Transport of Nutrients

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Uptake of Nutrients by the Cell

- Uptake mechanisms must be: specific—that is, the necessary substances, and not others, must be acquired.
- Microbes often live in nutrient-poor habitats, they must be able to transport nutrients from dilute solutions into the cell against a conc. gradient.
- Molecules must pass through a selectively permeable plasma membrane that will not permit free passage of most substances.
- Small nonpolar and fat soluble substances (fatty acids, alcohols) may readily enter or exit the cell by dissolved in lipid phase.
- Charged mols. do not readily pass the membrane barrier but instead specifically transported.
- Microbes make use of several different transport mechanisms:
  - Passive transport
    - Passive diffusion,
    - Facilitated diffusion
  - Active transport
    - ATP binding cassette (ABC) transporters
    - Active transport using proton and sodium gradient
  - Group translocation

Passive Diffusion

- **Passive diffusion (often simply called diffusion)**, is the process in which molecules move from a region of higher concentration to one of lower concentration because of random thermal agitation.
- A few substances, such as glycerol, can cross the plasma membrane by passive diffusion.
- The rate of passive diffusion is dependent on the size of the concentration gradient between a cell's exterior and its interior (i.e., the external nutrient concentration must be high) (figure 1).
- The rate of uptake decreases as more nutrient is acquired unless it is used immediately.
- Very small molecules such as H_2O, O_2, and CO_2 often move across membranes by passive diffusion.
- Larger molecules, ions, and polar substances do not cross membranes by passive or simple diffusion.

