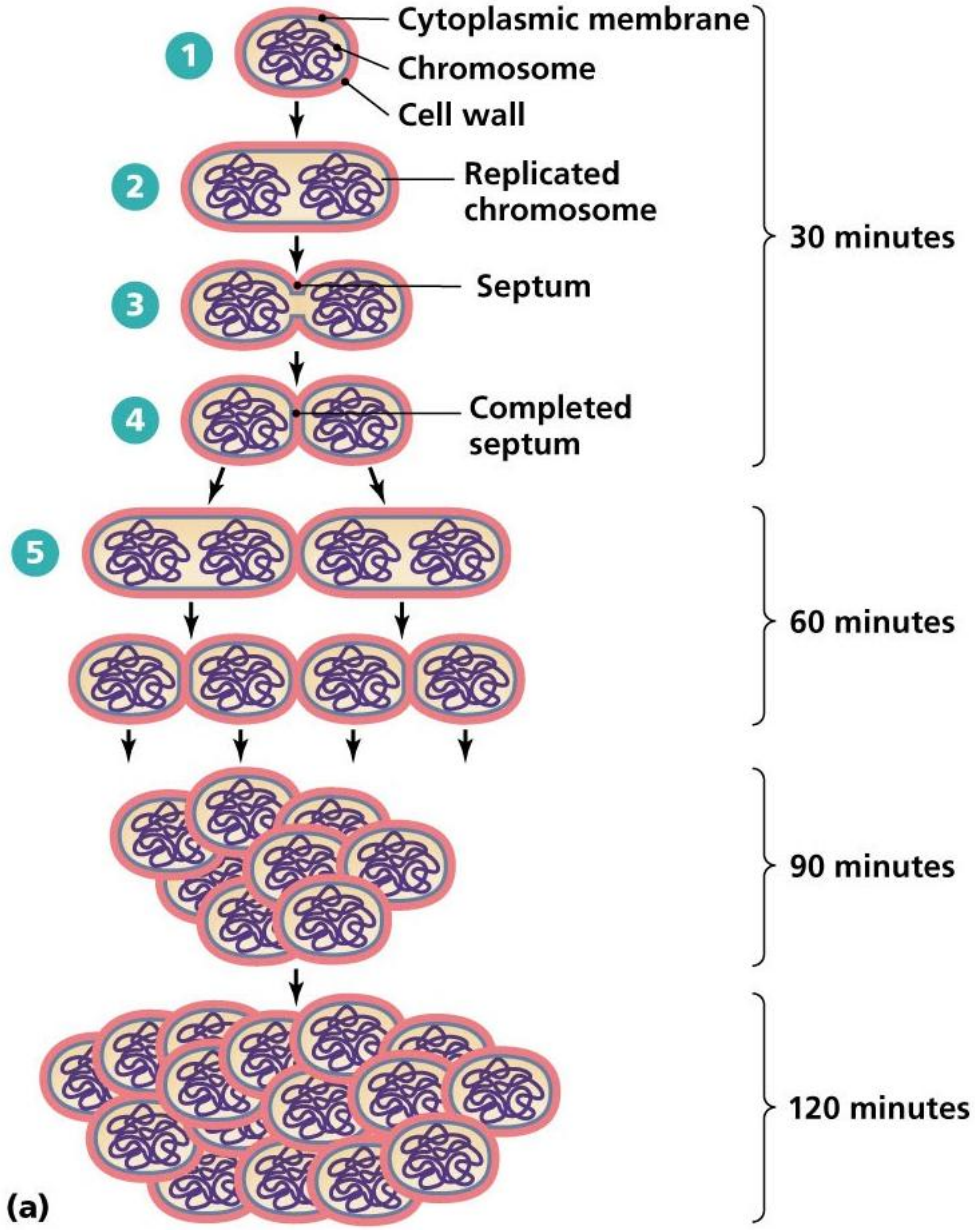
Microbial Growth

- Growth : When we speak of bacterial growth, we are talking about an increase in population size not an increase in the size of a single bacterium
- Binary Fission: Bacterial cells replicate by a form of asexual reproduction called binary fission
- Generation Time – time required to complete fission cycle from parent cell to 2 daughter cells. (Doubling time). In terms of a population it is the amount of time needed to double the population.
- The length of the generation time is a measure of the Growth Rate of the microbe.
- It varies depending on environmental conditions. , Different microbes have different generation times.
    - Mycobacterium leprae → 10-30 days
    - Staphylococcus aureus → 20-30 minutes

