

# Factors Effecting on Bacterial Growth

- In addition to nutritional factors, growth of bacteria is influenced by **genetic factors** and by **chemical, physical** and other **environmental factors**.

Growth of bacteria in culture is influenced by

- temperature,
- hydrogen ion concentration,
- availability of moisture,
- atmospheric composition
- osmotic pressure.

# Effect of Temperature on Bacterial Growth

- Most pathogenic bacteria can be grown aerobically on a nutrient medium at 37°C, close to normal body temperature.
- Although the optimal temperature for growth of these bacteria, termed **mesophiles**, is **37°C**, they can grow at temperatures **between 20°C and 45°C**.
- In contrast, many environmental bacteria grow at temperatures outside this range.
- Those with an optimal incubation temperature of **15°C** are termed **psychrophiles** and those with an optimal incubation temperature close to **60°C** are termed **thermophiles**

# Psychrophiles ("cold-loving") Bacteria

- **Optimum growth temperature:** ~15°C or lower
- **Growth range:** -5°C to 20°C
- **Habitat:** Polar regions, deep ocean waters, glaciers
- **Example species:**
  - *Psychrobacter cryohalolentis*
  - *Colwellia psychrerythraea*
  - *Polaromonas vacuolata*

These bacteria thrive in permanently cold environments and often have enzymes adapted to low temperatures.

# Psychrotrophs (or Psychrotolerant)

- **Optimum growth temperature:** 20–30°C
- **Growth range:** 0°C to 35–40°C
- **Habitat:** Soil, water, and food (especially refrigerated foods)
- **Example species:**
  - *Listeria monocytogenes*
  - *Pseudomonas fluorescens*
  - *Bacillus cereus*

Psychrotrophs can spoil refrigerated food and some are pathogenic, making them important in food microbiology.

# Mesophiles ("moderate-temperature-loving")

- **Optimum growth temperature:** 25–40°C
- **Growth range:** 10–45°C
- **Habitat:** Human body, soil, water
- **Example species:**
  - *Escherichia coli*
  - *Salmonella enterica*
  - *Staphylococcus aureus*

Most human pathogens are mesophiles because their optimum growth temperature aligns with the human body (~37°C).

# Thermophiles ("heat-loving")

- **Optimum growth temperature:** 50–60°C
- **Growth range:** 40–70°C
- **Habitat:** Hot springs, compost piles, geothermal soil
- **Example species:**
  - *Geobacillus stearothermophilus*
  - *Thermus aquaticus*
  - *Bacillus thermophilus*

Thermophiles have heat-stable enzymes, such as Taq polymerase from *T. aquaticus*, used in PCR.

# Hyperthermophiles ("extreme heat-loving")

- **Optimum growth temperature:** 80°C or higher
- **Growth range:** 65–110°C or more
- **Habitat:** Hydrothermal vents, volcanic springs
- **Example species:**
  - *Pyrolobus fumarii* (up to 113°C)
  - *Thermococcus litoralis*
  - *Sulfolobus solfataricus*

These organisms often belong to the Archaea domain and have uniquely adapted proteins and membranes.

# Effect of pH and Osmotic Pressure on Bacterial Growth

- As most bacteria grow optimally at **neutral pH**, it is standard practice to buffer culture media close to **pH 7**.
- Bacteria require **water** for growth, and species vary widely in their susceptibility to **desiccation**. The ability to tolerate desiccation is determined by the cell wall composition and the surrounding microenvironment.
- Moreover, the cell wall composition accounts for the ability of bacteria to withstand changing osmotic pressures.
- Change in the cell wall composition, induced by the action of **lysozyme** or of **antibiotics such as penicillin**, results in **protoplast** formation. These spherical structures lack rigidity and are susceptible to osmotic change.
- In the animal body, **pathogenic bacteria without cell walls (L forms)** can replicate, causing chronic or persistent infections. Bacterial cells in the environment are usually present in hypotonic solutions and, provided that the cell wall is intact, they remain in a state of turgor and do not lyse. In hypertonic solutions, bacterial cells undergo shrinkage.

