

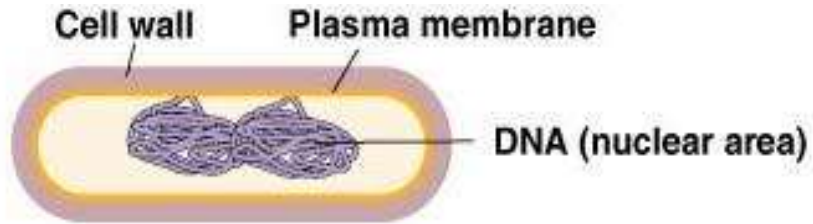
DIFFERENT PHASES OF GROWTH- GROWTH CURVE

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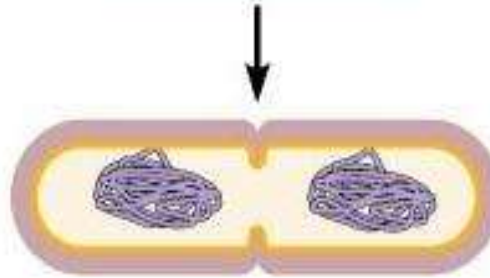
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- ▶ Growth is defined as an increase in cellular constituents which leads to a rise in cell number.
 - ▶ Microorganisms reproduce by binary fission or budding. The cells copy their DNA almost continuously and divide again and again by the process called binary fission.
 - ▶ Binary fission is a form of asexual reproduction in single-celled organisms by which one cell divides into two cells of the same size.



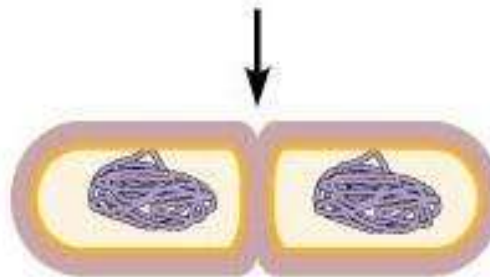
1 Cell elongates and DNA is replicated



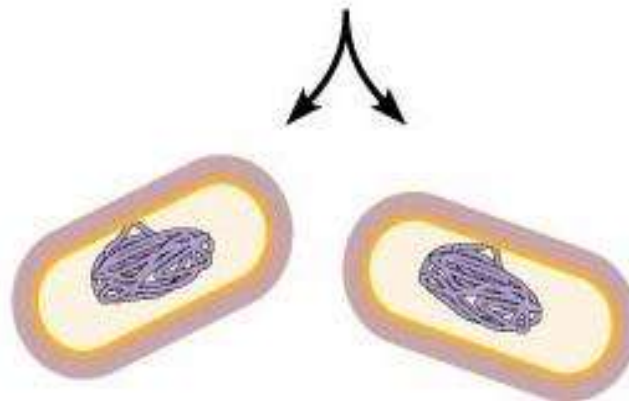
2 Cell wall and plasma membrane begin to divide



3 Cross-wall forms completely around divided DNA



4 Cells separate



-asexual reproduction
- increase population size
-DOES NOT increase genetic diversity



Growth Curve:

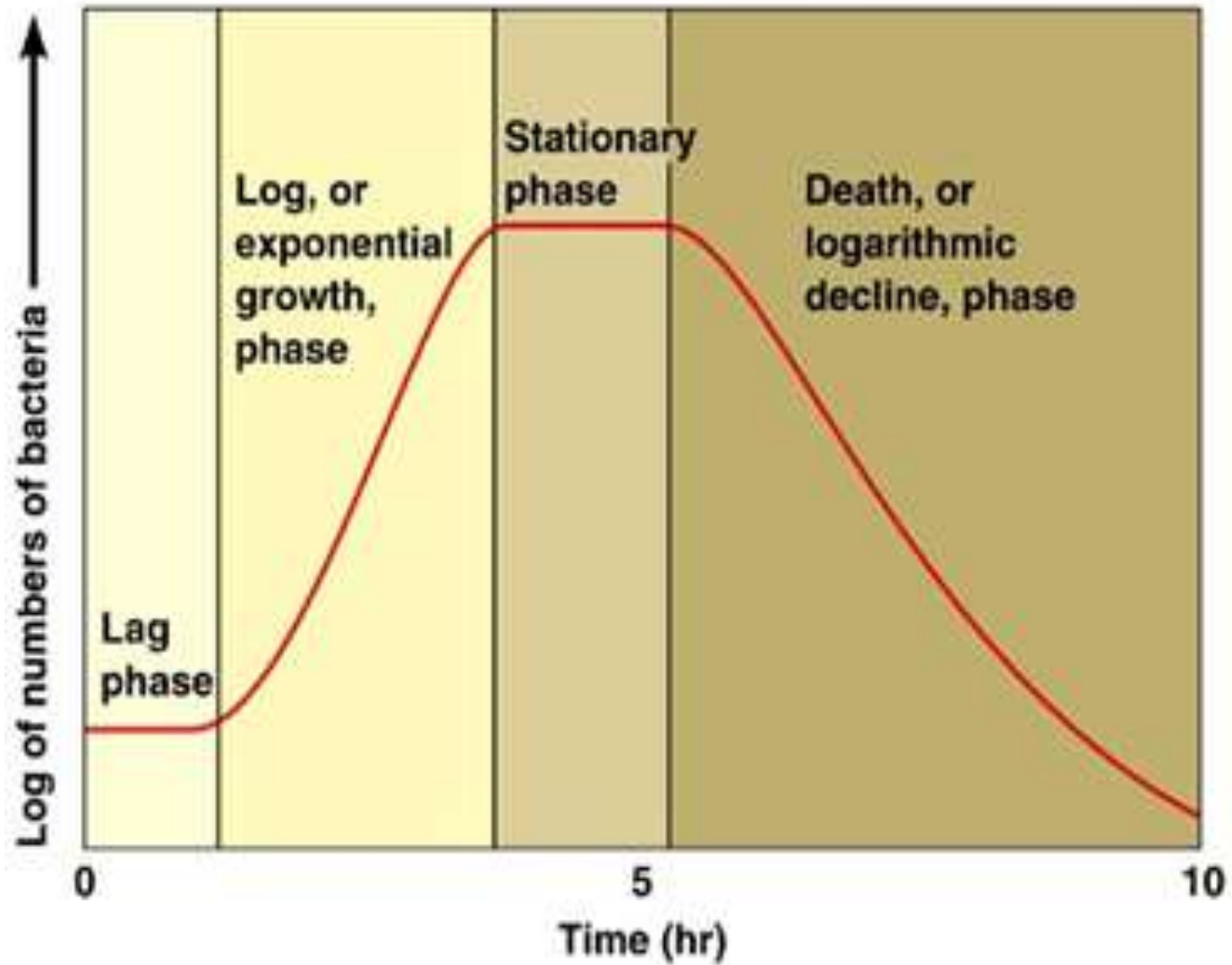
- ▶ The increase in cell number or growth in population is studied by analyzing the growth curve of a microbial culture.
- ▶ Bacteria can be grown or cultivated in a liquid medium in a closed system or also called as batch culture.
- ▶ In this method, no fresh medium is added and hence with time, nutrient concentration decreases and an increase in wastes is seen.
- ▶ As bacteria reproduce by binary fission, the growth can be plotted as the logarithm of the number of viable cells verses the time of incubation.



