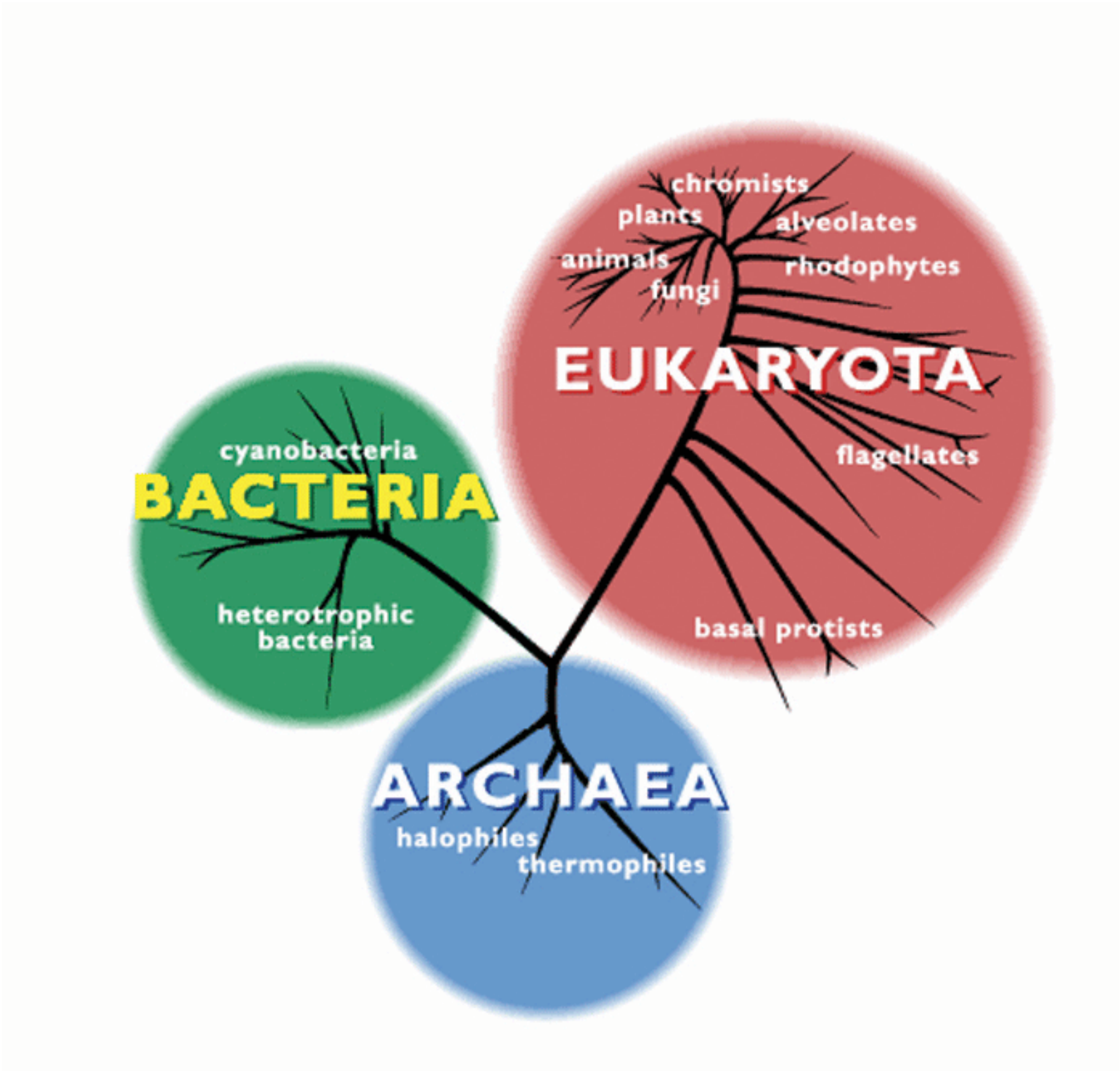
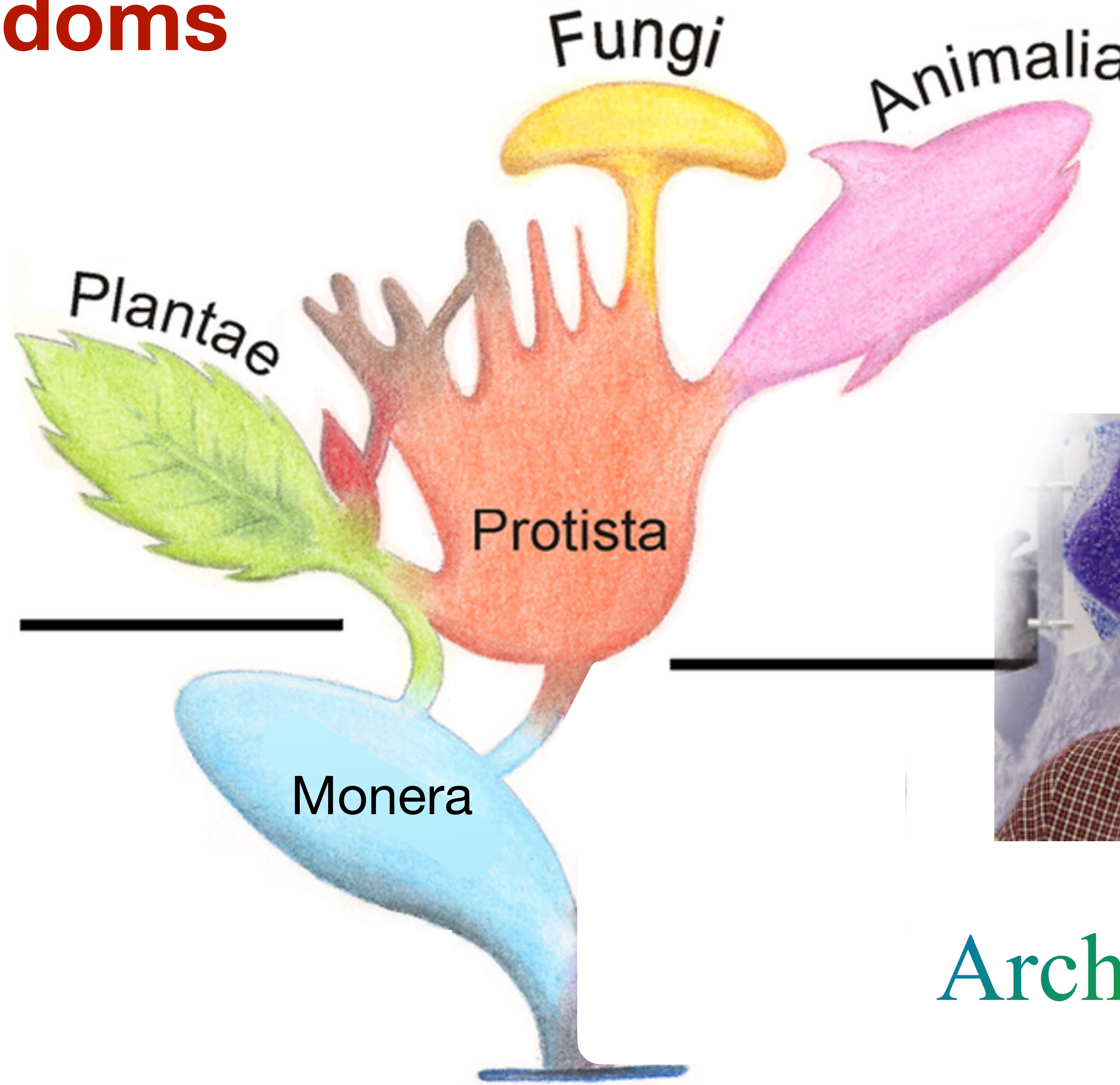
BIOL2107, Fall ’23

Lecture 8

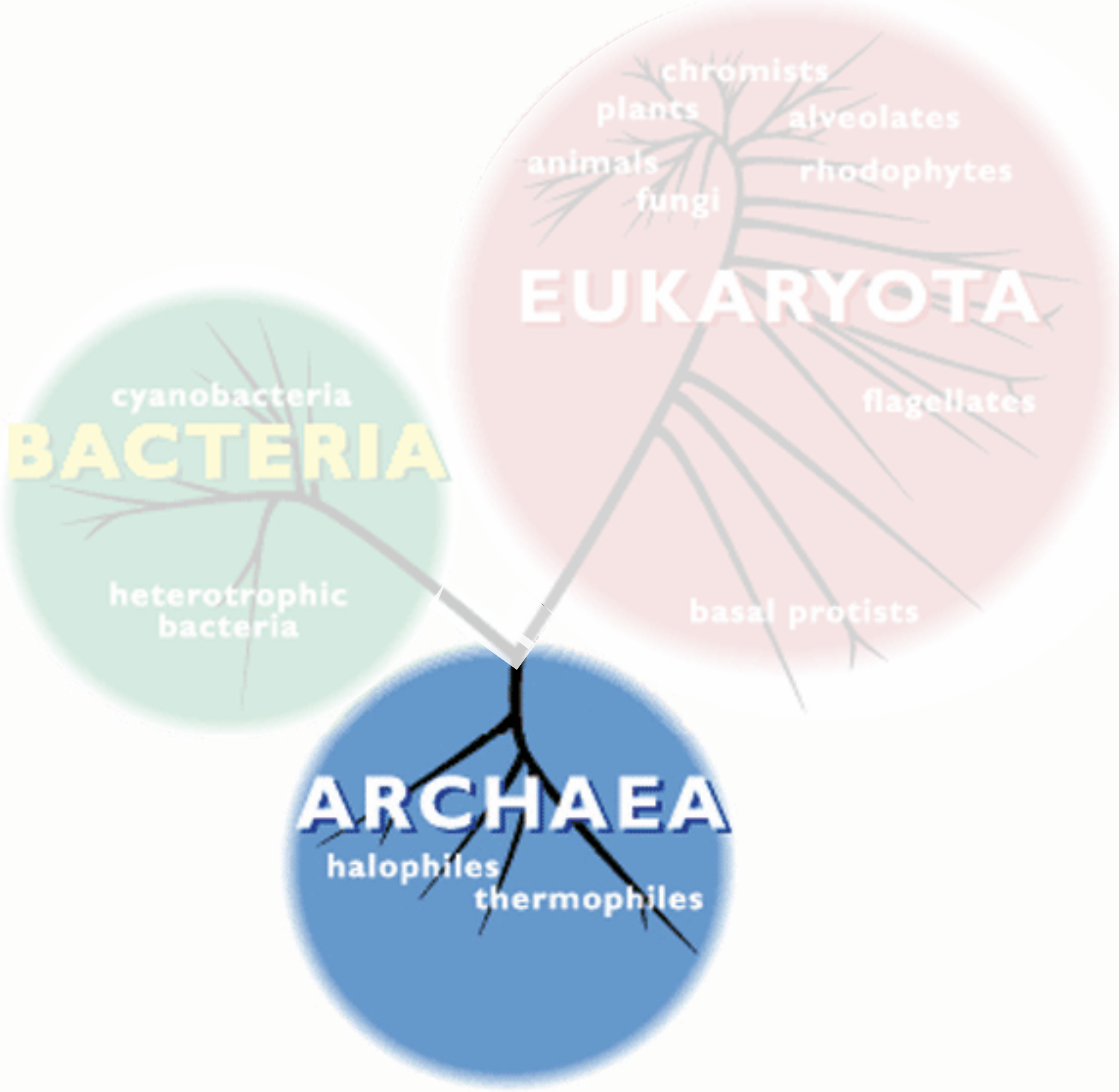


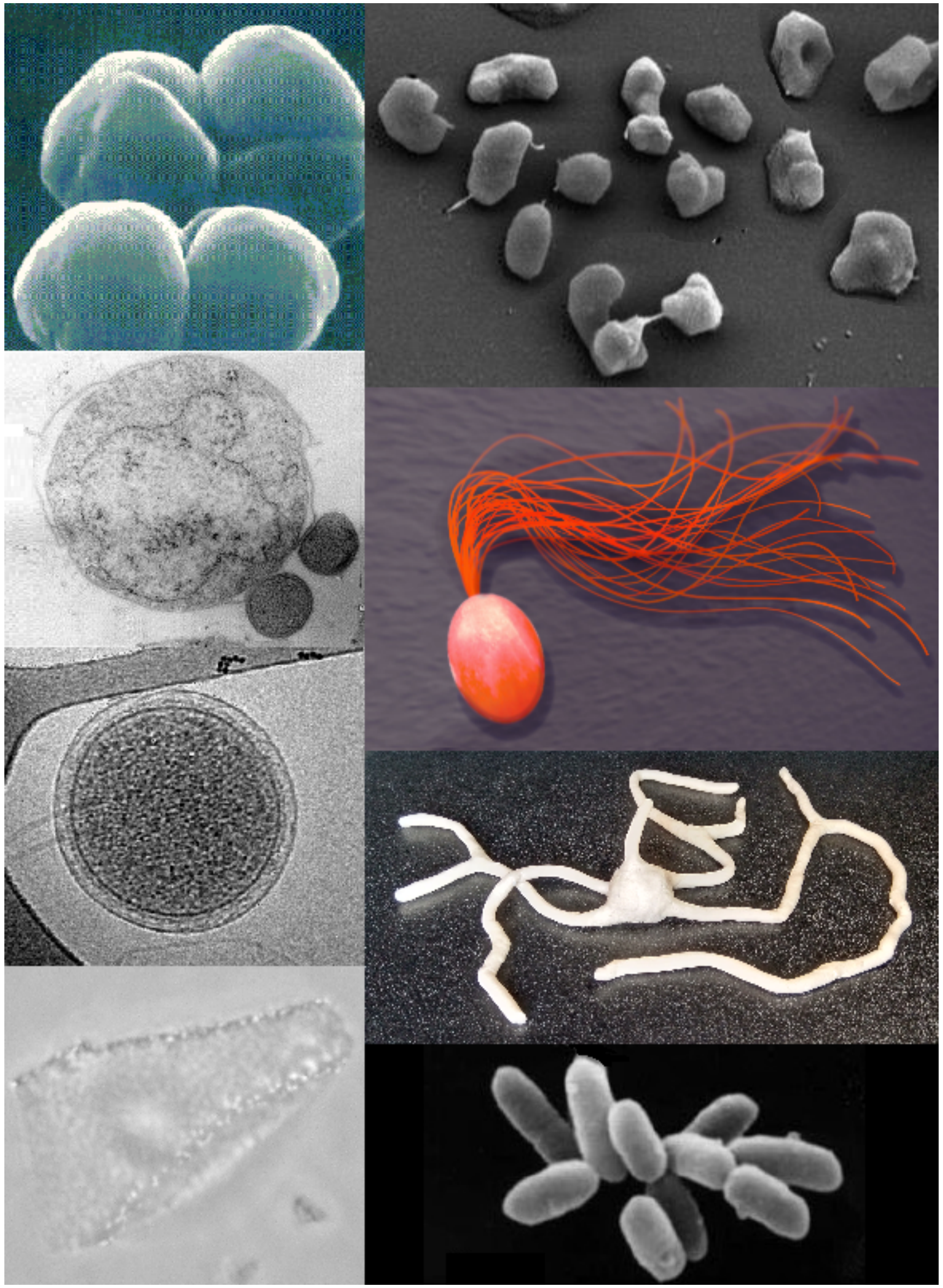
6 kingdoms

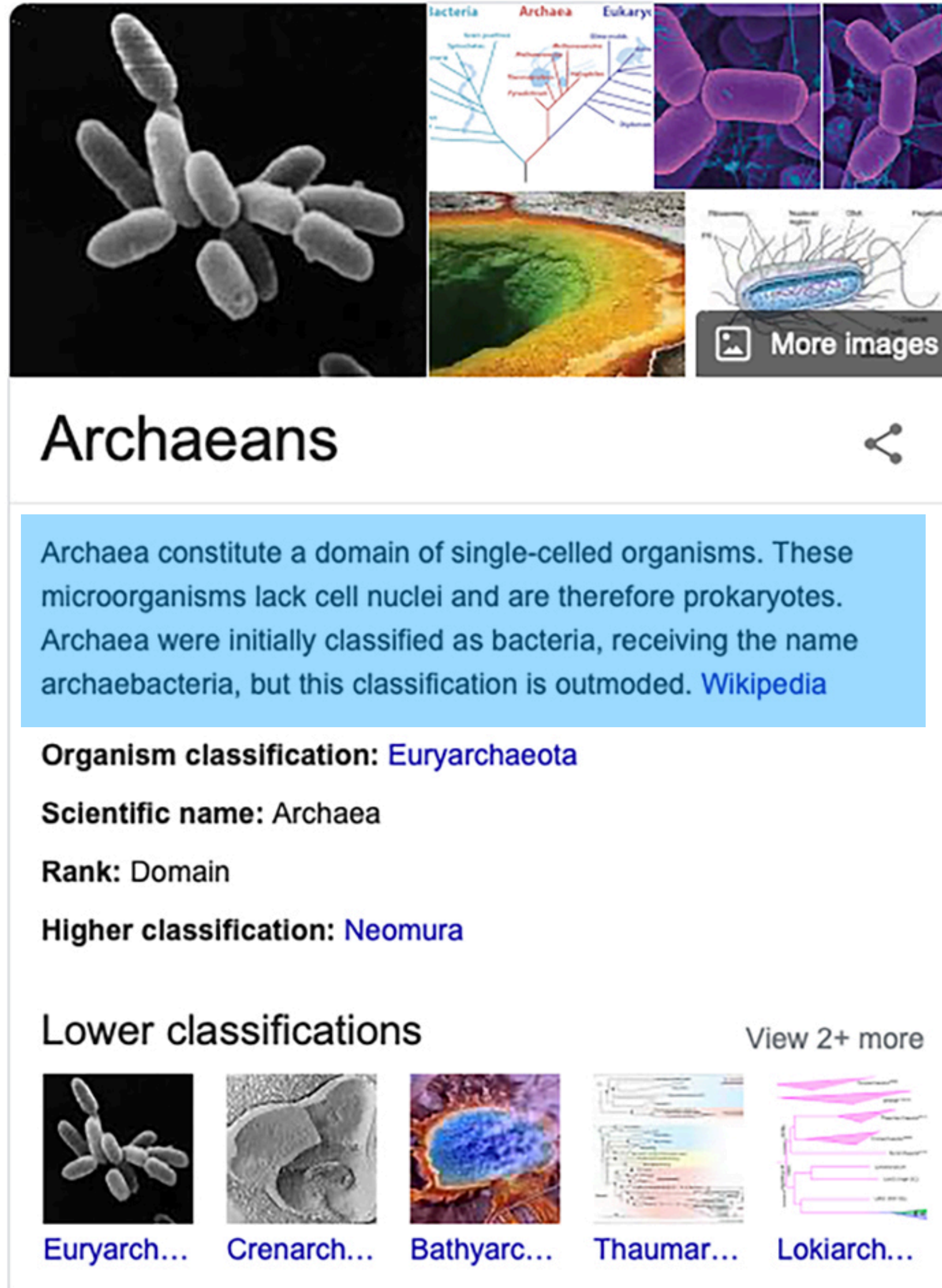


Carl Woes

Archaea


chromists
plants
alveolates
animals
rhodophytes
fungi
EUKARYOTA
flagellates
basal protists
cyanobacteria
BACTERIA
heterotrophic
bacteria
ARCHAEA
halophiles
thermophiles



