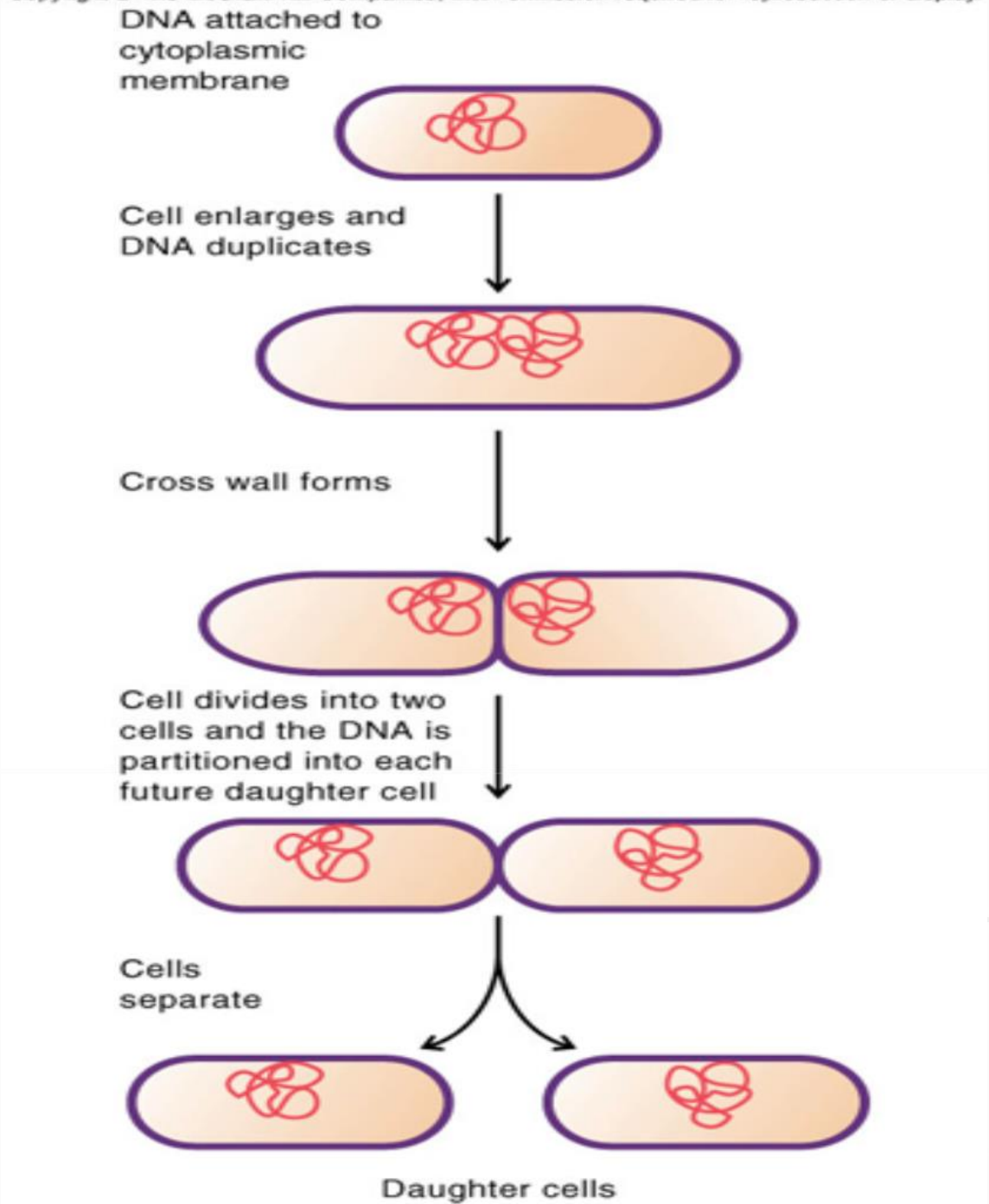
Kinetics of Bacterial Growth

Microbial growth physiology

Bacterial cells replicate by Binary fission

- In this process, the chromosomal DNA duplicates by replication,
- Then bacterial membrane and cell wall grow inward to meet one another and divide the cell in two.
- The two cells separate and the process are complete.
- The time taken by a cell to divide into two cells (Doubling time) varies by species and conditions

- Bacterial cell division by Binary Fission



Generation Time

When bacterial cells grow exponentially by binary fission, the increase in a bacterial population occurs by geometric progression.

The time interval required for the cells (or population) to divide into 2 daughter cells is termed as G, **Generation time/ Doubling time**

G (generation time) = t/n

t = time interval in hours or minutes

n= number of generations (no. of doublings/ no. of cell divisions)

- Bacteria have short **generation time**, (ranges between 30 minutes and three hours).
- *Escherichia coli*, for example, has a generation time of about 20 minutes when it is dividing under optimal conditions.

Generation Time

Practice Q1. 100 Bacterial cells grow and divide by binary fission for 1 hr and reach a population of 6400 cells. Calculate the number of generations and generation time (G).

Solution:

Progression of Cell division: 100 ->200 -> 400 -> 800 -> 1600 -> 3200 -> 6400

n= no. of generation= 6 generation/doublings

Genetation time, G=t/n

=60 min/6

=10 min

Exponential growth Kinetics

- During the exponential phase each microorganism is dividing at constant intervals.
- For a bacterial population growing by binary fission, the exponential growth can be expressed using the equation,

$$N_t = N_0 \times 2^n$$

Where, N_0 = number of bacteria at the beginning of a time interval

N_t = number of bacteria at the end of the time interval, t

n = number of generations (number of times the cell population doubles during the time interval)

Solving for n, by using Log at both sides,

$$\log N_t = \log N_0 + n\log 2$$

$$n = \frac{\log N_t - \log N_0}{\log 2}$$

$$n = \frac{\log N_t - \log N_0}{0.301}$$

Generation time, G = t/n $= t/\frac{\log N_t - \log N_0}{0.301}$

$$= \frac{t \quad X \quad 0.301}{\log N_t - \log N_0}$$

Practice Q2. A culture is inoculated with 1000 cells/ml . After 10 hrs the population is estimated to be 10^9 cells per ml. calculate the generation time.

Solution: G=t/n

Total time taken for division, t = 10 hr = 10 x 60 = 600 min

N_0 = number of bacteria at the beginning of a time interval

N_t = number of bacteria at the end of the time interval, t

N_0 = 1000; $N_t = 10^9$

$$\text{No of generation, } n = \frac{\log N_t - \log N_0}{0.301}$$

= (log 10^9 – log 1000) / 0.301

= 9 – 3 / 0.301 =6/ 0.301 = 19.9

= approx. 20 generation.

G = 600 /20 = 30 min

Growth Rate

- **mean growth rate constant *(k)* is the t**he rate of growth during the exponential phase in a batch culture
- This is the number of generations per unit time,
- Expressed as the generations per hour.

$$k = n / t$$

Assignment

- problem Q1. A culture is inoculated with 10^5 cells/ml . After 20 hrs the population is estimated to be 10^{20} cells per ml. calculate, no. of generations and the generation time.

References

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