AGRY 515 2012

- Radial Transport across the Root
- Ion Fluxes across Membranes

Table 1. (Table 2.2 in text) 3 Observations…?

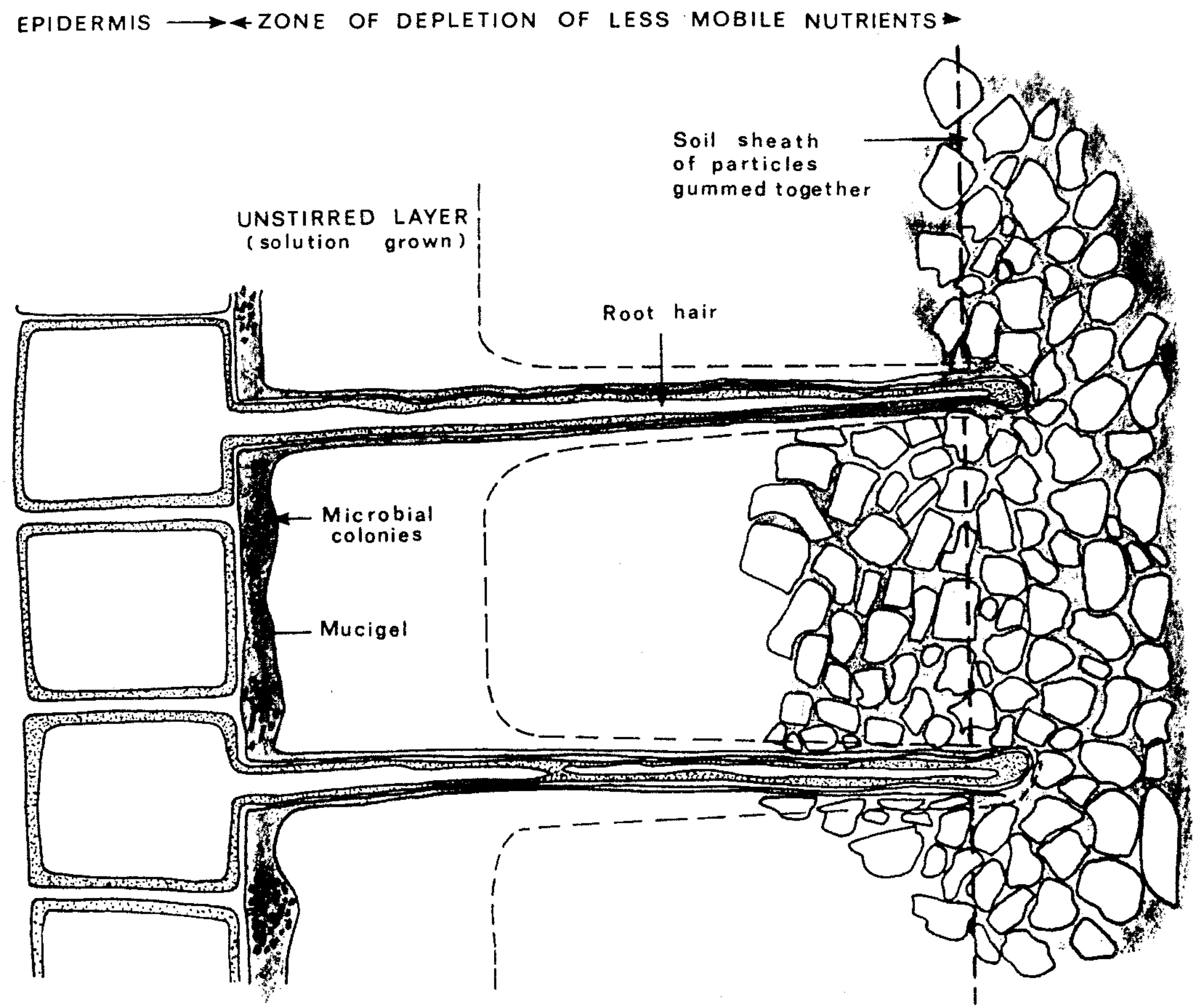
Table 2.2
Changes in the Ion Concentration of the External (Nutrient) Solution and in the Root Press Sap of Maize and Bean

	External concentration (mM)			Concentration in the root press sap (mM)	
		After 4 days[a]			
Ion	Initial	Maize	Bean	Maize	Bean
Potassium	2.00	0.14	0.67	160	84
Calcium	1.00	0.94	0.59	3	10
Sodium	0.32	0.51	0.58	0.6	6
Phosphate	0.25	0.06	0.09	6	12
Nitrate	2.00	0.13	0.07	38	35
Sulfate	0.67	0.61	0.81	14	6

[a]No replacement of water lost through transpiration.

Marschner, 1995

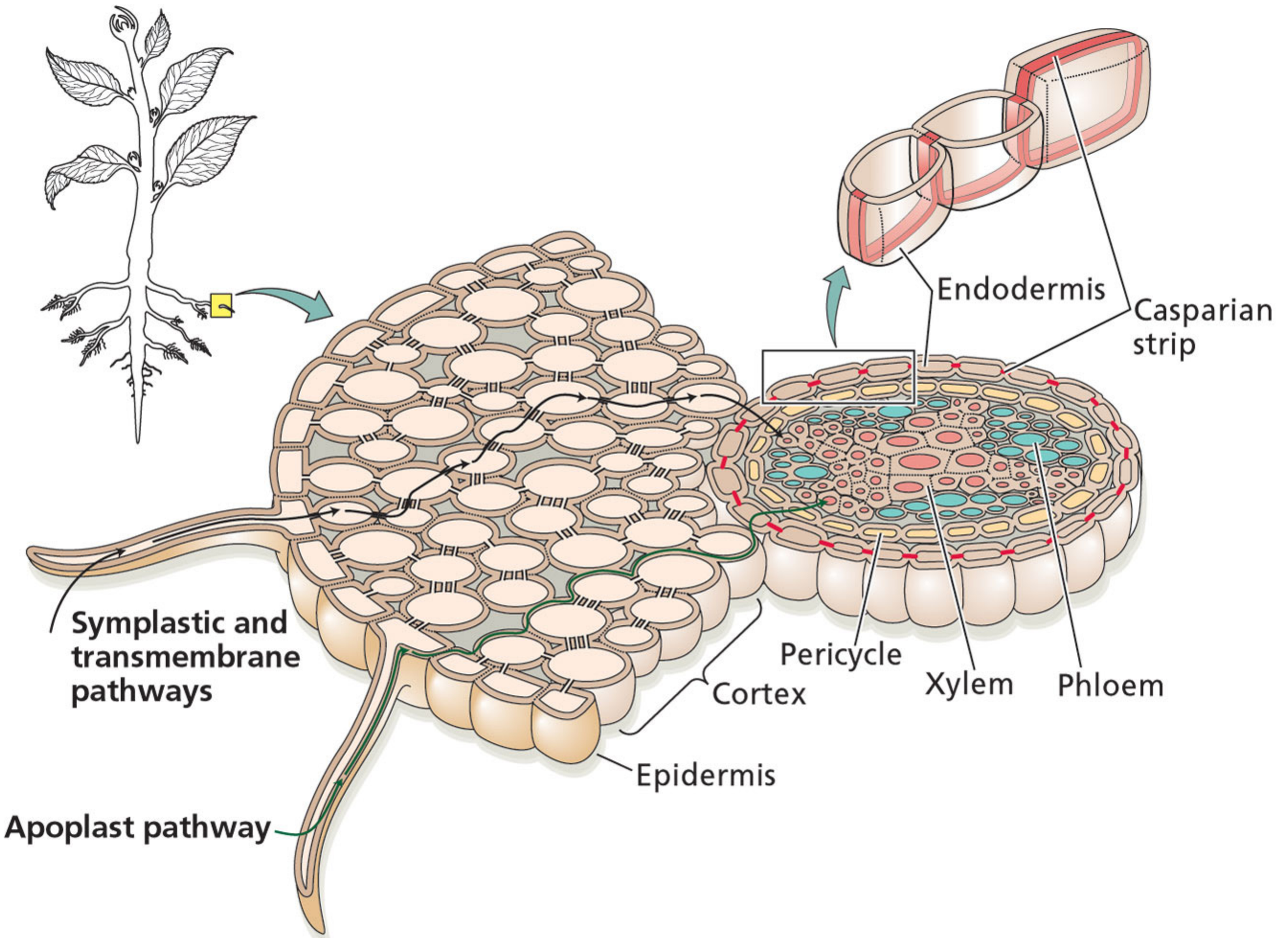
Fig. 1. How far can K^+ travel "passively"?



Waisel et al., 1995

Figure 1 Aspects of the rhizosphere that may influence the arrival of ions at the absorptive surface of the root. The extent of the unstirred layer that surrounds roots in solution culture is indicated. In this layer ions can be at quite different concentrations to those in the bulk solution.

Fig. 2. (Similar to Fig. 2.32) Apoplastic and Symplastic pathways



Taiz and Zeiger, 2002

Fig. 2A (Fig. 2.1 in text)

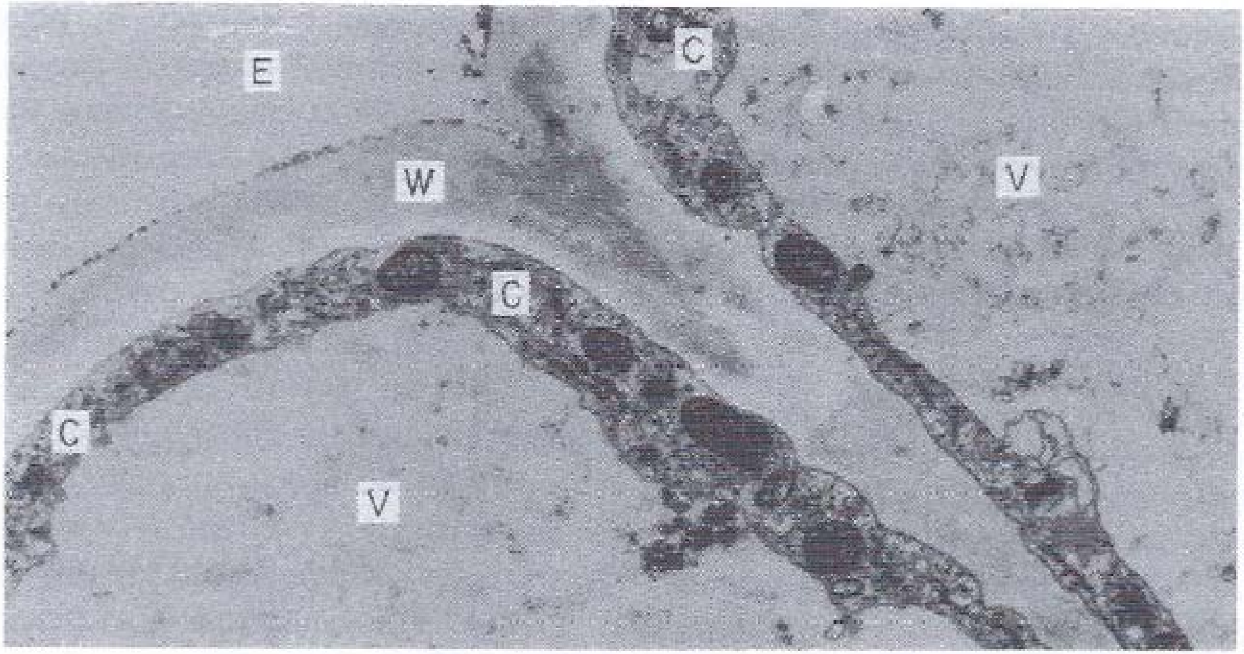


FIGURE 2.1 Cross-section of two rhizodermal cells of a maize root. V, vacuole; C, cytoplasm; W, cell wall, E, external solution. *Courtesy of C. Hecht-Buchholz.*

Fig. 3. (Fig. 2.15 in text) Exchange Adsorption

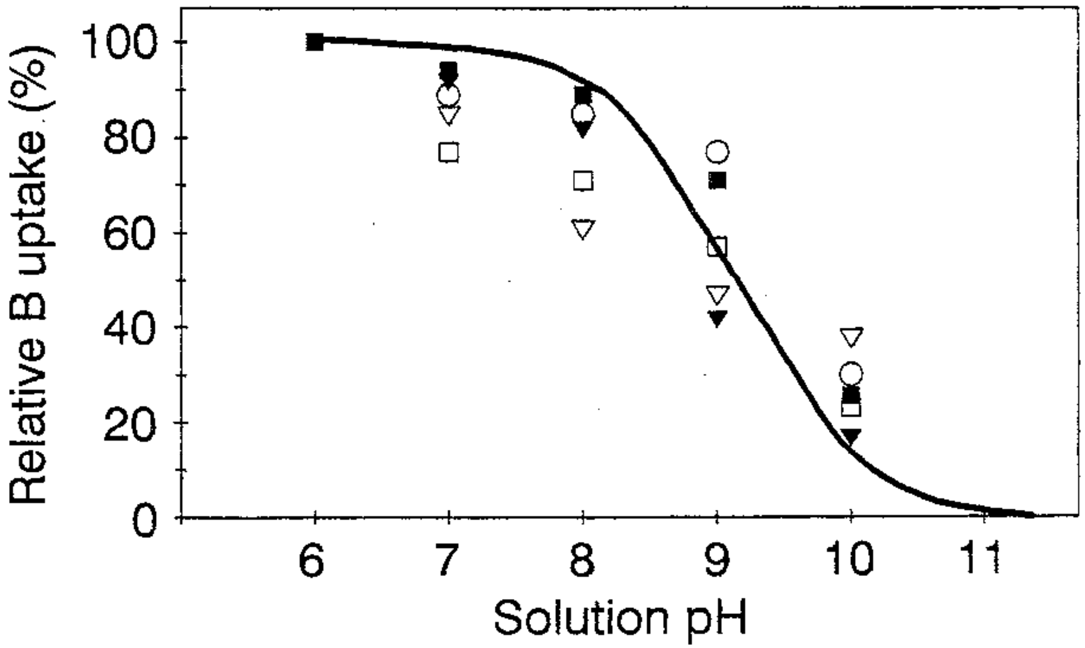


Fig. 2.13 Relative uptake of boron by barley roots as a function of the external solution pH. Uptake at pH 6 = 100 at each supply concentration. Solid line: percentage of undissociated H_3BO_3. Key for boron concentrations mg l^{-1}: ▽, 1.0; □, 2.5; ○, 5.0; ▼, 7.5; ■, 10.0. (Reproduced from Oertli and Grgurevic, 1975, by permission of the American Society of Agronomy.)

