Third stage/ Medical microbiology

Physiology and metabolism of microorganisms

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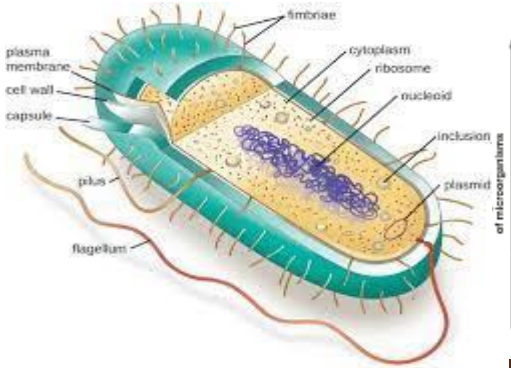
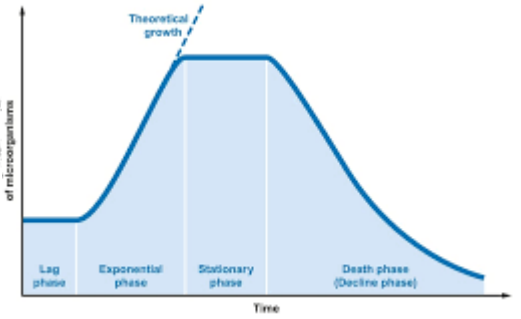
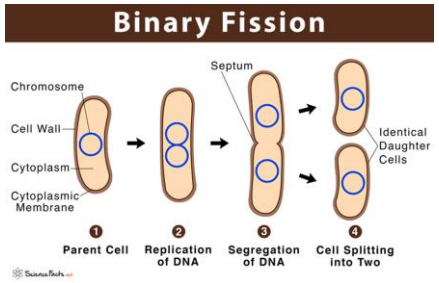






Summery

- Give an outline about structures of microbial cells.
- Explain the process of biosynthesis and microbial growth.
- Explain bacterial growth curve.
- Summarize growth yield and bacterial counts.
- Give an outline about media for microbial growth.

Structure of microbial cells

Microorganisms are grouped into either prokaryotes or eukaryotes according to their cellular structure. With only a few exceptions, prokaryotic cells do not have subcellular organelles separated from the cytoplasm by phospholipid membranes such as the nuclear and mitochondrial membranes. Organelles like the nucleus, mitochondria and endoplasmic reticulum are only found in eukaryotic cells. The detailed structure of prokaryotic cells is described below.

Flagella and pili

Motile prokaryotic cells have an appendage called a flagellum (plural, flagella) involved in motility, and a similar but smaller structure, the fimbria (plural, fimbriae). Fimbriae are not involved in motility and are composed of proteins.

Capsules and slime layers

Many prokaryotic cells are covered with polysaccharides. In some cases the polymers are tightly integrated with the cell while in others they are loosely associated. The former is called a capsule, and the latter a slime layer

