Bacterial Growth

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Outline

1. Bacterial Reproduction
2. Requirements for Bacterial Growth
   - Environmental Factors Affecting Growth
3. Methods for Measuring Bacterial Growth
4. Bacterial Growth Curve
5. Culture Media

Introduction to Bacterial Growth

- Bacterial growth refers to the **increase in the number** of bacterial cells within a population

Why Is Studying Bacterial Growth Important?

- Understanding how infections progress: bacterial growth rate determines how quickly an infection worsens.
- Choosing and timing antibiotics effectively: many antibiotics target actively dividing bacteria, so knowing when bacteria are in the growth phase improves treatment.
- Improving accuracy of lab tests: bacterial multiplication affects culture results

Bacterial Reproduction – Binary Fission

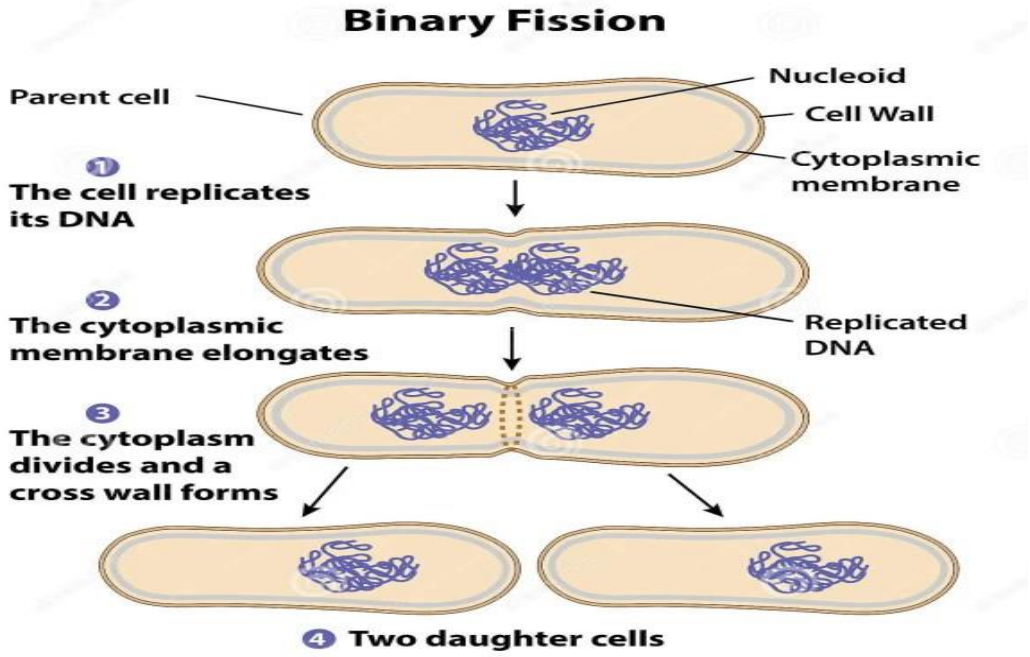
- Binary Fission is a type of asexual reproduction used by bacteria.
- One bacterial cell divides **into two identical daughter cells**
- No exchange of genetic material involved

Bacterial Reproduction – Binary Fission

Key Steps:

- DNA replication
- Cell elongation
- Septum formation
- Cell division

Duration: 20 minutes (*E. coli*) to several hours (slow growers)



"In just 20 minutes, one *E. coli* cell can become two. In 24 hours, under optimal conditions, one cell can theoretically produce billions of offspring. This is why bacterial infections can **escalate so quickly**."

