Lec.3
Bacterial physiology

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Theorical bacteriology

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Requirements for Microbial Growth

The requirements for microbial growth can be divided into two main categories: (A) Chemical and (B) Physical.

A. Chemical requirements: Chemical requirements include sources of carbon (C), nitrogen (N), sulfur (S), phosphorus(P) , trace elements, oxygen (O_2), and organic growth factors.

1-Major Elements (Macronutrients)

These include carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus, potassium, magnesium, calcium, and iron. Carbon is the structural back bone of living matter; it is needed for all the organic compounds that make up a living cell.

i. Autotrophs: Organisms that can use inorganic carbon in the form of carbon dioxide as their carbon source are called autotrophs (auto means self). They are soil are of no medical importance.

ii. Heterotrophs: Organisms that use organic carbon are called heterotrophs (hetero—different; troph—nourishment). They are unable to utilize carbon dioxide as the sole source of carbon and use reduced, preformed organic molecules as carbon sources.

2. Trace Elements

Some elements, termed as trace elements or(micronutrients),

are required in very minute quantities by all cells. They include cobalt, zinc, copper, molybdenum and manganese.

3. Growth Factors

Some bacteria require certain organic compounds in minute quantities known as (growth factors) or (bacterial vitamins). Growth factors are called ‘essential’ when growth does not occur in their absence, or ‘accessory’ when they enhance growth without being absolutely necessary for it.

B. Physical Factors Influencing Microbial Growth

1. Temperature:Optimum temperature: Each bacterial species has an optimal temperature for growth and Bacteria are divided into three groups on the basis of temperature ranges through which they grow:

i. Mesophilic: Bacteria which grow between 10°C and 45°C, with optimal growth between 20 and 40°C. Examples: All parasites of warm-blooded animals are mesophilic.

ii. Psychrophlic: Psychrophilic bacteria (cold-loving) are organisms that grow between 5 and 30°C, optimum at 10 to 20°C. They are soil and water saprophytes.

iii. Thermophilic: Thermophiles (heat-loving) have growth range of 25–80°C, optimum at 50–60°C. **Examples: Some thermophiles (like *Bacillus stearothermophiles)*** form spores that are exceptionally thermo tolerant.

