All microorganisms require nutrients for growth, reproduction and cell maintenance. These nutrients should be available in the form of dissolved molecules (solutes).

Uptake of the required nutrients by the microbial cell is important. Since microorganisms live in nutrient poor habitats, they must be able to transport nutrients from dilute solutions into the cell against concentration gradient. Finally, they must pass through a selectively permeable plasma membrane. Microorganisms use different transport mechanisms like facilitated diffusion, active transport and group translocation. Eukaryotic microorganisms do not employ group translocation but take up nutrients by endocytosis.

Movement of materials across the plasma membrane is mostly done by two processes:

Passive processes: Substances cross the area from an area of high concentration to an area of low concentration without any expenditure of energy (ATP). Example, simple diffusion, osmosis and facilitated diffusion.

Active process: The cell must use energy (ATP) to move substances from areas of low concentration to areas of high concentration. Example, Group translocation.

Passive or simple diffusion:

Passive or simple diffusion often called diffusion is the process in which molecules move from a region of higher concentration to one of lower concentration. The rate is dependent on the size of the concentration gradient between a cell's exterior and its interior. Very small molecules such as water and oxygen and carbon dioxide move across membranes by simple or passive diffusion. Larger molecules, ions, and polar substances do not cross membranes by this method.

Characteristics:

- Does not involve the use of carrier proteins
- Along the concentration gradient
- No metabolic energy is required
- If concentration gradient disappears, then net inward movement ceases
- Reversible movement
- No specificity as there are no carrier protein involved
- Shows saturation
- Slow process

Osmosis:

The net movement of solvent molecules across a selectively permeable membrane from an area in which the solvent molecules are highly concentrated to an area of low concentration until equilibrium is reached. In living systems the chief solvent is water. The three types of solutions which are normally found are isotonic, hypotonic and hypertonic.

- ✓ Isotonic solution – When the concentration of both the solution on either sides of a semi permeable membrane are same
- ✓ Hypotonic solution – When external environment of the membrane has higher concentration than the internal environment of the cell
- ✓ Hypertonic solution – When external environment of the membrane has lower concentration than the internal environment of the cell
- ✓ Plasmolysis – The shrinkage of a cell when the water is drawn out as and when placed in a hypertonic solution

Facilitated diffusion:

The rate of diffusion across selectively permeable membrane is greatly increased by using carrier proteins, sometimes called **permeases** which are embedded in the plasma membrane. Because a carrier aids the diffusion process, it is called as **facilitated diffusion.** Carrier proteins also resemble enzymes in their specificity for the substances to be transported; each carrier is selective and will transport only closely relate solutes. Because there is no energy input, molecules will continue to enter only as long as their concentration is greater on the outside. Two widespread major intrinsic protein channels in bacteria are aquaporins that transport water and glycerol facilitators which aid glycerol diffusion. The carrier protein complex spans the membrane (Figure below). After the solute molecule binds to the outside, the carrier may change conformation and release the molecule on the cell interior. The carrier would subsequently change back to its original shape and be ready to pick up another molecule. The mechanism is driven by concentration gradients and therefore is reversible.

Examples: Glycerol is transported by facilitated diffusion in *E.coli, Salmonella typhimurium, Pseudomonas, Bacillus* and many other bacteria. This is prominent in eukaryotes where it is used to transport a variety of sugars and amino acids.

Characteristics:

- Involves the use of permeases
- Along the concentration gradient
- No metabolic energy is required

- If concentration gradient disappears, then net inward movement ceases
- Reversible movement
- Permeases show high specificity
- Shows saturation

