Microbial nutrition

Microbial Growth Conditions

1. Macronutrients
2. Micronutrients
3. Growth factors
4. Environmental factors: temperature; pH; Oxygen *et al*.

Nutrient requirements

Microorganisms require about ten elements in large quantities, because they are used to construct carbohydrates, lipids, proteins, and nucleic acids. Several other elements are needed in very small amounts and are parts of enzymes and cofactors.

Microbial Nutrition

Nutrients: Substances in the environment used by organisms for catabolism and anabolism.

1. ***Macronutrients*: required in large amounts, including:** **carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus** **(Components of carbonhydrates, lipids, proteins, and mucleic acids); potassium, calcium, magnesium and iron (cations and part of enzymes and cofactors).**

2. ***Micronutrients*: *Microbes require very small amounts of other mineral elements, such as iron, copper, molybdenum, and zinc; these are referred to as trace elements. Most are essential for activity of certain enzymes, usually as cofactors.***

contaminants in water, glassware, and regular media components often are adequate for growth.

Growth Factors

(1)amino acids, (2) purines and pyrimidines, (3) vitamins

Amino acids are needed for protein synthesis,

purines and pyrimidines for nucleic acid synthesis.

Vitamins are small organic molecules that usually make up all or part enzyme cofactors, and only very small amounts are required for growth.

Classification of microorganism on the basis of Nutrition-Nutritional classification

- **Carbon**
- Hydrogen
- Oxygen
- Other elements macro & micro
- **Energy source**
- **Electron source**

Organic compound → electron → electron acceptor

(red uce) Organic compound (oxi dize) Energy (oxi dize) electron (red uce)

acceptor

Nutritional classification- based on how microorganism satisfy Carbon, Energy & Electron

Carbon source

Autotrophs	CO_2 sole or principal biosynthetic carbon source
Heterotrophs	Reduced, preformed, organic molecules from other organisms

Energy Sources

Phototrophs	Light
Chemotrophs	Oxidation of organic or Inorganic compounds

Electron Sources

Lithotrophs	Reduced inorganic molecules
Organotrophs	Organic molecules

Nutritional types of microorganisms

Major Nutritional Types	Energy source	Hydrogen/ electron	carbon source	Representative Microorganisms
Photo**lithotrophic autotrophy** (Photolithoautotrophy) (photoautotrophs)	Light energy	Inorganic hydrogen/electron (H/e–) donor	CO_2 carbon source	Algae Purple and green sulfur bacteria Cyanobacteria
Photo**organotrophic heterotrophy** (Photoorganoheterotrophy) (Photoheterotrophs)	Light energy	Organic H/e– donor	Organic carbon source	Purple nonsulfur bacteria Green nonsulfur bacteria
Chemolithotrophic autotrophy (Chemolithoautotrophy) (Chemoautotrophs)	Chemical energy source (inorganic)	Inorganic H/e– donor	CO_2 carbon source	Sulfur-oxidizing bacteria Hydrogen bacteria Nitrifying bacteria Iron-oxidizing bacteria
Chemoorganotrophic heterotrophy (Chemoorganoheterotrophy) (Chemoheterotrophs)	Chemical energy source (organic)	Organic H/e– donor	Organic carbon source	Protozoa, Fungi, Most nonphotosynthetic bacteria (including most pathogens)

- large majority of microorganisms

1) Photoautotrophs 2) Chemoheterotrophs

Photoautotrophs

- light energy
- CO_2 as their carbon source
- **algae** and cyanobacteria employ water as the electron donor and release oxygen
- Purple and green sulfur extract electrons from inorganic donors like hydrogen, hydrogen sulfide, and elemental sulfur.

Chemoheterotrophs

- organic compounds as sources of energy, hydrogen, electrons, and carbon
- Frequently the same organic nutrient will satisfy all these requirements
- Yeast, all pathogenic microorganisms are chemoheterotrophs

- other two nutritional classes have fewer microorganisms but often are very important ecologically

Photoheterotrophs

- purple and green bacteria are photosynthetic
- organic matter as their electron donor and carbon source
- common inhabitants of polluted lakes and streams

Chemoautotrophs

- oxidizes reduced inorganic compounds such as iron, nitrogen, or sulfur molecules to derive both energy and electrons
- Carbon dioxide is the carbon source
- contribute greatly to the chemical transformations of elements (e.g., the conversion of ammonia to nitrate or sulfur to sulfate)
- *Clostridium ljungdahlii*

Exceptions-Mixotropic- depending on environment condition

Uptake of nutrients

Nutrient molecules frequently cannot cross selectively permeable plasma membranes through passive diffusion and must be transported by one of three major mechanisms involving the use of membrane carrier proteins.