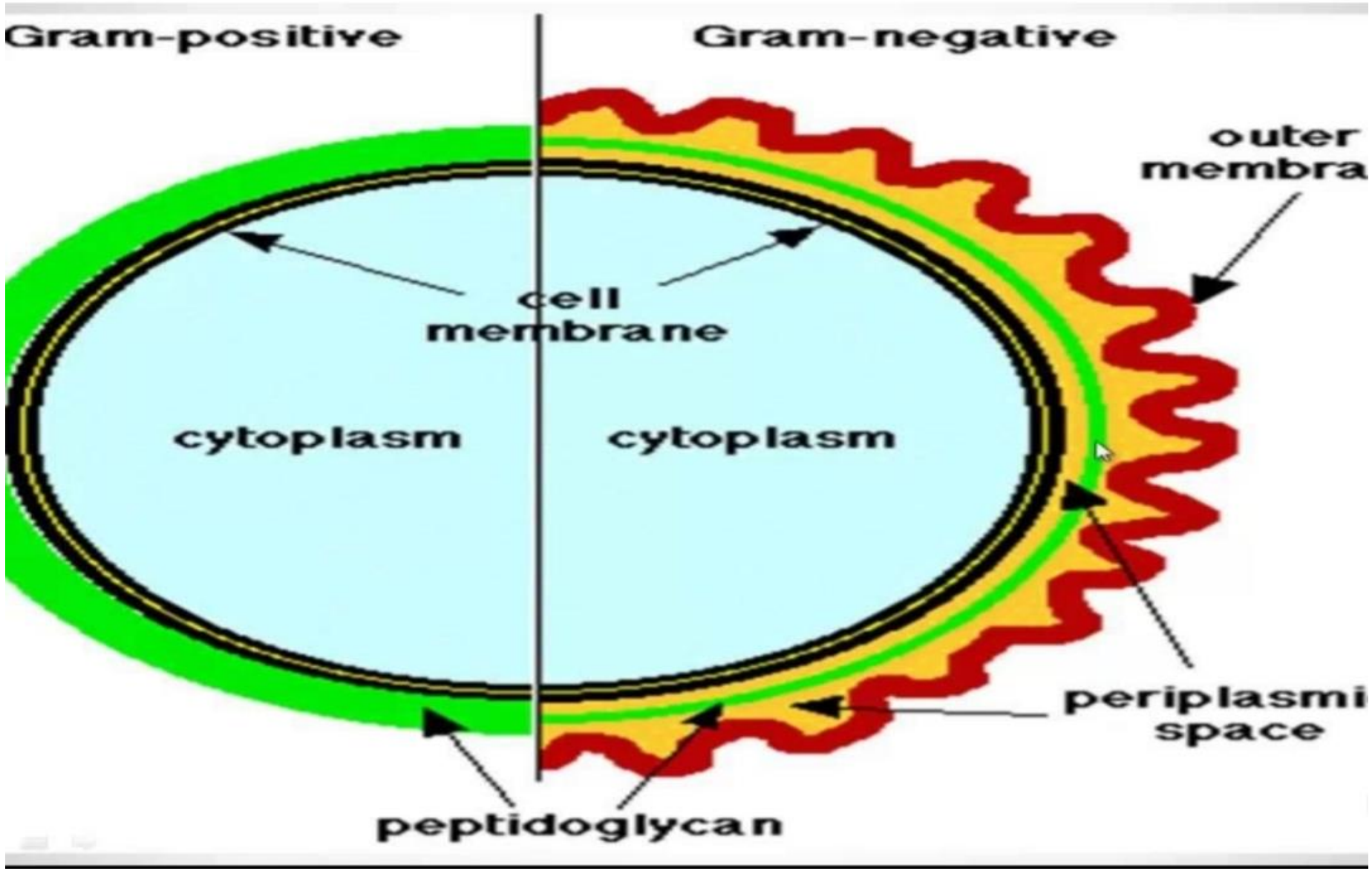
An important role for these structures is adhesion to host cells for invasion or to a solid surface to initiate and stabilize biofilm formation. These structures are also responsible for resistance to phagocytosis, thereby increasing virulence.

Cell wall and periplasm

- With a few exceptions, prokaryotic cells have a cell wall that provides the physical strength to maintain their shapes. Murein is the main component of the cell wall of bacteria.

- In gram-positive bacteria, the cell walls consist mainly of a thick layer of peptidoglycan, which is a mesh-like structure composed of sugars and amino acids. They may also contain teichoic acids.

- The cell wall of gram-negative bacteria, have a thinner layer of peptidoglycan surrounded by an outer membrane, which contains lipopolysaccharides (LPS) and proteins. The cell wall also have periplasmic space.


Gram-positive
Gram-negative
outer membra
cell membrane
cytoplasm
cytoplasm
periplasmi space
peptidoglycan

- **The periplasm is a region** located between the cell membrane (inner membrane in Gram-negative bacteria) and the cell wall. In Gram-positive bacteria, this space is less distinct since they lack an outer membrane.

- The periplasmic space is essential for various functions. It contains enzymes and proteins involved in nutrient uptake, detoxification, and other metabolic processes.

- It also serves as a buffer zone, protecting the cell from harmful substances in the external environment.

- In addition to enzymes, the periplasm may contain transport proteins, binding proteins, and other molecules required for the transport of nutrients into the cell.

- **The cytoplasm**

Refers to everything inside the cytoplasmic membrane. Cells are classified as prokaryotes or eukaryotes depending on the possession of a nucleus. Eukaryotic cells have well-developed intracellular organelles such as mitochondria, chloroplasts and endoplasmic reticulum in addition to the nucleus. With only a few exceptions, prokaryotic cells do not have subcellular organelles within the cytoplasm. Prokaryotic cytoplasm contains DNA, ribosomes, proteins, RNA, salts and metabolites and is viscous due to the high concentration of macromolecules.