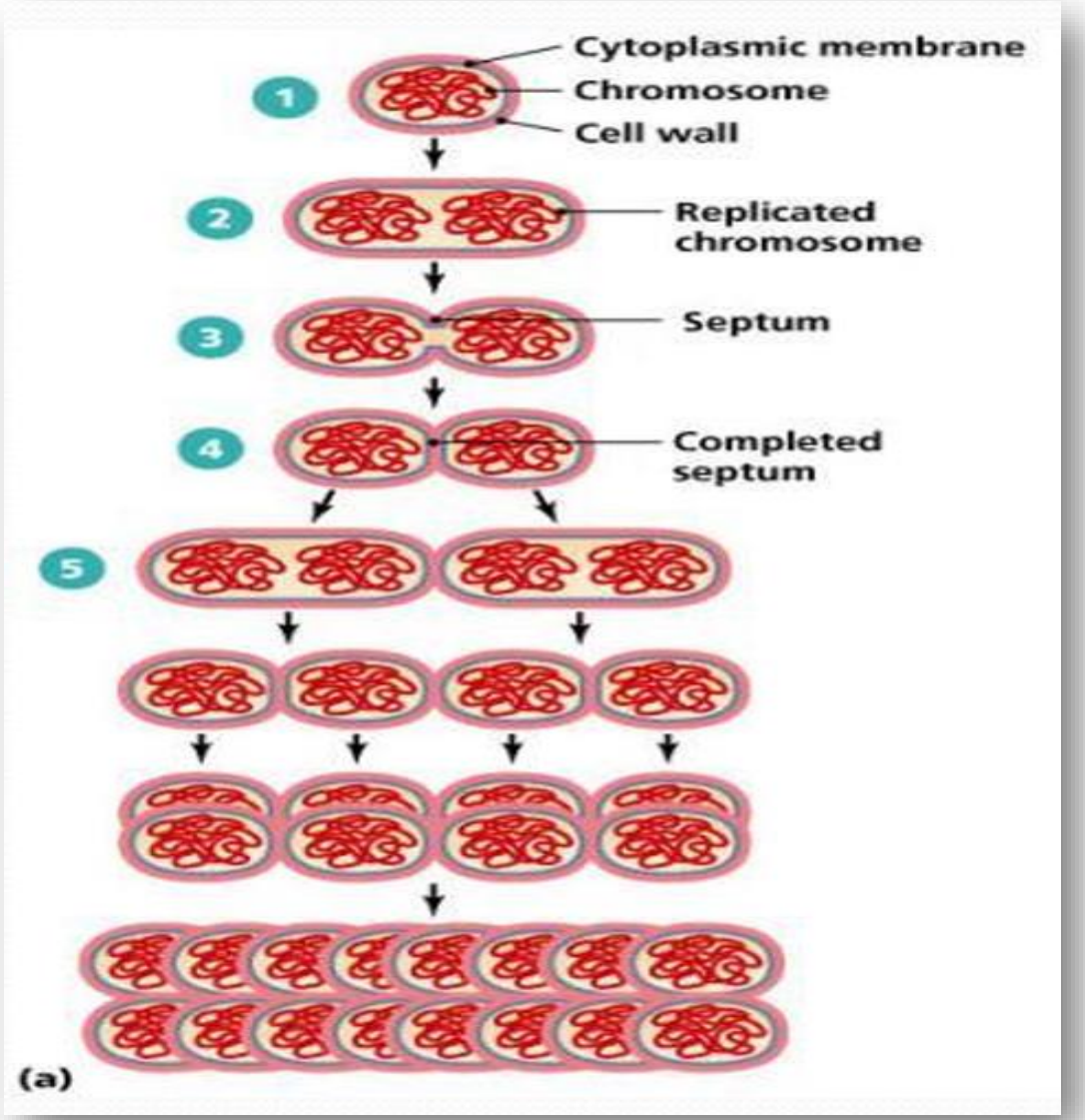
Bacterial Reproduction – Binary Fission

What is Generation Time?

- The time required for one bacterial cell to divide into two
- Also called doubling time
- Varies significantly between species

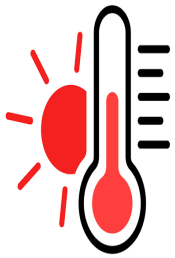
Why It Matters:

- **Fast growers** cause rapid onset of symptoms (e.g. UTIs by *E. coli*)
- **Slow growers** lead to chronic or latent infections (e.g. TB, syphilis)
- Affects **lab culture timing** and **duration of antibiotic therapy**



Requirements for Bacterial Growth

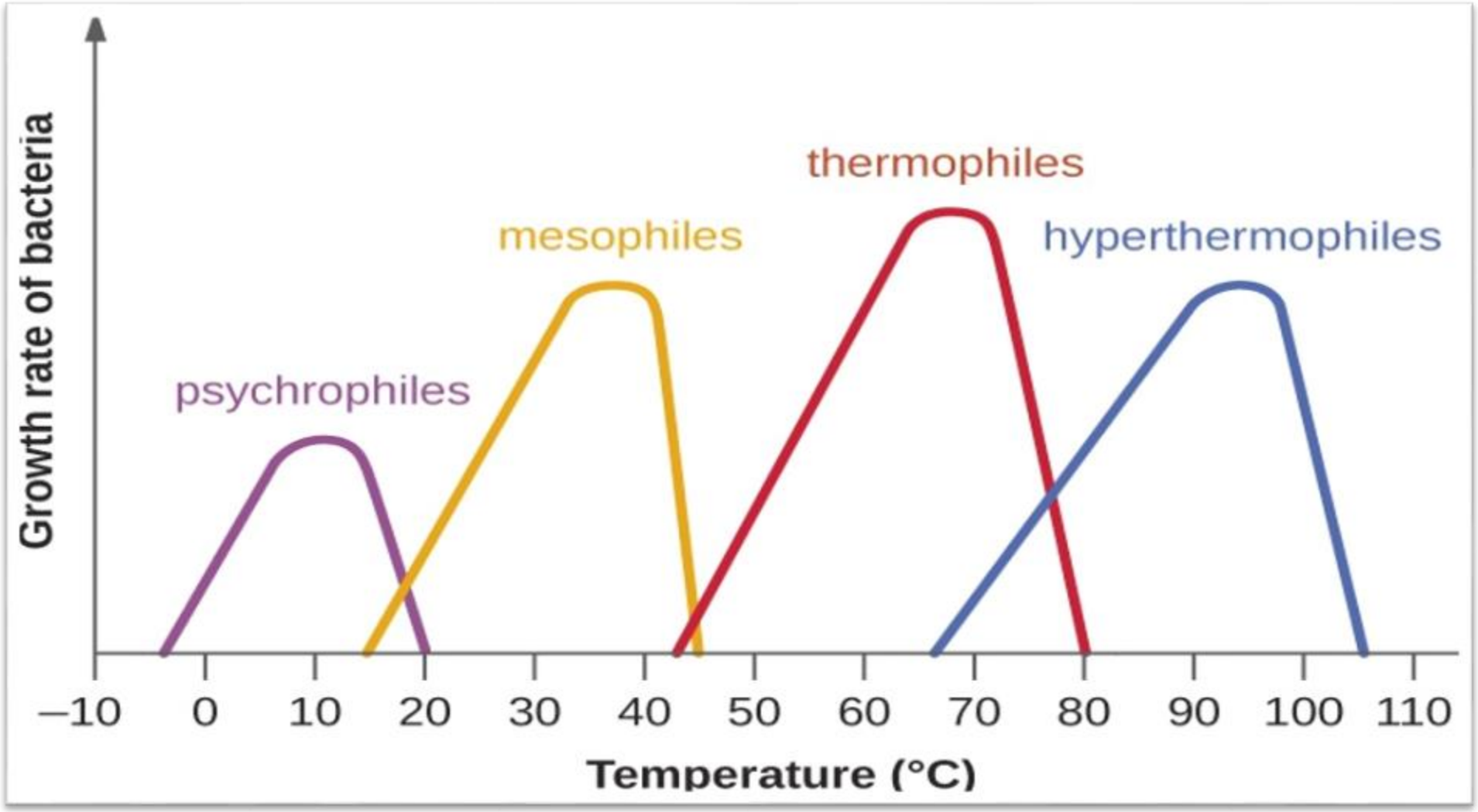
- Bacteria require nutrient and specific conditions to grow and multiply. These needs vary by species and **determine where bacteria can survive** — in the body or the environment.
- **Nutritional needs**: carbon, nitrogen, sulfur, phosphorus, trace elements
- **Environmental Factors Affecting Bacterial Growth:**
  - Temperature
  - Oxygen
  - pH
  - Osmotic pressure