Marschner, 1995

Fig. 4. Symplastic Movement

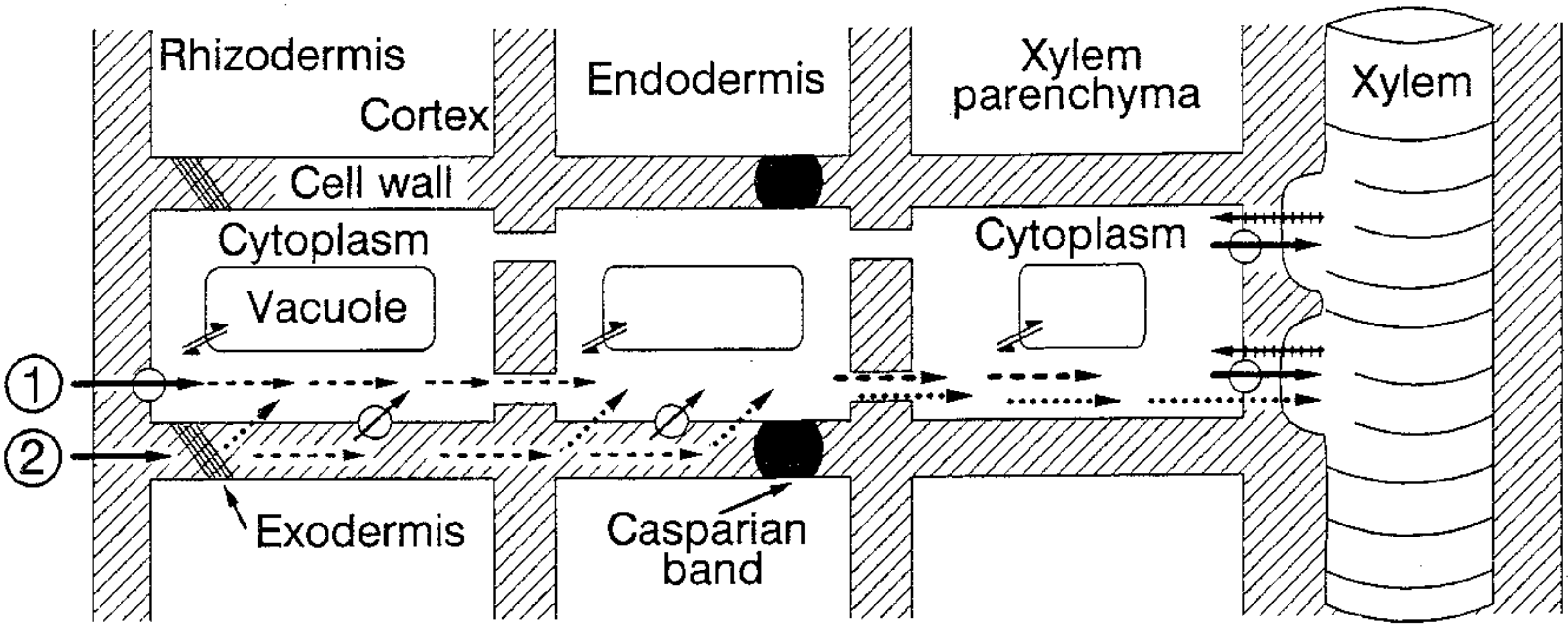


Fig. 2.35 Model for symplasmic (1) and apoplasmic (2) pathways of radial transport of ions across the root into the xylem. Key: ⊖→, active transport; ⟵, resorption. (Modified from Läuchli, 1976a.)

Marschner, 1995

Fig. 5. (Fig. 2.33 in text) Plasmodesmata

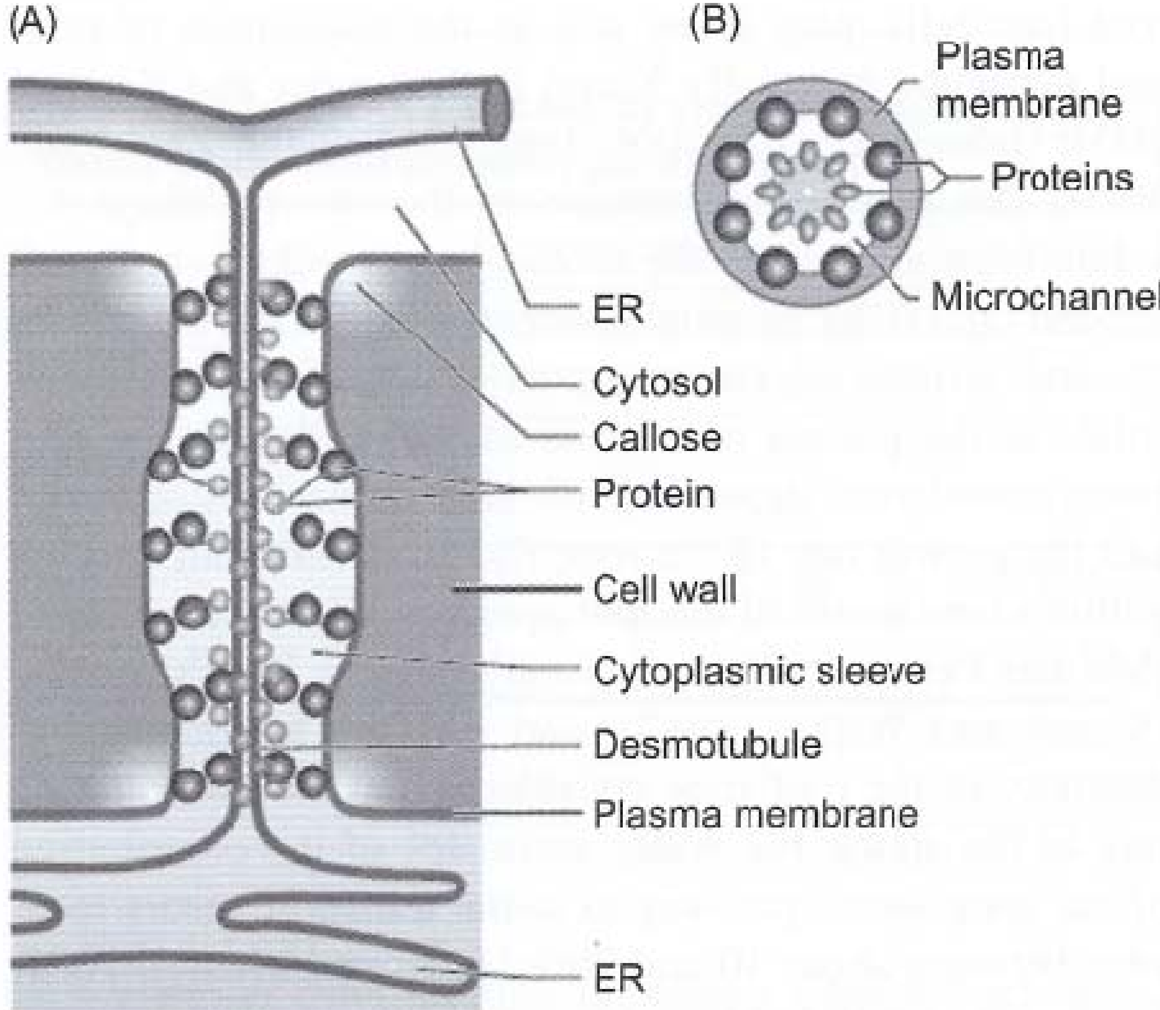


FIGURE 2.33 Schematic representation of plasmodesmata including substructural components. Solute fluxes between adjacent cells occur in the cytoplasmic sleeve, between the plasma membrane and the appressed endoplasmic reticulum (ER) forming the desmotubule. Partial control of solute fluxes by callose deposition in the cell wall. The cytoplasmic sleeve is interrupted by actin and other proteins that create microchannels through which solutes can diffuse. *Modified from Maule (2008).*

Fig. 6. Generalized Plant Cell

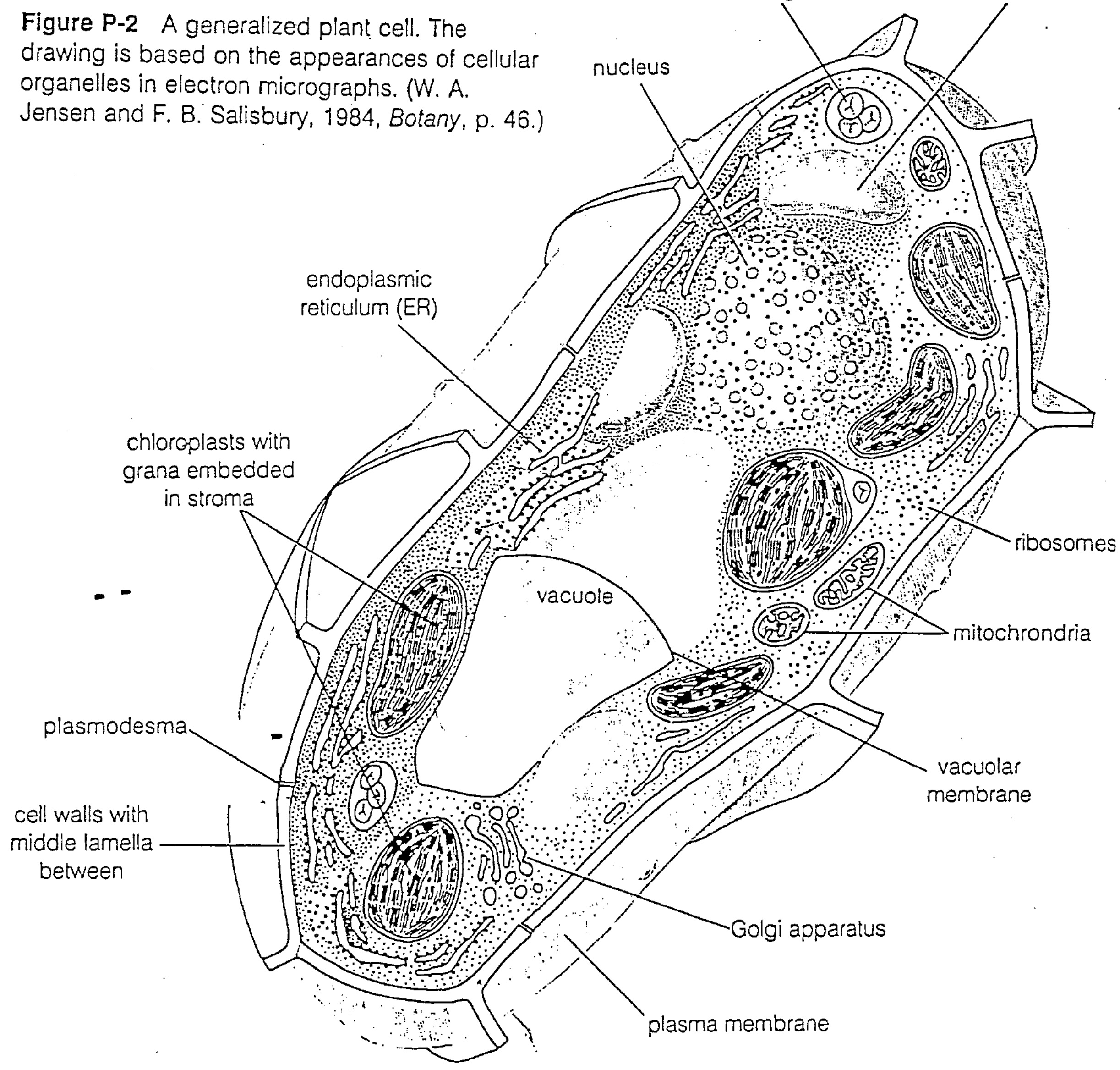
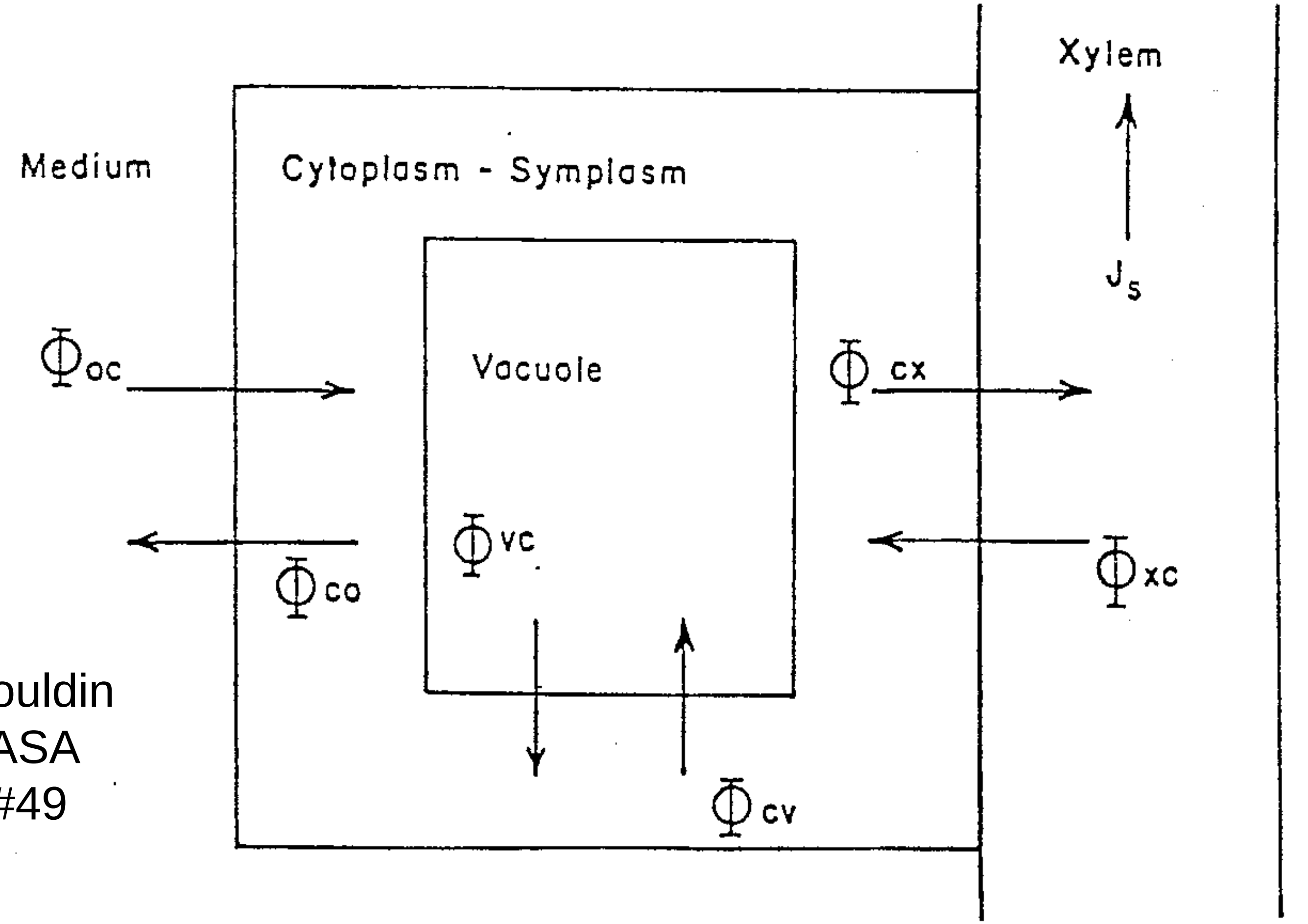


