Types of transports

1. Diffusion (passive)
2. Carrier-mediated transport (passive or active)
3. Vesicular transport (active

FACTORS AFFECTING RATE OF DIFFUSION

The rate of diffusion of substances through thecell membrane is directly proportional to the following factors:

1. Permeability of the cell membrane
2. Body temperature
3. Concentration gradient or electrical gradient of the substance across the cell membrane
4. Solubility of the Substance

The rate of diffusion of substances through the cell membrane is inversely proportional to the following factors:

1. Thickness of the cell membrane
2. Charge of the ions
3. Size of the molecule

"Active Transport" of Substances Through Membranes

When a cell membrane moves molecules or ions "uphill" against a concentration gradient (or "uphill" against an electrical or pressure gradient), the process is called active transport. Different substances that are actively transported through at least some cell membranes include sodium ions, potassium ions, calcium ions, iron ions, hydrogen ions, chloride ions, iodide ions, urate ions, several different sugars, and most of the amino acids.

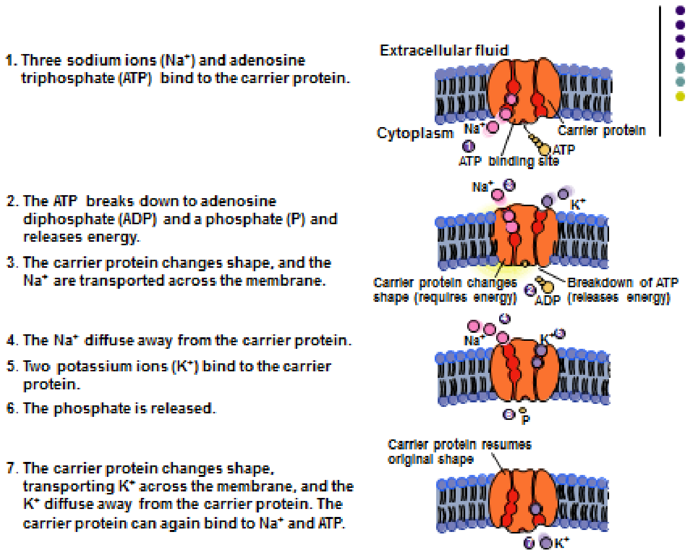
Active transport is divided into two types according to the source of the energy used to cause the transport: **primary active transport** and **secondary active transport**. In **primary active transport**, the energy is derived directly from breakdown of adenosine triphosphate (ATP) or of some other high-energy phosphate compound. In **secondary active transport,** the 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. 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**.

Sodium-Potassium Pump as an example of Primary Active Transport:

The active transport mechanism that has been studied in greatest detail is the **sodium-potassium (Na+-K+) pump**, a transport process that pumps sodium ions outward through the cell membrane of all cells and at the same time pumps potassium ions from the outside to the inside. This pump is responsible for maintaining the sodium and potassium concentration differences across the cell membrane, as well as for establishing a negative electrical voltage inside the cells. This pump is also the basis of nerve function, transmitting nerve signals throughout the nervous system. The carrier protein is a complex of two separate globular proteins: a larger one called the a subunit, and a smaller one called the b subunit, the larger protein has three specific features that are important for the functioning of the pump:

1. It has three **receptor sites for binding sodium ions** on the portion of the protein that protrudes to the inside of the cell.
2. It has two **receptor sites for potassium ions** on the outside.
3. The inside portion of this protein near the sodium binding sites has **ATPase activity**.

When two potassium ions bind on the outside of the carrier protein and three sodium ions bind on the inside, the ATPase function of the protein becomes activated. This then cleaves one molecule of ATP, splitting it to adenosine diphosphate (ADP) and liberating a high-energy phosphate bond of energy. This liberated energy is then believed to cause a chemical and conformational change in the protein carrier molecule, extruding the three sodium ions to the outside and the two potassium ions to the inside. For some cells, such as electrically active nerve cells, 60 to 70 per cent of the cells' energy requirement may be devoted to pumping Na+ out of the cell and K+ into the cell.



Secondary Active Transport— Co-Transport and Counter-Transport

When sodium ions are transported out of cells by primary active transport, a large concentration gradient of sodium ions across the cell membrane usually develops—high concentration outside the cell and very low concentration inside. This gradient represents a storehouse of energy because the excess sodium outside the cell membrane is always attempting to diffuse to the interior. Under appropriate conditions, this diffusion energy of sodium can pull other substances along with the sodium through the cell membrane. This phenomenon is called **co-transport**; it is one form of **secondary active transport.**

For sodium to pull another substance along with it, a coupling mechanism is required. This is achieved by means of still another carrier protein in the cell membrane.

The carrier in this instance serves as an attachment point for both the sodium ion and the substance to be co-transported. Once they both are attached, the energy gradient of the sodium ion causes both the sodium ion and the other substance to be transported together to the interior of the cell. In **counter-transport,** sodium ions again attempt to diffuse to the interior of the cell because of their large concentration gradient. However, this time, the substance to be transported is on the inside of the cell and must be transported to the outside. Therefore, the sodium ion binds to the carrier protein where it projects to the exterior surface of the membrane, while the substance to be counter-transported binds to the interior projection of the carrier protein. Once both have bound, a conformational change occurs, and energy released by the sodium ion moving to the interior causes the other substance to move to the exterior.

Co-Transport of Glucose and Amino Acids Along with Sodium Ions

Glucose and many amino acids are transported into most cells against large concentration gradients; the mechanism of this is entirely by co-transport. Note that the transport carrier protein has two binding sites on its exterior side, one for sodium and one for glucose.

Also, the concentration of sodium ions is very high on the outside and very low inside, which provides energy for the transport. A special property of the transport protein is that a conformational change to allow sodium movement to the interior will not occur until a glucose molecule also attaches. When they both become attached, the conformational change takes place automatically, and the sodium and glucose are transported to the inside of the cell at the same time. Hence, this is a **sodium-glucose co-transport** mechanism. **Sodium co-transport of the amino acids** occurs in the same manner as for glucose, except that it uses a different set of transport proteins. Five **amino acid transport proteins** have been identified, each of which is responsible for transporting one subset of amino acids with specific molecular characteristics. **Sodium co-transport of glucose and amino acids occurs especially through the epithelial cells of the intestinal tract and the renal tubules of the kidneys to promote absorption of these substances into the blood**. Other important co-transport mechanisms in at least some cells include co-transport of chloride ions, iodine ions, iron ions, and urate ions.

Vesicular Transport

Materials move into or out of the cell by means of vesicles, also called **bulk transport**

1. Endocytosis (Clathrin-mediated)
2. Receptor mediated endocytosis
3. Pinocytosis
4. Phagocytosis
5. Exocytosis

ALL are active processes (require ATP) though they are not usually referred to as “active transport”

Endocytosis:

Pinocytosis:

Non specific process.

Plasma membrane invaginates, fuses, vesicle containing ECF pinches off, and vesicle enters cell.

- Phagocytosis:

Phagocytic cells use pseudopods to surround and engulf particles.
Pseudopods join, fuse, and surround ingested particle (food vacuole).

Exocytosis:

- Process by which cellular products are secreted into extracellular environment.
- Proteins and other molecules to be secreted are packaged in vesicles by Golgi complex.
- Vesicles fuse with plasma membrane and release contents into extracellular environment.