Kurdistan Region -Iraq
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Fish Department
2nd Stage

Bacterial Growth

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2022-2023

General Microbiology

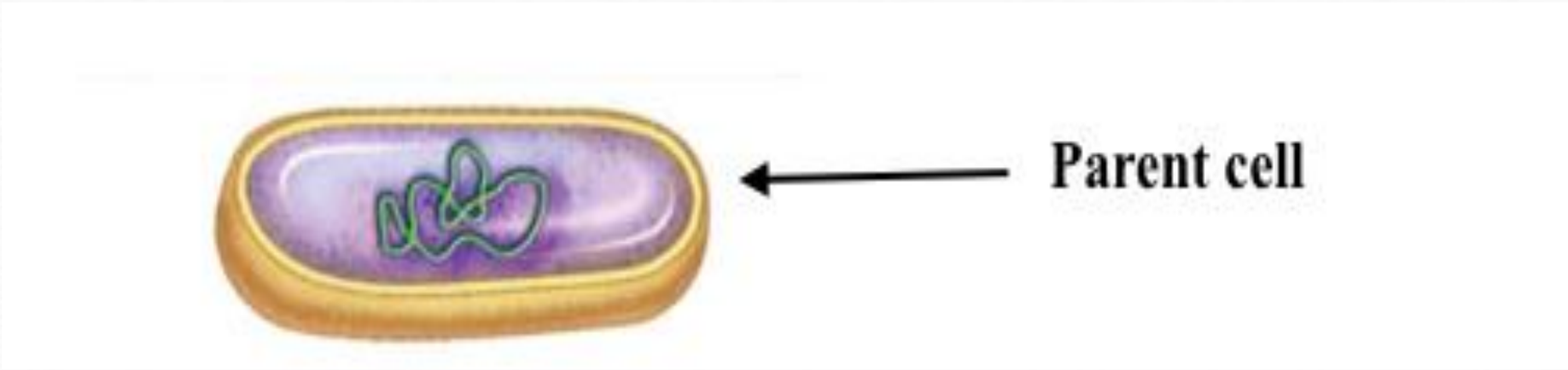
Bacteria Growth

- Bacterial growth is an increase in size, and number of cells.
- Growth leads to a rise in cell number when bacteria reproduce by **binary fission.**
- In binary fission bacterial cells enlarge and divide to yield two progeny of equal size.
- To study bacterial growth, change in the total population number will followed.

Binary fission

- A sexual reproduction in bacteria (cell division), in which a bacterial cell separates into two cells.
- Parental cell enlarges and duplicates its DNA
- Septum formation divides the cell into two separate chambers
- Complete division results in two identical cells

