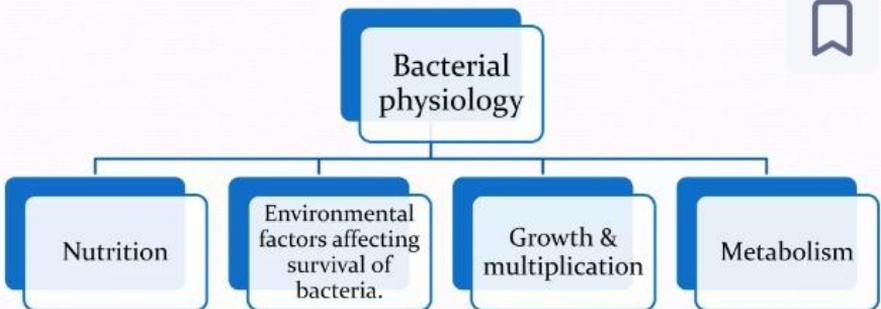




BACTERIAL PHYSIOLOGY

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❖ Nutrition-

- It is a process by which, chemical substances called nutrients, are obtained from surrounding environment & used for metabolic activity and growth of the cell.
- Most of medically imp bacteria grow on simple media with one source of organic material.
- Some bacteria requires more complex media

- Most of medically imp bacteria grow on simple media with one source of organic material.
- Some bacteria requires more complex media containing certain organic compounds k/a “fastidious bacteria”.

❖ Optimum nutritional requiremen for growth of bacteria.

- Water
- Source of carbon
- Source of nitrogen
- Inorganic salts
- Growth factors
- Source of energy

Water-

- Most imp requirement as it constitute 80% of t weight.
- Vehicle for entry of the nutrients into the cell.
- Elimination of all waste products.
- Participates in metabolic reaction.
- Is an integral part of protoplasm.

Source of carbon & energy-

Bacteria are divided into 2 groups

- ❑ **Autotrophic/Lithotrophic-** Can use CO_2 as a sole source of carbon for synthesis of all their organic metabolites
- They require water, inorganic salts & CO_2 for growth & derive energy either from
 - Light (photolithotrophic) or
 - Chemical reaction (chemolithotrophic)
- Are concerned with soil fertility & are medically less important .e.g. nitrogen fixing bacteria in soil



❑ **Heterotrophic/Organotrophic bacteria-**

- Unable to use CO_2 as a sole source of carbon.
- Require it in various organic form e.g. glucose, amino acids, nucleotides, lipids.



Source of nitrogen-

- N_2 atom of important biomolecules (like amino acids, purines, pyrimidines) comes from NH_4 ions.
- It may come from
 - a) Assimilatory nitrate production
 - b) Dissimilatory nitrate reduction

Certain species are able to fix atmospheric N_2 into usable organic form. e.g. azotobacter, blue green algae, kleb. pneumoniae



Inorganic salts



- These are required for osmotic regulation
- Are essential for certain enzyme systems.
 - The anions- phosphate & sulphate
 - The cations- sodium, potassium, magnesium, iron, calcium, manganese.

Growth factors-



- Many pathogenic species requires certain key substances for their growth k/a 'growth factors' or 'bacterial vitamins'.
- Includes B complex vitamins, purines, pyrimidines, amino acids
- They are provided by various body fluids & tissues 'in vivo' and in the form of yeast extract , blood & blood products 'in vitro'.

Environmental factors affecting growth of bacteria



- Moisture & dessication
- CO₂
- O₂ requirement
- Temperature
- p H
- Light
- Osmotic effect
- Mechanical & sonic stress



• Moisture & dessication-

- Moisture is an absolute requirement for growth.
- Therefore drying is lethal to cells.
- *Treponema* & *gonococci* are sensitive to drying.
- *Staphylococci* can withstand drying for months.

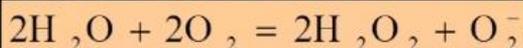
• CO₂-

- It is obtained either from environment or produced endogeneously
- A few bacteria require additional CO₂(5-10%) for their growth e.g. *Brucella abortus*, *Neisseria*, *pneumococci*.
- These are k/a *Capnophilic bacteria*.

