ACTIVE TRANSPORT

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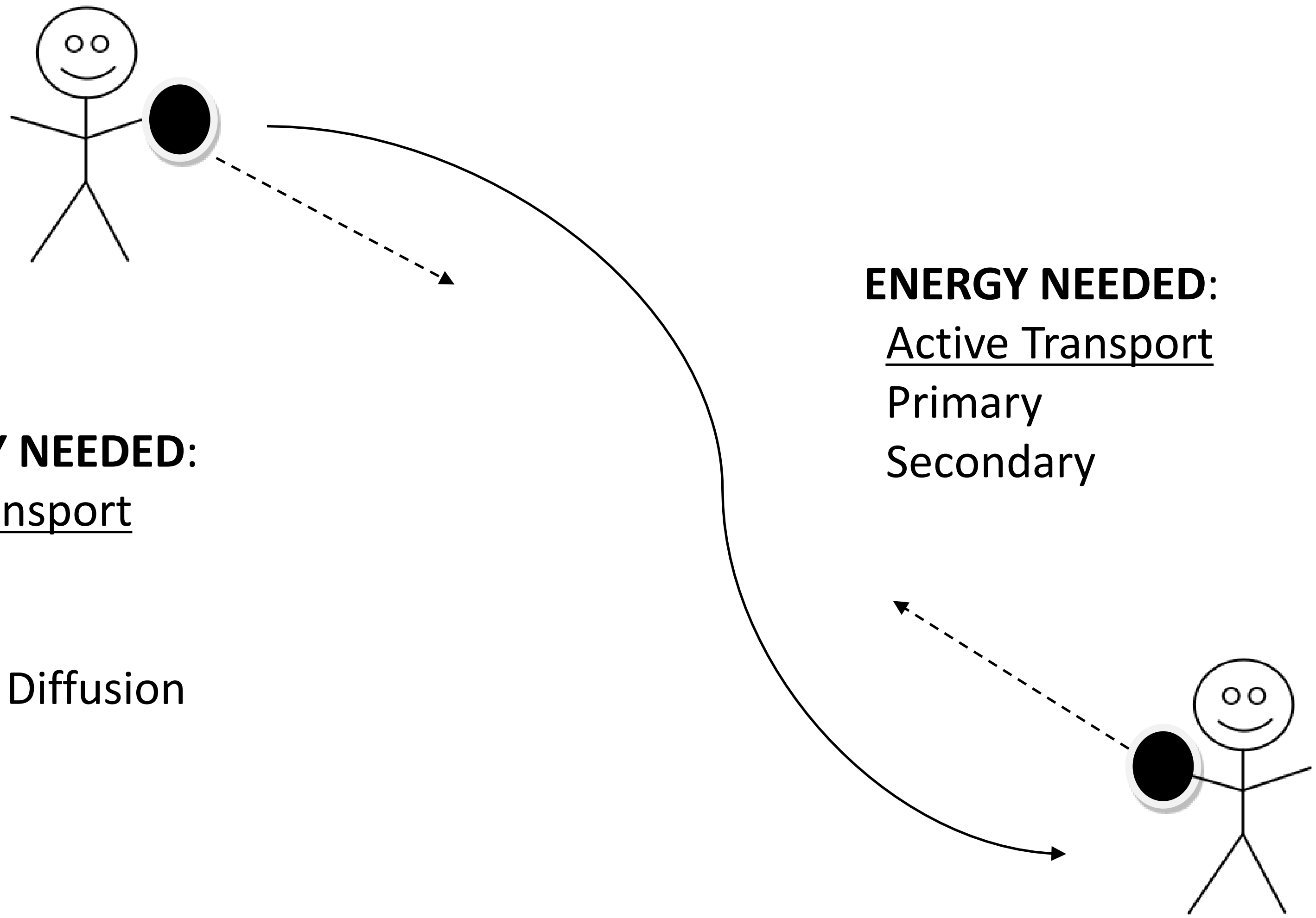
ANALOGY:



NO ENERGY NEEDED:

Passive transport

Diffusion

Osmosis

Facilitated Diffusion

ENERGY NEEDED:

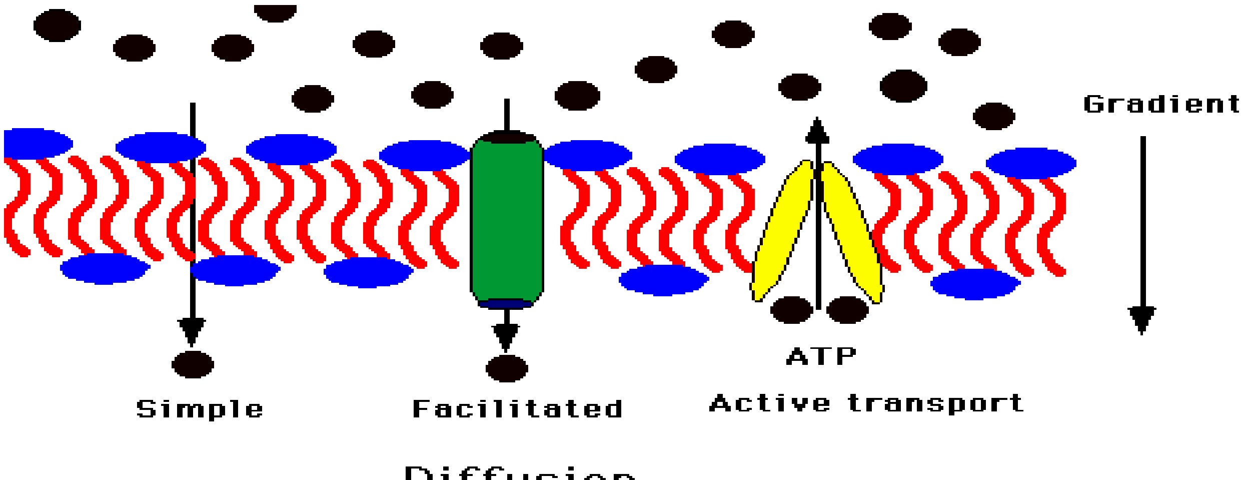
Active Transport

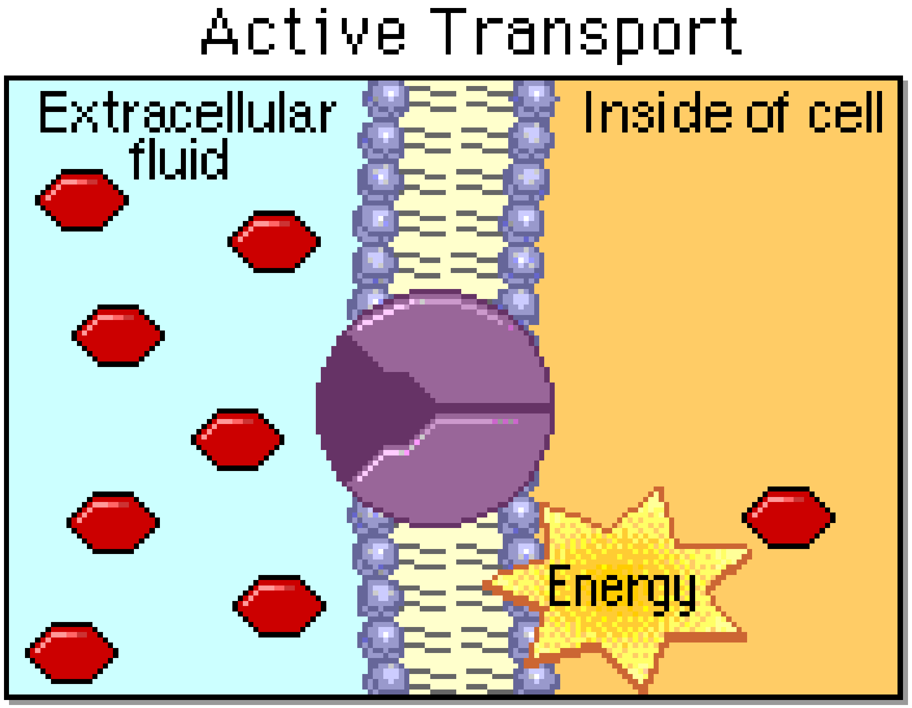
Primary

Secondary

Active Transport

- Molecules move **against** the concentration gradient (low to high)
- Energy must be provided
- Exhibit saturation kinetics




Active Transport
Extracellular fluid
Inside of cell
Energy

Active Transport

- Active transport is divided into two types according to the source of the energy used to cause the transport:

- 1. Primary active transport
- 2. Secondary active transport.

Primary active transport

- They use the energy directly from the hydrolysis of ATP.

