



Lecture 4. Physiology of bacteria

Learning objectives

Upon completion of this lecture, student should be able to:

1. Explain generation time of bacteria.
2. Describe bacterial growth curve.
3. Define bacterial sporulation and germination.

Bacterial growth

An **orderly increase of all the chemical components of the cell.**

Cell multiplication is a consequence of growth that leads to an **increase** in the **number** of bacteria making up a **population** or **culture**.

Most bacteria divide by **binary fission** in which the bacteria undergo cell division to produce **two daughter cells identical** to the **parent cell**.

The growth rate of a bacterium is measured by measuring the **change in bacterial number per unit time**.

Generation time

Is the time required for a bacterium to give rise to two daughter cells under **optimum** conditions.

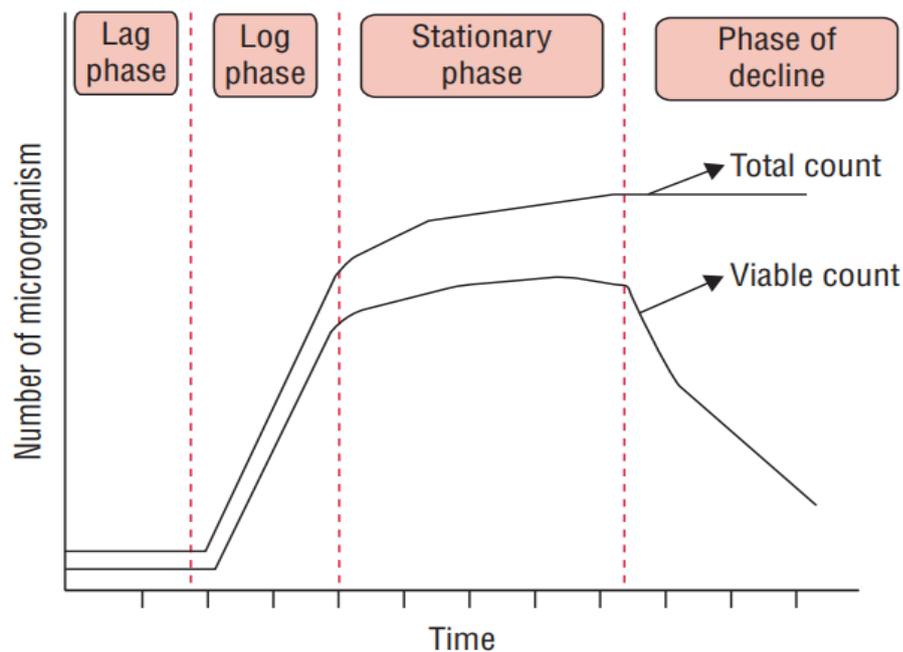
The generation time for most of the pathogenic bacteria, such as *E. coli*, is about **20 minutes**.

The generation time is **longer** (i.e., 20 hours) for *M. tuberculosis* and **longest** (i.e., 20 days) for *M. leprae*.

Bacterial growth curve

The bacterial growth curve shows **four distinct phases**:

Phase	Growth rate	Characteristic features
Lag phase	Zero	There is an increase in size of bacteria but no increase in number of bacterial cells
Log phase	Constant	Exponential increase in number of living bacterial cells
Stationary phase	Zero	Death rate of bacteria exceeds the rate of replication of bacteria
Decline phase	Negative (death)	Exponential decrease in number of living bacterial cells



Factors affecting bacterial growth

Oxygen, carbon dioxide, temperature, PH, light, and osmotic pressure.

Oxygen

Bacteria on the basis of their **oxygen requirements** can be classified broadly into:

1. Aerobic bacteria

Type	Definition	Example
Obligate aerobes	Grow only in the presence of oxygen	<i>P. Aeruginosa</i>
Facultative aerobes	Ordinary aerobes but can also grow without oxygen	<i>E. coli</i>
Microaerophilic bacteria	Grow in the presence of low oxygen and in the presence of low (4%) concentration of carbon dioxide	<i>Campylobacter jejuni</i>

2. Anaerobic bacteria

- Obligate anaerobes are the bacteria that can grow only in the absence of oxygen (e.g., *Clostridium botulinum*)
- These bacteria **lack superoxide dismutase** and **catalase**; hence **oxygen is lethal** to these organisms.

Carbon dioxide

Capnophilic bacteria: The organisms that **require higher amounts of CO₂** for their growth.



Temperature

The optimum temperature for most of the **pathogenic bacteria** is **37C**.

Depending on the **temperature range**, growth of bacteria is grouped as follows:

Type	Definition	Temperature	Example
Psychrophiles	Cold loving microbes	0-20C	<i>Pseudomonas</i>
Mesophiles	Moderate temperature loving microbes	25-40C	<i>E. coli</i>
Thermophiles	Heat loving microbes	55–80C	<i>B. stearothermophilus</i>

