Reproduction in Bacteria

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Asexual Reproduction

Definition

"Asexual reproduction is the mode of reproduction that is involved in the production of offsprings by a single parent."

Asexual reproduction is a mode of reproduction in which a new offspring is produced by a single parent. The new individuals produced are genetically and physically identical to each other, i.e., they are the clones of their parent.

Asexual reproduction is observed in both multicellular and unicellular organisms. This process does not involve any kind of gamete fusion and there won't be any change in the number of chromosomes either. It will inherit the same genes as the parent, except for some cases where there is a chance of rare mutation to occur.

Characteristics of Asexual Reproduction

- Single parent involved.
- No fertilization or gamete formation takes place.
- This process of reproduction occurs in a very short time.
- The organisms multiply and grow rapidly.
- The offspring is genetically similar.

Types of Asexual Reproduction

- Binary Fission
- Budding
- Fragmentation
- Vegetative Propagation
- Sporogenesis

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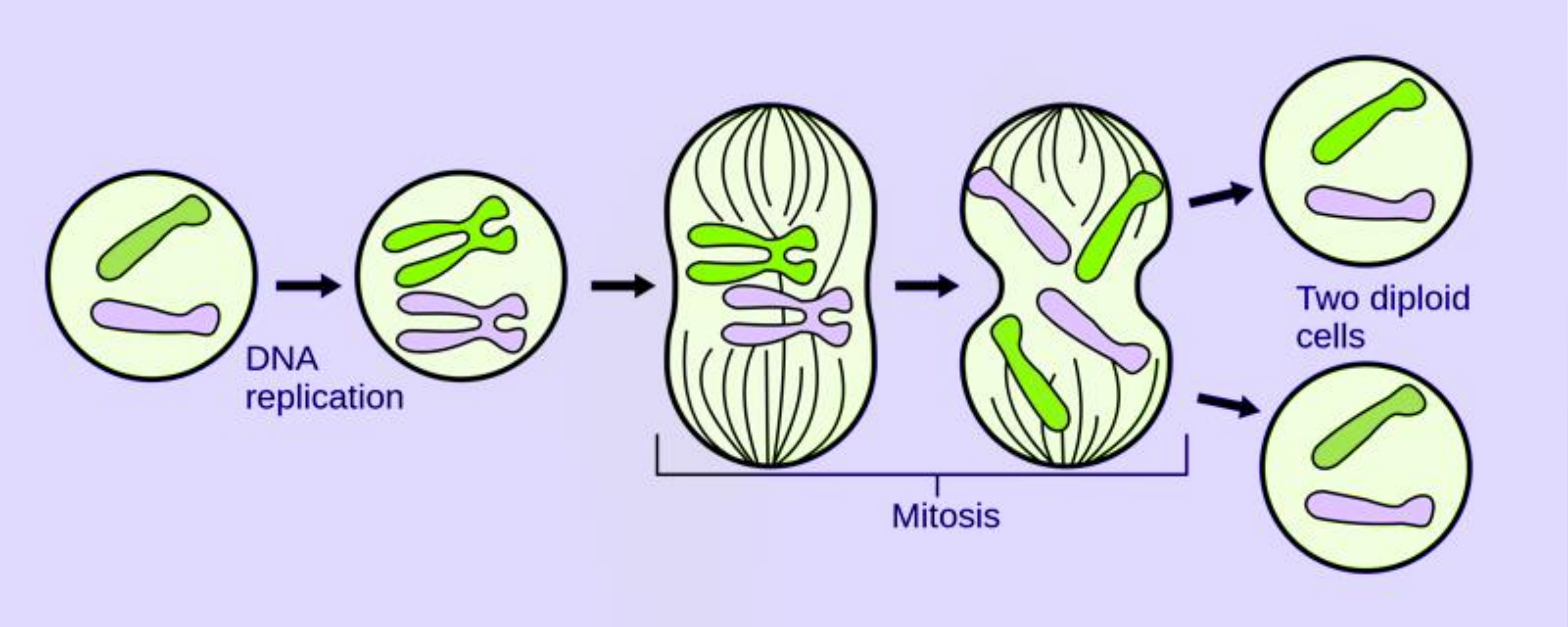
BINARY FISSION

The term “fission” means “to divide”. During binary fission, the parent cell divides into two cells. The cell division patterns vary in different organisms, i.e., some are directional while others are non-directional. Amoeba and euglena exhibit binary fission.