Factors Affecting Bacterial Growth: Temperature

- Bacterial growth depends on temperature because **it affects enzyme activity, membrane function, and metabolism.**
- Each bacterial species has a minimum, optimum, and maximum temperature for growth.
- Classification Based on Temperature Preference:
  - **Psychrophiles:** Thrive in cold (0–20°C); not medically relevant.
  - **Mesophiles:** Grow best at 20–45°C, especially 37°C — most human pathogens.
  - **Thermophiles:** Prefer heat (45–80°C); rarely cause disease
  - **Hyperthermophiles:** Grow above 80°C; found in extreme environments, not medically important.

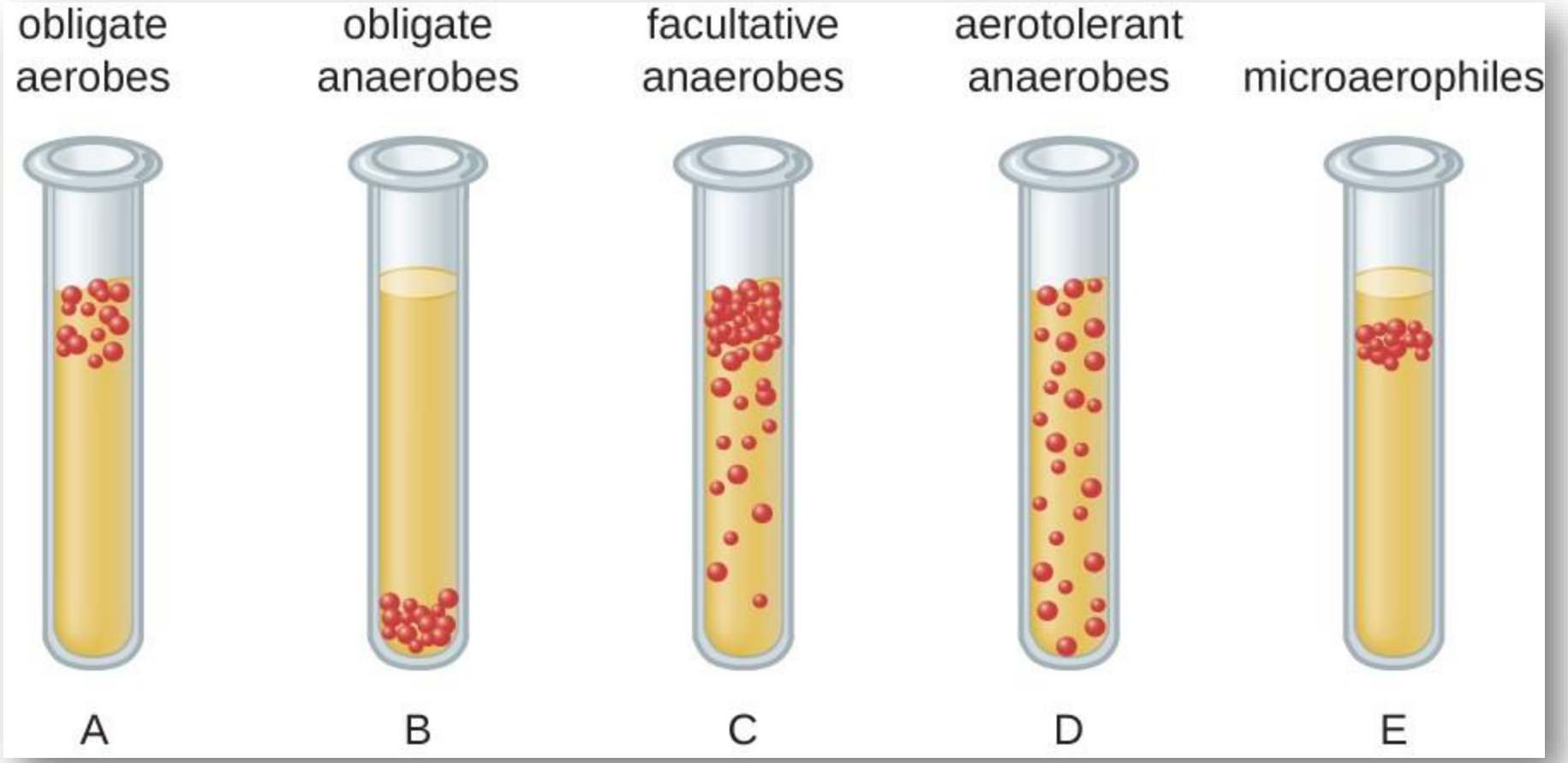
Factors Affecting Bacterial Growth: Temperature



Factors Affecting Bacterial Growth: Oxygen

- Oxygen is **essential for some bacteria** and **toxic to others.**
- Oxygen affects how bacteria **generate energy (ATP)**.
- Understanding this helps predict infection sites and choose lab culture methods.
- Types of Bacteria Based on Oxygen Requirement:
  - **Obligate aerobes:** Need oxygen to survive (e.g. *Mycobacterium tuberculosis*)
  - **Obligate anaerobes:** Killed by oxygen (e.g. *Clostridium tetani*)
  - **Facultative anaerobes:** Grow with or without oxygen (prefer oxygen) (e.g. S. *aureus*)
  - **Microaerophiles:** Require low oxygen levels (e.g. *Helicobacter pylori*)
  - **Aerotolerant anaerobes:** Don’t use oxygen but can tolerate it (e.g. *Lactobacillus*)

O_2 Factors Affecting Bacterial Growth: Oxygen



Factors Affecting Bacterial Growth: Oxygen

Why is oxygen toxic to some bacteria but not to others?

