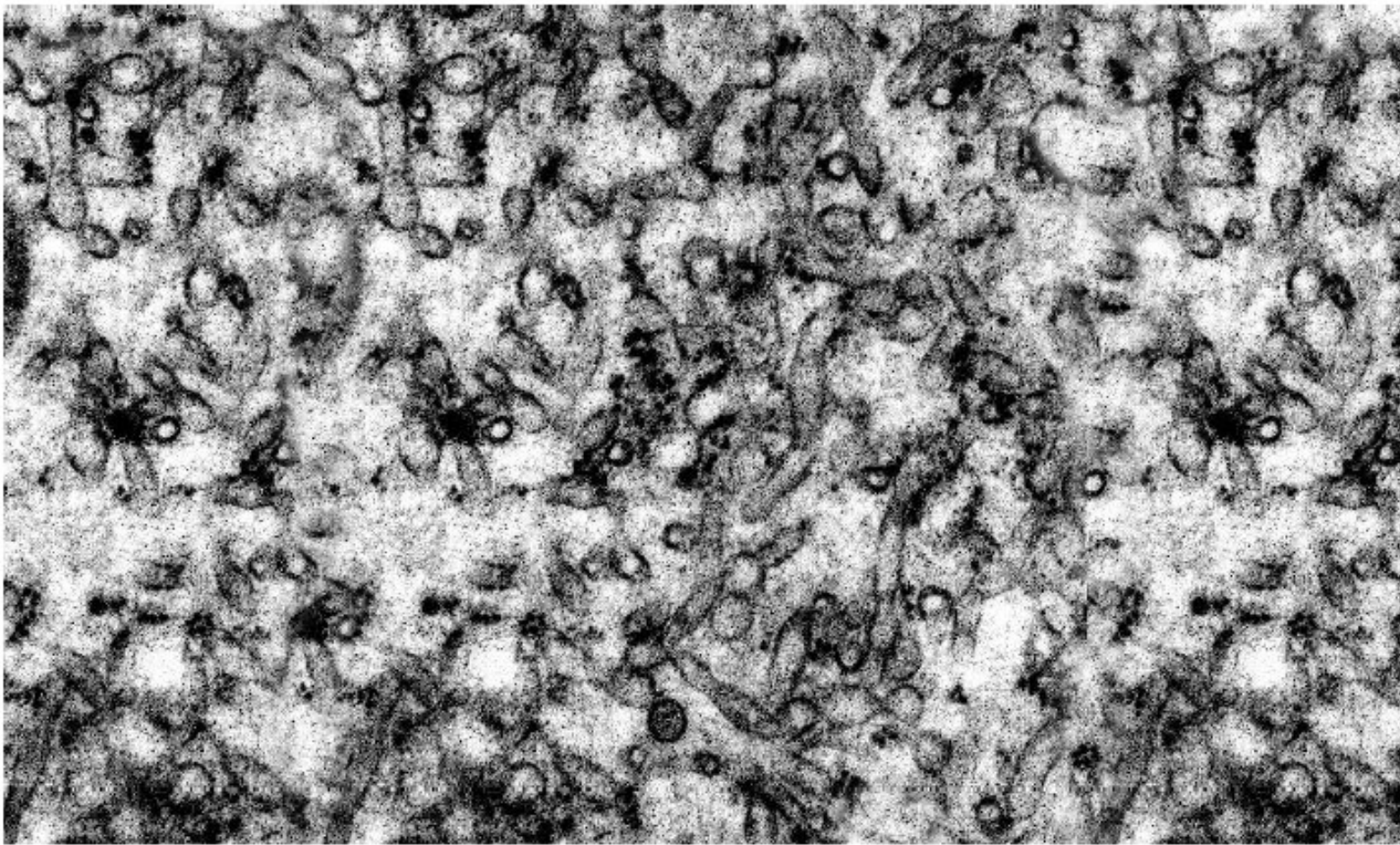




# ER – součást endomembránového systému



**FIGURE 1.15** Diagrammatic overview of the major membrane compartments of the endomembrane system and the directions of membrane trafficking between these compartments. Single-headed arrows represent anterograde and retrograde vesicle traffic. Double-headed arrows connected by a single line indicate that membrane components and lumen contents can diffuse laterally between these compartments (nuclear envelope and ER). Double-headed arrow connected by two lines signals interconversion between vacuole types.