It is one of the simplest and uncomplicated methods of asexual reproduction. The parent cell divides into two, each daughter cell carrying a nucleus of its own that is genetically identical to the parent. The cytoplasm also divides leading to two equal-sized daughter cells. The process repeats itself and the daughter cells grow and further divide.



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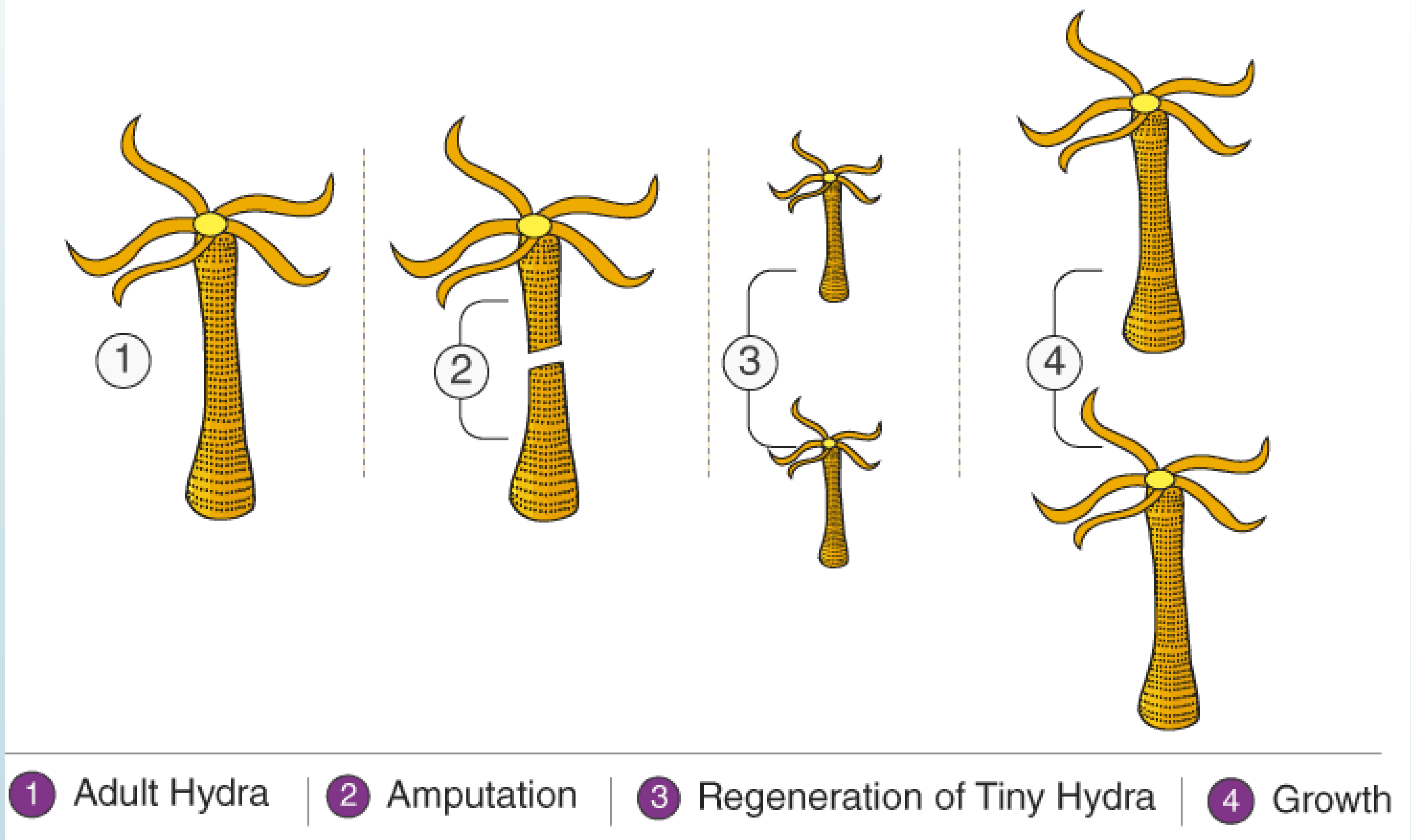
FRAGMENTATION

Fragmentation is another mode of asexual reproduction exhibited by organisms such as spirogyra, planaria etc. The parent body divides into several fragments and each fragment develops into a new organism.