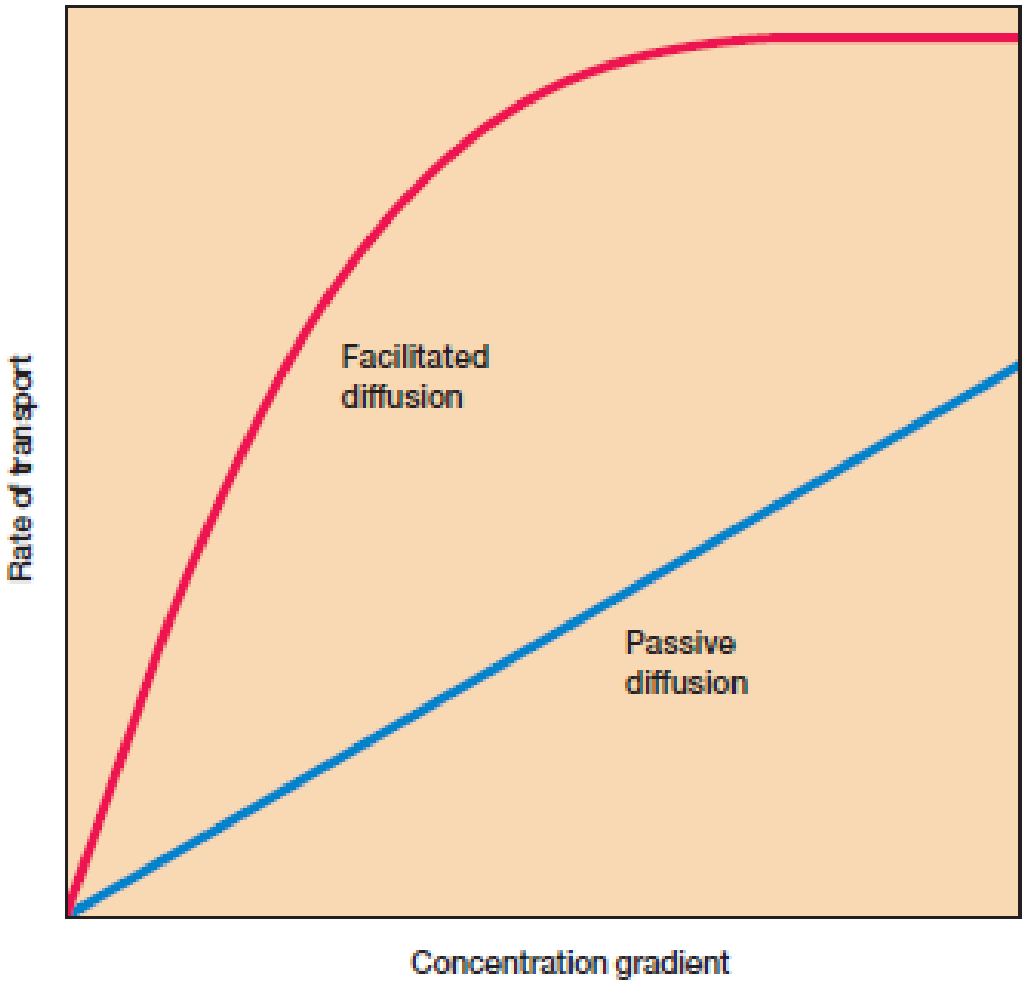


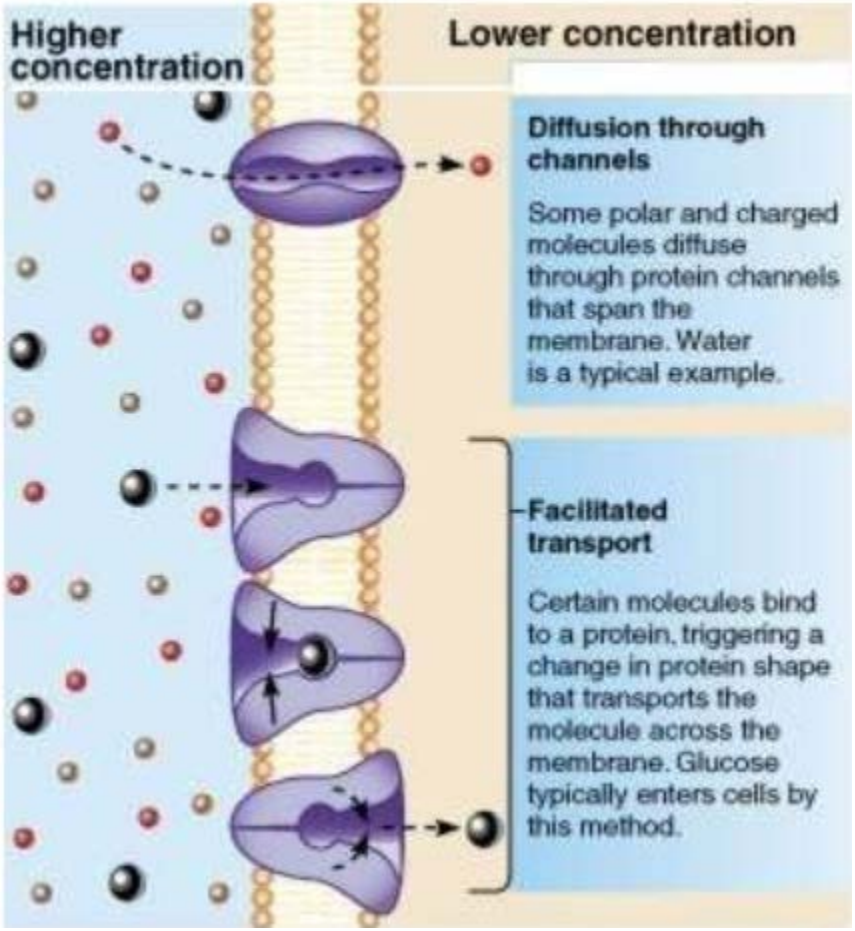
Figure 1. Passive and Facilitated Diffusion. The dependence of diffusion rate on the size of the solute's concentration gradient. Note the saturation effect or plateau above a specific gradient value when a facilitated diffusion carrier is operating. This saturation effect is seen whenever a carrier protein is involved in transport.

Facilitated Diffusion

- The rate of diffusion across selectively permeable membranes 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 **facilitated diffusion.**
- **The rate of facilitated diffusion increases with the concentration** gradient much more rapidly and at lower concentrations of the diffusing molecule than that of passive diffusion (figure 1).
- But the diffusion rate levels off or reaches a plateau above a specific gradient value because the carrier is saturated—that is, the carrier protein is binding and transporting as many solute molecules as possible.
- The resulting curve resembles an enzyme-substrate curve *and is different from the* linear response seen with passive diffusion.