The main structures of bacterial cell

1-Pili - hair-like structures that help bacteria attach to surfaces and other bacteria

2-Plasmids - genetic material (DNA)

3-Ribosomes - structures that make proteins

4-Cytoplasm - a gel-like material in which the ribosomes and genetic material are suspended

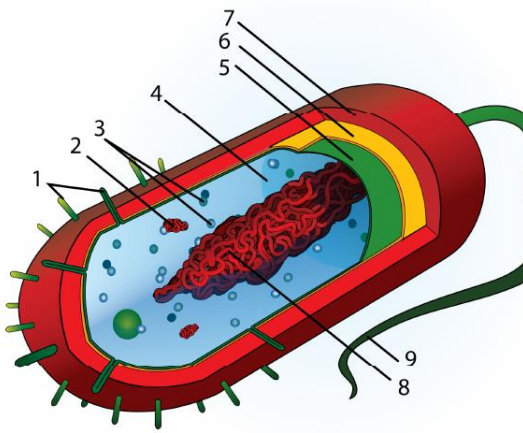
5-Cytoplasmic Membrane - a thin layer of phospholipids and proteins that controls the movement of nutrients in and out of the cell

6-Cell Wall - a rigid wall that gives the cell its structure and protects the plasma membrane

7-Capsule - a third layer that helps prevent the bacteria from drying out or being engulfed by larger microorganisms (only present in some types of bacteria)

8-Nucleoid - a mass of genetic material (DNA)

9-Flagellum - structure that helps the bacteria move around and sense their environme



Biosynthesis and microbial growth

Summarizes how the products of such anabolic reactions are used in biosynthesis and growth, ranging from monomer synthesis to the assembly of macromolecules within cells.

The biosynthetic process, known as anabolism, can be discussed in three steps:

- Monomer biosynthesis
- Polymerization of monomers
- Assembly of polymers into cellular structure.

Growth

- Microbial growth refers to the increase in the population of microorganisms, such as bacteria, viruses, fungi, and algae.

- These microorganisms can multiply and thrive under suitable environmental conditions, including temperature, pH, nutrient availability, and moisture.

- Microbial growth is a crucial concept in various fields, including microbiology, environmental science, and biotechnology.

- Understanding microbial growth is essential in various industries, including food production, healthcare, and water treatment.

- In medicine, understanding microbial growth is vital for diagnosing and treating infections. Antimicrobial agents, such as antibiotics, are used to inhibit or kill microbial growth.

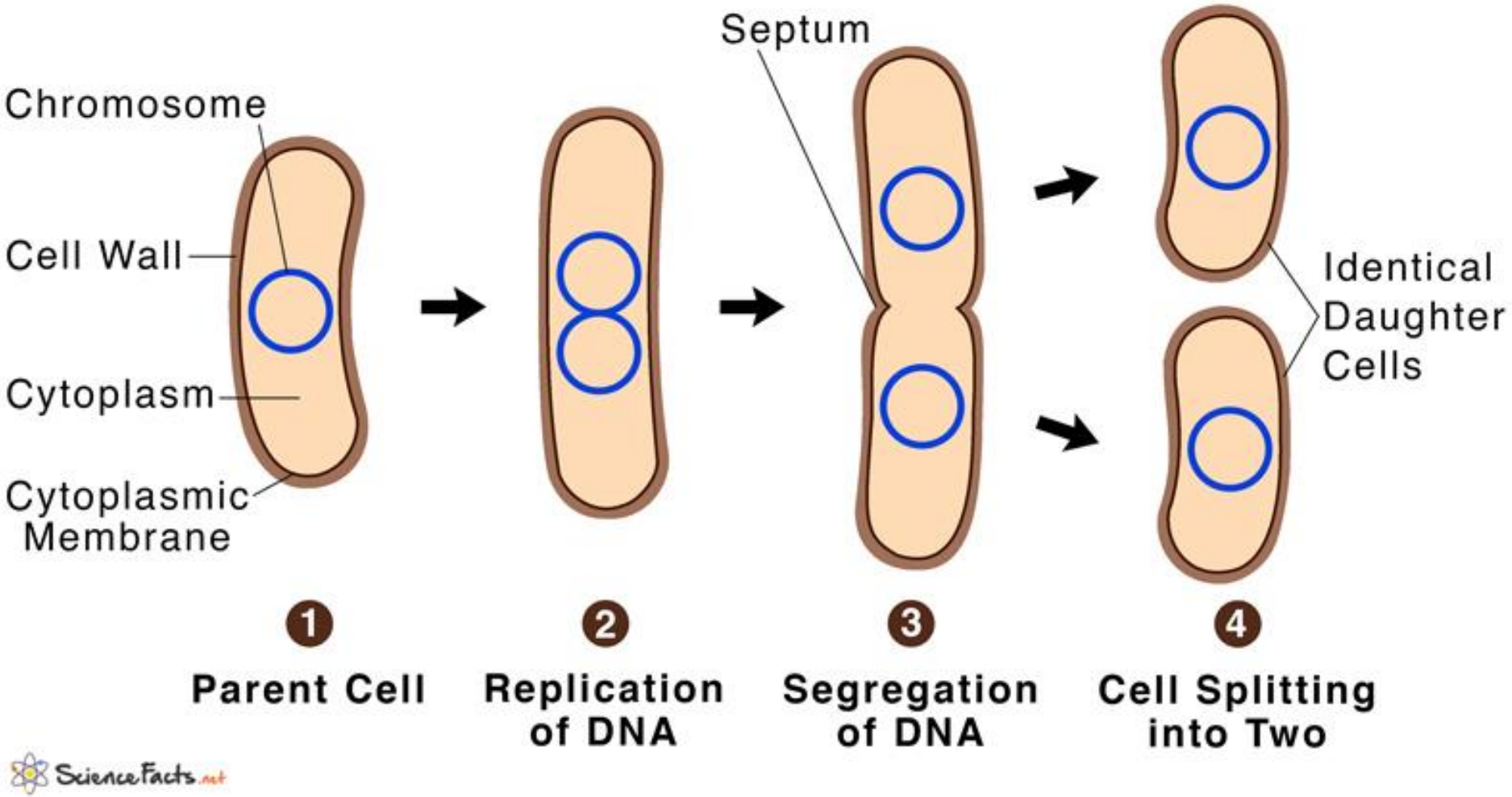
- Microbial growth is harnessed in biotechnology for processes like fermentation (e.g., brewing and yogurt production), bioremediation (cleaning up pollutants with microorganisms), and the production of pharmaceuticals and biofuels.

