Microbial Nutrition

To obtain **energy** and construct new cellular omponents, 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.

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.

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,Magnesium,and iron.

these are called macroelements or macronutrients because they are required by microorganism in relatively large amounts,

the first six**(C,O,H,N,S and P)** are components of carbohydrates,lipids ,proteins and nucleic acids,

the remaining four macroelements exist in the cell as cations and play a variety of roles;

potassium(k+) is required for activity by a number of enzymes, including some of those involved in protein synthesis.

Calcium(Ca),contributes to the heat resistance of bacterial endospores.

Magnesium(Mg) serves as a cofactor for many enzymes,complexes with ATP,and stabilizes ribosomes and cell membranes.

Iron(Fe and Fe)is a part of cytochromes and a cofactor for enzymes and electron –carrying proteins.

TABLE 7.1 Principal Inorganic Reservoirs of Elements

Element	Inorganic Environmental Reservoir
Carbon	CO_2 in air; CO_3^{2-} in rocks and sediments
Oxygen	O_2 in air, certain oxides, water
Nitrogen	N_2 in air; NO_3^-, NO_2^-, NH_4^+ in soil and water
Hydrogen	Water, H_2 gas, mineral deposits
Phosphorus	Mineral deposits (PO_4^{3-}, H_3PO_4)
Sulfur	Mineral deposits, volcanic sediments (SO_4^{2-}, H_2S, S^0)
Potassium	Mineral deposits, the ocean (KCl, K_3PO_4)
Sodium	Mineral deposits, the ocean ($NaCl$, $NaSi$)
Calcium	Mineral deposits, the ocean ($CaCO_3$, $CaCl_2$)
Magnesium	Mineral deposits, geologic sediments ($MgSO_4$)
Chloride	The ocean ($NaCl$, NH_4Cl)
Iron	Mineral deposits, geologic sediments ($FeSO_4$)
Manganese, molybdenum, cobalt, nickel, zinc, copper, other micronutrients	Various geologic sediments

All organisms,including M.O,need several **micronutrients** or trace elements;

manganese, zinc, cobalt, molybdenum, nickel, 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 is needed for the skeleton or backbone of all organic molecules, and molecules serving as carbon sources also contribute both oxygen and hydrogen atoms .

M.O also needs a source of electron,electron movement through electron transport chains and during other oxidation-reduction reactions can provide energy for use in work . Electron also are needed to reduce molecules during biosynthesis.

One important carbon that does not supply hydrogen or energy is carbon dioxide(CO_2). All M.O can fix it and reduce it to form organic molecules.

Nutritional types of microorganisms

M.O can be grouped into nutritional classes based on how they satisfy all their requirements (C,H,O, energy, electrons).

There are only two **sources of energy** available to M.O ; light energy & energy derived from oxidizing organic or inorganic molecules.

1-**Phototrophs** ; M.O that uses light as their energy source.

2-**Chemotrophs**; obtain energy from the oxidation of chemical compounds (organic & inorganic).

M.O also has only two sources for **electrons** ;

1-**Lithotrophs** ; use 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** ; CO_2 sole or principal biosynthetic carbon source.