… Facilitated Diffusion

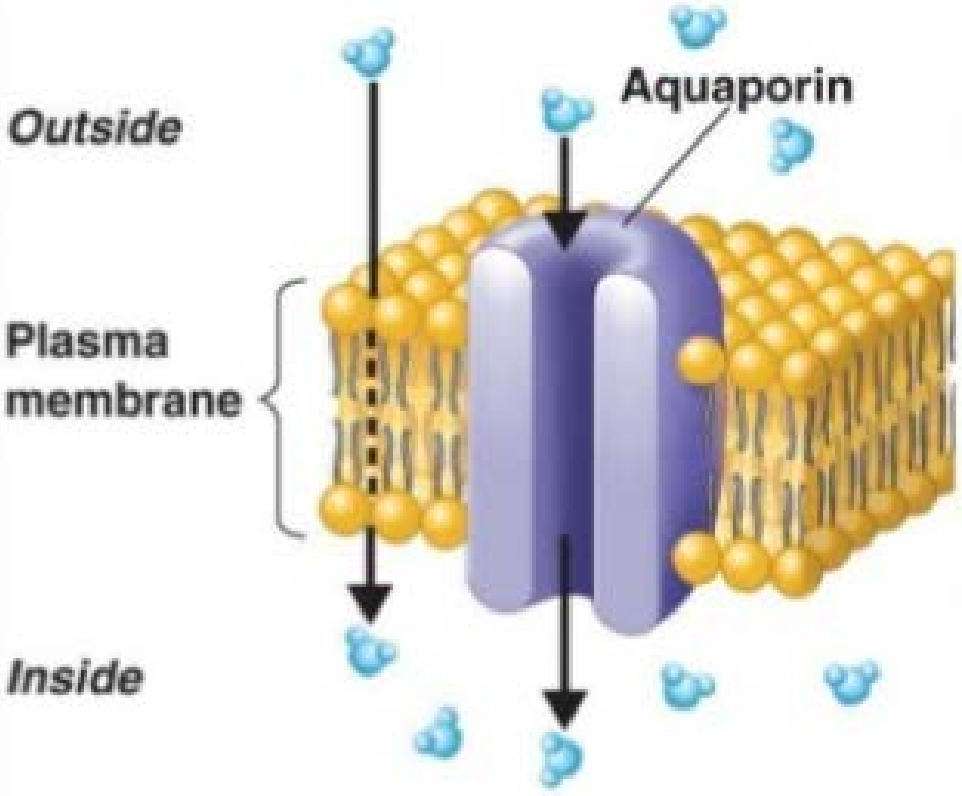
- Small charged ions (mineral ions) move across pore proteins.
- Pore proteins have specific shapes and charges to allow specific ions to pass through.
- Larger uncharged water soluble molecules (glucose, amino acids) move with the help of carrier proteins.
- The carrier proteins have specific binding sites to combine with specific molecules



… Facilitated Diffusion

- Each carrier is selective and will transport only closely related solutes.
- Although a carrier protein is involved, facilitated diffusion is truly diffusion.
  - A concentration gradient spanning the membrane drives the movement of molecules, and
  - no metabolic energy input is required.
- If the conc. gradient disappears, net inward movement ceases.
- The gradient can be maintained by transforming the transported nutrient to another compound or by moving it to another membranous compartment in eucaryotes.
- Interestingly, some of these carriers are related to the major intrinsic protein (MIP) of mammalian eye lenses and thus belong to the MIP family of proteins.
- The two most widespread MIP channels in bacteria are aquaporins and glycerol facilitators, which aid water and glycerol diffusion.

- Through lipid layer
- Aquaporins (water channels)



Diffusion through the lipid bilayer (left) and an aquaporin (right)

Mechanism of Facilitated Diffusion

- The mechanism of facilitated diffusion is not yet understood completely.
- It appears that the carrier protein complex spans the membrane (**figure 2).**
- 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 net effect is that a lipid-insoluble molecule can enter the cell in response to its concentration gradient.
- **The mechanism is driven by conc. gradients and therefore is reversible.**
- Because the cell metabolizes nutrients upon entry, influx is favored.
- Facilitated diffusion **does not seem to be important in procaryotes** because nutrient concentrations often are lower outside the cell so that facilitated diffusion cannot be used in uptake.
- Glycerol is transported by facilitated diffusion in *E. coli, Salmonella typhimurium, Pseudomonas, Bacillus, and many other bacteria.*
- The process is much more prominent in eucaryotic cells where it is used to transport a variety of sugars and amino acids.