Binary fission

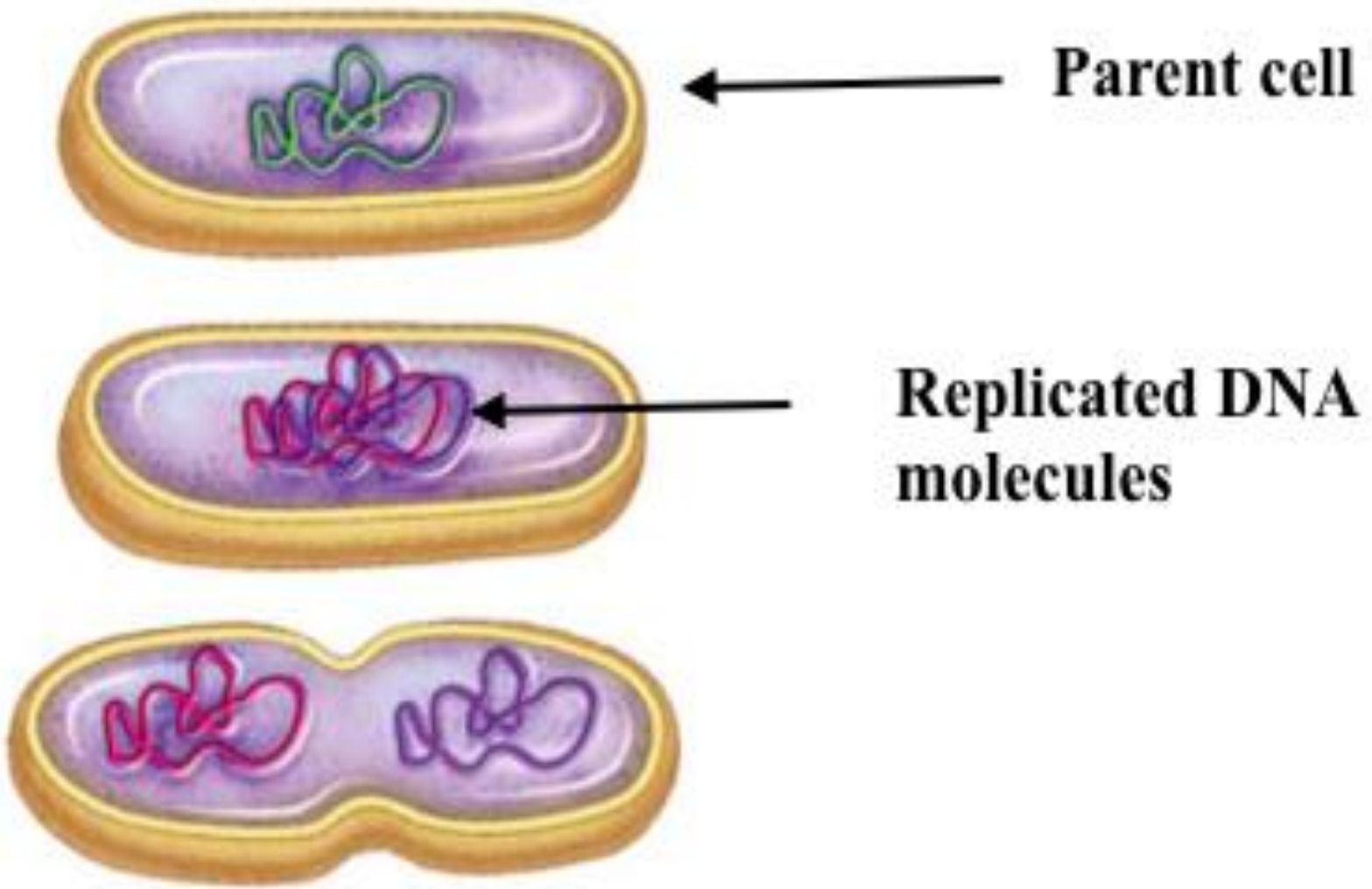


Binary fission

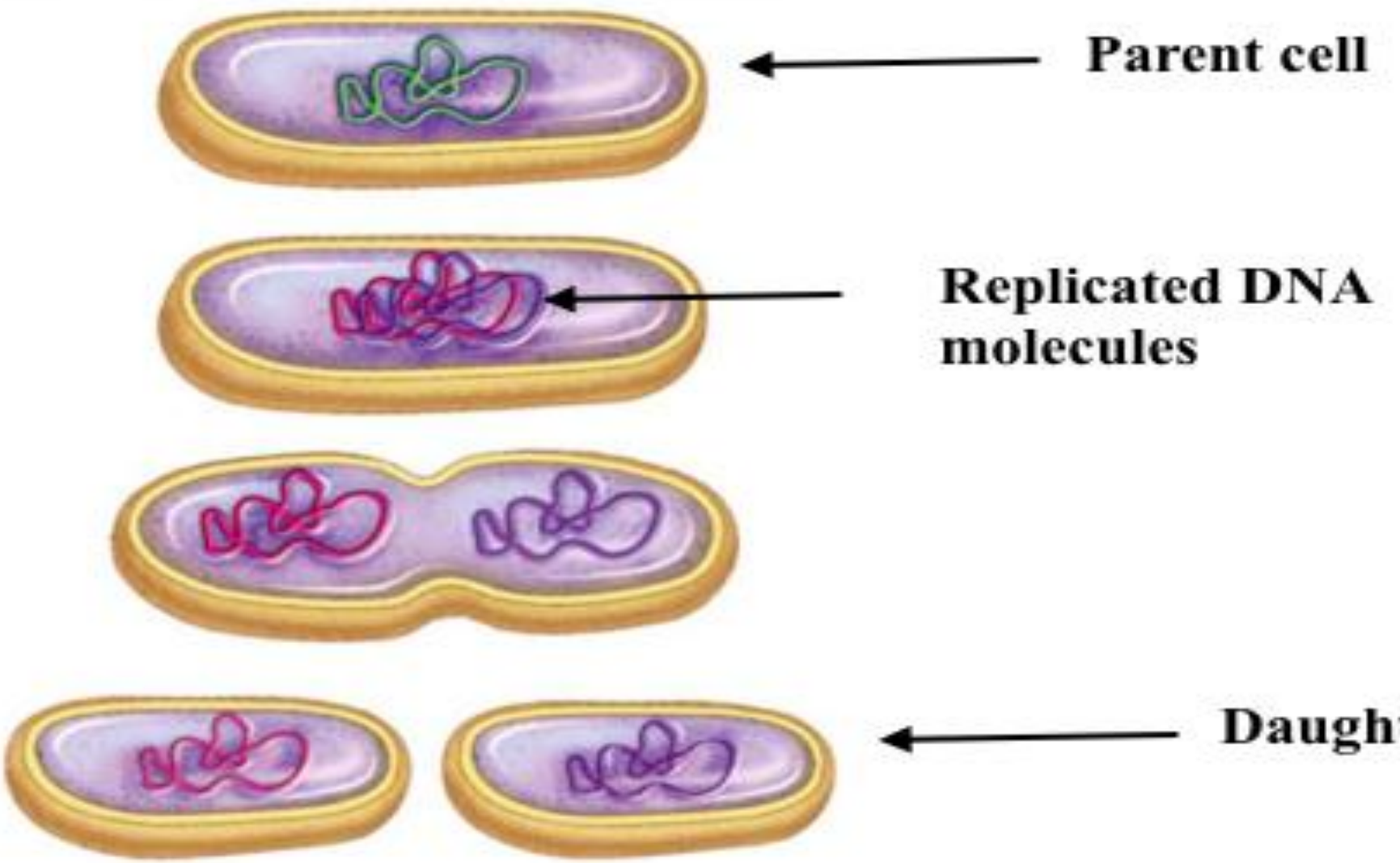
Parent cell

Replicated DNA molecules

Binary fission



Binary fission



The Growth cycle

Population growth in bacteria is studied by analyzing the growth curve of a microbial culture. When bacteria are cultivated in liquid medium, they usually are grown in a closed system (they are incubated in a closed culture vessel with a single batch of medium).