- Using oxygen (O2) in metabolism creates toxic waste as hydrogen peroxides (H_2O_2) and superoxide (O^-_2) anión radical
- Microbes that are able to use aerobic respiration produce enzymes to detoxify oxygen:
  - Catalase: H2O2 ---→ H2O and O2
  - Superoxide dismutase (SOD): oxygen radical (O^-_2) ---→ H2O and O2
- Microbes that don't make these enzymes cannot exist in the presence of oxygen

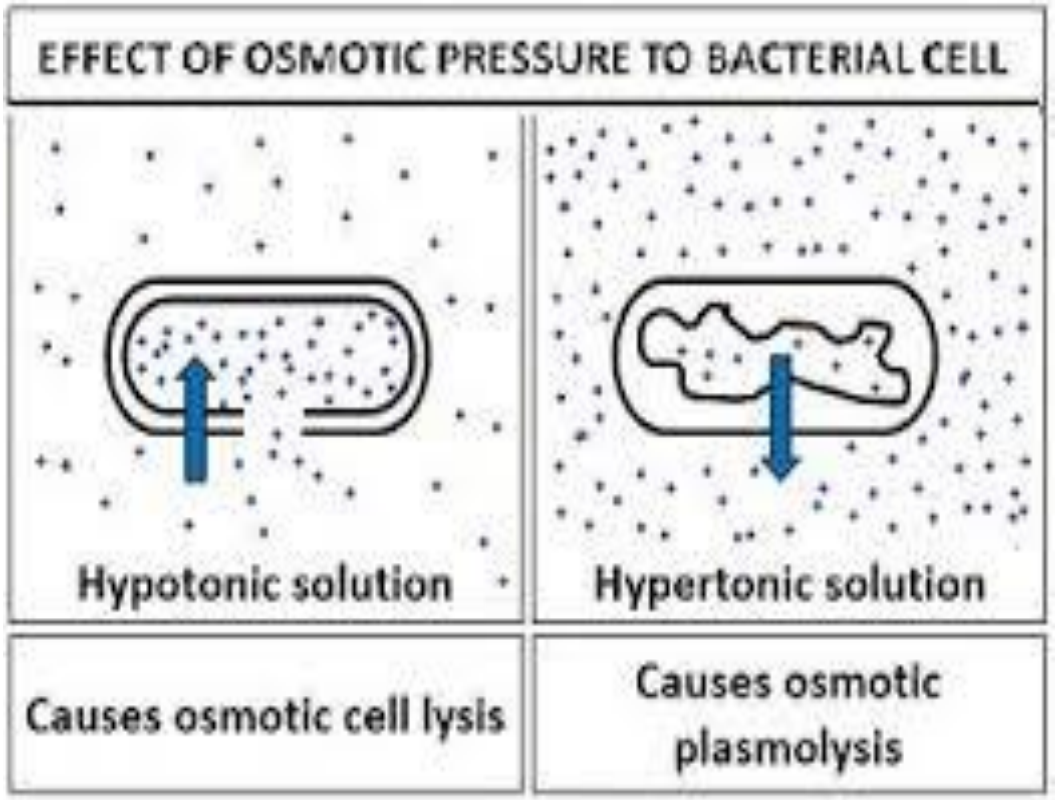
Factors Affecting Bacterial Growth: pH

- pH influences enzyme activity, membrane integrity, and survival in different body sites (e.g. stomach vs. intestine).
- Most bacteria are **neutrophiles**, meaning they grow best at **neutral pH** (6.5–7.5).

  → Most human pathogens (e.g. *E. coli*, *S. aureus*)
- Some adapt to extreme pH levels:
  - Acidophiles: Prefer acidic conditions → e.g. *Helicobacter pylori* (stomach)
  - Alkaliphiles: Prefer basic (alkaline) environments → e.g. *Vibrio cholerae* (small intestine)

Factors Affecting Bacterial Growth: Osmotic Pressure

- Most bacteria grow best in isotonic or slightly hypotonic conditions.
- Effects of Osmotic Pressure:
  - **Hypotonic** (low solute outside): Water moves IN → cell swelling → may burst (lysis)Bacteria resist this with rigid cell wall
  - **Hypertonic** (high salt/sugar): Water moves OUT → plasmolysis (shrinkage) → inhibits growth



Factors Affecting Bacterial Growth: Osmotic Pressure

- **Bacterial Adaptations:**
  - **Osmotolerant:** tolerate any high solute. ANY solute (salt, sugar, or other compounds)
  - **Osmophiles:** require high solute
  - **Halotolerant**: tolerate high salt (e.g., *S. aureus* on skin)
  - **Halophiles**: require high salt (e.g., *Vibrio* spp.)