2. Oxygen: Based on their O2 requirements, prokaryotes can be separated into aerobes and anaerobes.

A. Aerobic bacteria: Require oxygen for growth and may be:

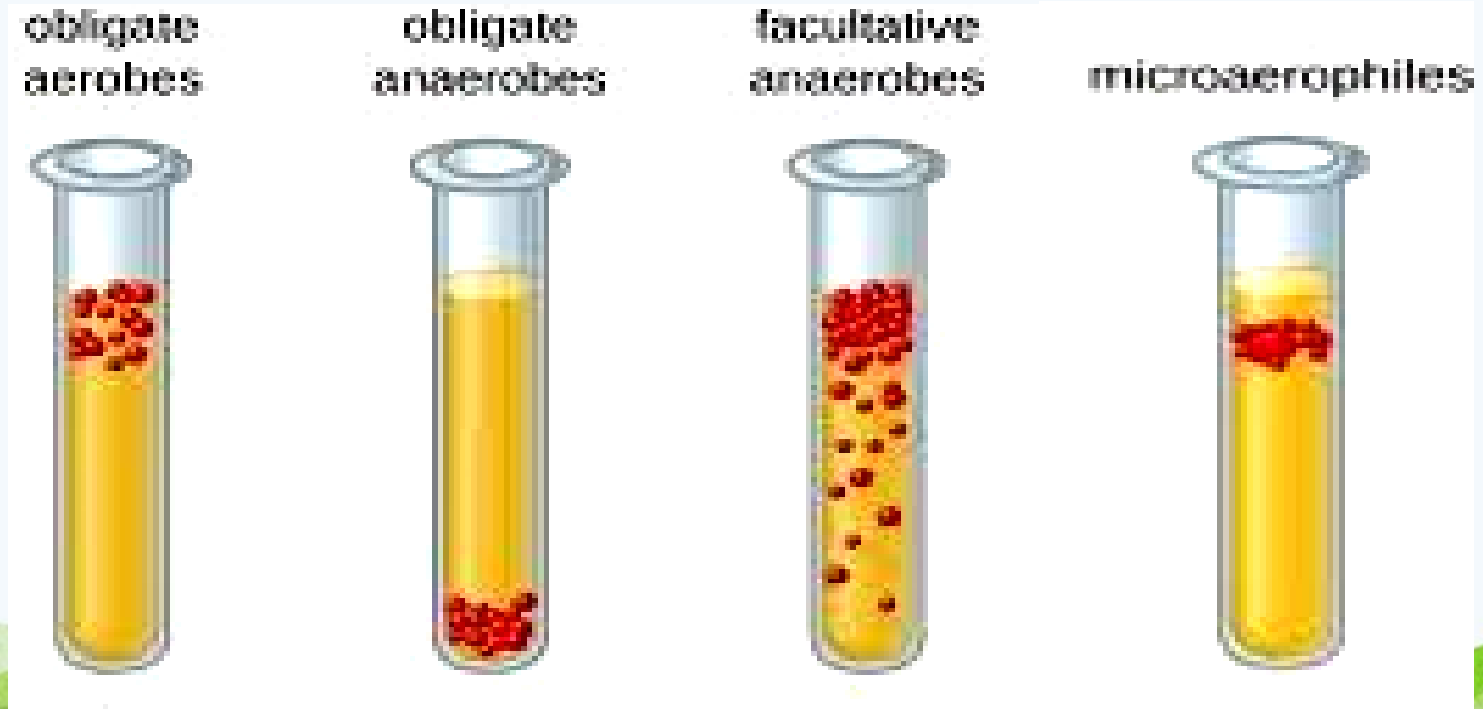
1. Obligate aerobes: These have an absolute or obligate requirement for oxygen (O2), like the cholera vibrio.

2. Facultative anaerobes: These are ordinarily aerobic but can also grow in the absence of oxygen, though less abundantly. Most bacteria of medical importance are facultative anaerobes.

3. Microaerophilic organisms: These grow best at low oxygen tension (~5%),
e.g. ***Campylobacter spp.***

B. Anaerobic bacteria: Grow in absence of oxygen.

1-Obligate anaerobes: These may even die on exposure to oxygen, e.g. *Clostridium tetani.*



3. Carbon dioxide: **All bacteria require small** amount of carbon dioxide (Co_2) for growth. Some organisms such as ***Brucella abortus require*** much higher levels of carbon dioxide (5–10%) for growth, especially on fresh isolation (**capnophilic bacteria), e.g. pneumococci and** gonococci.

4. Moisture and drying: **Moisture is very essential** for the growth of the bacteria. However, the effect of drying varies in different species.

5. pH: **Most pathogenic bacteria grow best at a** neutral or slightly alkaline pH (7.2–7.6). Some acidophilic bacteria such as lactobacilli grow under acidic conditions while *cholera vibrio* grow at high degrees of alkalinity (well above pH 8).

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6. **Light: Darkness provides a favorable condition** for growth and viability of bacteria. Bacteria are sensitive to ultraviolet light and other radiations.

7. **Osmotic effect: Tolerance to osmotic variation** bacteria are more tolerant to osmotic variation.

8. **Mechanical and sonic stresses: In spite of** tough walls of bacteria, they may be ruptured by mechanical stress such as grinding or vigorous shaking with glass beads.

Principles of bacterial growth

A. Bacterial Division

Bacteria divide by **binary fission where individual** cells enlarge and divide to yield two progeny of approximately equal size. Nuclear division precedes cell division. The cell division occurs by a constrictive or pinching process, or by the in growth of a transverse septum across the cell. The daughter cells may remain partially attached after division in some species.

Generation Time or Doubling Time

The interval of time between two cell divisions, or the time required for a bacterium to give rise to two daughter cells under optimum conditions, is known as the **generation time or doubling time.**

Examples: In coliform bacilli and many other medically important bacteria, it is about 20 minutes; in tubercle bacilli, it is about 20 hours and in lepra bacilli, it is about 20 days.