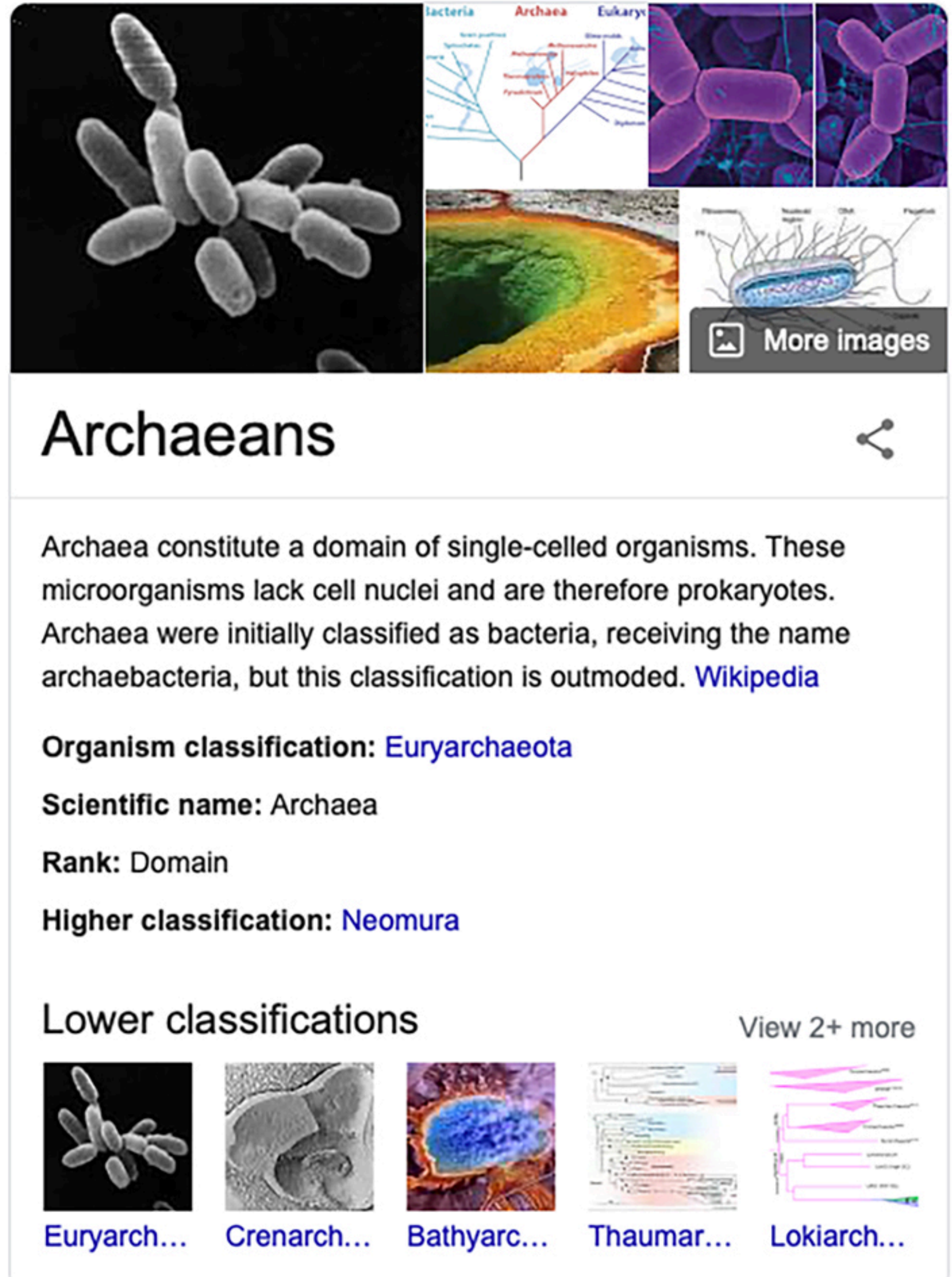

Bacteria
Archaea
More images
Archaeans
Archaea constitute a domain of single-celled organisms. These microorganisms lack cell nuclei and are therefore prokaryotes. Archaea were initially classified as bacteria, receiving the name archaebacteria, but this classification is outmoded. Wikipedia
Organism classification: Euryarchaeota
Scientific name: Archaea
Rank: Domain
Higher classification: Neomura
Lower classifications
View 2+ more
Euryarch…
Crenarch…
Bathyarc…
Thaumar…
Lokiarch…

X-TREME

Diversity of Archaea

Though archaeans are involved in many important ecological processes and present across Earth's ecosystems, they are most known for being **extremophiles**, existing in conditions that prevent most organisms from functioning:

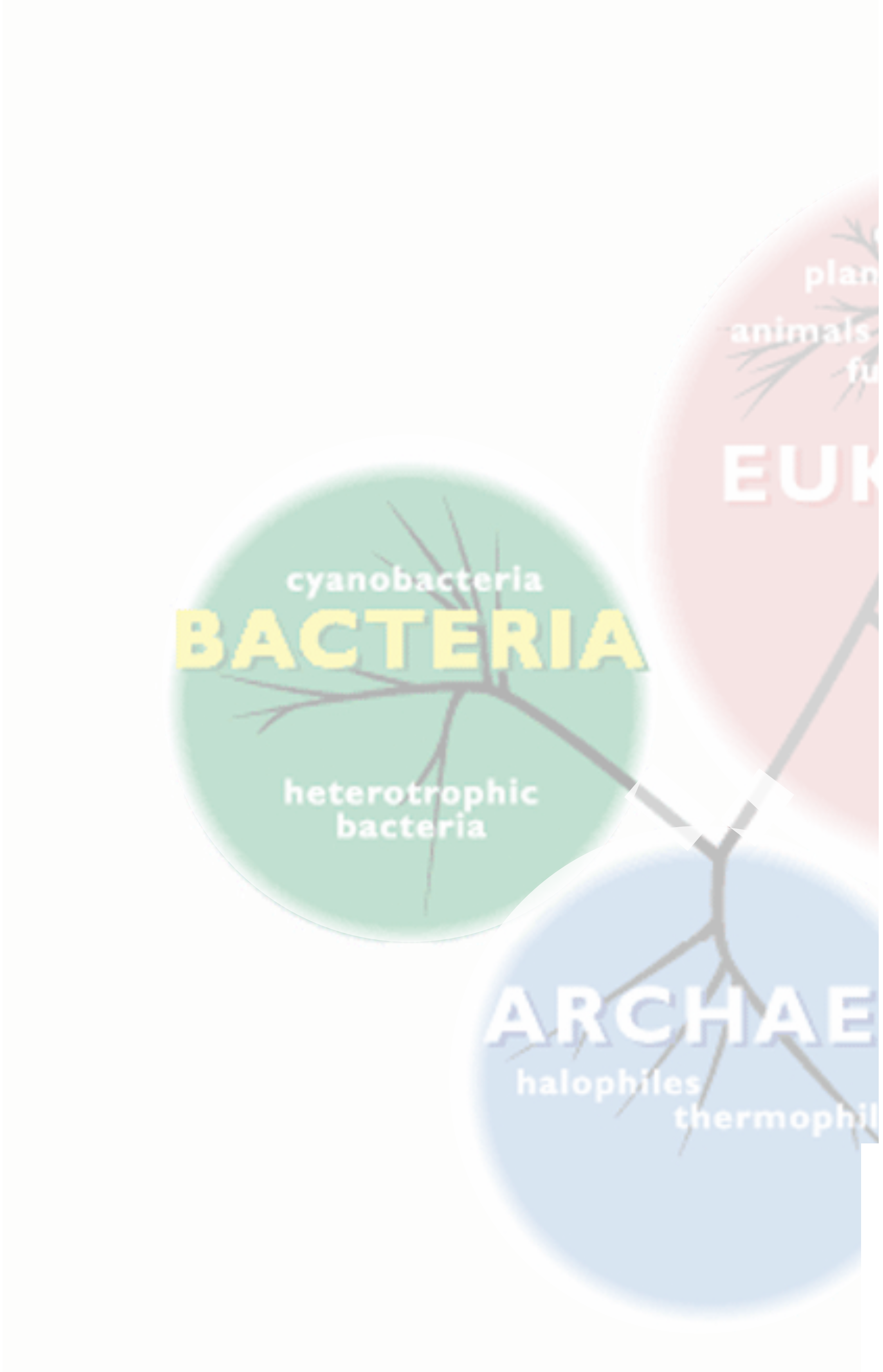
- **thermophiles** live at high temperatures
- **hyperthermophiles** live at really high temperatures (present record is 121°C!)
- **psychrophiles** (also called cryophiles) like it cold (one in the Antarctic grows best at 4°C)
- **halophiles** live in very saline environments (like the Dead Sea)
- **acidophiles** live at low pH (as low as pH 1 and who die at pH 7!)
- **alkaliphiles** thrive at a high pH.

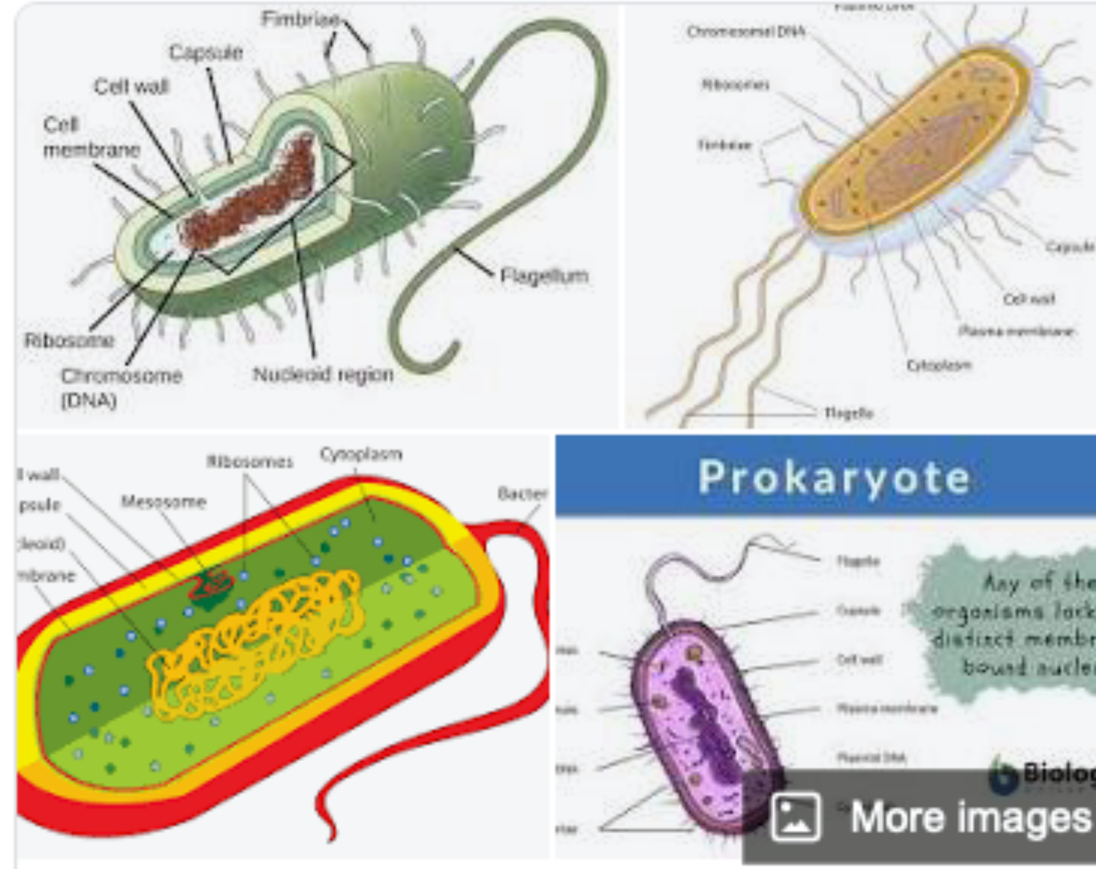


	Domain		
	Bacteria	**Archea**	**Eukarya**
Nucleus	absent	absent	present
Organelles	absent (?)	absent (?)	present
Peptidoglycan Wall	present	absent	absent
RNA polymerase	only one	several	several
Initiating tRNA amino acid	F-methionine	methionine	methionine
Introns	very rare	some	very common
Response to antibiotics strep and chloramphenicol	no growth	growth	growth
Circular chromosome	present	present	absent
Histones surround DNA	absent	some species	present
Growth at >100 C	No	some species	No

	Domain		
	Bacteria	Archea	Eukarya
Nucleus	absent	absent	present
Organelles	absent (?)	absent (?)	present
Peptidoglycan Wall	present	absent	absent
RNA polymerase	only one	several	several
Initiating tRNA amino acid	F-methionine	methionine	methionine
Introns	very rare	some	very common
Response to antibiotics strep and chloramphenicol	no growth	growth	growth
Circular chromosome	present	present	absent
Histones surround DNA	absent	some species	present
Growth at >100 C	No	some species	No

	Domain		
	Bacteria	**Archea**	**Eukarya**
Nucleus	absent	absent	present
Organelles	absent (?)	absent (?)	present
Peptidoglycan Wall	present	absent	absent
RNA polymerase	only one	several	several
Initiating tRNA amino acid	F-methionine	methionine	methionine
Introns	very rare	some	very common
Response to antibiotics strep and chloramphenicol	no growth	growth	growth
Circular chromosome	present	present	absent
Histones surround DNA	absent	some species	present
Growth at >100 C	No	some species	No





Prokaryote

A prokaryote is a typically unicellular organism that lacks a nuclear membrane-enclosed nucleus. The word prokaryote comes from the Greek πρό and κάρυον. In the two-empire system arising from the work of Édouard Chatton, prokaryotes were classified within the empire Prokaryota. Wikipedia