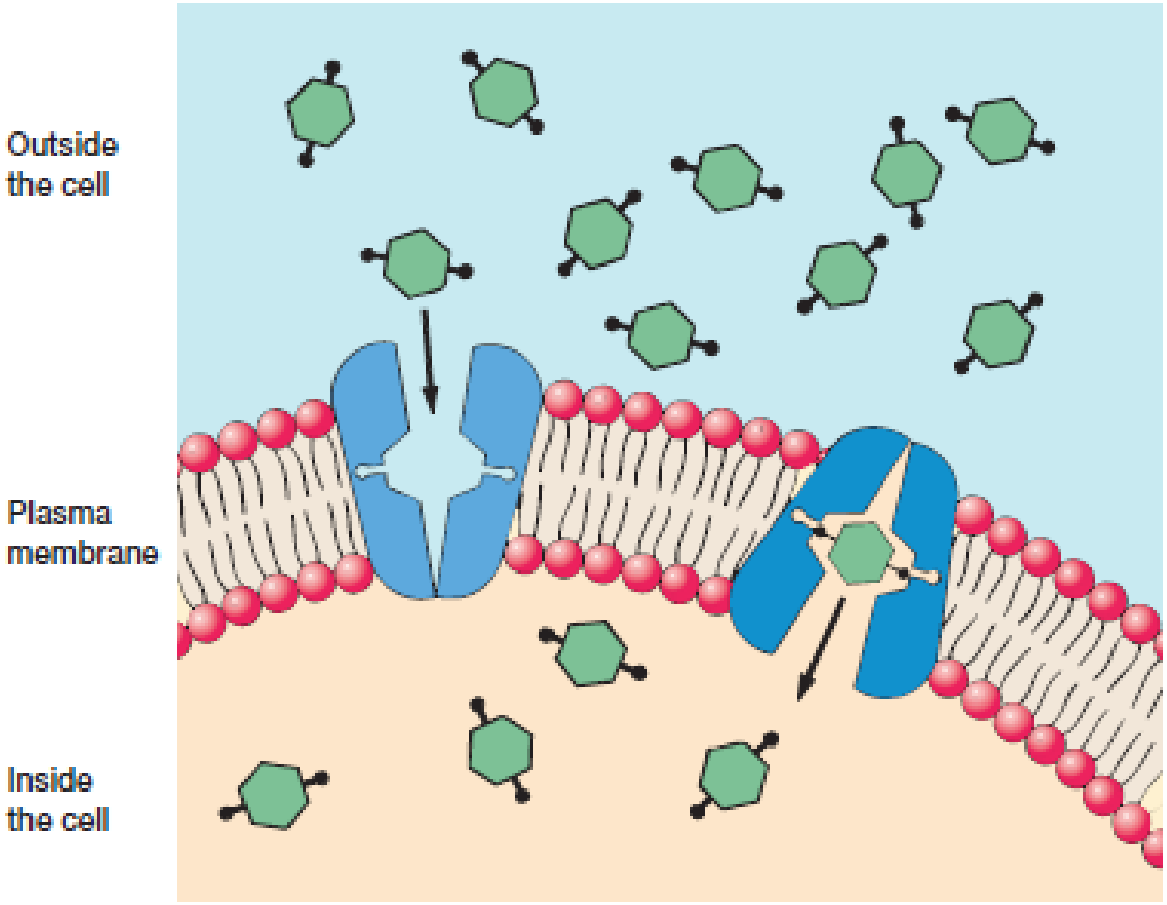


Figure 2. A Model of Facilitated Diffusion. The membrane carrier can change conformation after binding an external molecule and subsequently release the molecule on the cell interior. It then returns to the outward oriented position and is ready to bind another solute molecule. Because there is no energy input, molecules will continue to enter only as long as their concentration is greater on the outside.

Questions

- Write an essay on bacterial transport system.
- Write differences among passive diffusion, facilitated diffusion.
- Write short note on facilitated diffusion.
- Discuss mechanism of facilitated diffusion.