

NUTRITION AND GROWTH OF BACTERIA

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Bacterial requirements for growth include sources of energy, "organic" carbon (e.g. sugars and fatty acids) and metal ions (e.g. iron). Optimal temperature, pH and the need (or lack of need for oxygen) are important.

Bacteria can be classified into the following type according to the basis of their ability to synthesize essential metabolism.

A- Autotrophs:-

These are bacteria which are able to synthesize their own organic food from inorganic substances. They use carbon dioxide for obtaining carbon and utilize hydrogen sulphide (H₂S) or ammonia (NH₃) or hydrogen (H₂) as the source of hydrogen to reduce carbon

B- Heterotrophs:-

Microbes obtain their carbon from organic compound, such as sugar, protein and lipids. Hydrogen is usually obtained from water, and oxygen is obtained from atmosphere or from water where it is found in dissolved state.

Growth Factors:-

Growth factors are required in small amounts by cells because they fulfill specific roles in biosynthesis. The need for a growth factor results from either a blocked or missing metabolic pathway in the cells. Growth factors are organized into three categories.

1. **purines and pyrimidines:** required for synthesis of nucleic acids (DNA and RNA)
2. **amino acids:** required for the synthesis of proteins
3. **vitamins:** needed as coenzymes and functional groups of certain enzymes

Culture media:-

The growth of bacteria required culture media that provide:-

- 1- all the essential nutrient
- 2- the proper concentration of salts and ions
- 3- the proper pH (relative acidity or alkalinity)
- 4- moisture
- 5- gas requirement
- 6- temperature

*pH:-

The range of pH over which an organism grows is defined by **three cardinal points:** the **minimum pH**, below which the organism cannot grow, the **maximum pH**, above which the organism cannot grow, and the **optimum pH**, at which the organism grows best.

1- Acidophiles:- Microorganisms which grow at pH (3-5) are called.

2- Neutrophiles:- Microorganisms which grow best at neutral pH (6-8)

3- Alkaliphiles:- Microorganisms which grow best under alkaline conditions pH as high 10.5 are called.

***Moisture:-**

Water is needed for the growth and reaction of metabolism like glycolysis and protein synthesis, various nutrient must be in a soluble form to facilitate diffusion into the cell. In the absence of the water some bacteria will form a spore for continue its survival.

***Gas requirement:-**

Microorganisms fall into several groups with respect to the effect of oxygen on their growth and metabolism:

1. Obligate aerobes

- use and require oxygen as electron acceptor
- have respiratory enzymes and lack the capacity for fermentations
- examples: *Pseudomonas*, some *Bacillus*

2. Obligate anaerobes

- do not need or use O₂ as a nutrient. In fact, O₂ is a toxic substance, which either kills or inhibits their growth. Obligate anaerobic procaryotes may live by fermentation, anaerobic respiration
- examples: *Clostridium*, *Bacteroides*

3. Facultative organisms

- are organisms that can switch between aerobic and anaerobic types of metabolism. Under anaerobic conditions (no O₂) they grow by fermentation or anaerobic respiration, but in the presence of O₂ they switch to aerobic respiration.
- examples: all Enterobacteriaceae (*E.coli*), some *Bacillus*

4. Aerotolerant anaerobes

- grow either with or without oxygen, but metabolism remains fermentative and do not use oxygen
- examples: *Enterococcus faecalis*, some *Lactobacillus*

***Temperature:-**

The temperature range at which organism grow best is called optimum temperature. In human parasitic organism optimum temperature ranges between 30° C and 37° C. there are three groups of bacteria as regard to the temperature:-

1- Psychrophilic:-

The bacteria is growing between 0° C and 25° C. they are mostly soil and water bacteria

2- Mesophilic:-

Some bacteria grow between 20° C and 44° C this group include bacteria producing disease.

3- Thermophilic:-

The bacteria can grow between 50 and 80° C this bacteria will survive after pasteurization processes of milk.

***Energy source:-**

Either a source of carbon or other required nutrient.

