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Lec.5

Medical microbiology

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Bacterial Physiology and Metabolism

1- Bacterial Growth

Factors affecting bacterial growth include:

• Temperature

• Atmosphere – O2 & CO2

• H-ion concentration

• Moisture & drying

• Osmotic effects

• Radiation

• Mechanical & sonic stress

1-Temperature

- Bacteria vary in their temperature requirements.
- Temperature range – growth does not occur above the maximum or below the minimum.

- Optimum Temperature – It is the temperature at which growth occurs best, it is 37ºC for most pathogenic bacteria

Classification based on Temperature:

- Psychrophiles (15-20 °C) – Pseudomonas fluorescens
- Mesophiles (20-40 °C) – Escherichia coli, Salmonella enterica, Staphylococcus aureus
- Thermophiles (50-60 °C)- Bacillus stearothermophilus
- Extremely thermophiles (as high as 250 °C)

2-OXYGEN

• Depending on the O2 requirement, bacteria are divided into:

a- **Strict (Obligate) Aerobes** – require O2 for growth e.g., Pseudomonas aeruginosa

b- **Strict (Obligate) Anaerobes** – grow in the absence of O2 & may even die on exposure to O2.

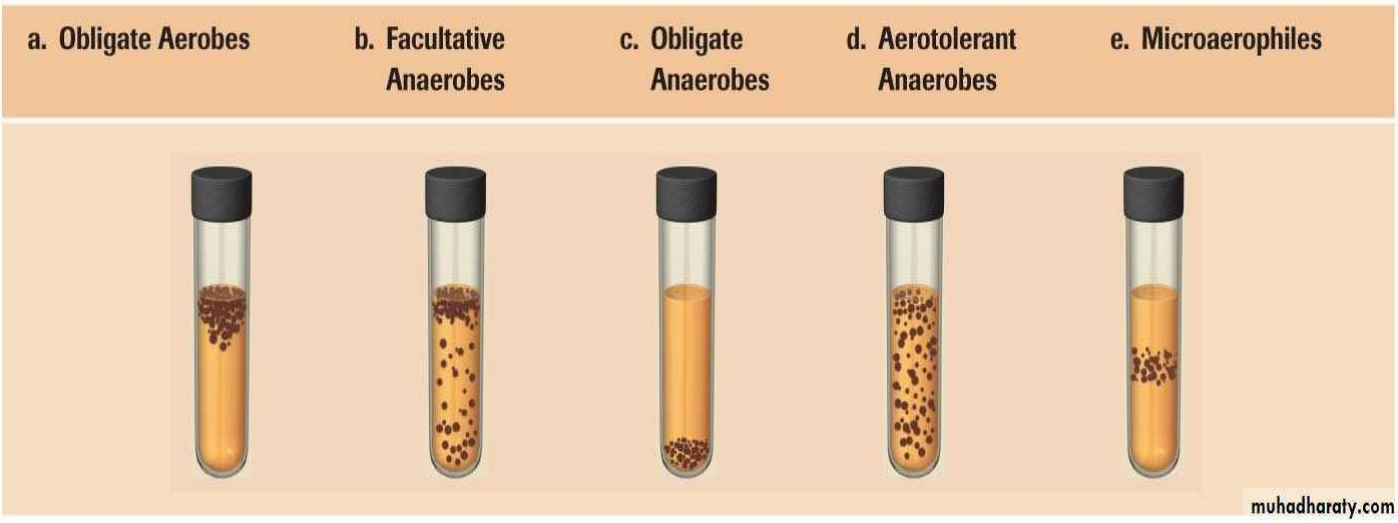
c- **Aerobe** (grow in ambient temperature, which contains 21% O2 and a small amount of CO2, 0.03%)

d- **Microaerophilic** – grow best in the presence of low oxygen levels e.g., Campylobacter spp, Helicobacter spp

e- **Facultative anaerobe** – aerobic but can also grow in the absence of O2 e.g., Staphylococcus spps

f- **Aerotolerant anaerobe** – anaerobic, but tolerates exposure to O2, e.g., Clostridium perfringens

g- **Capnophilic organism** – requires high CO2 levels eg Neisseria spps



• The Effect of Oxygen (O2) on Growth

a. Needs oxygen

b. Grows best in oxygen, but can grow without it

c. Only grows without oxygen

d. Grows in low concentrations of oxygen

e. Grows with or without oxygen

3- H-ion Concentration

- Acidophiles (Lactobacillus acidophilus)
- Alkaliphiles (Vibrio)
- Neutralophiles (pH 6-8)
- Majority of the medically important bacteria grow best at neutral or slightly alkaline reaction (pH 7.2-7.6)

4- Moisture and drying

Water is an essential ingredient of bacteria. Hence drying is lethal to cells.