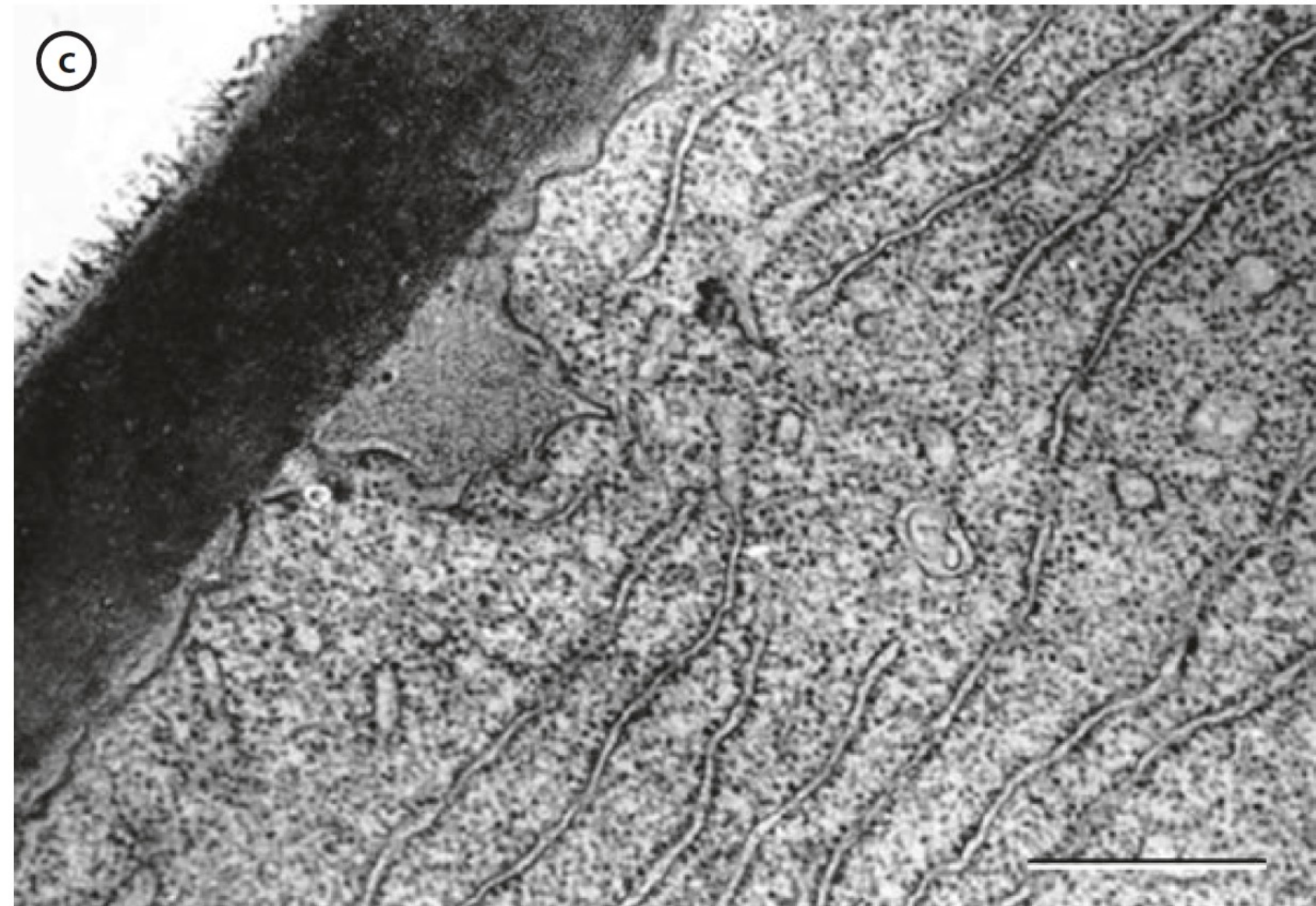


**FIGURE 1.18** *TEM of smooth ER tubules in a glandular trichome cell of a mint leaf. See domain 6 in Figure 1.14.*

*Source:* Micrograph by Glenn W. Turner, Washington State University, Pullman, WA.