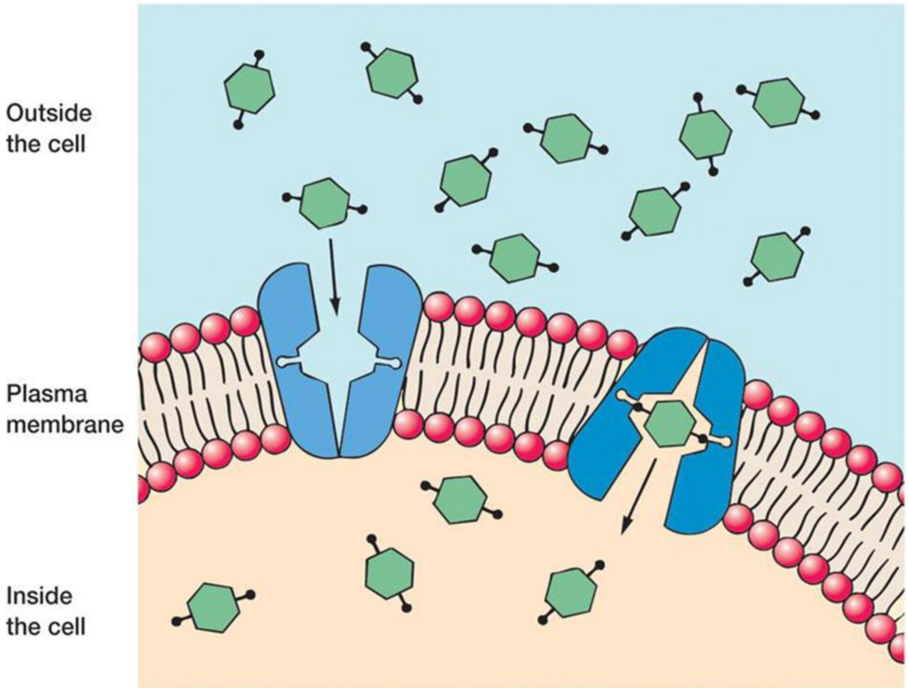

Figure: A model of facilitated diffusion the membrane can carrier change conformation after binding an external molecule and subsequently release

Active Transport

Many types of nutrient uptake require that a cell be able to transport substances against a concentration gradient (i.e. with a higher concentration inside the cell than outside). In order to do this, a cell must utilize metabolic energy for the transport of the substance through carrier proteins embedded in the membrane. This is known as **active transport**. All types of active transport utilize carrier proteins.

Characteristics:

- Involves the use of permeases
- Against concentration gradient
- Metabolic energy is required
- Shows saturation
- Permeases shows specificity