Effect of drying varies:

- Trepanoma pallidum are highly sensitive to drying
- Staphylococcus spp. withstand drying for months
- Spores are resistant to drying and may survive for several decades

5- Osmotic effects

• More tolerant to osmotic variation due to mechanical strength of their cell walls.

6- Radiation

• X rays & gamma rays exposure – lethal

7- Mechanical & Sonic Stress

• May be ruptured by mechanical stress.

2-Bacterial Nutrition

- Water constitutes 80% of the total weight of bacterial cells.
- Proteins, polysaccharides, lipids, nucleic acids & low molecular weight compounds make up the remaining 20%.
- For growth & multiplication, the minimum nutritional requirements are water, a source of carbon, a source of nitrogen & some inorganic salts

❖ Classification based on nutrition

• Based on nutrition, bacteria are classified as:

• **Autotrophs** – can synthesize all their organic compounds by utilizing atmospheric CO2 & N2. They have no medical importance.

• **Heterotrophs** – unable to synthesize their own metabolites & depend on the organic compounds.

• All pathogenic bacteria are heterotrophs.

❖ Nutritional Factors

• Some bacteria require certain organic compounds in minute quantities called as nutritional factors.

• It can be :

a- Essential – Compounds that bacterial growth does not occur in their absence.

b- non-Essential – Compounds that enhance growth but without being absolutely necessary for it

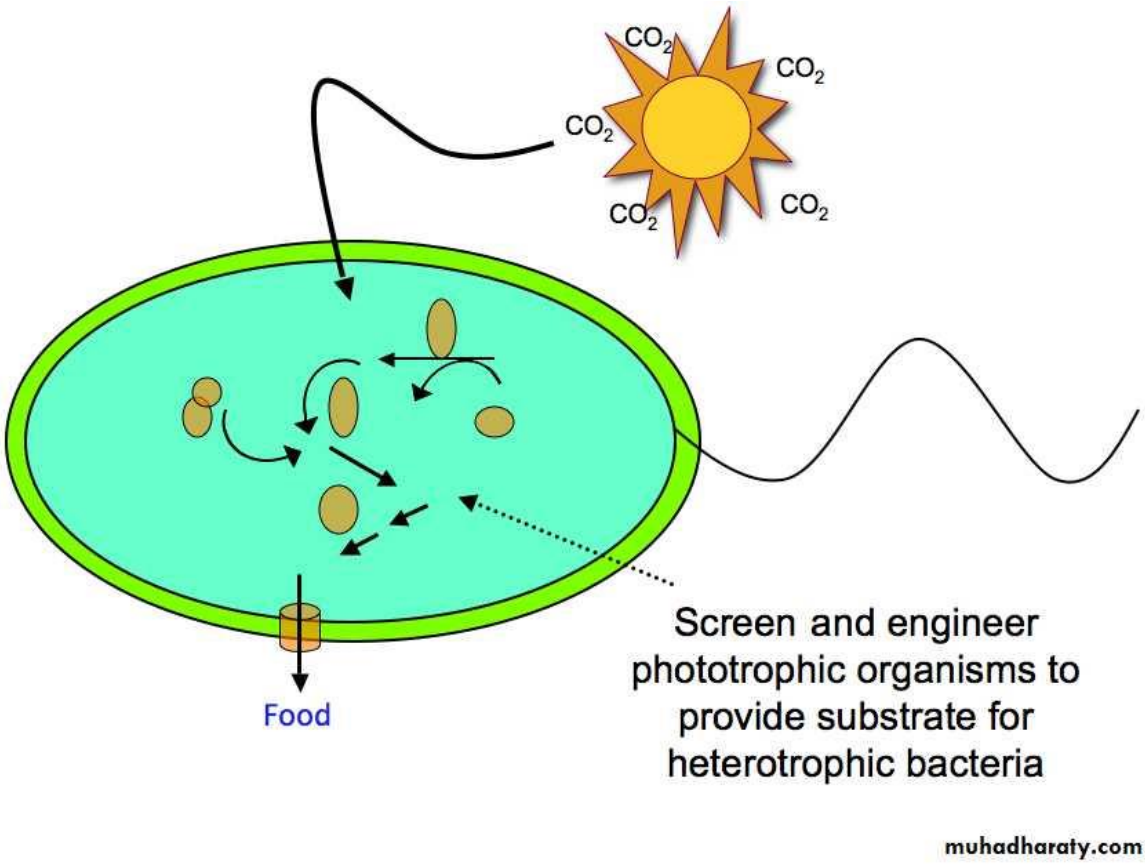
❖ Based on Nutritional Requirement Bacteria Can Be Classified As:

1- Phototrophs – Bacteria which derive their energy from sunlight.

2- Chemotrophs – Bacteria which derive energy from chemical reactions.