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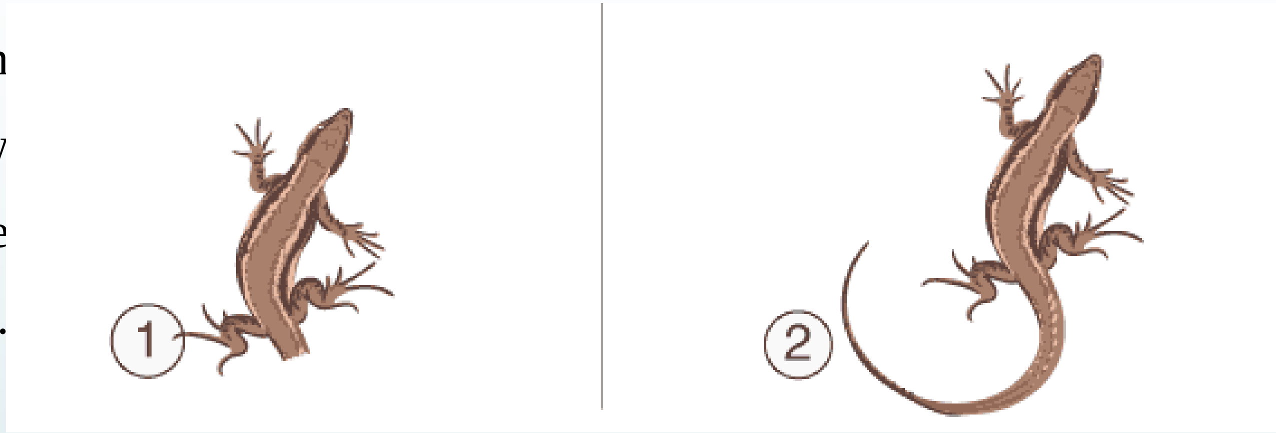
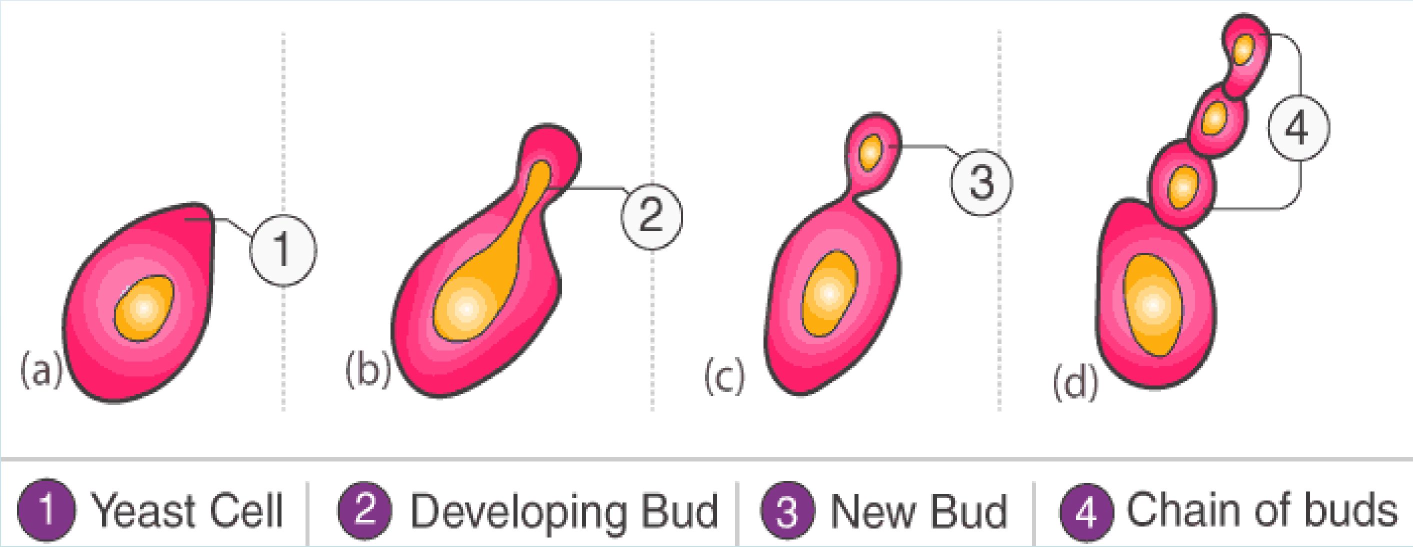
REGENERATION

