Growth of bacterial culture – Physical & Chemical requirements for Growth

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- Bacterial cells – in order to grow and divide, require various factors like water, nutrients, pH, temperature, etc..
- These factors directly affect the growth of bacterial cells and are definitely required for normal growth and division of the cells.
- Each of these factors in the environment of the cells are variables. The best condition or factor, at which the growth and division of the bacterial cells are high, is termed as the ‘Optimum condition’ for the cells. For example most bacterial cells grow best at 37°C. So the ‘optimum temperature’ for those cells is 37°C.
- Bacterial cells also have a ’minimum’ and ‘maximum’ limit for their requirements. The minimum condition is one, below which, no growth occurs and the maximum condition is one, above which the cells die.
- The various factors that can control the growth of bacterial cells are termed ‘Requirements for growth’.

- The conditions or factors required for bacterial growth are classified into Physical factors and Chemical factors.
- The physical factors include temperature, Oxygen requirement, pH and Osmotic pressure.
- The chemical factors include
  (1) Carbon source
  (2) Energy source
  (3) Nitrogen source
  (4) Minerals
  (5) Water
  (6) Growth factors

Physical Factors for bacterial growth:

(1) Temperature:

All bacterial members grow best at a specific temperature. This temperature is termed optimal growth temperature of that bacterium. For example most bacteria grow well at moderate temperatures of 25°C-45°C. These bacterial members are called **Mesophiles** (moderate tempt.)

Some bacterial members grow well at higher temperatures (45°C-70°C). Such bacterial members are called **Thermophiles**.

Some other bacterial members grow well at low temperatures like 0°C-20°C. They are called **Psychrophiles**.

2. Oxygen requirement:

Based on O_2 requirement for growth, bacterial members are classified as follows:

Aerobic bacteria: Bacterial members which grow in the presence of oxygen.

Anaerobic bacteria: Bacterial members which grow in the absence of oxygen.

Microaerophiles: Bacterial members that grow in the presence of moderate amounts of oxygen.

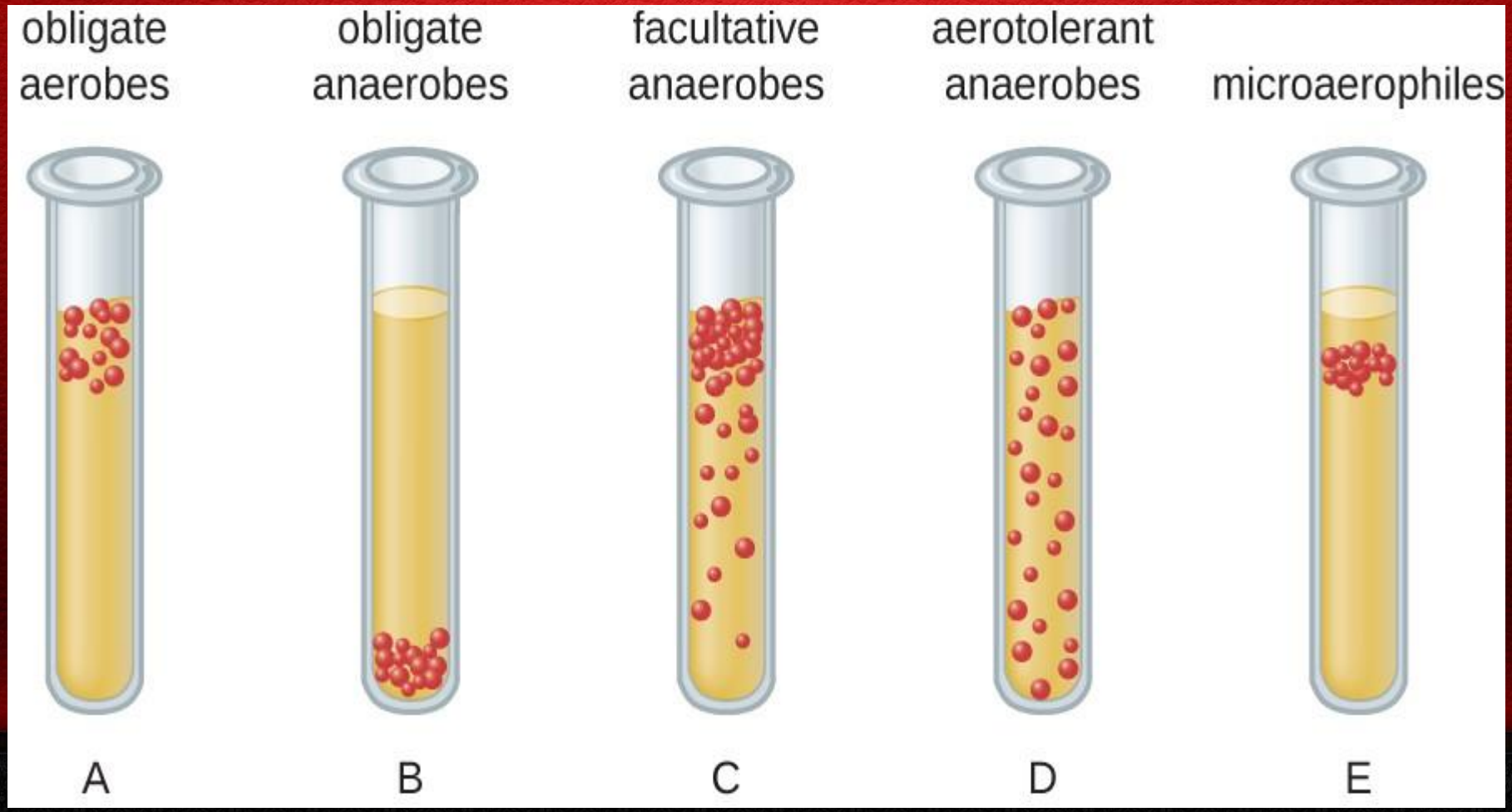
Obligate aerobes: Bacterial members that can grow only in the presence of oxygen.