©



■ **Fig. 3.9** c TEM image of rough endoplasmic reticulum in a rhizodermal cell of the water plant, *Limnobium bogotense* (a member of the grass family). Scale bar = 0.2  $\mu\text{m}$  (Image courtesy of Dr. Harry Horner)

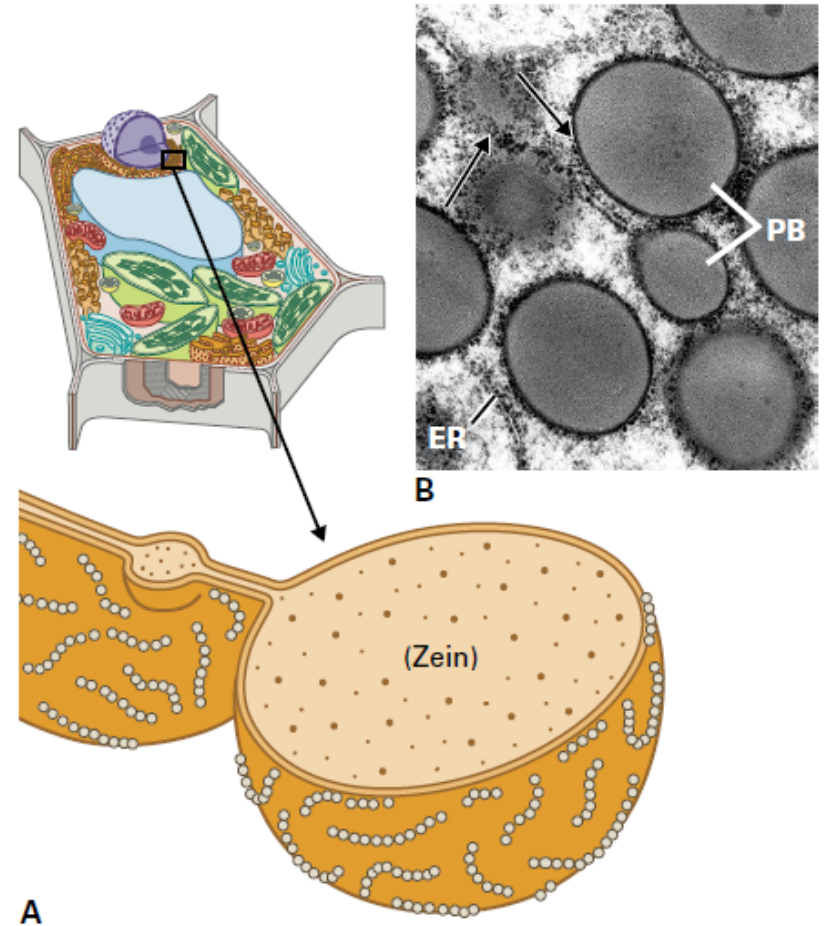
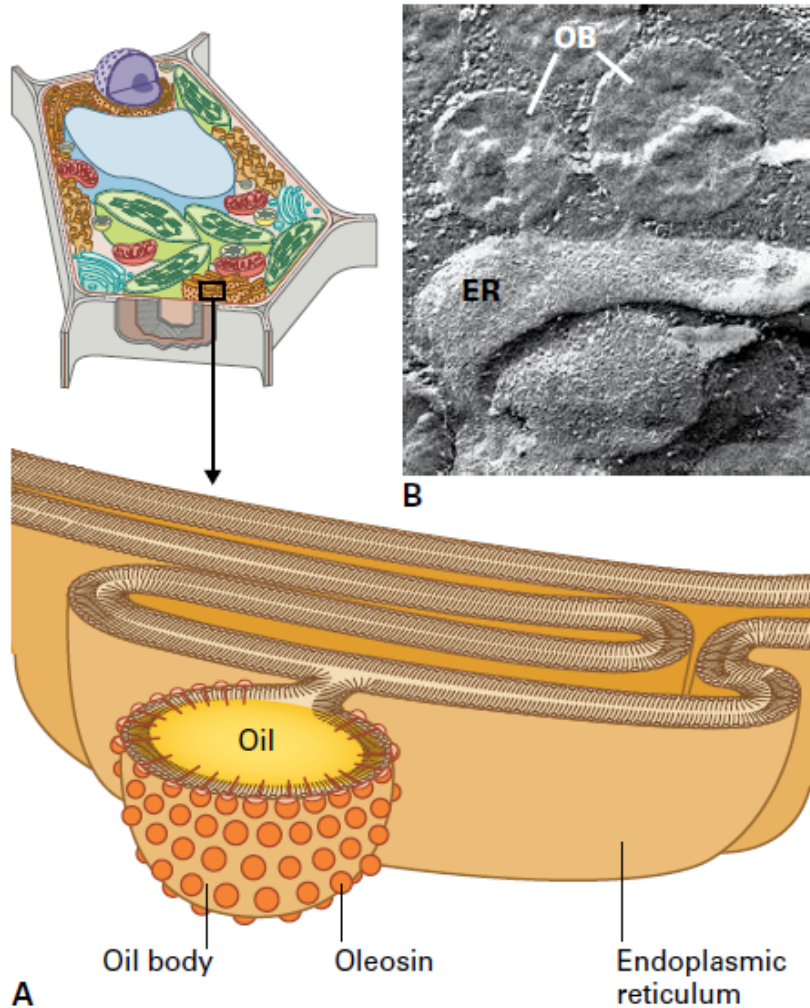
Richard Cobby  
Sheila Lyons-Sobaski  
Robert Wise