Regeneration is the power of growing a new organism from the lost body part. For eg., when a lizard loses its tail, a new tail grows. This is because the specialized cells present in the organism can differentiate and grow into a new individual. Organisms like hydra and planaria exhibit regeneration.



BUDDING

Budding is the process of producing an individual through the buds that develop on the parent body. Hydra is an organism that reproduces by budding. The bud derives nutrition and shelter from the parent organism and detaches once it is fully grown.



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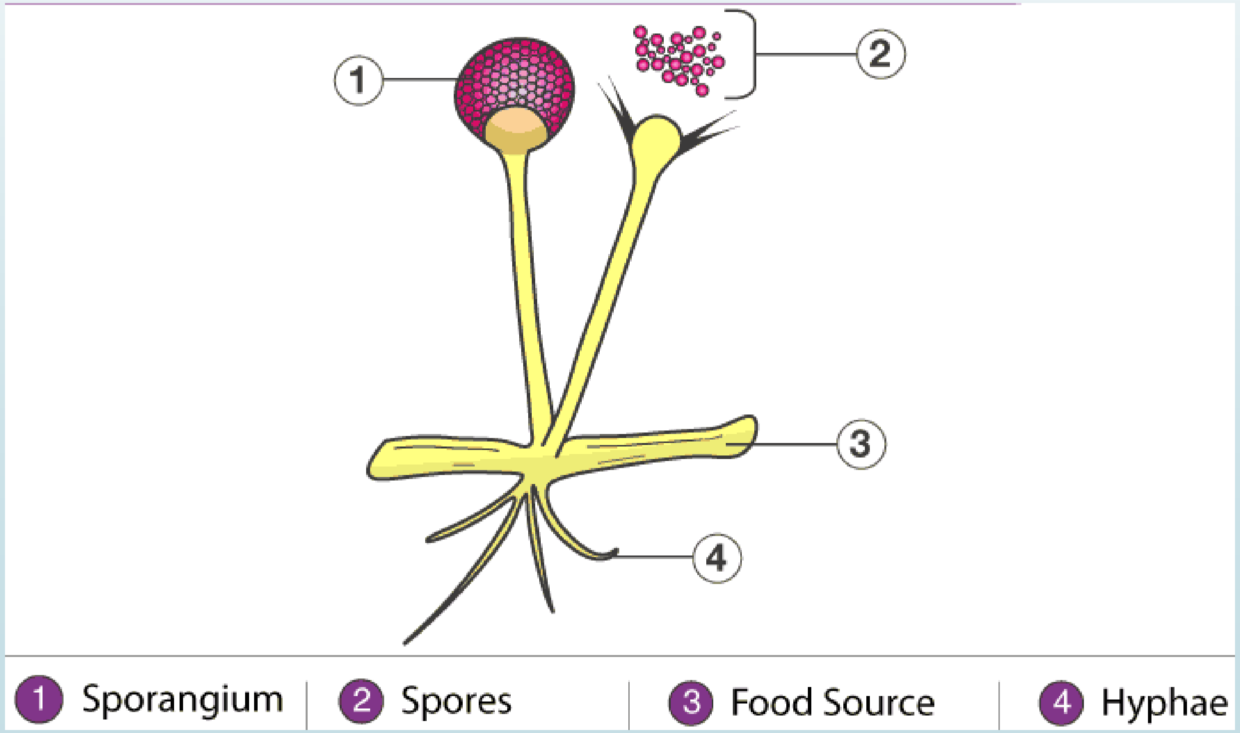
VEGETATIVE PROPAGATION