Bacteria prokaryotic

View 35+ more

Cyanoba… Spirocha… Escheric… Proteoba…

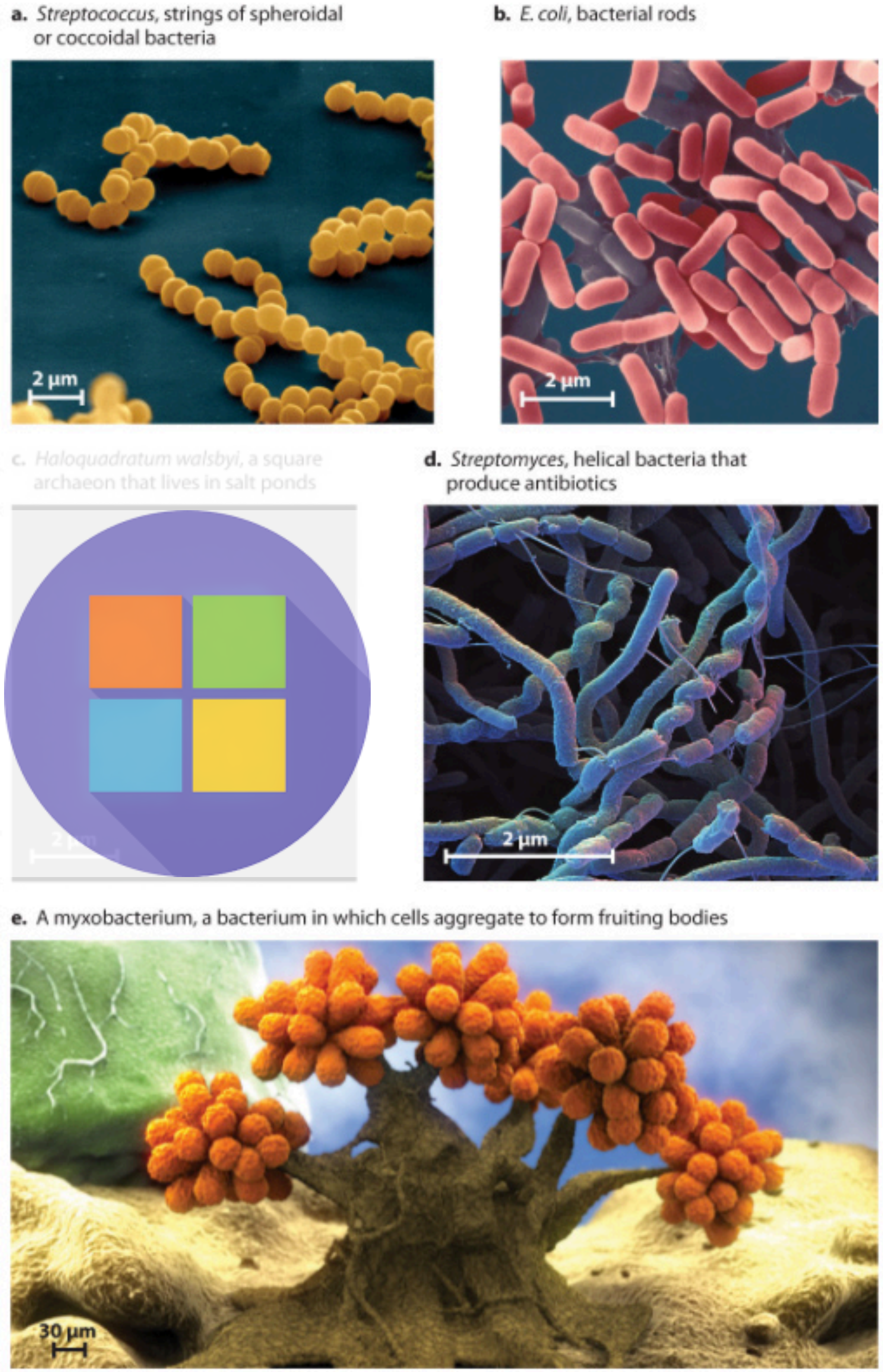
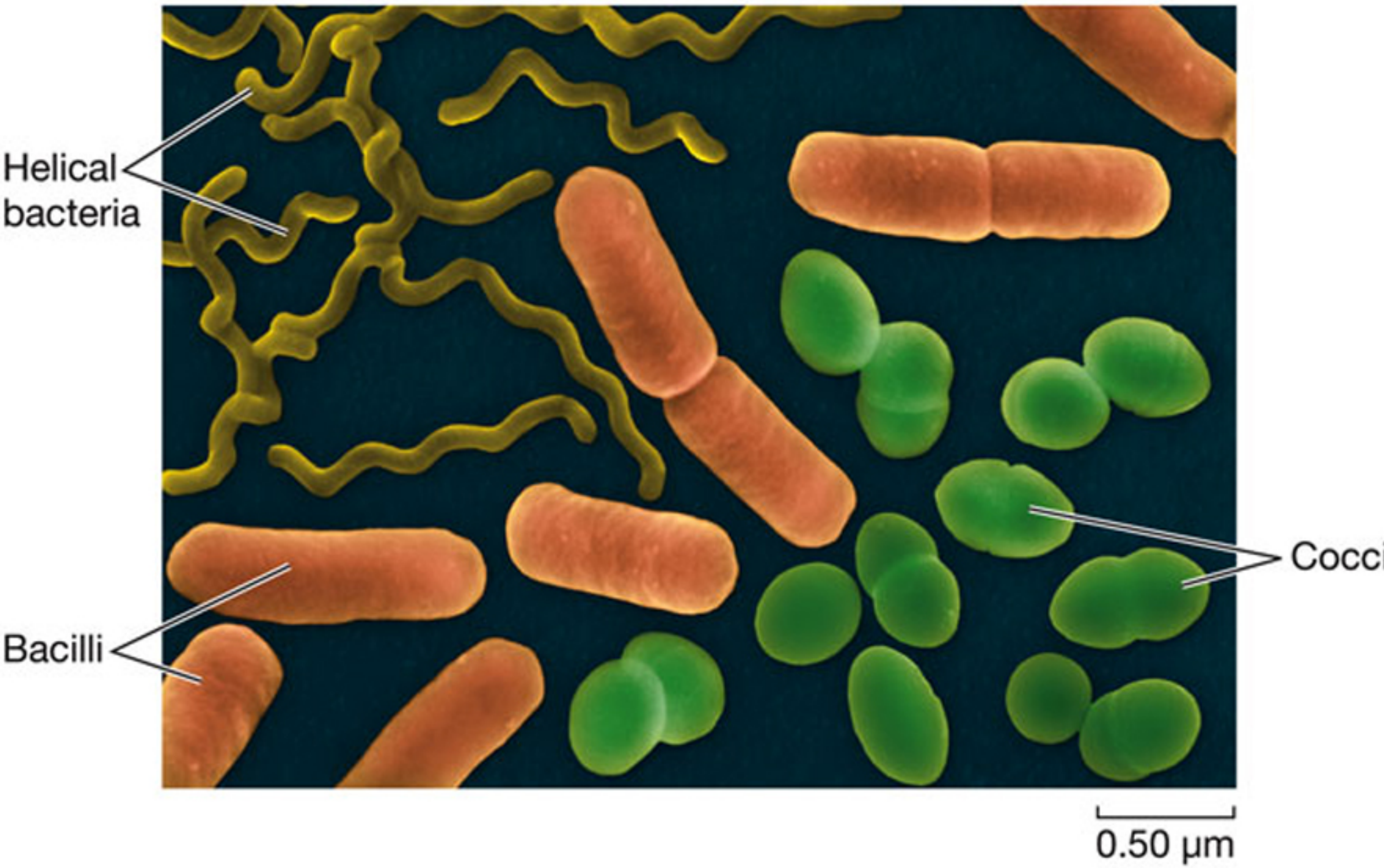
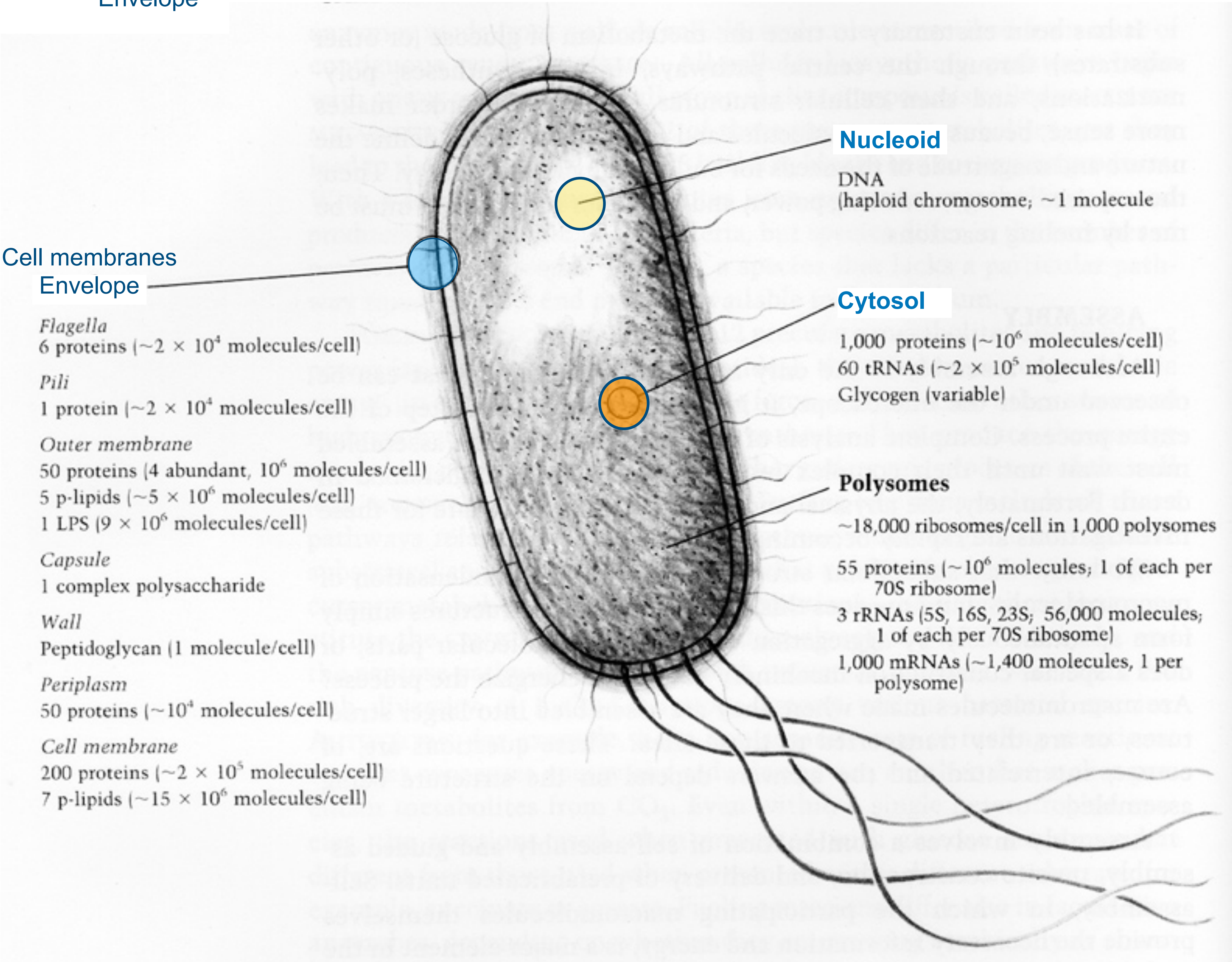
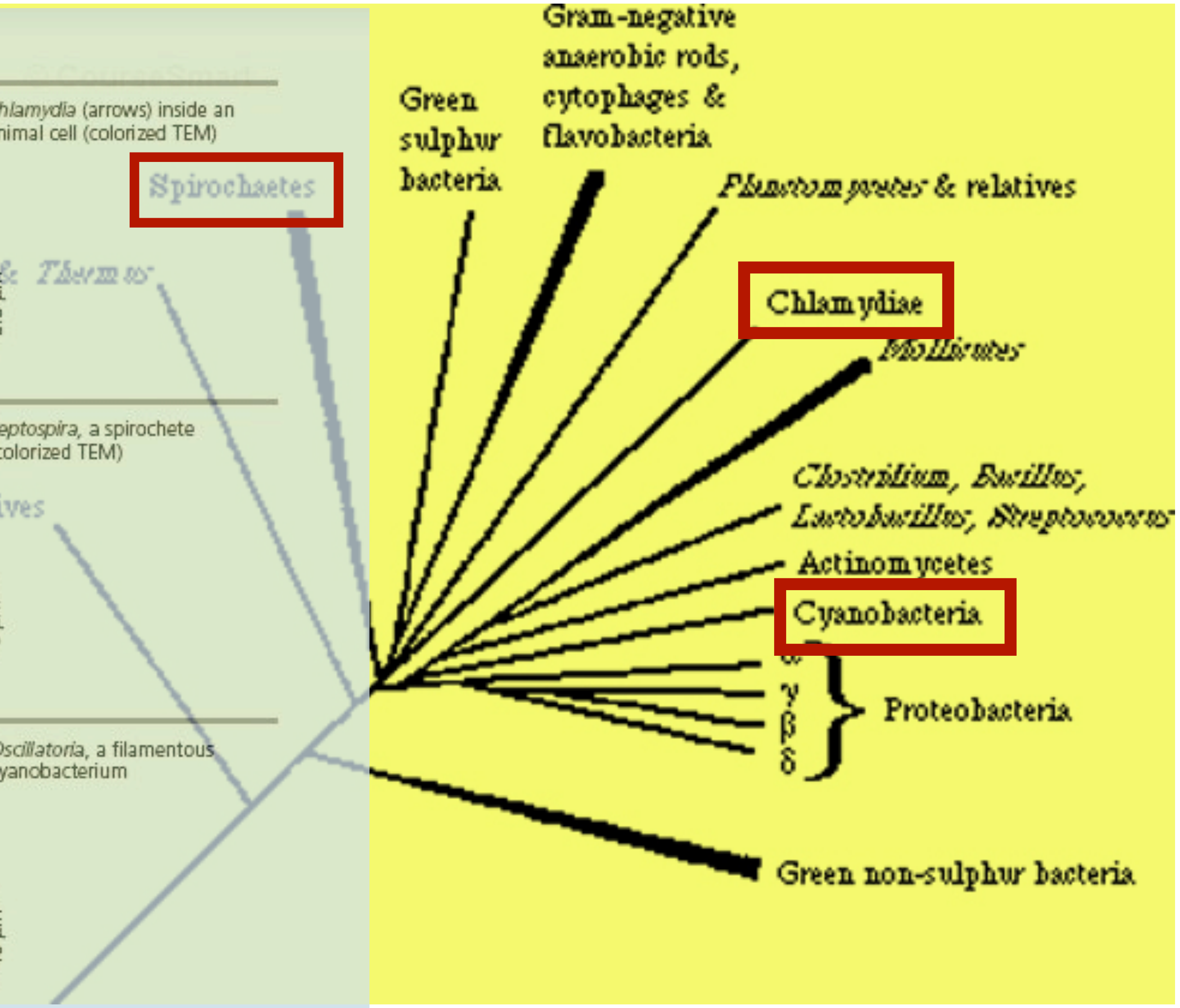


Figure 26.2: Cell shape and size in Bacteria and Archaea.


Helical bacteria
Cocci
Bacilli
0.50 µm

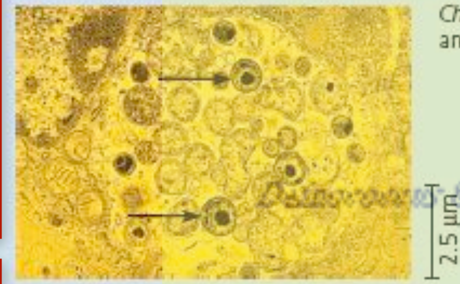
Cell membranes
Envelope





Chlamydias

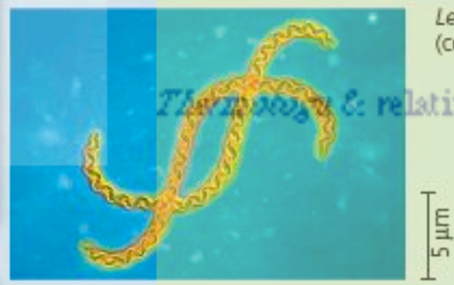
These parasites can survive only within animal cells, depending on their hosts for resources as basic as ATP. The gram-negative walls of chlamydias are unusual in that they lack peptidoglycan. One species, *Chlamydia trachomatis*, is the most common cause of blindness in the world and also causes nongonococcal urethritis, the most common sexually transmitted disease in the United States.



Chlamydia (arrows) inside an animal cell (colorized TEM)

Spirochetes

These helical heterotrophs spiral through their environment by means of rotating, internal, flagellum-like filaments. Many spirochetes are free-living, but others are notorious pathogenic parasites: *Treponema pallidum* causes syphilis, and *Borrelia burgdorferi* causes Lyme disease (see Figure 27.20).



Leptospira, a spirochete (colorized TEM)

Cyanobacteria

These photoautotrophs are the only prokaryotes with plantlike, oxygen-generating photosynthesis. (In fact, as we'll discuss in Chapter 28, chloroplasts likely evolved from an endosymbiotic cyanobacterium.) Both solitary and filamentous cyanobacteria are abundant components of freshwater and marine *phytoplankton*, the collection of photosynthetic organisms that drift near the water's surface. Some filaments have cells specialized for nitrogen fixation, the process that incorporates atmospheric N_2 into inorganic compounds that can be used in the synthesis of amino acids and other organic molecules (see Figure 27.14).

Oscillatoria, a filamentous cyanobacterium

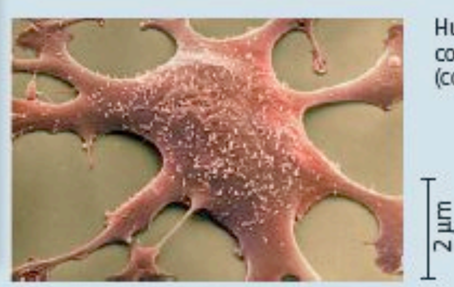
Gram-Positive Bacteria

Gram-positive bacteria rival the proteobacteria in diversity. Species in one subgroup, the actinomycetes (from the Greek *mykes*, fungus, for which these bacteria were once mistaken), form colonies containing branched chains of cells. Two species of actinomycetes cause tuberculosis and leprosy. However, most actinomycetes are free-living species that help decompose the organic matter in soil; their secretions are partly responsible for the "earthy" odor of rich soil. Soil-dwelling species in the genus *Streptomyces* (top) are cultured by pharmaceutical companies as a source of many antibiotics, including streptomycin.

Gram-positive bacteria include many solitary species, such as *Bacillus anthracis* (see Figure 27.9), which causes anthrax, and *Clostridium botulinum*, which causes botulism. The various species of *Staphylococcus* and *Streptococcus* are also gram-positive bacteria.

Mycoplasmas (bottom) are the only bacteria known to lack cell walls. They are also the tiniest known cells, with diameters as small as 0.1 µm, only about five times as large as a ribosome. Mycoplasmas have small genomes—*Mycoplasma genitalium* has only 517 genes, for example. Many mycoplasmas are free-living soil bacteria, but others are pathogens.

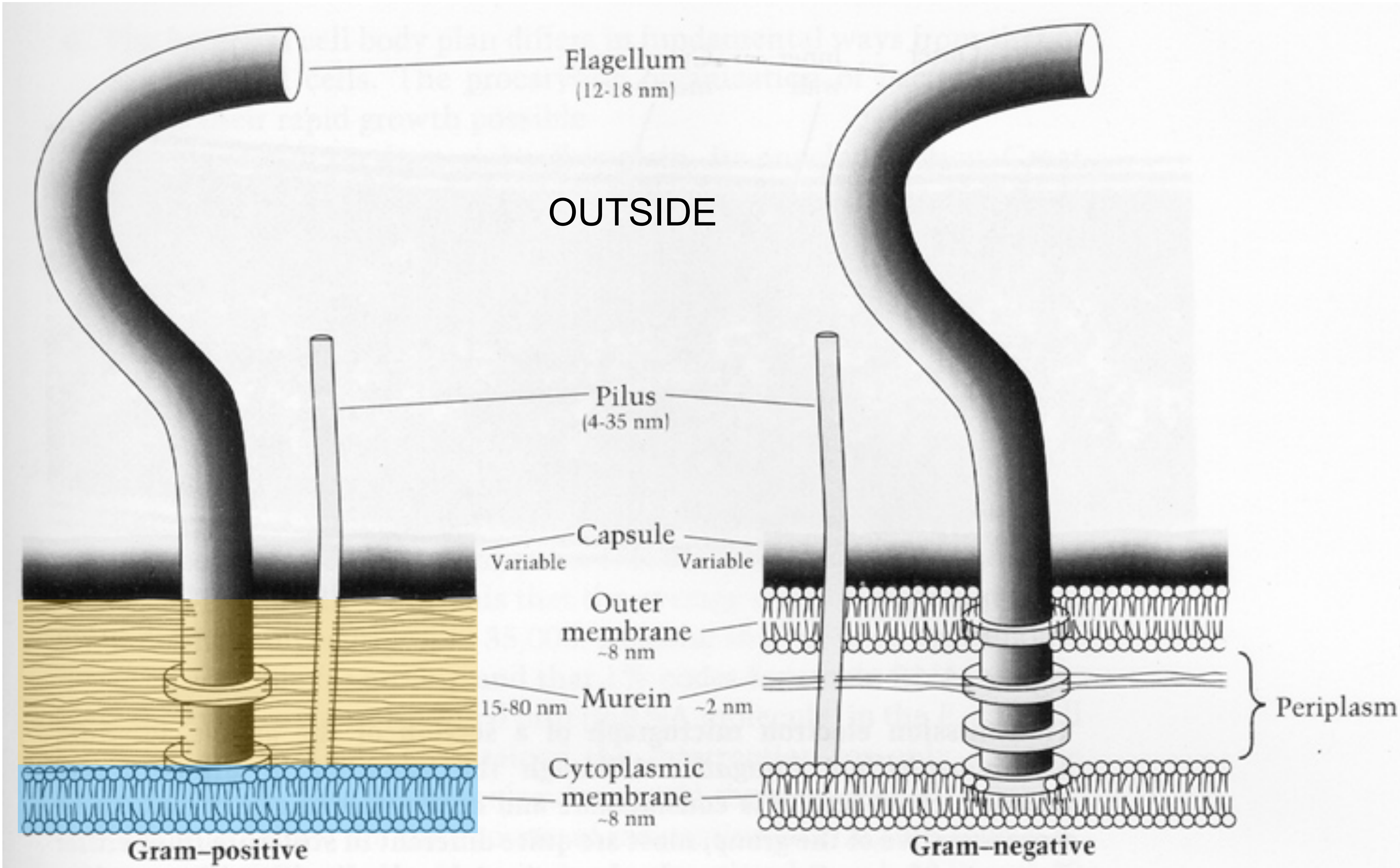
Streptomyces, the source of many antibiotics (SEM)



Hundreds of mycoplasmas covering a human fibroblast cell (colorized SEM)

