MEDICAL UNIVERSITY – PLEVEN
FACULTY OF PHARMACY

DIVISION OF PHYSICS AND BIOPHYSICS, HIGHER MATHEMATICS AND INFORMATION TECHNOLOGIES

LECTURE No9

MEMBRANE TRANSPORT. FREE DIFFUSION OF UNCHARGED AND CHARGED PARTICLES

Membrane transport – classification. Fick's law.
Nernst-Planck molar flux equation.

Prof. M. Alexandrova, DSc

1. Transport classification

Depending on the transport mechanism

Nonmediated and *Mediated* transport

occurs through simple diffusion

occurs through the action of specific carrier proteins.

The driving force for the nonmediated flow of a substance through a medium is its chemical potential gradient.

The substance diffuses in the direction that eliminates its concentration gradient, at a rate proportional to the magnitude of this gradient. The rate of diffusion of a substance also depends on its solubility in the membrane's nonpolar core.

Depending on the type of energy supply

Passive transport in which a specific molecule flows from high concentration to low concentration.

Three distinctive types of passive transport are recognised in biological systems:

- simple diffusion;
- osmosis and hydrostatic pressure driven flow;
- facilitated diffusion.

Active transport, in which a specific molecule is transported from low concentration to high concentration, i.e. against its concentration gradient. Such an endergonic process must be coupled to a sufficiently exergonic process to make it favourable ($dG < 0$).

1. *Primary active transport* – directly powered by the chemical reaction (like ATP hydrolysis). Sodium-potassium pump is a known example of primary active transport.

2. *Secondary active transport* – coupled with primary active transport. Transport of glucose from the intestine lumen into the epithelial cells is an example of such a transport.

Depending on the number of transported species and direction of their translocation

Uniport – transport of one substance in one direction.

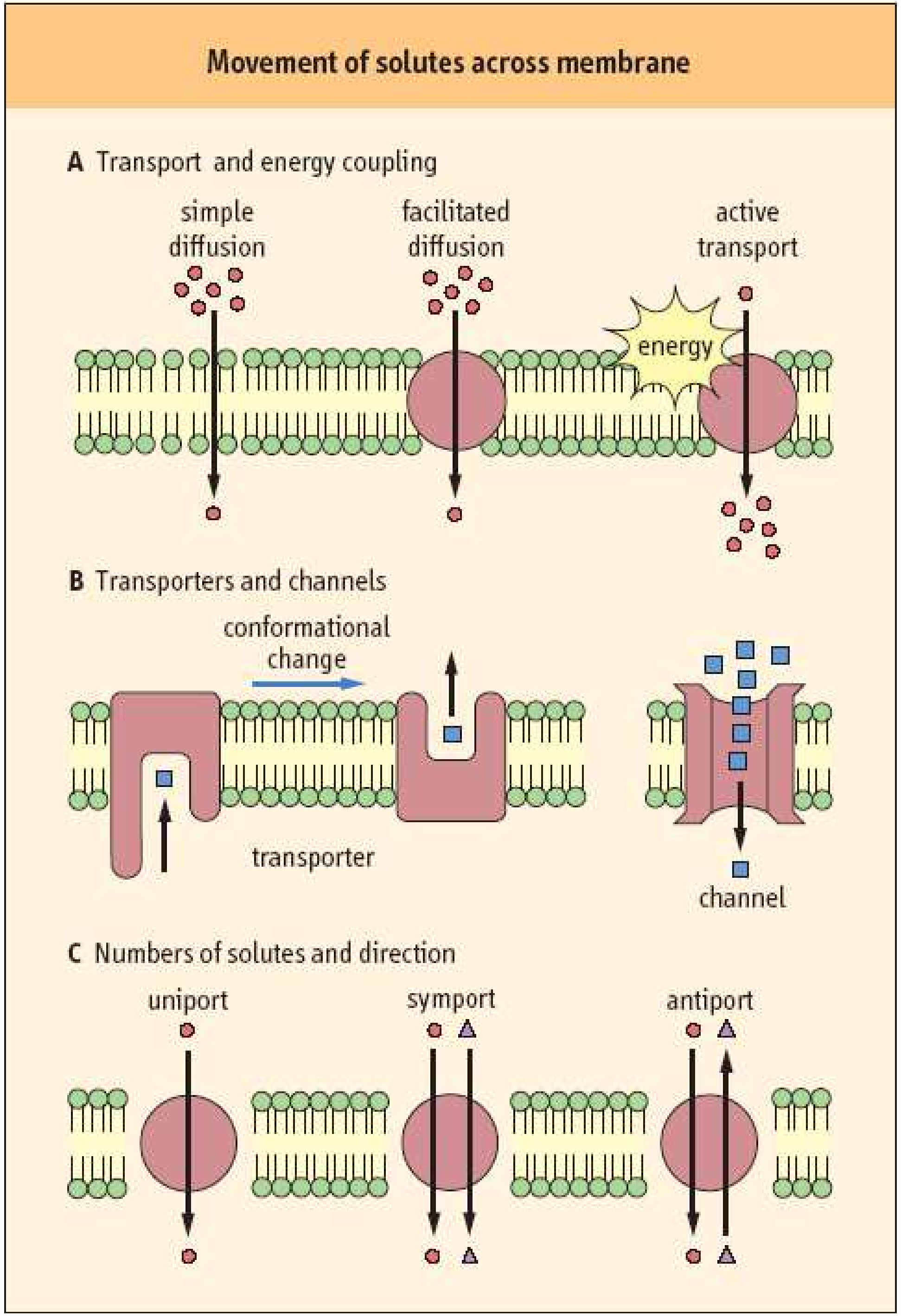
Joint transport – simultaneous transport of two or more substances by one transport system