1, Phagocytosis – Protozoa

2, Permeability absorption – Most microorganisms

- passive transport (simple diffusion)
- facilitated diffusion
- active transport
- group translocation

passive diffusion

A few substances, such as glycerol, H_2O, O_2 can cross the plasma membrane by **passive diffusion.** Passive diffusion is the process in which molecules move from a region of higher concentration to one of lower concentration as a result of random thermal agitation.

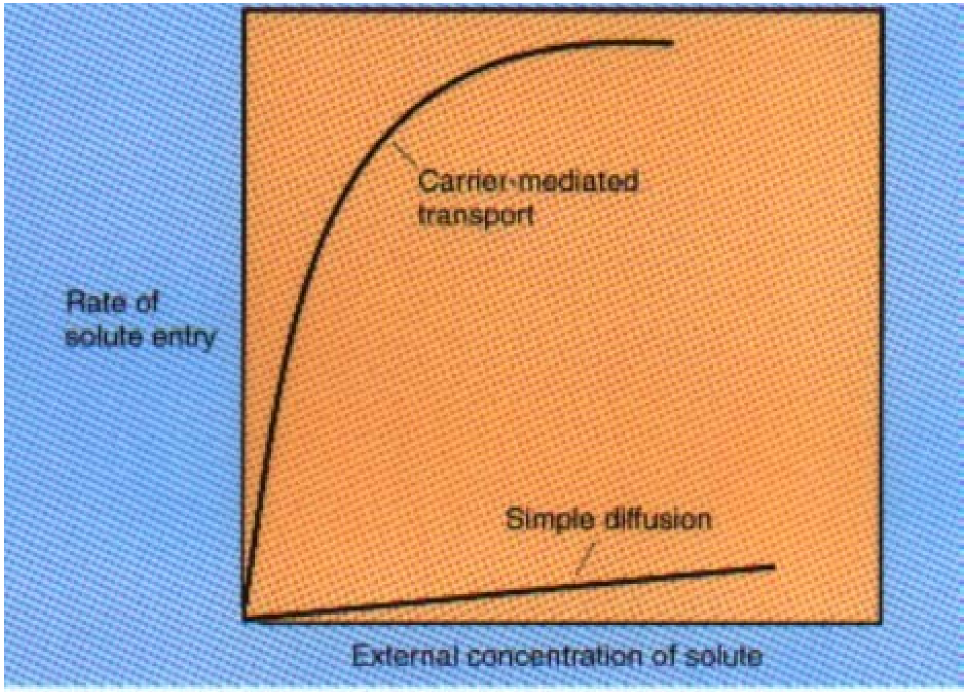
no carrier protein;

no energy.

Facilitated diffusion

The rate of diffusion across selectively permeable membranes is greatly increased by the use of carrier proteins, sometimes called **permeases,** which are embedded in the plasma membrane. Since the diffusion process is aided by a carrier, 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.

