Bacterial Growth and Physiology

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SUPPORT BACTERI

it's the only culture some people h

What does physiology mean ?

IT'S:

1- GROWTH.

2-NUTRITION.

3- METABOLISM OF BACTERIA.

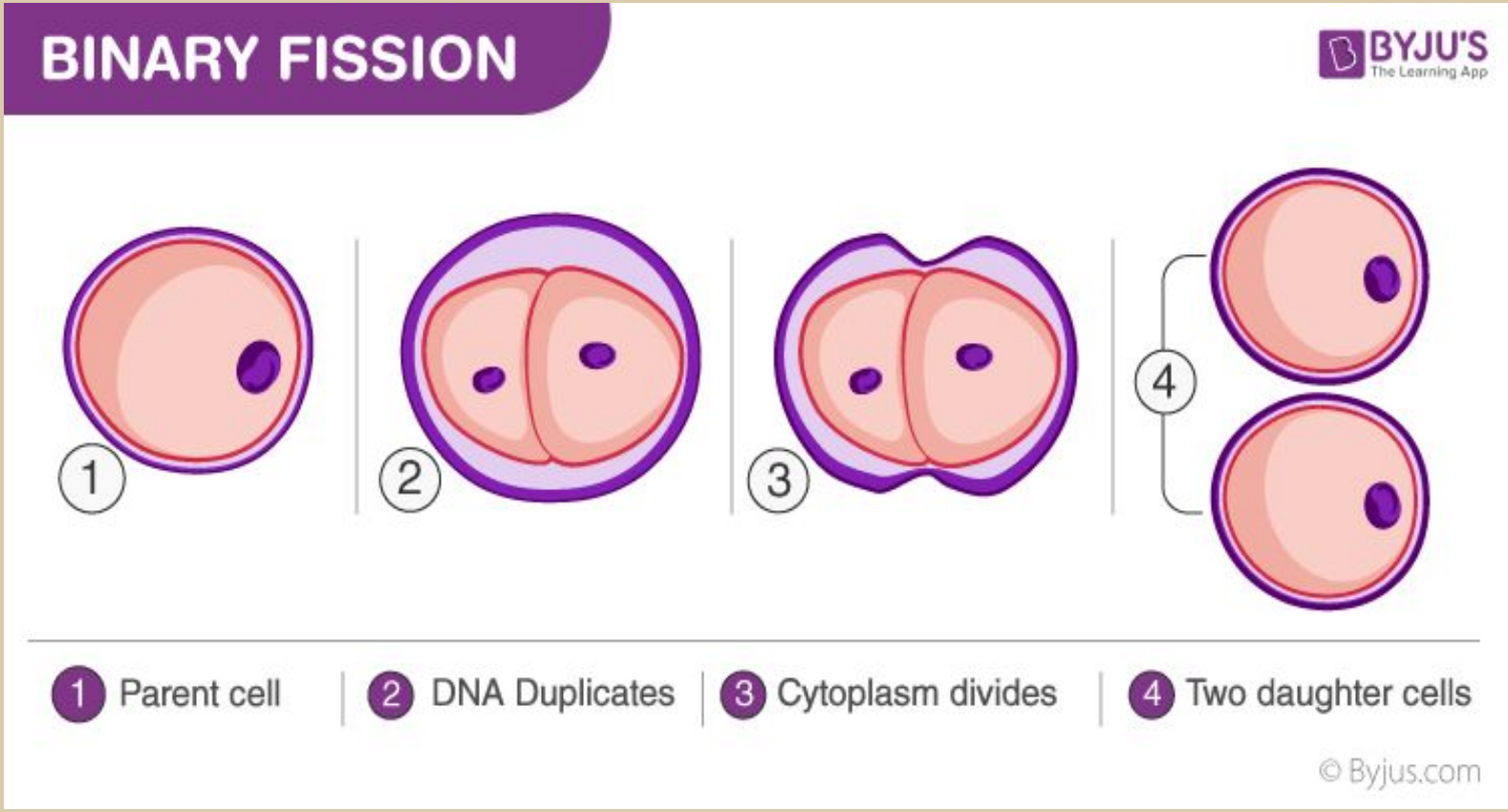
I-BACTERIAL GROWTH

- **It is an increase in all the cellular components, which end in multiplication of the cell leading to an increase in population.**

