**Microbial Nutrition**

 Microorganisms require about 10 elements in large quantities, used to construct carbohydrates, lipids, proteins and nucleic acids. Several other factors are needed in very small amounts and are parts of enzymes and cofactors.

To obtain energy and construct new cellular components, organisms must have a supply of raw materials or nutrients. Nutrients are substances used in biosynthesis and energy release and therefore are required for microbial growth. Analysis of microbial cell composition shows that over 95% of cell dry weight is made up of a few major elements; ;Carbon,Oxygen,Hydrogen,Nitrogen,Sulfur,Phosphorus,Potassium,Calcium,Magnesiumand iron which are called macro-elements or macronutrients because they are required by microorganisms in relatively large amounts. First six (C,O,H,N,S and P) are components of carbohydrates, lipids, proteins and nucleic acids while the remaining four macroelements exist in the cell as cations and play a variety of roles ; potassium (K+) is required for activity by number of enzymes, including some of those involved in protein synthesis.

Calcium (Ca+2) contributes to the heat resistance of bacterial endospores. Magnesium (Mg+2) serves as a cofactor for many enzymes complexes with ATP and stabilizes ribosomes and cell membranes. Iron (Fe+2 and Fe+3 )is a part of cytochromes and a cofactor for enzymes and electron–carrying proteins.

 All organisms including M.O need several micronutrients or trace elements; manganese ,zinc, cobalt , molybdenumnickel and copper. They are a part of enzymes and cofactors and they aid in the catalysis of reactions and maintenance of protein structure. Zinc (Zn) is present at the active site of some enzymes.

**Requirements for Carbon, Hydrogen and Oxygen**

Carbon requirements considers as a skeleton or backbone of all organic molecules. Molecules serving as carbon sources also contribute both oxygen and hydrogen atoms. M.O also needs a source of electron. The electron movement through electron transport chains and during other oxidation-reduction reactions can provides energy which can use in microbial activates. Electron also requires in the reduction reactions during biosynthesis. carbon dioxide(CO2) does not supply hydrogen or energy is for the cell. All M.O can fix (CO2) and reduce it to form organic molecules.

**Nutritional types of microorganisms**

M.O can be classified into nutritional classes based on how they satisfy all their requirements (C, H, O, energy and electrons). There are two sources of energy available to M.O

* Light energy: Energy derived from oxidizing organic or inorganic molecules.
1. Phototrophs: M.O that use light as their energy source.
2. Chemotrophs: M.O obtain energy from the oxidation of chemical compounds (organic &inorganic molecules).

Classification of M.O according to their source of electrons

1- Lithotrophs: reduced inorganic substances as their electron source.

2-Organotrophs: extract electrons from organic compounds.

 According to carbon sources ,M.O can be divided into two groups ;

1-Autotrophs ; CO2 sole or principal biosynthetic carbon source.

2-Heterotrophs ;Reduced, preformed, organic molecules are their carbon sources.

**Major Nutritional Types**

Most M.O may be placed in one of four nutritional classes based on their primary sources of carbon ,energy, and electrons :

1-Photolithoautotrophy : L/E ; Inorganic H/Electron donor; CO2

2-Photoorganoheterotrophy : L/E ;Organic H/Electron donor ;O/ C source

3-Chemolithoautotrophy : CH/E Inorganic ;Inorganic H/Electron donor ;CO2

4-Chemoorganoheterotrophy : CH /E Organic ;Organic H/Electron donor ;O/ C source.

5- Mixotrophic: M.O that combine ch.li.au. tr. & heterotrophic metabolic processes

**Requirements for Nitrogen, Phosphorus and Sulfur**

M.O must be able to incorporate large quantities of N, P & S in order to growth. Nitrogen requires for synthesis of amino acids, purines, pyrimidines, some carbohydrates, lipids, enzyme cofactors and other substances.

Phosphorus is present in nucleic acids, phospholipids, nucleotides like ATP several cofactors, some proteins and other cell components. All M.O use inorganic phosphate as their phosphorus source. Sulfur is needed for the synthesis of some amino acids like cysteine, methionine, some carbohydrates, biotin and thiamine. Most M.O use sulphate as a source of sulfur and reduce it by assimilatory sulfate reduction.

Growth factors: are an essential organic compounds required which are unable to synthesis by the organism. There are three major classes of growth factors:

1. Amino acids: require for protein synthesis.
2. Purines and pyrimidines: requires for nucleic acid synthesis .
3. Vitamins: small organic molecules that make up all or part of enzyme cofactors, only very small amounts sustain growth. Most common vitamins are Biotin ,Folic acid and Riboflavin (B2)

**Uptake of nutrients by the cell**

The first step in nutrient use is uptake of the required nutrients by the microbial cell, uptake mechanism must be specific for necessary substances. Nutrients must pass through a selectively permeable plasma membrane that will not permit the free passage of most substances.

The most important transport mechanisms are :

**Passive diffusion**: the process in which molecules move from a region of higher concentration to one of lower concentration because of random thermal agitation. The rate of passive diffusion is dependent on the size of the concentration gradient between a cell’s exterior and it’s interior. A very small molecules (H 2O, O2 and CO2) often move across membranes by passive diffusion.

**Facilitated diffusion**: the rate of diffusion across selectively permeable membranes is greatly increased by using carrier proteins, called permeases, which are embedded in the plasma membrane. Because carrier aids the diffusion process,it is called facilitated diffusion. The rate of transport increases with the concentration gradient much more rapidly and at lower concentrations of the diffusing molecule than that of passive diffusion. The curve below resembles an enzyme – substrate and is different from the linear response seen with passive diffusion. Carrier proteins also resemble enzymes in their specificity for the substance to be transported ;each carrier is selective and will transport only closely related solutes.

**Active transport**: M.O often live in habitats with very dilute nutrient sources, must be able to transport and concentrate these nutrients, thus facilitated diffusion mechanisms are not always adequate and other approaches must be used. Most important transport mechanisms in such situations are; active transport and group translocation, both energy –dependent processes.

**Active transport**: is the transport of solute molecules to higher concentrations or against concentration gradient, with the use of metabolic energy. The carrier proteins or permeases bind particular solutes with great specificity. it is also characterized by the carrier saturation effect at high solute concentration.

**Group translocation**: Many bacteria up take molecules by group translocation ,a process in which a molecule is transported into the cell while being chemically altered. It is energy –dependent transport because metabolic energy is used. In the 1,2,3 types the solute molecules move across a membrane without modification. The best –known group translocation system is the phosphoenolpyruvate; Sugar phosphotransferase system(PTS). It is transports a variety of sugars into cells while phosphorylating them using phosphoenolpyruvate (PEP) as the phosphate donor.

Figure: passive and facilitated diffusion

 

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

 