Obligate anaerobes: Bacterial members that can grow only in the absence of oxygen.

Facultative anaerobes: Bacterial members that can grow in the presence or absence of oxygen.

Aerotolerant anaerobes: Bacterial members that can grow in the presence of oxygen but do not need oxygen for growth.

Classification of bacteria based on oxygen requirement



(2) pH:

Similar to O_2, bacterial members require a suitable pH (hydrogen ion conc.) for their growth. For example most bacterial members grow best at the neutral pH of 7.0. They are termed **Neutrophiles**.

Some bacteria grow well at acidic pH (1.0-6.0). They are termed **Acidophiles**.

Bacterial members that grow well at alkaline pH (8.0-14.0), are termed **Alkaliphiles**.

(3) Osmotic Pressure:

Bacterial cells are made up of 80-90% water. The cell contents are maintained intact, due to the maintenance of pressure within the cells. Movement of water molecules into and out of cells is based on the differences in osmotic concentration – between the exterior and interior of the cells. This osmotic conc. is due to differences in the amount of salt.

Some bacterial cells require high conc. of salt for their optimal growth. They are called **Halophiles**. Among halophiles, some members require very high salt conc. for their growth. They are termed **extreme or obligate halophiles**. Some bacterial members grow best in the presence of low salt conc. (2%). They are termed **facultative halophiles**.

Chemical factors for bacterial growth:

1. Carbon and Energy source:

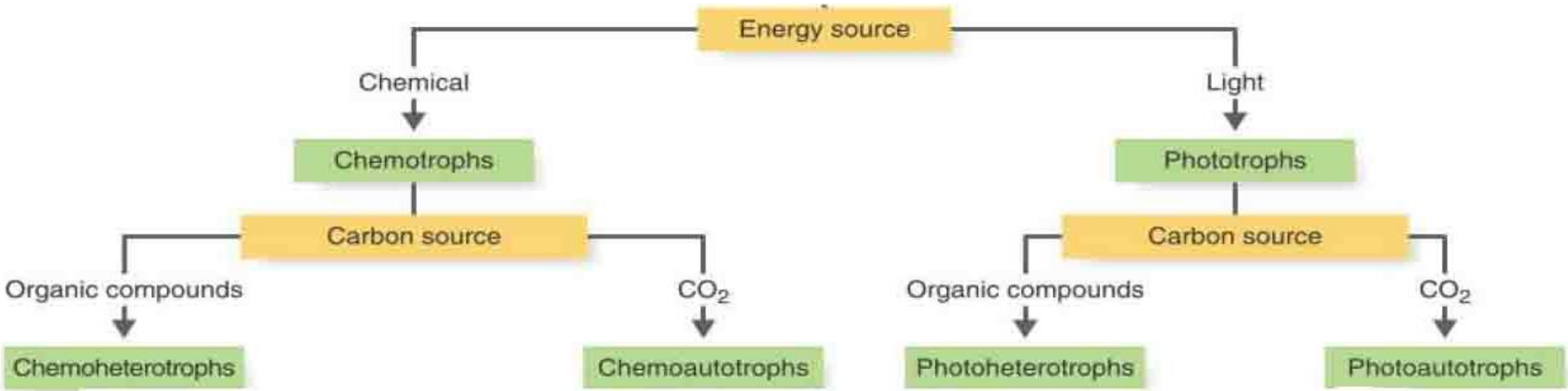
Carbon is the backbone of all biological molecules. Carbon sources are mainly used for cell growth and biomolecule formation, including aminoacids – which are components of proteins.

All living organisms require energy for carrying out the various functions of the cell. Based on the energy source required, cells are classified as **Phototrophs** and **Chemotrophs**. Phototrophs use light as energy source, whereas chemotrophs depend on the oxidation–reduction reactions of inorganic or organic chemical compounds, for their energy.

Based on the Carbon source, cells are classified as autotrophs and heterotrophs. Autotrophs use CO_2 as carbon source. Heterotrophs use an organic compound as carbon source.

- Combining the energy and carbon sources, the nutritional classification of bacterial cells is divided into Photoautotrophs, Photoheterotrophs, Chemoautotrophs and Chemoheterotrophs.
- Photoautotrophs use light as energy source and CO_2 as carbon source.
- Photoheterotrophs use light as energy source and an organic compound as carbon source.
- Chemoautotrophs use chemicals as energy source and CO_2 as carbon source.
- Chemoheterotrophs use chemicals as energy source and an organic compound as carbon source.

Classification of organisms based on Carbon and Energy source



3. Nitrogen source:

- Nitrogen is needed for the synthesis of molecules like amino acids, DNA, RNA and ATP . Depending on the organism, nitrogen, nitrates, ammonia, or organic nitrogen compounds may be used as a nitrogen source.

4. Minerals:

Minerals like K^{+}, MG^{++}, Fe^{++}, Mn^{++}, Co^{++}, Cu^{++}, Zn^{++}, etc.. are required for various biochemical reactions in the cell. They are also called as cofactors.

5. Water:

Water is the medium – in which all the nutritional requirements of the cell are dissolved and is absolutely required for the growth of all cells.

6. Growth factors:

They include additional organic compounds for the growth of cells, if they cannot synthesize by themselves. Examples include vitamins, amino acids, purines, pyrimidines, etc..

References:

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- Joanne M. Willey, Linda M. Sherwood and Christopher J. Woolverton, Prescott's Microbiology, 10th Ed., 2017, Library of Congress Cataloging-in-Publication Data, NY.