O₂ requirement-



CLASS	DEFINITION	EXAMPLE
Obligate aerobe	Grows only in presence of O ₂	<i>Mycobacterium tuberculosis</i>
Obligate anaerobe	Grows only in absence of O ₂	<i>Clostridia</i>
Facultative anaerobes	Are generally aerobes, but can also grow in absence of O ₂	Most bacteria of medical importance
Microaerophilic bacteria	Grows under low O ₂ tension	<i>Campylobacter</i>

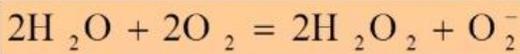


🌱 In the presence of oxygen, two toxic substances to the bacteria are produced which are hydrogen peroxide and superoxide anion



🌱 **In obligate aerobes and facultative anaerobes:**

- Superoxide dismutase enzyme degrades superoxide anion.
- Catalase and peroxidase enzymes degrade hydrogen peroxide.



In the presence of oxygen, two toxic substances to the bacteria are produced which are **hydrogen peroxide** and **superoxide anion**.

In obligate aerobes and facultative anaerobes:

- **Superoxide dismutase** enzyme degrades **superoxide anion**.
- **Catalase** and **peroxidase** enzymes degrade **hydrogen peroxide**.

BUT

In obligate anaerobes:

- These enzymes are **not present**.
- So, the presence of oxygen is **toxic to them**.

Temperature-

- Pathogenic bacteria grows best at body temp. i.e. 37°C

Bacteria type	Temperature	Example
Psychrophilic	0-20	Soil & water saprophytes
Mesophilic	25- 40	Majority of pathogenic bacteria
Thermophilic	55-80	Bacillus & Clostridia

- **Thermal death point**- Lowest temp that kills a bacterium under standard condition in a given time.
- Mesophilic bacteria having thermal death point 50-65°C
- Spores have thermal death point between 100-120°C.

pH-

- Most bacteria grows best at optimum pH of 7.2-7.6
- Growth is poor below pH 6.0 & above 7.8
- Growth stops below pH 5.0 & above 9.0
- *Lactobacillus* species grows at acidic pH & k/a acidophiles
- *Vibrios* are sensitive to acid but tolerate alkali.

Light-

- Bacteria grows well in dark
- They are sensitive to UV rays & other radiation.
- Photosynthetic bacteria require light for photosynthesis.
- Photochromogenic bacteria produce pigment only when exposed to light.



• Osmotic effect-

- Sudden exposure to hypertonic solution causes osmotic withdrawal of water & shrinkage of the cell k/a *Plasmolysis*.
- Sudden transfer from concentrated solution to distilled water causes imbibition & rupture of cell & is k/ a *plasmolysis*.

• Mechanical & sonic stress-

- Cell wall may be ruptured by grinding & vigorous shaking.
- It may be disintegrated by exposure to ultrasonic vibration.



❖ Growth & Multiplication of bacteria

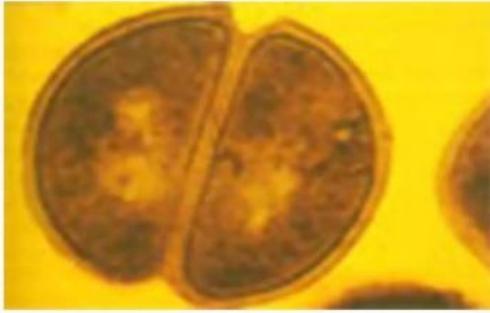
Bacterial growth means balanced increase in mass in terms of-

- a) Increase in size OR
- b) Increase in number of cells

When growth reaches critical mass, cell divides



Cell divides by constrictive or pinching by ingrowth of septum across cell wall



Bacteria showing binary fission

Generation time-

- Time required for bacterium to give rise to 2 daughter cells under optimum condition is k/a 'generation time' or 'population doubling time'. e.g.

