NUTRITION AND GROWTH

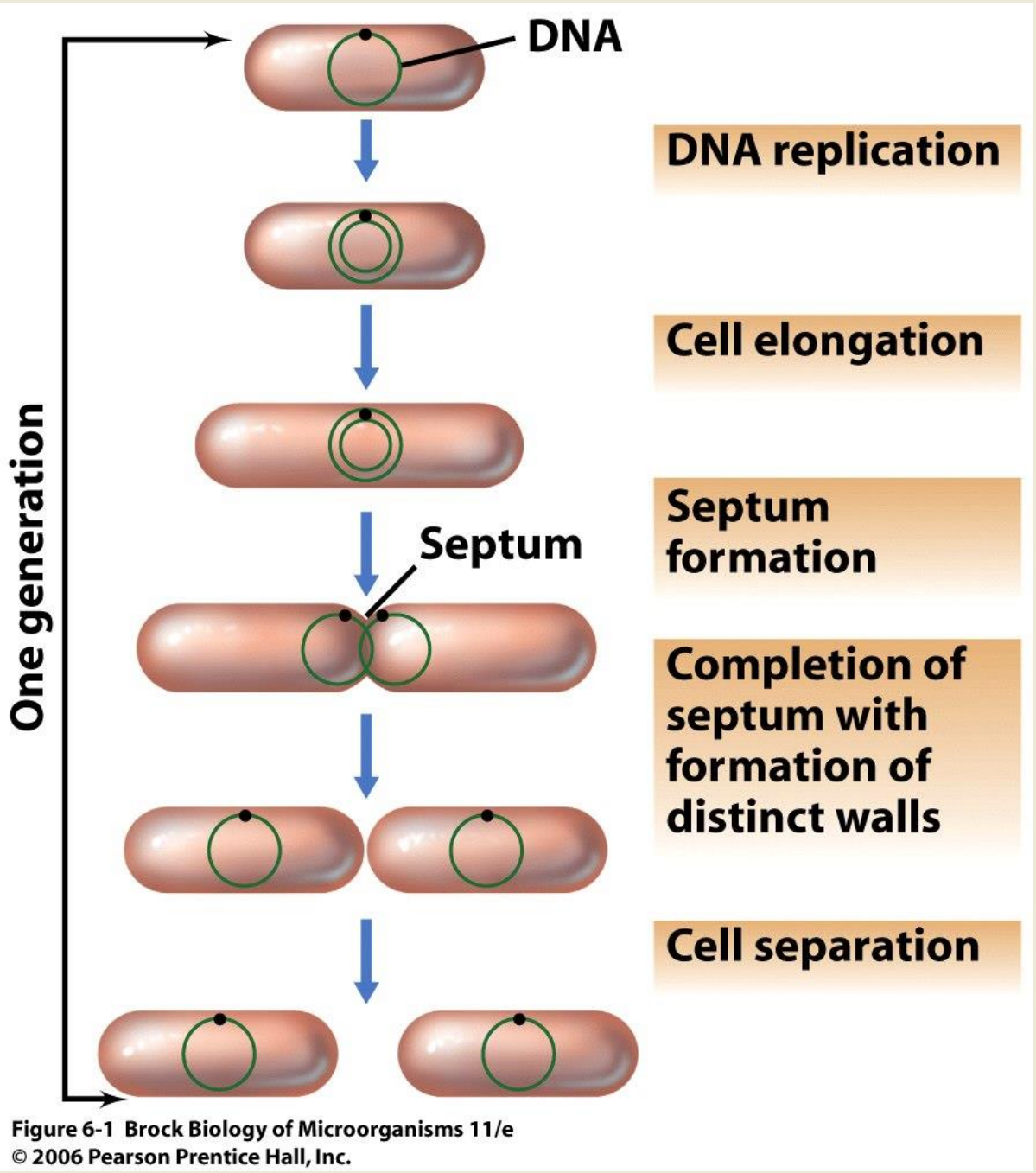
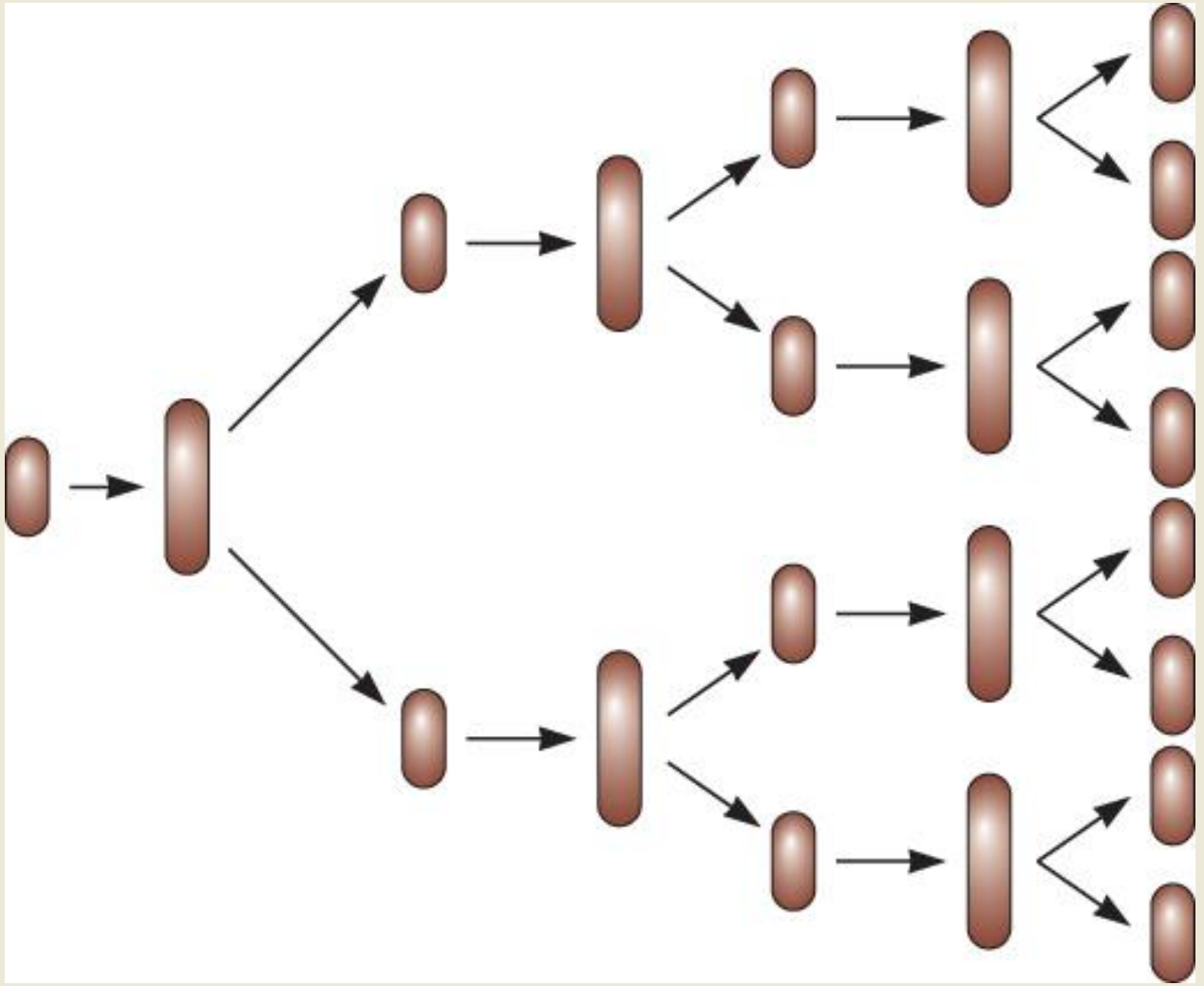