- **It involves an increase in the number of individual cells.**

- **Bacteria divide by binary fission.**

Binary Fission



Generation time

- **Interval of time between two cell divisions**

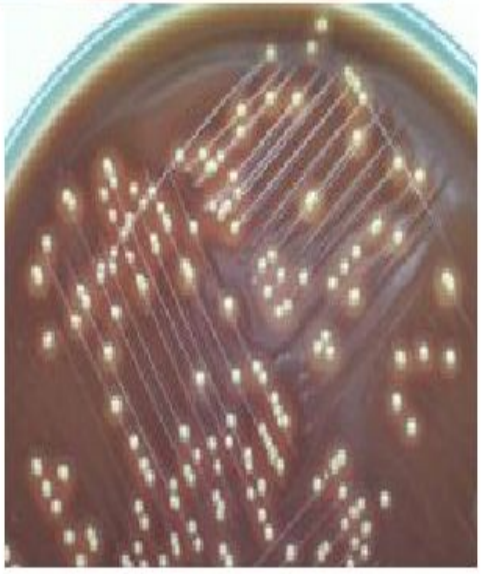
  OR

- **The time required for a bacterium to give rise to 2 daughter cells under optimum conditions**

- **Generation time of *E.coli* & other medically important bacteria is 20 mins**
- **For Tubercle bacilli is 20 hrs**
- **For *Treponema pallidum* bacilli (causative agent of syphlis) is 20 days**

Colony – formed by bacteria growing on solid media.

Each bacterial colony represents a clone of cells derived from a single parent cell.



The signs that indicate the bacterial growth are:-

1. **Turbidity** :which can be detected by naked eyes or spectrophotometry.
2. **Color changes** :some microorganisms are capable of producing pigments .
3. **Gas production** :some bacteria produce gasses that can be collected in inverted tubes .
4. **Change in pH** :due to acid production by bacteria .

FACTORS AFFECTING BACTERIAL GROWTH INCLUDE:

1. Temperature
2. Atmosphere – O_2 & CO_2
3. H-ion concentration
4. Moisture & drying
5. Osmotic effects
6. Radiation
7. Mechanical & sonic stress

1-Temperature

- **Bacteria vary in their temperature requirements.**
- **Optimum Temperature – It is the temperature at which growth occurs best, it is 37ºC for most pathogenic bacteria**

CLASSIFICATION BASED ON TEMP.

