Bio Factsheet

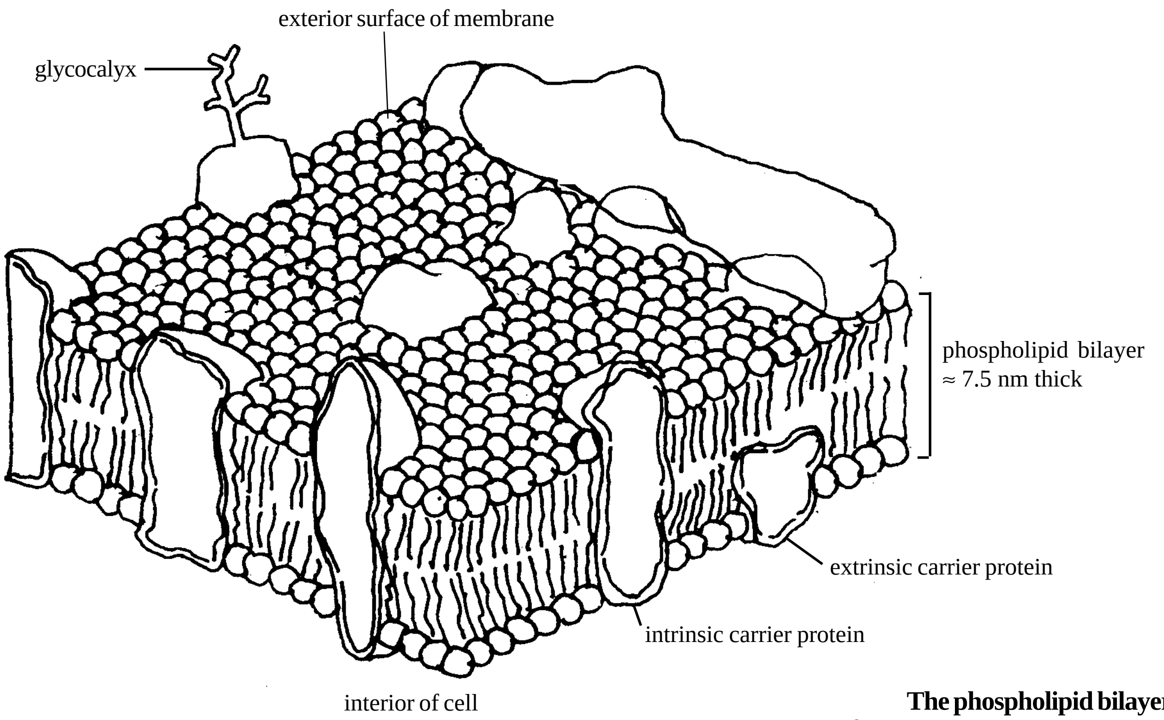
www.curriculumpress.co.uk Number 128

Active Transport

Active transport is the movement of molecules or ions across a differentially permeable membrane up a concentration or electrochemical gradient. Active transport is not passive, it requires ATP. In fact, in some cells nearly 50% of all the energy used is for active transport.

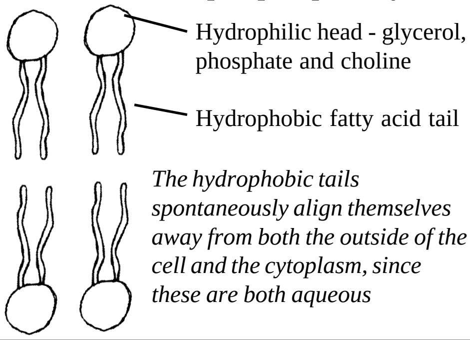
Active transport involves transport proteins. These proteins span the cell surface membrane (Fig 1).

Fig 1. Cell surface membrane (fluid mosaic model)



Glycocalyx -	allow cell recognition
Proteins -	intrinsic: span the membrane extrinsic: embedded in one half
Lipids -	phospholipids, glycolipids, cholesterol

The phospholipid bilayer



Transport proteins may move:
- A single substance in a single direction across a membrane
- Two substances in the same direction across a membrane
- Two substances in opposite directions across a membrane

