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Manures , Fertilizers and Soil Fertility Management

13. Mechanisms of nutrient transport

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13.1

Nutrient uptake by roots:

Nutrient uptake by roots is shared by all young root parts and especially by a zone of root hairs which up to hundreds of times increases the surface area of a root.

The number of root hairs in 1 mm fluctuates according to humidity, soil aeration and plant type. For instance, regarding alfalfa, maize and English ryegrass grown on a light soil 1 mm of the root length comprises the number of hairs of 105, 161, 88 and their total length reached 37, 146, 99 mm.

Root hairs have a limited lifetime (about 10-12 days). Gradual growth of new hairs enables new and new connection of a plant with the soil environment.



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Absorption speed of single nutrients by **plant leaves** (Hudská 1976)

Nutrients	Time at 50% absorption
Nitrogen in urea	1/2 to 2 hr.
magnesium	2-5 hr
potassium	10-24 hr.
calcium, manganese, zinc	1-2 days
phosphorus	5-10 days
iron, molybdenum	10-20 days



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Absorption and relative **mobility of foliarly** applied nutrients (Wittwer a Bukovac 1989)

Adsorption order	Mobility order mobility
Fast: N (urea), Rb, Na, K, Cl, Zn	Mobile: N (urea), Rb, Na, K, P, Cl, S
Medium fast: Ca, S, Ba, P, Mn, Br	Partly mobile: Zn, Cu, Mn, Fe, Mo, Br
Slow: Mg, Sr, Cu, Fe, Mo	Immobile: Mg, Ca, Sr, Ba



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After taken in by the roots, the nutrients move into the plant and are used for various functions and processes. ... There's general agreement among plant physiologists that there are three mechanisms by which nutrients reach the surface of the root hairs. These are:

- 1) Root interception,**
- 2) Mass flow, and**
- 3) Diffusion.**



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Root interception:

Root interception occurs when a nutrient comes into physical contact with the root surface. As a general rule, the occurrence of root interception increases as the root surface area and mass increases, thus enabling the plant to explore a greater amount of soil.

The CEC of roots for monocots is 10 - 30 meq/100 g and takes up monovalent cations more readily and that of Dicots is 40 - 100 meq/100 g and takes up divalent cations more readily.



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Factors affecting root interception:

- A. Anything that restricts root growth
 - i. Dry soil
 - ii. Compaction
 - iii. Low soil pH
 - iv. Poor aeration
 - v. Root disease, insects, nematodes
 - vi. High or low soil temperature

- B. Root growth is necessary for all three mechanisms of nutrient supply, but absolutely essential for root interception to occur



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Mass flow:

Mass flow occurs when nutrients are transported to the surface of roots by the movement of water in the soil (i.e. percolation, transpiration, or evaporation). The rate of water flow governs the amount of nutrients that are transported to the root surface.

Therefore, mass flow decreases as soil water decreases. Most of the nitrogen, calcium, magnesium, sulfur, copper, boron, manganese and molybdenum move to the root by mass flow. Quantity of nutrients transported is proportional to:

- i. Rate of flow (volume of water transpired)
- ii. Solution concentration of nutrient

Nutrients supplied primarily by mass flow are considered mobile nutrients. e.g. N, S, B



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Factors affecting mass flow:

a. Soil water content:

- i. Dry soil where there is no nutrient movement

b. Temperature:

- i. Low temperature reduces transpiration and evaporation

c. Size of root system :

- i. Affects water uptake and therefore movement
- ii. Root density much less critical for nutrient supply by mass flow than for root interception and diffusion



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Diffusion:

Diffusion is the movement of a particular nutrient along a concentration gradient. When there is a difference in concentration of a particular nutrient within the soil solution, the nutrient will move from an area of higher concentration to an area of lower concentration.