Gram Stain

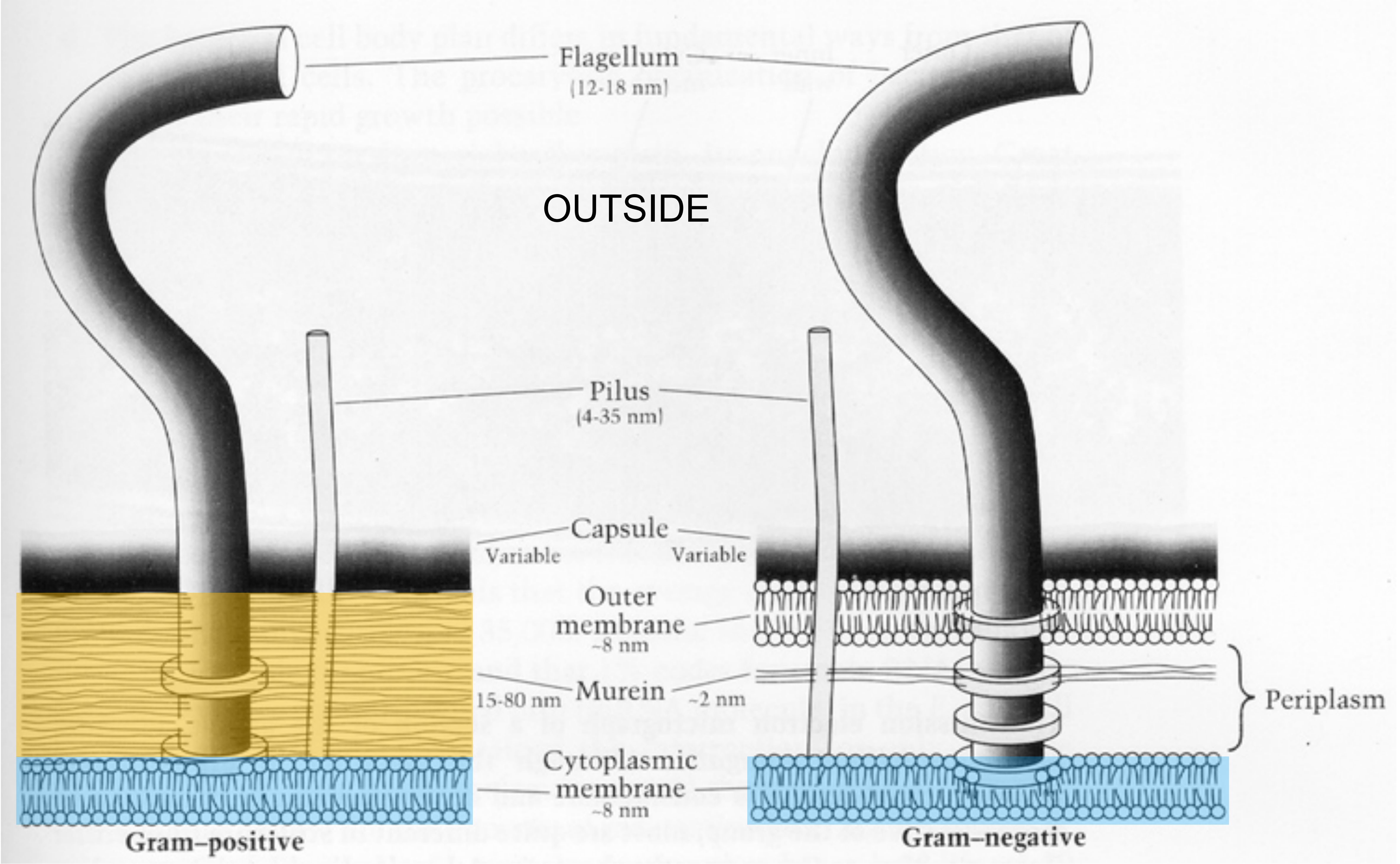
Gram negative **Gram positive**



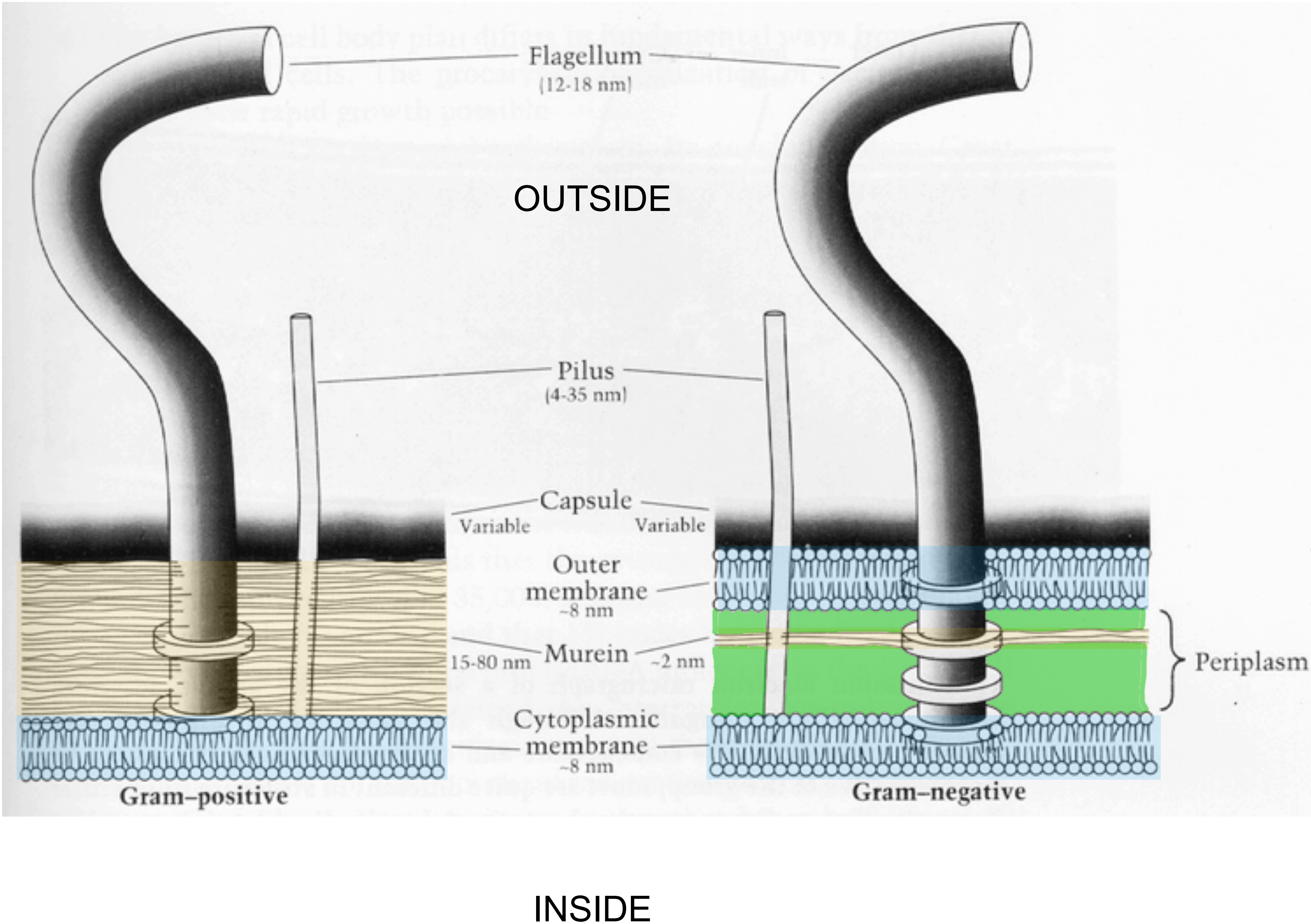
OUTSIDE
Flagellum
(12-18 nm)
Pilus
(4-35 nm)
Capsule
Variable
Variable
Outer
membrane
~8 nm
Murein
15-80 nm
~2 nm
Periplasm
Cytoplasmic
membrane
~8 nm
Gram–positive
Gram–negative

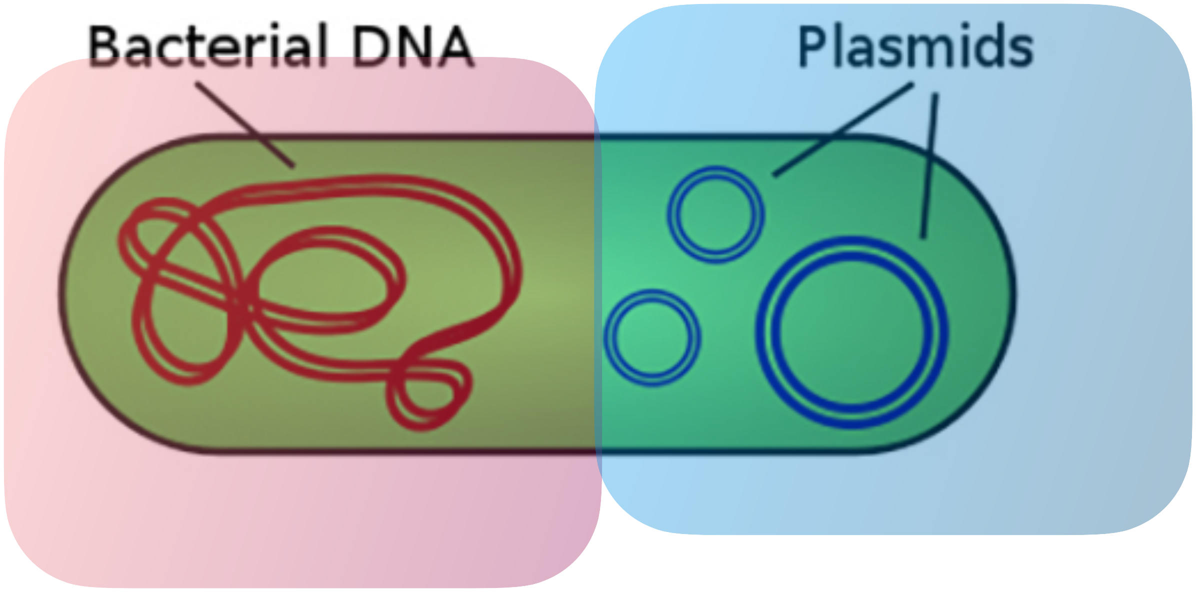
INSIDE

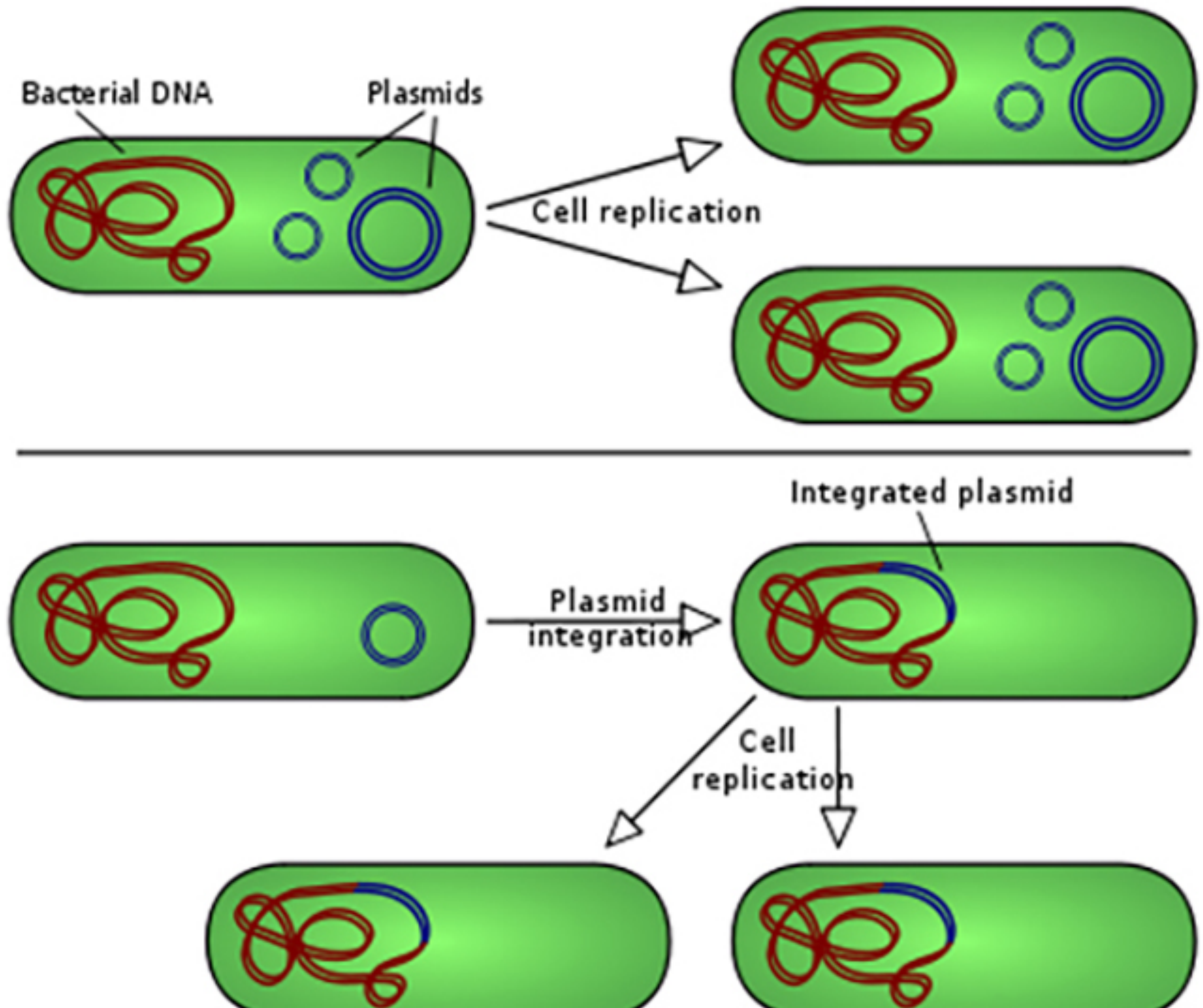
OUTSIDE



INSIDE


OUTSIDE
Flagellum
(12-18 nm)
Pilus
(4-35 nm)
Capsule
Variable
Variable
Outer
membrane
~8 nm
Murein
15-80 nm
~2 nm
Periplasm
Cytoplasmic
membrane
~8 nm
Gram–positive
Gram–negative
INSIDE


Bacterial DNA
Plasmids


Bacterial DNA
Plasmids
Cell replication
Integrated plasmid
Plasmid integration
Cell replication

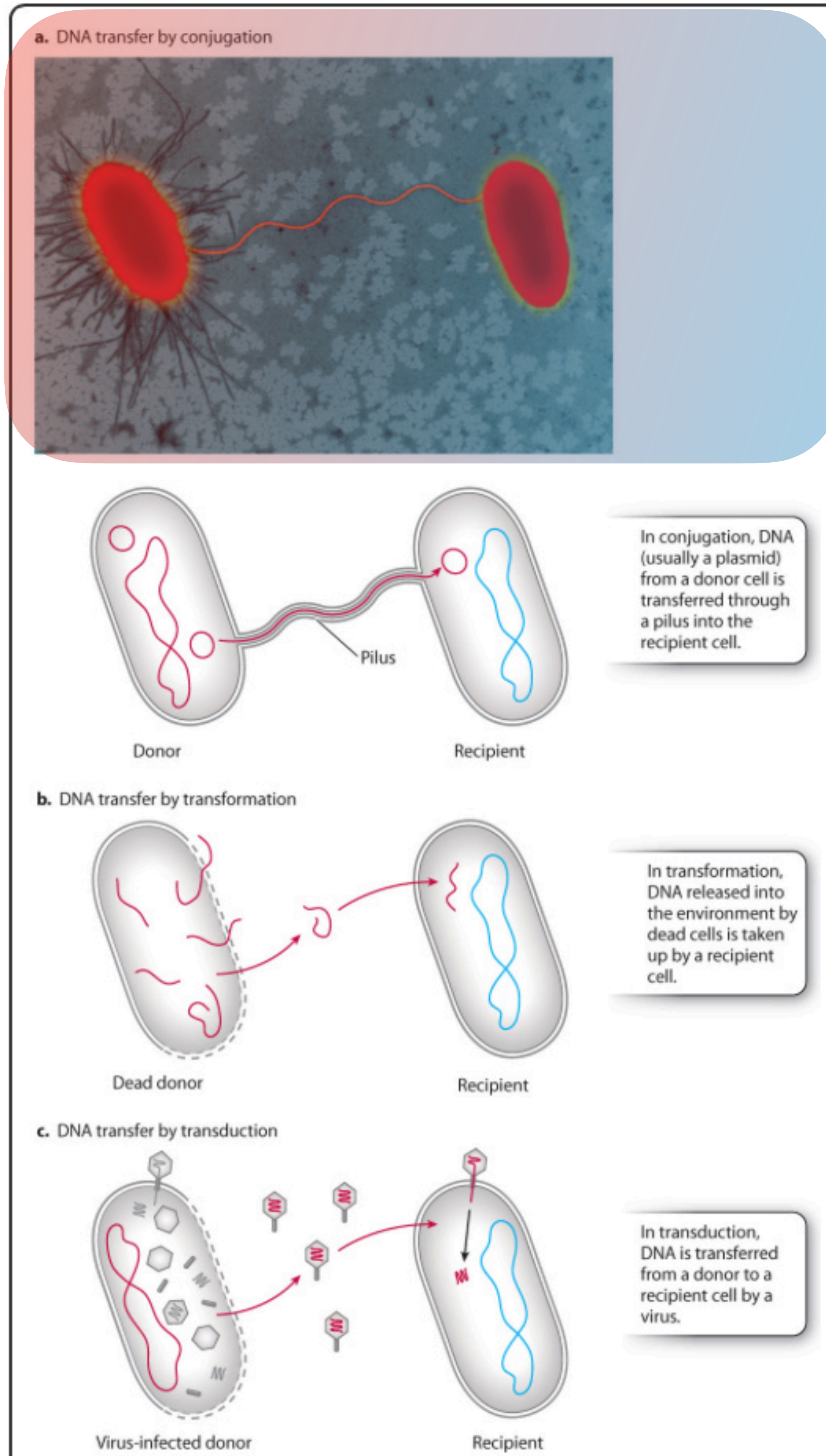


Figure 26.4: Horizontal gene transfer in bacteria. DNA shown in red originates from the donor cell. DNA shown in blue is that of the recipient cell.

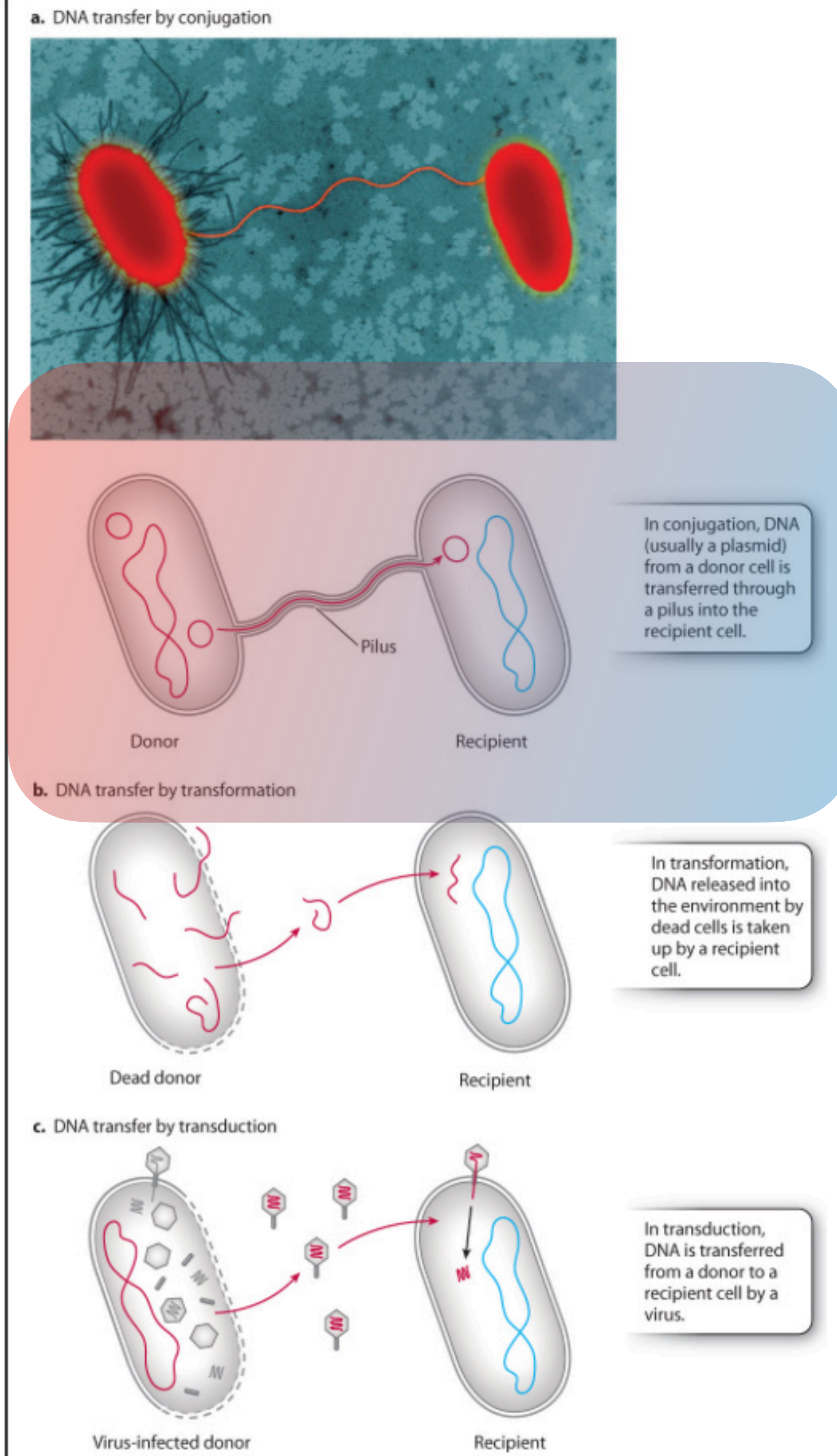


Figure 26.4: Horizontal gene transfer in bacteria. DNA shown in red originates from the donor cell. DNA shown in blue is that of the recipient cell.

