RAMA UNIVERSITY

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FACULTY OF ENGINEERING &TECHNOLOGY

DEPARTMENT OF BIOTECHNOLOGY

Factors affecting microbial growth

pH: pH is a measure of the hydrogen ion activity of a solution and is defined as the negative logarithm of the hydrogen ion concentration (expressed in terms of molarity).

- ❖pH dramatically affects microbial growth.
- ❖Each species has a definite pH growth range and pH growth optimum.
- ❖Drastic variations in cytoplasmic pH can harm microorganisms by disrupting the plasma membrane or inhibiting the activity of enzymes and membrane transport proteins.
- ❖Procaryotes die if the internal pH drops much below 5.0 to 5.5.
- ❖Changes in the external pH also might alter the ionization of nutrient molecules and thus reduce their availability to the organism.
- ❖Buffers often are included in media to prevent growth inhibition by large pH changes.
- ❖Phosphate is a commonly used buffer and a good example of buffering by a weak acid (H2PO4) and its conjugate base (HPO42–).
- ❖Peptides and amino acids in complex media also have a strong buffering effect.

Categorization on the basis of pH

Each species has a definite pH growth range and pH growth optimum. **Acidophiles** have their growth optimum between pH 0 and 5.5; **neutrophiles,** between pH 5.5 and 8.0; and **alkalophiles** prefer the pH range of 8.5 to 11.5. Extreme alkalophiles have growth optima at pH 10 or higher.

Temperature

Environmental temperature profoundly affects microorganisms, like all other organisms. when organisms are above the optimum temperature, both function and cell structure are affected. If temperatures are very low, function is affected but not necessarily cell chemical composition and structure. A most important factor influencing the effect of temperature on growth is the temperature sensitivity of enzyme catalyzed reactions. At low temperatures a temperature rise increases the growth rate because the velocity of an enzyme-catalyzed reaction. double for every 10°C rise in temperature. Because the rate of each reaction increases, metabolism as a whole is more active at higher temperatures, and the microorganism grows faster. Beyond a certain point further increases actually slow growth, and sufficiently high temperatures are lethal. High temperatures damage microorganisms by denaturing enzymes, transport carriers, and other proteins. Microbial membranes are also disrupted by temperature extremes; the lipid bilayer simply melts and disintegrates.