Diffusion delivers appreciable amounts of phosphorus, potassium, zinc, and iron to the root surface. Diffusion is a relatively slow process compared to the mass flow of nutrients with water movement toward the root. Nutrients supplied primarily by diffusion are considered immobile nutrients e.g. P, K

Factors



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Factors affecting diffusion

Diffusion rate:

It is directly proportional to concentration gradient, diffusion coefficient, and the area available for diffusion to occur

Fick's law is given as

$$dC/dt = D_e * A * dC/dX$$

dC/dt = diffusion rate (change in concentration over time)

D_e = effective diffusion coefficient

A = cross sectional area for diffusion

dC/dX = concentration gradient (change in concentration over distance)

Factors affecting diffusion:

Effective diffusion coefficient

a. Diffusion coefficient in water (D_w)

i. Includes a temperature factor

ii. Colder = slower diffusion

b. Soil water content

i. Drier soil = slower diffusion

ii. Less water = less area to diffuse through

c. Tortuosity

i. Pathways through soil are not direct

ii. Around soil particles, through thin water films

iii. Affected by texture and water content
1. More clay = longer diffusion pathway
2. Thinner water films = longer path

d. Buffering capacity

i. Nutrients can be removed by adsorption as they move through soil, reducing diffusion rate



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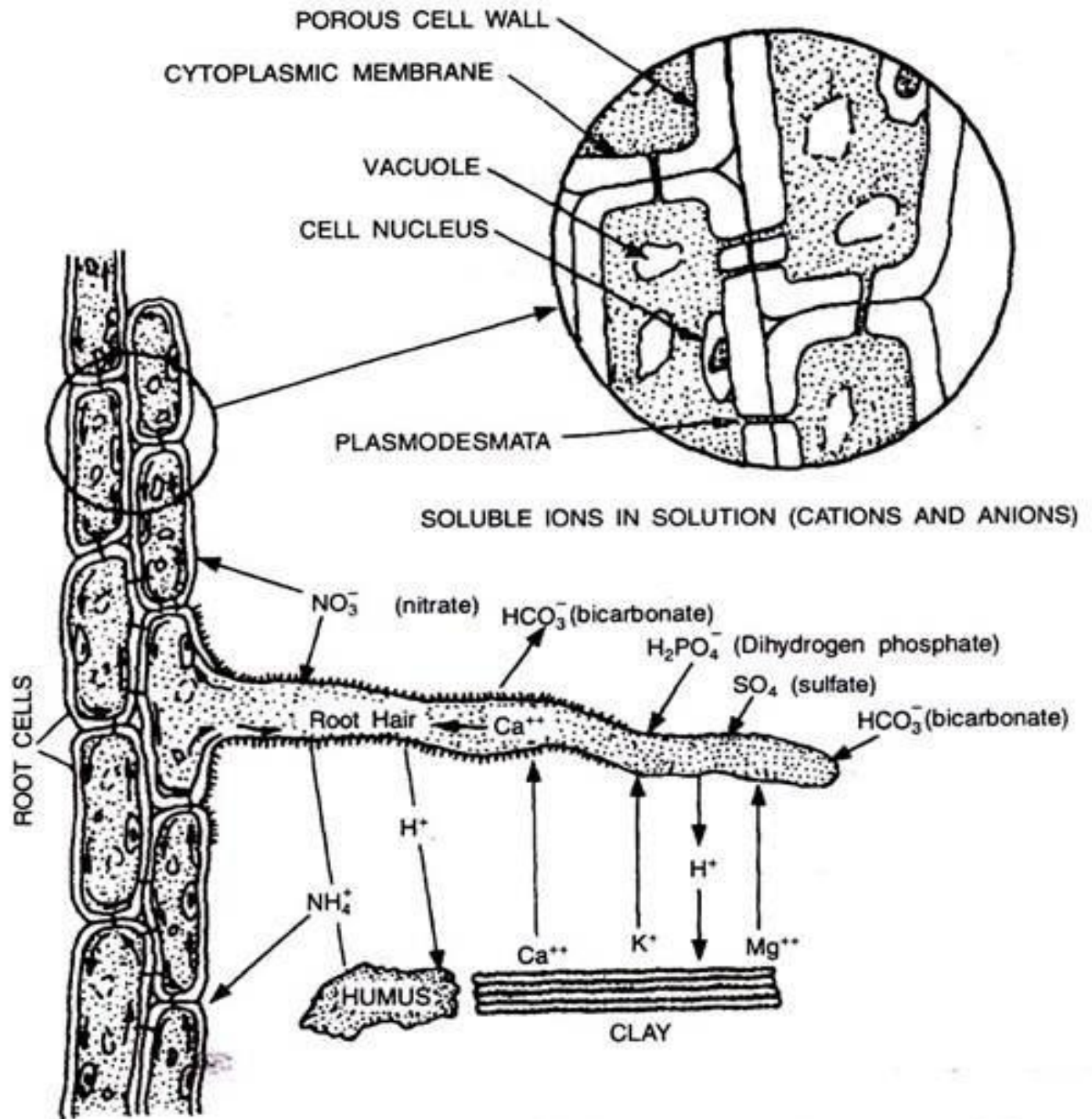
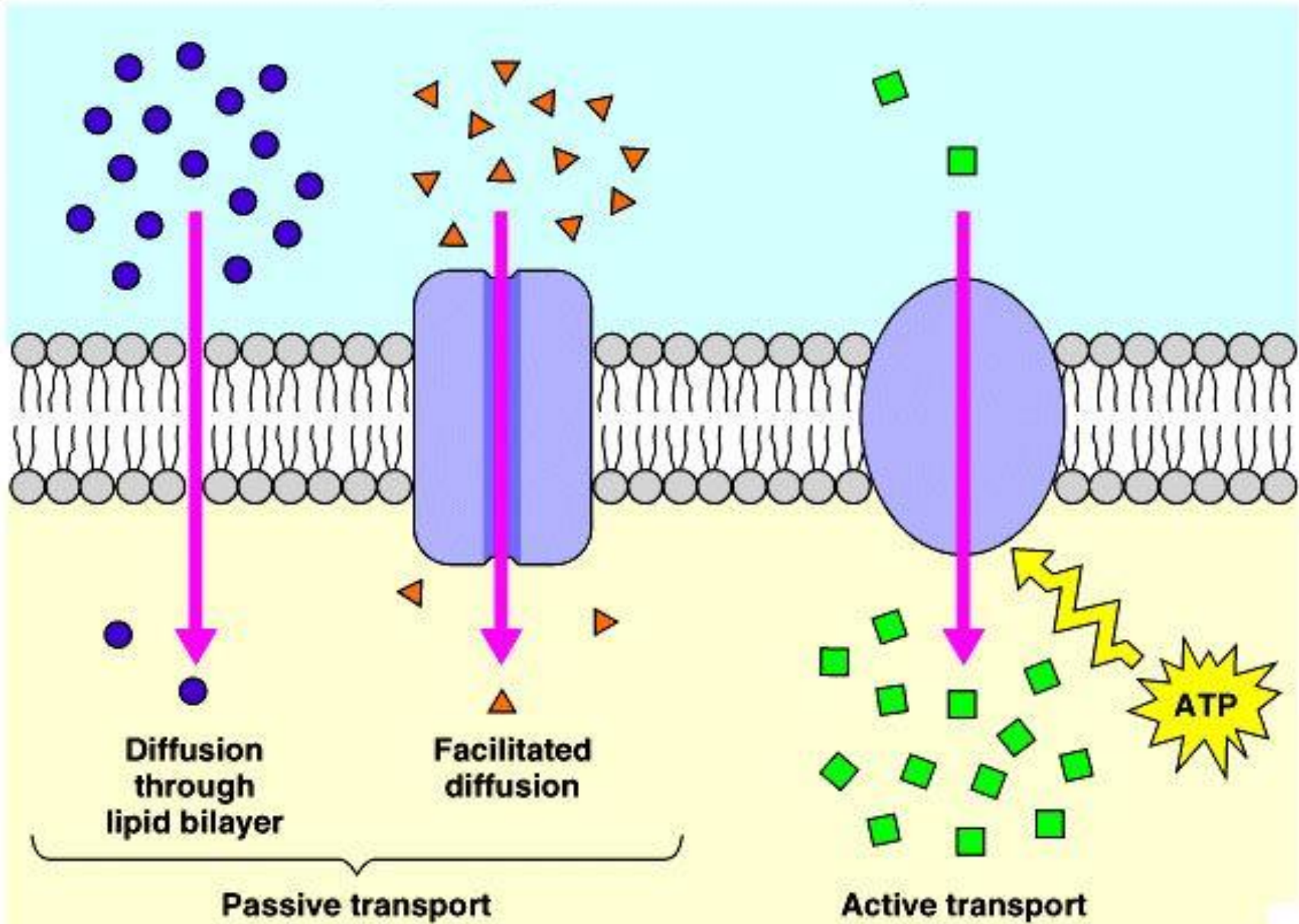


Fig. 20.4. Mechanism of nutrient absorption from the soil solution by root hairs.