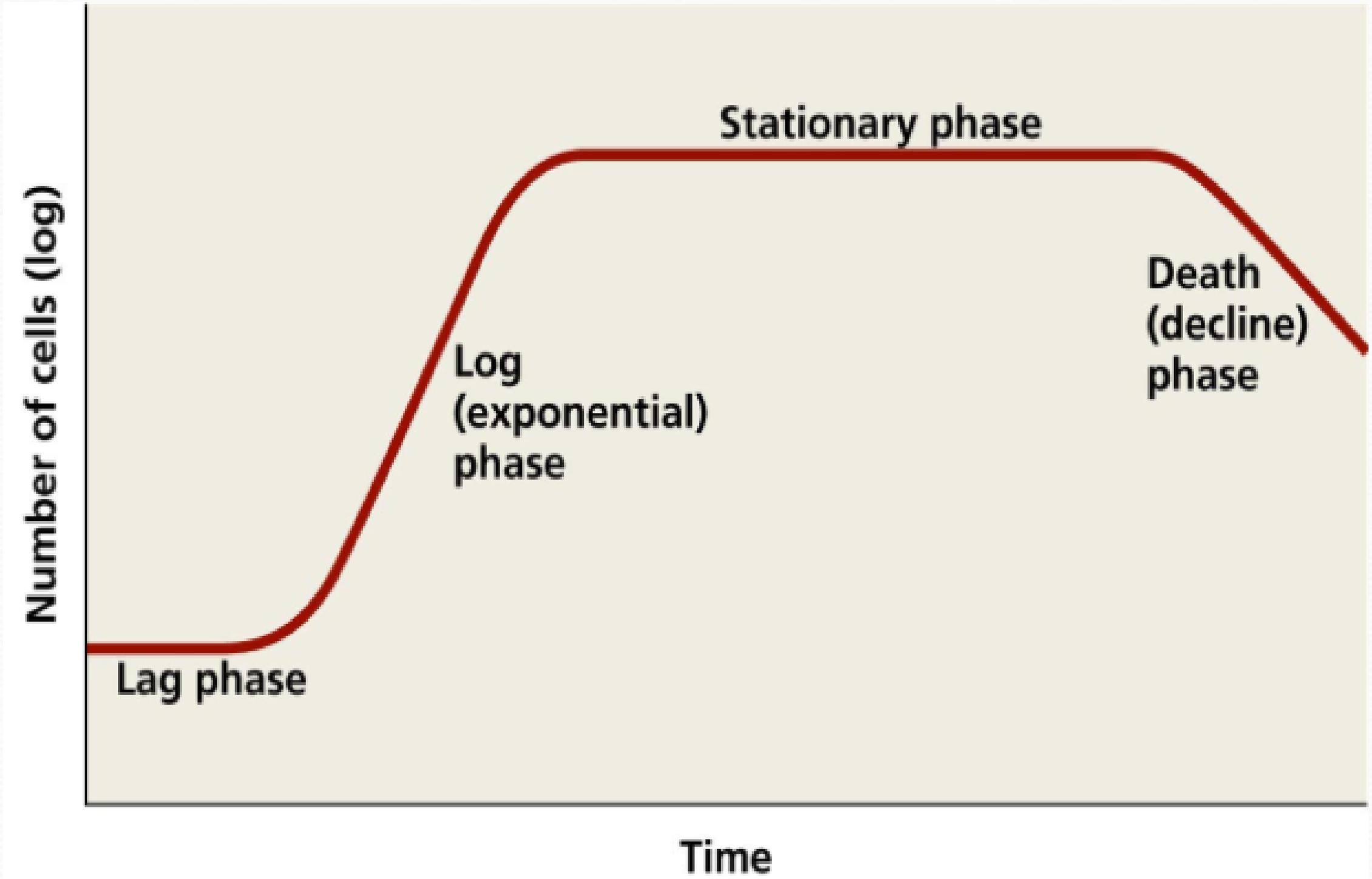
The Growth Curve

Because no fresh medium is provided during incubation, nutrient concentrations decline and concentration of waste increase. This will terminate of bacterial growth. The growth of bacterial population by binary fission can be plotted as the logarithmic of cell number versus the incubation time.

Bacterial Growth phases

- The growth cycle indicates multiplication and death of bacteria, it passes through four growth phases
- Lag phase, Log phase, Stationary phase and Death phase
- Growth curve drawn by plotting the logarithm of the cell number against time.

Growth curve has four major phases



Lag phase

Lag phase is the period when the bacteria are adjusting to the environment. The lag phase varies in length with the condition of the bacteria and the nature of the medium. This phase may be quite long if the inoculum is from an old culture or one that has been refrigerated. The new medium may be different from the one the bacteria was growing in previously. Thus cells need new enzymes to use different nutrients.