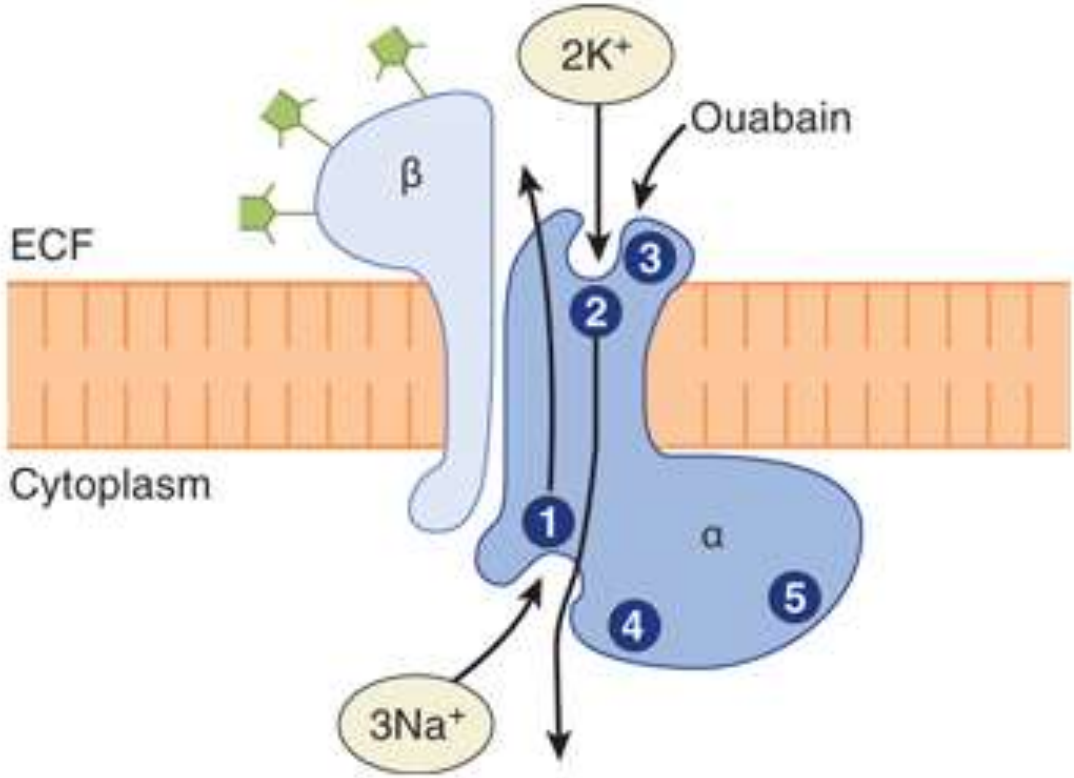
❑Sodium potassium Pump

❑Calcium pump

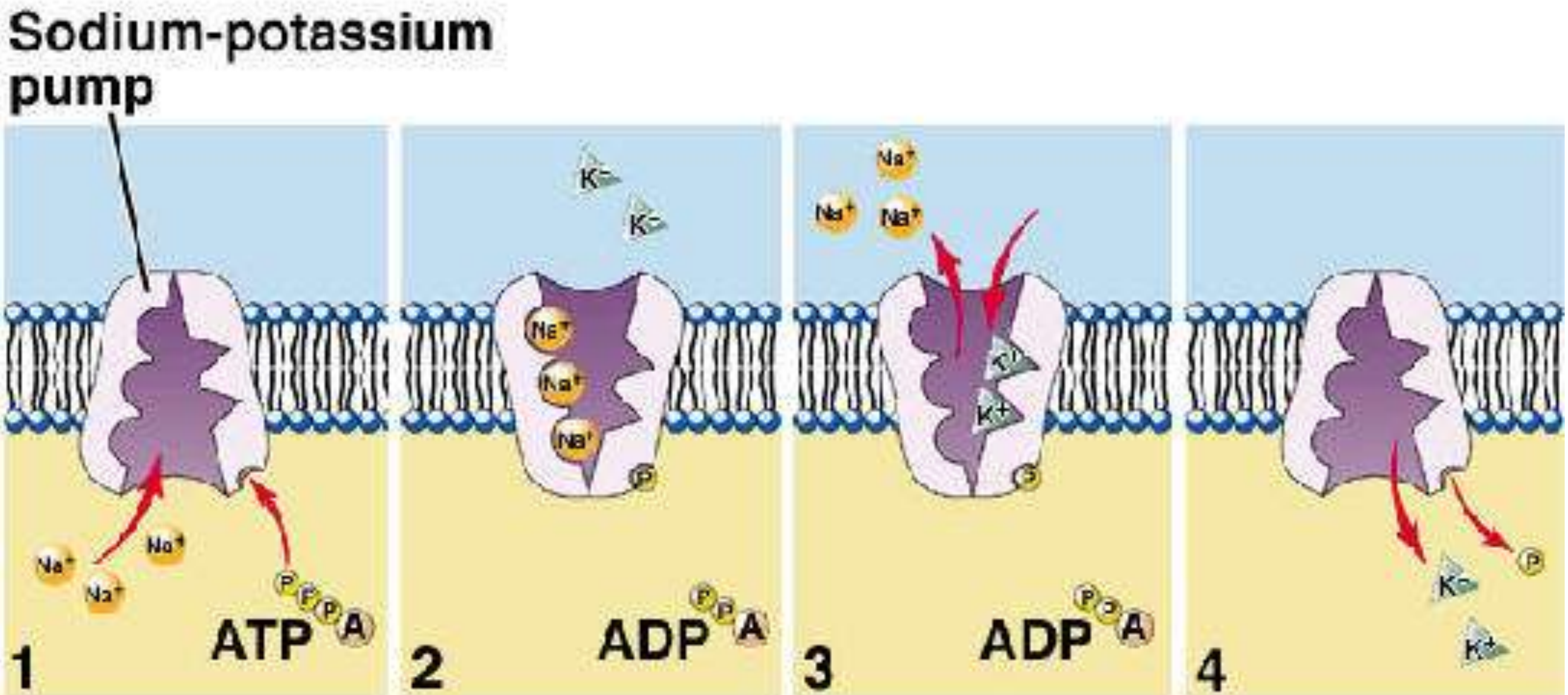
❑Hydrogen Potassium pump

❑Hydrogen / Proton pump

Sodium potassium pump



Sodium-Potassium Pump



Sodium potassium pump

- present in all eukaryotic cells

Functions:

1. Maintains sodium potassium concentration difference across the cell membrane.

2. Maintains volume of the cell.

3. Causes negative electrical charge inside the cell – electrogenic pump

4. Essential for oxygen utilization by the kidneys

Calcium pump

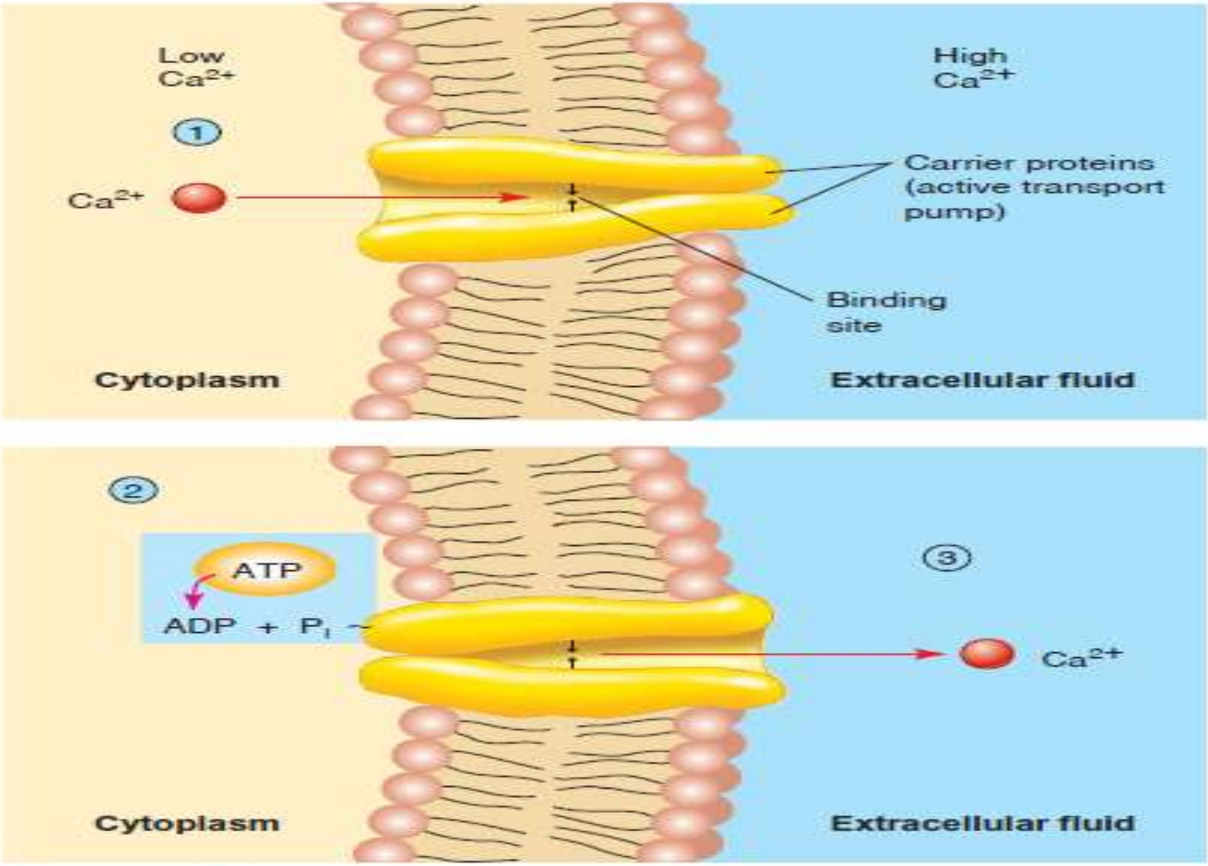


Figure 6.18 **An active transport pump.** This carrier protein transports Ca^{2+} from a lower concentration inside the cell to a higher concentration outside of the cell, and is thus known as a Ca^{2+} pump. (1) Ca^{2+} within the cell binds to sites in the carrier protein. (2) ATP is hydrolyzed into ADP and phosphate (P_i), and the phosphate is added to the carrier protein; this phosphorylation causes a hingelike motion of the carrier. (3) The hingelike motion of the carrier protein allows Ca^{2+} to be released into the extracellular fluid.

Calcium pump

- Calcium ions are normally maintained at extremely low concentration in the intracellular cytosol of virtually all cells in the body, at a concentration about 10,000 times less than that in the extracellular fluid.

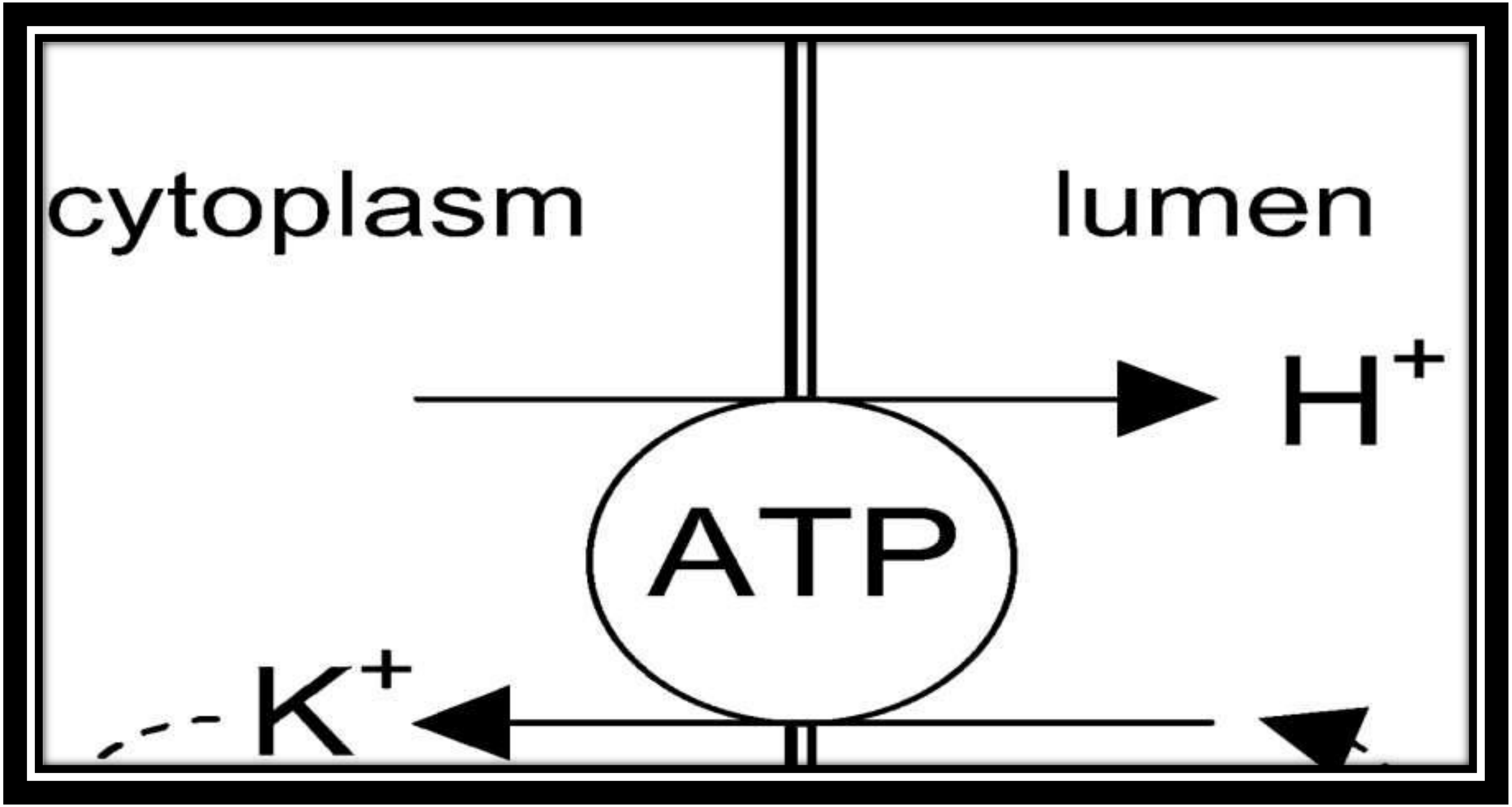
- This is achieved mainly by two primary active transport calcium pumps.
- One is in the cell membrane and pumps calcium to the outside of the cell.
- The other pumps calcium ions into one or more of the intracellular vesicular organelles of the cell, such as the sarcoplasmic reticulum of muscle cells and the mitochondria in all cells.