Figure 8.14 Review: A comparison of passive and active transport



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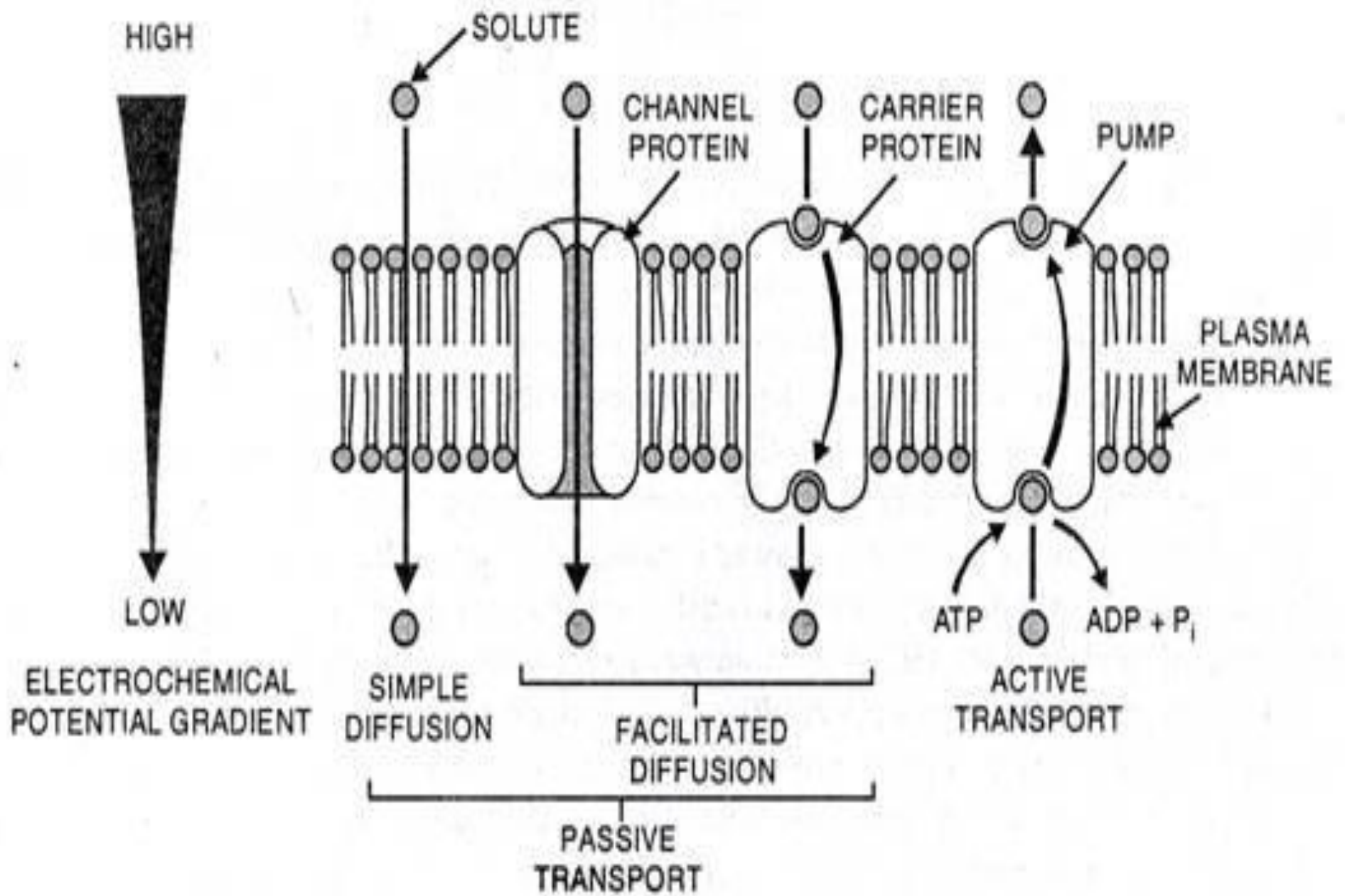


Fig. 7.6. Diagrammatic representation of passive and active transport of solutes across the membrane.