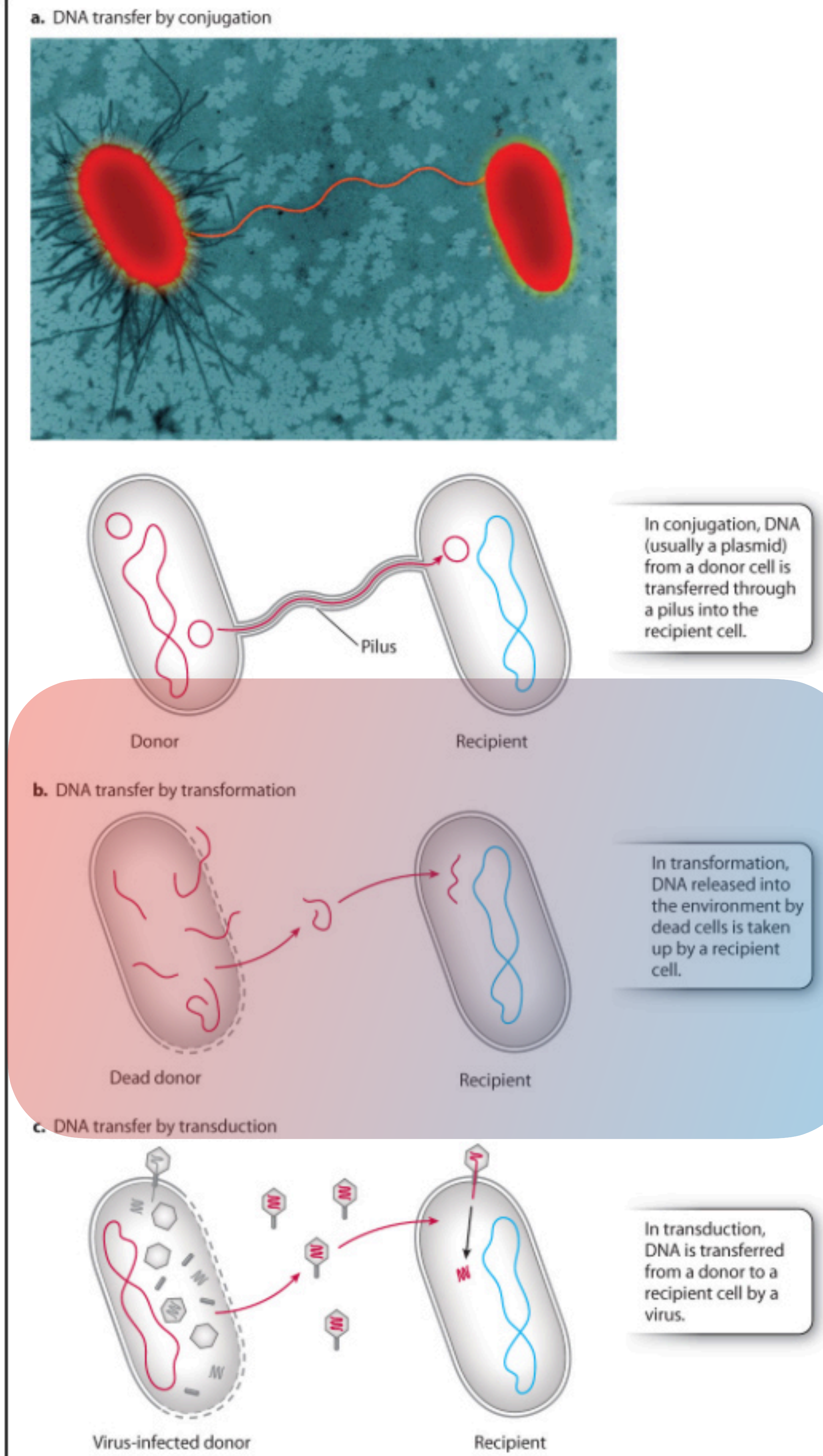


Figure 26.4: Horizontal gene transfer in bacteria. DNA shown in red originates from the donor cell. DNA shown in blue is that of the recipient cell.

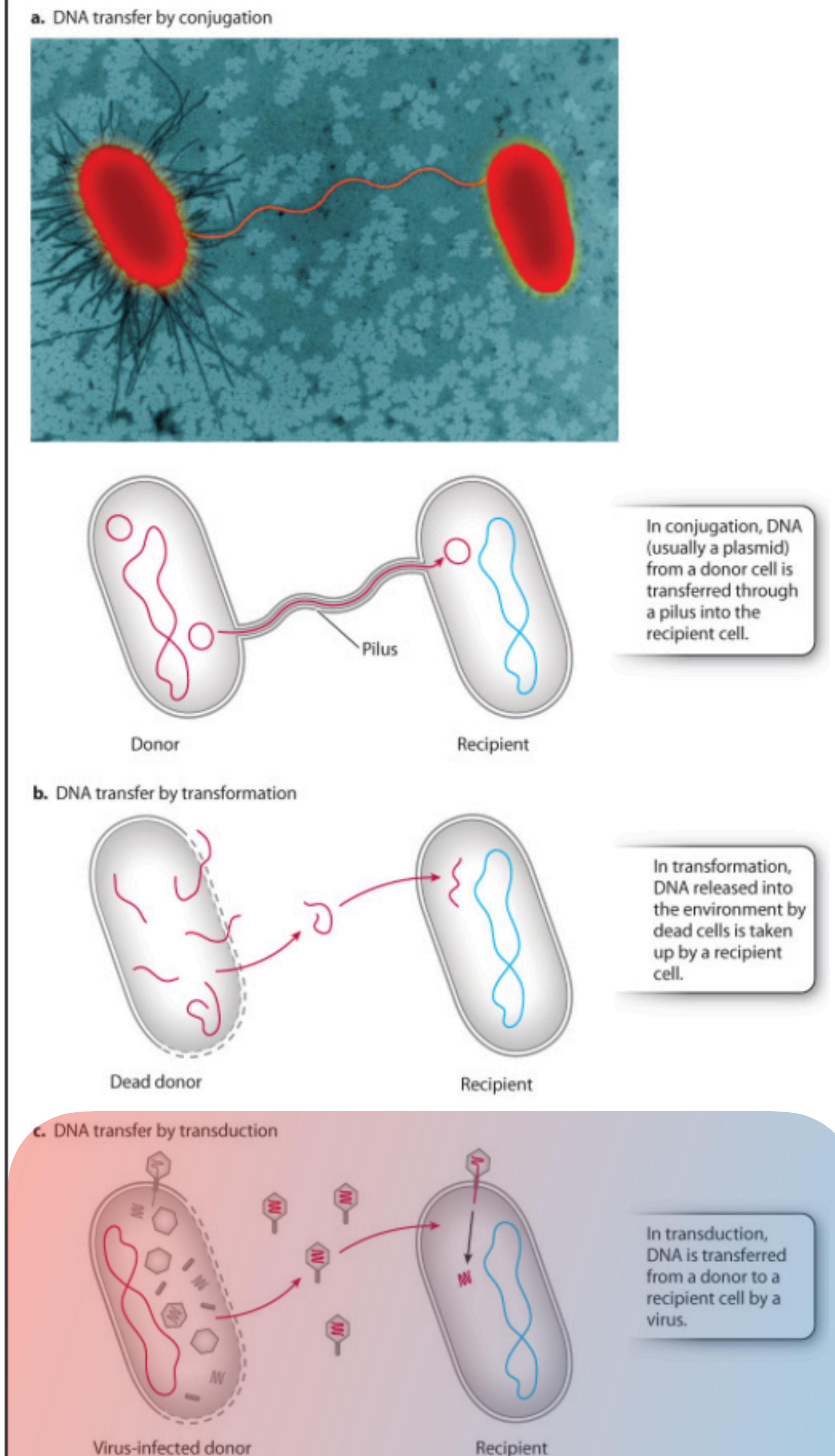
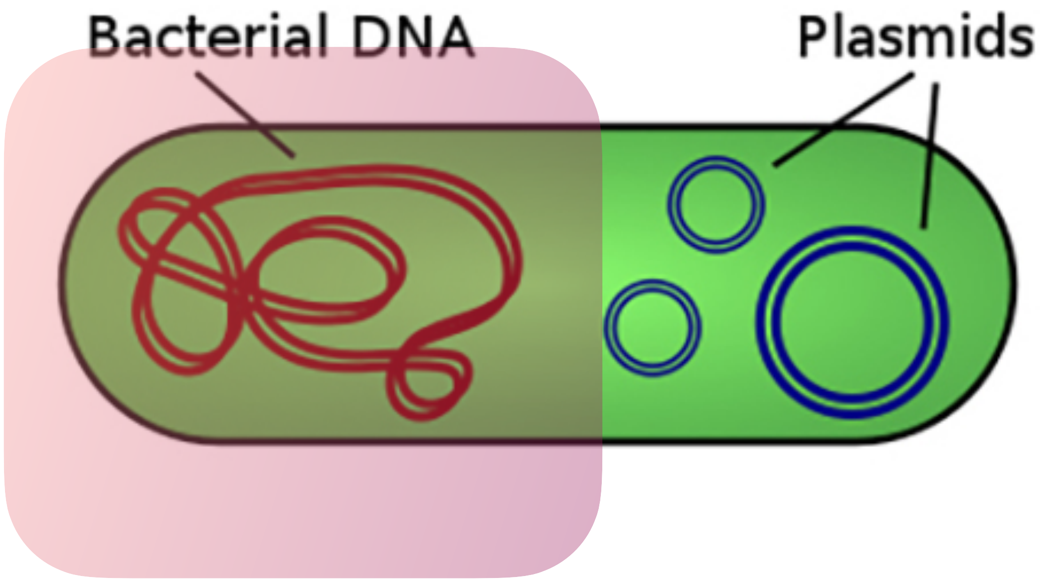
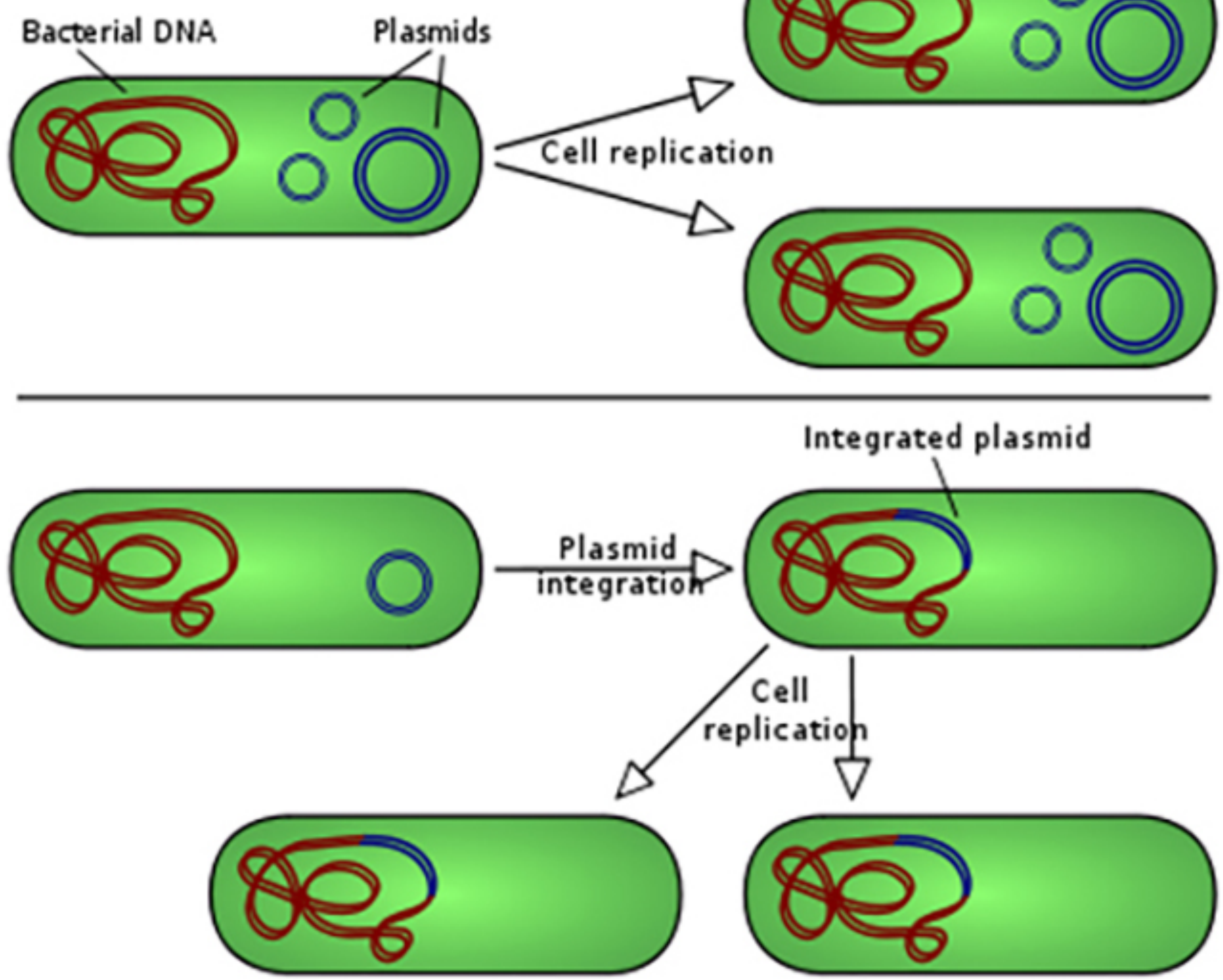


Figure 26.4: Horizontal gene transfer in bacteria. DNA shown in red originates from the donor cell. DNA shown in blue is that of the recipient cell.


Bacterial DNA
Plasmids


Bacterial DNA
Plasmids
Cell replication
Integrated plasmid
Plasmid integration
Cell replication

1. The circular bacterial DNA molecule is attached by proteins to the inner membrane (red).

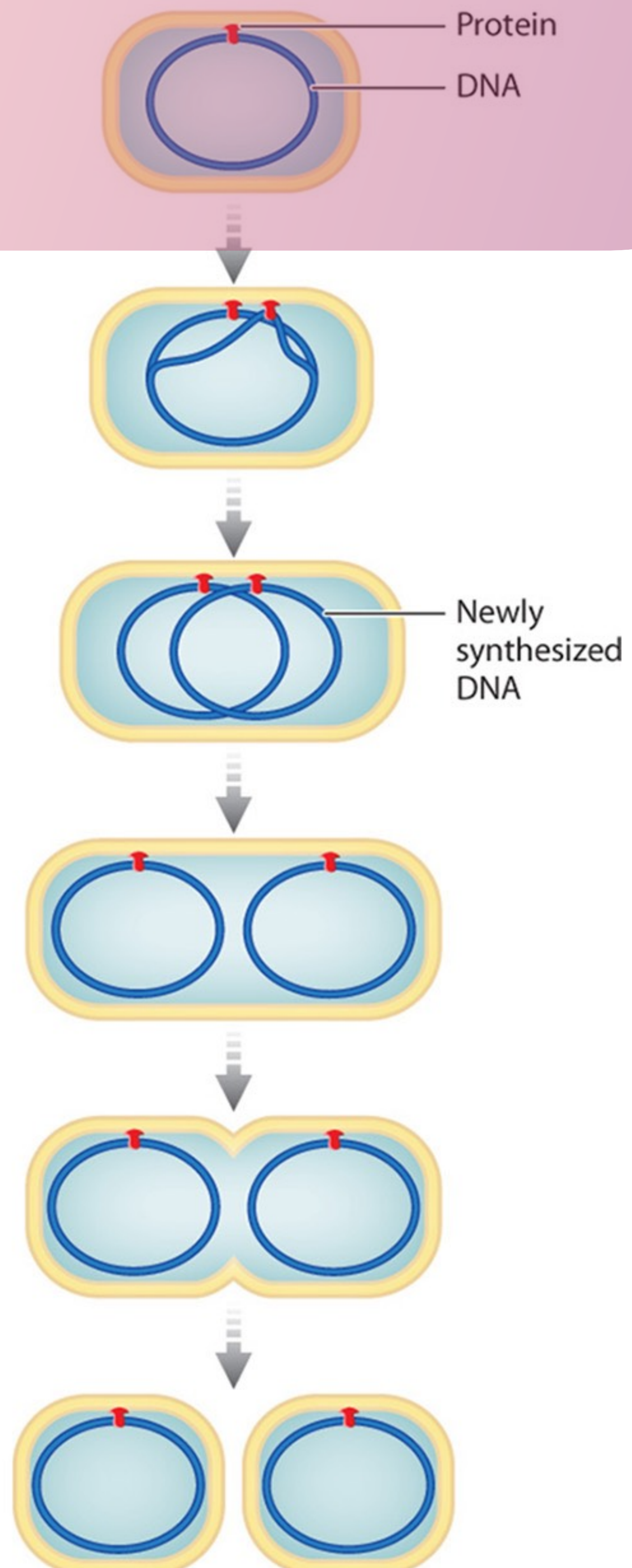
2. DNA replication begins at a specific location and proceeds bidirectionally around the circle.

3. The newly synthesized DNA molecule is also attached to the inner membrane, near the attachment site of the initial molecule.

4. As replication proceeds, the cell elongates symmetrically around the midpoint, separating the DNA attachment sites.

5. Cell division begins with the synthesis of new membrane and wall material at the midpoint.

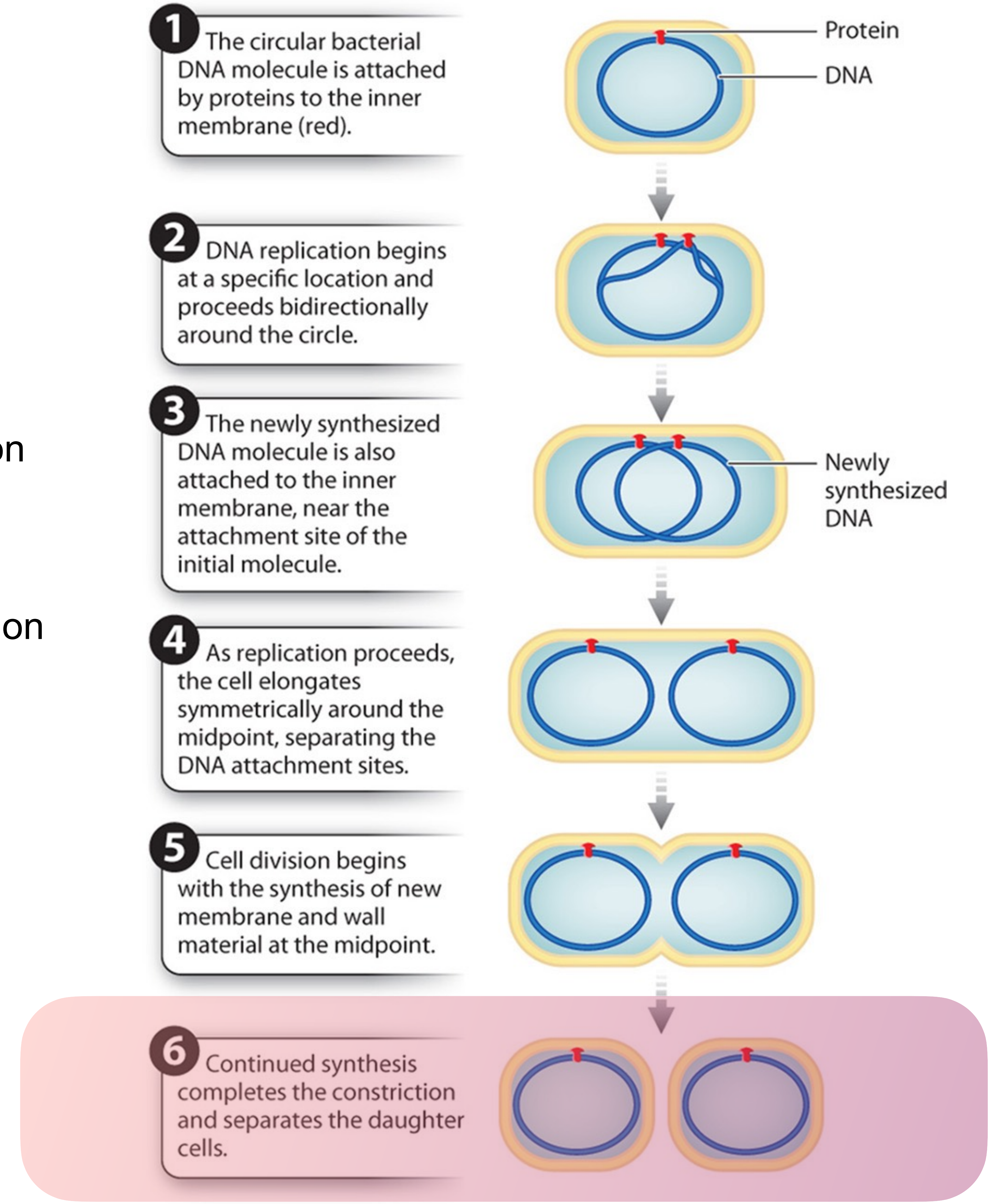
6. Continued synthesis completes the constriction and separates the daughter cells.