Growth of Microbial Populations

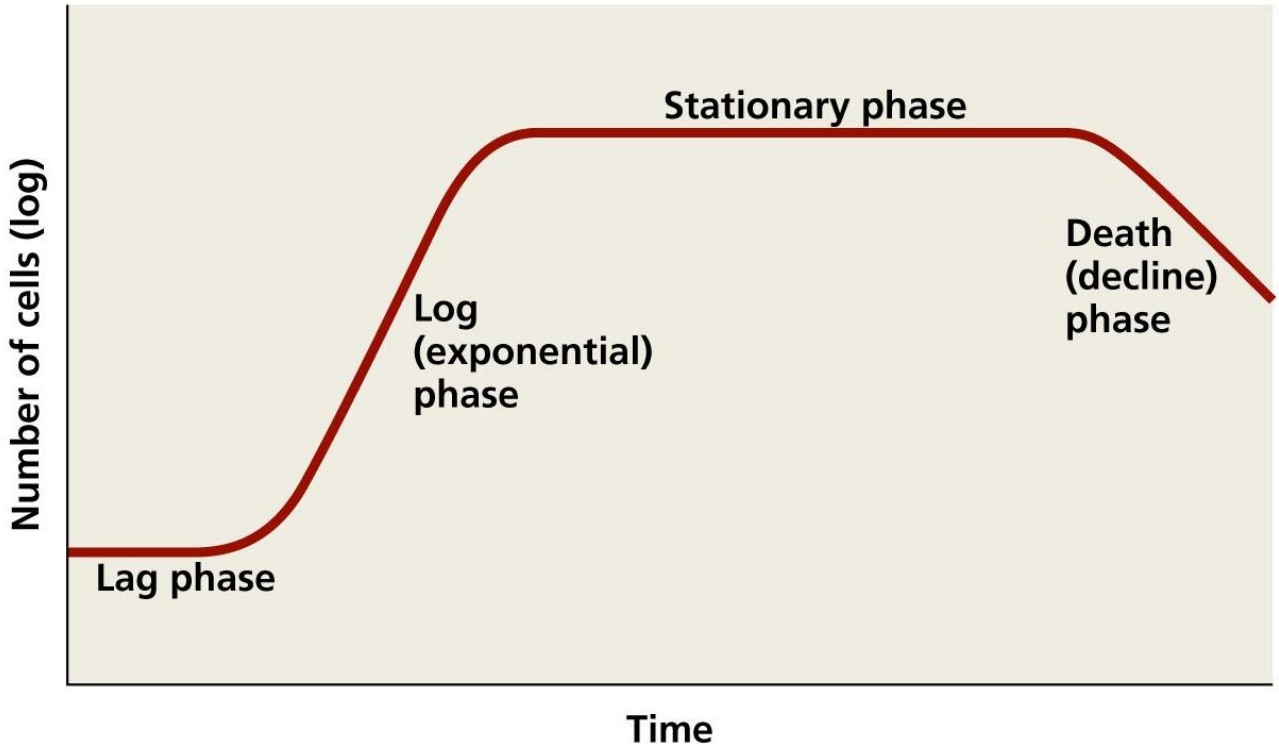


Microbial Growth Cycle (batch culture)

- *Batch culture*: a closed-system microbial culture of fixed volume
- Typical growth curve for population of cells grown in a closed system is characterized by four phases
  - Lag phase , Exponential phase , Stationary phase,