**Plant  
Anatomy**

A Concept-Based Approach  
to the Structure of Seed Plants





**FIGURE 1.21** (A) Prolamin storage proteins (e.g., zein) aggregate in protein bodies that bud from specialized rough ER. (B) TEM of protein bodies (PB) forming in maize endosperm. Polysomes (arrows) are attached to the delimiting ER membrane. See domain 8 in Fig. 1.14. Source: (B) Micrograph by Brian A. Larkins, University of Arizona, Tucson, AZ.

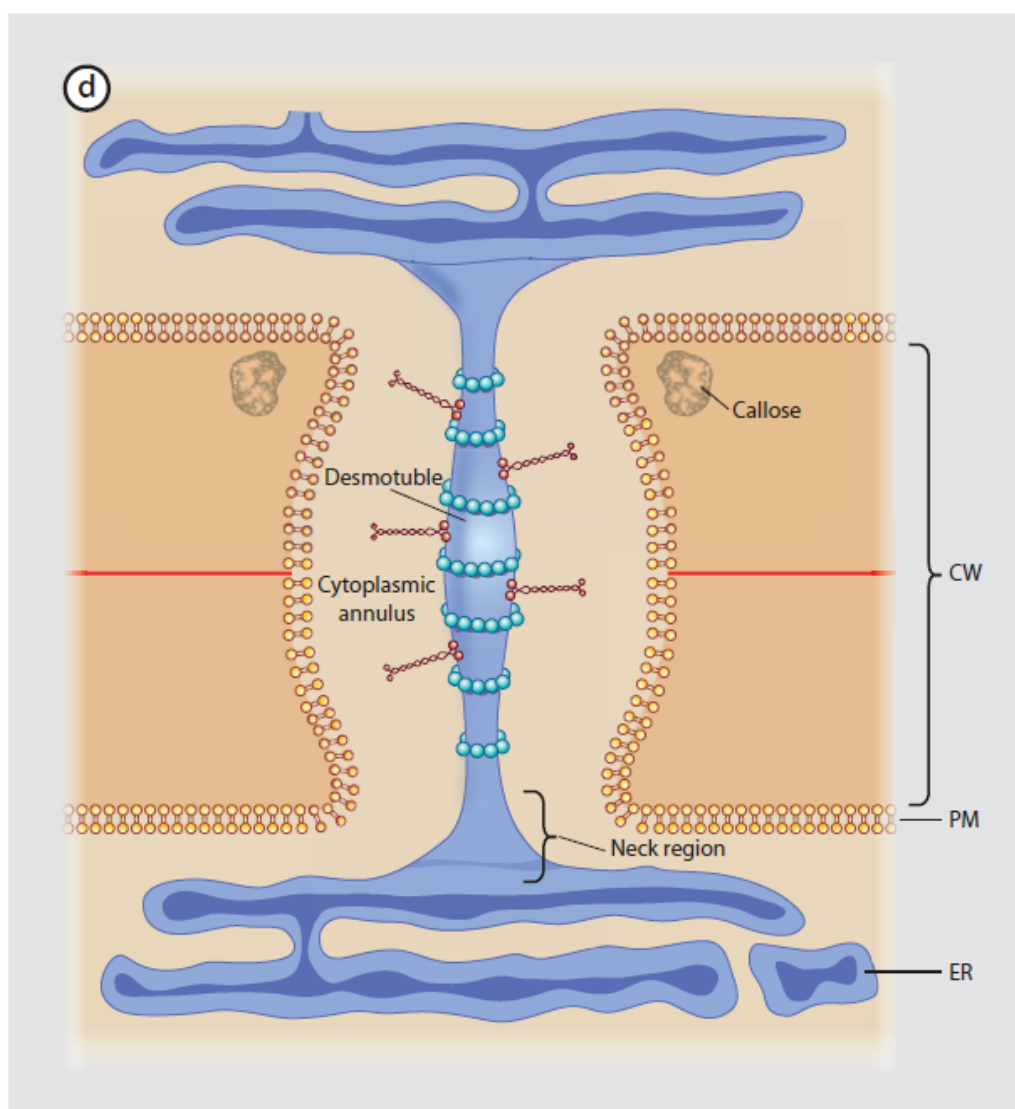
**FIGURE 1.20** (A) Triacylglycerides accumulate between the two lipid monolayers of a smooth ER membrane and bud off as oil bodies at sites defined by oleosin molecules. (B) TEM of oil bodies (OB) budding from an ER membrane into the cytoplasm. See domain 9 in Figure 1.14.

Source: (B) Micrograph by Donna Fernandez, from Fernandez, D. and Staehelin, L.A. (1987). *Plant Physiol* 85: 487–496.