Figure P-2 A generalized plant cell. The drawing is based on the appearances of cellular organelles in electron micrographs. (W. A. Jensen and F. B. Salisbury, 1984, *Botany*, p. 46.)

Salisbury and Ross, 1985

Fig. 7. Lauchli's principal membrane fluxes



Barber and Bouldin (eds.), 1982. ASA Special Pub. #49

Fig. 2. Model of principal membrane fluxes in a root (net salt flux in xylem, $J_s = \Phi_{cx} - \Phi_{xc}$).

Fig. 7A (Fig. 2.12 in text)

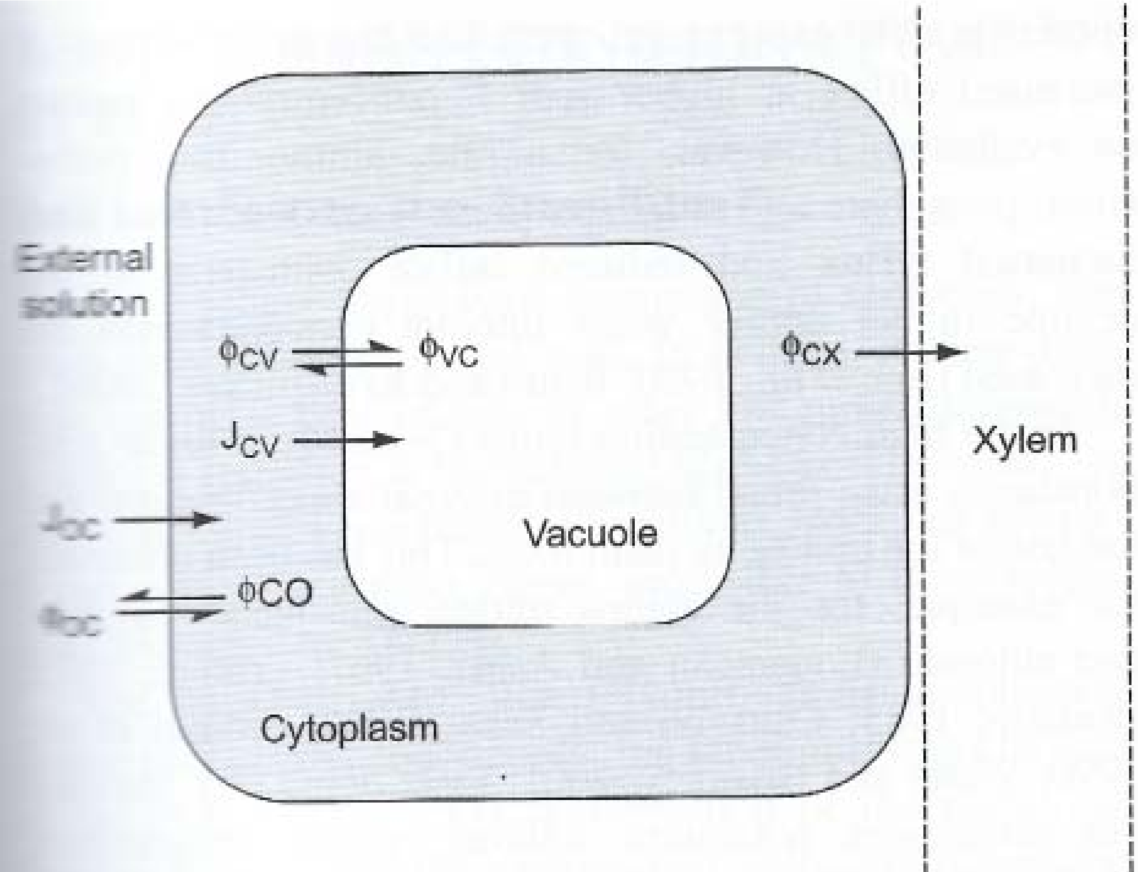


FIGURE 2.12 Nomenclature of unidirectional (ø) and net (J) solute fluxes across the plasma membrane between cytoplasm (c) and the external solution (o) or xylem (x), and across the tonoplast between the cytoplasm (c) and the vacuole (v) of a stereotypical root cell. *Figure adapted from White and Broadley (2001).*

Fig. 8. Active and Passive Transport

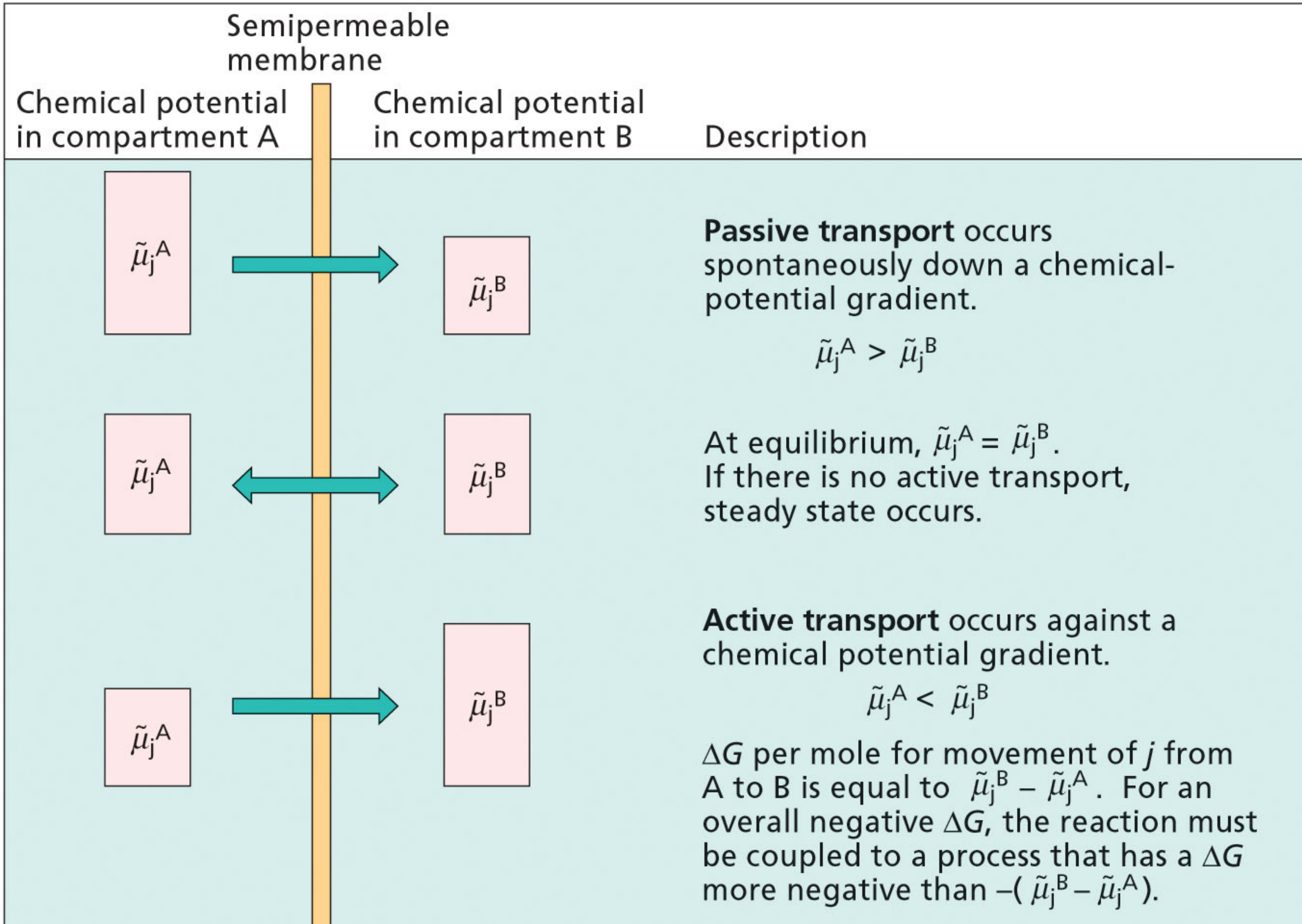


Fig. 9. Active and Passive Transport (cont.)

Initial conditions:
$[KCl]_A > [KCl]_B$

Diffusion potential exists until chemical equilibrium is reached.

Equilibrium conditions:
$[KCl]_A = [KCl]_B$

At chemical equilibrium, diffusion potential equals zero.