- Bacterial growth is the division of one bacterium into two daughter cells in a process called binary fission.

- The growth rate of microbes is influenced by various environmental factors including nutrient concentration, temperature, pH, etc.

- **Catabolic** and **anabolic** pathways are coordinated in such a way that each cellular component increases in the same proportion for balanced growth at any given condition.

Binary Fission

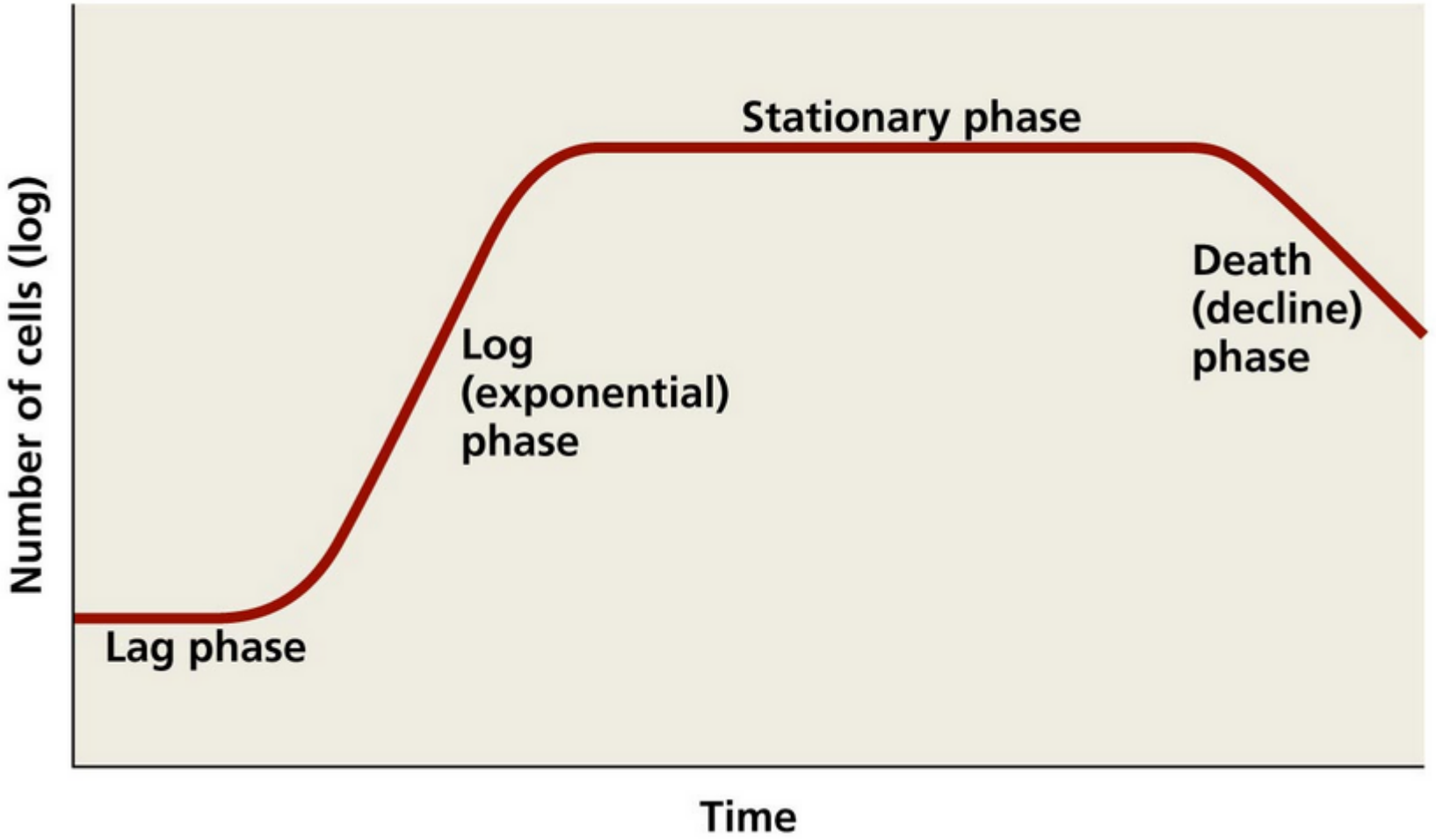


BACTERIAL GROWTH CURVE

- A bacterial growth curve is a graphical representation of the growth of a population of bacteria over time under specific conditions.
- When a bacterium is added to a suitable liquid medium and incubated, its growth follows a definite course.
- If bacterial counts are made at intervals after inoculation and plotted in relation to time, a growth curve is obtained.
- Understanding the bacterial growth curve is crucial in microbiology and various other fields, as it provides insights into how bacterial populations respond to changing environmental conditions and helps researchers study factors that influence bacterial growth and survival. Understanding these phases helps researchers and scientists manipulate bacterial growth for various purposes, including biotechnology, medical research, and food production.
- The growth curve shows four phases : Lag, Log or Exponential, Stationary & phase of Decline.

CULTURE GROWTH

Growth of culture goes through four phases with time



1-Lag phase

When cells are transferred to fresh media they require time to detect the environment, express specific genes, and synthesize components necessary for rapid growth. The cells are not dividing at this time.

2-Log phase

Binary fission occurs at a maximum rate and the cells are dividing as rapidly as possible.

3- Stationary phase

At this point growth has stopped no net increase in the number of cells. Bacteria use new forms of metabolism to survive , in some cases producing secondary metabolites which are often useful to humans such as antibiotics. Spores are also produced during this phase.