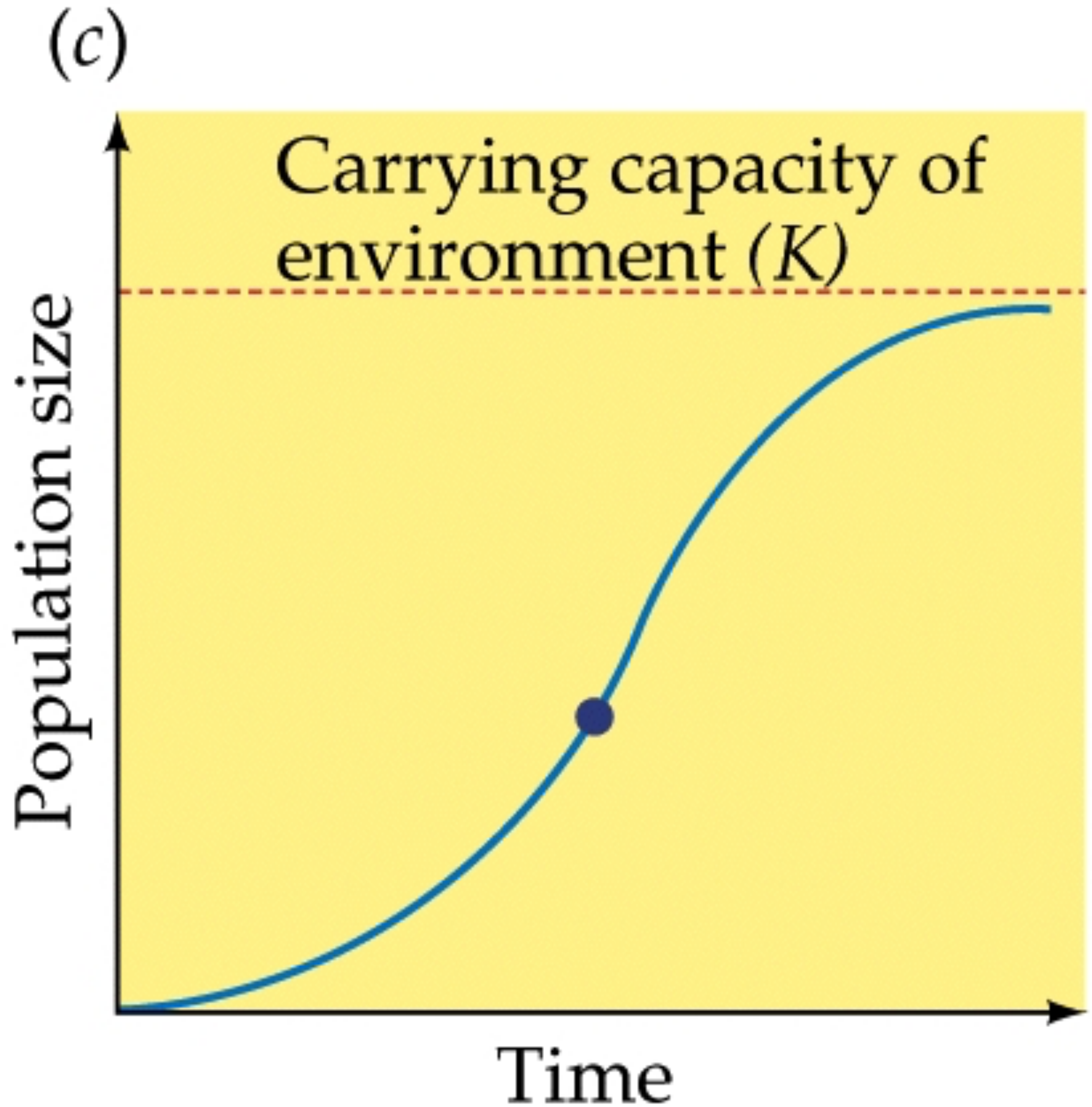
Cell Division

by

Simple Fission



https://www.youtube.com/watch?v=KIpcCyuypzg&t=6s



Theoretical Population Growth
-with No limitations.

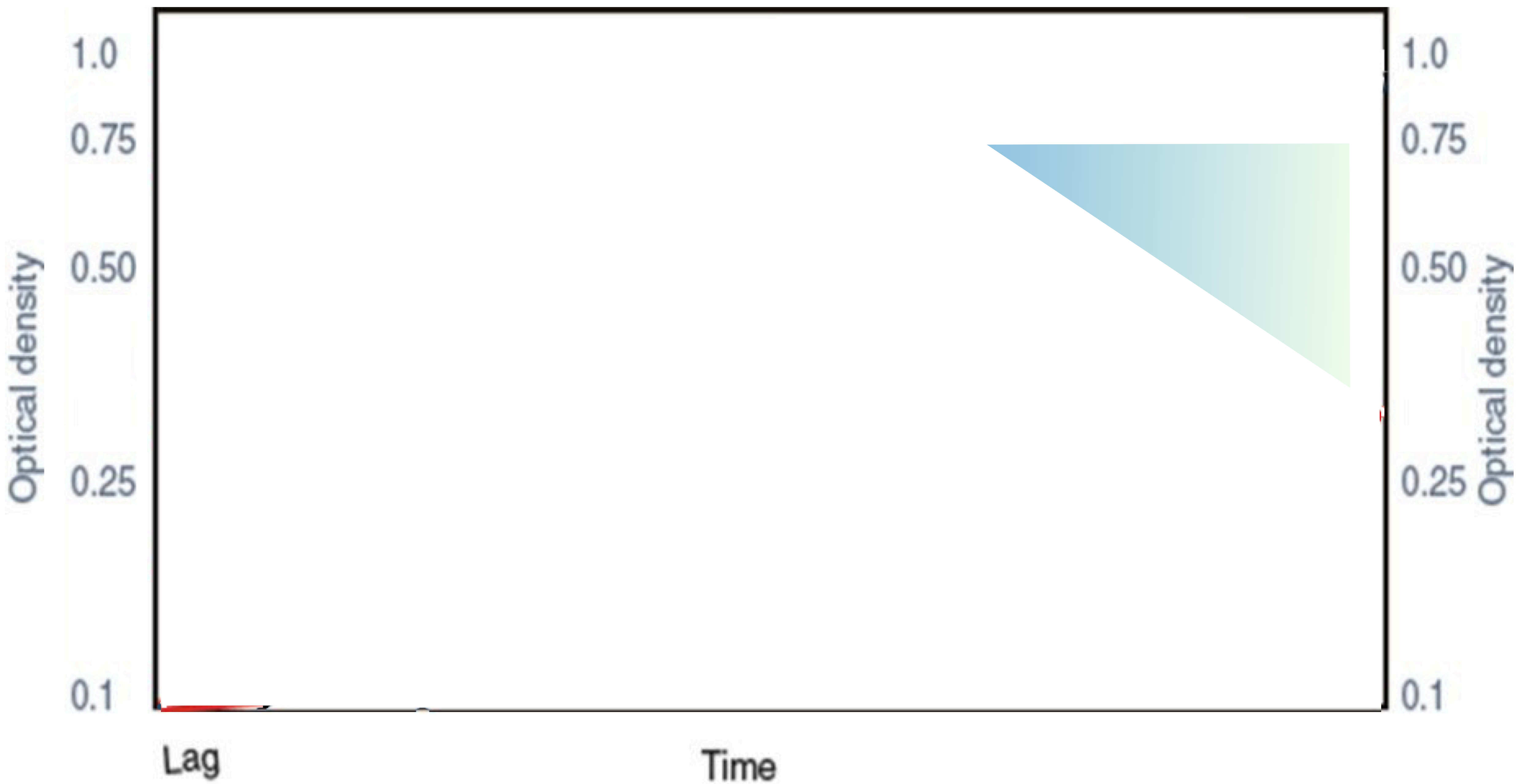
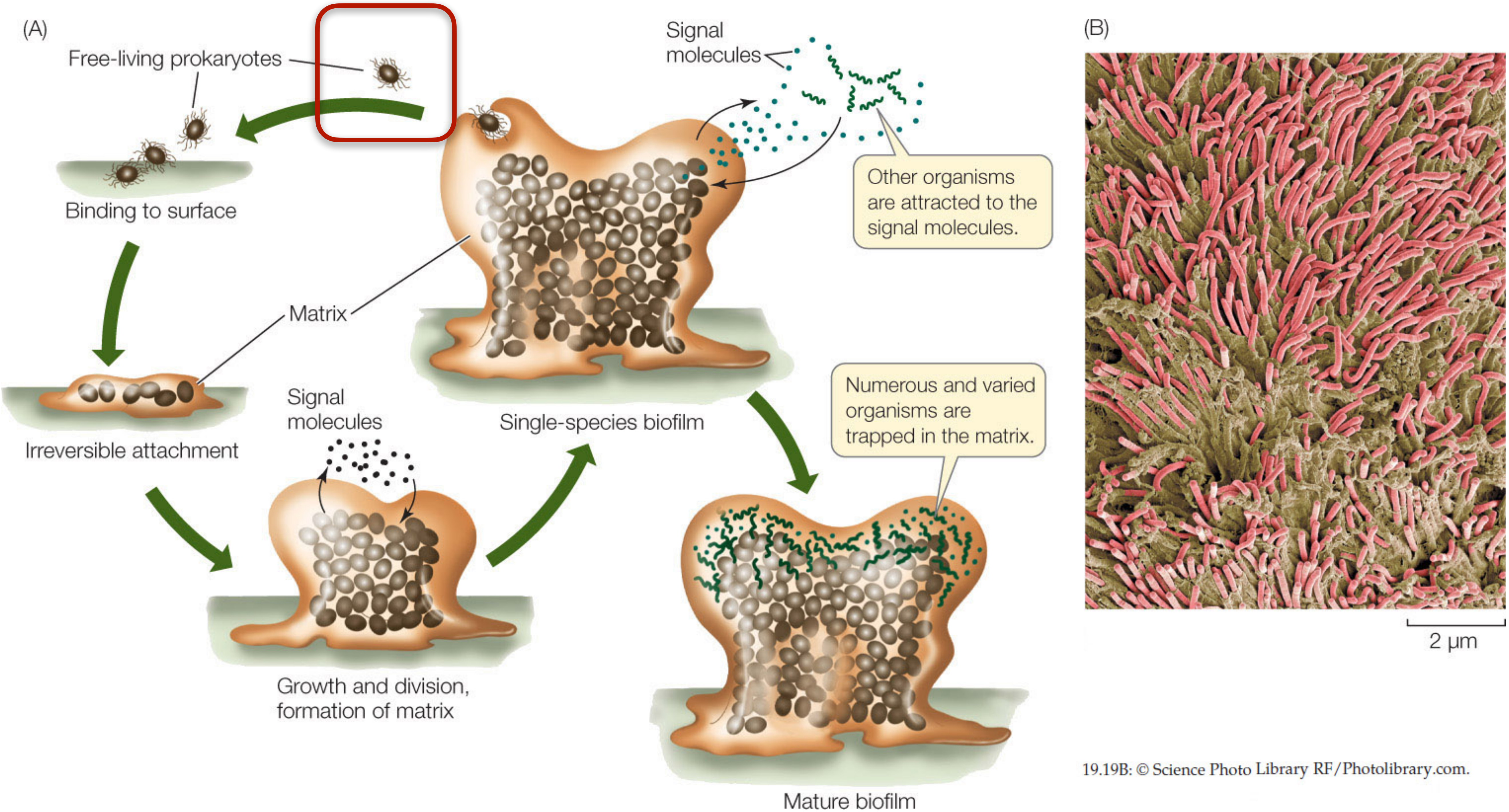


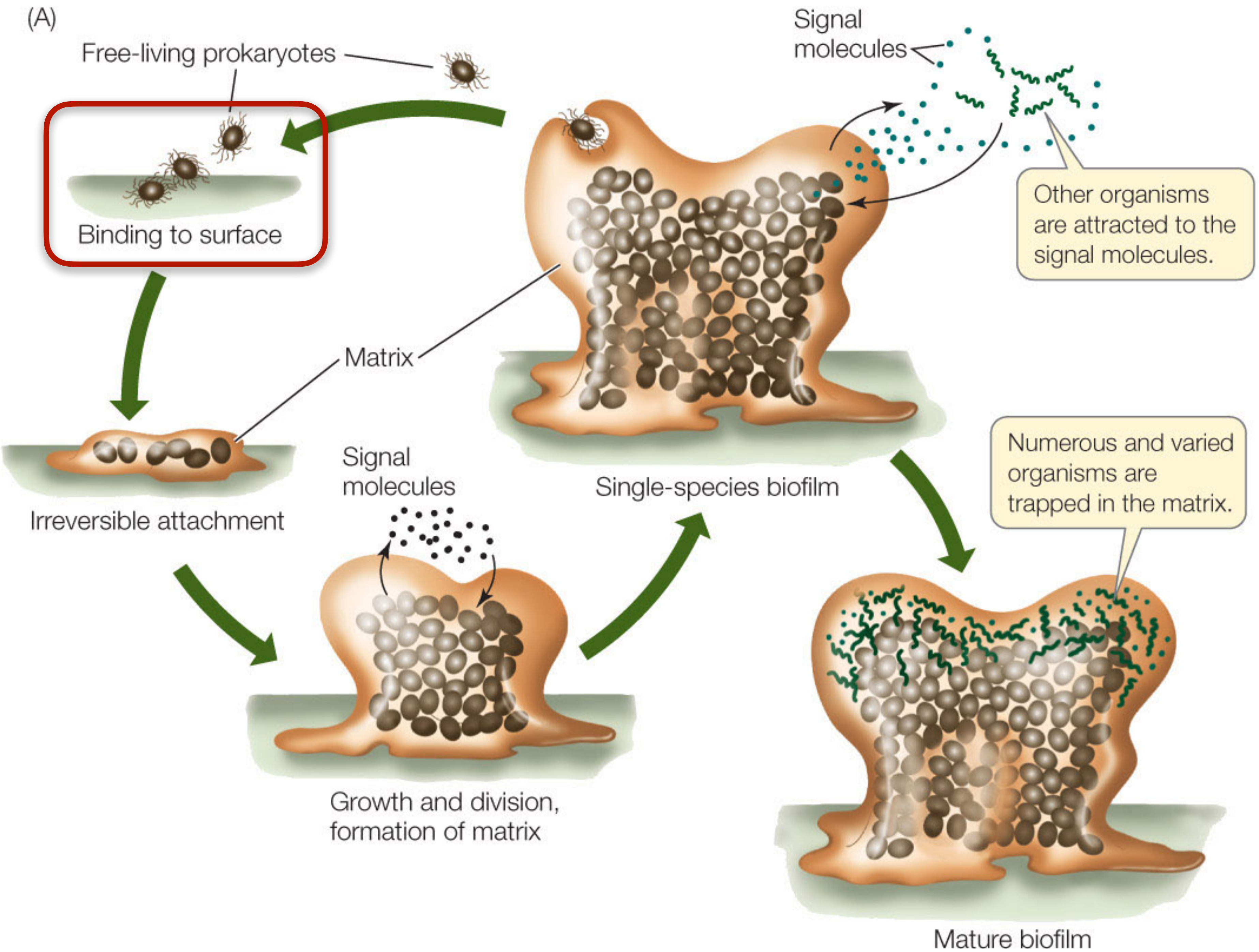
FIGURE 3.3 A typical growth curve for a bacterial population. Compare the difference in the shape of the curves in the death phase (colony-forming units versus optical density).

Prokaryote



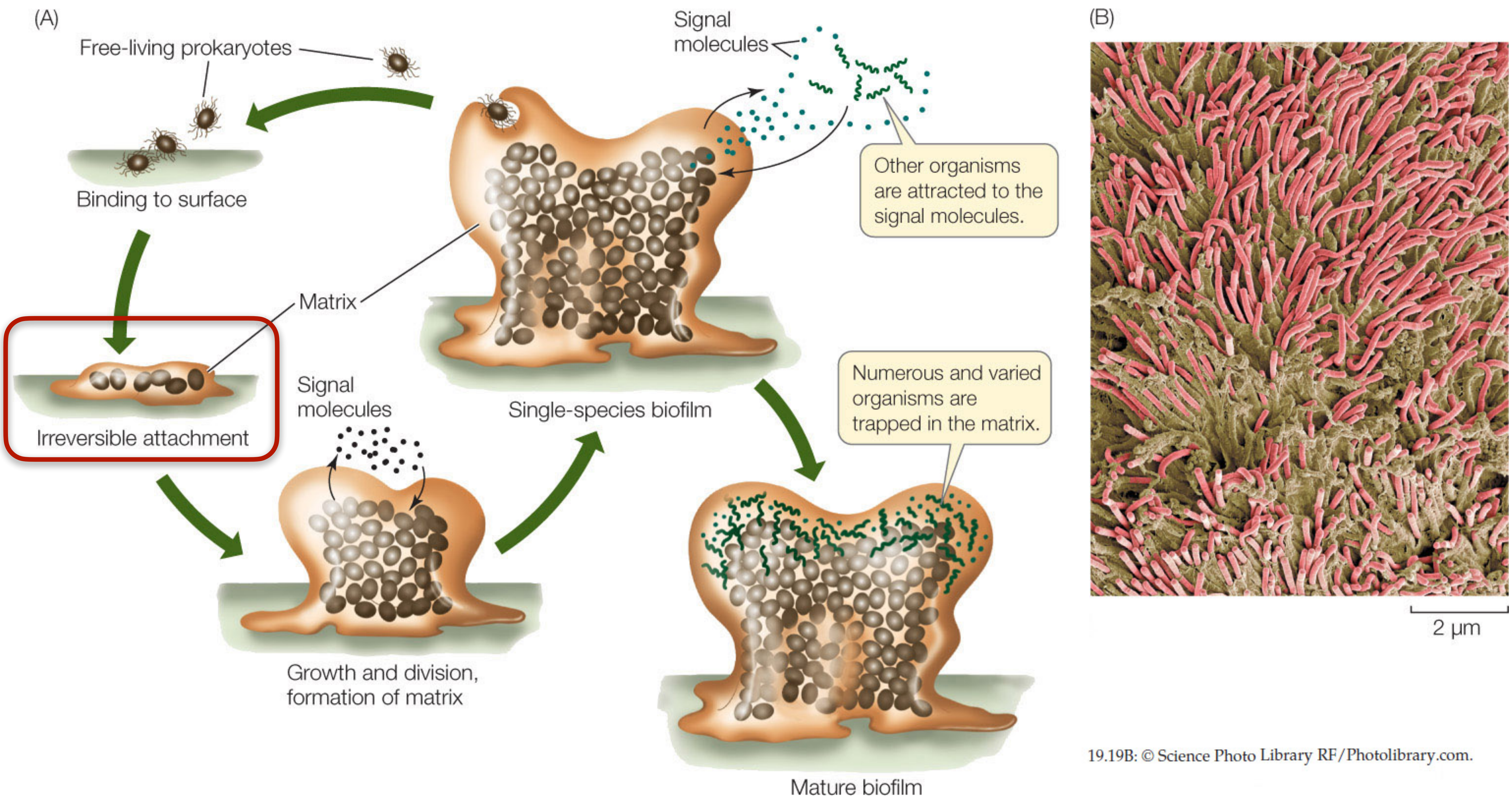
19.19B: © Science Photo Library RF/Photolibrary.com.