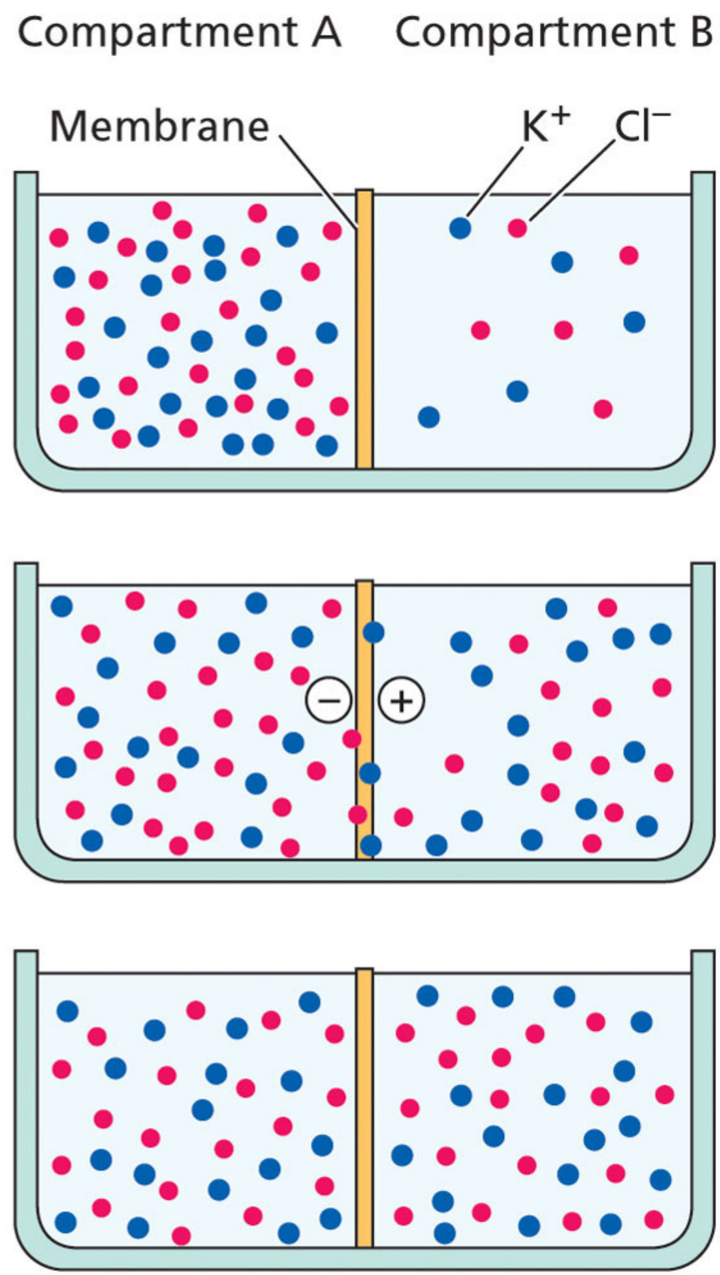


Fig. 10. Measure Membrane potential (also see Fig. 2.8b in text

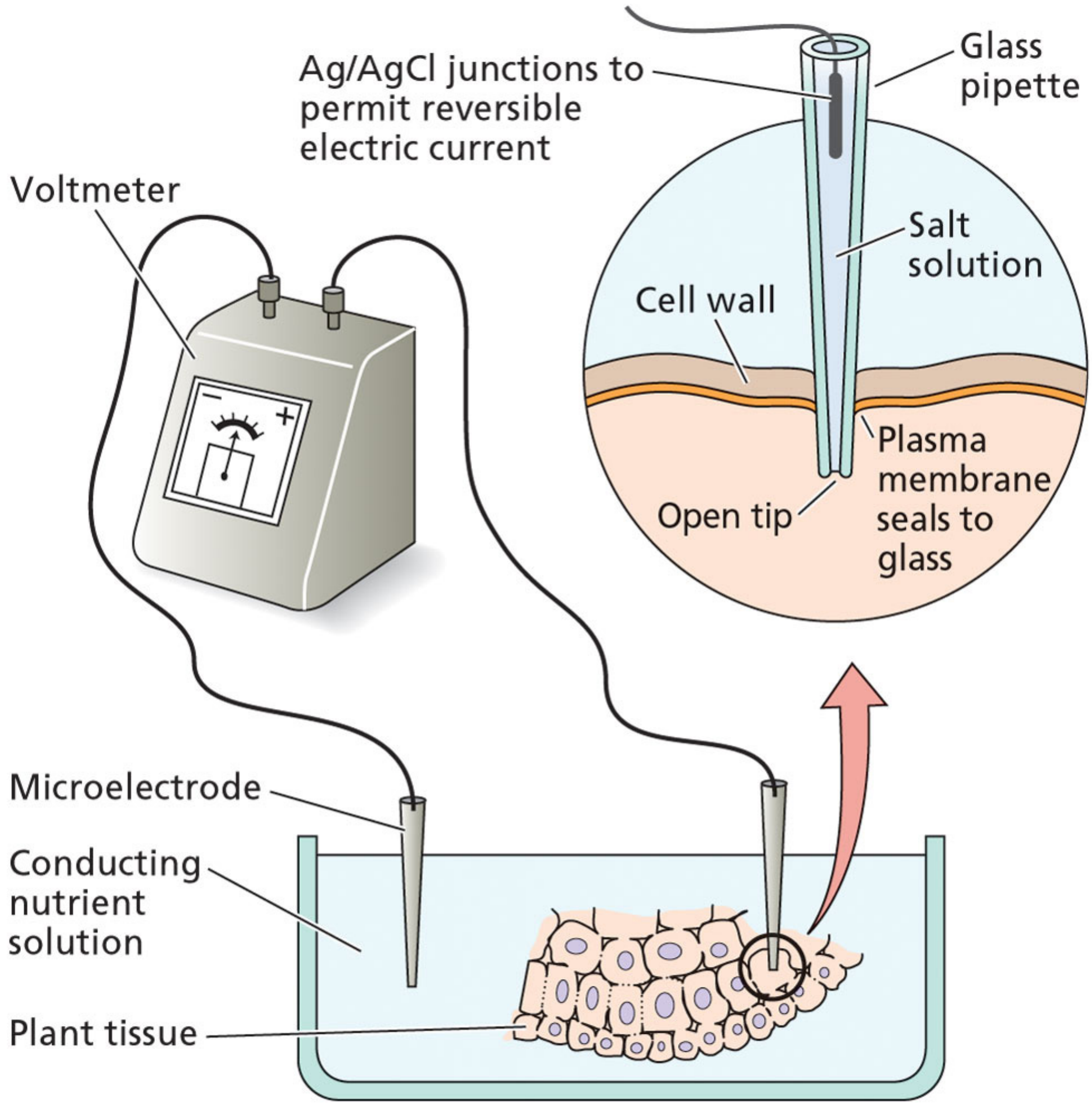


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Table 2. Nerst Equation Applied

TABLE 6.1
Comparison of observed and predicted ion concentrations in pea root tissue

Ion	Concentration in external medium (mmol L^{-1})	Internal concentration (mmol L^{-1})	
		Predicted	Observed
K^+	1	74	75
Na^+	1	74	8
Mg^{2+}	0.25	1340	3
Ca^{2+}	1	5360	2
NO_3^-	2	0.0272	28
Cl^-	1	0.0136	7
$H_2PO_4^-$	1	0.0136	21
SO_4^{2-}	0.25	0.00005	19

Source: Data from Higinbotham et al. 1967.
Note: The membrane potential was measured as –110 mV.

Fig. 11 Active Vs. Passive Ion Fluxes

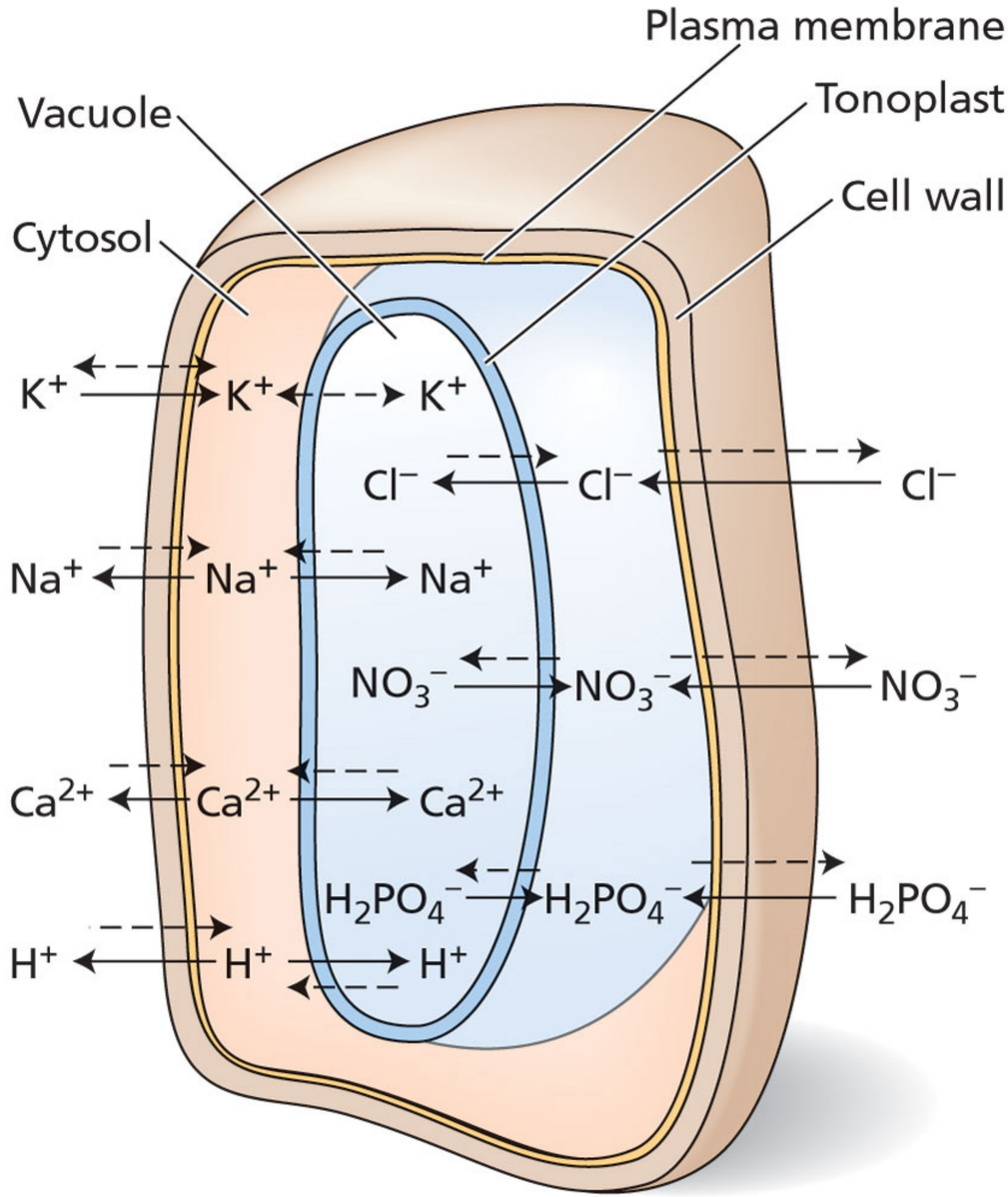

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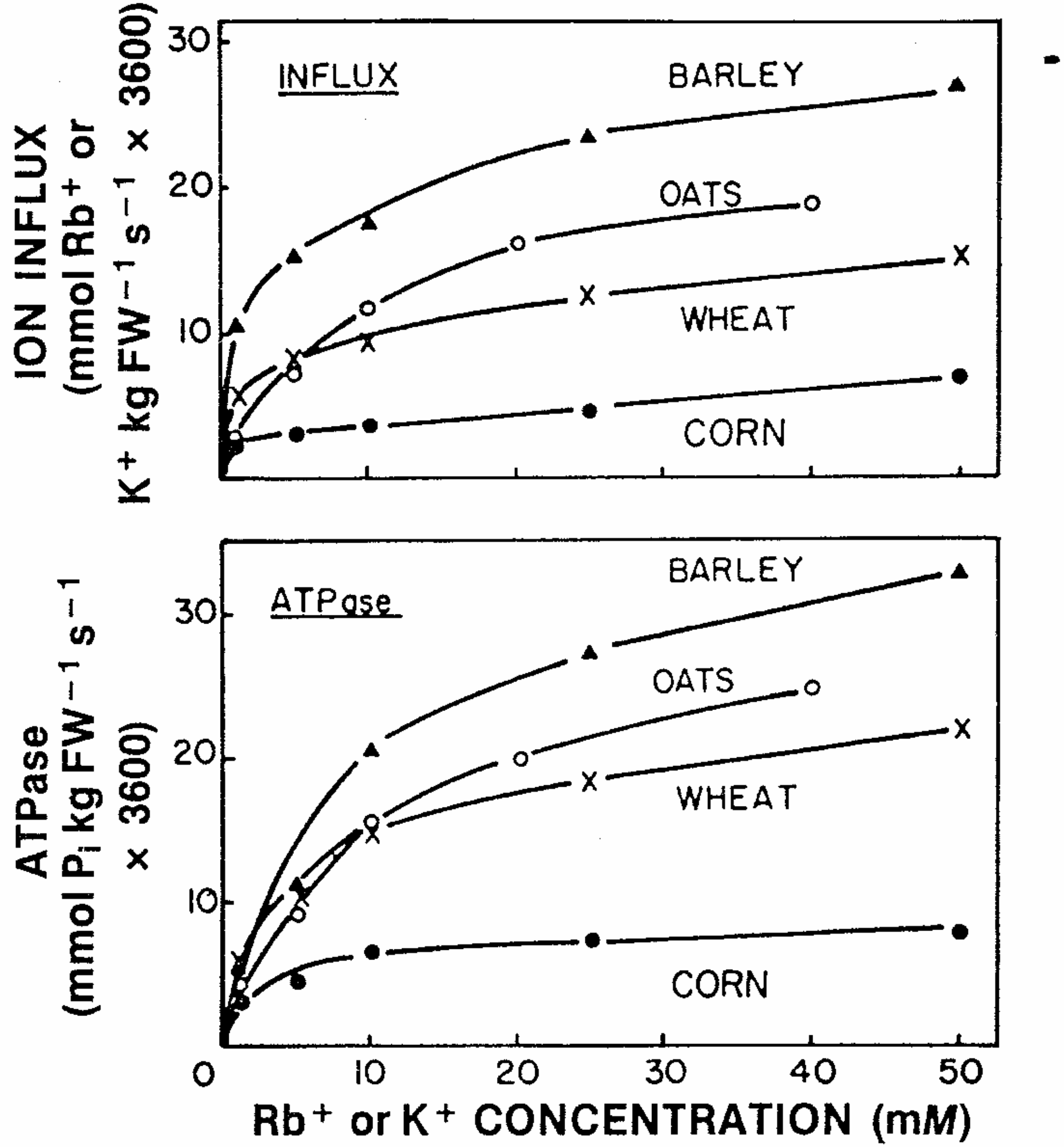
Fig. 12. Evidence: Consumption of ATP

Barber and Bouldin (eds.), 1982. ASA Special Pub. #49



:orrelation between influx of K^+ and K^+-stimulated ATPase activity of membr :ations in four different cereal roots (r = 0.94) (Fisher et al., 1970).

Fig. 13. Evidence: ATP / H+ Pump

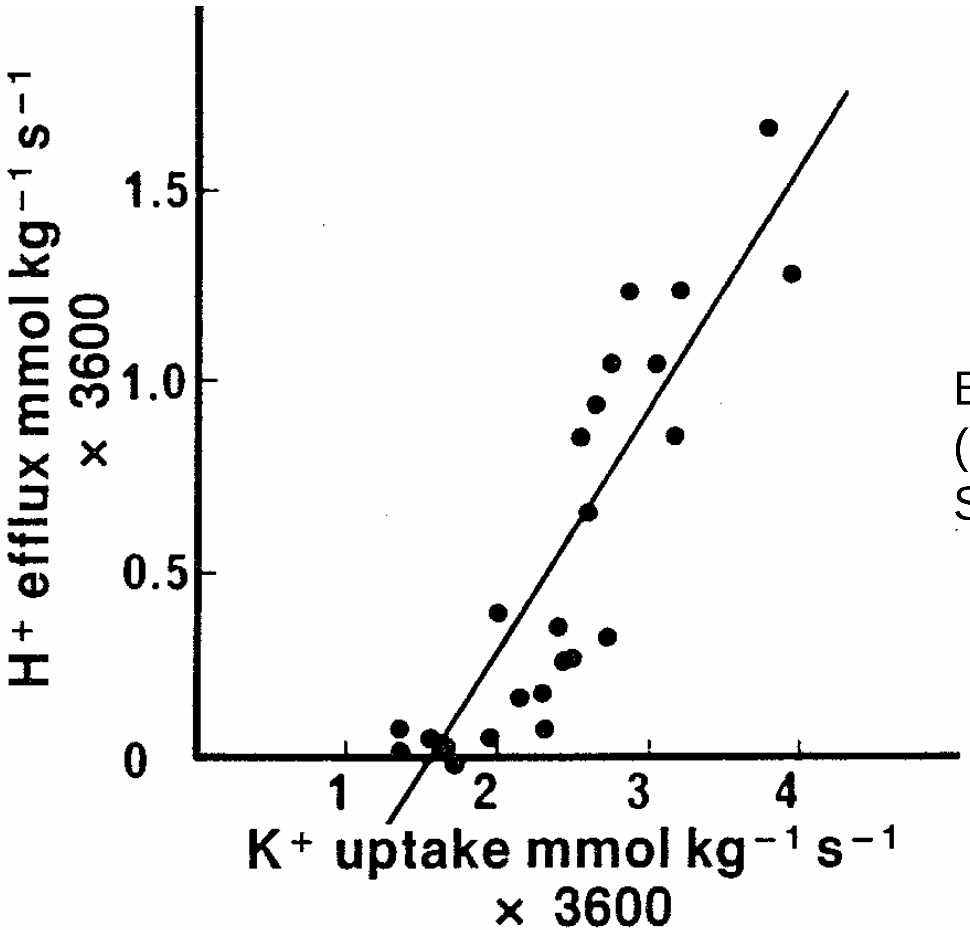


Fig. 4. Correlation between net H^+ efflux and K^+ influx in roots of 24 barley varieties. Roots of intact seedlings exposed to 1 m*M* K_2SO_4 plus 0.5 m*M* $CaSO_4$ for 24 h (r = 0.88) (Glass et al., 1981).

