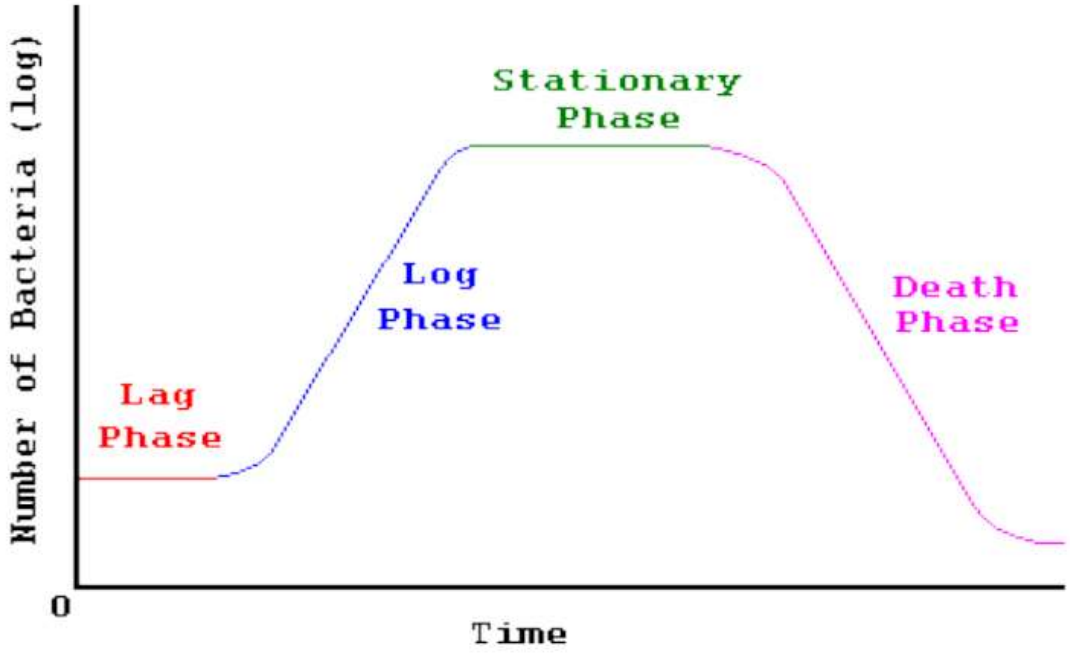
Bacterial Growth Curve

- Bacteria 's growth can be take place by binary fission and during that so many phases happen during that different events takes place.
- Five type of growth curves:
  1) Growth cycle
  2) Biphasic growth
  3) Maintenance of cells in exponential phase
  4) Synchronous growth
  5) Bacterial growth in vivo

Growth cycle or Growth Curve

- Bacterial growth is regulated by nutritional environment.
- When suitable environment is there that time bacterium is incubated its growth leads to increase in number of cells which allow definite course.
- The growth curve has got four phases:
  - Lag phase
  - Log phase (logarithmic) or exponential phase
  - Stationary phase
  - Decline phase



Lag Phase (1-4 Hrs)

- Bacteria adapt themselves to growth conditions.
- It is the period where the individual bacteria are maturing and not yet able to divide.
- During the lag phase of the bacterial growth cycle, synthesis of RNA, enzymes and other molecules occurs.
- Length of this phase depend on type of bacterial spesis, culture medium, and environmental factors.

Log Phase (8 Hrs)

- Sometimes called the log phase or the logarithmic phase
- It is a period characterized by cell doubling. The number of new bacteria appearing per unit time is proportional to the present population.
- If growth is not limited, doubling will continue at a constant rate so both the number of cells and the rate of population increase doubles with each consecutive time period.
- For this type of exponential growth, plotting the natural logarithm of cell number against time produces a straight line.
- The slope of this line is the specific growth rate of the organism, which is a measure of the number of divisions per cell per unit time.
- The actual rate of this depends upon the growth conditions, which affect the frequency of cell division events and the probability of both daughter cells surviving.
- Under controlled conditions, cyanobacteria can double their population four times a day.
- Exponential growth cannot continue indefinitely, however, because the medium is soon depleted of nutrients and enriched with wastes.

Stationary phase

- Stationary phase is due to a growth-limiting factor; this is mostly depletion of a nutrient, and/or the formation of inhibitory products such as organic acids.
- An awkward but unfortunately widespread explanation is that the stationary phase results from a situation in which growth rate and death rate have the same values (newly formed cells per time = dying cells per time);but this is not logical, and it is better to forget this.
- Such an explanation would not be in accordance with the observed substrate depletion and also could never explain the rather “smooth,” horizontal linear part of the curve during the stationary phase.
- Death of cells as a function of time is rather unpredictable and very difficult to explain.
- Another not really logical explanation of the stationary phase is that there isn’t anymore enough space for the cells.
- However, under the microscope you will see that there is still plenty of water between the cells Only in an agar colony with densely packed cells space is obviously limiting.