Asexual reproduction in plants occurs through their vegetative parts such as leaves, roots, stem, and buds. This is called vegetative propagation. For example, potato tubers, runners/stolon, onion bulbs, etc., all reproduce through vegetative propagation.

SPORE FORMATION

Spore formation is another means of asexual reproduction. During unfavorable conditions, the organism develops sac-like structures called sporangium that contain spores. When the conditions are favorable, the sporangium burst opens and spores are released that germinate to give rise to new organisms.



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ADVANTAGES OF ASEXUAL REPRODUCTION

- Mates not required.
- The process of reproduction is rapid.
- An enormous number of organisms can be produced in very less time.
- Positive genetic influences pass on to successive generations.
- It occurs in various environments.

DISADVANTAGES OF ASEXUAL REPRODUCTION

- Lack of diversity. Since the offspring's are genetically identical to the parent they are more susceptible to the same diseases and nutrient deficiencies as the parent. All the negative mutations persist for generations.
- Since only one organism is involved, the diversity among the organisms is limited.
- They are unable to adapt to the changing environment.
- A single change in the environment would eliminate the entire species.

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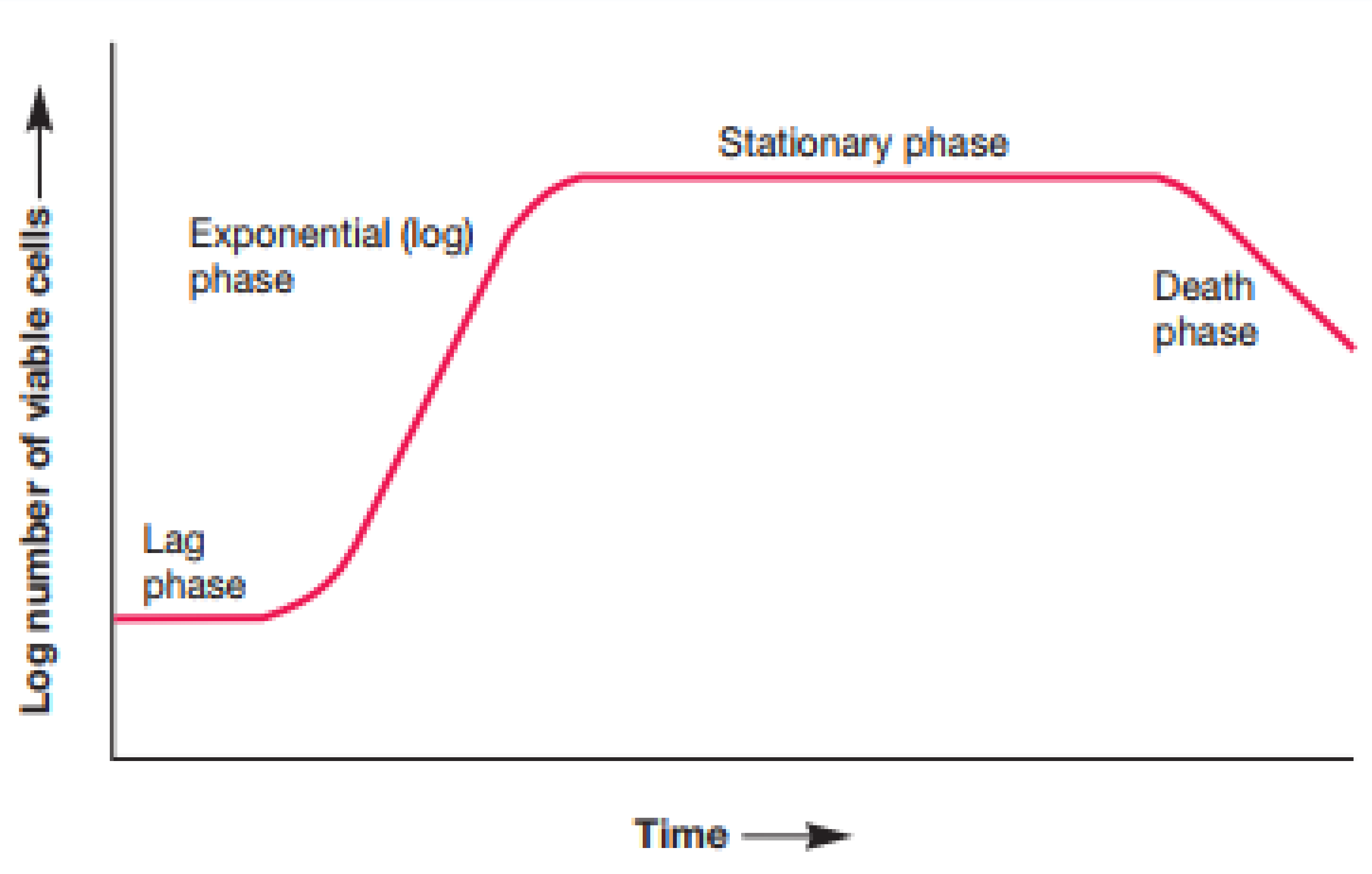
ASEXUAL REPRODUCTION EXAMPLES