  Death phase

The Growth Curve

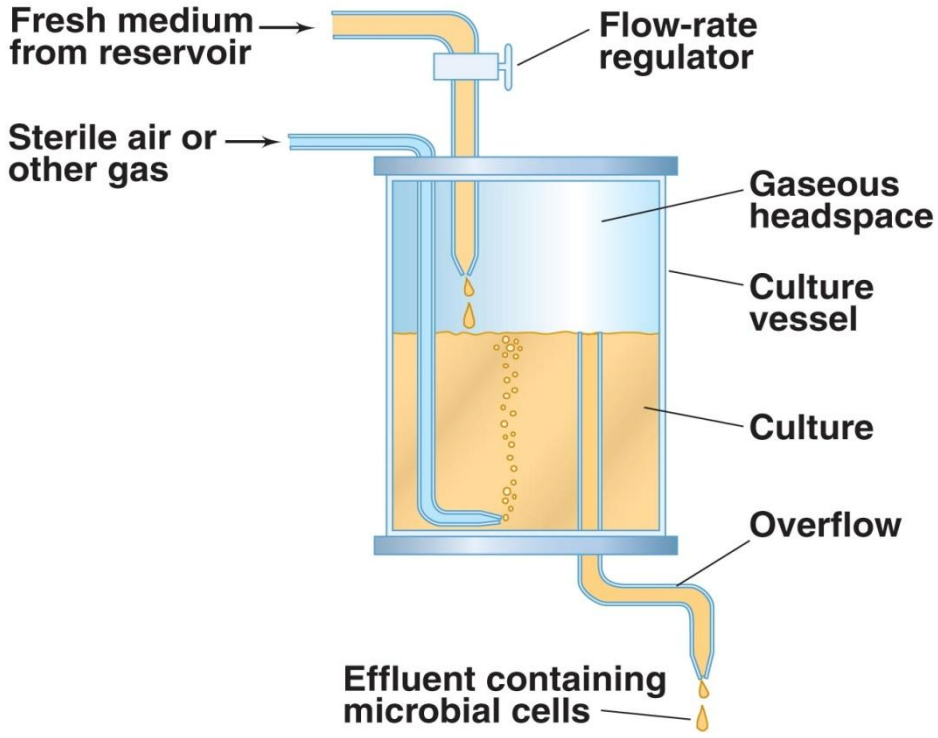


Microbial Growth Cycle (batch culture)

- *Lag phase*
    - Interval of time between when a culture is inoculated and when growth begins.
- *Exponential phase*
    - Cells in this phase are typically in the healthiest state. Growth is at maximal rate.
- *Stationary phase*
    - Growth rate of population is zero.
        - Number new divisions=number of cells dying
    - Either an essential nutrient is used up or waste product of the organism accumulates in the medium
- *Death phase*
    - Lack of nutrients and increasing accumulation of wastes lead to… number of cell deaths > number of new divisions

Continuous Culture: The Chemostat

- *Continuous culture*: an open-system microbial culture of fixed volume
- *Chemostat*: most common type of continuous culture device

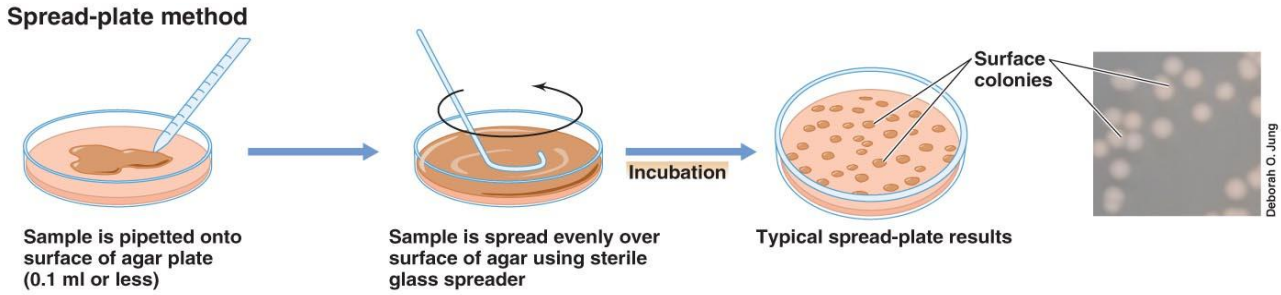


Measuring Growth (Direct Measurement)