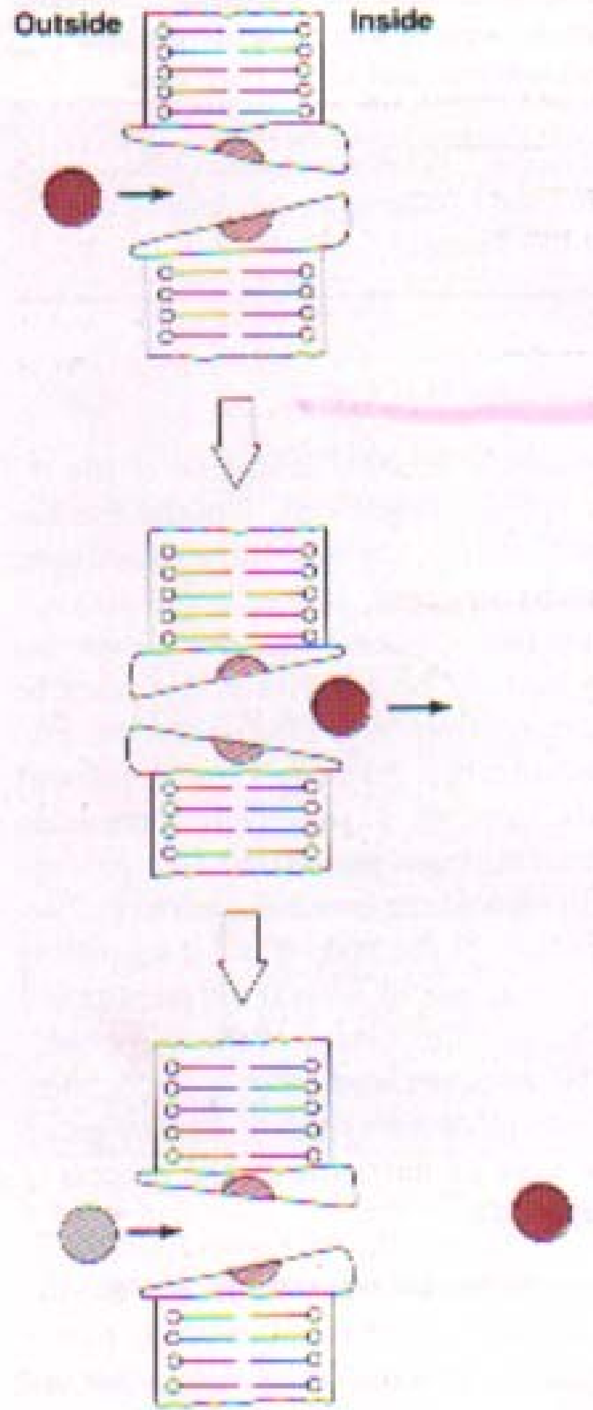


Facilitated diffusion

- higer con.→ lower con.
- Facilitated diffusion: carrier protein, permeases.

- Each carrier is selective and will transport only closely related solutes.

  Seem not to be important in procaryotes, much more prominent in Eucaryotic cells.



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.