Hydrogen Potassium pump
H^{+}-K^{+} ATPase

- Gastric glands - parietal cells - hydrochloric acid secretion – pumps hydrogen ions into the gastric lumen in exchange for potassium

- Renal tubules - intercalated cells in the late distal tubules and cortical collecting ducts – secretion of hydrogen ions & reabsorption of potassium ions.

Hydrogen Potassium pump
H^+-K^+ ATPase



Proton pump
H^+ ATPase

- Present in lysosome and endoplasmic reticulum
- Pumps proton from cytosol into these organelles.

Secondary active transport

Secondary active transport

- Energy utilized in the transport of one substance helps in the movement of the other substance.

- Energy is derived secondarily, from energy that has been stored in the form of ionic concentration differences of secondary molecular or ionic substances between the two sides of a cell membrane, created originally by primary active transport.

Co-transport/ Symport

- The transport of Na^+ via its concentration gradient is coupled to the transport of other substances in the same direction
- Carrier protein
- E.g SGLT
- Sodium glucose Co-transport

Co-transport/ Symport

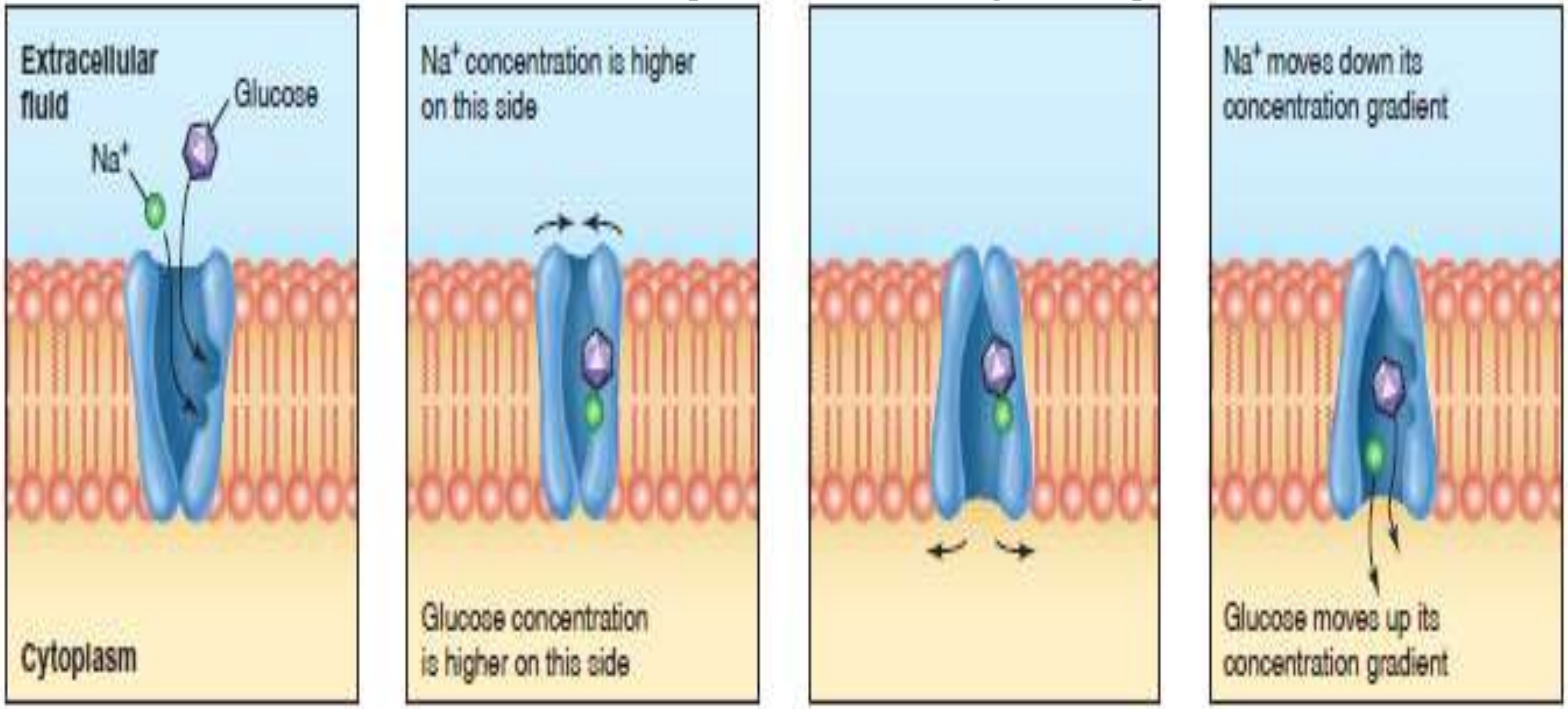
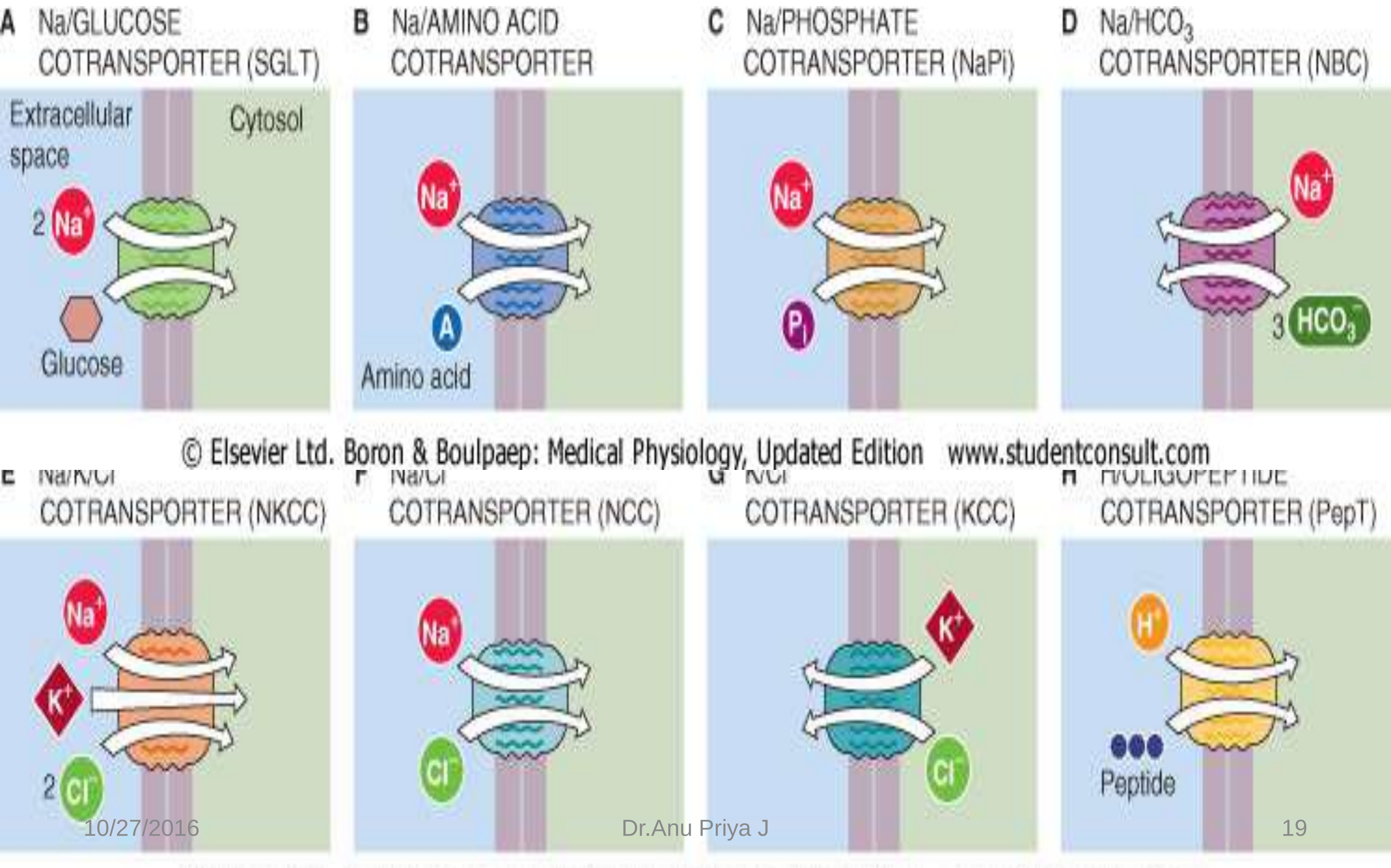


Figure 6.20 **The cotransport of Na^+ and glucose.** This carrier protein transports Na^+ and glucose at the same time, moving them from the lumen of the intestine and kidney tubules into the lining epithelial cells. This cotransport requires a lower intracellular concentration of Na^+, which is dependent on the action of other carriers, the Na^+/K^+ (ATPase) pumps. Because ATP is needed to power the Na^+/K^+ (ATPase) pumps, the cotransport of Na^+ and glucose depends indirectly on ATP, and so can be considered secondary active transport. The cotransport carrier shown here transports 1 Na^+ to 1 glucose, as most commonly occurs in the kidney; the carrier in the small intestine transports 2 Na^+ for 1 glucose (not shown).