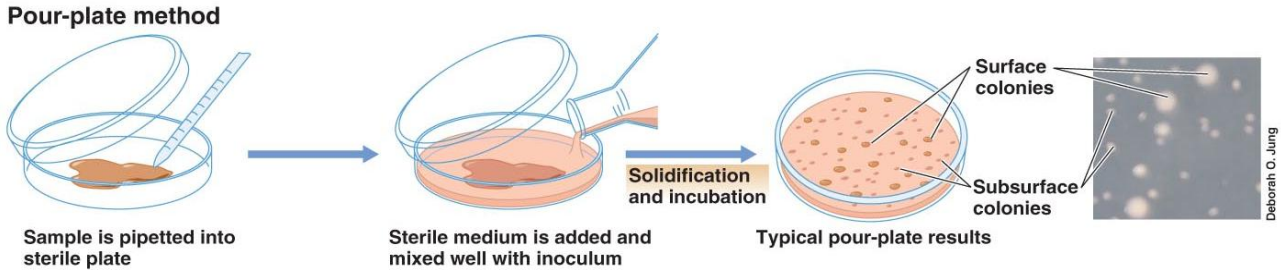
Viable Count

- Measurement of living, reproducing population
- Two main ways to perform plate counts
    - *Spread-plate method*
    - *Pour-plate method*
- To obtain the appropriate colony number, the sample to be counted may need to be diluted (serial dilutions)

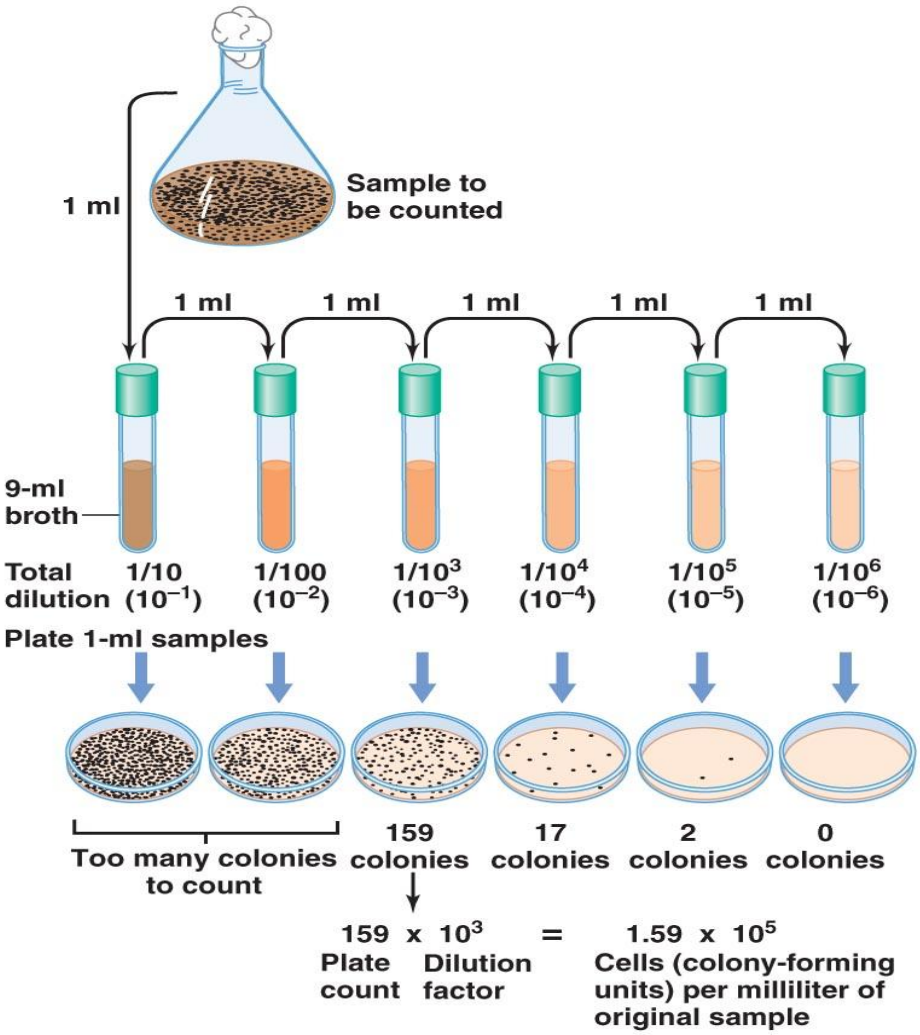
- **Spread-Plate Method for the Viable Count**