- Irreversible movement

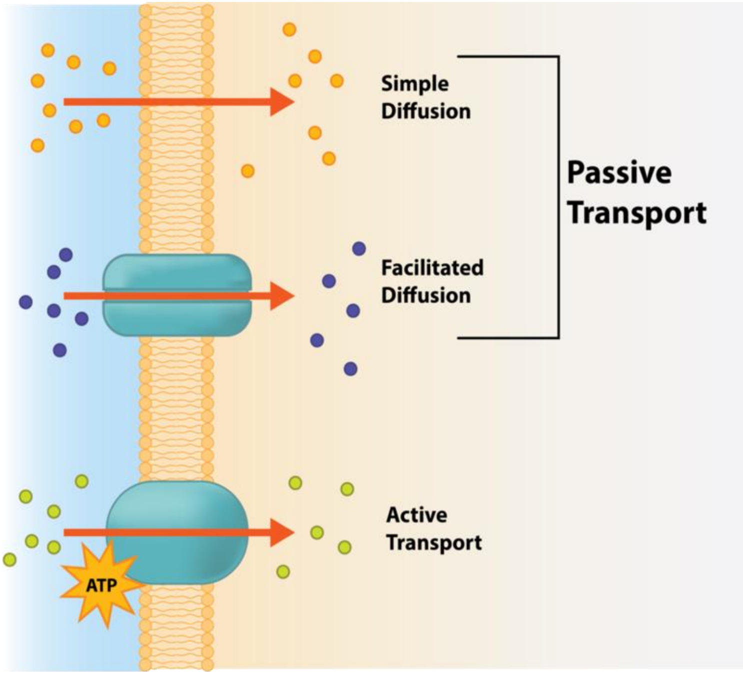

Fig: Active Transport Versus Facilitated Diffusion

Primary active transport

Primary active transport involves the use of chemical energy, such as ATP, to drive the transport. One example is the **ABC system**, which utilizes **ATP-Binding Cassette transporters**. Each **ABC transporter** is composed of three different components: 1) membrane-spanning proteins that form a pore across the cell membrane (i.e. carrier protein), 2) an ATP binding region that hydrolyzes ATP, providing the energy for the passage across the membrane, and 3) a substrate-binding protein, a peripheral protein that binds to the appropriate substance to be transporter and ferries it to the membrane-spanning proteins. In gram negative bacteria the substrate-binding protein is located in the cell's periplasm, while in gram positive bacteria the substrate-binding protein is attached to the outside of the cell membrane.

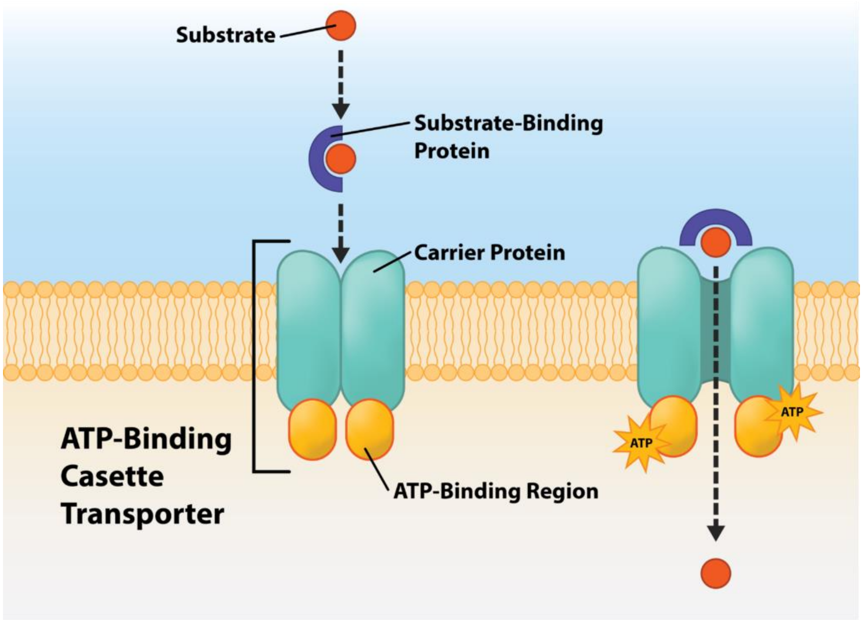

Fig: ABC Transporter Structure

Secondary active transport

Secondary active transport utilizes energy from a **proton motive force (PMF)**. A PMF is an ion gradient that develops when the cell transports electrons during energy-conserving processes. Positively charged protons accumulate along the outside of the negatively charged cell, creating a proton gradient between the outside of the cell and the inside.

There are three different types of transport events for simple transport: **uniport**, **symport**, and **antiport** and each mechanism utilizes a different protein **porter**. **Uniporters** transport a single substance across the membrane, either in or out. **Symporters** transport two substances across the membrane at the same time, typically a proton paired with another molecule. **Antiporters** transport two substances across the membrane as well, but in opposite directions. As one substance enters the cell, the other substance is transported out.