Tolerant = can survive

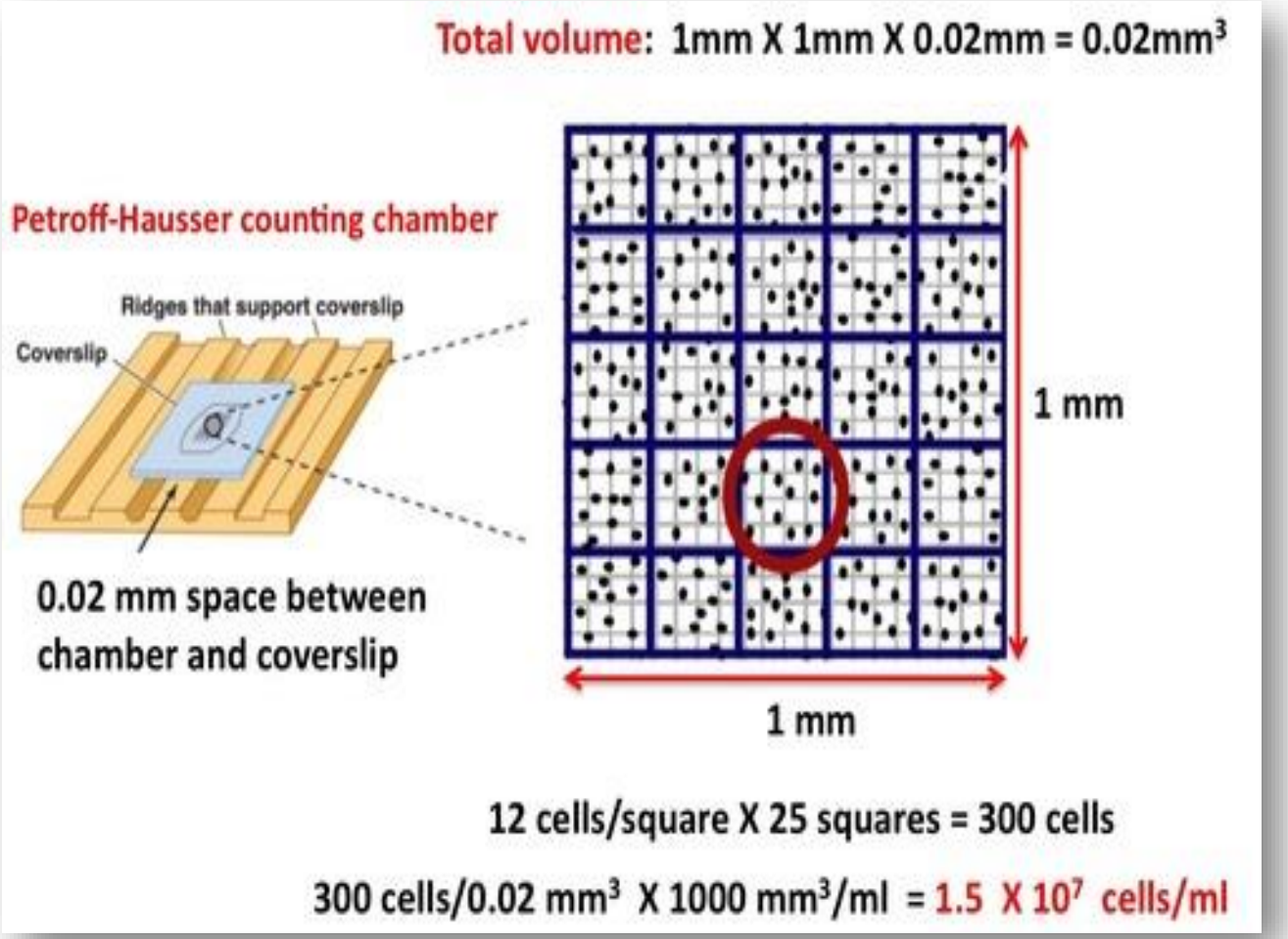
Phile = requires it

Methods for Measuring Bacterial Growth

- **Direct methods**:
  - Microscopic counts
  - Plate counts (CFU)
- **Indirect methods**:
  - Turbidity (spectrophotometry)
  - Metabolic activity (e.g. CO_2, ATP)

Methods for Measuring Bacterial Growth: Direct Method – Microscopic Counts

- Counts individual bacterial cells directly under a microscope.
- Uses a counting chamber (e.g. Petroff–Hausser chamber) with a grid of known dimensions.
- Calculates the number of cells per mL from a known volume.



Methods for Measuring Bacterial Growth: Direct Method – Plate Counts (CFU)

Bacterial sample (often **diluted**) are cultured on agar plates, and the resulting colonies are counted to measure bacterial growth.

- Each colony represents one Colony Forming Unit (CFU) from a viable cell.

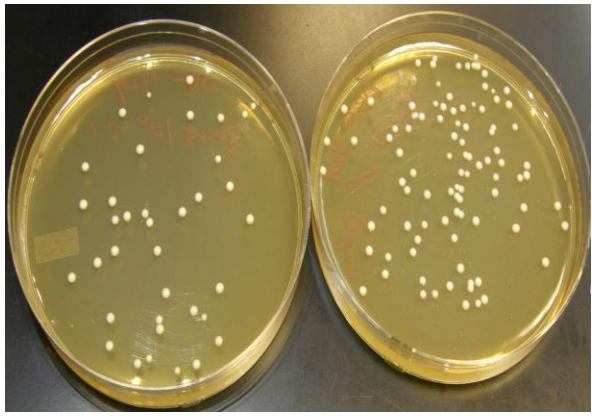
Bacterial Colony?

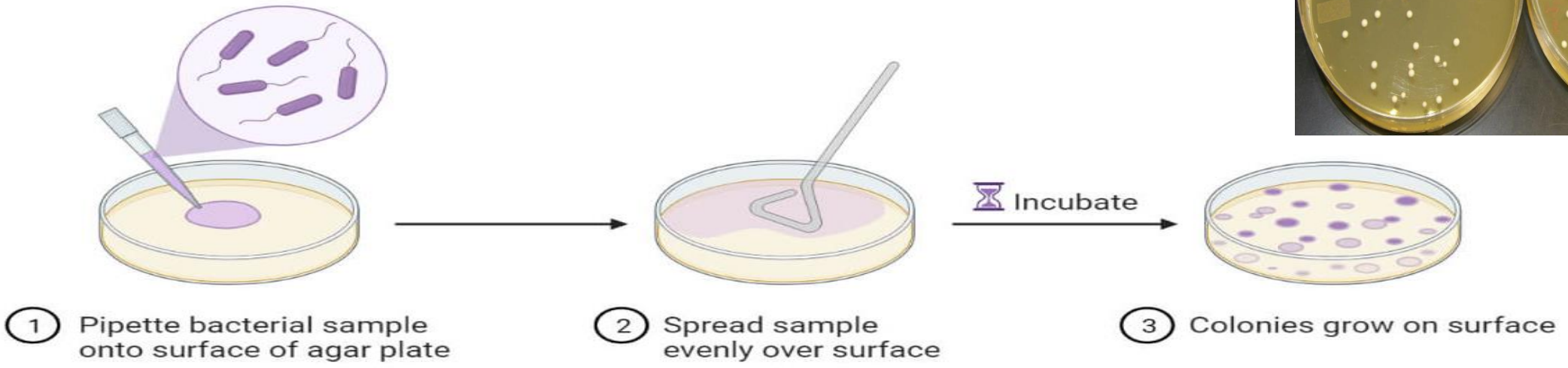
A visible cluster of bacteria on solid media. A single bacterial cell must divide about 20–30 times to form a visible colony (millions of cells).