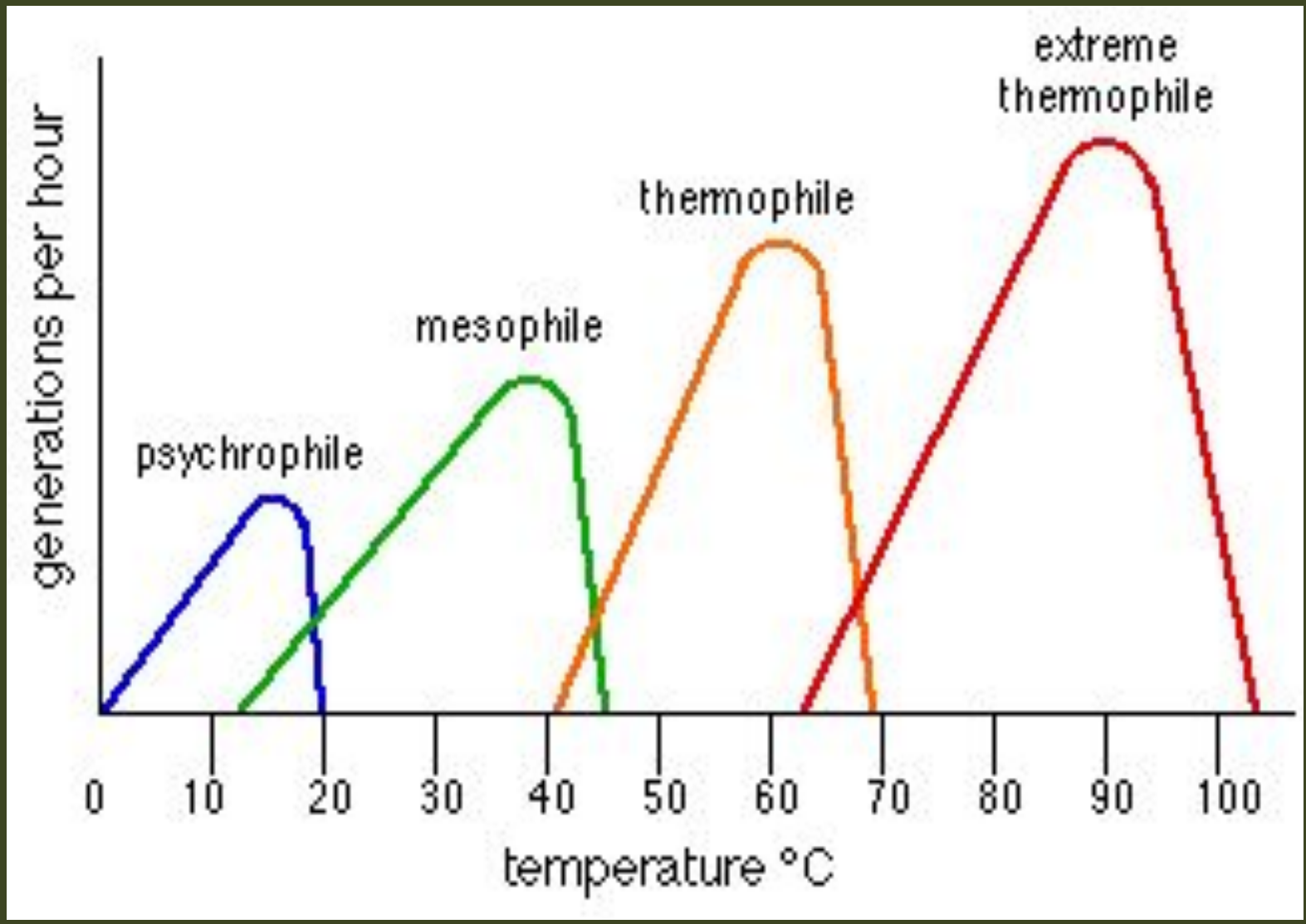
- **Mesophilic – grows best between 25ºC and 40ºC.**

  e.g. most pathogenic bacteria

- **Psychrophilic (cold loving) – grows best below 20ºC**

  e.g. Flavobacterium spps

- **Thermophilic – grows best at high temp, 55- 80ºC**
- **e.g. Bacillus spp.**


extreme
thermophile
thermophile
mesophile
psychrophile
generations per hour
0
10
20
30
40
50
60
70
80
90
100
temperature °C

2-OXYGEN

- **Depending on the O_2 requirement, bacteria are divided into :**

1. **Strict (Obligate) Aerobes – require O_2 for growth e.g. *Pseudomonas aeruginosa***

2. **Strict (Obligate) Anaerobes – grow in the absence of O_2 & may even die on exposure to O_2 e.g. *Bacteroides fragilis***