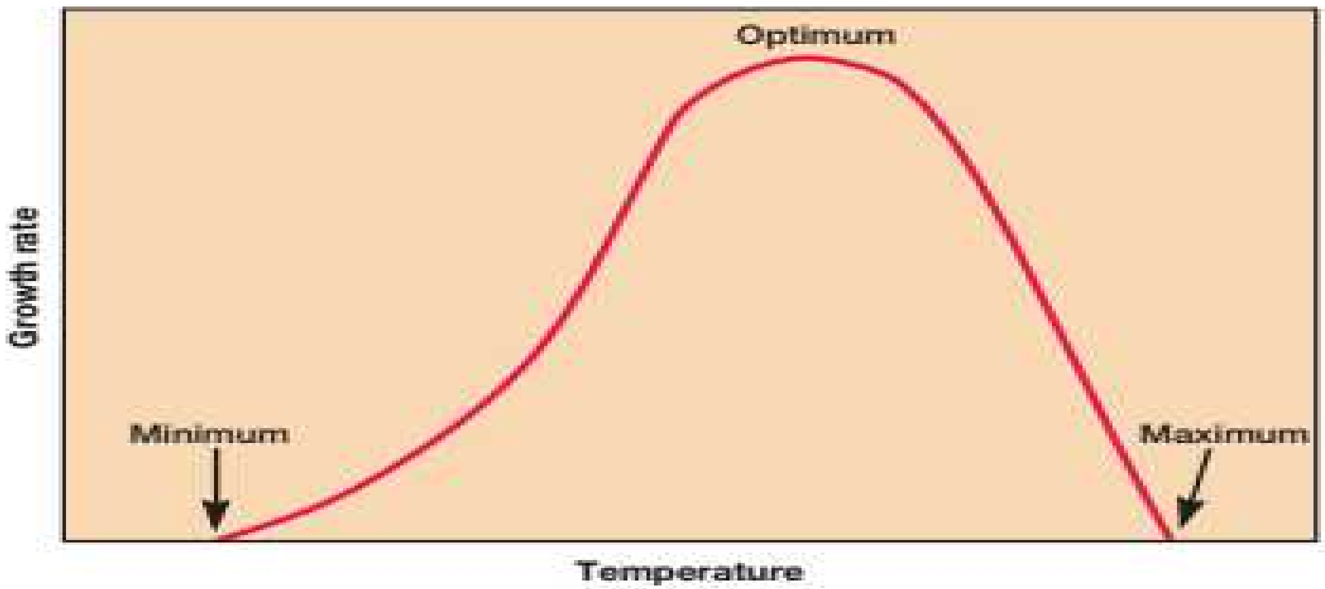

Figure 6.12 Temperature and Growth. The effect of temperature on growth rate.

Figure: Temperature dependence curve. Curve also shows cardinal temperature i.e. minimum, maximum and optimum

Categorization on the basis of temperature

Microorganisms can be placed in one of five classes based on their temperature range for growth.

These are as follows:

Psychrophiles:

Psychrophiles grow well at 0°C and have an optimum growth temperature of 15°C or lower; the maximum is around 20°C. Their enzymes, transport systems, and protein synthetic mechanisms function well at low temperatures. The cell membranes of psychrophilic microorganisms have high levels of unsaturated fatty acids and remain semifluid when cold. Indeed, many psychrophiles begin to leak cellular constituents at temperatures higher than 20°C because of cell membrane disruption.

Psychrotrophs or **facultative psychrophiles: These s**pecies can grow at 0 to 7°C even though they have optima between 20 and 30°C, and maxima at about 35°C. Psychrotrophic bacteria and fungi are major factors in the spoilage of refrigerated foods.

Mesophiles are microorganisms with growth optima around 20 to 45°C; they often have a temperature minimum of 15 to 20°C. Almost all human pathogens are mesophiles, as might be expected since their environment is a fairly constant 37°C.

Thermophiles;

they can grow at temperatures of 55°C or higher. Their growth minimum is usually around 45°C and they often have optima between 55 and 65°C. Thermophiles differ from mesophiles in having much more heat-stable enzymes and protein synthesis systems able to function at high temperatures. Their membrane lipids are also more saturated than those of mesophiles and have higher melting points; therefore thermophile membranes remain intact at higher temperatures.

Hyperthermophiles: These microorganisms can grow at 90°C or above and some have optimum above 100°C. Procaryotes that have growth optima between 80°C and about 113°C.