Light

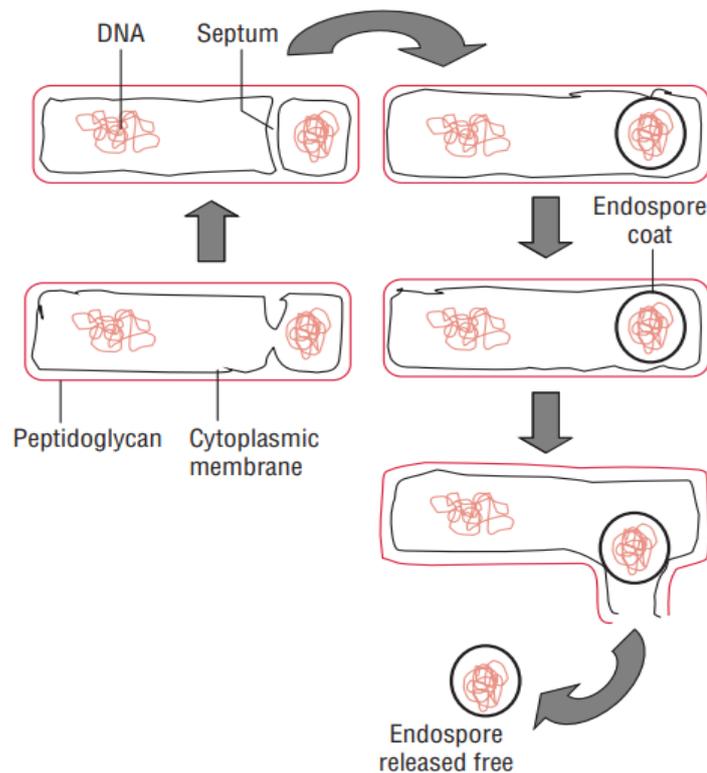
Depending on the source of energy, bacteria may be classified as:

- **Phototrophs** (from sunlight)
- **Chemotrophs** (from chemical sources)

Sporulation

Sporulation is a **primitive process** of **differentiation with formation of endospores** (**highly resistant resting phase** of some of the bacteria). Such as Spores of aerobic *Bacillus spp.* and anaerobic *Clostridium spp.*

Sporulation in bacteria, is **not** a method of **reproduction** but of **preservation**.



Properties of endospores

1. Core

- The spore protoplast containing the normal cell structures but is metabolically inactive.

2. Spore wall

- The innermost layer surrounding the inner spore membrane.
- It contains normal peptidoglycan and becomes the cell wall of the germinating vegetative cell.

3. Cortex

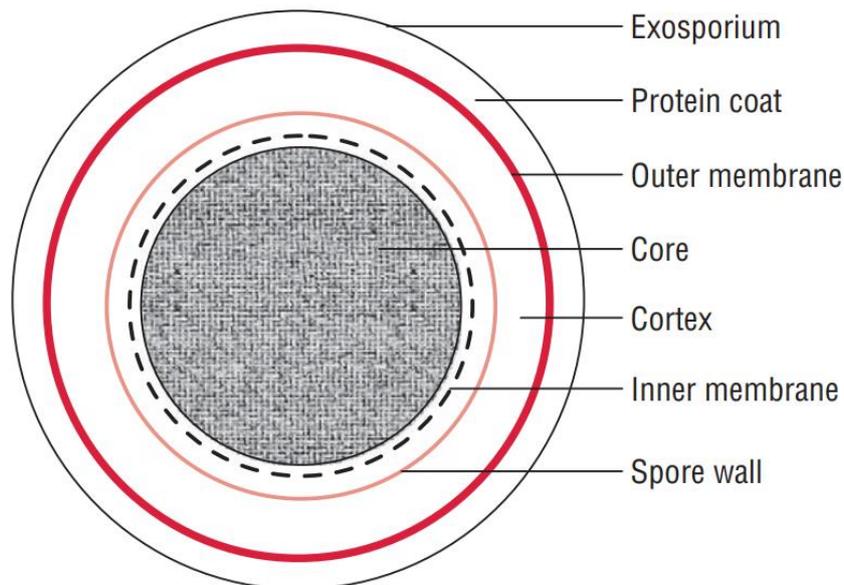
- The thickest layer of the spore envelope.
- Cortex peptidoglycan is extremely sensitive to lysozyme, and plays a role in spore germination.

4. Spore coat

- Fairly thick coat surrounding the cortex.

5. Exosporium

- An additional loose covering with distinctive ridges and grooves.



Shape, size and position of endospore

Depending on the **shape**, endospores maybe:

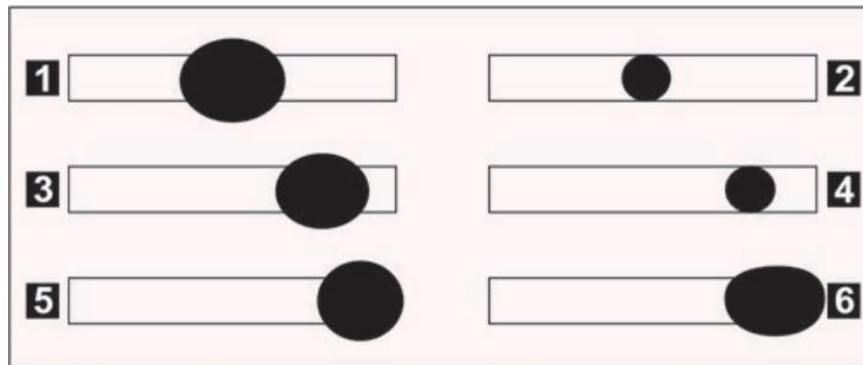
- **Spherical, ovoid, or elongated.**

Depending on the **size**, endospores maybe:

- The **same** or **less than** the **width of bacteria**
- **wider** than the bacillary body producing a distension or **bulge** in the cell

Depending on the **position**, endospores maybe:

- **Central** (equatorial), **subterminal**, or **terminal**



Germination

It is the process of conversion of a **spore** into **vegetative cells** under **suitable conditions**.

It occurs in three stages: **activation**, **initiation** and **outgrowth**.