Microbiology 1

2025-2024

Dr.Saja Ebdah

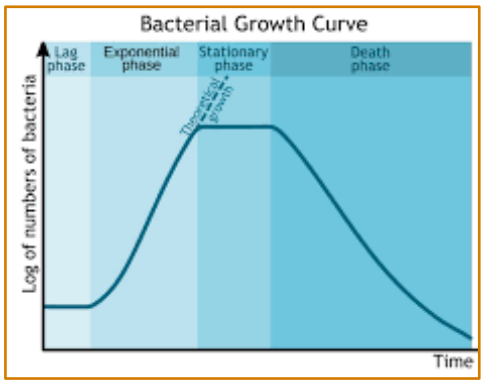
ARKAN
ACADEMY

Bacterial physiology, metabolism and growth

- **The importance**
  - Understanding physiology & metabolism is <u>important</u> for *bacterial identification* & to *design antibacterial agents*.

- **Bacterial growth:**
  - *Increase* in the size of organisms and an *increase* in their number.
  - The balance between these processes results in a net *increase* in the *total biomass* of the culture
  - *Growth stages* include metabolism, regulation, division (growth) and replication for *bacterial survival*
  - <u>Types of growth:</u>
    - ✓ *Fast growing* bacteria that divide each 10-30 minutes e.g *vibrio*
    - ✓ *Slow growing:* each 24 hours e.g *Mycobacterium tuberculosis*
  - Growth *needs* <u>materials (nutrient)</u> and <u>energy/metabolism</u>

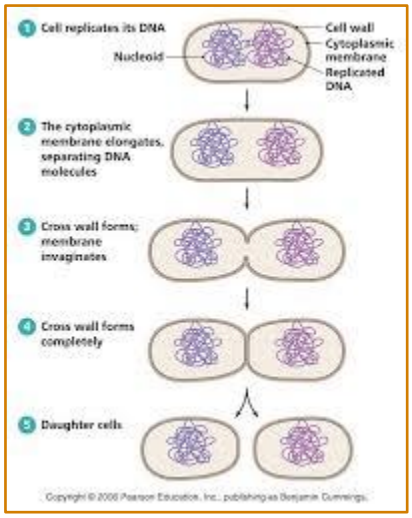
- **Bacterial growth stages:**
  - *Lag phase*, there is little or *no change* in the number of cells (adjustment stage), but metabolic activity is high.
  - *Log* or *exponential phase*, the bacteria multiply at the *fastest rate* possible under the conditions provided. The bacterial population doubling occurs at a constant rate.
  - *Stationary phase*, there is an *equilibrium* between cell division and death (nutrients start to deplete & toxic materials start to be produced).
  - *Death (decline) phase*, the number of *deaths* exceeds the number of new cells formed.



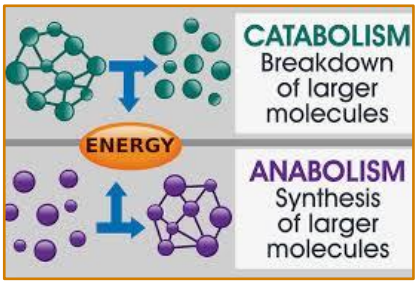
iop

- **Extendi9Yng the log phase:**
  - *Chemostat* (chemical environment is static):
    - ✓ Cells of a growing culture are *harvested continuously* and nutrients replenished continuously
    - ✓ For *industrial* and *research purposes*

- **Bacterial division and generation time:**
  - *Binary fission:* the *reproduction method* of bacteria in which a single cell ***divides*** into two identical cells.
  - Cell division occurs by the *development* of constrictions mediated by the assembly of an actin-like protein.
  - Constrictions proceed from the periphery inwards and, in some cases, produce a *transverse* cell wall known as a septum or cross-wall