Figure 6-1 Brock Biology of Microorganisms 11/e

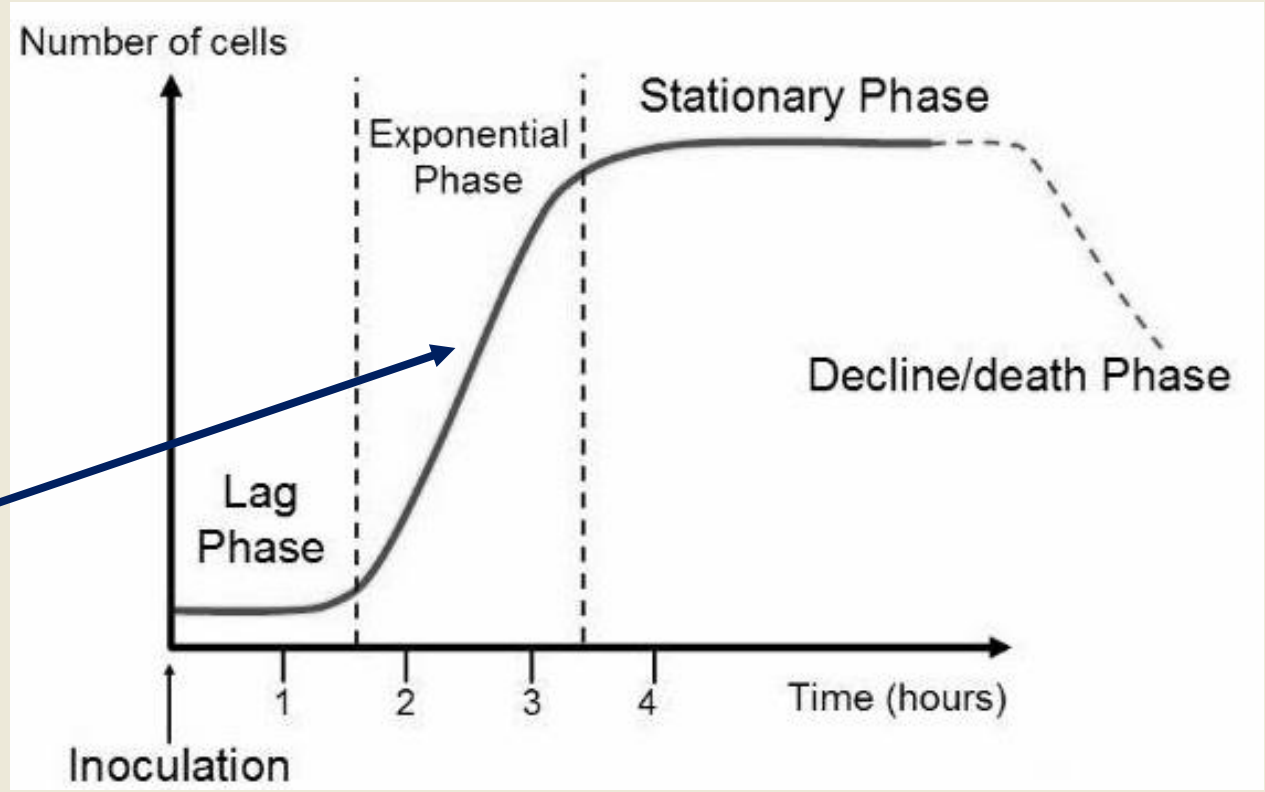
Most bacteria grow by doubling in size and then dividing in two. This is called binary fission.

If all cells are growing at the same rate the population will double in size every time cells divide.

This is called exponential growth.



The exponential phase of growth is the time-period when the population is doubling in size



Generation time is the length of time necessary for the population to double in size

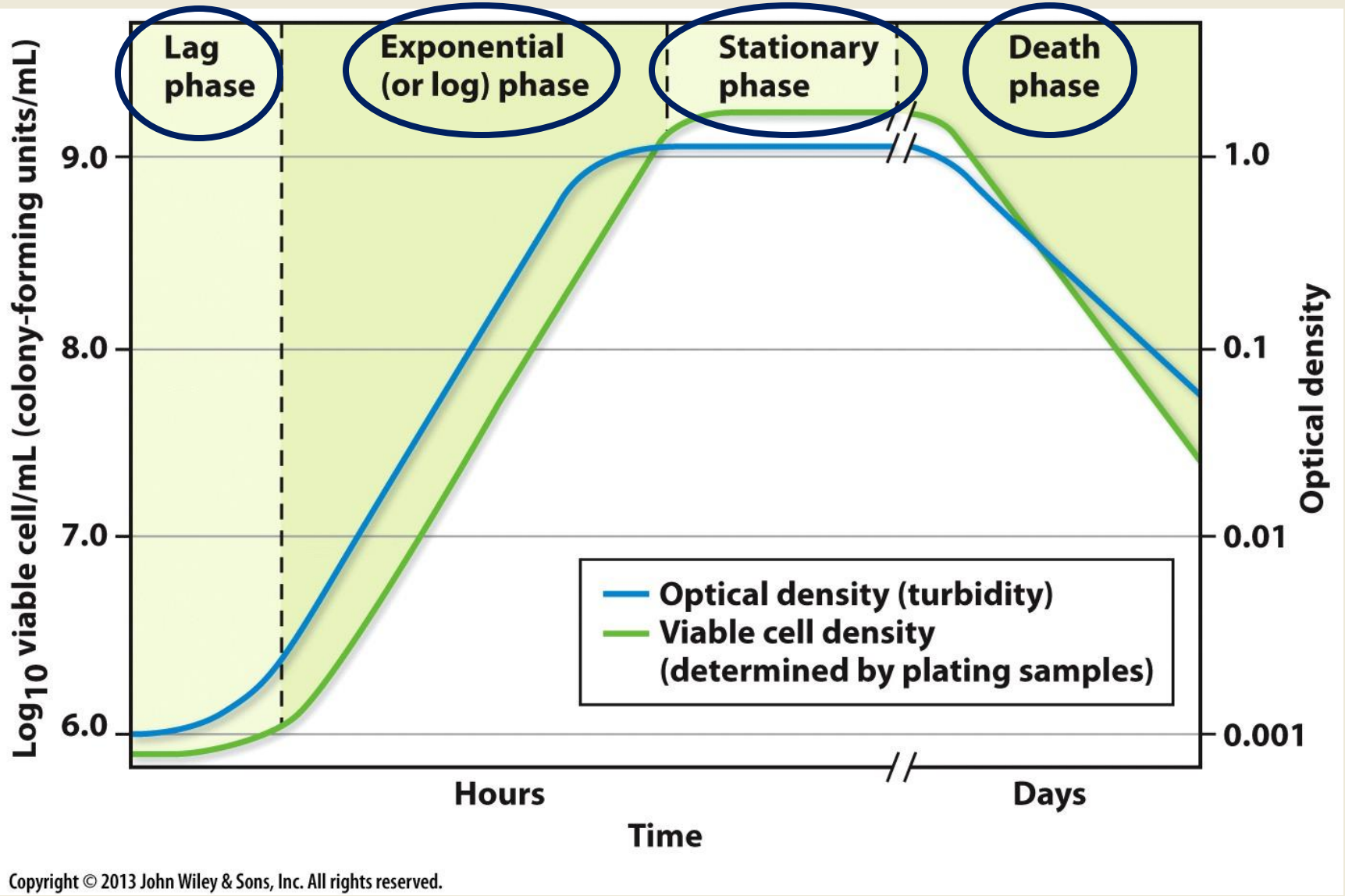
A *generation* has passed when the # of cells has doubled

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})

Figure 6-6a Brock Biology of Microorganisms 11/e

Generation times can range from 10 - 800 minutes (13 days).
Most bacteria have a generation time of 0.5 – 3 hours

The doubling of the population results in a predictable pattern for cells growing in a closed system.