Colonies: Bacteria growing on solid media form Colonies

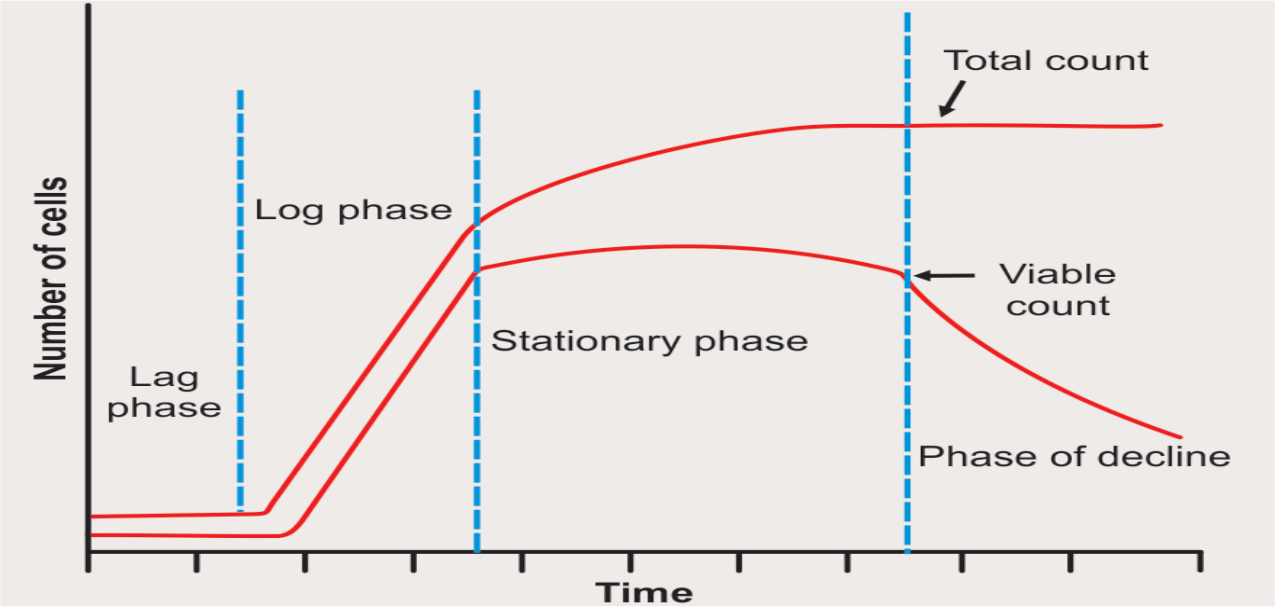
Each colony represents a clone of cells derived from a single parent cell.