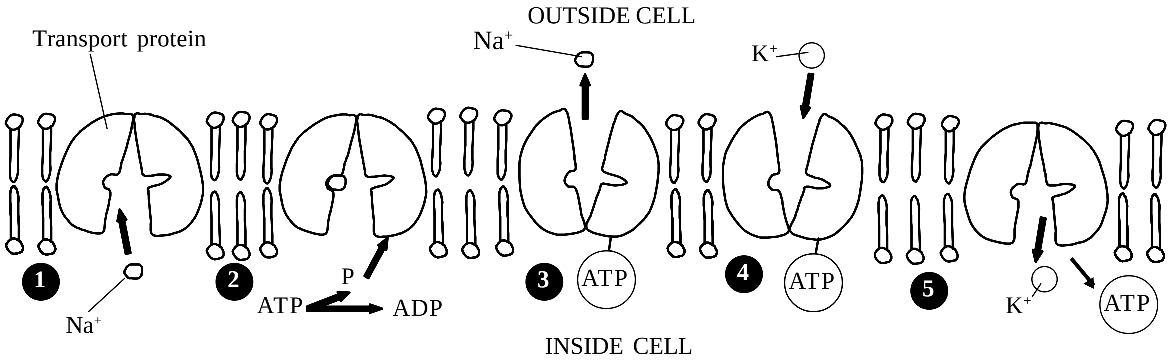
The process of active transport is still not fully understood. However, it is the general principles only that are important at this level and these can be illustrated by a form of active transport that occurs in almost every animal cell: the sodium-potassium pump (Fig 2).

Exam Hint: *You do not need to be able to reproduce Fig 1. However you may be asked to:*
1. *Draw a simple diagram of the phospholipid bilayer and recall its approximate width*
2. *Describe the functions of the phospolipids, proteins and the glycoycocalyx*
3. *Explain how the properties of the phospholipids influence the properties of the membrane*

The sodium - potassium pump

The sodium concentration is much greater outside the cell than inside it. There is therefore a tendency for sodium ions to diffuse into the cell down their concentration gradient. In order to work against this tendency the cell uses active transport to push out more of the sodium ions. By removing sodium ions in this way the cell reduces the volume of water that enters it by osmosis. Thus, one function of the sodium-potassium pump is to help the cell regulate its volume.

Fig. 2. Sodium-potassium pump

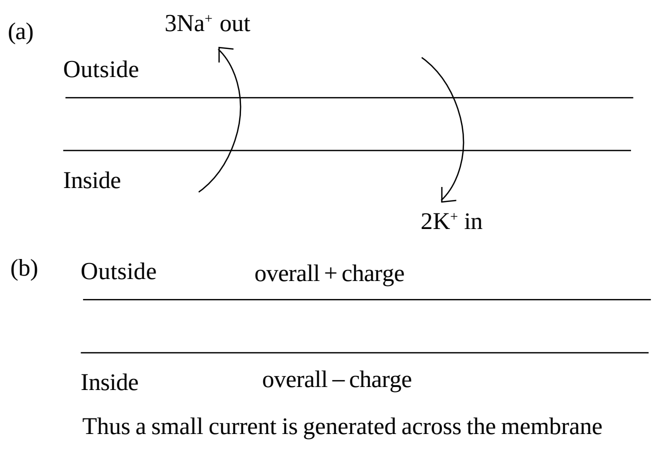


The ATP donates energy-rich phosphate to the transport protein thus activating it to bond with the specific solutes.

1. Sodium ions bind to the transport protein at specific binding site
2. This triggers hydrolysis of ATP into ADP and phosphate. The phosphate binds to the protein, phosphorylating it.
3. Phosphorylation causes the protein to change shape. This propels the sodium ion to the other side of the membrane i.e out of the cell, allowing it to enter the tissue fluid that bathes the cell.
4. Potassium ions in the tissue fluid now bind to the protein at their specific binding site (which is a different site to where the sodium ions bond).
5. This triggers dephosphorylation of the protein (i.e. the phosphate becomes detached from the protein carrier). Dephosphorylation causes the protein to change back to its original shape and this propels the potassium ion into the cell.

For each cycle of the pump, i.e. for each ATP molecule used, three sodium ions are expelled and two potassium ions are brought in. The net effect is to make the inside of the cell less positively charged i.e. more negatively charged relative to the outside (Fig 3). Thus, an electric current is generated across the membrane. In nerve cells, this is the basis of the membrane potential.

Fig 3 Sodium and potassium ions create the membrane potential



The major examples of active transport that feature on A level and Scottish Higher specifications are summarised in Table 1.

