Bacteriology

Lec 8 Factors affecting growth

Microorganisms are affected by the physical nature of their environment. Environmental factors such as temperature, pH, osmotic pressure and radiation, influence the growth of M.O

1- Temperature

Temperature affects the growth of bacteria by various ways.

- The lowest temperature that allows the growth is called minimum temperature and the highest temperature that allows growth is called maximum temperature.
- There is no growth below minimum and above maximum temperature.
- Below minimum temperature cell membrane solidifies and become stiff to transport nutrients in to the cell, hence no growth occurs.
- Above maximum temperature, cellular proteins and enzymes denatures, so the bacterial growth ceases.

The relationship between temperature and growth rate is shown in figure below.

Microorganisms have been divided into three groups based on their optimum temperature:

A-Psychrophiles:

Psychrophilic (cold loving) microorganisms, have a preferential temperature for growth at less than 15 C exhibit an optimum range of growth between 0^{o}C and 20; over this temperature the ribosome will be unstable. Bacteria that can grow at such cold temperature, but which prefer a high growth temperature are known as psychrotrophs. psychrophiles found in Antarctic, cold soil, deep sea, stream, rivers and lake mud they are growing in a household refrigerator where they are important agents of food spoilage including *Listeria* monocytogenes ,these microorganisms are unable to live in high temperature because of the inhibition of enzymes. The enzymes of the bacteria are structurally unstable and fail to operateeven at room temperature. The enzymes of these organisms allow functions such as the cleaning of clothes in cold water. Psychrophiles are adapted to their cold environment because the cytoplasmic membrane of psychrophile contains much more of a certain kind of unsaturated fatty acid which generally does not occur in prokaryotes.

B-Mesophiles

They have an optimal temperature range between 20-50^{o}C.Most of them grown in the microbiological laboratories, some of them involved in biodegradation (digestion and decomposition of organic matter),they take part in the web of micro- organic activity that form the humus layer forests and other fertile soils, by decomposing both vegetable and animal matter.

Many mesophile have an optimal temperature of about 37^{o}C.Many of normal resident M.O of the human body such as *E.coli* is mesophilic. Mesophile bacteria are also involved in food contamination and degradation such as bread,and meat. Bacterial infection in humans is mostly caused by mesophilic

bacteria that find their optimum growth temperature around 37C, the normal human body temperature. Beneficial bacteria found in human intestinal flora are also mesophiles, such as dietary *Lactobacillus acidophilus* .The ability of mesophiles to survive at cold as well as hot temperature appears to be related to the composition of the fatty acids in the cell membrane. Examples of common mesophilic bacteria are *Staphylococcus aureus* , *Streptococcus pyogenes* .

C-Thermophiles:

Thermophiles are classified into obligate and facultative thermophiles :obligate thermophiles (also called extreme thermophiles) require such high temperatures for growth (above 40C), and the temperature span for optimuim growth of different thermophiles is 40-80C, such as *Themusaquaticus*, and *Thermusthermophilus* whereas facultative thermophiles (also called moderate thermophiles) can thrive at high temperature, but also at lower temperatures. Hyperthermophiles are particularly extereme thermophiles for which the optimal temperatures is 90-100C. Such as *Bacillus staerothermophilus*. Their membranes and proteins are unusually stable at these extremely high temperatures. Thermophiles are found among many groups of M.O such as cyanobacteria, photosynthetic bacteria, gram positive, gram negative bacilli, and protozoa. Most of them found in springs in many areas of the world. Thermophiles haveribosome, enzyme system, metabolic pathways, and regulatory devices that are functionally the same as those found in mesophiles. Experiment show that the cytoplasmic proteins from thermophiles are resistant to temperature that denatures mesophilic proteins. Thermophiles contain enzymes that can function at high temperature, some of these enzymes are used in molecular biology (heat –stable DNA polymerases for PCR) also, many important biotechnological processes use thermophilic enzymes because

of their ability to withstand intense heat , in washing agents, industrial processes(pulp and paper processing). Resistance to heat is a property associated with the endospores of such bacteria as the *Clostridia* these M.O release potent toxins (*Clostridia botulinum* toxin). Some spore forming Clostridia are also thermophilic and the vegetative cells can grow at high temperature. Many of the hyperthermophiles require elemental sulfur for growth; some are anaerobes that use the sulfur instead of oxygen as an electron acceptor during cellular respiration. Some are lithotrophs that oxidize sulfur to sulfuric acid as an energy source, thus requiring the microorganisms to be adapted to very low PH (i.e., it is an acidophile as well as thermophile).

