RAMA UNIVERSITY

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FACULTY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF BIOTECHNOLOGY

Microbial Growth Kinetics

- Increase in cell number or cell mass of population
- Growth rate: change in cell number or mass/time
- Generation: the interval of two cells from one
- Generation time (doubling time)

  -time for cell mass or # to double
  -Varies greatly

  i. Type of organism
  ii. Temperature
  iii. Nutrients
  iv. Other conditions

  Norm= 1-3 hours

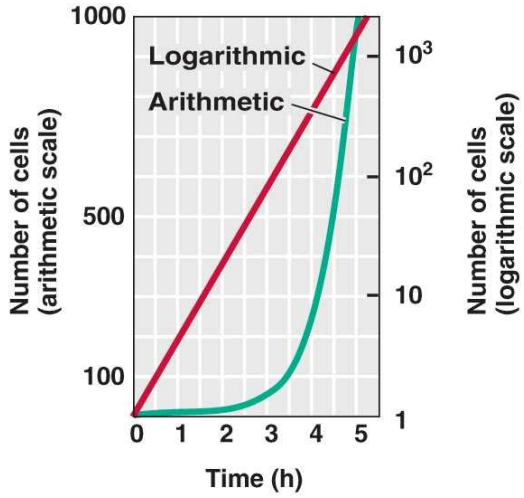
- Exponential growth (Log phase growth)
  -When population doubles/ unit of time

Bacteria grow exponentially

•Most bacteria divide in a short amount of time and produce a large amount of bacteria – easier to represent these large numbers by logarithmic scales

Time (h)	Total number of cells	Time (h)	Total number of cells
0	1	4	256 (2^8)
0.5	2	4.5	512 (2^9)
1	4	5	1,024 (2^{10})
1.5	8	5.5	2,048 (2^{11})
2	16	6	4,096 (2^{12})
2.5	32	.	.
3	64	.	.
3.5	128	10	1,048,576 (2^{19})

(a)



(b)

•Generation time = the time it takes a microbial population to double in number

G = t/n

t = time of exponential growth

n = # of generations between original and final

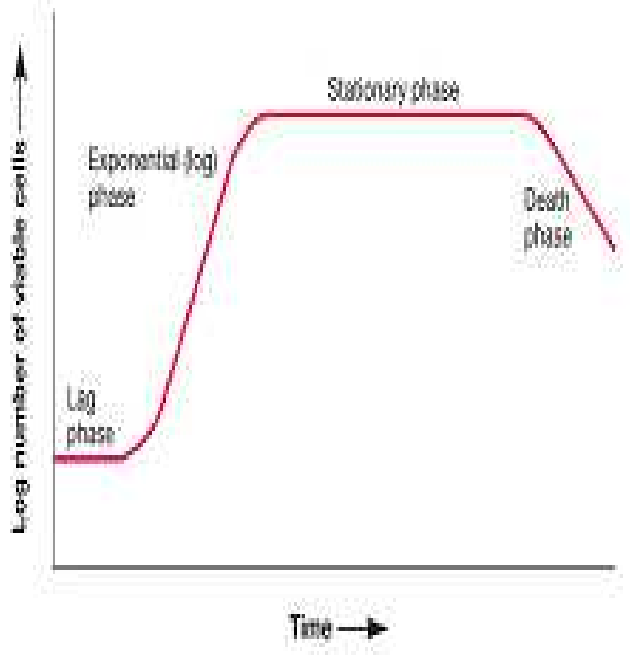
The Growth cycle or phases of microbial growth

•observed when microorganisms are cultivated in batch culture

-culture incubated in a closed vessel with a single batch of medium

•usually plotted as logarithm of cell number versus time

•usually has four distinct phases



Lag phase:

▪The cells are adjusting to their new environment

▪Most cells do not reproduce immediately, but instead actively synthesize enzymes to utilize novel nutrients in the medium.

▪Bacteria inoculated from a medium containing glucose as a carbon source into a medium containing lactose must synthesize two types of proteins:

- membrane proteins to transport lactose into the cell

-the enzyme lactase to catabolize the lactose.

Log phase:

•bacteria synthesize the necessary chemicals for conducting metabolism in their new environment, and they then enter a phase of rapid chromosome replication, growth, and reproduction.

•population increases logarithmically

•reproductive rate reaches a constant as DNA protein syntheses are maximized.

•more susceptible to antimicrobial drugs that interfere with metabolism

- Preferred for Gram staining because most cells' walls are intact – an important characteristic for correct staining.

- The metabolic rate of individual cells is at a maximum during log phase

- This phase is sometimes preferred for industrial and laboratory purposes.

Stationary phase

- If bacterial growth continued at the exponential rate of the log phase, bacteria would soon overwhelm the earth.

- Does not occur because as nutrients are depleted and wastes accumulate, the rate of reproduction decreases.

- The number of dying cells equals the number of cells being produced, and the size of the population becomes stationary

- During this phase the metabolic rate of surviving cells declines.

- The onset of the stationary phase can be postponed indefinitely by a special apparatus called a *chemostat,* which continually removes wastes (along with old medium and some cells) and adds fresh medium.

- Chemostats are used in industrial fermentation processes.

•Total number of viable cells remains constant

-may occur because metabolically active cells stop reproducing

-may occur because reproductive rate is balanced by death rate

Possible reasons for entry into stationary phase

•nutrient limitation

•limited oxygen availability

•toxic waste accumulation

•critical population density reached

Starvation responses

•morphological changes

e.g., endospore formation

•decrease in size, protoplast shrinkage, and nucleoid condensation

•production of starvation proteins

•long-term survival

•increased virulence

Death Phase

- If nutrients are not added and wastes are not removed, a population reaches a point at which cells die at a faster rate than they are produced.

- Such a culture has entered the death phase (or *decline phase).*

- during the death phase, some cells remain alive and continue metabolizing and reproducing, but the number of dying cells exceeds the number of new cells produced, so that eventually the population decreases to a fraction of its previous abundance.

- In some cases, all the cells die, while in others a few survivors may remain indefinitely. The latter case is especially true for cultures of bacteria that can develop resting structures called *endospore*

- two alternative hypotheses
  - -Cells are Viable But Not Culturable (VBNC)
  - -Cells alive, but dormant
- programmed cell death
  - -Fraction of the population genetically programmed to die (commit suicide)