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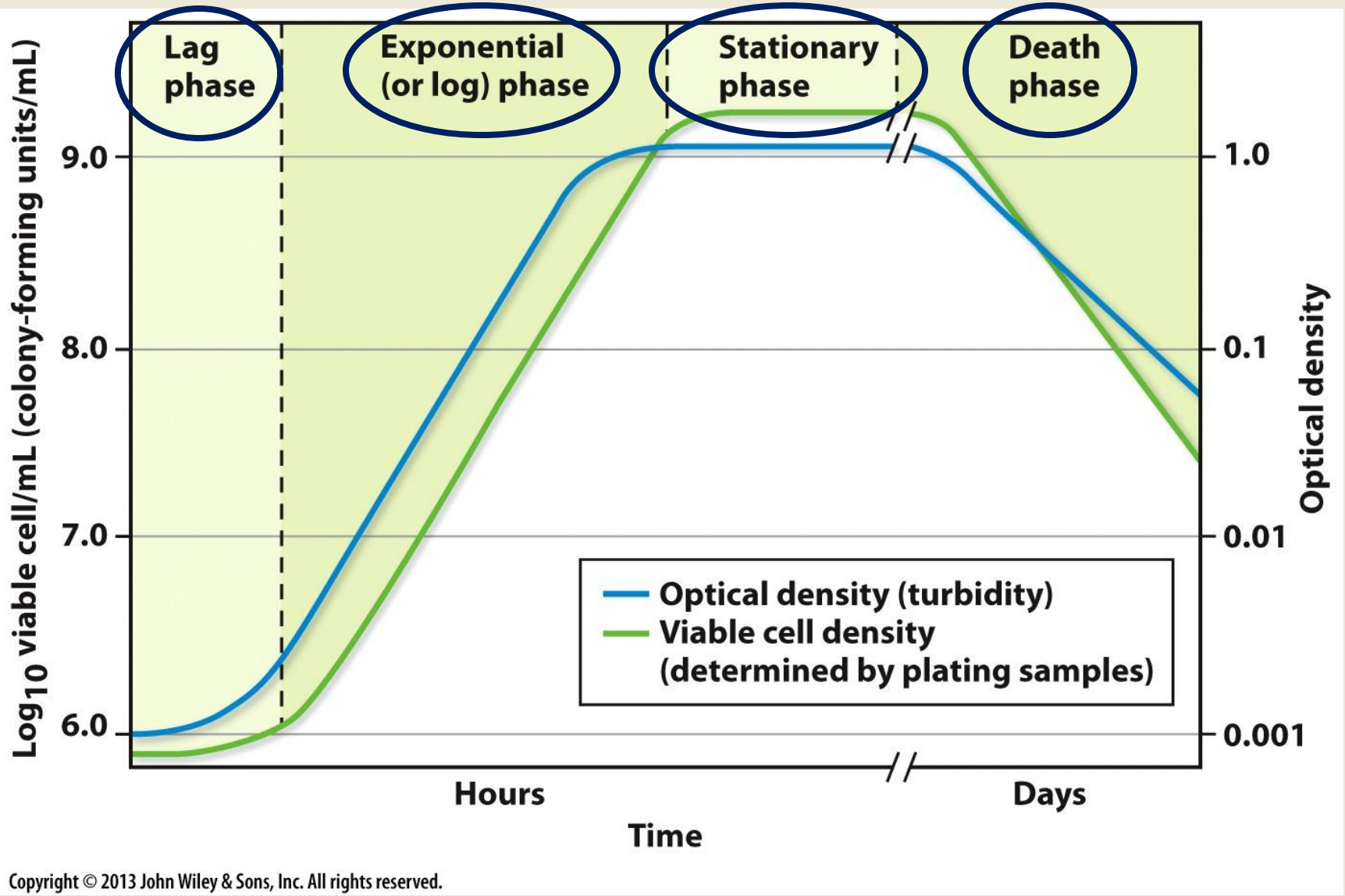
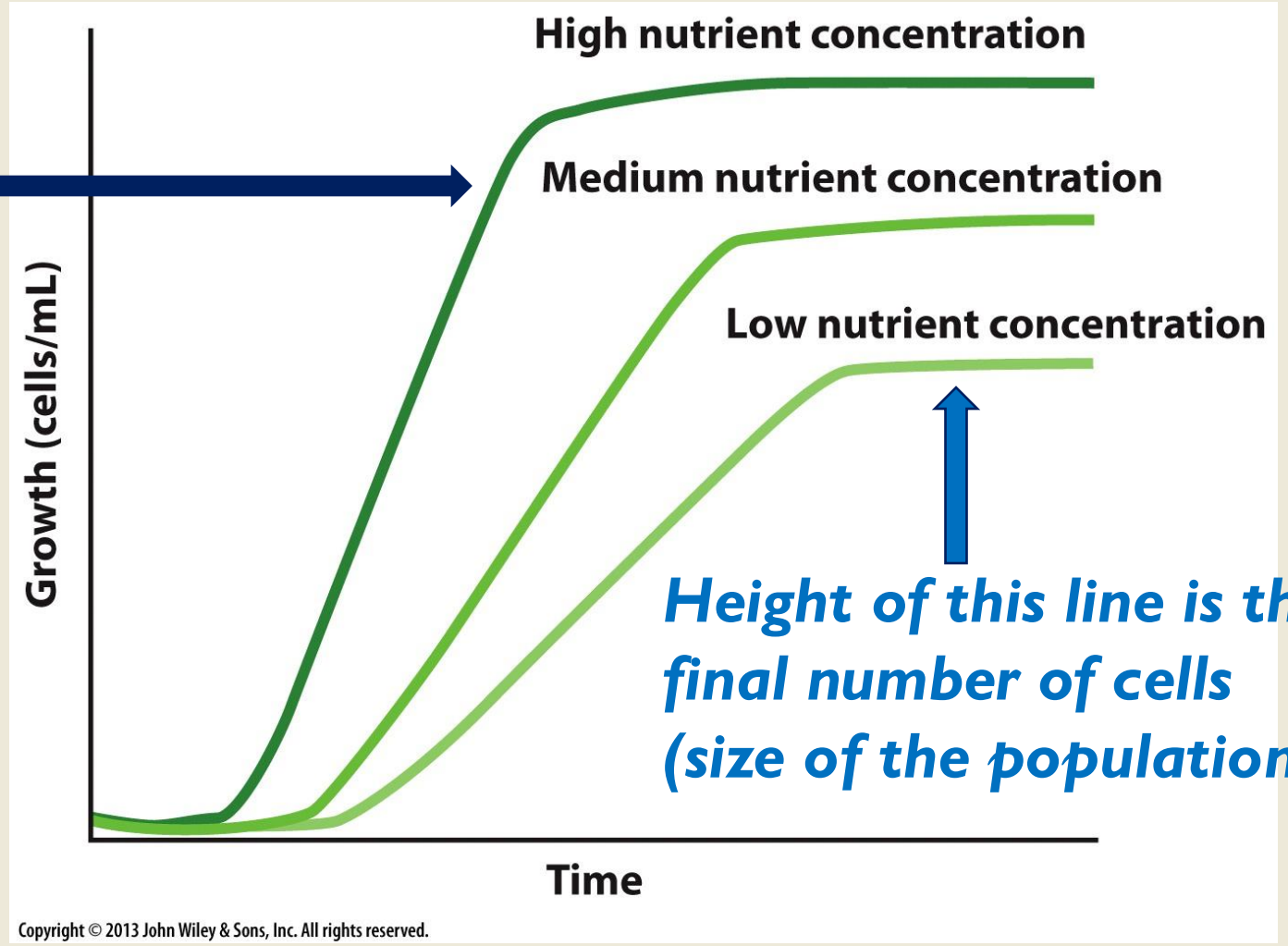


What is happening during the

- ***Lag phase?***
- ***Exponential growth phase?***
- ***Stationary growth phase?***
- ***Death phase?***

Many factors can change the shape of the curve. For example, one key nutrient, available in the lowest amount, will control how much growth can occur over time.

