Dr. zaman salman
Zaman.Salman.Hamza@mustaqbal-college.edu.iq

Lec:2 Bacterial Classification and Growth

•The classification of bacteria is based on various criteria, such as the nature of the cell wall, staining characteristics, ability to grow in the presence or absence of oxygen, and ability to form spores.

• The criterion currently used is the base sequence of the genome DNA. Several bacteria have been reclassified on the basis of this information.

• Bacteria reproduce by binary fission, whereas eukaryotic cells reproduce by mitosis.

• Some bacteria can grow in the presence of oxygen (aerobes and facultatives), but others die in the presence of oxygen (anaerobes). The use of oxygen by bacteria generates toxic products such as superoxide and hydrogen peroxide. Aerobes and facultatives have enzymes, such as superoxide dismutase and catalase, that detoxify these products, but anaerobes do not and are killed in the presence of oxygen.

• The fermentation of certain sugars is the basis of the laboratory identification of some important pathogens. Fermentation of sugars, such as glucose, results in the production of ATP and pyruvic acid or lactic acid. These acids lower the pH, and this can be detected by the change in color of indicator dyes.

Growth Cycle

Bacteria reproduce by binary fission, a process by which one parent cell divides to form two progeny cells. Because one cell gives rise to two progeny cells, bacteria are said to undergo exponential growth (logarithmic growth). The concept of exponential growth can be illustrated by the following relationship:

Number of cells	1	2	4	8	16
Exponential	2^0	2^1	2^2	2^3	2^4

Thus, 1 bacterium will produce 16 bacteria after 4 generations. The doubling (generation) time of bacteria ranges from as little as 20 minutes for Escherichia coli to as long as 18 hours for Mycobacterium tuberculosis. The exponential growth and the short doubling time of some organisms result in rapid production of very large numbers of bacteria.

For example, 1 E. coli organism will produce over 1000 progeny in about 3 hours and over 1 million in about 7 hours. The doubling time varies not only with the species, but also with the amount of nutrients, the temperature, the pH, and other environmental factors.

The growth cycle of bacteria has four major phases. If a small number of bacteria are inoculated into a liquid nutrient medium and the bacteria are counted at frequent intervals, the typical phases of a standard growth curve can be demonstrated (Figure 3–1).

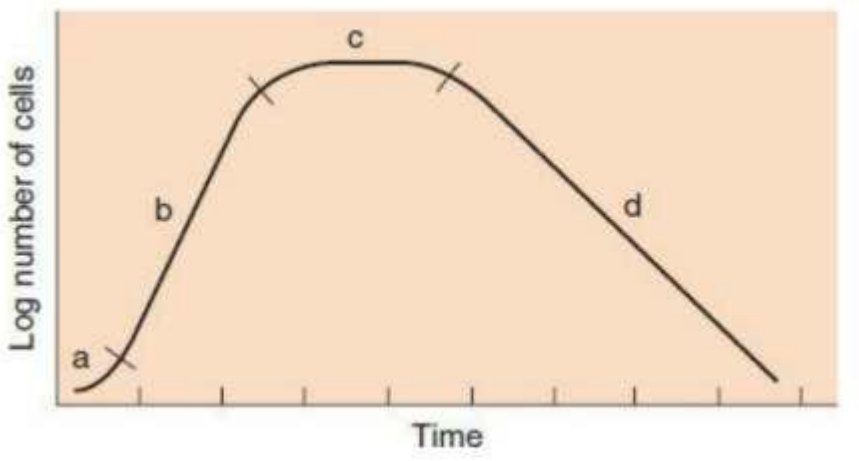

Figure 3–1 Growth curve of bacteria: a, lag phase; b, log phase; c, stationary phase; d, death phase.

(1) The first is the lag phase, during which vigorous metabolic activity occurs but cells do not divide. This can last for a few minutes up to many hours.

(2) The log (logarithmic) phase is when rapid cell division occurs. β-Lactam drugs, such as penicillin, act during this phase because the drugs are effective when cells are making peptidoglycan (i.e., when they are dividing). The log phase is also known as the exponential phase.

(3) The stationary phase occurs when nutrient depletion or toxic products cause growth to slow until the number of new cells produced balances the number of cells that die, resulting in asteady state. Cells grown in a special apparatus called a "chemostat," into which fresh nutrients are added and from which waste products are removed continuously, can remain in the log phase and do not enter the stationary phase.

(4) The final phase is the death phase, which is marked by adecline in the number of viable bacteria.

Aerobic & Anaerobic Growth

For most organisms, an adequate supply of oxygen enhances metabolism and growth. The oxygen acts as the hydrogen acceptor in the final steps of energy production catalyzed by the flavoproteins and cytochromes. Because the use of oxygen generates two toxic molecules, hydrogen peroxide (H_2O_2) and the free radical superoxide (O_2), bacteria require two enzymes to utilize oxygen. The first is superoxide dismutase, which catalyzes the reaction

$$2O_2 + 2H^+ \rightarrow H_2O_2 + O_2$$

and the second is catalase, which catalyzes the reaction

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The response to oxygen is an important criterion for classifying bacteria and has great practical significance because specimens from patients must be incubated in a proper atmosphere for the bacteria to grow.

(1) Some bacteria, such as M. tuberculosis, are obligate aerobes; that is, they require oxygen to grow because their ATPgenerating system is dependent on oxygen as the hydrogen acceptor.

(2) Other bacteria, such as E. coli, are facultative anaerobes; they utilize oxygen, if it is present, to generate energy by respiration, but they can use the fermentation pathway to synthesize ATP in the absence of sufficient oxygen.

(3) The third group of bacteria consists of the obligate anaerobes, such as Clostridium tetani, which cannot grow in the presence of oxygen because they lack either superoxide dismutase or catalase, or both. Obligate anaerobes vary in their response to oxygen exposure; some can survive but are not able to grow, whereas others are killed rapidly.