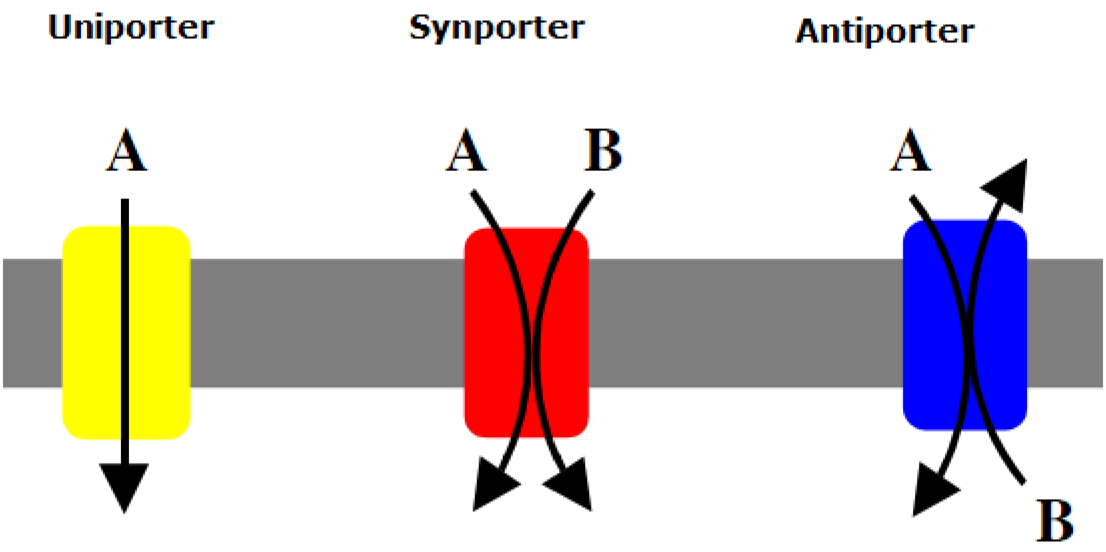

Fig: Uniport; Synport and Antiport

Group Translocation

Group translocation is a distinct type of active transport, using energy from an energy-rich organic compound that is not ATP. Group translocation also differs from both simple transport and ABC transporters in that the substance being transported is chemically modified in the process.
One of the best studied examples of group translocation is the **phosphoenolpyruvate: sugar phosphotransferase system (PTS)**, which uses energy from the high-energy molecule **phosphoenolpyruvate (PEP)** to transport sugars into the cell. A phosphate is transferred from the PEP to the incoming sugar during the process of transportation.