Slope of this line is the rate of growth = change in population size (N) over time (t) = dN/dt.



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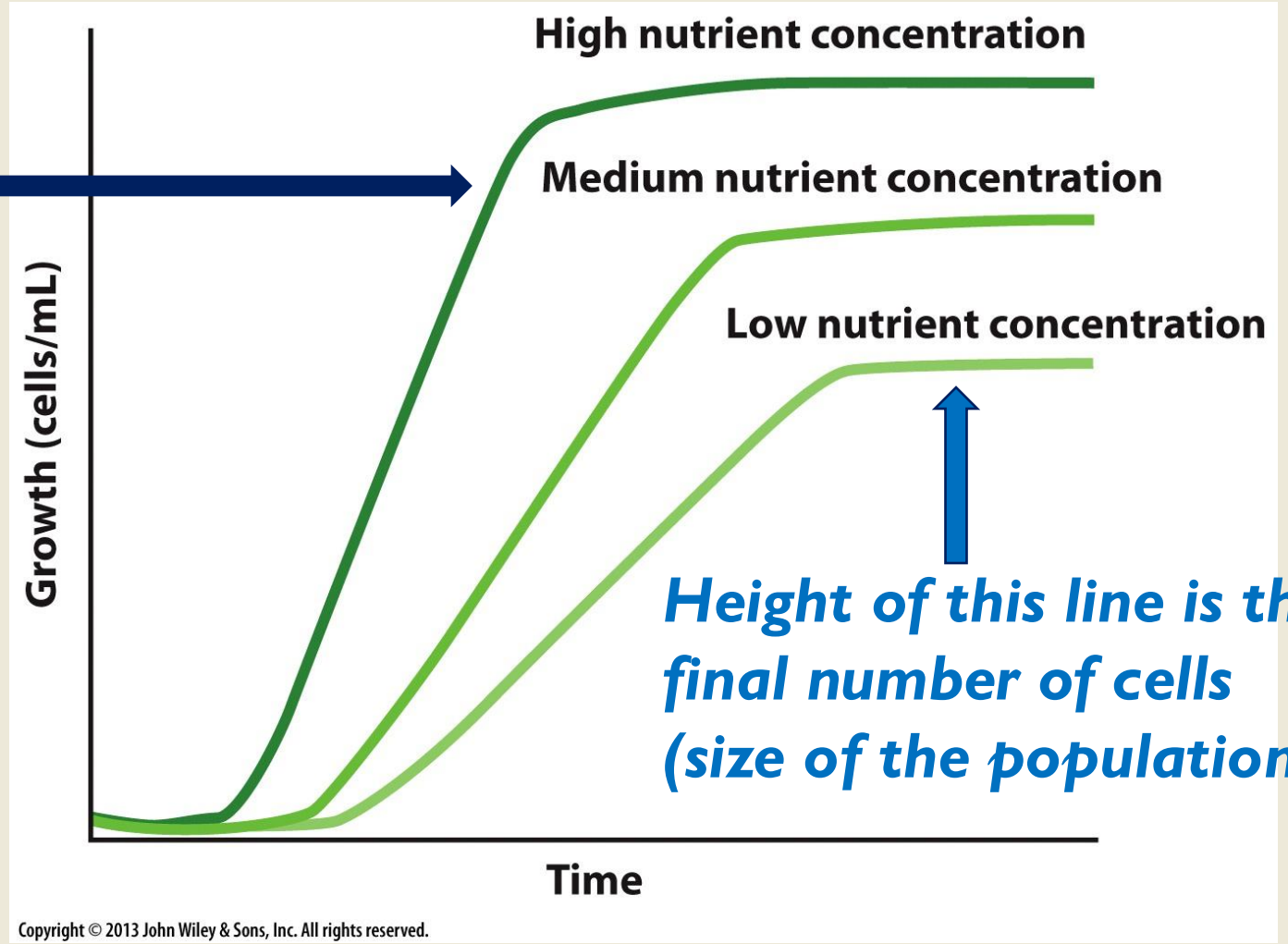
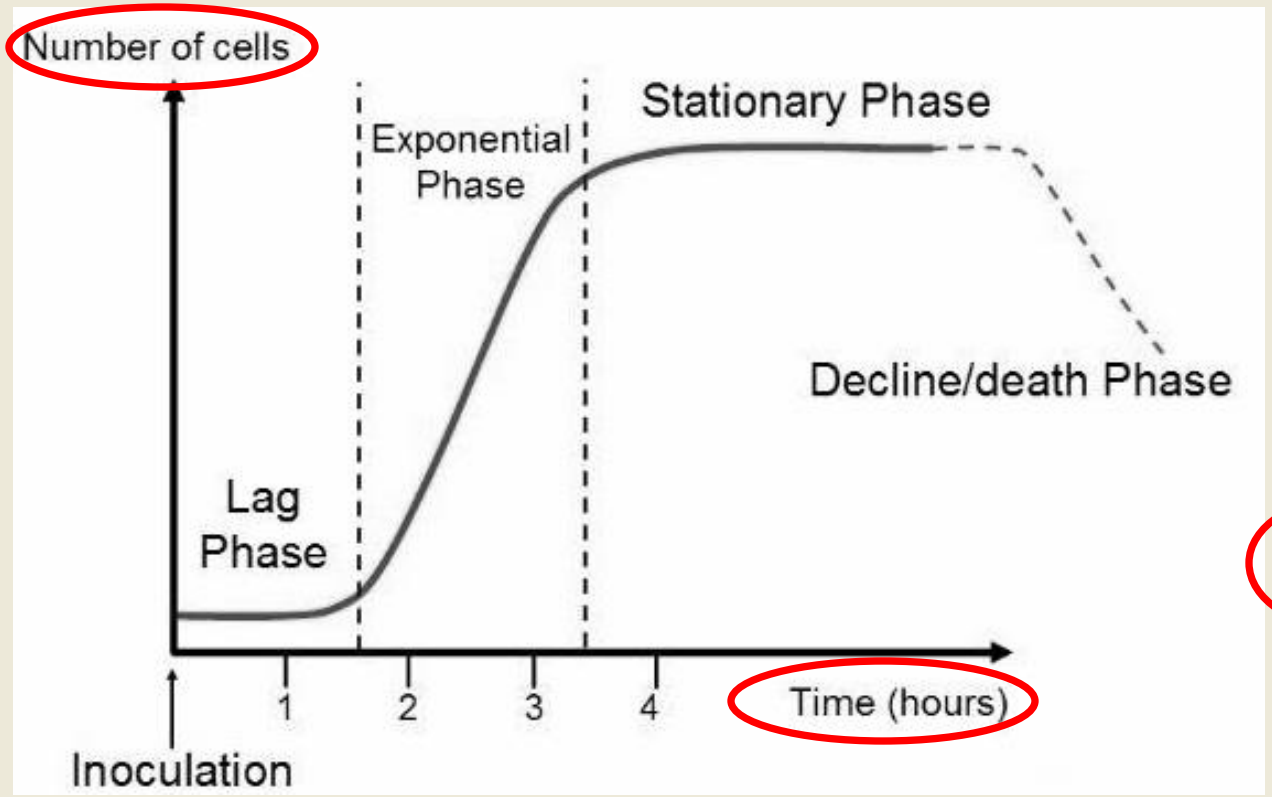
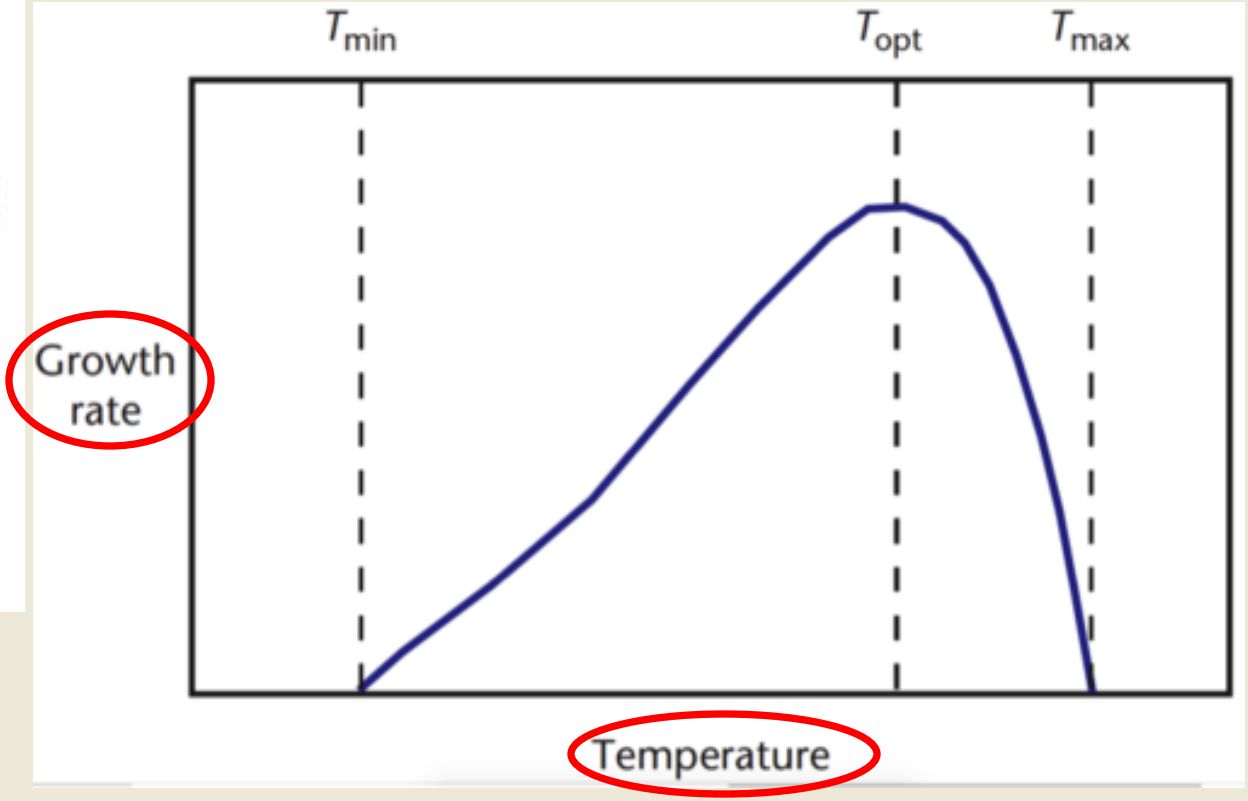


