Microbial growth: chapter 6

Population growth

- 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
      - Type of organism
      - Temperature
      - Nutrients
      - Other conditions
    - Norm= 1-3 hours
- Exponential growth (Log phase growth)
  - When population doubles/ unit of time

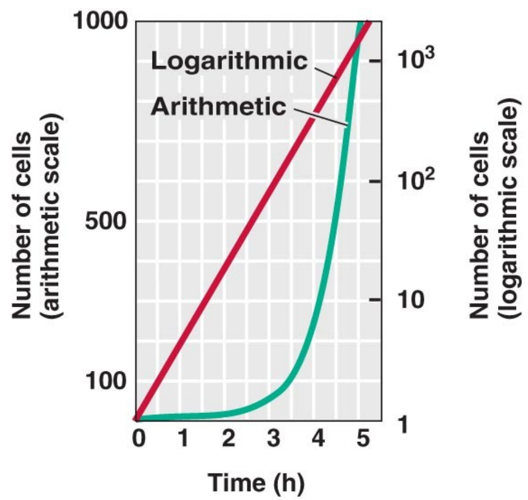
Bacteria grow exponentially

- 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

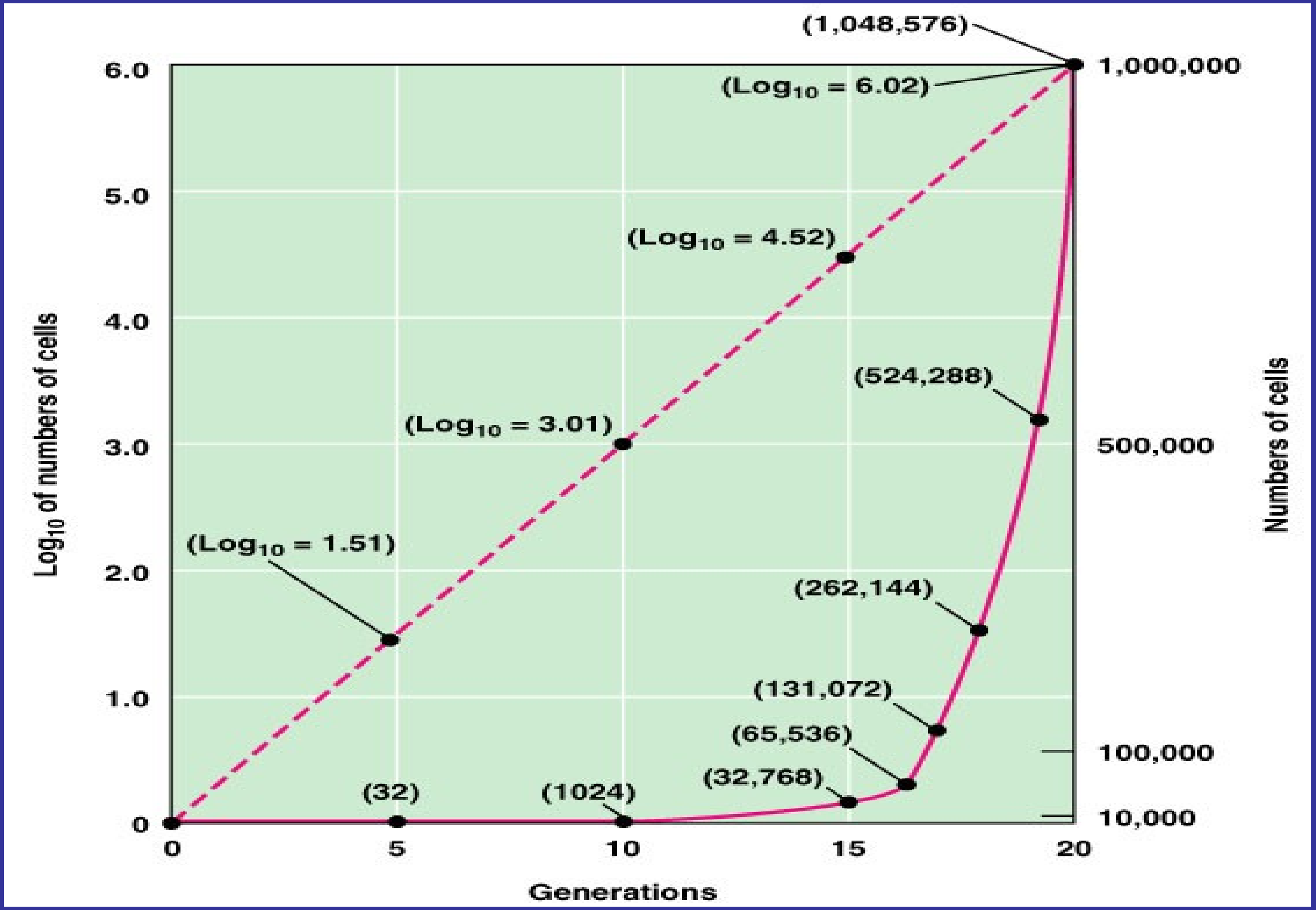
Time (h)	Total number of cells	Time (h)	Total number of cells
0	1	4	256 (2^8)
0.5	2	4.5	512 (2^9)
1	4	5	1,024 (2^{10})
1.5	8	5.5	2,048 (2^{11})
2	16	6	4,096 (2^{12})
2.5	32	.	.
3	64	.	.
3.5	128	10	1,048,576 (2^{19})