Barber and Bouldin (eds.), 1982. ASA Special Pub. #49

Fig. 14. Evidence: ATP & Membrane Potential

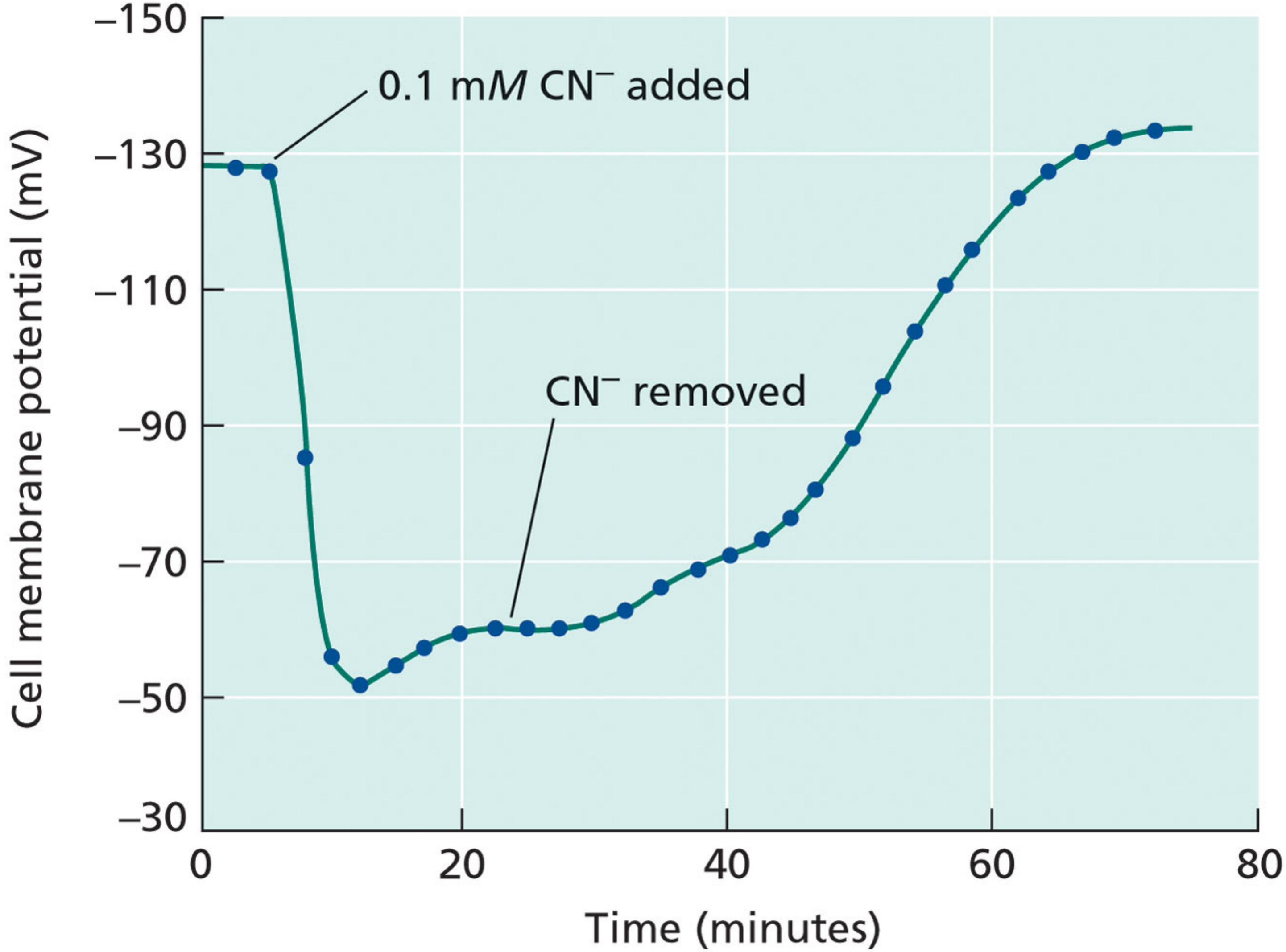
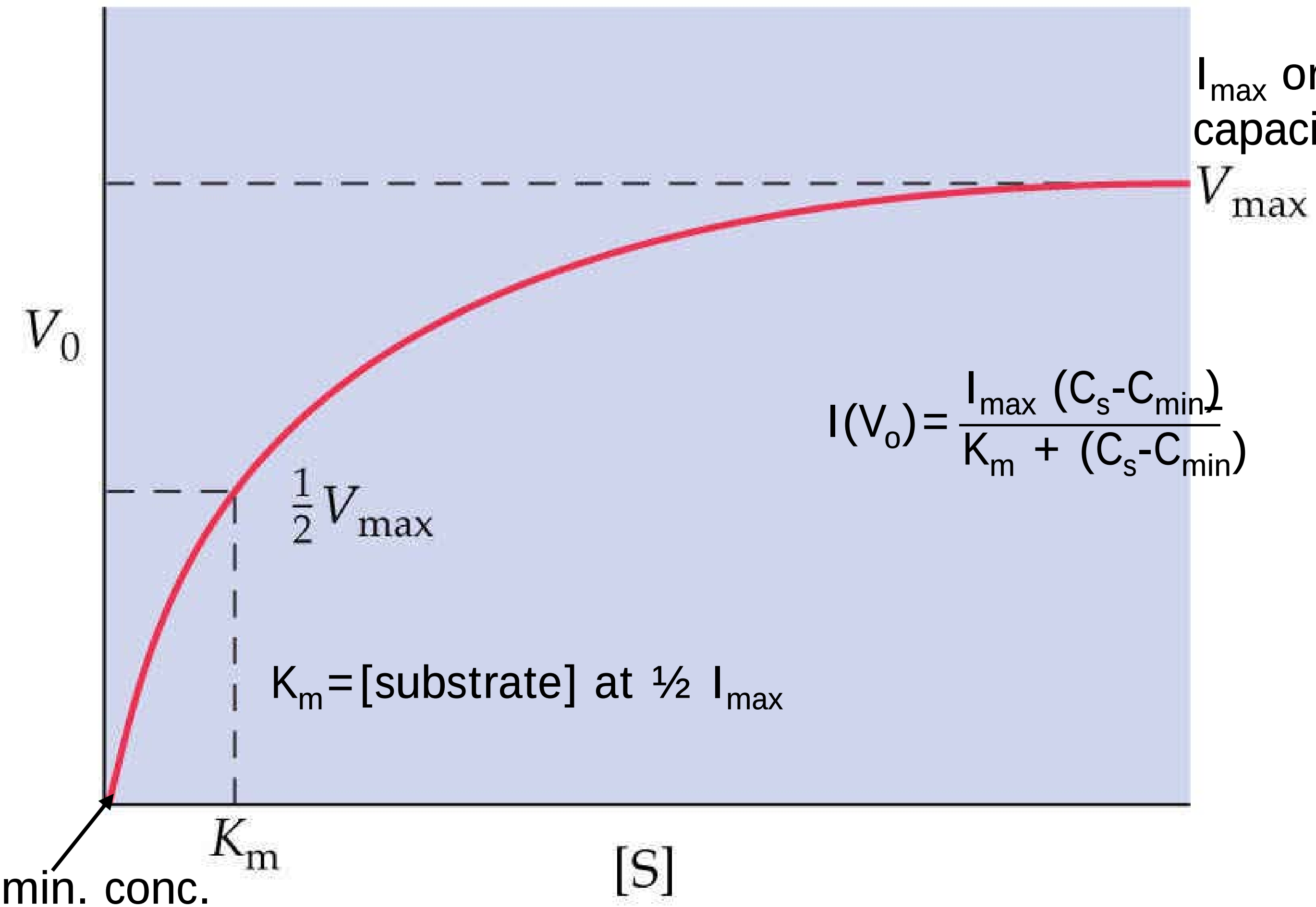


Fig. 15. Carrier Concept & Michaelis-Menten Kinetics



C_{min}=the min. conc. needed for uptake

Fig. 16. More than one carrier or transport mechanism?

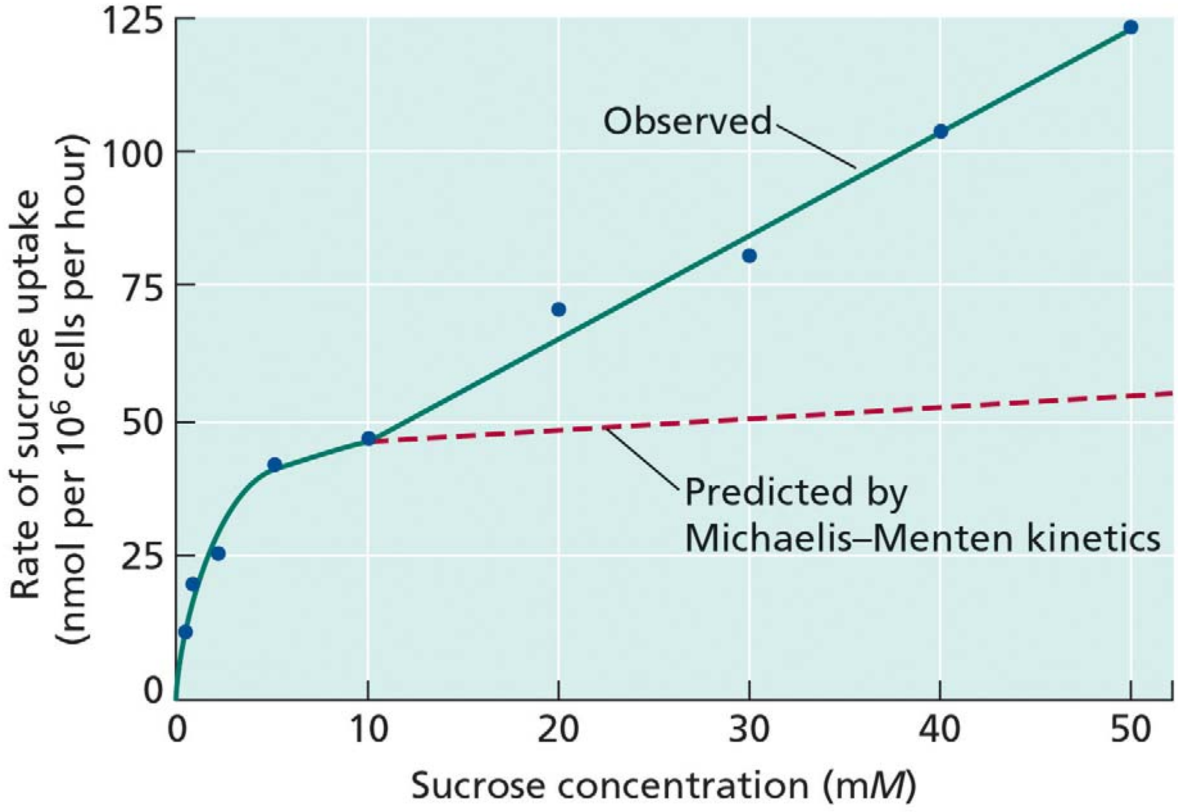


Fig. 17 (Fig. 2.7 in text) Types of transport mechanisms

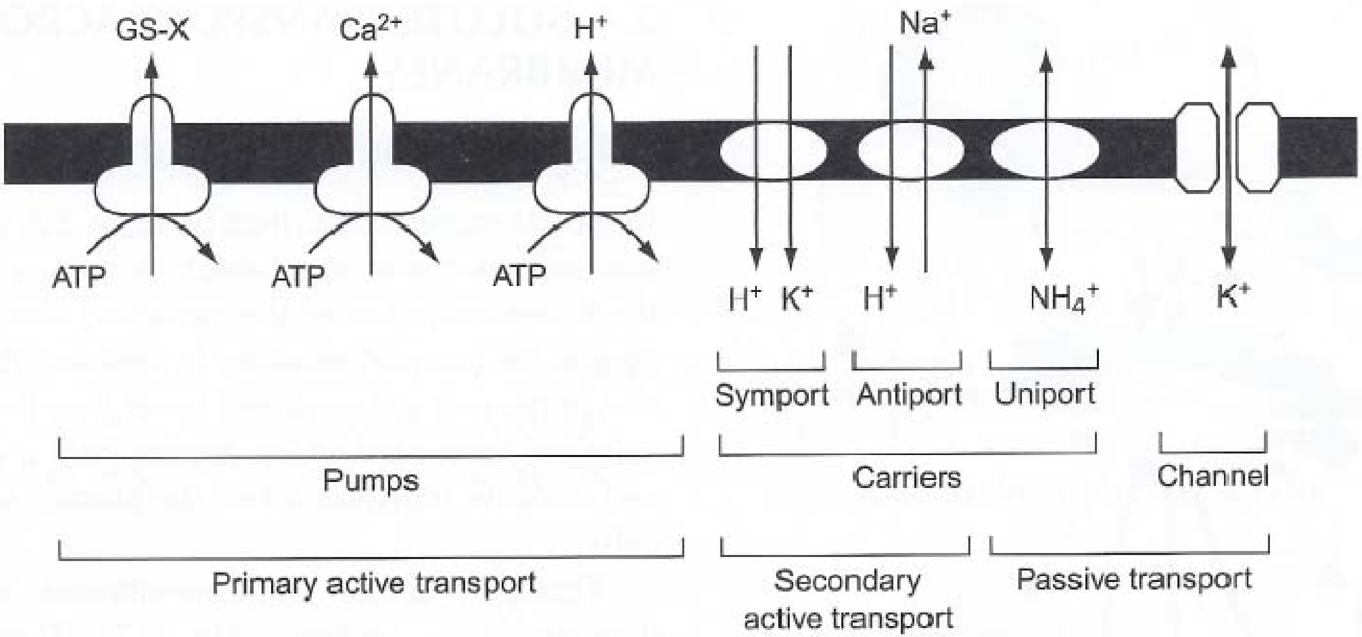


FIGURE 2.7 Nomenclature of transport proteins. Schematic representation of primary active transport mechanisms, such as ABC transporters (e.g., glutathione conjugate pump), metal transporters (e.g., Ca^{2+}-ATPase) and H^+-ATPases, secondary active transport mechanisms, such as the K^+/H^+ symporter or the Na^+/H^+ antiporter, and passive transport mechanisms, such as the NH_4^+ carrier and the K^+ channel. *Figure adapted from White (2003).*