Whatever the causes and conditions of the new medium, eventually the cells retool, replicate their DNA, begin to increase in mass, and finally divide. On the other hand, when a young, vigorously growing exponential phase culture is transferred to fresh medium of the same composition, the Lag phase will be short or absent.

Lag phase

Whatever the causes and conditions of the new medium, eventually the cells retool, replicate their DNA, begin to increase in mass, and finally divide. On the other hand, when a young, vigorously growing exponential phase culture is transferred to fresh medium of the same composition, the Lag phase will be short or absent.

Main characteristics of the Lag phase

- When bacteria introduced into culture medium, cell division does not immediately take place.
- Increase in cell size and vigorous metabolic activity occurs.
- Enzymes and intermediates are formed
- Adaptation to the new environment occurred.
- Prolonged by low inoculum size and age as well as poor inoculum condition.

Log Phase (Exponential phase)

During the Log phase bacteria are growing and dividing at the maximal rate possible. This depend on cells genetic potential, the nature of the medium and the condition under which they are grown. The cell population is most uniform in terms of chemical and physiological properties during this phase. Therefore log phase culture cells are usually used in biochemical and physiological studies.

Log Phase (Exponential phase)

- The cells multiply at the maximum rate
- The population increases exponentially with respect to time (linear relationship)
- This continues until nutrients in the medium become exhausted, or toxic metabolic products accumulated.
- The cell population will double in number during a specific length of time called **“generation time”**

Generation Time

- The original cell divides to form two new cells, then four, 8, 16....
- Cells grow exponentially, thus one bacterium will produce 16 after 4 generations
- Cell number 1 2 4 8 16 ...
- Exponential 2^0 2^1 2^2 2^3 2^4...

Generation Time

- Generation time is the average time required for the population to double, for most bacteria it ranges from 20mins to few hours.
- In *E. coli* the generation time is about 20mins and in *Mycobacterium tuberculosis* is about 12hrs in a good environmental conditions.
- The generation time varies not only with species but also with environmental factors.
- The exponential growth and short doubling time for some bacteria results in rapid production of very large numbers of bacteria.

Stationary phase

- Eventually population growth cease and the growth curve becomes horizontal.
- Death of bacteria starts due to high cell density, nutrient depletion and accumulation of toxic products
- The number of cells remains stationary due to balance between multiplication and death rate.

Stationary phase

For example, streptococci can produce so much lactic acid and other organic acids from sugar fermentation. This makes the medium becomes acidic and low pH and growth is inhibited. Thus entrance into the stationary phase may result from several factors operating in the surrounding medium.

Death phase

- After extended stationary, nutrient concentration so low and toxins so high that cells can't survive
- Cells progressively start to death and number of viable cells decline
- Cell death is due to lose their ability to divide