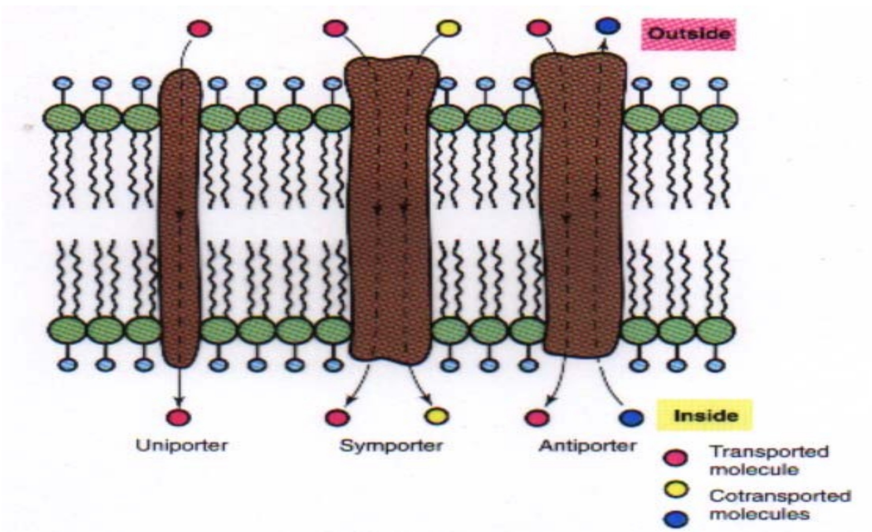
Active transport

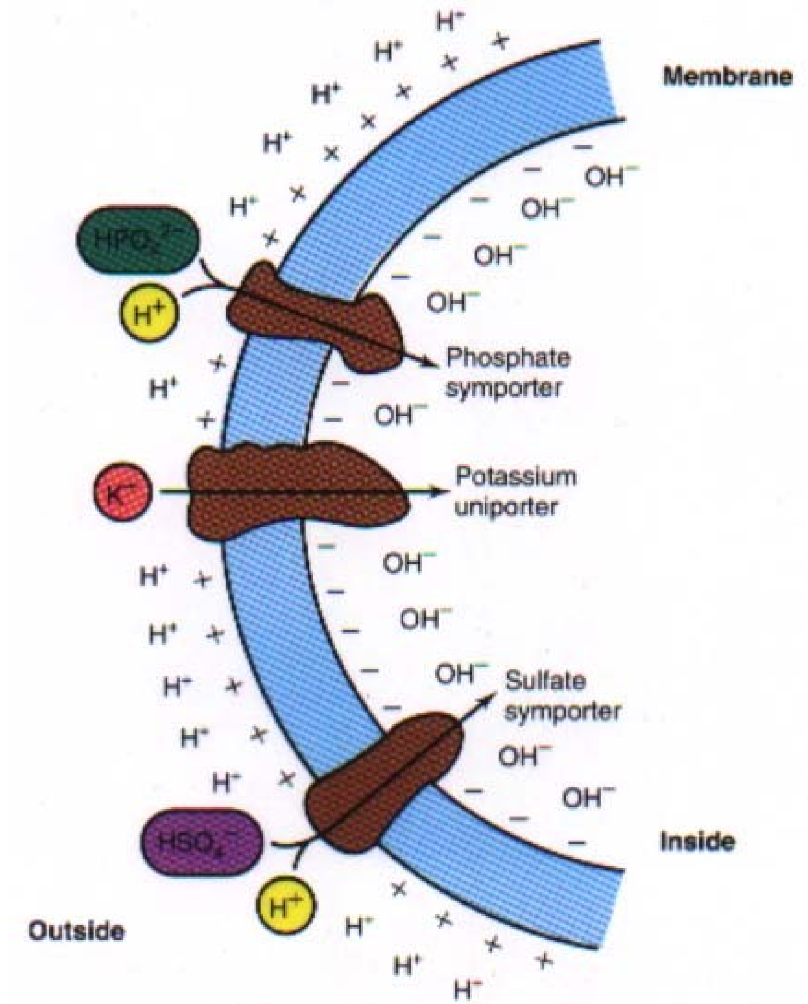
Active transport is the transport of solute molecules to higher concentrations, or against a concentration gradient, with the use of metabolic energy input.

- lower con.→ higer con.
- Permeases, energy

Proton gradients

- Symport: linked transport of two substances in the same direction.
- Antiport: linked transport of two substances in the opposite direction.
- Uniport: one substance enter





Group translocation

A process in which a molecule is transported into the cell while being chemically altered.

The best-known group translocation system is the *phosphoenolpyruvate: sugar phosphotransferase system (PTS),* which transports a variety of sugars into procaryotic cells while Simultaneously phosphorylating them using phosphoenolpyruvate (PEP) as the phosphate donor.

PTS: sugar phosphortransferase system

PEP+sugar(outside)→pyruvate+sugar-P(inside)

The following components are involved in the system:

phosphoenolpyruvate, *PEP*;

EI (enzyme I), Hpr (the low molecular weight heat-stable protein): cytoplasmic, common to all PTSs.