Co-transport/ Symport



Counter transport / Antiport

- The transport of Na^+ via its concentration gradient is coupled to the transport of other substance in the opposite direction

- ❑ Sodium-Hydrogen counter transport in the proximal tubule of the kidneys

- ❑ Sodium-Calcium exchanger in the cardiac cells

Counter transport / Antiport

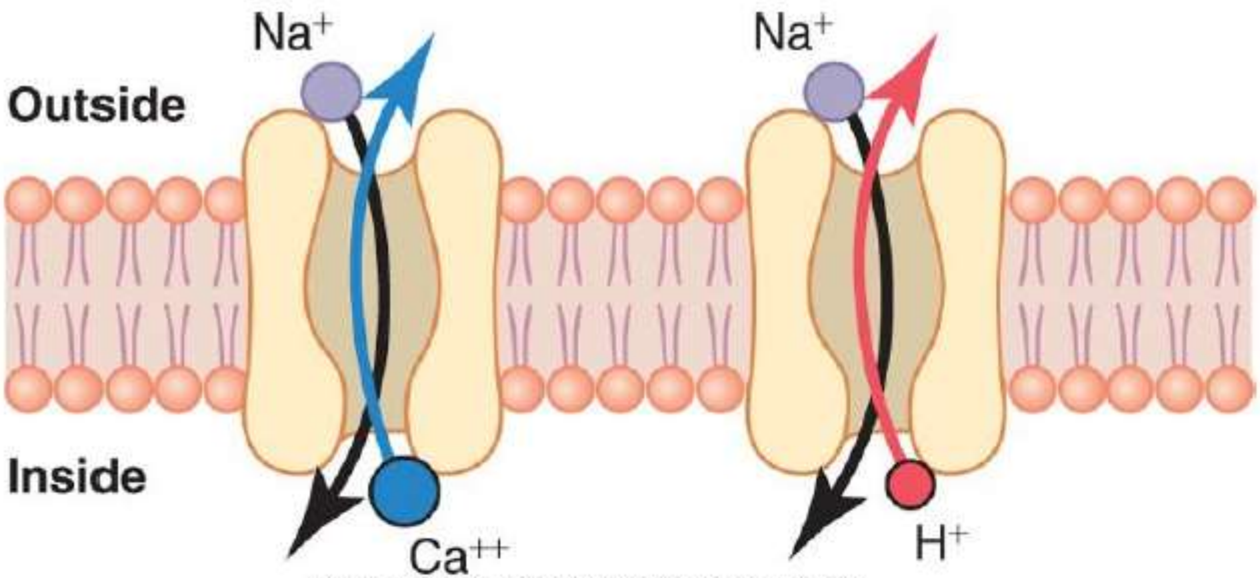


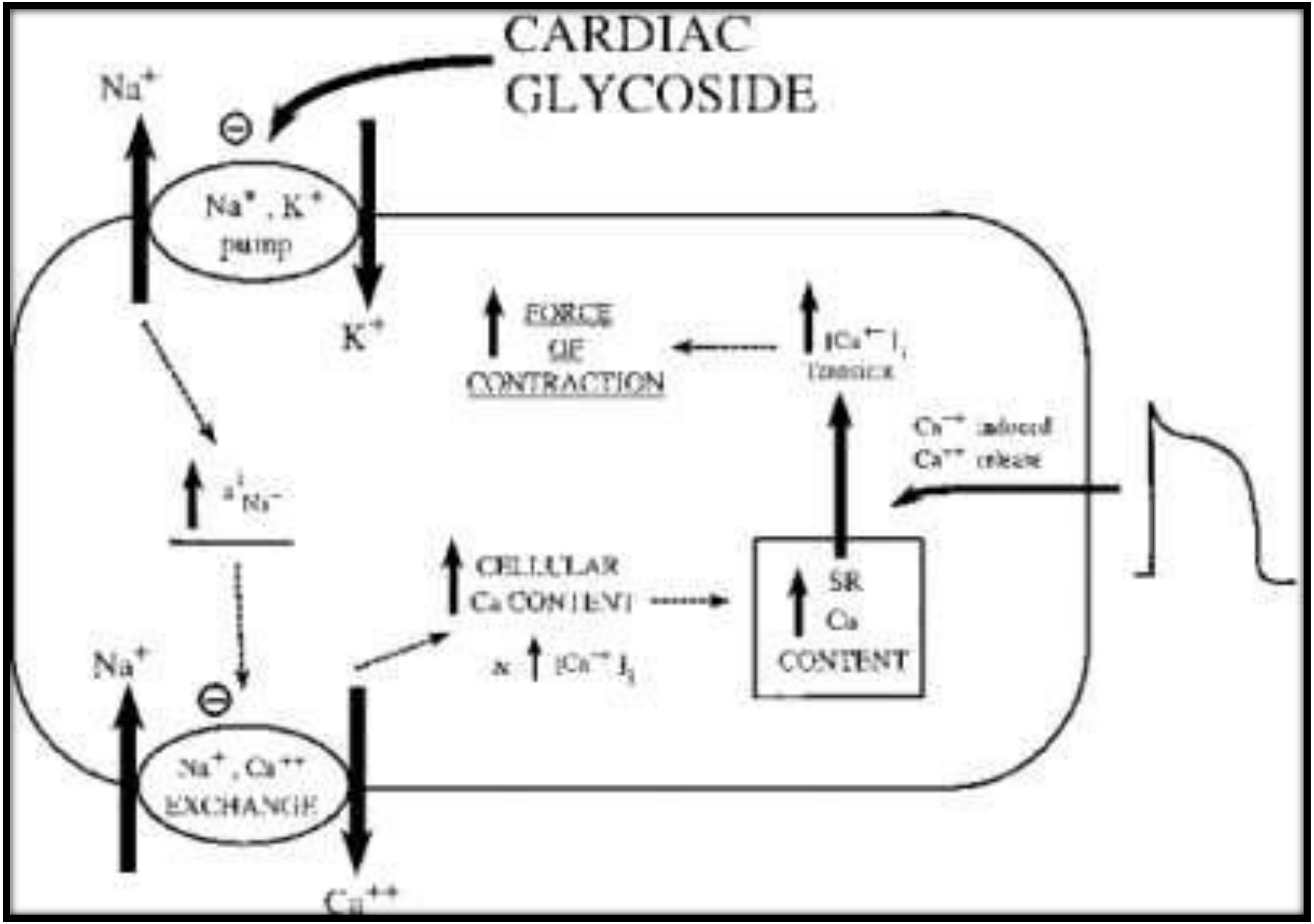
Figure 4-14 Sodium counter-transport of calcium and hydrogen ions.