lipidická tělíska, oleozómy, sférozomy

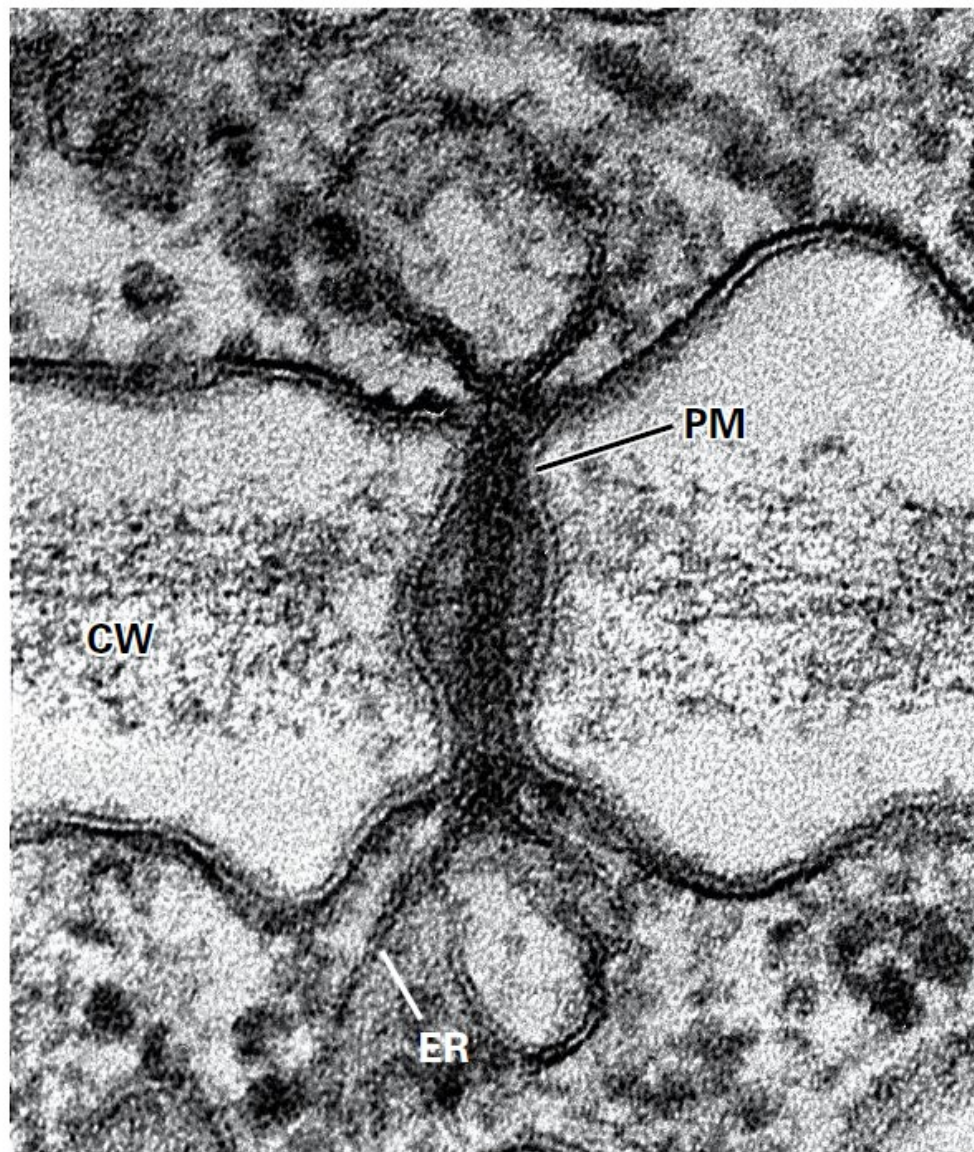
# Plazmodezmata

- naprostá většina buněk v rostlinném organismu je navzájem propojena systémem plazmodezmat; rostlina symplazmický celek - syncytium!
- až  $10^3$  -  $10^5$  plazmodezmat mezi dvěma sousedními buňkami!
- transport: nejen malé molekuly, ale i proteiny, transkripční faktory, mRNA, viry...
- **výjimky: stomata, mateřské buňky mikrospor**
- průměr plazmodezmat: 30-60 nm; regulace **kalózou**
- sdružená do perforací BS (primary pit field), pokud sekundární BS: ztenčeniny (jednoduché, dvůrkaté)
- primární plazmodezmata (vznikají v buněčné desce během cytokineze) a sekundární plazmodezmata
- **dezmotubulus a cytoplazmatický prstenec**