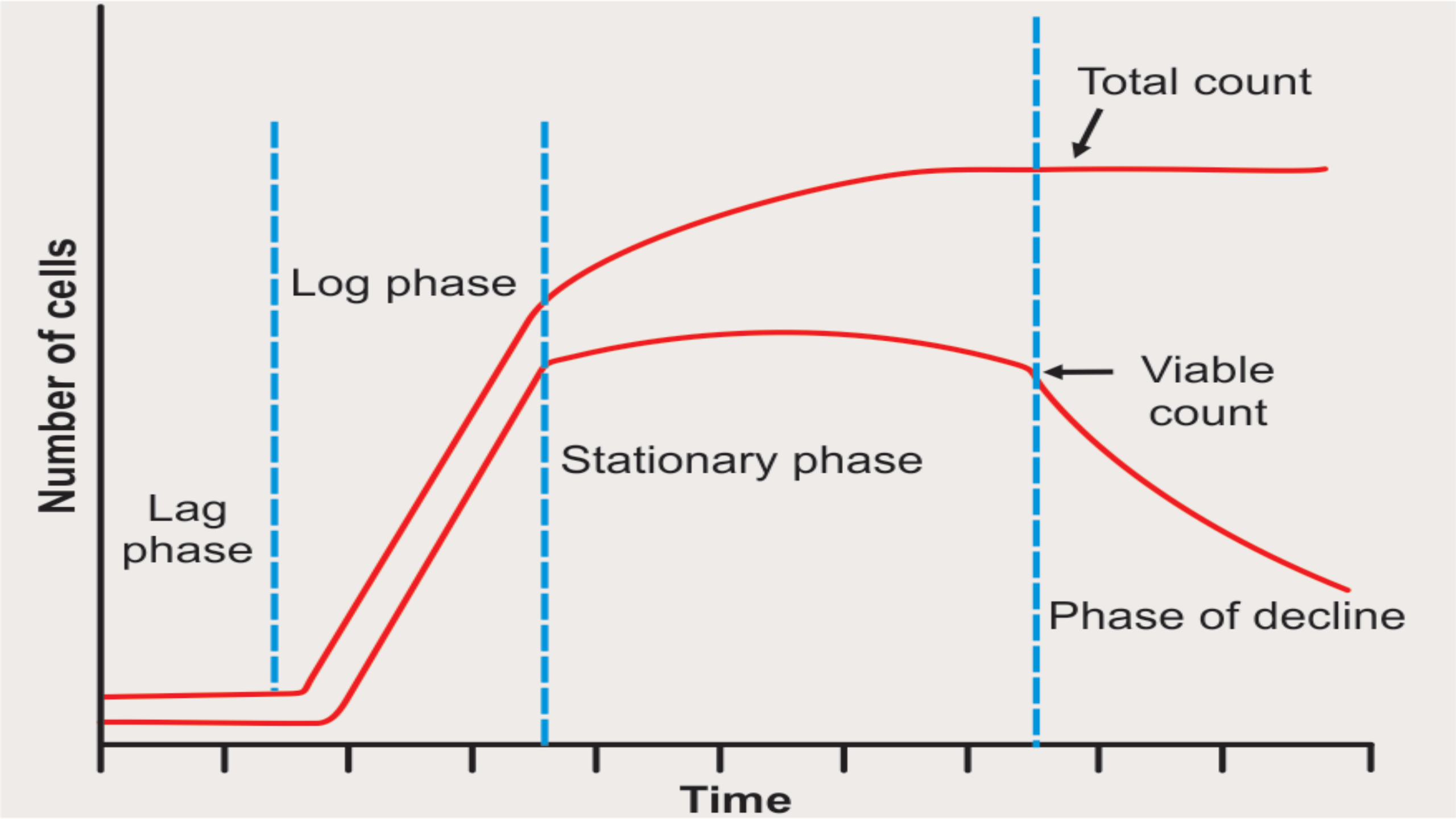
Bacterial Growth Curve

The bacterial growth curve can be divided into four major phases: lag phase, exponential or log (logarithmic) phase, stationary phase and decline phase.

1. Lag phase: When microorganisms are introduced into fresh culture medium, usually no immediate increase in cell number occurs, and therefore this period is called the **lag phase. After inoculation,** there is an increase in cell size at a time when little are no cell division is occurring. During this time, however, the cells are not dormant. This initial

period is the time required for adaptation to the new environment, during which the necessary enzymes and metabolic intermediates are built up in adequate quantities for multiplication to proceed.




Total count
Log phase
Number of cells
Viable
count
Stationary phase
Lag
phase
Phase of decline
Time

2. Log (logarithmic) or exponential phase: Following the lag phase, the cells start dividing and their numbers increase exponentially or by geometric progression with time.

3. Stationary phase: After a varying period of exponential growth, cell division stops due to depletion of nutrients and accumulation of toxic products. Eventually growth slows down, and the total bacterial cell number reaches a maximum and stabilizes. The number of progeny cells formed is just enough to replace the number of cells that die.
The growth curve becomes horizontal.
*The viable count remains stationary as an equilibrium exists between the dying cells and the newly formed cells.

4. Decline or death phase: The death phase is the period when the population decreases due to cell death. Cell death may also be caused by autolysis besides nutrient deprivation and build-up of toxic wastes.