

Growth of Bacterial Cells



Growth cycle

- Bacteria reproduce by binary fission i.e. one parent cell divides into two progeny cells. It is called exponential growth or logarithmic growth
- 1, 2, 4, 8, 16, 32
- 2^0 , 2^1 , 2^2 , 2^3 , 2^4 , 2^5
- The production of bacteria keeps on increasing after every generation e.g. one bacteria will give rise to 16 bacteria after 4th generation.

- This generation is also called doubling time of bacteria. The doubling time varies as long as 20 min for E. coli to more than 24 hours for mycobacterium tuberculosis.
- The doubling time and exponential growth results in very rapid production of large number of bacteria e.g. one E.coli organism will produce over 1000 progeny in about 3 hours and 1 million in 7 hours.

- The doubling time depends on amount of nutrients available , temperatures, pH and other environmental factors.

Phases of Bacterial Growth

- Four phases of bacteria growth in Liquid medium
- **Lag Phase:**
 - Vigorous metabolic activity occurs but no cell division. It can last for few minutes to many hours.
- **Log Phase:**
 - Rapid division occurs. B-lactum drugs like penicillin act on cells at this stage since it is the time when cells make their peptidoglycan for the cell wall.

- **Stationary Phase:**

- Occurs when nutrients depletion and toxic products accumulation slows down the growth process. There is a balance between the new cell production and old one's death. This stage can be extended if additional nutrients are supplied and toxic waste products are removed, then the cells do not enter the stationary phase.

- **Death Phase:**

- Marked by decreasing in the number of live bacteria.

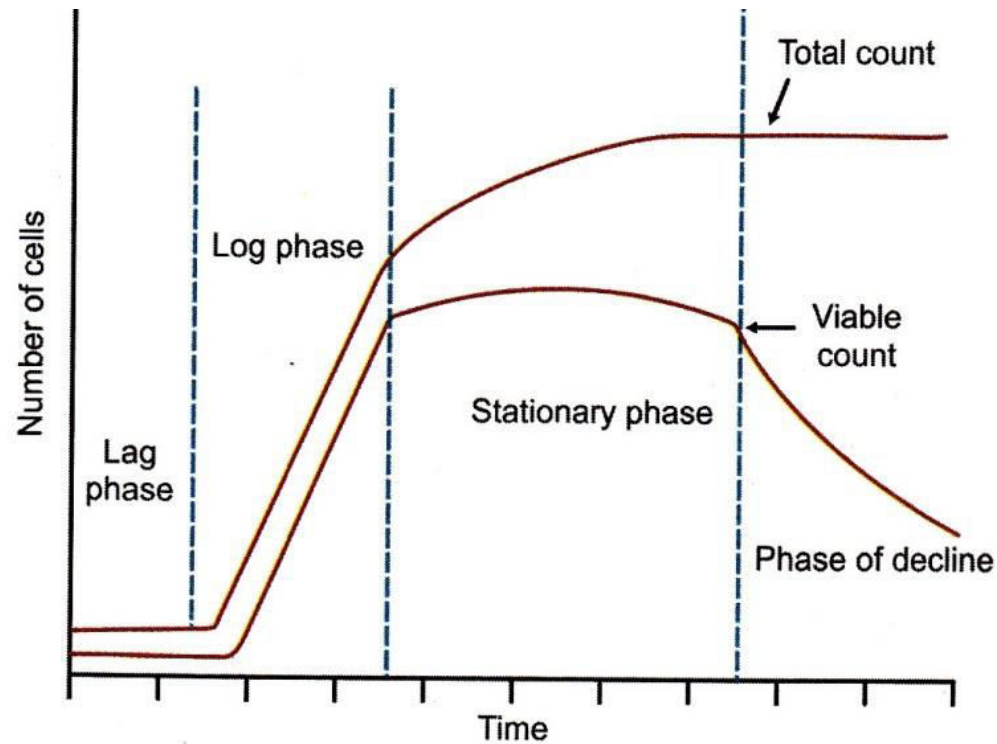


Fig. 4.2: Bacterial growth curve. The viable count shows lag, log, stationary and decline phases. In the total count, the phase of decline is not evident

Aerobic and Anaerobic growth

- Most of the organisms grow better in the presence of oxygen. O_2 acts as hydrogen acceptor in the final energy production which is catalyzed by the flavoproteins and cytochromes.
- O_2 generates two toxic molecules H_2O_2 and a free superoxide radical O_2^- .
- Bacteria require two enzymes to utilize O_2 i.e. superoxide dismutase and catalase.

- $2\text{O}_2 + 2\text{H}^+ \rightarrow \text{H}_2\text{O} + \text{O}_2$
- $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$

- **Aerobic**

- Some bacteria such as mycobacterium tuberculosis are obligate aerobe i.e. they require oxygen to grow since their ATP generation system is dependent on oxygen as hydrogen acceptor.

- **Facultative Anaerobe**

- Other bacteria such as E. coli are facultative anaerobe i.e. they utilize oxygen if present to generate energy by respiration but they can use the fermentation path way to syntheses ATP in the absence of oxygen.

- **Obligate Anaerobes**

- Obligate anaerobes (clostridium tetani) cannot grow in the presence of oxygen because they lack either superoxide dismutase or catalase enzymes or both.
- Vary in their response to oxygen exposure, some can survive but cannot grow while others are killed rapidly.

Sugar Fermentation

- Identification of organisms is done by fermentation of sugars in the clinical lab.
- *Neisseria gonorrhoeae* (glucose) and *N. meningitidis* (maltose) can be distinguished on the basis of sugar fermentation. *E. coli* (Lactose), *salmonella* and *shigella* can be differentiated on the basis of fermentation of lactose.
- Fermentation means break down of sugar to pyruvic acid and finally to lactic acid.

- Sugars are mono or disacchirde. Lactose is disacchride composed of glucose and galactose.
- Its is first cleaved by B-galactosidase in E coli before fermentation.
- Fermentation is also called glycolytic cycle and it is the process by which facultative bacteria generates ATP in the absence of oxygen.

- In the presence of O_2 pyrovates produced during fermentation enters the Kerbs cycle and is metabolized to CO_2 and H_2O . Kerbs cycle generates much more ATP than glycolytic cycle, so facultative bacteria grow faster in the presence of oxygen.

- Facultative and anaerobes ferment, but aerobes do not. Aerobes such as pseudomonas produce metabolites which enter the Kerbs cycle by process of deamination of amino acids.
- In clinical laboratory the production of pyrovic and lactic acid turn the medium acid and change the color of pH in the presence of phenol red indicator.
- If the sugar is fermented the color becomes yellow and if not fermented the color remains red.

Iron metabolism

- Ferric iron is required in bacterial cell growth.
- It is an essential part of cytochromes and other enzymes.
- Available amount of iron in the body is very low and mostly stored in the form of transferrin.
- Bacteria produce iron binding compounds called siderophores which have very high affinity for iron binding.