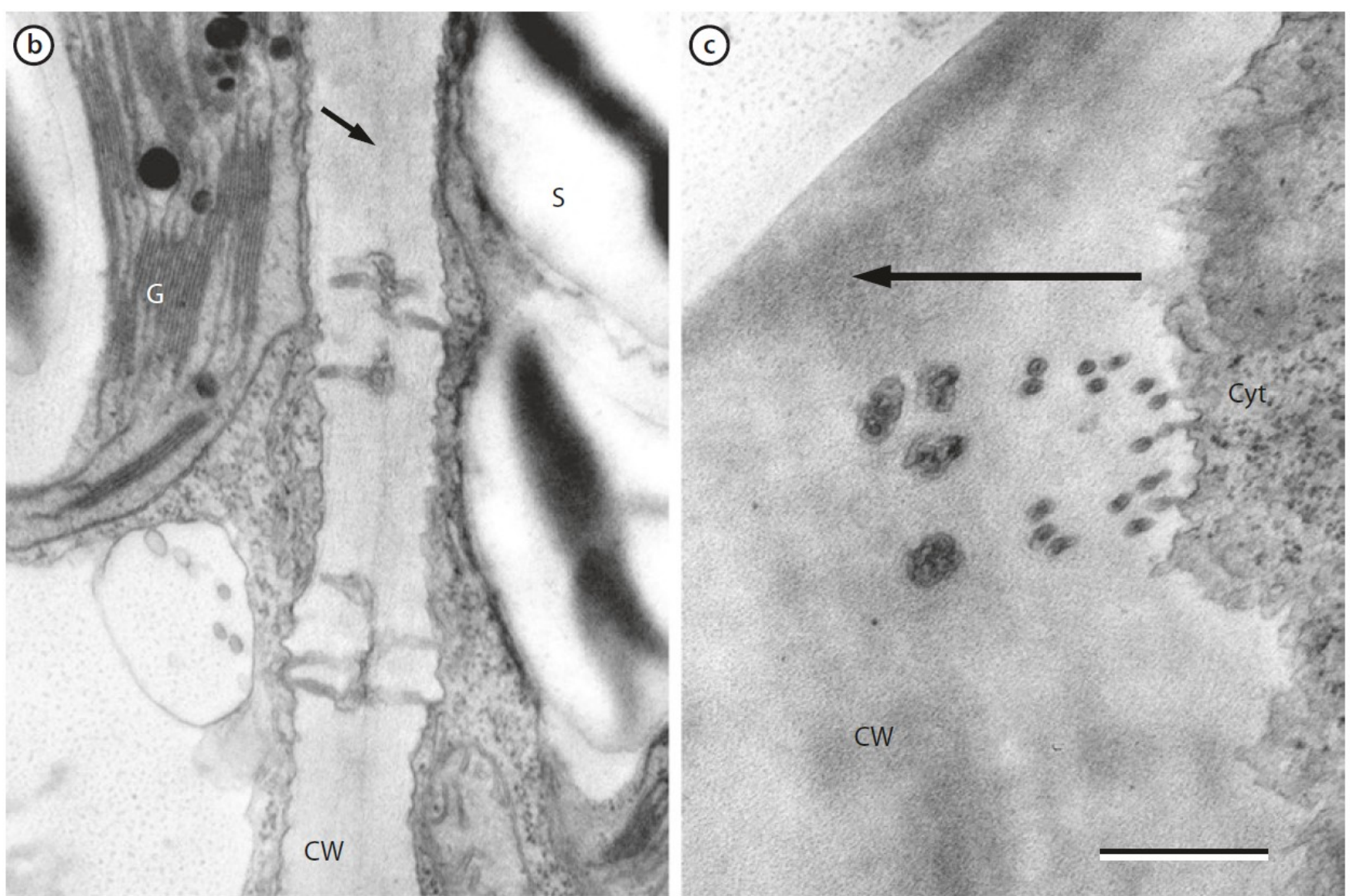
■ Fig. 5.3 d The structure of an unbranched plasmodesmata. Light green area cytoplasmic sleeve; *CW* cell wall, *CA* callose, *PM* plasma membrane, *ER* endoplasmic reticulum, *DM* desmotubule, purple circles and spokes – other agents such as ATP and proteins within the cytoplasmic sleeve that may include myosin. The combination of actin and myosin may be in the selective transport of large molecules between two cells through the plasmodesmata and along the desmotubule. (Figure modified from Sevilem et al. (2015))