if in the same direction - symport

if in the opposite directions - antiport

The movement of one substrate uphill can be driven by the movement of another substrate (usually a cation such as Na^+ or H^+) down a gradient. Uniport of charged substrates may also be electrophoretically driven by the membrane potential of the cell.

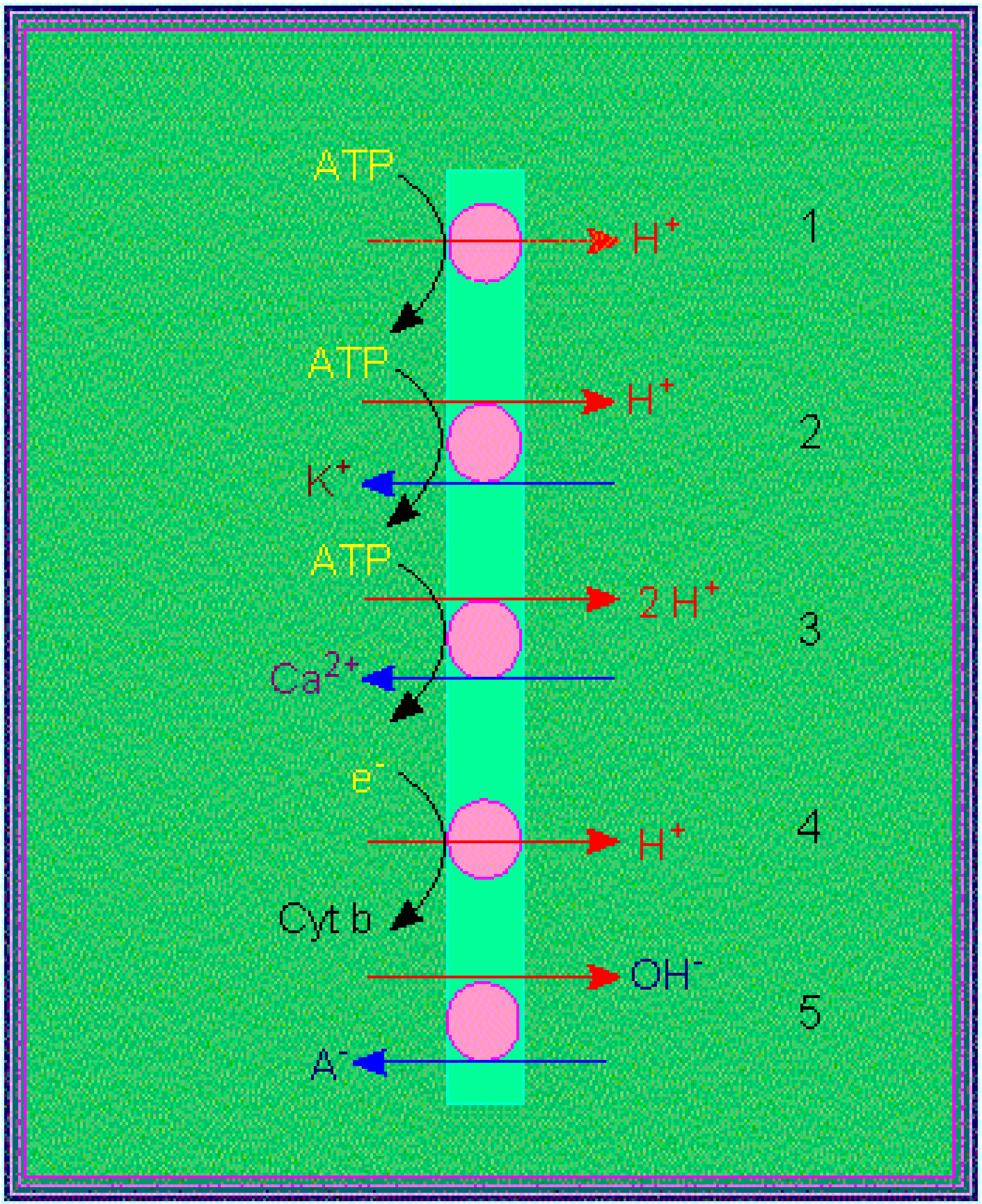
The proteins participating in these transport systems are termed uniporters, symporters, and antiporters, respectively. Uniport, symport, and antiport are alternative mechanisms of facilitated transport.