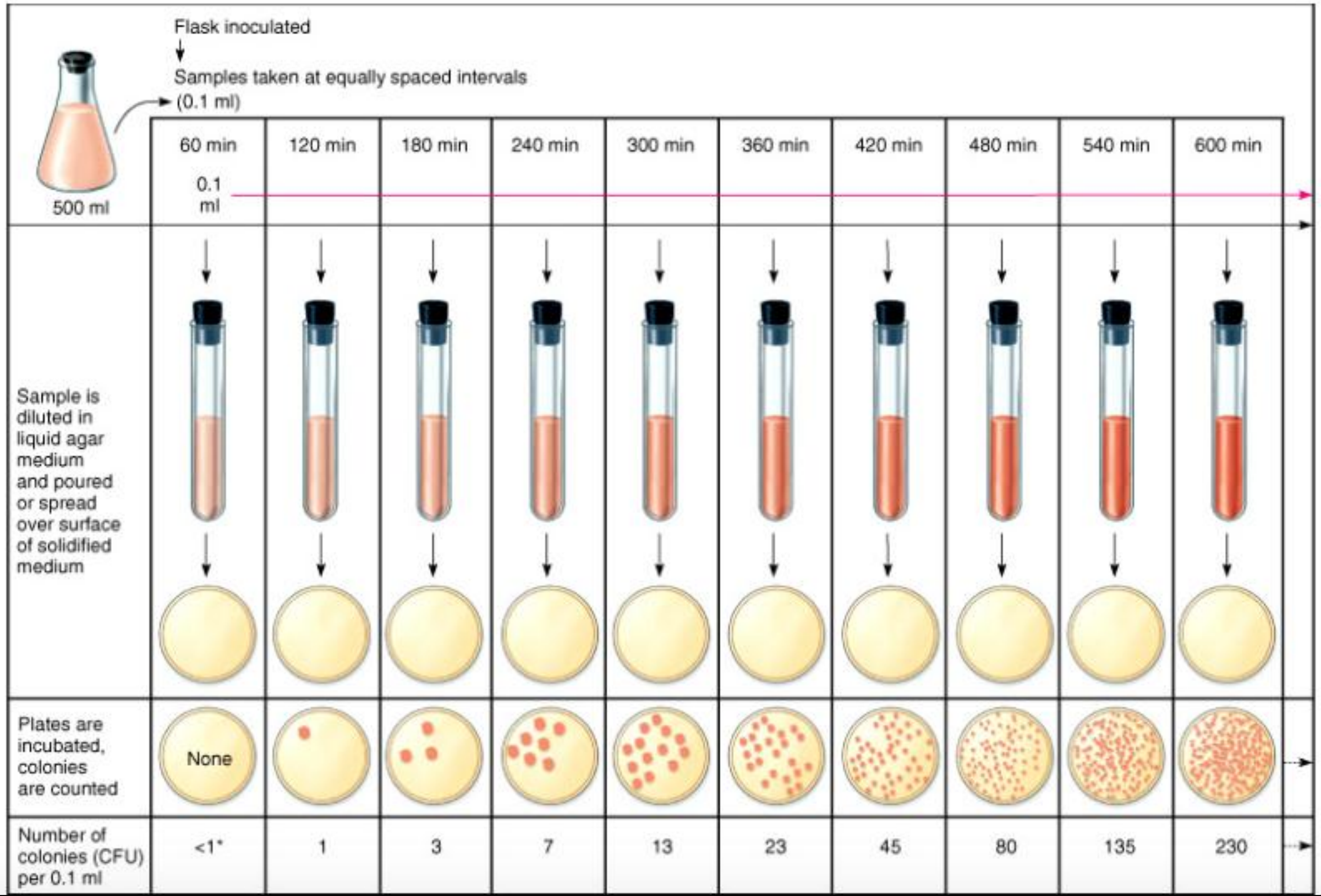
Environmental Factors Required for Bacterial Growth

- Nutrients (macromolecules): Hydrogen, Carbon & Nitrogen sources
- Growth factors: amino acids, purines, pyrimidines & vitamins
- Trace elements (micro-molecules): Mg, Fe & Mn.
- Oxygen: for most organisms, an adequate supply of Oxygen enhances metabolism and growth
- pH: Most bacteria grow best in pH 7.2-7.4.
- Temperature: Optimum temperature for growth of common pathogenic bacteria is 37°C.