Table 1. Active Transport in animals and plants

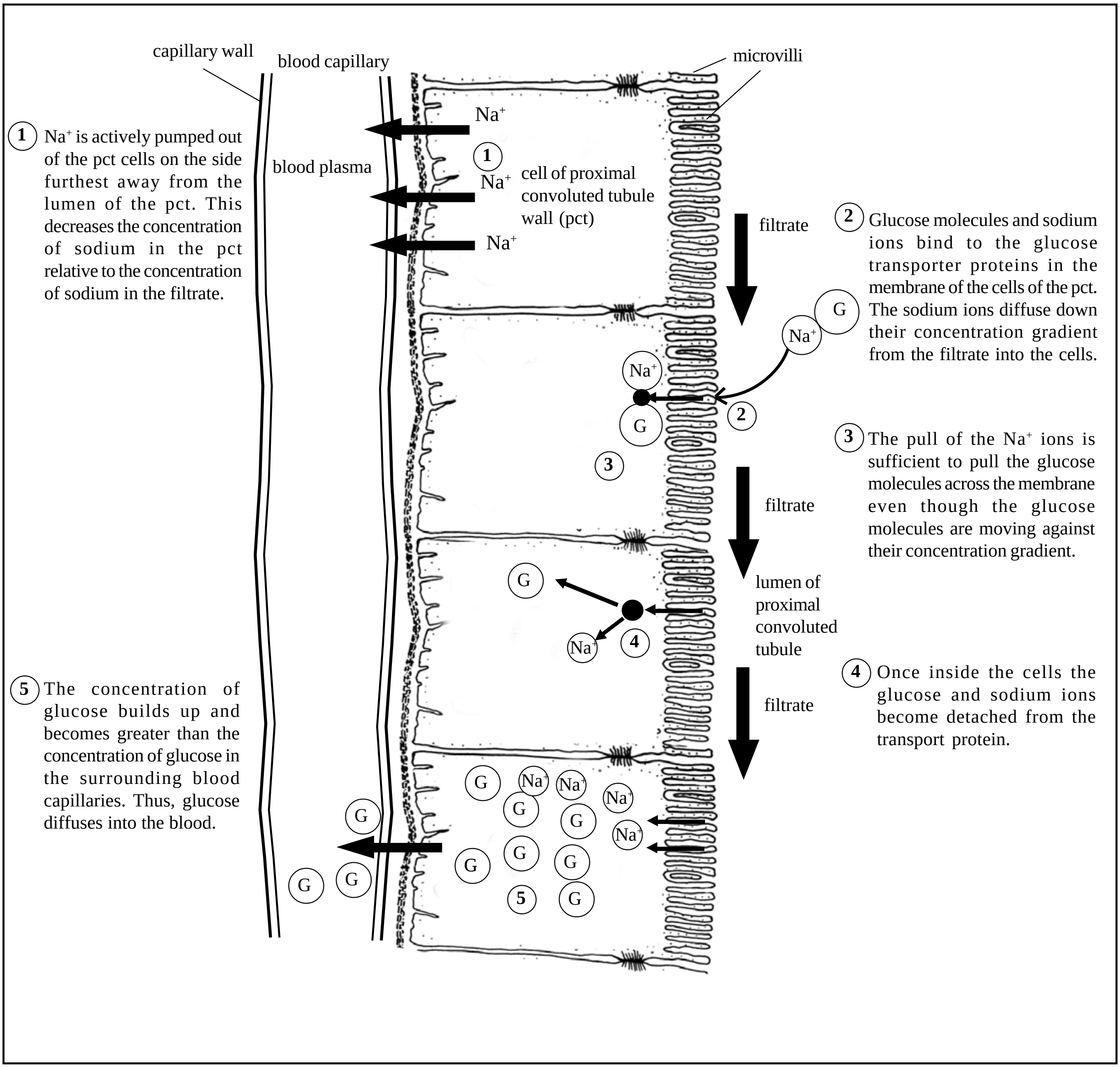
Location	Process
Root hair cells	Active transport of ions into the root hair
Guard cells of stomata (stomatal opening)	K^+ ions pumped into guard cells from epidermal cells. This lowers the water potential of the guard cells, drawing water in osmotically. Guard cells swell but the toughened wall around the pore is stiff and the pore of the stomata is pulled open
Placenta	Amino acids are actively transported from the mother to the foetus
Almost all animal cells	Sodium-potassium pump maintains low intracellular sodium concentration, helping to regulate cell volume and generating a resting potential
Proximal convoluted tubules of kidney	Active transport of sodium ions allows reabsorption of glucose from the filtrate

Examples of Active Transport

The proximal convoluted tubules of the nephron

Remember that the glomerular filtrate that enters the lumen of the cells of the convoluted tubule contains many substances that the body wishes to reabsorb: glucose and amino acids being good examples. Fig 4 shows how reabsorption of glucose is achieved.

Fig 4. Reabsorption in the proximal convoluted tubules



Acknowledgements:
This Factsheet was researched and written by Kevin Byrne.
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ISSN 1351-5136