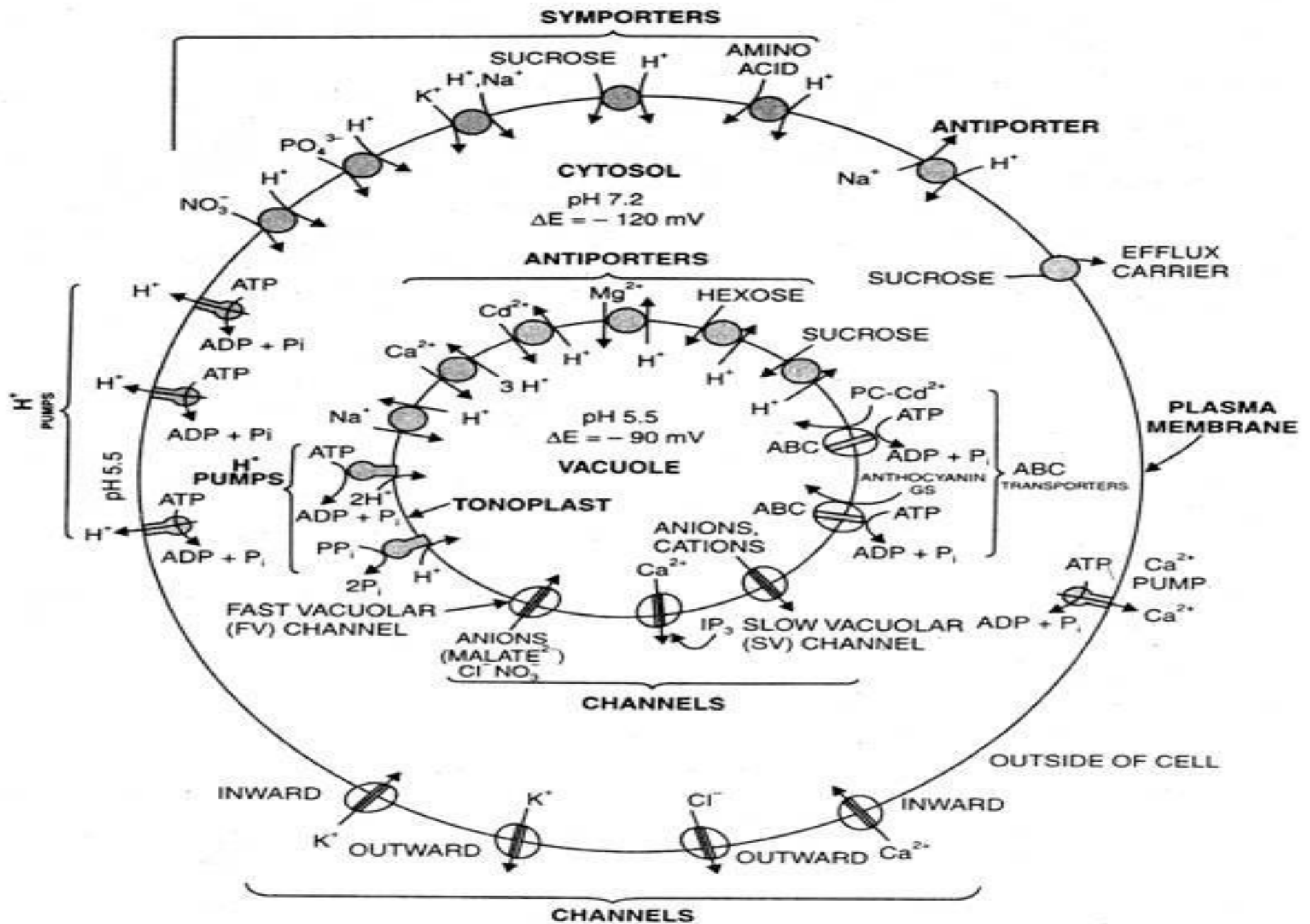


Fig. 7.10. An overview of various solute transport processes through plasmamembrane and tonoplast in plants. IP_3 = inositol triphosphate, a secondary messenger that triggers opening of calcium channels; ΔE = Nernst* potential *i.e.*, electric potential difference at equilibrium in millivolts (mV). The minus sign indicates that the inside is negative relative to the outside



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Thank you