3- Organotrophs - require organic sources of hydrogen

4- Lithotrophs - require inorganic sources of hydrogen like NH3, H2S



❖ OTHER GROWTH REQUIREMENTS

• Vitamin B complex –

• Thiamine

• Riboflavine

• Nicotinic acid

• Pyridoxine

• Folic acid

• Vit.B 12

3-Bacterial Metabolism

• Metabolism is the totality of chemical reactions occurring in bacterial cells.

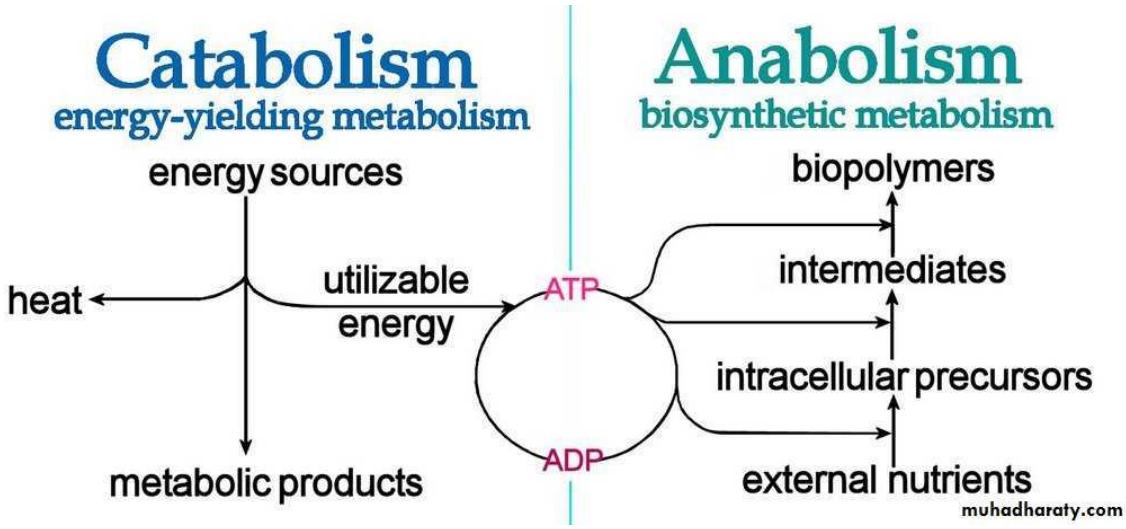
• They can be subdivided into :

A- Catabolic reactions that supply energy.

B- Anabolic (synthetic) reactions that consume energy

-Catabolic reactions supply both energy and the basic structural elements for the synthesis of specific bacterial molecules.

-In the anabolic reactions , the energy requirement is consumed in form of light or chemical energy—by photosynthetic or chemosynthetic bacteria, respectively.



A-Catabolic Reactions

-Organic nutrient substrates are catabolized in a wide variety of enzymatic processes that can be schematically divided into three phases:

1-Digestion:

-Bacterial exoenzymes split up the nutrient substrates into smaller molecules outside the cell.

-The exoenzymes represent important pathogenicity factors in some cases.

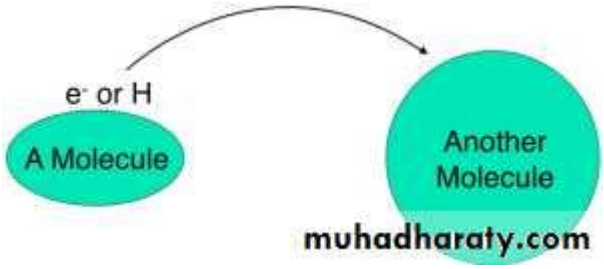
2-Uptake:

-Nutrients can be taken up by means of passive diffusion or, more frequently, specifically by active transport through the membrane(s).

3-Oxidation:

-This process is defined as the removal of electrons and H+ ions.

-The substance to which the H2 atoms are transferred is called the hydrogen acceptor.



- **The two basic forms of oxidation are defined by the final hydrogen acceptor:**

A – Respiration:

-A series of reactions that convert glucose to CO2 and allow the cell to recover significant amounts of energy

- Glucose + O2 ⟍ Carbon dioxide + Water +Energy

- C6H12O6 + O2 ⟍ 6CO2 + 6H2O + 38 ATP

B-Fermentation:

-Here an organic compound serves as the hydrogen acceptor.

-The main difference between fermentation and respiration is the energy yield, which can be greater from respiration than from fermentation for a given nutrient substrate by as much as 10 times.

B-Anabolic Reactions

-Some bacteria (like E. coli) are capable of synthesizing all the complex organic molecules that they are comprised of from the simplest nutrients in a very short time. These capacities are utilized in the field of microbiological engineering.

-Some bacteria are capable of using hydrocarbon compounds as an energy source.