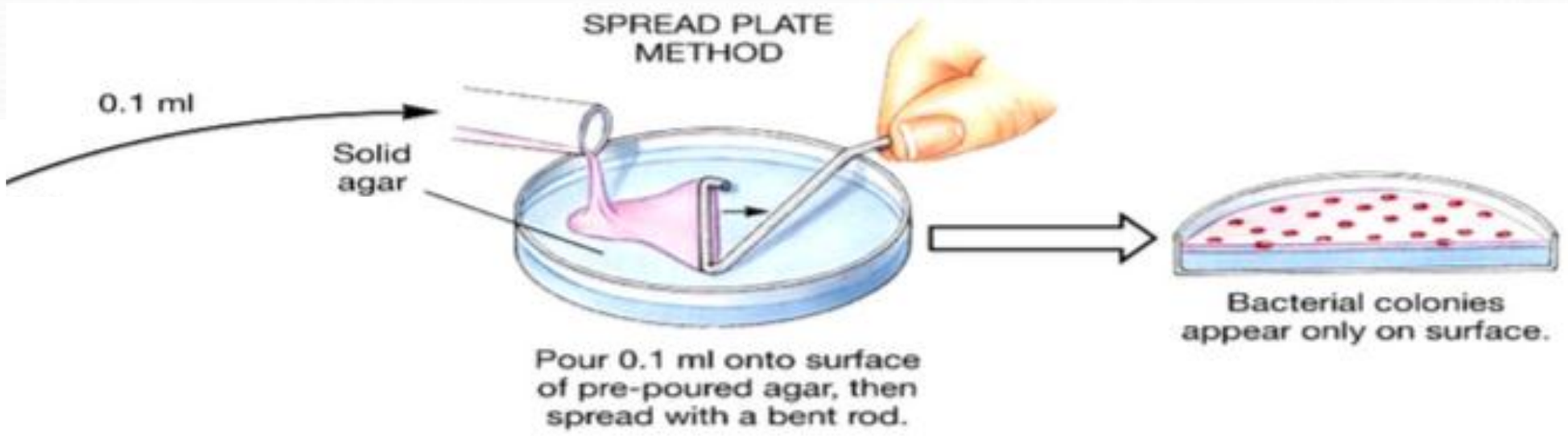
Measurement of bacterial growth

- Direct cell count under microscope.
- Colony forming units (CFU)
- Turbidity

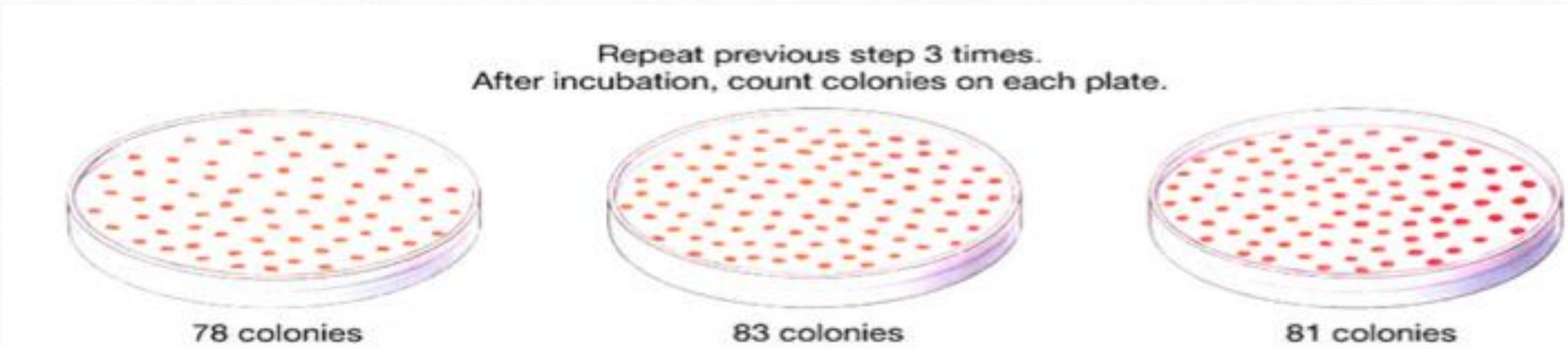
Colony forming unit (CFU)



Colony forming unit (CFU)



1: 10,000 dilution bacterial culture in broth



Summary

- Growth is an increase in cellular constituents, size and number of cells
- When bacteria grow in a culture media, they undergo through four growth phases: Lag, Log, Stationary and Death phases.
- Nutrients, pH, temp & O_2 are among most important environmental factors for bacterial growth