Methods for Measuring Bacterial Growth: Direct Method – Plate Counts (CFU)

Procedure:

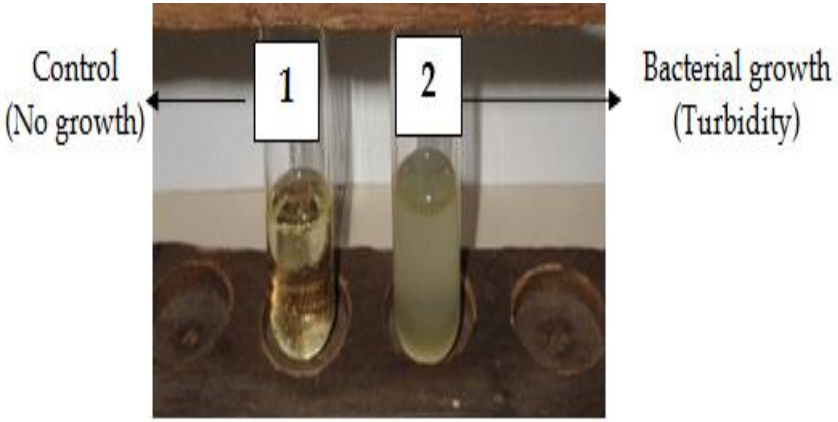
1. Serially dilute the sample to reduce cell numbers.
2. Spread or pour diluted samples on agar plates.
3. Incubate until colonies are visible.
4. Count colonies and calculate bacterial concentration in the original sample (CFU/mL).





Methods for Measuring Bacterial Growth: Indirect Method – Turbidity (Spectrophotometry)

- As bacteria grow in a liquid medium, the culture becomes cloudy (turbid).
- Measured using a spectrophotometer at a specific wavelength (commonly 600 nm).
- Higher turbidity → more bacterial cells.
- Quick method, but measures both live and dead cells. 📌



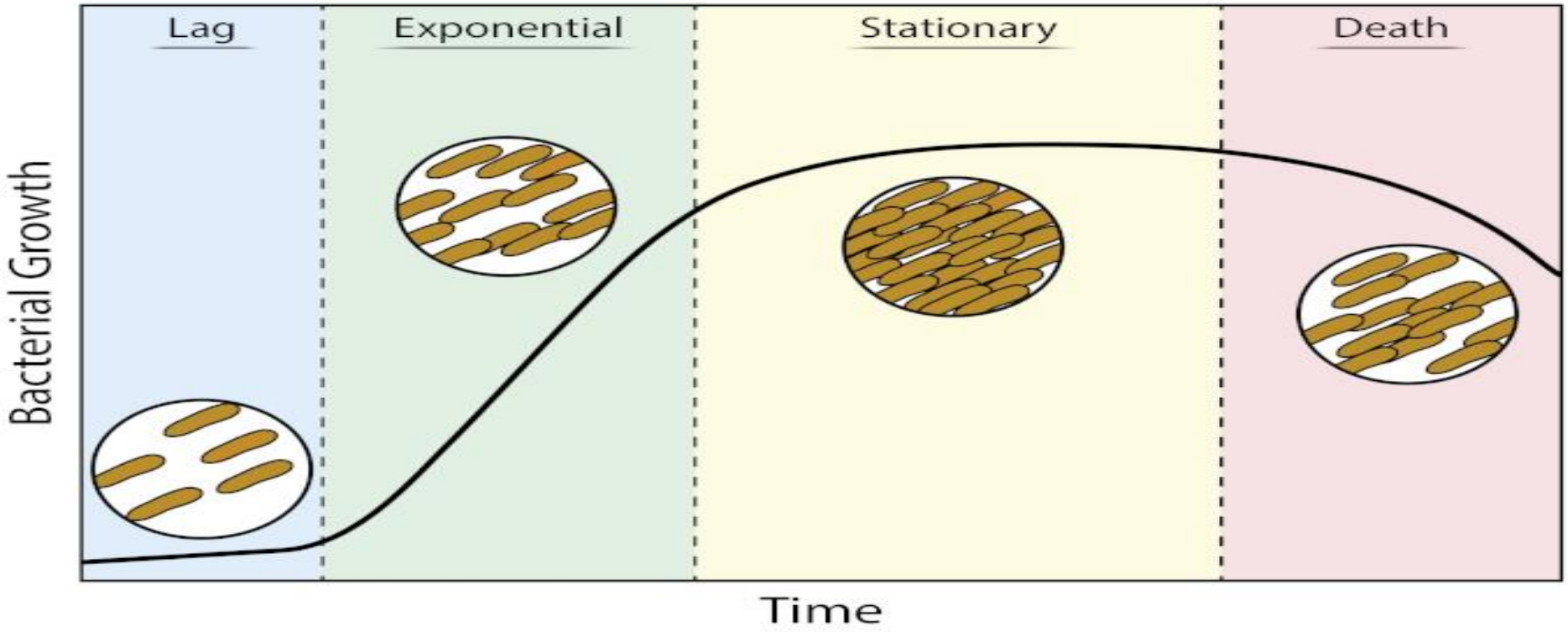
Methods for Measuring Bacterial Growth: Indirect Method – Metabolic Activity

- Measures bacterial growth by detecting products of metabolism:
  - CO_2 production
  - O_2 consumption
  - ATP measurement
- Useful when direct counting is difficult (e.g. slow-growing bacteria).
- Can be specific for viable, metabolically active cells.