Bacterial growth:-

Growth involves increase in cell mass and number of ribosomes, duplication of the bacterial chromosome, synthesis of new cell wall and plasma membrane, partitioning of the two chromosomes, septum formation, and cell division. The growth of microorganism can be measured by:-

- 1- increase in size but this a poor criterion of growth.
- 2- increase in the number of microorganism by either counting the number of living cells (viable count) or all cells (total count).
- 3- measurement of some component of cell structures such as protein or DNA as an indication of microbial increase (growth) or decrease (death).

Generation time:-

Is the time required for one complete cell division. Some microbes are able to divide as rapidly as once every 12 to 15 minutes, other require up to several hours, and a few very slow growing bacteria may require more than 24 hour per cell division.

Growth curve:-

When a fresh medium is inoculated with a given number of cells, and the population growth is monitored over a period of time, plotting the data will yield a **typical bacterial growth curve**. Four characteristic phases of the growth cycle are recognized.

1. Lag Phase.

Immediately after inoculation of the cells into fresh medium, the population remains temporarily unchanged. Although there is no apparent cell division occurring, the cells may be growing in volume or mass, synthesizing enzymes, proteins, RNA, etc., and increasing in metabolic activity.

The length of the lag phase is apparently dependent on a wide variety of factors including the size of the inoculum; time necessary to recover from physical damage

or shock in the transfer; time required for synthesis of essential coenzymes or division factors; and time required for synthesis of new (inducible) enzymes that are necessary to metabolize the substrates present in the medium.

2. Exponential (log) Phase.

The exponential phase of growth is a pattern of balanced growth where in all the cells are dividing regularly by binary fission, and are growing by geometric progression. The cells divide at a constant rate depending upon the composition of the growth medium and the conditions of incubation. The rate of exponential growth of a bacterial culture is expressed as **generation time**, also the **doubling time** of the bacterial population.

3. Stationary Phase.

Exponential growth cannot be continued forever in a **batch culture** (e.g. a closed system such as a test tube or flask). Population growth is limited by one of three factors:

1. accumulation of toxic product and/ or exhaustion of available nutrients;
2. accumulation of inhibitory metabolites or end products;
3. exhaustion of space, in this case called a lack of "biological space".

During the stationary phase, the number of new cell produce balance the number of that cell die resulting in steady state.

4. **Death Phase.** If incubation continues after the population reaches stationary phase, a death phase follows, in which the viable cell population declines.

During the death phase, the number of viable cells decreases geometrically (exponentially), essentially the reverse of growth during the log phase.



Although the characteristic growth curve shown above probably occurs under selected condition, modification do happen in nature and in some clinical circumstance.

Growth of bacteria in an open environment, such as soil, water, or even the intestine generally does not follow the curve shown above, in these circumstances bacterial growth is most often continuous, so that the number of viable microorganisms remain fairly constant over long periods of time.

Laboratory (in vitro) studies of bacterial growth in continuous culture have shown that the microorganisms grow exponentially in a condition of balanced growth, and the generation time is determined by the rate at which fresh nutrients are supplied to the culture. continuous culture is usually used by genetic engineering for synthesis of some wanted things like; insulin, vitamins, toxins, enzyme,.....etc.

Growth media:-

1- Selective medium:- is one which has a component(s) added to it which will inhibit or prevent the growth of certain types or species of bacteria and/or promote the growth of desired species, penicillin or other antibiotics for isolation of eukaryotes, bile salts to suppress gram positive bacteria. Eosin methylene blue (EMB) is used to differentiate lactose fermenters; In EMB agar lactose fermenters (e.g. *E. coli*) produce a colony with dark color and metallic Sheen

2- Differential media - to distinguish between different types of bacteria based on some observable trait in their pattern of growth on the medium add some kind of indicator (such as dye) to differentiate the organisms. such as blood agar and MacConkey agar.

3- Minimal media:- are those that contain the minimum nutrients possible for colony growth, generally without the presence of amino acids

4- Complex medium:- is a medium that contains: a carbon source such as glucose for bacterial growth, water, various salts needed for bacterial growth, amino acid, nucleotide, is used for fastidious bacteria