3. **Microaerophilic – grow best in the presence of low oxygen levels**

   e.g., *Helicobacter* spp

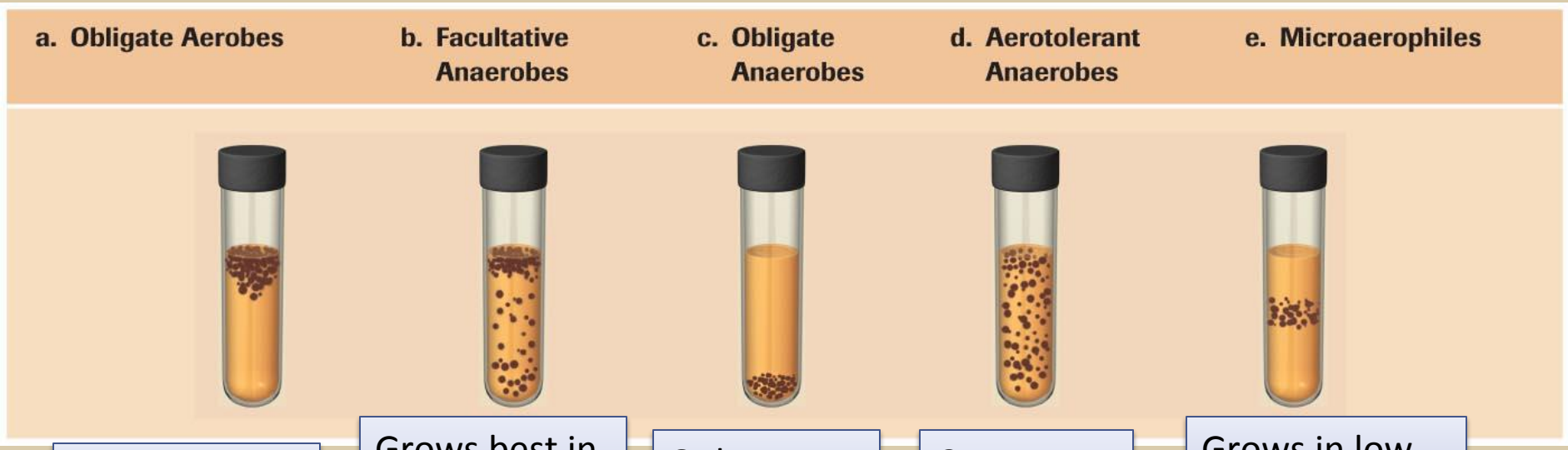
4. **Facultative anaerobe** – aerobic but can also grow in the absence of O_2

e.g. *Staphylococcus* spps

5. **Aerotolerant anaerobe** – anaerobic, but tolerates exposure to O_2

e.g. *Clostridium perfringens*

The Effect of Oxygen (O2) on Growth



3- H-ion Concentration

- **pH range, optimum pH**
- **Majority of pathogenic bacteria grow best at neutral or slightly alkaline pH (7.2 – 7.6) .**
- **Lactobacilli require acidic pH**
- ***Vibrio cholerae* require alkaline pH**

4- Moisture and drying

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

- **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.**

BACTERIAL GROWTH CURVE

- When a bacterium is added to a suitable medium & incubated, its growth follows a definite course.
- Growth curve shows 4 phases: :
- 1- Lag
- 2- Log or Exponential
- 3- Stationary
- 4-Decline.