Fig. 18 (Fig. 2.9 in text

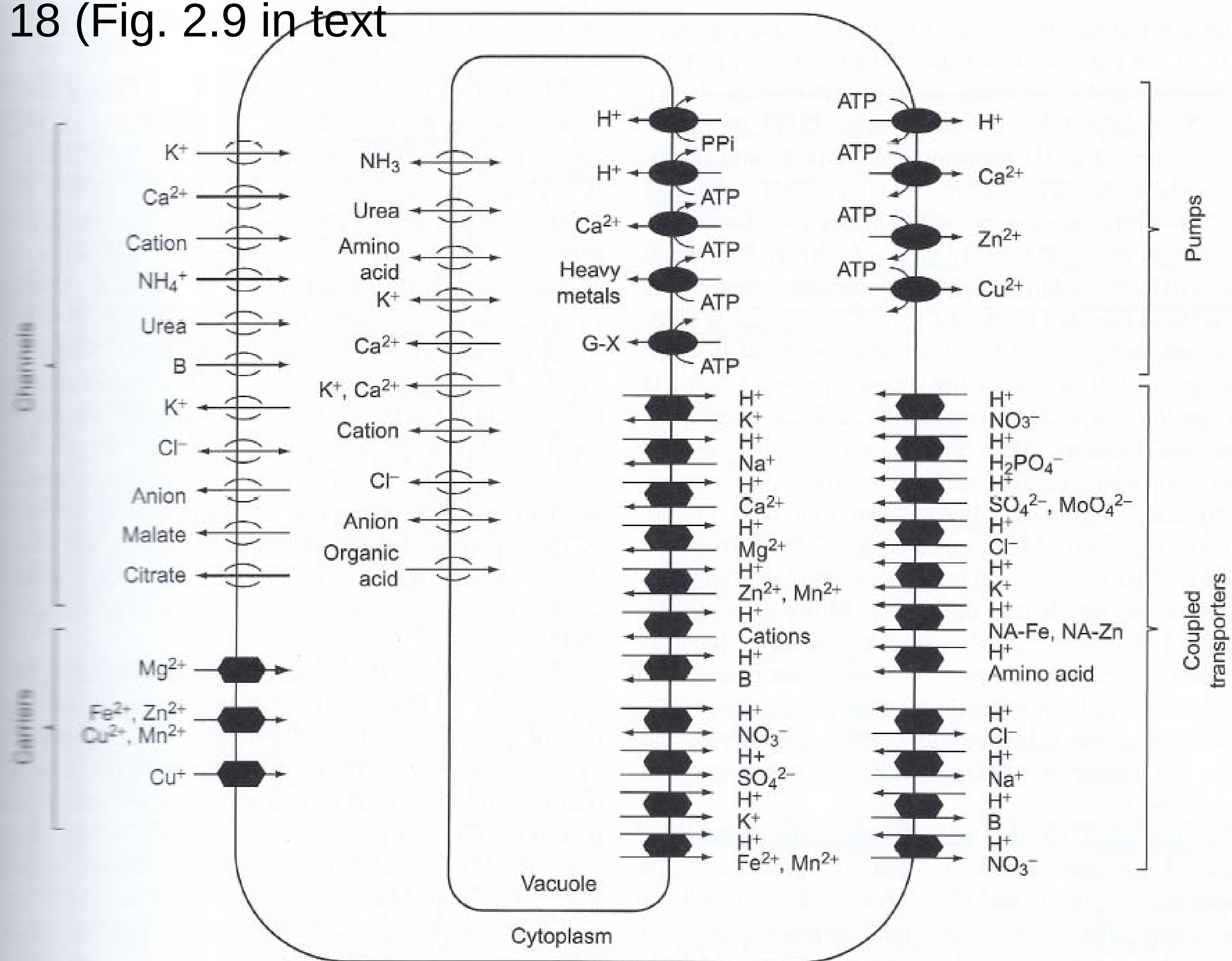


FIGURE 2.9 Transport proteins of the tonoplast and plasma membrane of plant cells. See text (Section 2.4.1) for details.

Fig. 19. Schematic of principal mechanisms of ion transport

Marschner, 1995

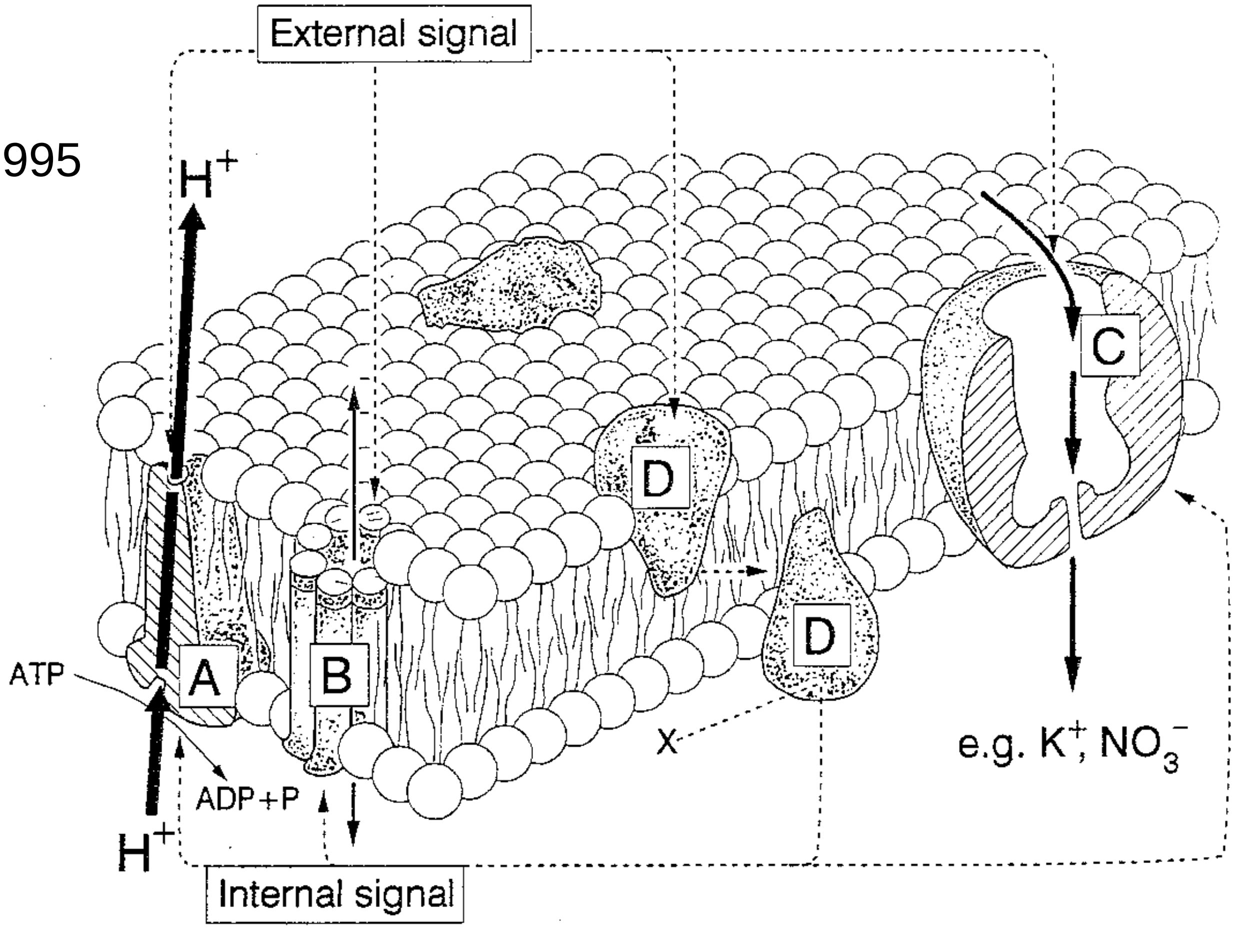


Fig. 2.8 Principal mechanisms of ion transport in plasma membranes. (A) H^+ pumping ATPase; (B) ion channel; (C) carrier; (D) coupling proteins for signal perception and transduction. (Modified from Hedrich *et al.*, 1986; with permission from Trends in Biochemical Sciences.)

Fig. 20 (Fig. 2.21 in text)

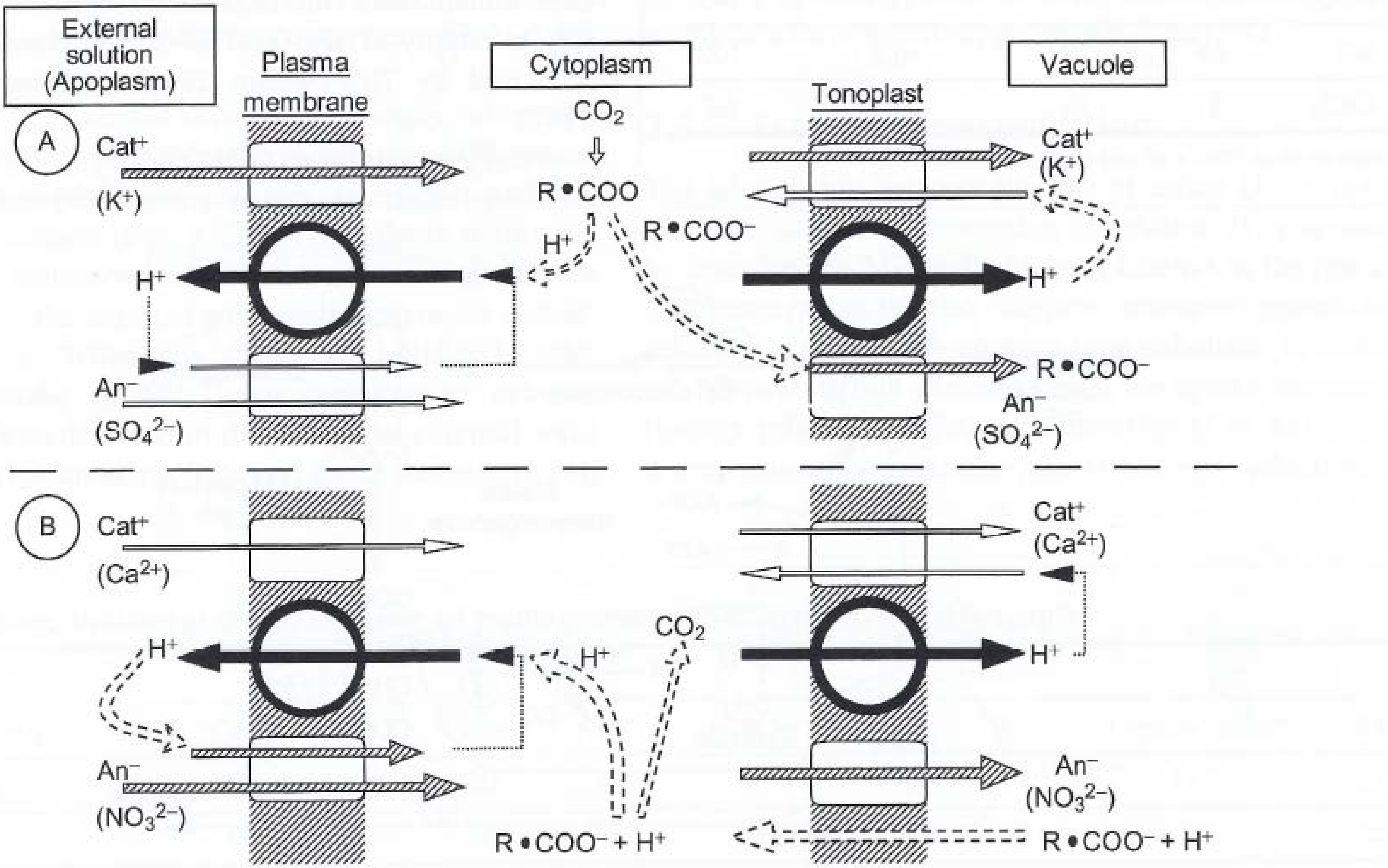


FIGURE 2.21 Model for internal pH stabilization and for charge compensation at different ratios of cation:anion uptake from the external solution. A. Excessive uptake of cations (Cat^+), for example, with K_2SO_4 supply. B. Excessive uptake of anions (An^-), for example, with $Ca(NO_3)_2$ supply.