(a)



(b)

The number of cells produced after X-generations is better expressed logarithmically



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

Mathematics of exponential growth

- **$Nt = N_0 \times 2^n$**
- No = # of cells in population initially
- Nt = # of cells in population at time t
- n = number of generations that have occurred

- $\log (Nt = N_O \times 2^n)$
- $\log Nt = \log N_O + n\log 2$

- $\log Nt - \log N_O = n \log 2$

- $(\log Nt - \log N_O)/ \log 2 = n$
- $(\log Nt - \log N_O)/0.301$
- **$3.3 (\log Nt - \log N_O)$**

Problems

determine the number of cells in a population at time t

- 1. If you start with 1 cell how many do you have after 4 generations?
- **$Nt = N_0 \text{ X } 2^n$**
- $16 = 1 \text{ x } \mathbf{2^4}$
- 2. If you start with 100 cells, how many do you have after 4 generations?
- **$Nt = N_0 \text{ X } 2^n$**
- $1600 = 100 \text{ x } \mathbf{2^4}$

Problem

- 4. *E. coli* has a generation time of 20 minutes. If you start with 1 *E. coli* cell how many do you have after 2 hours?
- **$Nt = N_0 \times 2^n$**
- $64 = 1 \times \mathbf{2^6}$

- If it is 2 hours, then 6 generations
- 120 minutes/20 minutes = 6

Problems: determine number of generations

- 5. Example
- If $No = 1 \times 10^4$, $Nt = 6.5 \times 10^7$, t =240 min. minutes, then what is the number of generations?

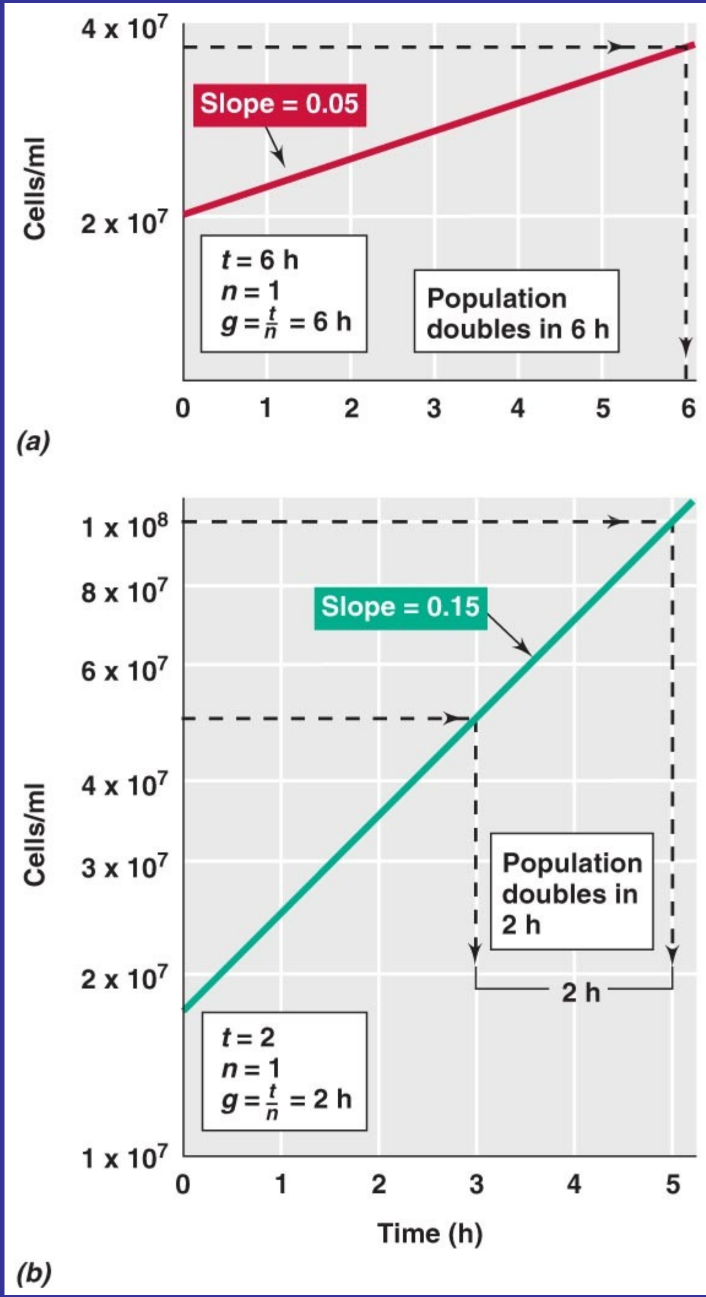
- $(\log Nt - \log N_O)/ \log 2 = n$
- $(\mathrm{Log}\ (6.5 \times 10^7) - \log (1 \times 10^4))/\log 2$