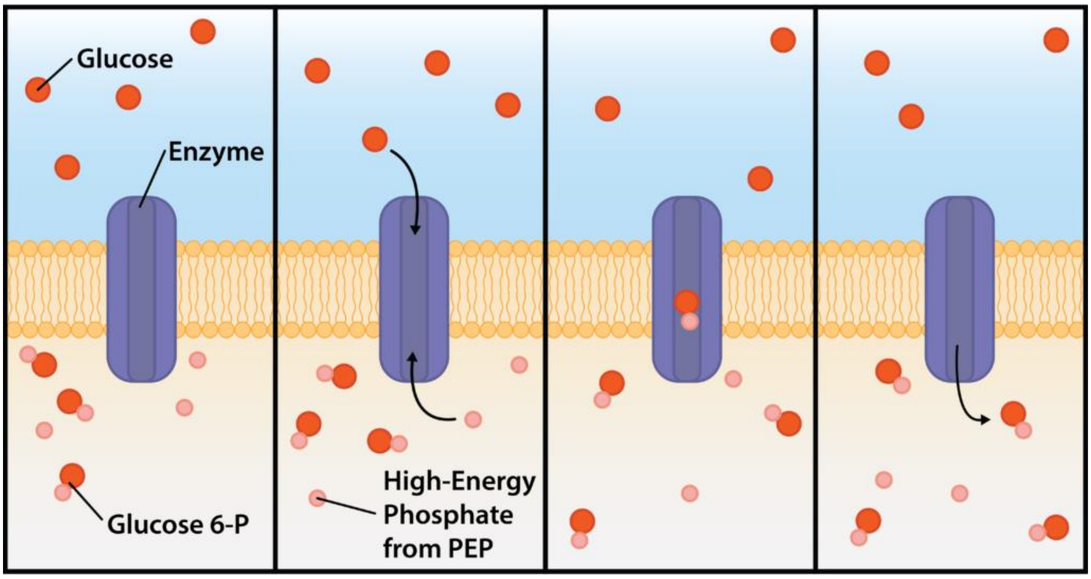

Fig: Group Translocation via PTS

Iron Uptake

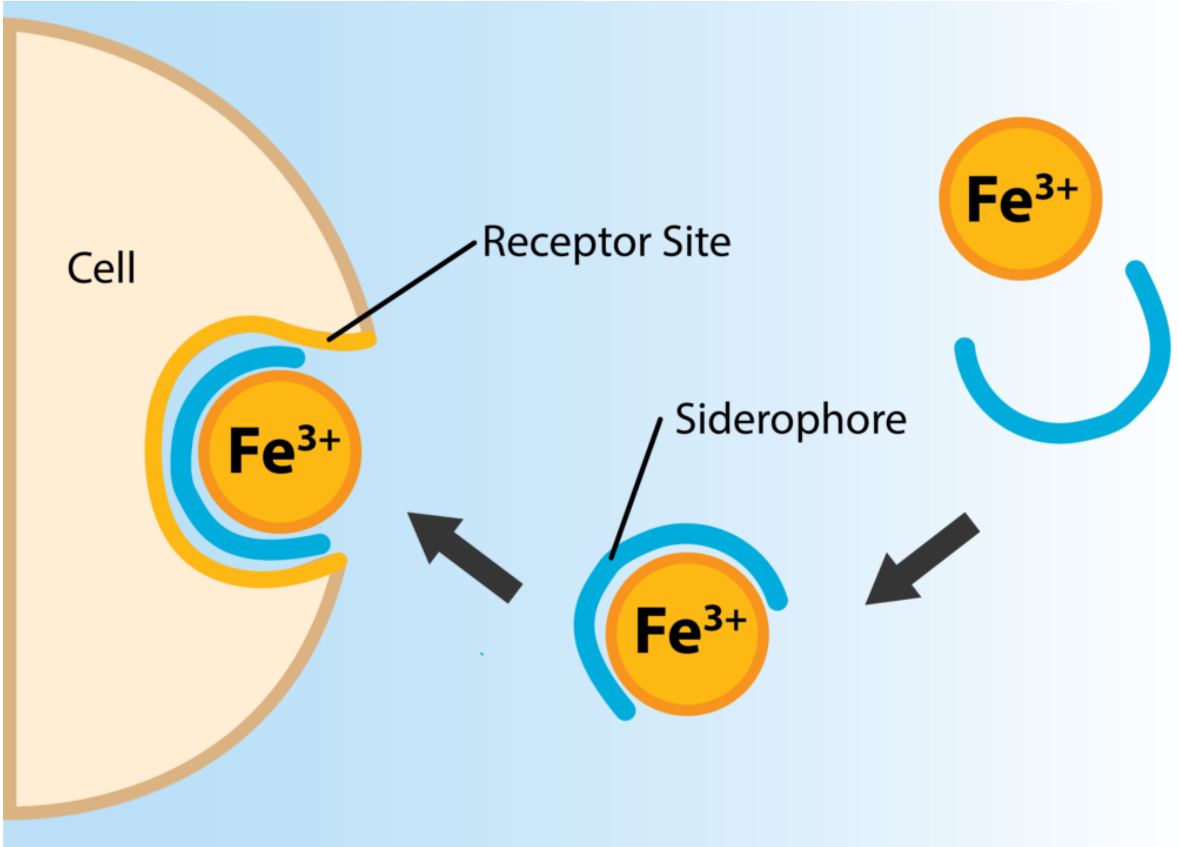

Fig: Siderophores and Receptor Sites

Iron is required by microbes for the function of their cytochromes and enzymes, resulting in it being a growth-limiting micronutrient. However, little free iron is available in environments, due to its insolubility. Many bacteria have evolved **siderophores**, organic molecules that chelate or bind ferric iron with high affinity. Siderophores are released by the organism to the surrounding environment, whereby they bind any available ferric iron. The iron-siderophore complex is then bound by a specific receptor on the outside of the cell, allowing the iron to be transported into the cell.

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