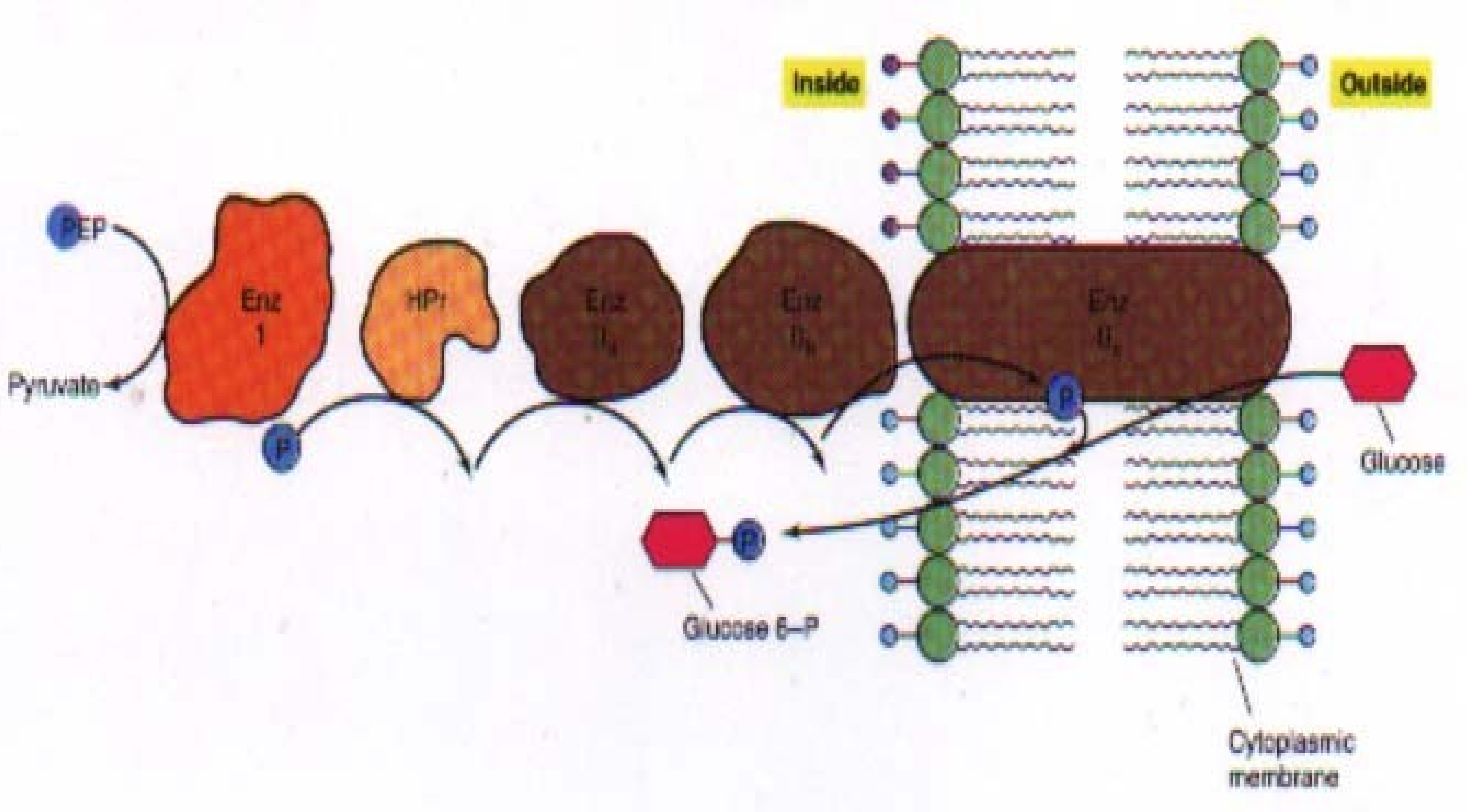
EII (enzyme II) : EIIa: cytoplasmic and soluble

EIIb: hydrophilic but frequently is attached toEIIc.

EIIc: a hydrophobic protein that is embedded in the membrane.

Only specific sugars and varies with PTS.

The phosphoenolpyruvate: sugar phosphotransferase system of *E. coli*.



Simple comparison of transport systems

Items	Passive diffusion	Facilitated diffusion	Active transport	Group translocation
carrier proteins	Non	Yes	Yes	Yes
transport speed	Slow	Rapid	Rapid	Rapid
against gradient	Non	Non	Yes	Yes
transport molecules	No specificity	Specificity	Specificity	Specificity
metabolic energy	No need	Need	Need	Need
Solutes molecules	Not changed	Changed	Changed	Changed

Iron uptake

- Cytochromes and many enzymes
- Extreme insolubility of ferric iron(Fe^{3+}) and its derivatives. Difficult
- Siderophores: low M.W., be able to complex with ferric iron and supply it to the cell.
- Microorganisms secrete siderophores when little iron is available in the medium.

iron-siderophore complex bind the receptor of cell surface: Fe^{3+} release; complex enter by ABC transporter.

Siderophores (S)