Microbial nutrition

BY

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Microbial nutrition and growth

PRINCIPLES OF BACTERIAL GROWTH

- Growth may be defined as the orderly increase of all of the chemical constituents of the cell. Bacterial growth involves both an increase in the size of individuals and increase in the number of individuals.

- 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 production and therefore are required for microbial growth.

Categories of Requirements for Microbial Growth

The requirements for microbial growth can be divided into two main categories:

1-chemical

2-physical.

1. Chemical Requirements

Chemical requirements include sources of

A- Macroelements or macronutrients

B- trace elements or micronutrients

C- organic growth factors

A. Major elements (Macroelements or macronutrients)

Elements that make up cell constituents are called **major elements (macroelements or macronutrients)** and over 95 percent of cell dry weight is made up of a few major elements. These include carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus, potassium, magnesium, calcium, and iron.

Requirements for Carbon, Hydrogen, and Oxygen

The requirements for carbon, hydrogen, and oxygen often are satisfied together.

Carbon is needed for the skeleton or backbone of all organic molecules, and molecules serving as carbon sources normally also contribute both oxygen and hydrogen atoms.

They are the source of all three elements.

Because these organic nutrients are almost always reduced and have electrons that they can donate to other molecules, they also can serve as energy sources.

Requirements for Nitrogen, Phosphorus, and Sulfur

To grow, a microorganism must be able to incorporate large quantities of nitrogen, phosphorus, and sulfur.

1- Nitrogen is needed for the synthesis of amino acids, purines, pyrimidines, some carbohydrates and lipids, enzyme cofactors, and other substances.

2- Phosphorus is present in nucleic acids, phospholipids, nucleotides like ATP, several cofactors, some proteins, and other cell components. Almost all microorganisms use inorganic phosphate as their phosphorus source and incorporate it directly.

3- Sulfur is needed for the synthesis of substances like the amino acids cysteine and methionine, some carbohydrates, biotin, and thiamine. Most microorganisms use sulfate as a source of sulfur and reduce it by assimilatory sulfate reduction

B. Trace elements or micronutrients

Some elements, termed **trace elements or micronutrients** are required in very minute amounts by all cells. They include **cobalt, zinc, copper, molybdenum**, and **manganese.** These elements form parts of enzymes or may be required for enzyme function.

C . Growth Factors

Most bacteria require certain organic compounds in minute quantities known as growth factors.

A growth factor is an organic compound which a cell must contain in order to grow, but which it is unable to synthesize. These low molecular weight compounds that must be provided to a particular bacterium

There are three major classes of growth factors:

(1) Amino acids, are needed for protein synthesis

(2) purines and pyrimidines, are needed for nucleic acid synthesis

(3) vitamins. are small organic molecules that usually make up all or part of enzyme cofactors

Nutritional Types of Microorganisms

In addition to the need for carbon, hydrogen, and oxygen, all organisms require sources of energy and electrons for growth to take place. Microorganisms can be grouped into nutritional classes based on how they satisfy all these requirements

- **microorganisms can be classified as either heterotrophs or**
- **autotrophs** with respect to their preferred source of carbon.

There are only two sources of energy available to organisms:

(1) light energy,

(2) the energy derived from oxidizing organic or inorganic molecules

- **Phototrophs** use light as their energy source;

- **Chemotrophs** obtain energy from the oxidation of chemical compounds

Microorganisms also have only two sources for electrons.

(1) Organic compounds

(2) In organic compounds

Lithotrophs use reduced inorganic substances as their electron source, whereas **organotrophs** extract electrons from organic compounds

2. Physical requirements include

1. Temperature

Each bacterial species has an optimal temperature for growth and a temperature range above and below which growth is blocked. The temperature at which growth occur best is known as the '**optimum temperature**'.

Thus, bacteria pathogenic for humans usually grow at 37ºC .

- **Bacteria are divided into three groups on the basis of temperature ranges through which they grow:**

Mesophilic: Bacteria which grow between **10ºC and 45ºC**, with optimal growth between 20-40ºC.

Psychrophilic: Psychrophilic bacteria (cold-loving) are organisms that grow between 5 to 30ºC, optimum at **10 to 20ºC.**

Thermophilic: Thermophiles (heat-loving) have growth range 25-80ºC, optimum at 50-60ºC. They may cause spoilage of under processed canned food.

2. Oxygen

Based on their O2 requirements, prokaryotes can be separated into

a- Aerobic bacteria

Require oxygen for growth and may be:

1-Obligate aerobes: They have an absolute or obligate requirement for oxygen (O2), like the cholera vibrio.

2-Facultative anaerobes: They are ordinarily aerobic but can also grow in the absence of oxygen, though less abundantly,

3-Microaerophilic organisms: They grow best at low oxygen tension (~5%) e.g. *Campylobacter spp., Helicobacter spp*.

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B. Anaerobic bacteria

Grow in absence of oxygen.

Obligate anaerobes: They may even die on exposure to oxygen, e.g. *Clostridium tetani*

3. Carbon Dioxide

All bacteria require small amount of carbon dioxide for growth. Thus, this requirement is usually met by the carbon dioxide present in the atmosphere, or produced endogenously by cellular metabolism. (CO2)is one important carbon source that does not supply hydrogen or energy .This is because CO2 is oxidized and lacks hydrogen.

However, by definition, only **autotrophs** can use CO2 as their sole or principal source of carbon.

4. Moisture and Drying

Moisture is very essential for the growth of the bacteria because water is essential ingredient of bacterial protoplasm and hence drying is lethal to cells. However, the effect of drying varies in different species.

5. pH

Most bacteria can live and multiply within the range of pH 5 (acidic) to pH 8 (basic) and have a pH optimum near neutral (pH 7).

Most pathogenic bacteria grow best at a neutral or slightly alkaline pH (7.2 to 7.6).

Some acidophilic bacteria such as lactobacilli grow under acidic conditions while ***Cholerae vibrio***, grow at high degrees of alkalinity (well above pH 8), whereas most other bacteria grow in a range of 6 to 7.5. Numerous fungi grow well at pH 4 or 5.

6. Light

Darkness provides a favorable condition for growth and viability of bacteria. Bacteria are sensitive to ultraviolet light and other radiations as ultraviolet rays from direct sunlight or a mercury lamp are bactericidal. Bacteria are also killed by ionizing radiations.

Exposure to light may influence pigment production. Photochromogenic mycobacteria form pigment only on exposure to light.

7. Osmotic Effect

Tolerance to osmotic variation: Bacteria are more tolerant to osmotic variation because of the mechanical strength of the cell wall. Except for the mycoplasma and other cell wall defective organisms, the majority of the bacteria are osmotically tolerant.