(A)

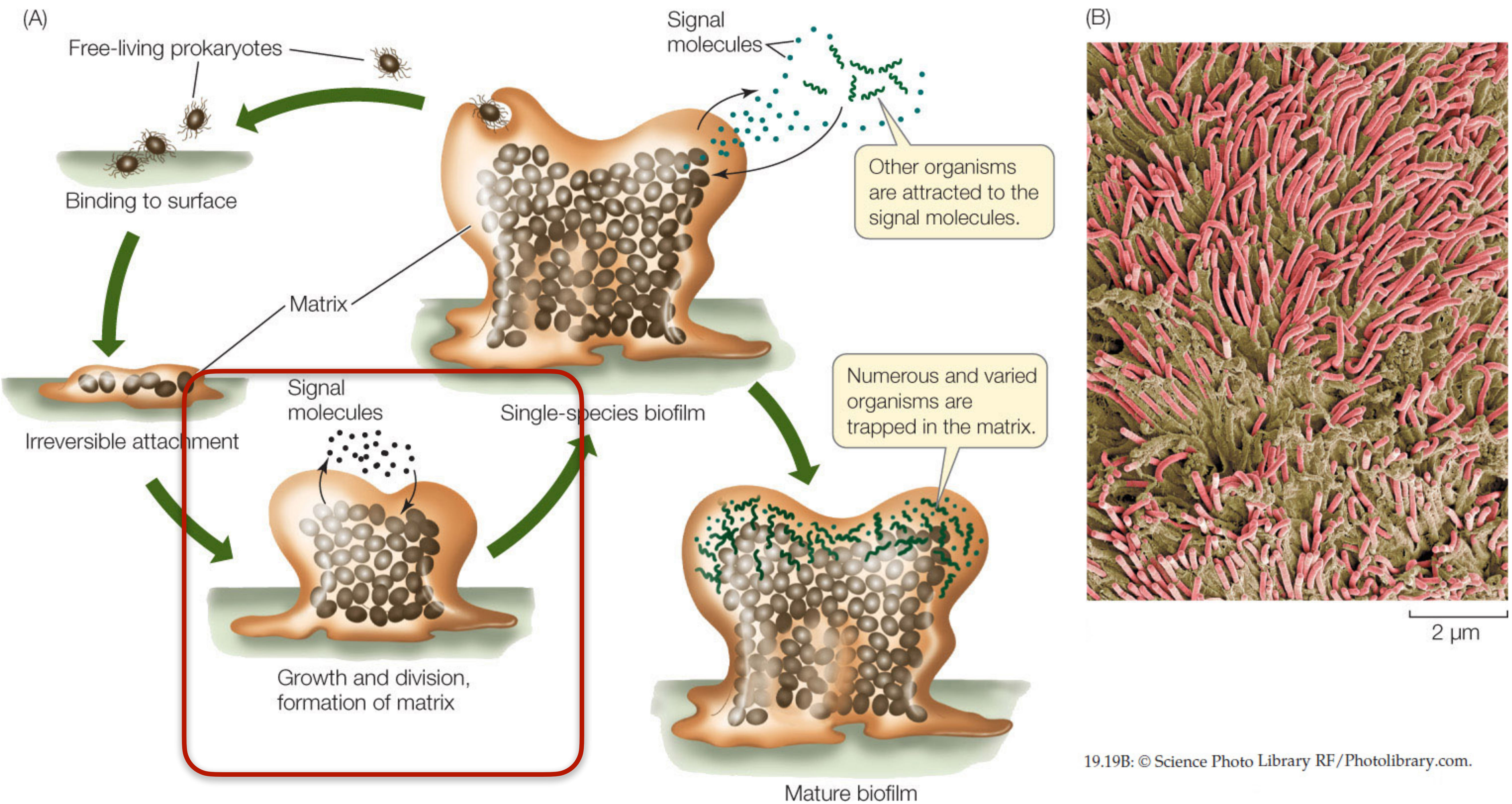

Free-living prokaryotes
Binding to surface
Matrix
Irreversible attachment
Signal
molecules
Growth and division,
formation of matrix
Signal
molecules
Single-species biofilm
Other organisms
are attracted to the
signal molecules.
Numerous and varied
organisms are
trapped in the matrix.
Mature biofilm

(B)

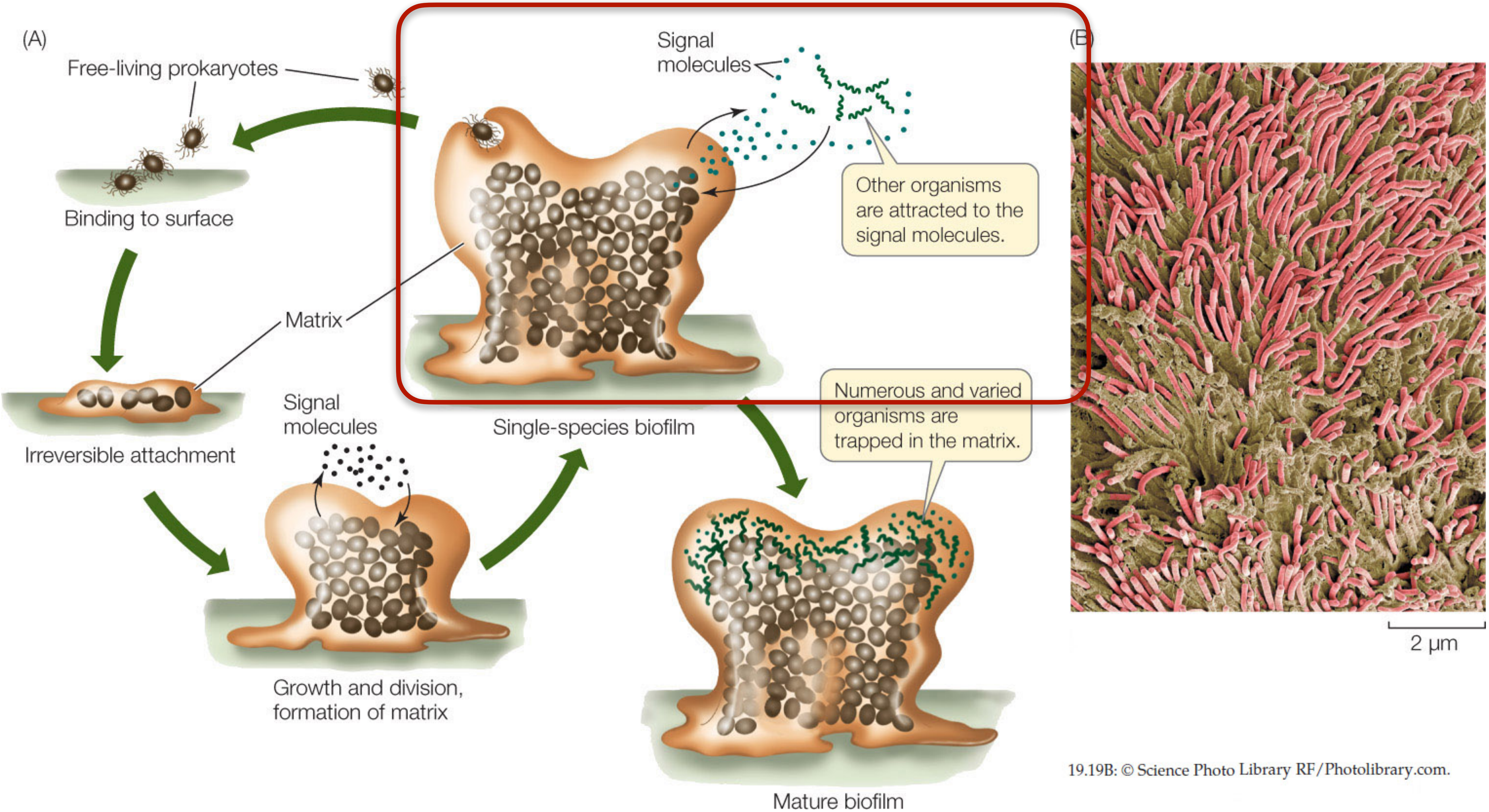

2 μm

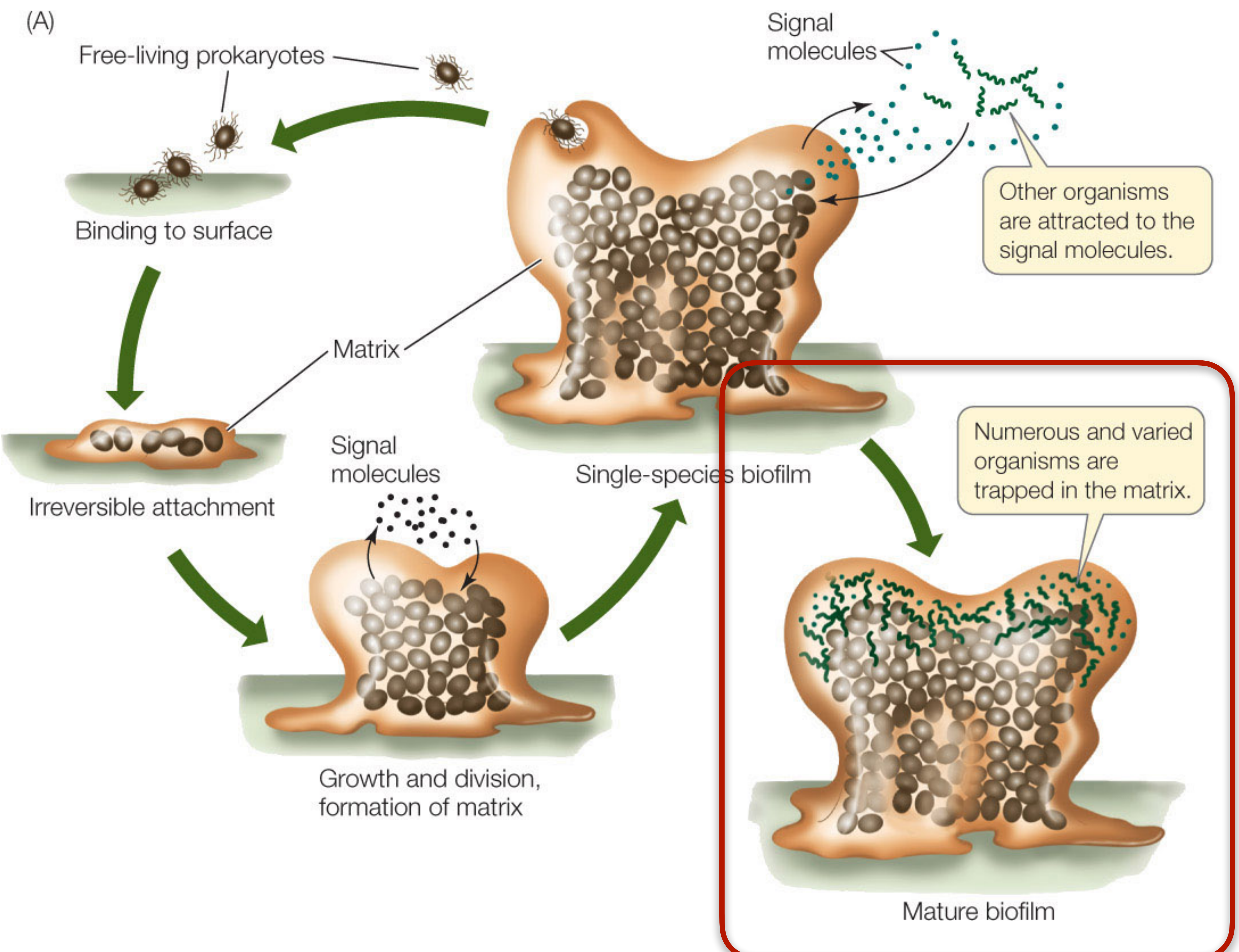


19.19B: © Science Photo Library RF/Photolibrary.com.



19.19B: © Science Photo Library RF/Photolibrary.com.


(A)
Free-living prokaryotes
Binding to surface
Matrix
Irreversible attachment
Signal molecules
Growth and division, formation of matrix
Signal molecules
Other organisms are attracted to the signal molecules.
Single-species biofilm
Numerous and varied organisms are trapped in the matrix.
Mature biofilm
(B)
2 µm


(A)
Free-living prokaryotes
Binding to surface
Signal
molecules
Other organisms are attracted to the signal molecules.
Matrix
Irreversible attachment
Signal
molecules
Single-species biofilm
Numerous and varied organisms are trapped in the matrix.
Growth and division,
formation of matrix
Mature biofilm


(B)
2 µm

C H O N P S

Chemical symbol
Atomic number
Atomic mass (average of all isotopes)

1 H 1.0079																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.4778	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.4	47 Ag 107.870	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30
55 Cs 132.905	56 Ba 137.34	71 Lu 174.97	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	103 Lr (260)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 (269)	111 (272)	112 (277)	113	114 (285)	115 (289)	116	117	118 (293)

Lanthanide series	57 La 138.906	58 Ce 140.12	59 Pr 140.9077	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04
Actinide series	89 Ac 227.028	90 Th 232.038	91 Pa 231.0359	92 U 238.02	93 Np 237.0482	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)

C H O Carbon cycle

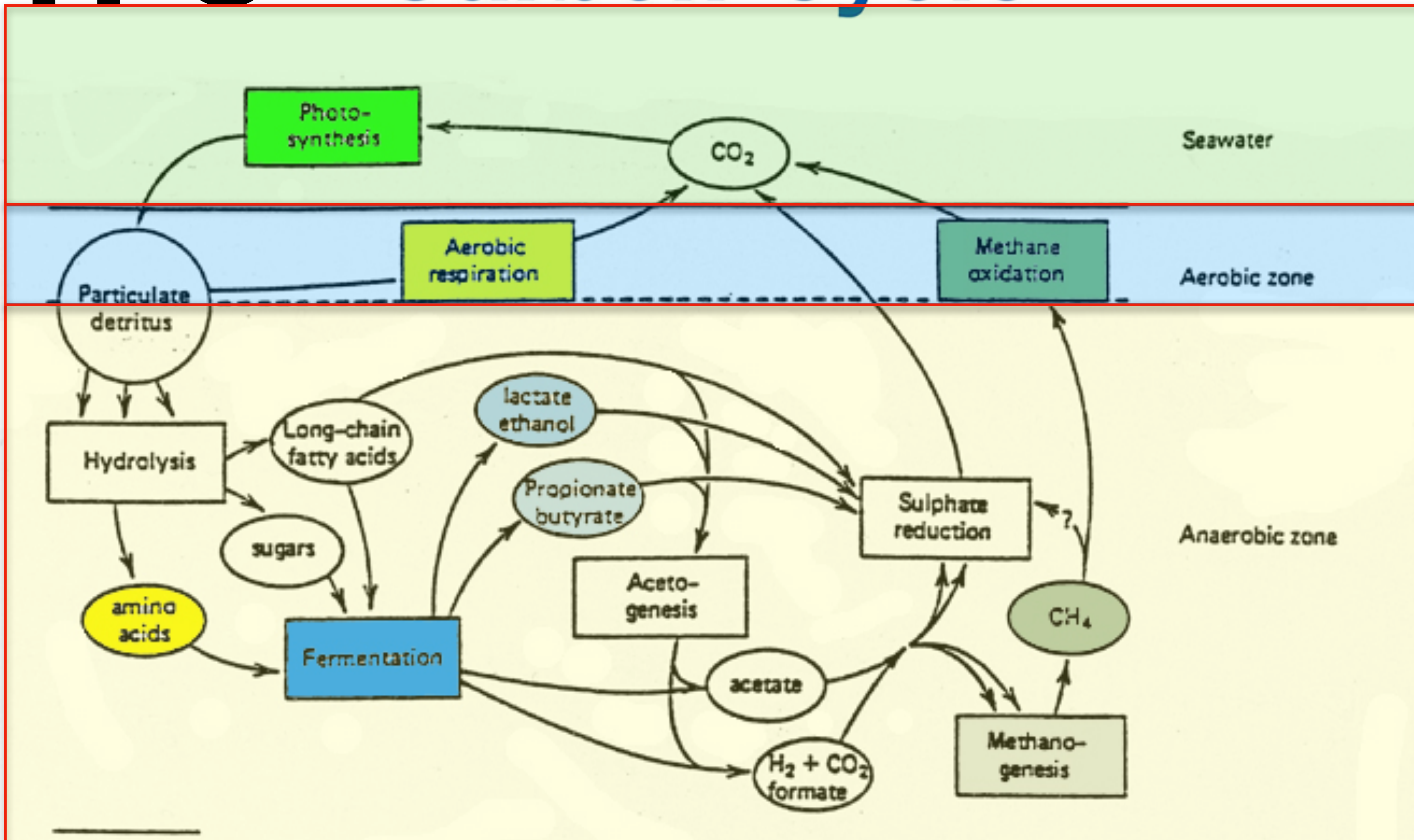
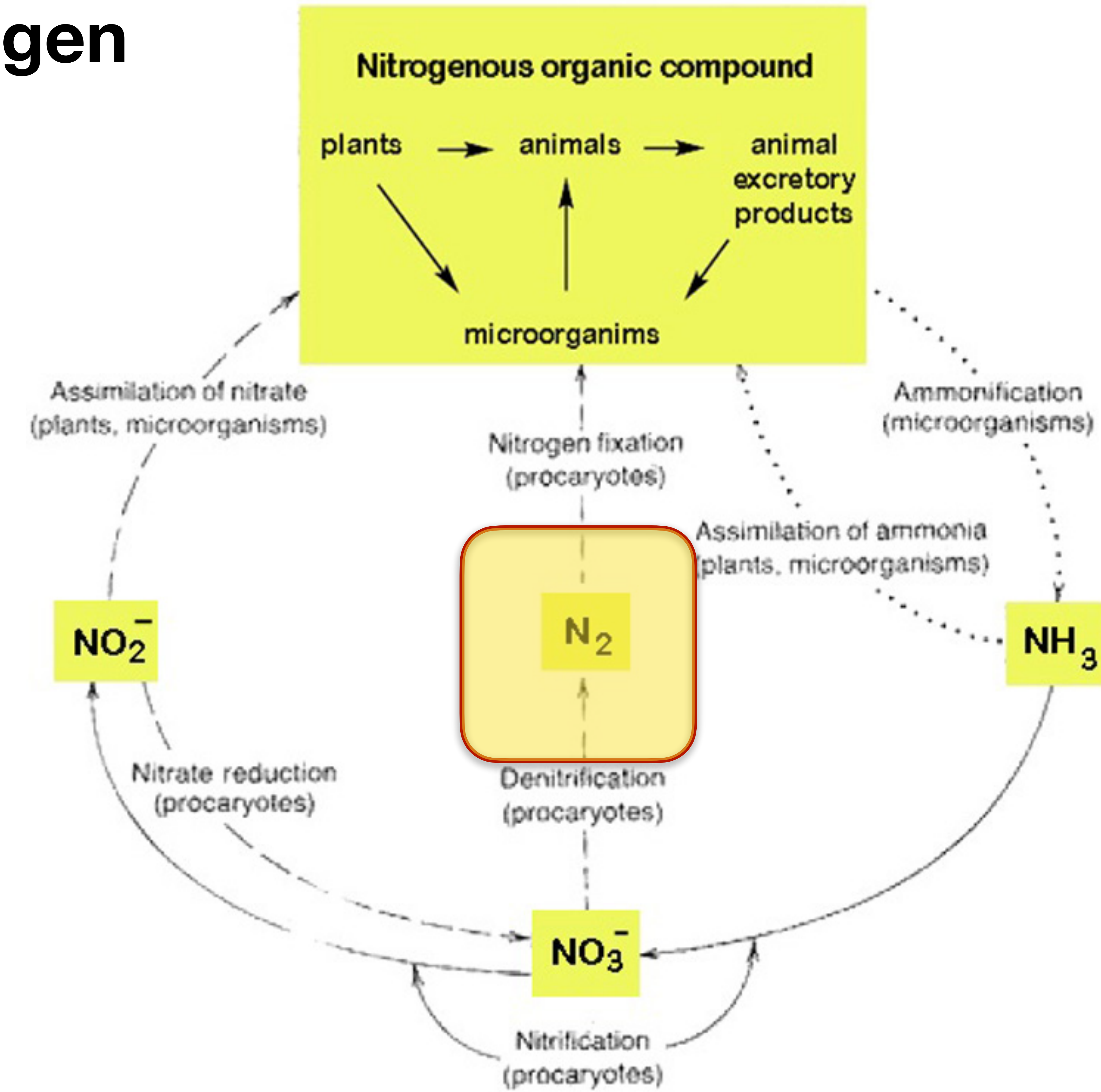