Fig. 21. Distribution of channels, symporters, and antiporters in a typical plant cell

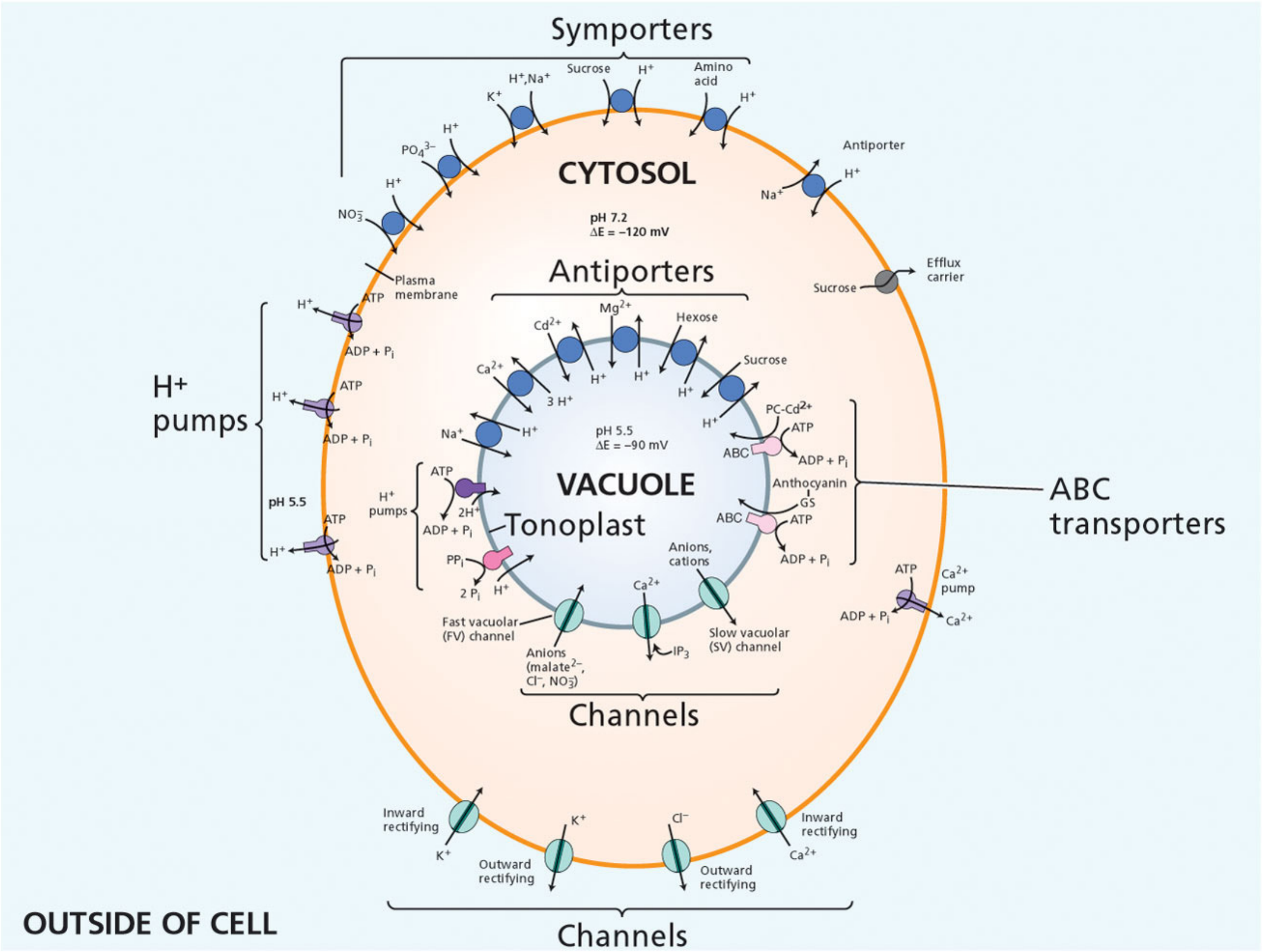


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Fig.22. Additional schematics of transport mechanisms…

Uniport channels (pores, no binding) and carriers (bind) for passive ion uptake, and pumps that use ATP to transport ions against a concentration gradient

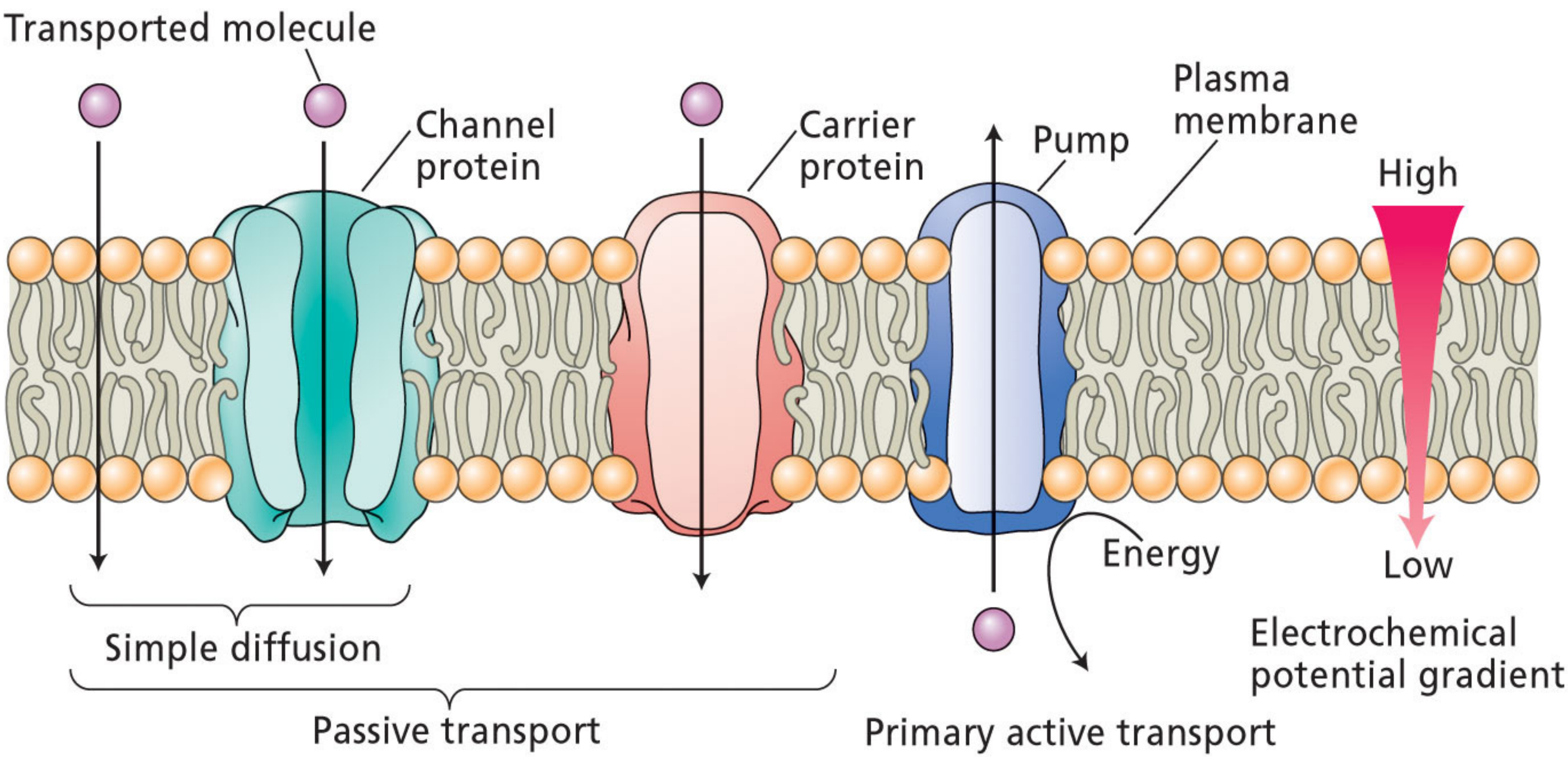

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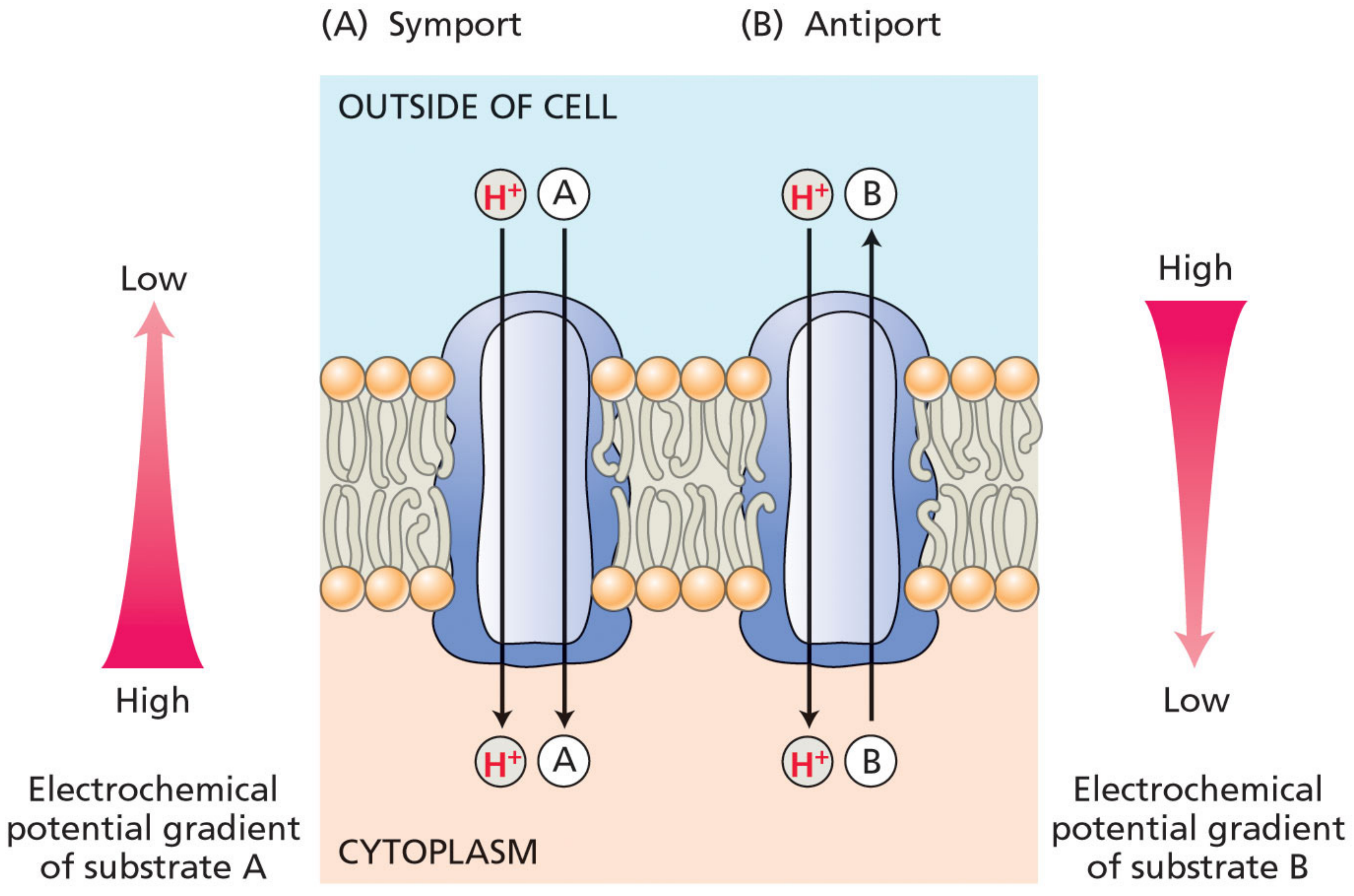
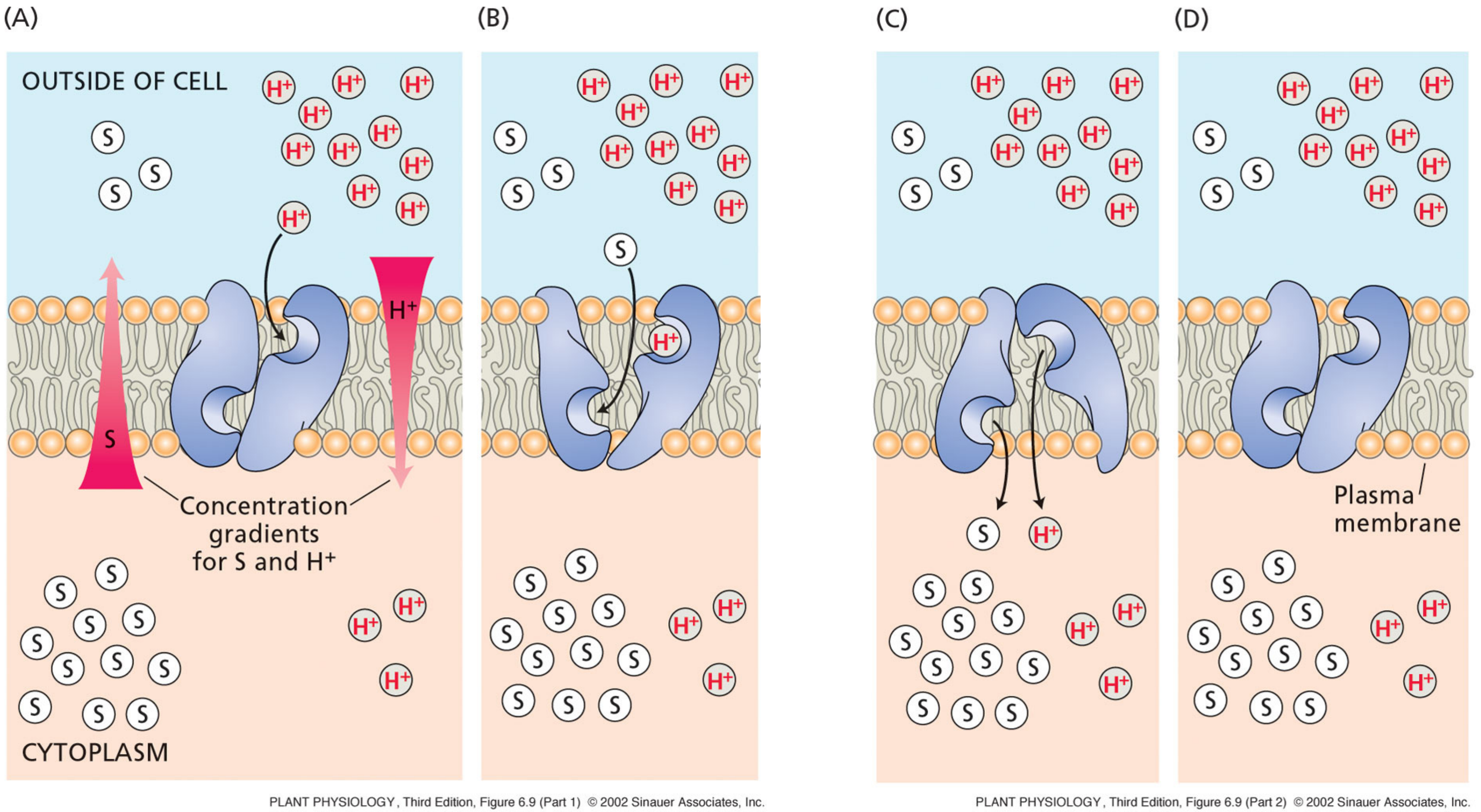
Fig. 23. Schematic of symport and antiport