Bacterial Growth Curve

What is a Bacterial Growth Curve?

A graph showing the pattern of **bacterial population growth** over time in a closed system.

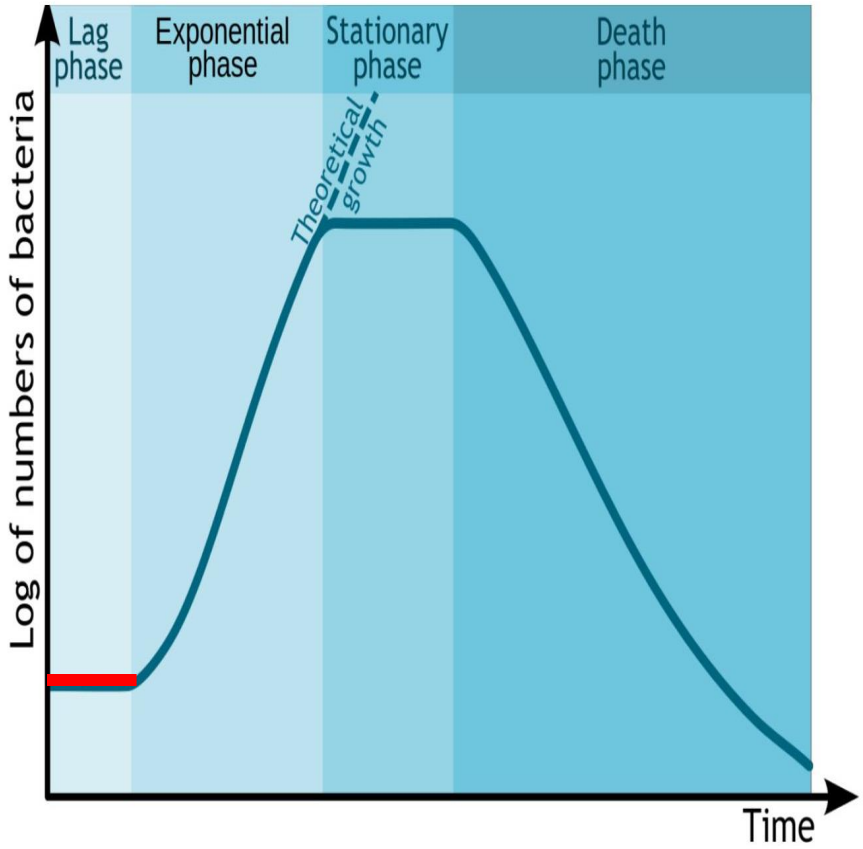


Bacterial Growth Curve: Lag Phase

What happens:

- Bacteria adjust to the new environment, synthesize enzymes, repair damage.
- No cell division yet, but metabolic activity is high.

Clinical relevance: Patients may have infection but no obvious symptoms; antibiotics targeting dividing cells are less effective here.



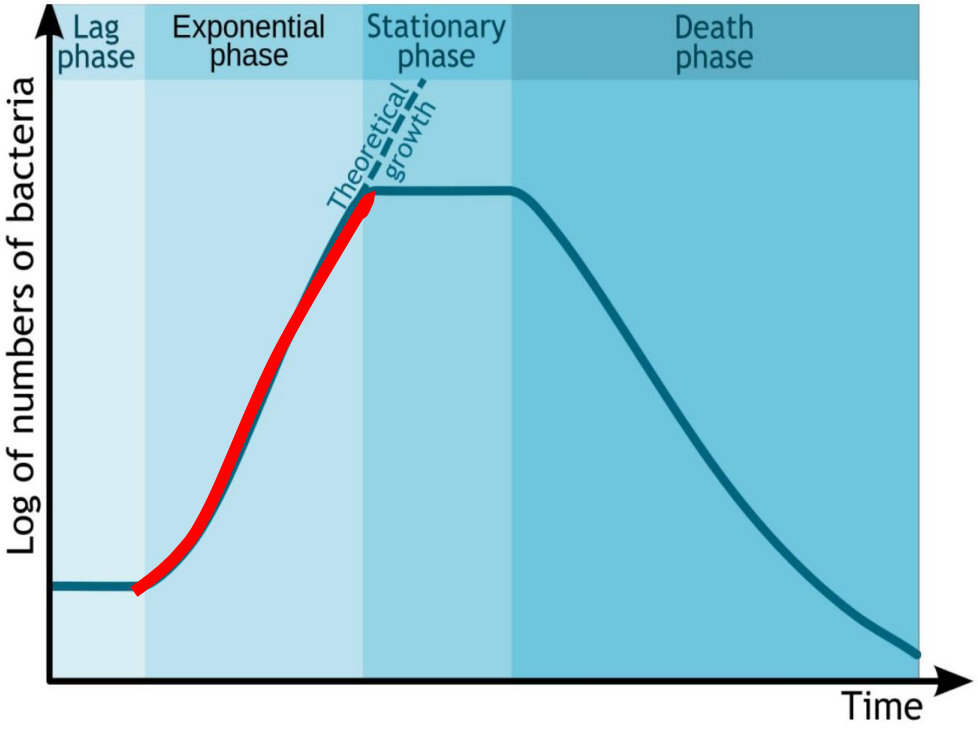
Bacterial Growth Curve: Log (Exponential) Phase

What happens:

- Cells divide at a constant rate; population doubles each generation time.
- Nutrients are abundant, waste is minimal.

Clinical relevance:

- Rapid spread of infection.
- Most susceptible to antibiotics that target cell wall or protein synthesis.
- Optimal time for laboratory studies of bacteria.