Movement of solutes across membrane
A Transport and energy coupling
simple diffusion
facilitated diffusion
active transport
energy
B Transporters and channels
conformational change
transporter
channel
C Numbers of solutes and direction
uniport
symport
antiport

Depending on the changes produced in the transmembrane electric voltage

ELECTRONEUTRAL TRANSPORT – it does not change the value of the transmembrane potential ($1Na^+$ and $1Cl^-$ in one direction or $1Na^+$ and $1K^+$ in opposite directions).

ELECTROGENIC TRANSPORT – it changes the membrane potential. For example charged particles of the same magnitude and sign of the charge are transported in one direction or charged particles of the different magnitude and same sign of the charge are transported in opposite direction ($3Na^+$ against $2K^+$).



Proton pumps:

1. electrogenic pump
2. electroneutral pump

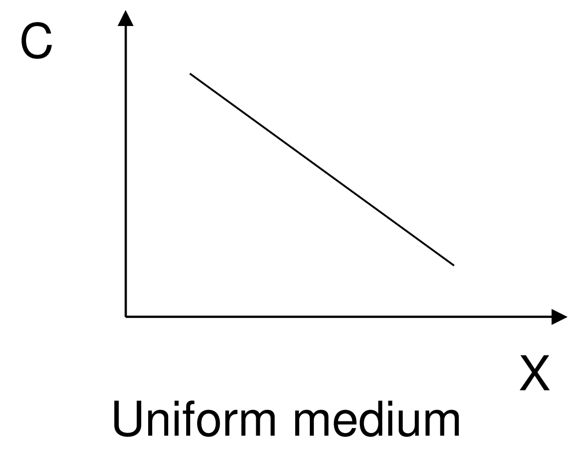
3. electroneutral pump with calcium as its counterion

4. electrogenic proton transport

5. electroneutral anion / OH antiport

Free diffusion of non-charged particles

$$J = -D\frac{dc}{dx}$$



Einstein in 1905 showed that diffusion coefficient (D) and mobility (u) can be related by:

$D = uRT$, where T is absolute temperature and u is particle mobility.

$v = u\,F$ (u is a coefficient of proportionality which can be defined as the velocity of molecule per unit force). Thus Fick's law can be rewritten in the following way:

$$J = -uRT\frac{dc}{dx}$$

Free diffusion of charged particles (Drift)

It is also called electrophoresis. It is the movement of electrically charged particles in electric fields.

$$J = -cuFz\frac{d\varphi}{dx}$$

$$J = -uRT\frac{dc}{dx} - cuFz\frac{d\varphi}{dx}$$

Nernst-Planck molar flux equation