Applied aspects

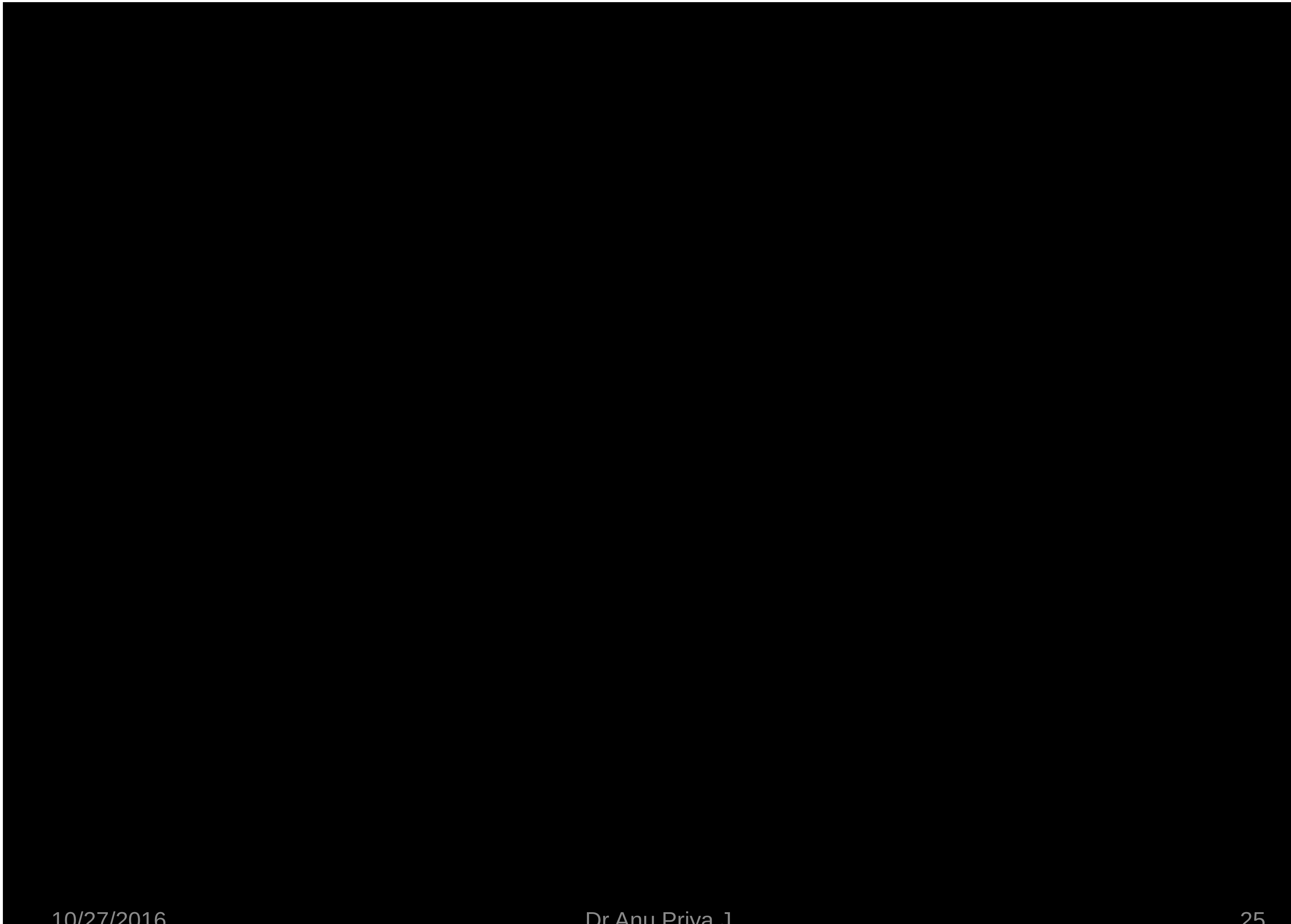
- Cardiac glycosides -Digitalis & Ouabain – management of heart failure
- Inhibits Na^+-K^+ pump
- Accumulation of Na^+ inside the cell & prevention of K^+ influx
- Intracellular accumulation of Na^+ , decreases Na^+ gradient from outside to inside.

Applied aspects

- Calcium efflux through sodium-calcium exchanger in the membrane utilizes sodium gradient.
- Decreased sodium gradient decreases calcium efflux causing increase in cytosolic calcium concentration, that promotes myocardial contractility.


CARDIAC GLYCOSIDE
Na+
Na+, K+ pump
K+
FORCE OF CONTRACTION
CELLULAR Ca CONTENT
SR Ca CONTENT
Na+
Na+, Ca++ EXCHANGE
Ca++

CLICK TWICE TO WATCH VIDEO




Thank you

Difference between Facilitated diffusion and Active transport

- In both instances, transport depends on carrier proteins that penetrate through the cell membrane, as is true for facilitated diffusion. However, in active transport, the carrier protein functions differently from the carrier in facilitated diffusion because it is capable of imparting energy to the transported substance to move it against the electrochemical gradient.

Applied aspects

- Activation of Na^+-K^+ pump:

  Thyroxine, Insulin, Aldosterone

- Inhibition of Na^+-K^+ pump:

  Dopamine, Digitalis, Hypoxia, Hypothermia