Data for these curves came from growing populations separately, each under a specific set of environmental conditions.



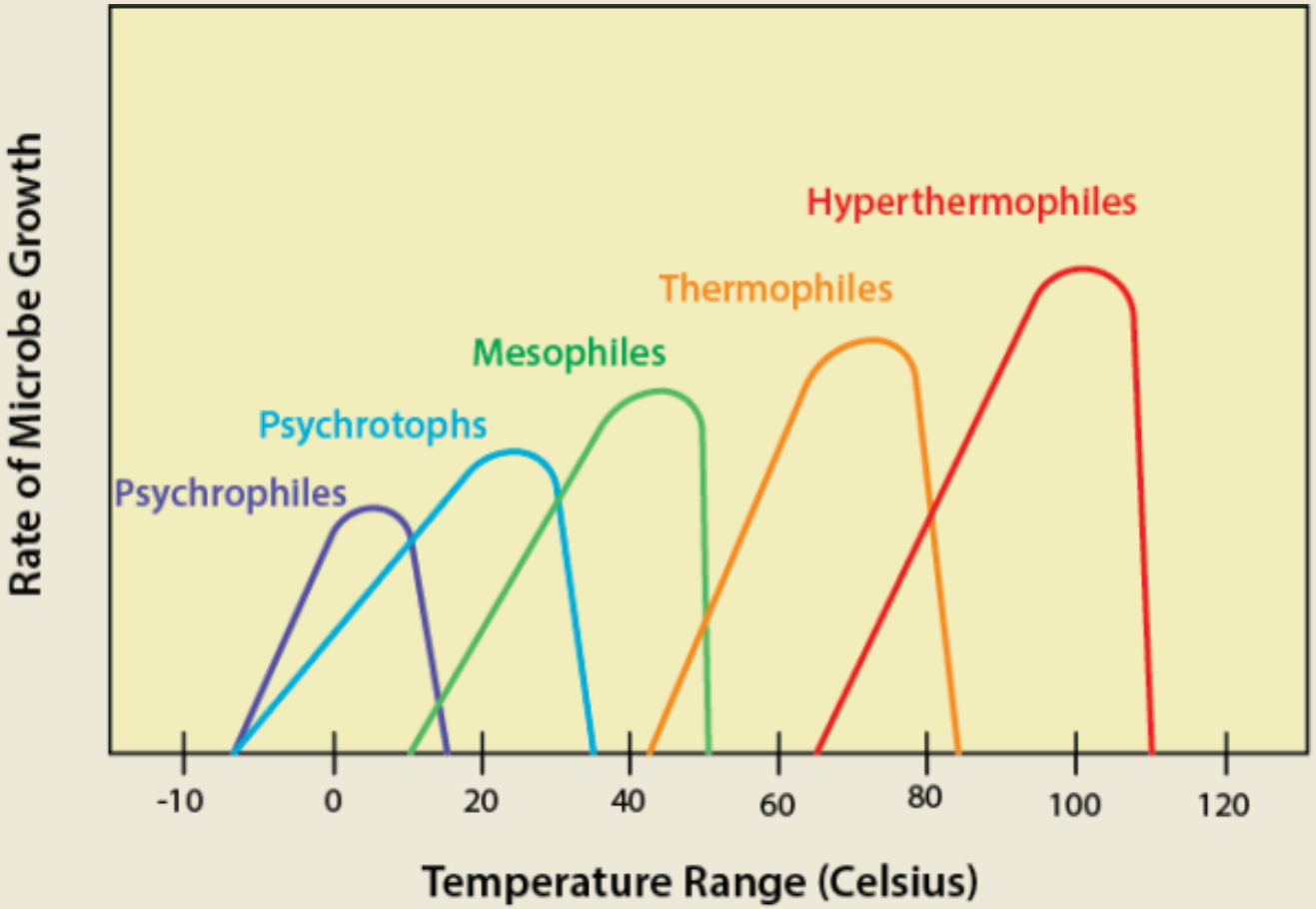
Results from multiple experiments like this one can be combined . . .