- Bacterium undergoes binary fission in which the cell divides into two along with the nucleus.
- Blackworms or mudworms reproduce through fragmentation.
- Hydras reproduce through budding.
- Organisms such as copperheads undergo parthenogenesis.
- Sugarcane can be grown through vegetative propagation.

Phases of growth



Microbial Growth Curve in a Closed System.
The four phases of the growth curve are identified on the curve

Logarithmic representation of bacterial populations

The most common means of bacterial reproduction is binary fission; one cell divides, producing two cells. Thus, if we start with a single bacterium, the increase in population is by geometric progression:

$$1 \rightarrow 2 \rightarrow 2^2 \rightarrow 2^3 \rightarrow 2^4 \rightarrow 2^5 \ldots 2^n$$

Let N_0 = the initial population number

N_t = the population at time t

n = the number of generations in time t

Then inspection of the results in table 7.1 shows that

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

Solving for n, the number of generations, where all logarithms are to the base 10,

$$\log N_t = \log N_0 + n \cdot \log 2, \text{ and}$$

$$n = \frac{\log N_t - \log N_0}{\log 2} = \frac{\log N_t - \log N_0}{0.301}$$

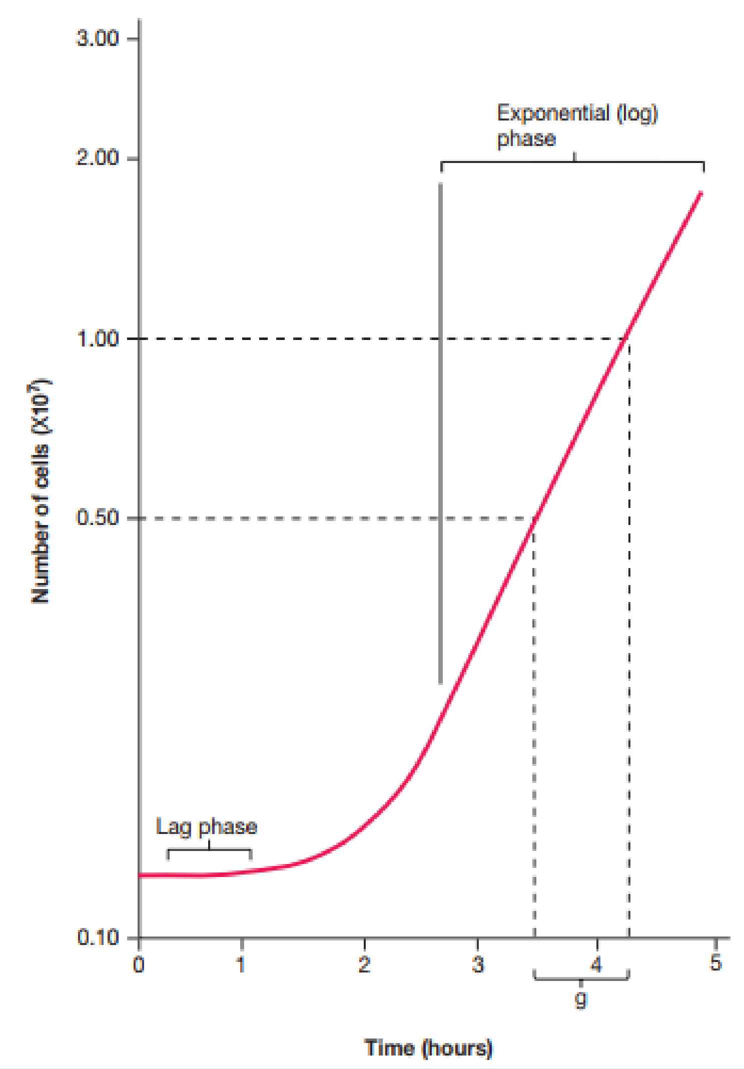
Calculation of generation time

During the exponential phase, each microorganism is dividing at constant intervals. Thus the population doubles in number during a specific length of time called the **generation (doubling) time.** This can be illustrated with a simple example. Suppose that a culture tube is inoculated with one cell that divides every 20 minutes (**table 7.1**). The population will be 2 cells after 20 minutes, 4 cells after 40 minutes, and so forth. Because the population is doubling every generation, the increase in population is always 2*n* where *n* is the number of generations. The resulting population increase is exponential—that is, logarithmic (**see figure**).

Table 7.1 An Example of Exponential Growth