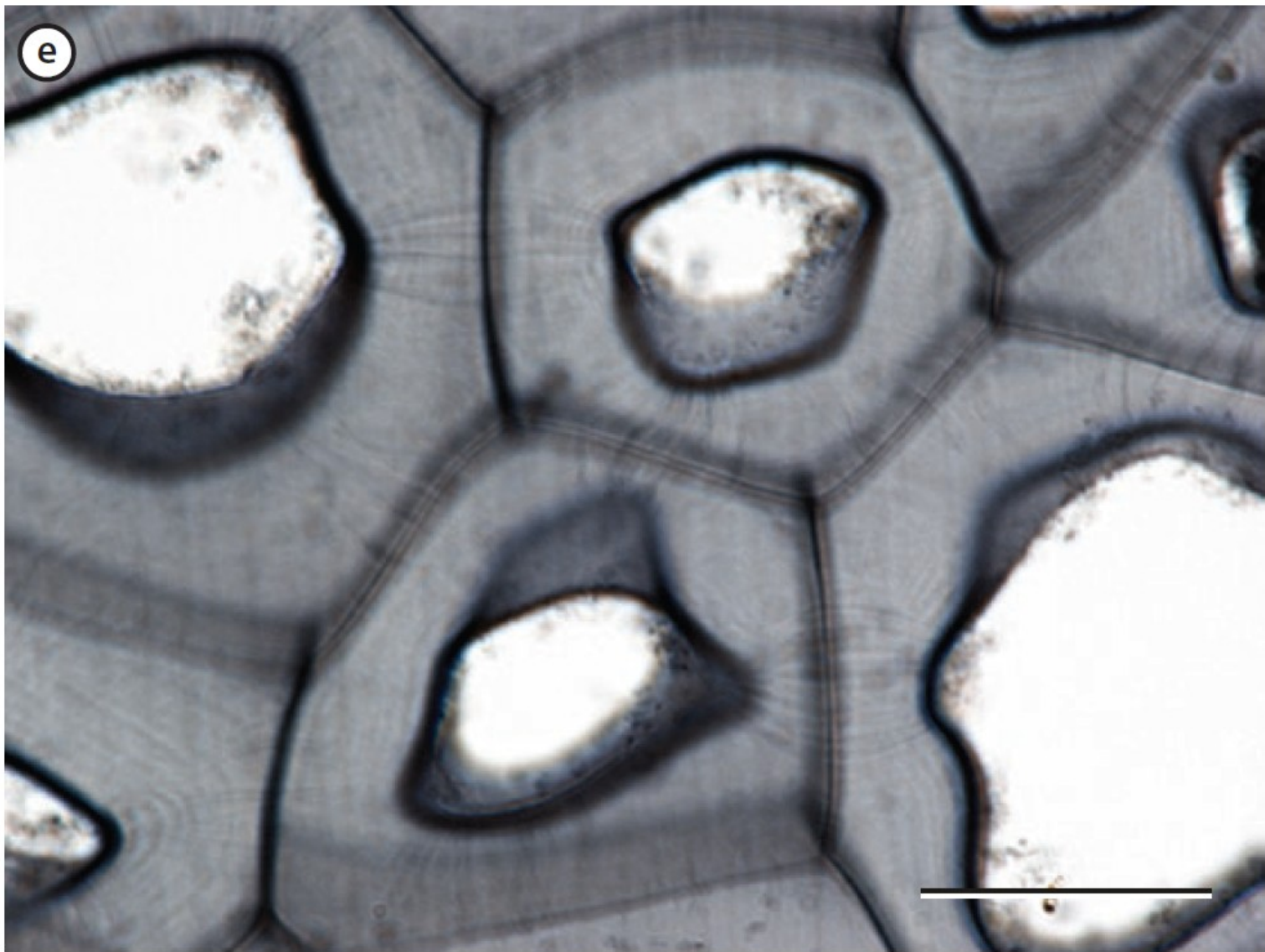


**FIGURE 1.12** *Longitudinal section through a plasmodesma. Plasma membrane (PM), endoplasmic reticulum (ER), cell wall (CW).*  
Source: TEM by Lewis Tilney, from Tilney et al. (1991). *J Cell Biol* 112: 739–747.





■ **Fig. 5.3** **b** Branched plasmodesmata seen in cross-section traversing the two primary cell walls (CW) separating two leaf cells. The middle lamella is indicated with an arrow. Chloroplasts with grana (G) and starch (S) are also indicated. **c** Plasmodesmata seen in face view in an oblique section of a primary cell wall (CW). Cytoplasm (Cyt) is to the right in the image, and the arrow indicates increasing depth into the cell wall. Both images are from the leaf of the lyre-leaved sand cress (*Arabidopsis lyrata*). Scale bar = 0.1  $\mu\text{m}$  for both panels (**b**, **c** RR Wise)



■ **Fig. 5.3** e Cell walls of persimmon (*Diospyros* sp.) in cross-section showing fine bundles of plasmodesmata traversing the walls, through the middle lamella, and interconnecting every cell in the field of view. Scale bar = 25  $\mu$ m (RR Wise)