- **Metabolism:**
  - Metabolism in bacteria leads to *faster growth* than our bodies' metabolism.
    - ✓ *Metabolism* = Anabolism + Catabolism.
    - ✓ *Anabolism* = synthesis.
    - ✓ *Catabolism* = degradation.
    - ✓ Energy Production = Energy Consumption → Bacterial survival



- **Nutritional requirements**:
  - Includes <u>many elements</u> like:
    - ✓ Carbon, hydrogen, O2, nitrogen, phosphorus& sulphur: needed for the *synthesis of structural components*.
    - ✓ B. potassium, calcium magnesium and iron: *needed for cellular functions*.
  - Can be obtained from simple elements or by <u>breaking down large molecules</u> such as *protein* breakdown into amino acids using bacterial enzymes.
  - Many bacteria have to ***synthesize*** some nutrients such as folic acid which makes these bacteria susceptible to agents that interfere with the biosynthesis of *folic acid*
    - ✓ Example: by trimethoprim& sulfonamides antibiotics.

- ***Nutrients can be obtained from different sources:***
  - *Elements* such as:
    - ✓ *Hydrogen* & *oxygen* are obtained from *wate*
    - ✓ *Carbon:* usually obtained from *degradation* of *carbohydrates* by oxidation or fermentation. Carbon is necessary to provide energy in the form of ATP (adenosine triphosphate).
    - ✓ *Nitrogen:* from ammonia in the environment or proteins '*deamination'* using bacterial enzymes.
  - *Organic factors* (from exogenous source/can't be synthesized by bacteria) such as:
    - ✓ *Amino acids:* e.g from proteins breakdown.
    - ✓ *Purines* and *pyrimidine* (Nucleic acid precursors)
      - must be converted into nucleotides (sugar +base +phosphate) & nucleosides (sugar +base) before being incorporated into the DNA or RNA.
  - *Vitamins:* most are needed for the formation of coenzymes in some bacteria.

- **Energy source:**
  - *Phototrophs:* use *light* as their energy
  - *Chemotrophs:* obtain energy from the oxidation of *chemical compounds* (either)

- **Hydrogen source** (Organic or inorganic)
  - *Organotrophs:* extract electron or hydrogen from *organic compounds*
  - *Lithotroph:* if it can use *inorganic sources* (e.g ammonia or hydrogen sulphide), use reduced inorganic substances

- **Energy and Hydrogen donor** designations are referred to routinely by combining the two terms :
  - *Chemo-organotrophs:* the vast majority of currently recognized medically important organisms
  - *Chemolithotrophs:* e.g. some Pseudomonas spp

- **Carbon source**
  - *Autotrophs* —can draw carbon from *carbon dioxide*
  - *Heterotrophs* —carbon from *organic compounds*
  - *Mixotrophic* – carbon is obtained from *both* organic compounds and by fixing carbon dioxide

- **These requirements can be combined:**
  - Energy and carbon sometimes
    - ✓ *Chemoheterotrophs* —energy from chemical compounds, carbon from organic compounds, this group includes most as well as all protozoa, fungi, and animals.

- Inside the cell, sugar molecules or other sources of carbon and energy are metabolized by *different pathways*, mainly by:
  - *The Embden–Meyerhof glycolytic pathway.*
  - *The pentose phosphate pathway.*
  - *The Krebs cycle* to yield the carbon compounds needed for biosynthesis.

- Bacteria ***generate energy*** by two ways *fermentation* and/ or *oxidation*.

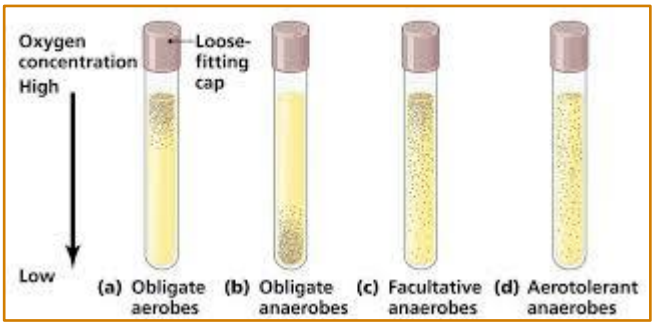
- **Comparison of metabolism**:
  - *Aerobic respiration* (oxidation)
    - ✓ Total ATP Prokaryotes=38, Eukaryotes=34
    - ✓ Final electron receptor is usually oxygen.
    - ✓ CO2 is produced