Time[a]	Division Number	2^n	Population[b] ($N_0 \times 2^n$)	$\log_{10} N_t$
0	0	$2^0 = 1$	1	0.000
20	1	$2^1 = 2$	2	0.301
40	2	$2^2 = 4$	4	0.602
60	3	$2^3 = 8$	8	0.903
80	4	$2^4 = 16$	16	1.204

[a]The hypothetical culture begins with one cell having a 20-minute generation time.
[b]Number of cells in the culture.



Generation Time Determination.

The rate of growth during the exponential phase in a batch culture can be expressed in terms of the **mean growth rate constant (*k*).** This is the number of generations per unit time, often expressed as the generations per hour.

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

The time it takes a population to double in size—that is, the **mean generation (doubling) time** (*g*)—can now be calculated. If the population doubles ($t = g$), then

$$N_t = 2N_0$$

Substitute 2*N*0 into the mean growth rate equation and solve for *k*.

$$k = \frac{\log (2N_0) - \log N_0}{0.301g} = \frac{\log 2 + \log N_0 - \log N_0}{0.301g}$$

$$k = \frac{1}{g}$$

$$g = \frac{t}{n} = \frac{t}{3.3\ (\log_{10} N - \log_{10} N_0)}$$

The mean generation time is the reciprocal of the mean growth rate constant.

$$R = \frac{3.3(\log_{10} N - \log_{10} N_0)}{t}$$

$$g = \frac{1}{k}$$

g = generation time; R = Growth rate

For example, suppose that a bacterial population increases from 10^3 cells to 10^9 cells in 10 hours.

$$k = \frac{\log 10^9 - \log 10^3}{(0.301)(10\text{ hr})} = \frac{9-3}{3.01\text{ hr}} = 2.0\text{ generations/hr}$$

$$g = \frac{1}{2.0\text{ gen. hr}} = 0.5\text{ hr/gen. or 30 min/gen.}$$

1. Define generation (doubling) time and mean growth rate constant. Calculate the mean growth rate and generation time of a culture that increases in the exponential phase from 5×10^2 to 1×10^8 in 12 hours.

2. Suppose the generation time of a bacterium is 90 minutes and the initial number of cells in a culture is 10^3 cells at the start of the log phase. How many bacteria will there be after 8 hours of exponential growth?

Thank You