Pour-Plate Method for the Viable Count

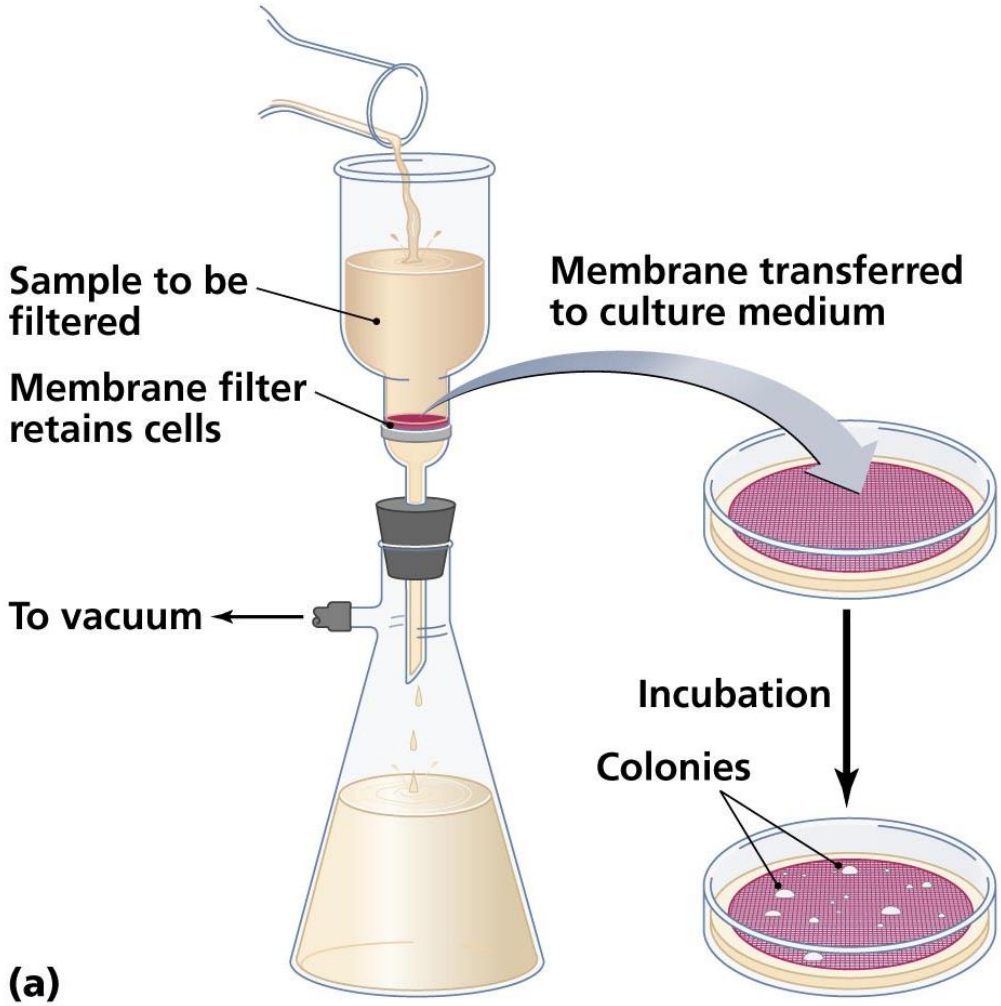


Procedure for Viable Counting Using Serial Dilutions



Measuring Growth (Direct Measurement)