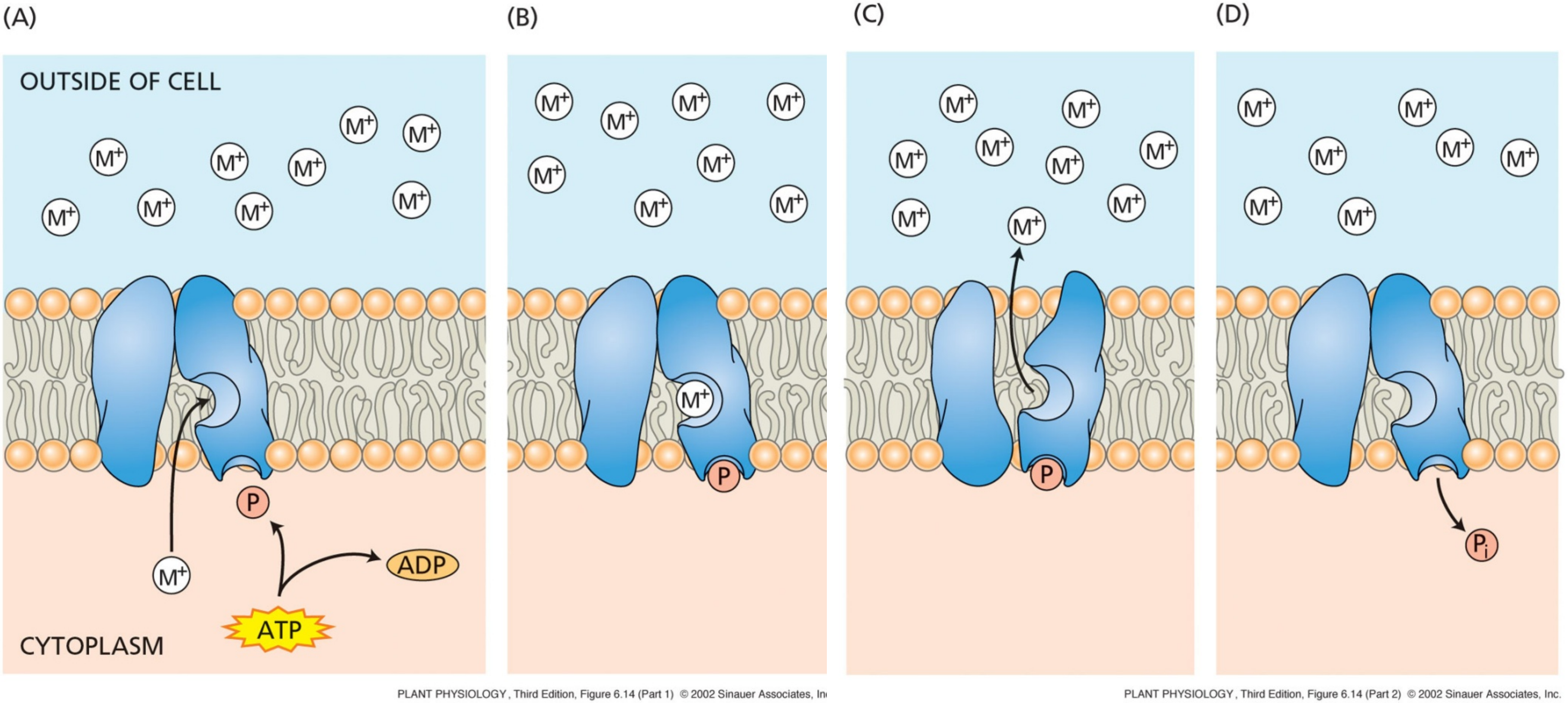
PLANT PHYSIOLOGY , Third Edition, Figure 6.10

Fig. 24. Schematic of a symport in action



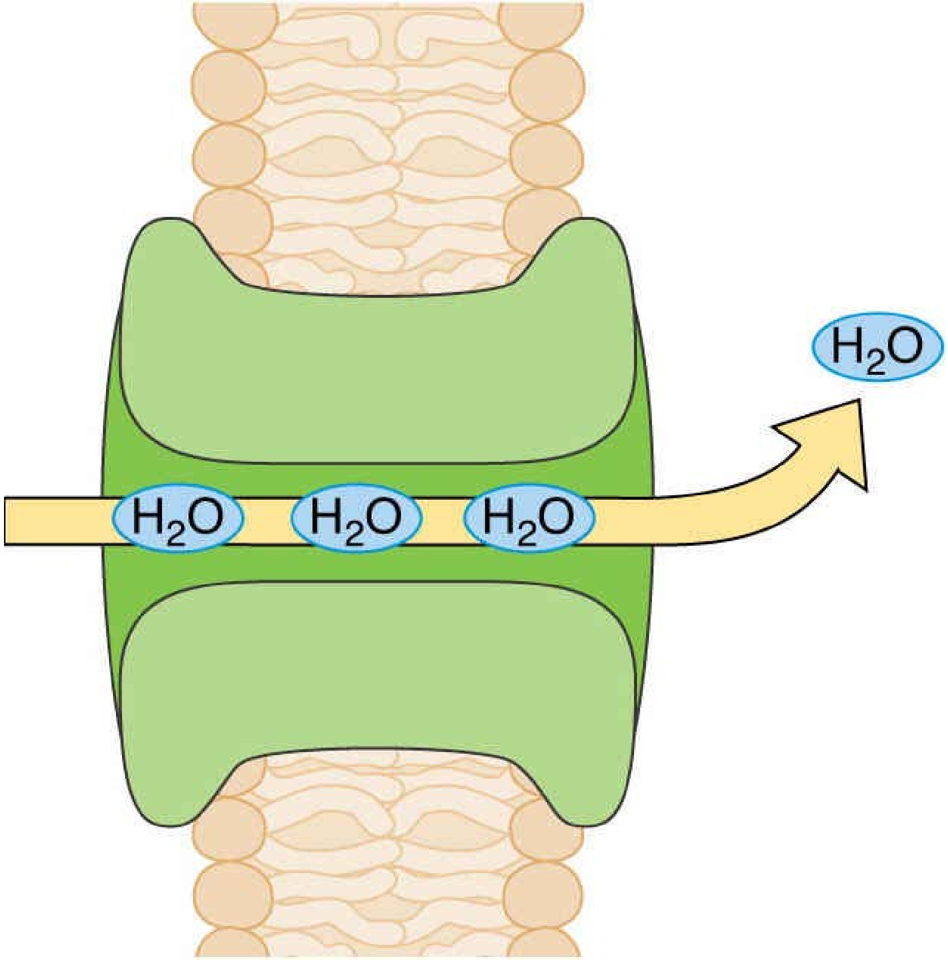
Active uptake of an ion (S) through a symport using the energy stored in the proton gradient across the membrane

Fig. 25. Schematic of a PP$_i$ase pump



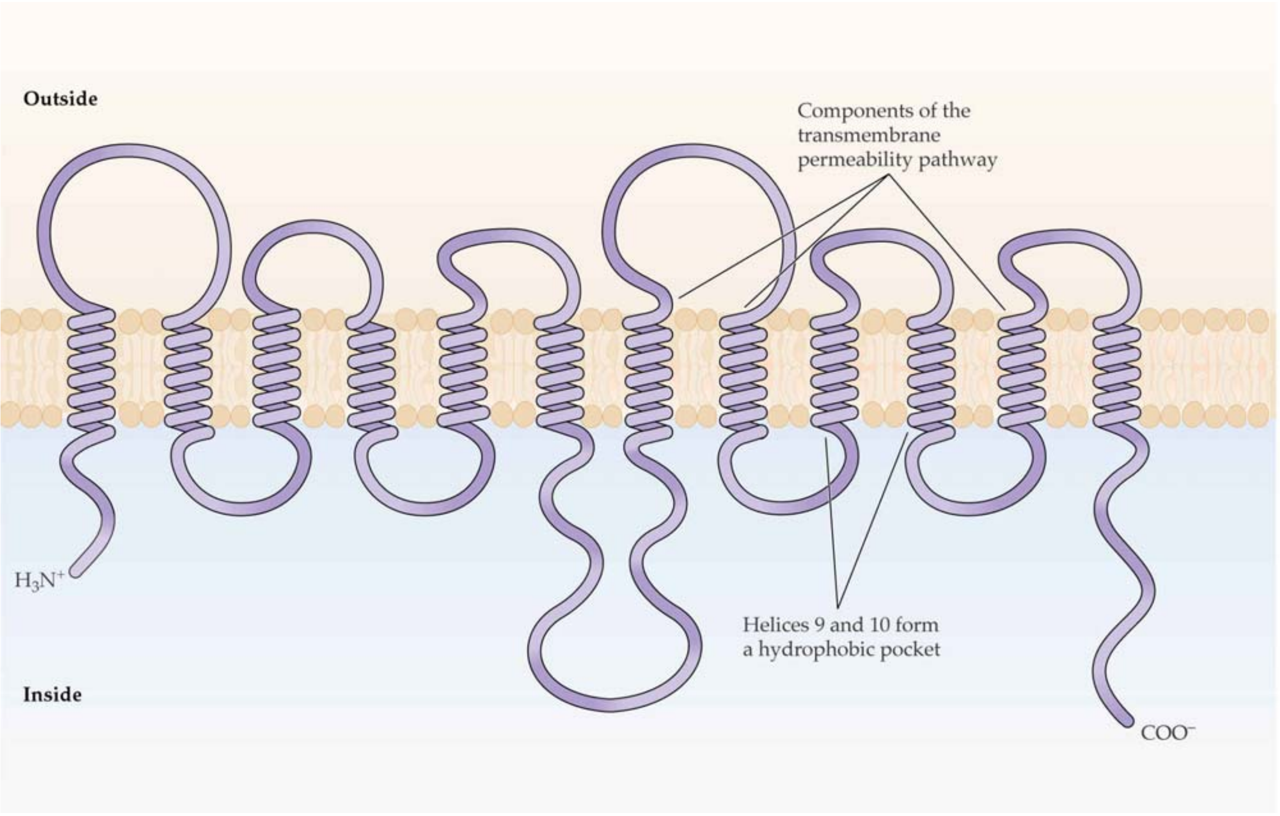
Cation (M^+) transport against a concentration using an ATP-driven carrier

Fig. 26. Aquaporin water channel in a membrane are involved in water transport and osmoregulation. Flux is influenced by phosphorylation

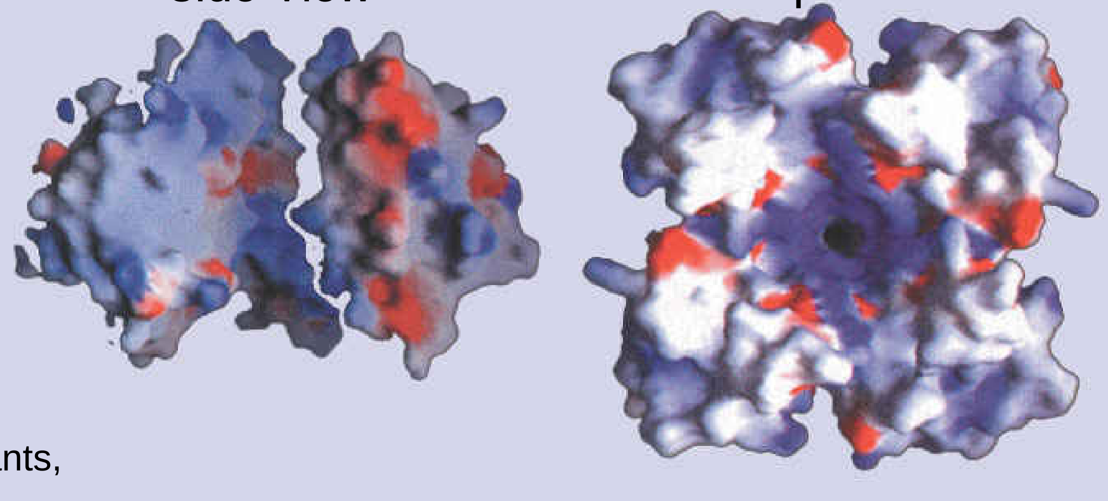


ASPB,
Biochemistry and Molecular Biology of Plants,
2000

Fig. 27. Features of Transporters



Two dimensional view of a carrier protein spanning a membrane



Three dimensional model of a potassium channel showing the pore through which K ions travel. Positively charged regions are blue, while negatively charges regions are red.

ASPB,
Biochemistry and Molecular Biology of Plants,
2000