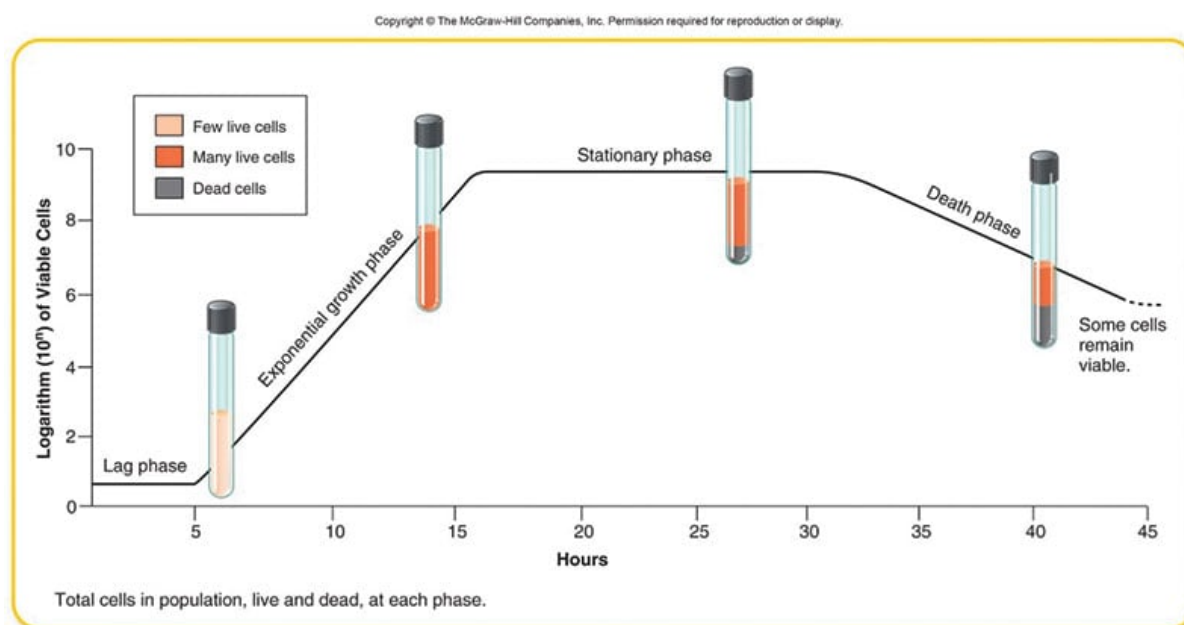


Chapter 5 : Characteristics of microbial growth in foods

The growth of microorganisms in food determines its **safety**, **quality**, and **shelf life**. Understanding these characteristics is fundamental for the food industry.

1. The phases of microbial growth (growth curve)

When a microorganism is introduced into a favorable food environment, its population follows a typical growth curve, divided into four phases:



Phase	Description	Impact on the Food
1. Lag Phase	A period of adaptation. Microbes adjust to the environment (pH, water activity, temperature) and synthesize necessary enzymes. They do not multiply yet, but their metabolism is highly active.	Critical control period. This is the most effective time for interventions (e.g., cooling, acidification) to prevent growth.
2. Log (Exponential) Phase	Microbes divide at a constant and maximum rate. The population doubles with each generation. This is the fastest growth phase.	Rapid spoilage and highest health risk. Toxin production (e.g., by <i>Staphylococcus aureus</i>) often begins in this phase.

3. Stationary Phase	The growth rate equals the death rate. Growth is limited by nutrient depletion, accumulation of toxic waste products, or lack of space.	Obvious spoilage (off-odors, slime, discoloration). The microbial population is at its peak. Some microbes form spores to survive.
4. Death (Decline) Phase	The death rate exceeds the growth rate. The environment becomes too hostile (lack of nutrients, high toxin levels).	The food is typically completely spoiled and unfit for consumption. Some resilient pathogens may survive for a long time.

2. Intrinsic factors (inherent to the food itself)

These are the physico-chemical properties of the food that influence microbial growth.

- **pH (Acidity):**
 - Most pathogenic bacteria (e.g., *Salmonella*, *E. coli*) grow best in a neutral pH range (6.6 - 7.5).
 - Yeasts and molds are more tolerant of acidic conditions (below pH 4.5).
- **Water activity (a_w):**
 - A measure of the "free" water available for microbes, not the total water content.
 - Most bacteria require $a_w > 0.91$. *Staphylococcus aureus* can grow as low as $a_w = 0.86$.
 - Yeasts ($a_w > 0.88$) and especially molds ($a_w > 0.80$) are more tolerant.
- **Nutrient composition:**
 - Foods rich in nutrients (proteins, carbohydrates, lipids) are ideal growth media.
 - Meats and fish are susceptible to proteolytic bacteria.
 - Fruits and vegetables are more susceptible to yeasts and molds.
- **Physical structure and oxidation-reduction potential (O_2):**
 - Obligate aerobes (e.g., *Pseudomonas*, molds) require oxygen and grow on surfaces.
 - Obligate anaerobes (e.g., *Clostridium botulinum*) grow only in the absence of oxygen (vacuum-packed foods, canned goods).
 - Facultative anaerobes (e.g., *Lactobacillus*, *Salmonella*) can grow with or without O_2 .
- **Natural microflora and antimicrobial substances:**
 - Some foods contain natural inhibitors (lysozyme in egg white, organic acids in fruits).
 - The presence of competitive microflora (e.g., lactic acid bacteria) can inhibit pathogens.

3. Extrinsic factors (related to the environment)

These are the storage and handling conditions of the food.

- **Temperature:**

- Psychrotrophs (0 to 25°C): Can grow at refrigerator temperatures. Major cause of spoilage in fresh products (*Pseudomonas*, *Listeria*).
- Mesophiles (20 to 45°C): This group includes most foodborne pathogens (*E. coli*, *Salmonella*).
- Thermophiles (45 to 70°C): Important in under-processed canned foods or products held hot for long periods.

- **Relative humidity of the storage environment:**

If the air is humid, dry foods can absorb moisture on their surface, increasing the local a_w and allowing mold growth.

- **Gaseous atmosphere (packaging):**

- Vacuum packaging: Removes O_2 , limiting aerobes but potentially favoring anaerobes.
- Modified atmosphere packaging (MAP): Replaces air with a gas mix (e.g., CO_2 , N_2) to selectively inhibit specific microbes.

4. Consequences for food safety and quality

Microbial growth in foods manifests in two primary ways:

1. Spoilage:

- Makes the food unacceptable for consumption (bad flavor, odor, texture, appearance).
- Mainly caused by non-pathogenic microorganisms (e.g., *Pseudomonas*, yeasts, molds).
- A major economic problem.

2. Foodborne illness (food poisoning):

- Caused by the presence and/or growth of **pathogens** (e.g., *Salmonella*, *Listeria*, *Campylobacter*).
- Two main mechanisms:
 - **Infection:** Ingestion of a high number of living pathogenic cells that colonize the gut.
 - **Intoxication:** Ingestion of preformed **toxins** in the food by microbes (e.g., toxin from *S. aureus*, botulinum toxin from *C. botulinum*). Cooking may kill the microbe but not always destroy the toxin.