2-Osmotic pressure:

Changing the solute concentration not only alters the availability of water but also alters the osmotic pressure. The cell wall structure of bacteria makes them resistant to changes in osmotic pressure but extremity in osmotic pressure can result in the death of M.O. In hypertonic solutions M.O may shrink and in hypotonic solution the cell may burst. M.O that can grow in solution with high solute concentration is called **Osmotolerant**.

Some M.O areosmophilic requiring a high solute concentration to grow like some fungi. Some microorganisms known as **Halophiles** require NaCl for growth. Extreme halophiles show maximum growth rate in saturated solutions. These microorganisms grow well in salt con. Of greater than 15%NaCl and can grow in salt lakes and pickle barrels. High salt concentration normally disrupts membrane transport system and denatures proteins.

Halobacterium

Extreme halophilic bacteria possesses an unusual cytoplasmic membrane and

unusual enzymes.

Staphylococcus :

Are salt tolerant and grow at salt con. Greater than 10%, so one of the reasons for mixing high con. Of salt or sugar with foods is to prevent growth of M.O through dehydration. The addition of 12%NaCl is the best technique for reducing microbial growth, but this has no effect on certain halophilies.

The importance of halophiles:

A- In ecosystem.

Halophiles play an important part in ecosystems ex: halophiles often support entire population of wild birds. Halophiles are useful for cleaning up polluted environments. Waste water with salt concentration more than 2% is ideal for halophiles to remove organic pollutants; halophiles have been shown to remove phenol (a poisonous chemical) from their environments. This could lead to future use in cleaning up oil spills.

B- In fermentation:

Halophile plays an important part in the fermentationof somefood ex: halophile ferment soy and fish sauces.

C- In biotechnology:

The salt- tolerant enzymes that halophiles produce can be used in a variety of ways ex: these enzymes could be used for rough industrial processes, like food processing. Some moderate halophiles produce sugar outside the cell. This sugar can be used as thickeners and emulsifiers in the petroleum and medicine.

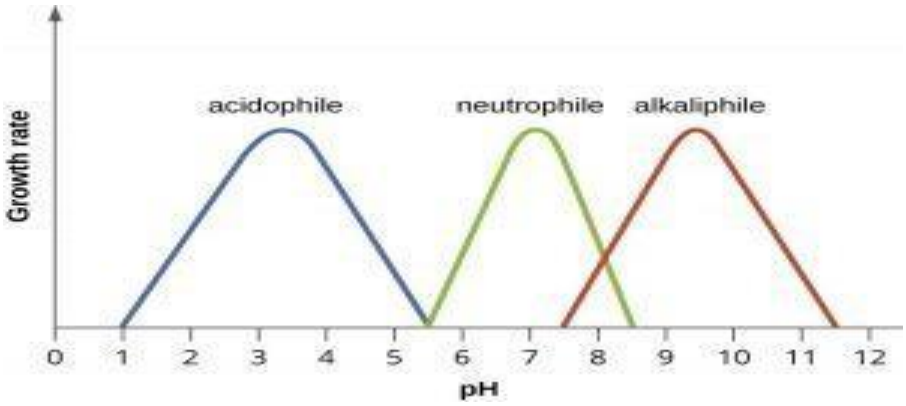
3-Hydrostatic pressure:

It refers to the pressure exerted by a water column as a result of the weight of the water column. Most M.O are relatively tolerant to the hydrostatic pressure, but cannot tolerate the extremely high hydrostatic pressure of 200 atm since this will inactivates the enzymes and disrupt membrane transport system.

Some microorganisms are referred to as **barotolerant** (they are classified into obligate and facultative barotolerant) can grow at high hydrostatic pressure. The inhibition of microbial cell is attributed to the accumulation of acids inside the cell.

4-pH:

- pH affects the ionic properties of bacterial cell so it affects the growth of bacteria.
- Most of the bacteria grow at neutral pH (60.5-7.5). However there are certain bacteria that grow best at acidic or basic pH.
- relationship between pH and bacterial growth is given in figure below.



In general, M.O may divide into three categories:

1-Alkalophiles

Grow in a pH range of 7-11 with an optimum of 10.

2- Neutrophiles

Grow in a pH grow of 4-9 with an optimum near neutrality.

3-Acidophiles

Live at low pH values and can be divided into facultative such as fungi,obligate such as *sulfolobus.*

5-Radiation:

The electromagnetic spectrum divided into certain categories of radiation including gamma rays, X-ray, UV light, high energy, and short-wave length radiation disrupt DNA molecules and exposure to short wavelength radiation may cause mutation many of which are lethal.

The visible light is a source of energy for photosynthetic M.O such as cyanbacteria and purple and green bacteria where the light energy is converted into chemical energy in the cell.

6-Nutrient concentration:

- If culture media is rich in growth promoting substance, growth of bacteria occurs faster. Decrease in nutrient concentration decreases the growth rate.
- Different bacteria have different nutritional requirement.