4-Death phase

At this point more cells are dying than are dividing and there is a net decrease in the numbers of cells.

Growth yield

In microbiology growth is defined as a process of

- Increase in the no. of microorganisms by asexual method or
- Increase in cell mass
- Increase in cell activity
- Here growth refers to population growth rather than growth of individual cells

There are several methods for measuring cell mass, including

- **The gravimeter method** which uses ordinary balances to weigh a sample (dry weight/ml) after the water has been removed.
- **An indirect method for calculating cell mass is turbidimetry**.

Cell cultures are turbid: they absorb some of the light and let the rest of it pass through. The higher the cell concentration is, the higher the turbidity.

Spectrophotometers are electrical appliances that can measure turbidity very accurately.

The culture is placed in a translucent cuvette; the cuvette is placed in the machine and the turbidity measured immediately.

BACTERIAL COUNTS

Growth in numbers can be studied by bacterial counts.

For counting bacterial cell there are two ways:

a- Total cell count: total number of cells in the sample – living + dead

b- Viable cell count: measures the number of living cells.

Media for microbial growth

Bactria is growth on different types of bacteriologic media. The general cultivation of most bacteria requires media rich in metabolic nutrients. These media generally include:-

- agar
- a carbon source
- and an acid hydrolysate or enzymatically degraded source of biologic material (eg, casein).

Additionally, these types of media may be supplemented by vitamins and even intact red blood cells in the case of blood agar media. Because of their undefined composition, these types of media are referred to as complex media.

Note:- the details of bacterial media will be explain in the microbiology lab

Thank you