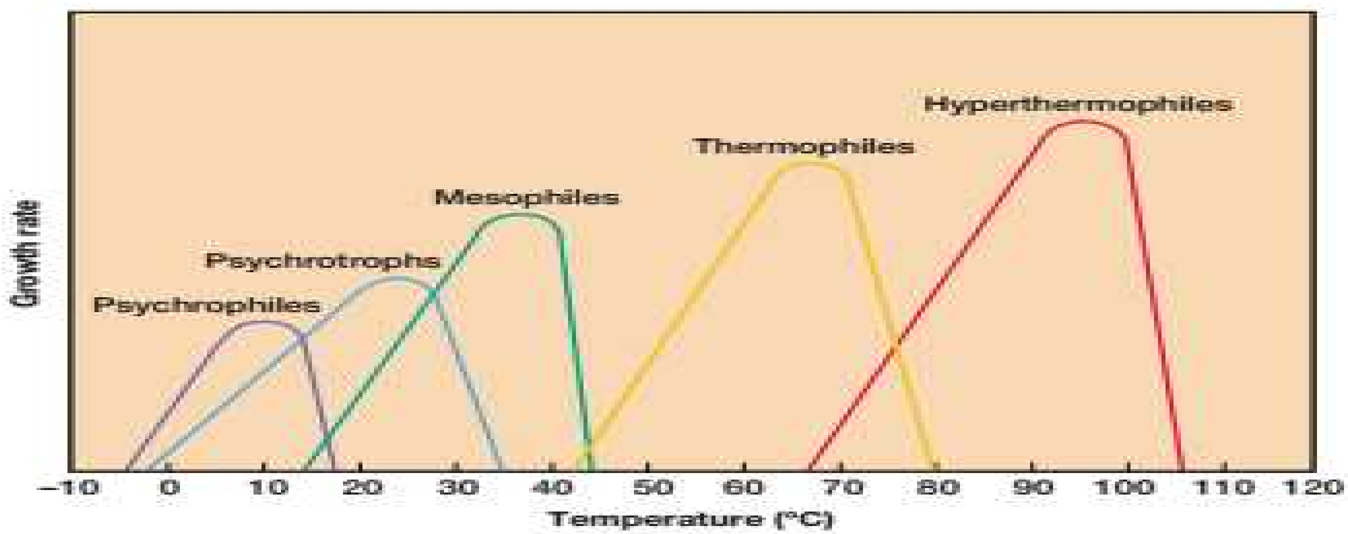

Figure 6.13 Temperature Ranges for Microbial Growth. Microorganisms can be placed in different classes based on their temperature ranges for growth. They are ranked in order of increasing growth temperature range as psychrophiles, psychrotrophs, mesophiles, thermophiles, and hyperthermophiles. Representative ranges and optima for these five types are illustrated here.

Oxygen concentration

An organism able to grow in the presence of atmospheric O2 is an **aerobe,** whereas one that can grow in its absence is an **anaerobe.**

Almost all multicellular organisms are completely dependent on atmospheric O2 for growth—that is, they are **obligate aerobes.**

Oxygen serves as the terminal electron acceptor for the electron-transport chain in aerobic respiration. In addition, aerobic eucaryotes employ O2 in the synthesis of sterols and unsaturated fatty acids.

Facultative anaerobes do not require O2 for growth but do grow better in its presence. In the presence of oxygen they will use aerobic respiration.

Aerotolerant anaerobes such as *Enterococcus faecalis* simply ignore O_2 and grow equally well whether it is present or not. In contrast, **strict** or **obligate anaerobes** (e.g., *Bacteroides, Fusobacterium, Clostridium pasteurianum, Methanococcus*) do not tolerate O2 at all and die in its presence

Aerotolerant and strict anaerobes cannot generate energy through respiration and must employ fermentation or anaerobic respiration pathways for this purpose.

Finally, there are aerobes such as *Campylobacter,* called **microaerophiles,** that are damaged by the normal atmospheric level of O_2 (20%) and require O_2 levels below the range of 2 to 10% for growth.

Relationship of O_2 to microbial group

Different relationships with O2 appear due to several factors, including the inactivation of proteins and the effect of toxic O2 derivatives.

Enzymes can be inactivated when sensitive groups like sulfhydryls are oxidized.

A notable example is the nitrogen-fixation enzyme nitrogenase which is very oxygen sensitive.

During reduction of oxygen several oxygen reductive products are generated. These products are superoxide radical, hydrogen peroxide and hydroxyl radical. These products of oxygen reduction are extremely toxic because they are powerful oxidizing agents and rapidly destroy cellular constituents.

A microorganism must be able to protect itself against such oxygen products or it will be killed.

Neutrophils and macrophages use these toxic oxygen products to destroy invading pathogens.

$O_2 + e^- \rightarrow O_2^-\cdot$ (superoxide radical)

$O_2^-\cdot + e^- + 2H^+ \rightarrow H_2O_2$ (hydrogen peroxide)

$H_2O_2 + e^- + H^+ \rightarrow H_2O + OH\cdot$ (hydroxyl radical)