Decline Phase

- Bacteria run out of nutrients and die although number of cells remain constant.
- The decline phase is brought by exhaution of nutrients, accumalation of toxic products and autolytic enzymes
- Sometimes a small numbers of survivors may persist for month even after death of majority of cells these few surviving cells probably grow at expence of nutrients released

Factor affecting bacterial growth

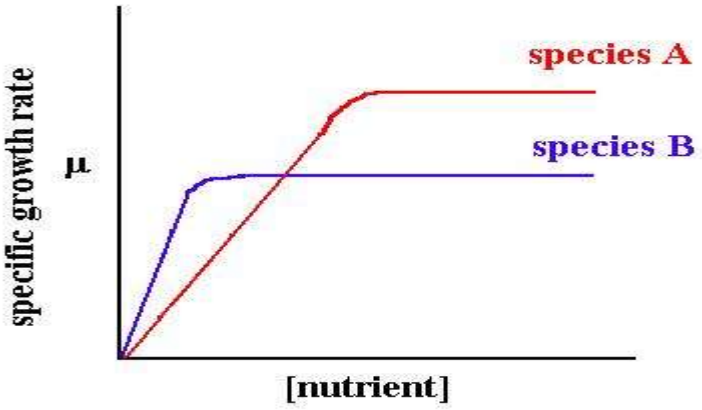
- Growth of bacteria is affected by many factors such as nutrition concentration and other environmental factors.

Some of the important factors affecting bacterial growth are:

1. Nutrition concentration
2. Temperature
3. Gaseous concentration
4. pH
5. Ions and salt concentration
6. Available water

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.
- With increase in concentration nutrition, growth rate of bacteria increases up to certain level and then growth rate remains constant irrespective of nutritional



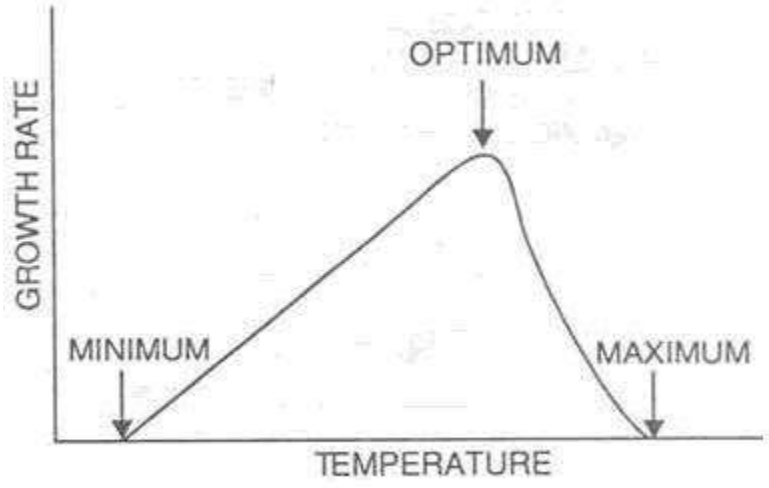
addition.

The relationship between substrate concentration (nutrition) and growth rate is shown in figure

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.

- When temperature is increases continuously from its minimum, growth rate of bacteria increases because the rate of metabolic reaction increases with increase in temperature.
- At certain temperature the growth rate become maximum, this temperature is known as optimal temperature.
- On further increasing the temperature above optimal, growth rate decreases abruptly and completely ceases with reaching maximum temperature.

pH:

- pH affects the ionic properties of bacterial cell so it affects the growth of bacteria.
- Most of the bacteria grow at neutral pH (6.5-7.5). However there are certain bacteria that grow best at acidic or basic pH.
- relationship between pH and bacterial growth is given in figure below.

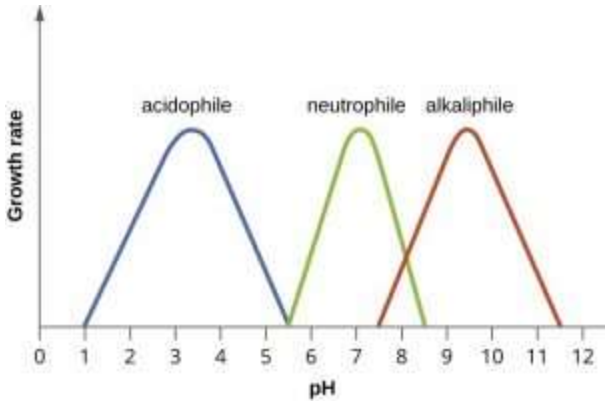


figure: pH vs growth rate

Ions and salt:

- All bacteria requires metal ions such as K+, Ca ++, Mg++, Fe++, Zn++, Cu++,Mn++ etc to synthesize enzymes and proteins.
- Most bacteria do not require NaCl in media however they can tolerate very low concentration of salt.
- There is some halophilic bacteria such as *Archeobacteria* that require high concentration of salt in media.

Gaseous requirement:

- Oxygen and carbon-dioxide are important gases that affects the growth of bacteria.
- Oxygen is required for aerobic respiration and obligate aerobic bacteria must require O2 for growth. Eg. *Mycobacterium, Bacillus.*
- For obligate anaerobes Oxygen is harmful or sometime lethal. However facultative anaerobes can tolerate low concentration of O2.
- Carbon-dioxide is needed for capnophilic bacteria. Such as *Campylobacter, Helicobacter pylori*

6. Available water:

- Water is the most essential factor for bacterial growth.
- Available water in the culture media determines the rate of metabolic and physiological activities of bacteria.
- Sugar, salts and other substances are dissolved in water and are made available for bacteria.