  - *Fermentation*
    - ✓ Yield = 2 ATP (less efficient)
    - ✓ Final electron receptor is organic molecule.
    - ✓ End products: acids/Alcohol.
    - ✓ CO2 is produced

- **Environmental conditions governing growth:**
  - *Temperature*: majority of medically important bacteria are mesophilic, grow at 37°C (i.e body temperature)
  - *Water*: at least 80% of bacterial cell consists of water
  - *Oxygen* and *Carbon dioxide*

- Metabolism in the presence of oxygen may give rise to some **toxic substances**:
  - *Hydrogen peroxide* (H2O2) and the *Superoxide anion* (O^{2-})
  - *Superoxide* is partially detoxified by an enzyme,superoxide dismutase, *Hydrogen peroxide* is degraded by peroxidases (Catalase)
  - Bacteria that possess these protective enzymes can grow in the presence of oxygen.

- **Oxygen requirements:**



- **PH**
  - ***Neutral*** or ***slightly alkaline*** pH (pH 7.0 – 7.4)
    - ✓ Example: Majority of bacteria grow
    - ✓ This is near most normal body fluids ?
  - ***Acidophiles*:** grow BEST at low pH (acid: pH 0 – 1.0)
    - ✓ Example: T.B. - pH 6.5-6.8
  - ***Alkalophiles:*** grow BEST at high pH(alkaline: pH 10.0)
    - ✓ Example: V. cholerae - pH 8.4-9.2

- **Types of growth in the laboratory**:
  - **3 *forms*:**
    - ✓ By the development of *colonies*, the macroscopic product of 20–30 cell divisions of a single cell.
    - ✓ By the transformation of a clear *broth* medium to a turbid suspension of 107–109 cells per ml.
    - ✓ In *biofilm* formation, in which growth is spread thinly (300–400 µm thick) over an innert surface and nutrition obtained from a bathing fluid.

- **Biofilm:**
  - *Definition:* is a *layer* of prokaryotic organisms that have aggregated to form a colony.
  - *Formation:* The colony *attaches* to a surface with a slime layer which aids in protecting the microorganisms.
  - Biofilms often form on the inert surfaces of *implanted devices* such as catheters, prosthetic, cardiac valves and intrauterine devices.

- **Media to isolate bacteria**
  - ***Main features*** of media in medical bacteriology are:
    - ✓ *Source* of protein or protein hydrolysate, often derived from casein.
    - ✓ Control of pH in the final product (after sterilization)
    - ✓ A defined *salt content*

- **In the laboratory:**
  - *Culture media:* is a *nutrient material* prepared for the growth of bacteria in a laboratory.
  - Microbes that *grow* and *multiply* in or on a culture medium are known as a culture.
  - *Agar:* is a common *solidifying agent* for a culture medium.
  - Agar media are usually contained in *Petri dishes* or *test tubes (*slant or deep)

- **Growth requirements in the lab**
  - *Fastidious* organisms require *many nutrients*.
  - *Simple* requirements can make everything from *scratch.*
  - *Selective* (enrichment) with *indicator*.
  - Some bacteria cannot be cultured in vitro (Lab)
    - ✓ Chlamydia and Rickettsia : need *tissue culture* like viruses
    - ✓ Treponema pallidum, Mycobacterium leprae, require *animal infection*
  - Cannot predict virulence by growth (some slow or non-culturable bacteria can be fatal).

ARKAN

ACADEMY

علم في كل مكان

Arkan academy

Arkanacademy

www.arkan-academy.com

+962 790408805