There are four basic phases of growth:

- ▶ Lag phase
- ▶ Log phase
- ▶ Stationary phase
- ▶ Death phase.





Lag Phase:

- ▶ As the cells are introduced into the new medium, no immediate increase in cell number occurs.
- ▶ During this phase, the cells are undergoing a period of intense metabolic activity involving synthesis of enzymes and various other molecules required to divide in the coming phase.
- ▶ This phase can vary considerably in length depending on the nature of the medium and the microorganism. The medium may be different from the one in which the microorganism was growing previously.

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- ▶ The cells may be old and depleted of ATP, and essential cofactors and ribosomes must be synthesized before growth can begin.
 - ▶ So, the microorganism requires time to recover and young, vigorously growing cultures and fresh medium are to be used for the lag phase to be short.



Log Phase:

- ▶ In this phase the cell starts dividing in a logarithmic way and this is also called as exponential phase and the growth is balanced.
 - ▶ Cellular reproduction is high during this period and the plot during this phase is a straight line.
 - ▶ The cells are most active metabolically and the population is most uniform during this phase during this phase; hence exponential phase cultures are usually used in biochemical and physiological studies.
 - ▶ The cells are growing and dividing and increasing in cell number.
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- ▶ But during this phase, the microorganisms may be particularly sensitive to adverse conditions.

- ▶ The rate of exponential growth of a bacterial culture is expressed as **generation time (doubling time)** of the bacterial population.
- ▶ Generation time (G) is defined as the time (t) per generation/ n (n = number of generations). Hence, $G=t/n$ is the equation from which calculations of generation time can be derived.
- ▶ Exponential phase or log phase is balanced growth. That is, all cellular constituents are manufactured at constant rates relative to each other. If nutrient levels or other environmental conditions change, unbalanced growth results.
- ▶ Organisms in a tube of culture medium can maintain logarithmic growth for only a limited time. As the number of organisms increases, nutrients are used up, metabolic wastes accumulate, living space may become limiting factor and aerobes suffer from oxygen depletion.



Stationary Phase:

Exponential growth cannot be continued forever in a **batch culture** (e.g. a closed system such as a test tube or flask).

Population growth is limited by one of three factors:

1. exhaustion of available nutrients;
2. accumulation of inhibitory metabolites or end products;
3. exhaustion of space, in this case called a lack of "biological space".

Bacteria that produce **secondary metabolites**, such as antibiotics, do so during the stationary phase of the growth cycle and also the spore-forming bacteria have to induce the activity of dozens of genes that may be involved in sporulation process.

Starving bacteria frequently produce a variety of starvation proteins, which make the cell much more resistant to damage.



Death Phase:

- ▶ In death phase, there is a decline in the number of viable cells.
- ▶ This phase also is like the log phase but the cell number is declining in a logarithmic way.
- ▶ The cell is said to be dead if it does not revive itself and reproduce when incubated again in a fresh medium.
- ▶ In this phase, the number of live cells decreases at a logarithmic rate, as indicated by the straight downward sloping diagonal line.
- ▶ The duration of this phase is as highly variable as the duration of log phase. Both depend primarily on the genetic characteristics of the organism.

Measurement of Microbial Growth:

Direct measurement of cell numbers	Indirect methods of measurement of cell mass
<ul style="list-style-type: none">Serial dilution and pour and spread plate	<ul style="list-style-type: none">Turbidity
<ul style="list-style-type: none">Membrane Filtration	<ul style="list-style-type: none">Dry weight
<ul style="list-style-type: none">Microscopic count	



Thank You