PHASES OF GROWTH

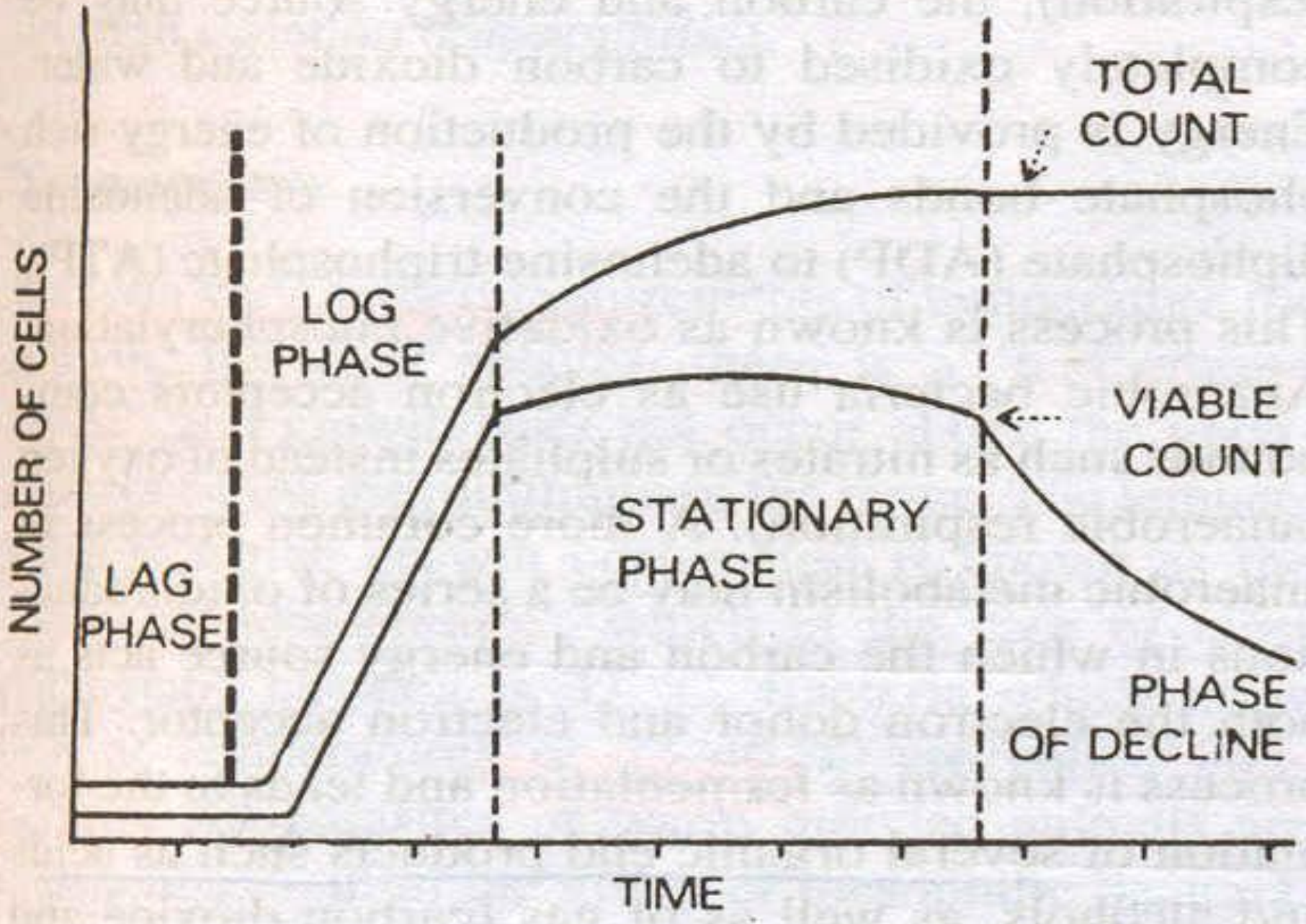
- **Lag phase – no increase in number but there may be an increase in the size of the cell.**

- **Log or Exponential phase – cells start dividing and their number increases exponentially.**

- **Stationary phase – cell division stops due to depletion of nutrients & accumulation of toxic products.**

  Equilibrium exists between dying cells and the newly formed cells, so viable count remains stationary.

- **Phase of decline – Population decreases due to the death of cells by autolytic enzymes.**


NUMBER OF CELLS
LAG PHASE
LOG PHASE
STATIONARY PHASE
PHASE OF DECLINE
TOTAL COUNT
VIABLE COUNT
TIME

BACTERIAL COUNTS

- **Growth in numbers can be studied by bacterial counts.**

- **2 methods – Total cell count**
  - Viable cell count

TOTAL COUNT

- **Total number of cells in the sample – living + dead.**

Can be obtained by :

Direct counting under microscope using counting chambers.

Viable Cell Count

- **Measures the number of living cells.**
- **Methods – Surface colony count**

1. **Dilution method**
2. **Plating method**

- **Number of colonies that develop after incubation gives an estimate of the viable count.**

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 :**

1. **Autotrophs – can synthesize all their organic compounds by utilizing atmospheric CO_2 & N_2.**
   They have no medical importance.