Filtration

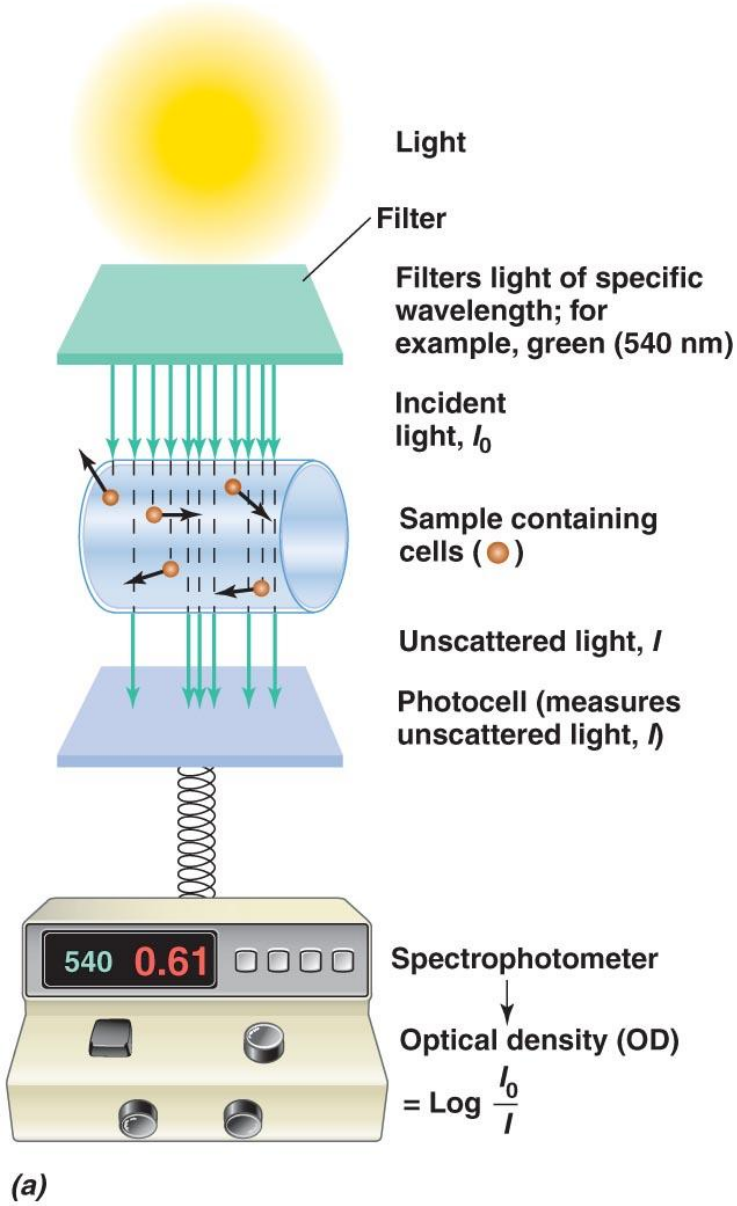


Measuring Growth (**Indirect Measurement**)

- Indirect Methods
    - Metabolic activity
    - Dry weight
    - Turbidity

- Spectrophotometer-measures amount of light that passes through a sample. Absorbance is related to the number of bacteria

Turbidity



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Effects of Temperature on Microbial Growth

- Microorganisms can be classified into groups by their growth temperature optima
    - Psychrophile: low temperature
    - Mesophile: midrange temperature
    - Thermophile: high temperature
    - Hyperthermophile (extreme thermophile): very high temperature

pH

- Organisms sensitive to changes in acidity because H^+ and OH^- interfere with H bonding in proteins and nucleic acids
- Most bacteria and protozoa grow best in a narrow range around neutral pH (6.5-7.5) – these organisms are called **neutrophiles**
- Other bacteria and fungi are **acidophiles** – grow best in acidic habitats
    - Acidic waste products can help preserve foods by preventing further microbial growth
- **Alkalinophiles** live in alkaline soils and water up to pH 11.5

Physical Effects of Water

- Microbes require water to dissolve enzymes and nutrients required in metabolism
- Water is important reactant in many metabolic reactions
- Most cells die in absence of water
    - Some have cell walls that retain water
    - Endospores and cysts cease most metabolic activity in a dry environment for years
    - Two physical effects of water: Osmotic pressure
    - Hydrostatic pressure

Osmotic Pressure

- Is the pressure exerted on a semipermeable membrane by a solution containing solutes that cannot freely cross membrane; related to concentration of dissolved molecules and ions in a solution
- Hypotonic solutions have lower solute concentrations; cells placed in these solutions will swell and burst\
- Hypertonic solutions have greater solute concentrations; cells placed in these solutions will undergo crenation (shriveling of cytoplasm)
    - This effect helps preserve some foods
- Restricts organisms to certain environments
    - Obligate halophiles – grow in up to 30% salt
    - Facultative halophiles – can tolerate high salt concentrations