- Use your calculator to figure this out

Problems: determine generation time

- If No = 1 X 10^4, Nt = 6.5 X 10^7, t =240 min. minutes, then what is the generation time?

- Use the formula, g = t/n
- = g = 240 minutes/n (this you get from the last question)



Plotting growth versus time:

The smaller the generation time, the faster the growth. The faster the growth, the greater the slope in the line.

G=6 hours; slope 0.05

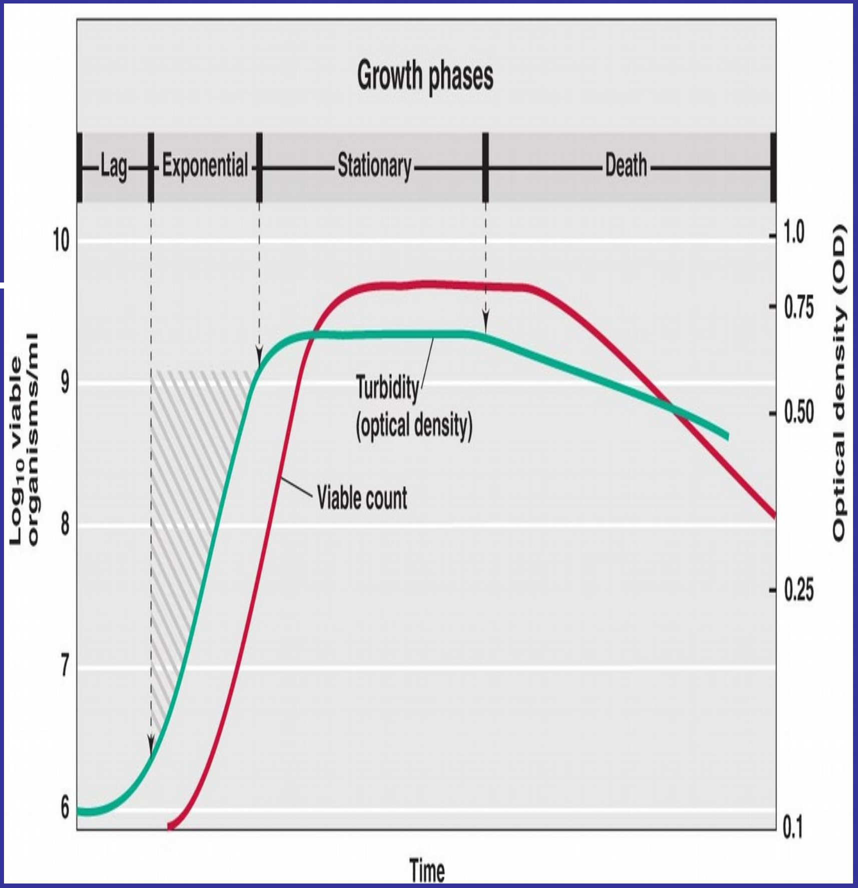
G=2 hours; slope 0.15

The growth calculations pertain to EXPONENTIAL PHASE ONLY!

- Bacteria have other phases of growth also

Bacterial population growth undergoes 4 phases

- **1. Lag phase**
- **2. Exponential phase**
- **3. Stationary phase**
- **4. Death phase**



Lag phase

- **No increase in cell number**

- **Synthesize macromolecules needed for protein synthesis and enzymes required for cell division**

- **The length of the lag phase depends on:**
  - **Conditions of bacteria before transfer into growth medium**
  - **The content of the growth medium**

Log (exponential) phase

- **Cells are dividing at maximal rate**

- **Cells are most susceptible to the action of antibiotics and other deleterious agents**

Stationary phase

- **Occurs when the number of viable cells stops increasing**
- **Due to nutrients being used up and/or toxic products accumulating from cell’s metabolism**

Death phase

- **Exponential decrease in the number of viable cells**

- **Dead cells are cells that can no longer multiply**