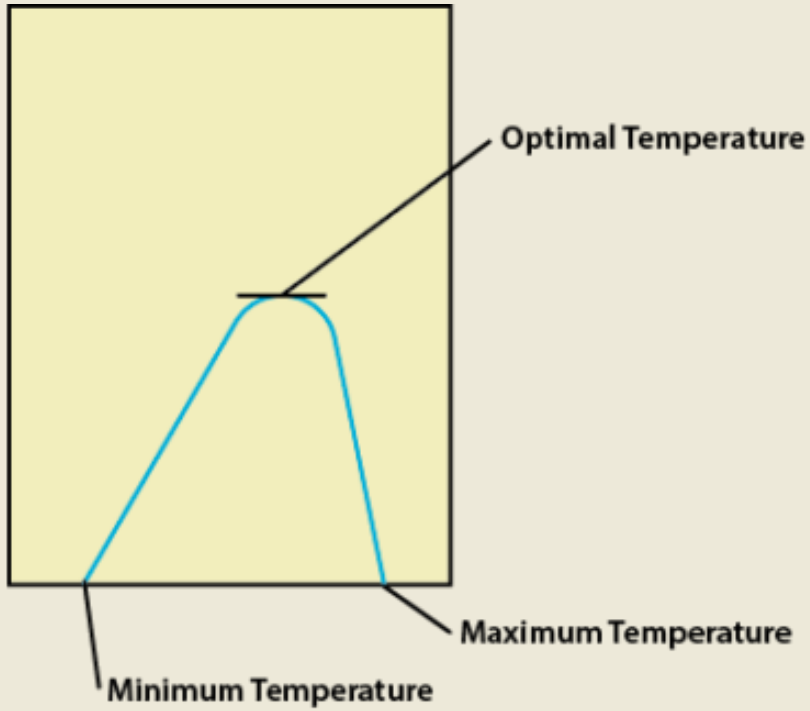
NOTE – the x- and y-axes on the two graphs show different measures.



. . . to show how growth rate changes across a range of environmental conditions. Temperature in this example.

Graphs of growth rates across the range of an environmental condition allow us to determine the minimum, optimal and maximum growth temperatures (or pH, or salt concentration, or oxygen concentration, etc.) of specific groups of microbes

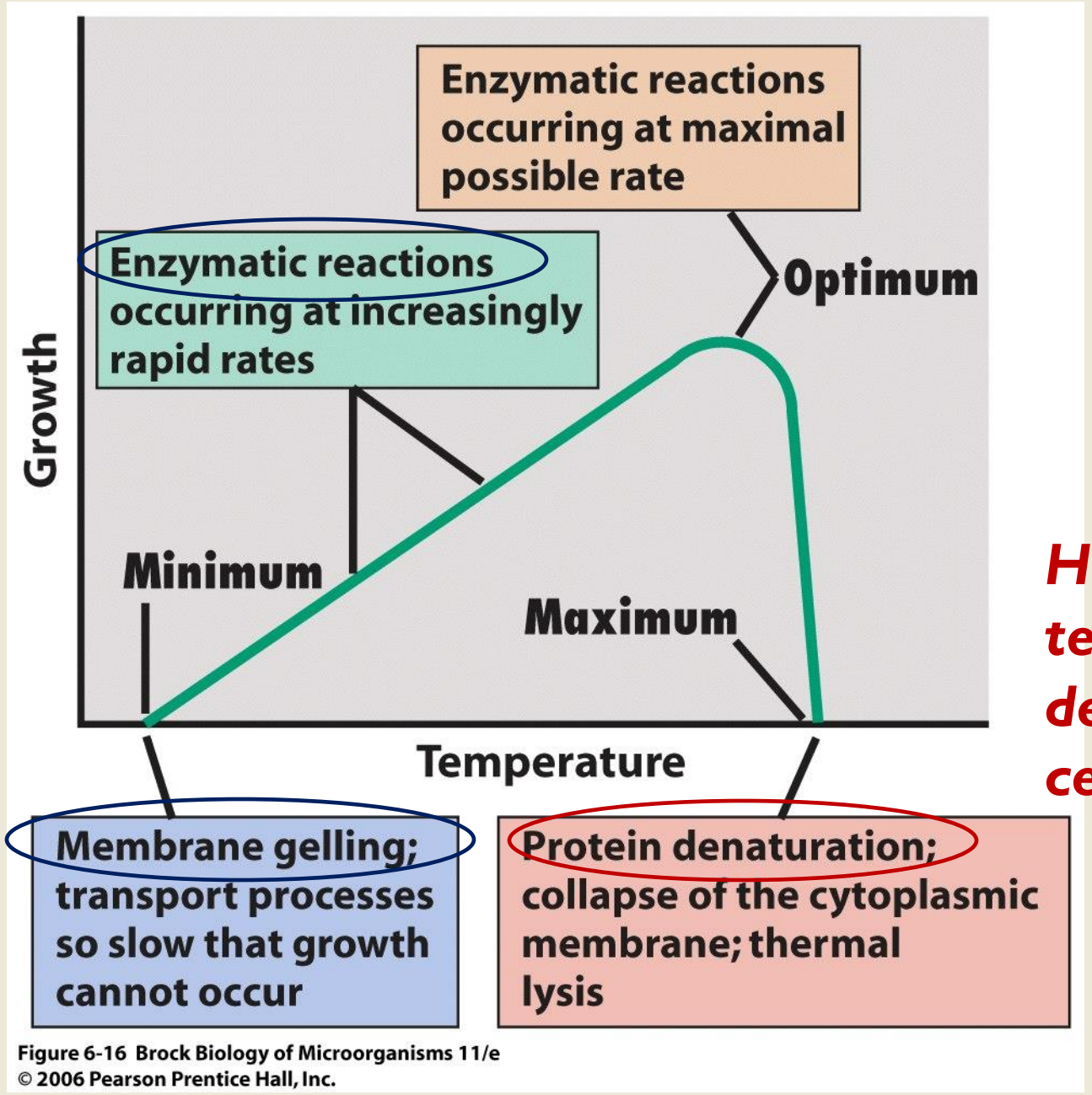




The minimum, optimal and maximum are based upon the effects an environmental variable has on cells.

Temperature, for example.

Low temperatures slow or stop the growth but do not kill cells.