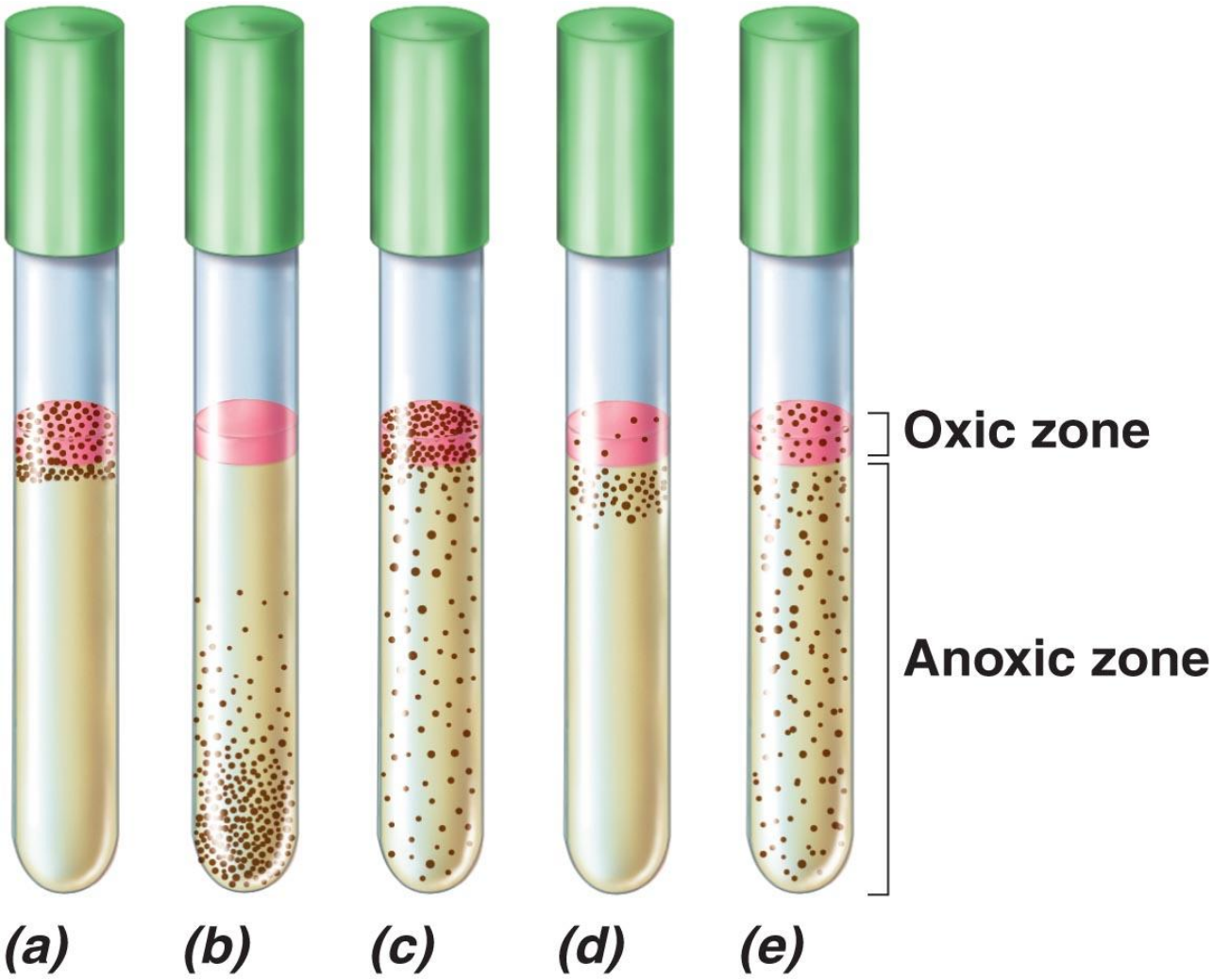
Hydrostatic Pressure

- Water exerts pressure in proportion to its depth
- Organisms that live under extreme pressure are **barophiles**
    - Their membranes and enzymes depend on this pressure to maintain their three-dimensional, functional shape

Oxygen and Microbial Growth

- *Aerobes*: require oxygen to live
- *Anaerobes*: do not require oxygen and may even be killed by exposure
- *Facultative organisms*: can live with or without oxygen
- *Microaerophiles*: can use oxygen only when it is present at levels reduced from that in air

Growth : Oxygen Concentration



- Superoxide dismutase (SOD)
- Catalase
- Peroxidase