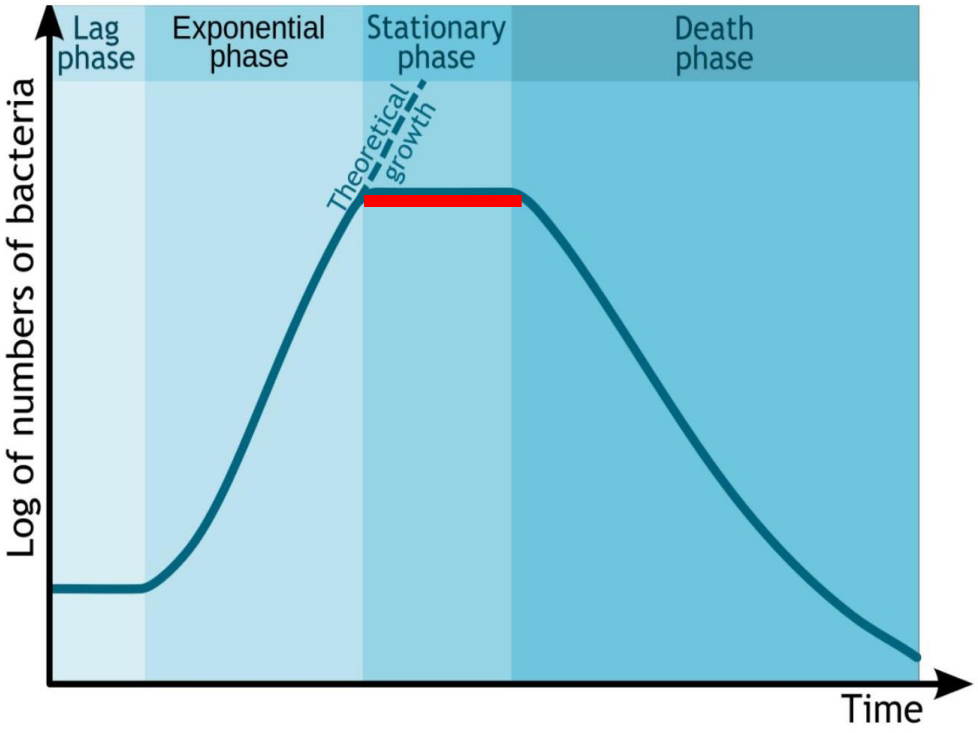
Bacterial Growth Curve: Stationary Phase

What happens:

- Growth rate slows; number of new cells equals number of dying cells.
- Nutrients deplete, waste accumulates, pH changes.

Clinical relevance:

- Chronic or persistent infections often have bacteria in this phase.
- Some bacteria produce toxins or form spores here (e.g. *Clostridium* spp.).



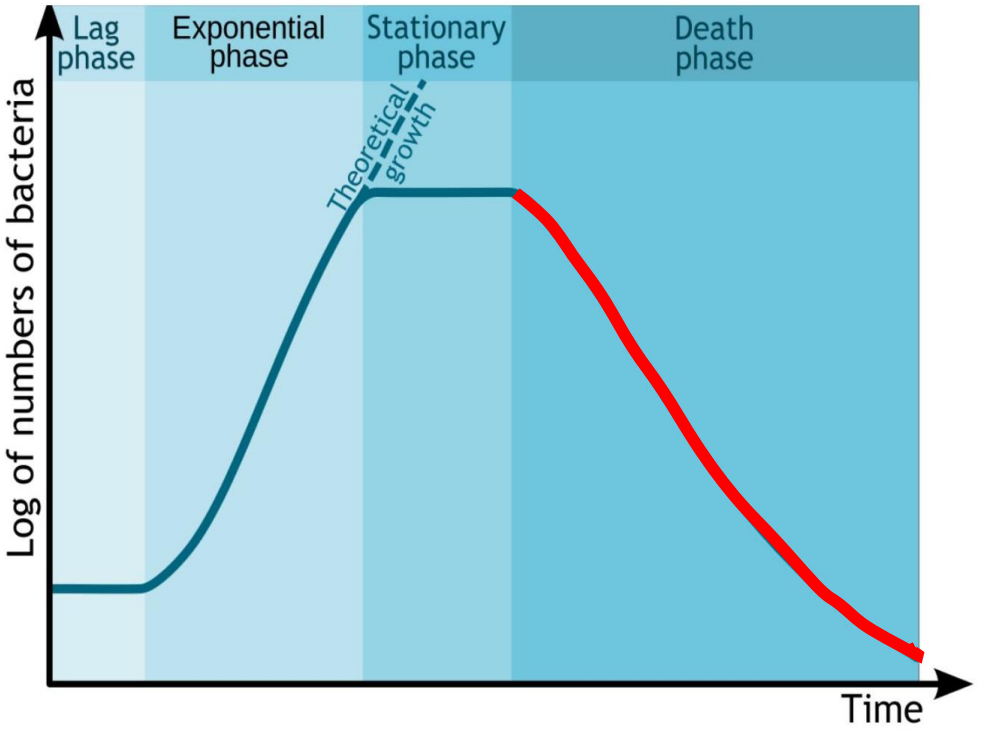
Bacterial Growth Curve: Death (Decline) Phase

What happens:

- More cells die than are produced.
- Caused by severe nutrient depletion, toxic waste buildup.

Clinical relevance:

- Infections may resolve naturally or with immune help.
- Some bacteria enter dormant states (persisters) that can reinitiate infection later.



Bacterial Growth Curve: Memory Aid

"Lag = Loading phase"

Loading up resources, not growing yet

"Exponential = Explosion"

Population exploding, time is critical

"Stationary = Stressed and Surviving"

Plateau, not growing, but not dead

"Death = Decline = Done"

Culture Media

What is Culture Media?

Nutrient substance used to grow and maintain microorganisms in the laboratory.

Provides essential requirements for bacterial growth: nutrients (carbon, nitrogen, minerals), water, appropriate ph, and energy source

Forms of Media:

- **Solid** (agar plates) – for isolation & colony counting
- **Liquid** (broth) – for rapid growth & biochemical tests
- **Semi-solid** – for motility testing

Thank you