# Effect of Oxygen on Bacterial Growth

- Based on their preference for particular levels of oxygen, bacteria can be assigned to four main groups, namely **aerobes**, **anaerobes**, **facultative anaerobes** and **microaerophiles**.
- **Capnophiles**, a fifth group, are aerobic bacteria with a requirement for carbon dioxide.
- Aerobic bacteria require oxygen for growth and they are incubated in air.
- Anaerobic bacteria are unable to grow in an atmosphere containing oxygen. Obligate anaerobes survive only briefly in the presence of oxygen.
- Facultative anaerobes are bacteria which have the ability to grow well under both aerobic and anaerobic conditions.
- Microaerophilic bacteria require a reduced oxygen concentration for growth.

# Aerobic Bacteria

**Oxygen requirement:** Require oxygen for growth.

**Mechanism:** Use oxygen as the final electron acceptor in aerobic respiration.

## **Examples:**

- *Mycobacterium tuberculosis* – causes tuberculosis.
- *Pseudomonas aeruginosa* – opportunistic pathogen, especially in burn wounds or cystic fibrosis.
- *Bacillus subtilis* – a model organism, non-pathogenic.

# Anaerobic Bacteria

**Oxygen requirement:** Cannot grow in the presence of oxygen (often toxic to them).

**Mechanism:** Use fermentation or anaerobic respiration.

## Examples:

- *Clostridium botulinum* – causes botulism.
- *Clostridium tetani* – causes tetanus.
- *Bacteroides fragilis* – part of normal gut flora, can cause infection if displaced.

# Facultative Anaerobic Bacteria

**Oxygen requirement:** Can grow with or without oxygen but grow better with it.

**Mechanism:** Use aerobic respiration when oxygen is available; switch to fermentation or anaerobic respiration without it.

## Examples:

- *Escherichia coli* – common gut bacterium, can be pathogenic.
- *Staphylococcus aureus* – causes skin infections, food poisoning.
- *Salmonella enterica* – causes foodborne illness.

# Microaerophilic Bacteria

**Oxygen requirement:** Require low levels of oxygen (2–10%); high concentrations are toxic.

**Mechanism:** Limited oxidative metabolism.

## Examples:

- *Helicobacter pylori* – associated with peptic ulcers.
- *Campylobacter jejuni* – causes gastrointestinal infections.

# Capnophilic Bacteria

**Oxygen requirement:** Require increased CO<sub>2</sub> (often 5–10%) along with low oxygen.

**Mechanism:** Thrive in CO<sub>2</sub>-rich environments like human tissues or blood.

## Examples:

- *Neisseria gonorrhoeae* – causes gonorrhoea.
- *Haemophilus influenzae* – causes respiratory tract infections and meningitis.

# Cultivation of Anaerobic Bacteria

- Strict anaerobes are cultured in **tightly sealed jars** in an atmosphere from which free oxygen has been removed.
- One commercially available system employs a **gas-producing envelope**.
- On the **addition of water to the envelope**, hydrogen and carbon dioxide are released into the jar. A **palladium catalyst**, either in the jar or attached to the envelope, accelerates the reaction of the hydrogen with free oxygen in the jar to form water. In addition, the release of carbon dioxide enhances the growth of anaerobes.
- A more convenient alternative system, in which oxygen is removed by reacting with **ascorbic acid contained in a porous envelope**, has been developed. This system, which eliminates the need to generate hydrogen, releases carbon dioxide into the jar.
- **Anaerobic bags** may be used as an alternative to jars, and a number of such anaerobic pouches are commercially available and are suitable for use with small numbers of plates.
- **Specially designed anaerobic chambers** which are particularly useful when large numbers of specimens are being processed.
- Media, such as **thioglycollate broth** and **cooked meat broth** with low redox potentials may be used.

# Cultivation of Microaerophilic Bacteria

- For the cultivation of microaerophiles, **reduced oxygen levels** are required.
- A **gas-producing envelope**, which delivers up to **10% carbon dioxide into a sealed jar**, is available commercially. This system is also suitable for the cultivation of capnophilic bacteria.

# References

1. Quinn PJ, Markey BK, Leonard FC, FitzPatrick ES, & Fanning S (2011). *Veterinary Microbiology and Microbial Disease*. 2nd Ed., Wiley-Blackwell.
2. Tortora GJ, Funke BR, Case CL (2019). *Microbiology, An Introduction*. 13rd Edition, Pearson Education Inc.