2. **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 nutritional factors .
- It can be :

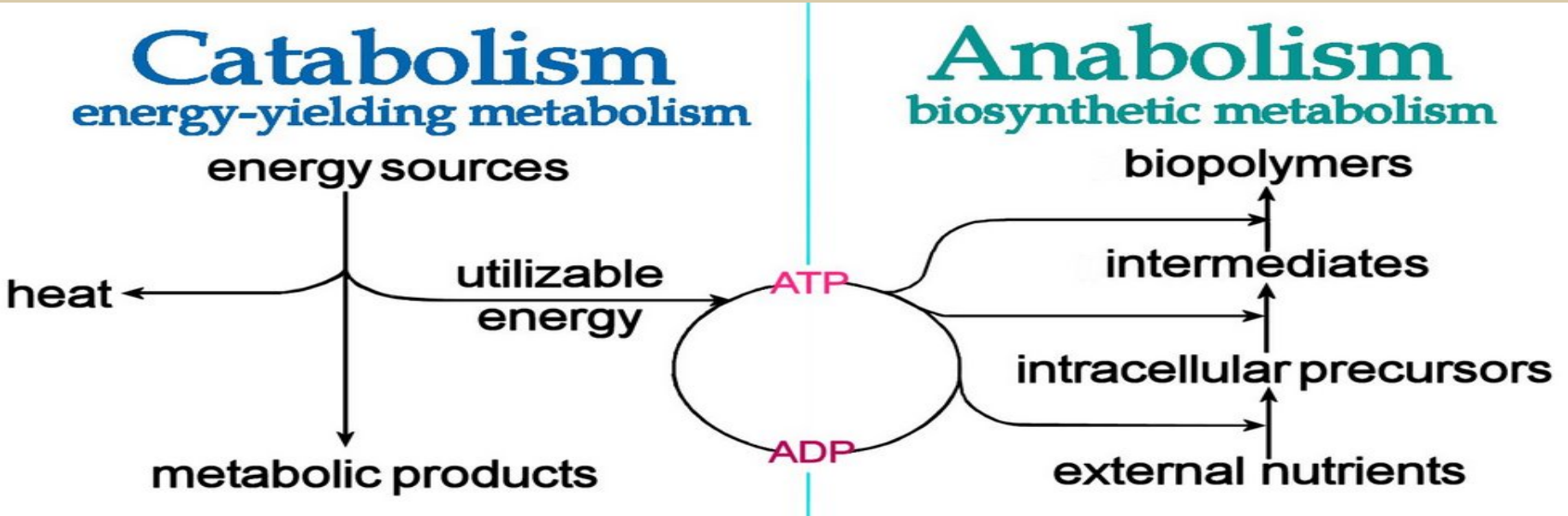
1. Essential – Compounds that bacterial growth does not occur in their absence.
2. Accessory – Compounds that enhance growth but without being absolutely necessary for it

3-Bacterial Metabolism

- **Types of 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.



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

A – Respiration:

-A series of reactions that convert glucose to CO_2 and allow the cell to recover significant amounts of energy

Glucose + O_2 → Carbon dioxide + Water +Energy

$C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + 6H_2O$ + 38 ATP

Energy Yield of Respiration

theoretical energy yields

- 38 ATP per glucose for bacteria
- 36 ATP per glucose for eukaryotes

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 .

- **On the basis of the kind of electron acceptor, energy, in the form of ATP, in**
- **microorganisms is produced by 3 ways;**

Fermentation; it is an oxidation-reduction process for the production of energy, where the electron donors and electron acceptors both are organic compounds….and the amount of energy produced is only 2 ATP.

Aerobic respiration; it is an oxidation-reduction process for production of energy where the electron donors are either organic or inorganic compounds, and the final electron acceptor is oxygen….and the amount of energy produce is 36 ATP.

Anaerobic respiration; it is an oxidation-reduction process, where the electron donors are either organic or inorganic compounds, and the electron acceptor is inorganic molecules, such as; NO^-_3, NO^-_2, SO_4^{--}, CO_2, H_2S, …….etc. The amount of energy produced is only 1 or 2 ATP.

THANK YOU