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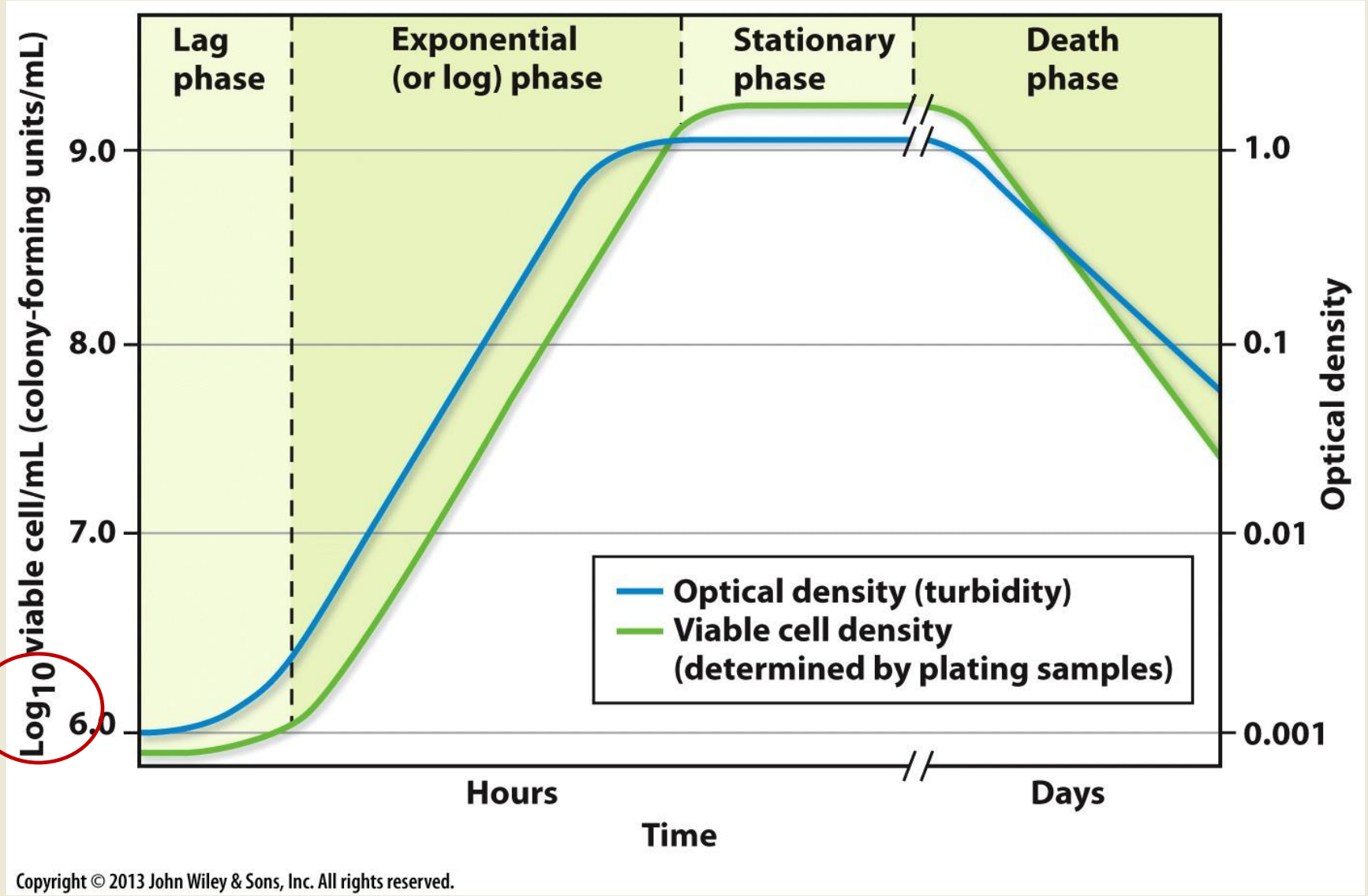
High temperatures destroy/kill cells.

Bacterial growth is normally represented by a logarithmic scale because the numbers are too large to see the growth pattern on an arithmetic scale

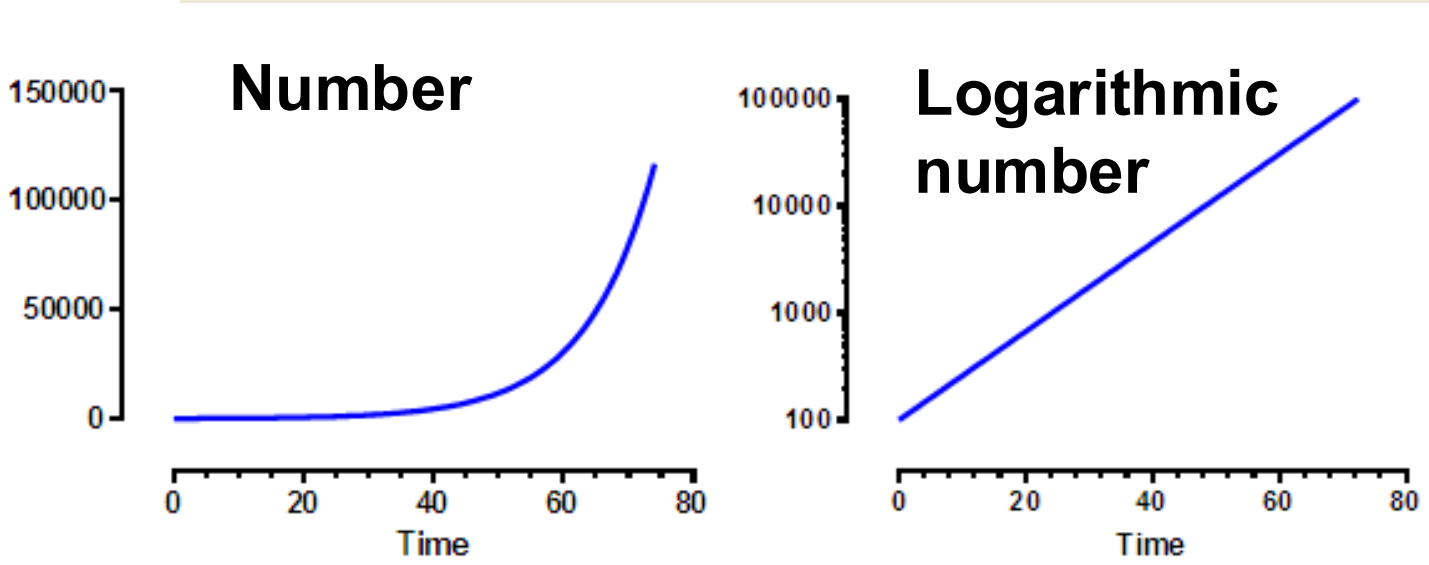


Number of Cells

- 5
- 10
- 20
- 40
- 80
- 160
- 320
- 640
- 1,280
- 2,560
- 5120

Logarithmic # of Cells

- 0.6
- 1
- 1.3
- 1.6
- 1.9
- 2.2
- 2.5
- 2.8
- 3.1
- 3.4
- 3.7



You need to know how to calculate simple log numbers

- $\log_{10} 1{,}000 = 3$
- $10^3 = 1{,}000$
- $\log_{10} ? = 2$
- $\log_{10} 10{,}000 = ?$

MICROBIOLOGISTS USE MATH ☺ TO DESCRIBE MICROBIAL GROWTH

$N_t = 2^n N_0$

N_t = population size at time t

n = # of generations

N_0 = starting population size

# of generations (number)

$n = (\log N_t - \log N_0)/0.301$

generation time (time)

$g = \frac{t}{n}$

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N_t = population size at time t

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This equation you need to know by memory

# of generations (number)

$n = (\log N_t - \log N_0)/0.301$

generation time (time)

$g = \frac{t}{n}$

To grow, all cells require sources of energy and chemical nutrients for building new cells:

- **large amounts of carbon, nitrogen, phosphorus, sulfur, and oxygen (macronutrients),**
- **various micronutrients (Na^+, Mg^{2+}, Mn^{2+}, etc.)**