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

Major Nutritional Types

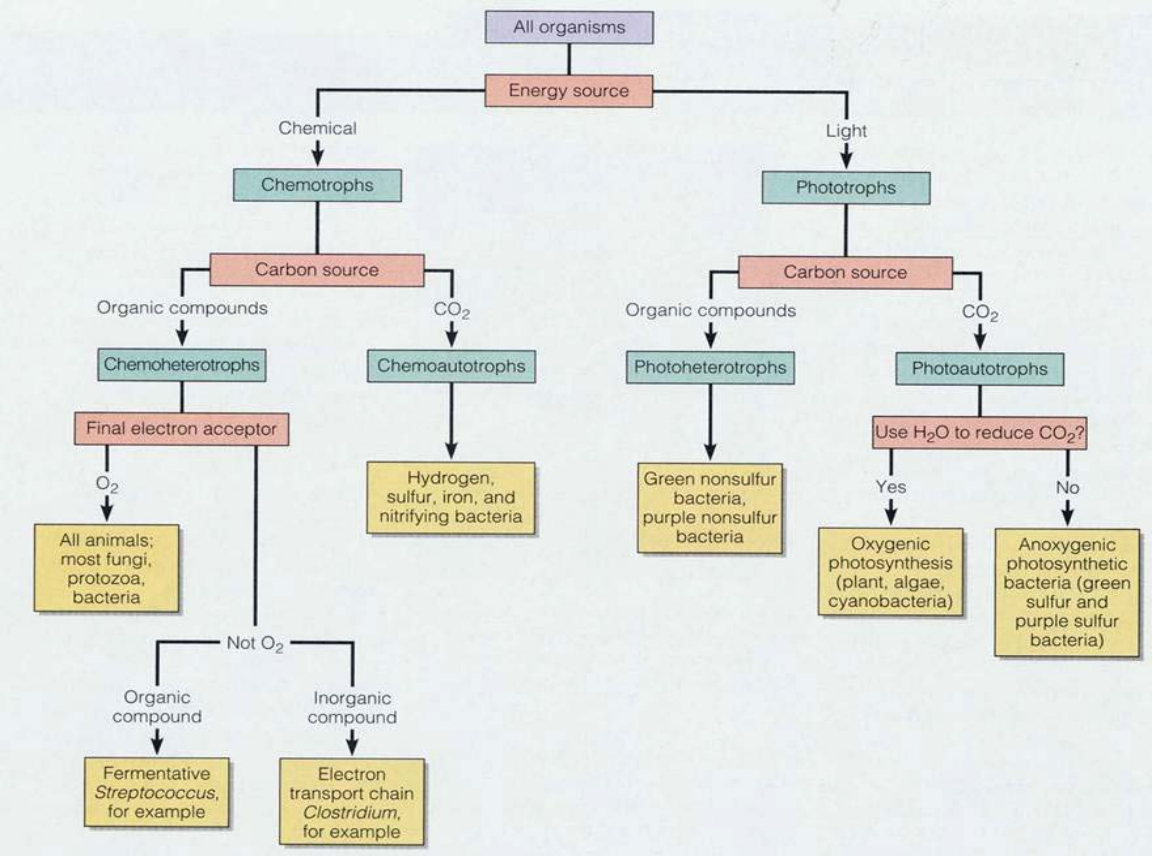
Most M.O may be placed in one of four nutritional classes based on their primary sources of carbon ,energy, and electrons :

1-**Photolithoautotrophy** : Light/Energy ; Inorganic H/Electron donor; CO_2

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

3-**Chemolithoautotrophy** : Chemical/E. Inorganic ; InorganicH/Electron donor ;CO_2

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



Mixotrophic

M.O that combine chemolithoautotrphic & heterotrophic metabolic processes.

6.2 Nutritional types of microorganisms

Major nutritional type	Sources of energy, hydrogen/electrons, and carbon	Representative microorganisms
Photoautotroph (Photolithotroph)	Light energy, inorganic hydrogen/electron(H/e^-) donor, CO_2 carbon source	Algae, Purple and green bacteria, Cyanobacteria
Photoheterotroph (Photoorganotroph)	Light energy, inorganic H/e^- donor, Organic carbon source	Purple nonsulfur bacteria, Green sulfur bacteria
Chemoautotroph (Chemolithotroph)	Chemical energy source (inorganic), Inorganic H/e^- donor, CO_2 carbon source	Sulfur-oxdizing bacteria, Hydrogen bacteria, Nitrifying bacteria
Chemoheterotroph (Chenoorganotroph)	Chemical energy source (organic), Organic H/e^- donor, Organic carbon source	Most bacteria, fungi, protozoa

Requirements for Nitrogen, Phosphorus and Sulfur

To grow, M.O must be able to incorporate large quantities of N,P,& S.

Nitrogen is needed for the 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 ,& other cell components, all M.O uses inorganic phosphate as their phosphorus source and incorporate it directly.

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 factots ; are organic compounds required because they are essential cell components and cannot be synthesized by the organism, 3 major classes of growth factors:

1- **Amino acids** ; are needed for protein synthesis.
2- **Purines and pyrimidines** ; 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 ,Riboflavin (B2).