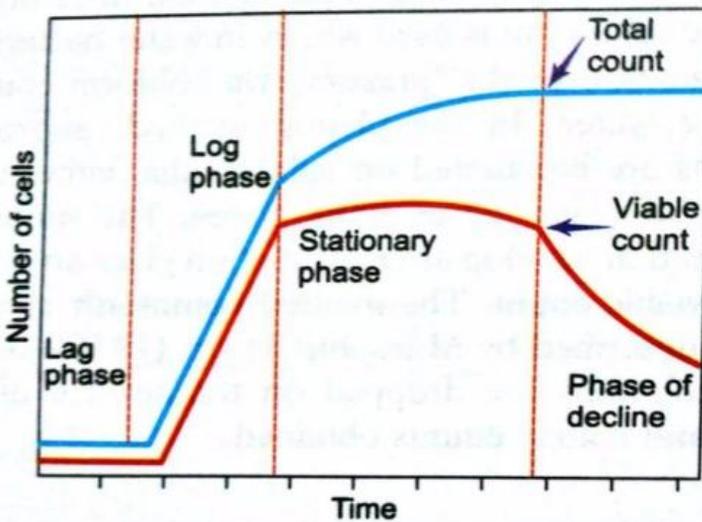
Coliform bacteria	20 min
Tubercular bacilli	20 hrs
Lepra bacilli	20 days

Bacterial counts

- Total count**- gives total number of cells irrespective of whether they are living or dead.
- Viable count**- gives total number of living cells only.
- Total count can be obtained by
 - Direct counting under microscope
 - Counting in 'Coulter chamber'.
 - By 'Absorptiometer' or 'Nephelometer'.
 - By chemical assay with N_2
 - Using their wet or dry weight

❖ Bacterial growth curve-

- When bacterium is seeded into a suitable liquid medium & incubated, its growth follows a definitive curve & is k/a 'bacterial growth curve'.
- In this graph bacterial count is determined at different intervals & plotted in relation with time.



❖ Lag phase-

- No appreciable increase in number but there may be increase in size. Max cell size is obtained.
- This is time required for adaptation to new environment.
- Enzymes & metabolic intermediates are built up.
- Lasts for 1-4 hrs & its duration varies with species, nature of medium, temperature.
- **Clinical significance-** incubation period of disease

❖ Log phase-

- **Clinical significance-** incubation period of disease

❖ **Log phase-**

- Cells starts dividing & their number increases exponentially with time.
- Cells are smaller & stain uniformly.

- No. of newly formed cells > no. of cells dying
- **Clinical significance-** symptoms & signs appears.

❖ **Stationary phase-**

- Growth rate slows d/t depletion of nutrients & accumulation of toxic products.
- No. of newly formed cells = no. of cells dying
- Cells are gram variable & shows irregular staining d/t presence of storage granules.
- Sporulation occurs.

❖ **Declining phase-**

- More nutritional exhaustion & toxin accumulation.
- Death of cells d/t autolytic enzymes.
- **Clinical significance-** phase of convalescence.

❖ **Bacterial metabolism-**

- ✓ Absorbed food(carbohydrates, fats, proteins) are utilized & eliminated by certain metabolic pathways
- ✓ Aerobic bacteria obtain their energy by oxidation involving O₂ as a ultimate hydrogen acceptor.
- ✓ In anaerobic bacteria, hydrogen acceptor is other than O₂.
- ✓ Facultative bacteria can utilize both pathways.

☐ Oxidation-

- Ultimate electron acceptor is O_2
- Carbon & energy source are broken down into CO_2 & H_2O
- Energy is generated by **oxidative phosphorylation**, i.e production of energy rich phosphate bonds & their transfer to ADP to form ATP

☐ Fermentation

- In anaerobic bacteria, growth occurs by process in which carbon & energy source acts as both- electron donor & acceptor in a series of oxidoreduction k/a fermentation.
- e- acceptors are nitrates & sulphites.
- Following products are formed
 - Acids -lactic acid, formic acid, Pyruvic acid
 - Alcohols
 - Gases - H_2 , CO_2

➤ Substrate level phosphorylation-

- During fermentation energy rich phosphate bonds are produced by introduction of organic phosphate into intermediate metabolites k/a substrate level phosphorylation.
- These phosphate bonds are transferred to ADP to form ATP.