Without these, there can be no binary fission

PHYSICAL FACTORS ALSO INFLUENCE GROWTH

- Temperature
- Oxygen
- Osmolarity
- pH
- . . . and more

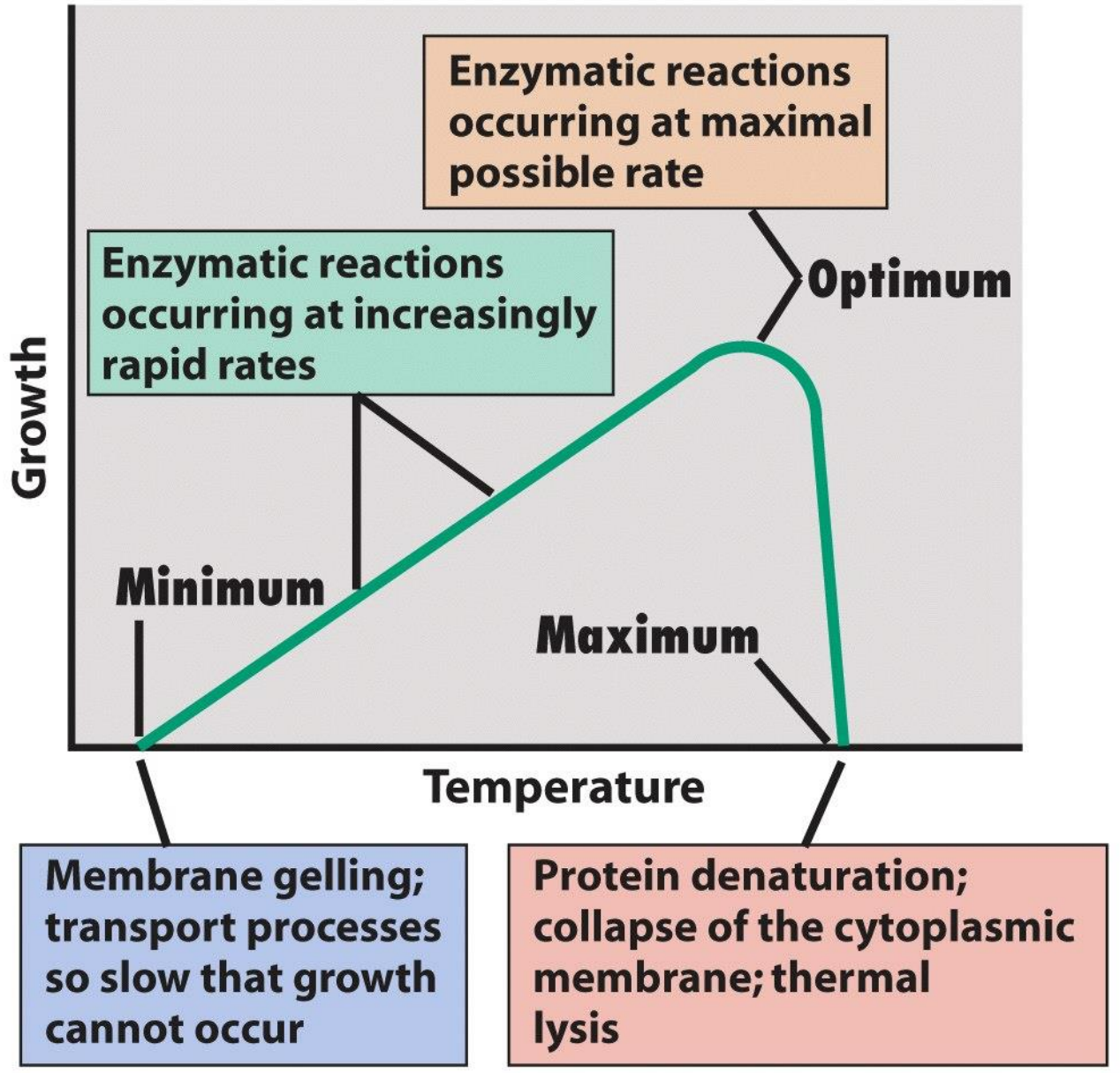

Figure 6-16 Brock Biology of Microorganisms 11/e
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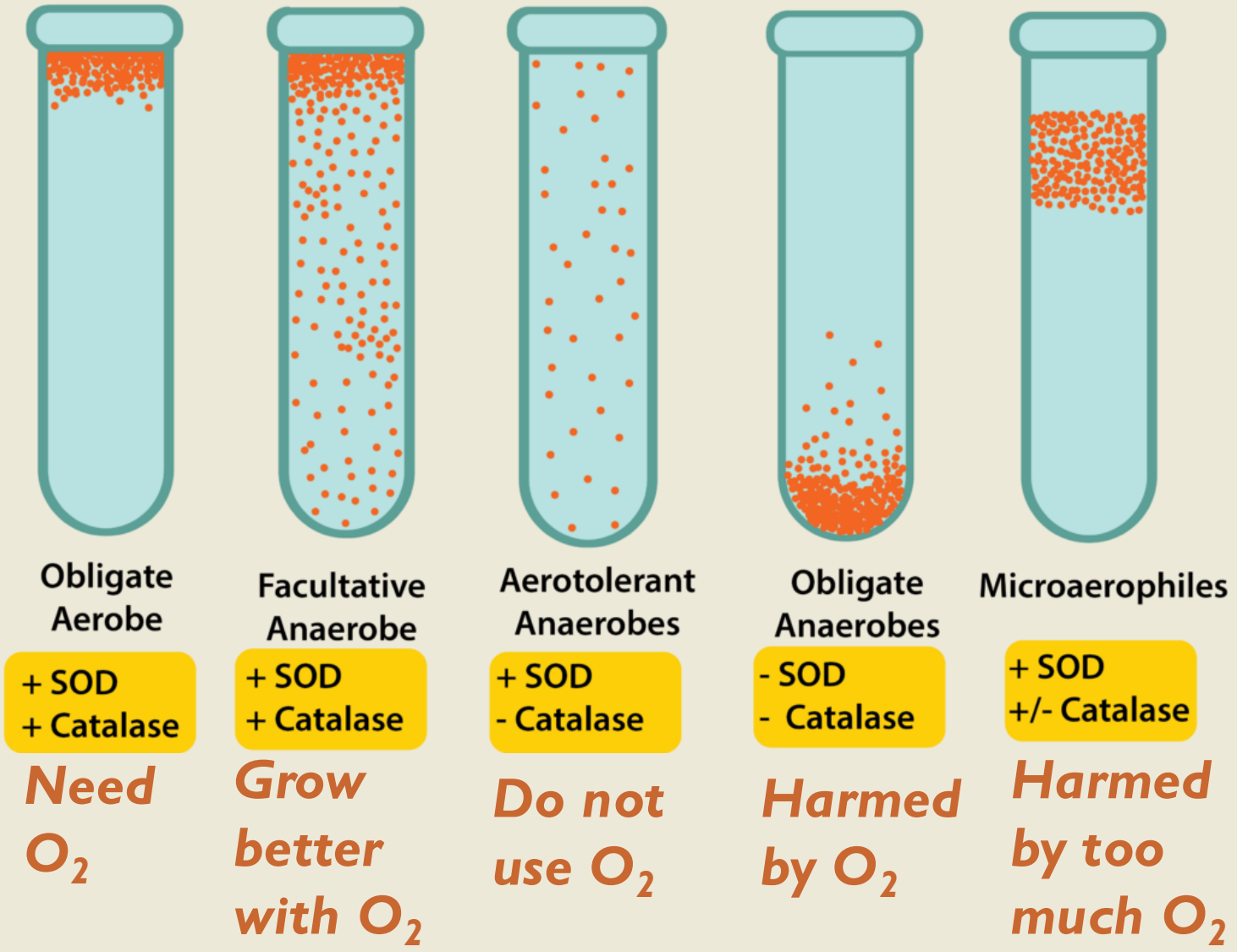
OXYGEN

Unlike most eukaryotes, many microbes can grow with or without oxygen, or require the absence of oxygen.



https://open.oregonstate.education/app/uploads/sites/54/2019/08/test-tubes-Recovered-1024x644.png

Low pH, or addition of a solute (salt, sugar) keeps microbes from growing. This is why many fermented foods, jams, salted fish, etc. do not need to be refrigerated.