FIGURE 27.2

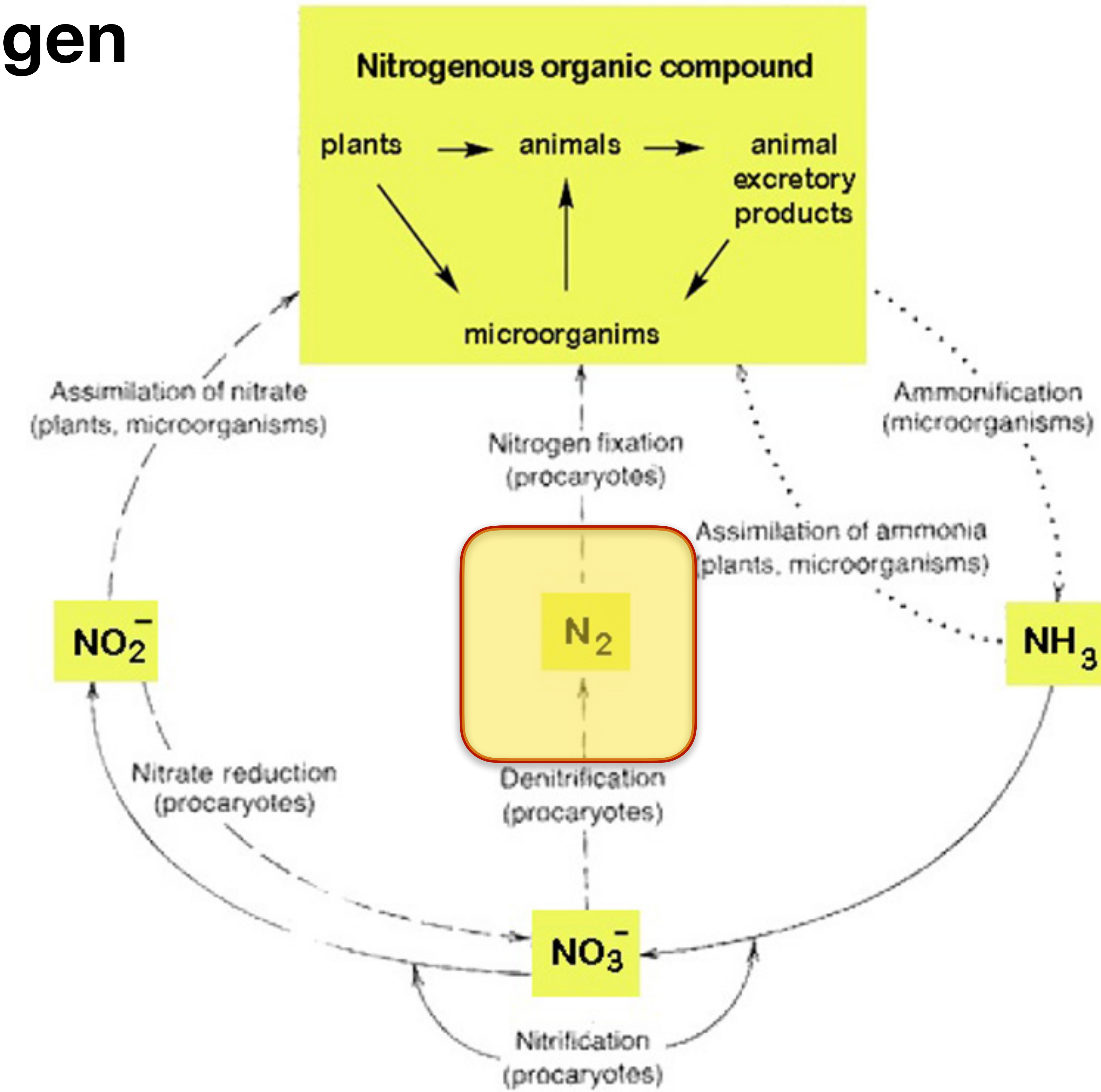
Degradation and cycling of organic matter in sediments in relation to bacterial sulphate reduction and methanogenesis. After T. H. Blackburn, "The Microbial Nitrogen Cycle," in Krumbein, W. E., ed., *Microbial Geochemistry*, Boston: Blackwell Publications (1983).

Nitrogen



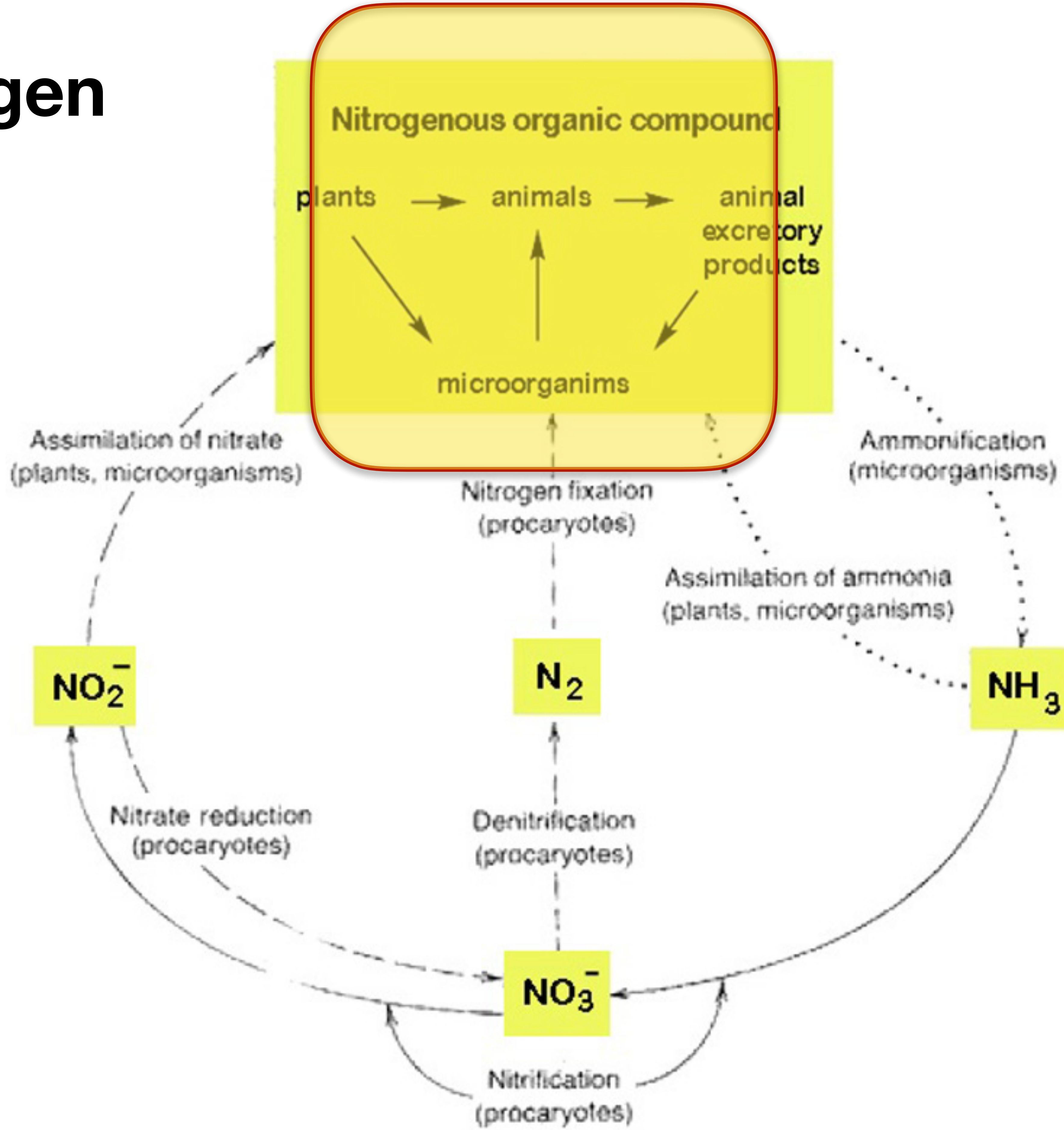
Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Ammonification (microorganisms)
Assimilation of ammonia (plants, microorganisms)
NO_2^-
N_2
NH_3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO_3^-
Nitrification (procaryotes)

Nitrogen

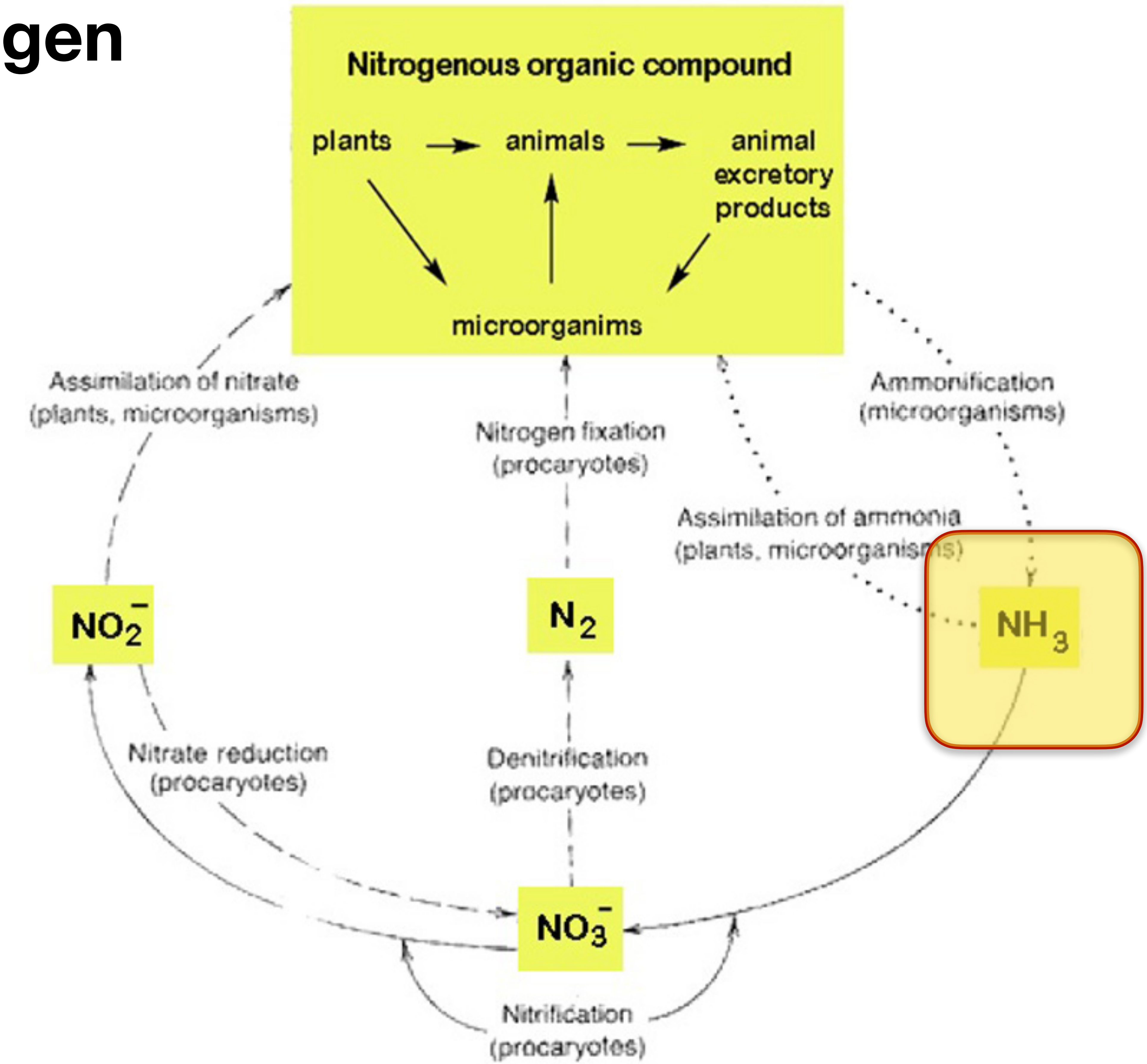


Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Ammonification (microorganisms)
Assimilation of ammonia (plants, microorganisms)
NO_2^-
N_2
NH_3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO_3^-
Nitrification (procaryotes)

Nitrogen

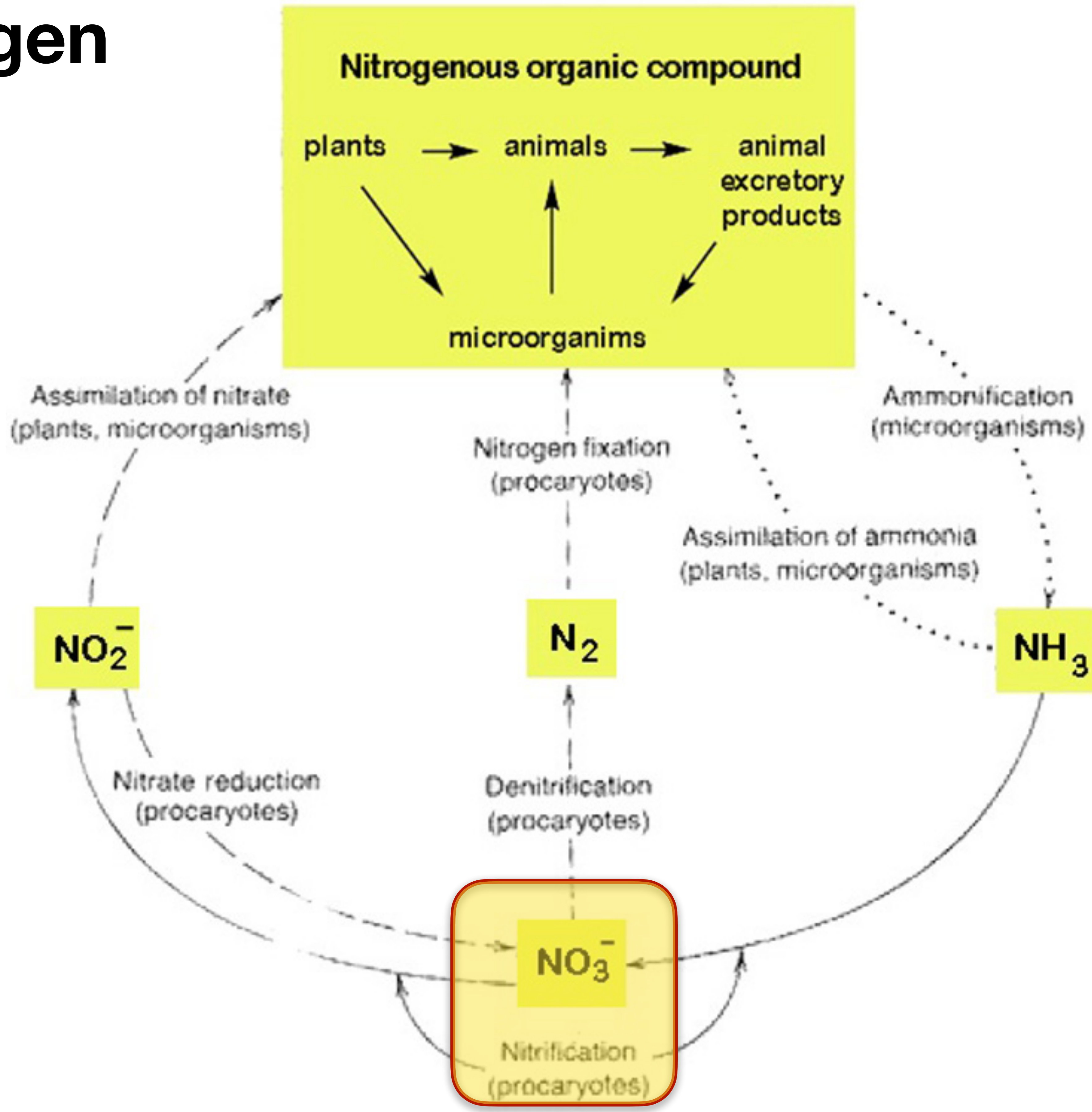

Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Assimilation of ammonia (plants, microorganisms)
Ammonification (microorganisms)
NO2⁻
N2
NH3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO3⁻
Nitrification (procaryotes)

Nitrogen



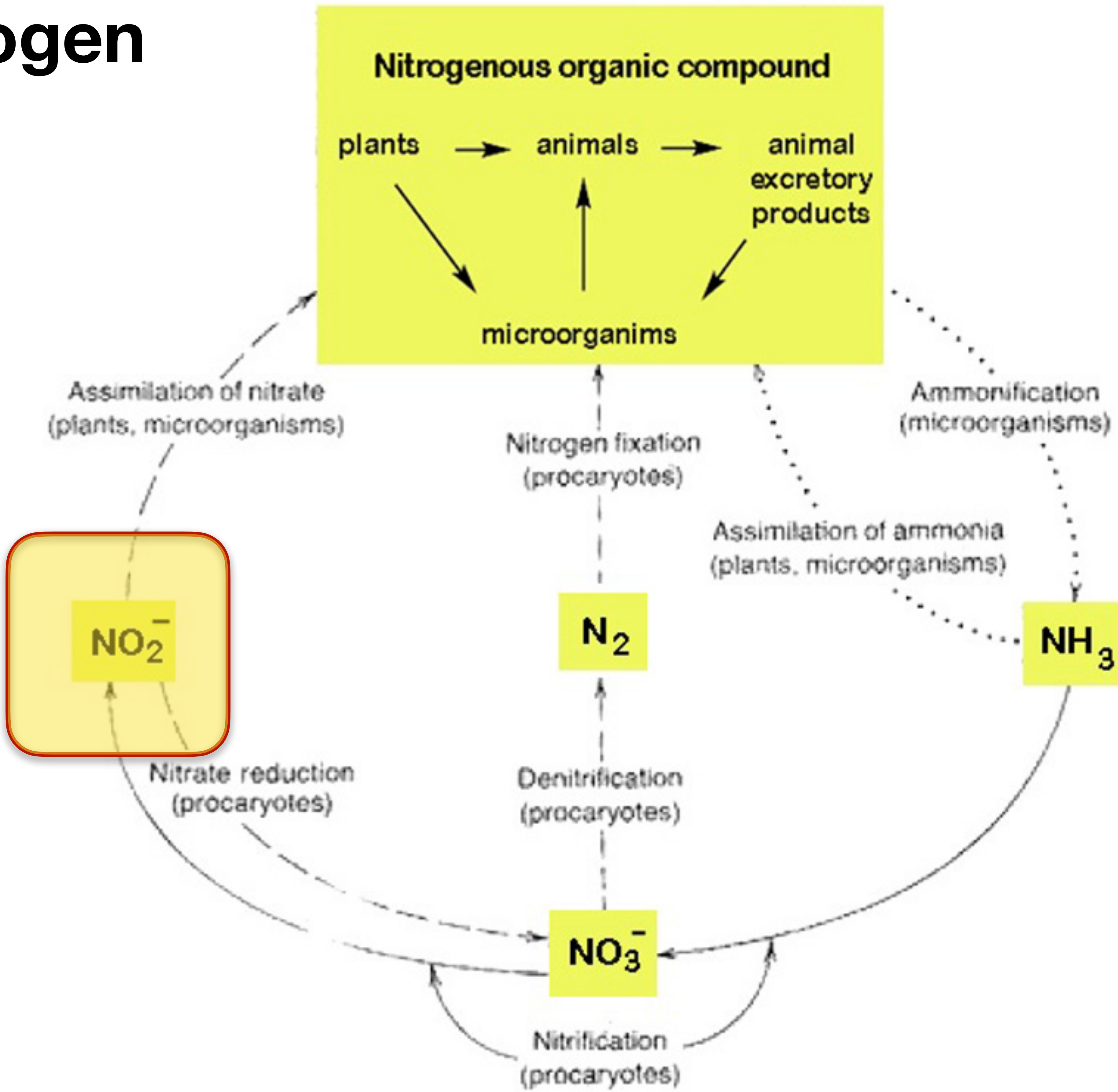
Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Assimilation of ammonia (plants, microorganisms)
Ammonification (microorganisms)
NO_2^-
N_2
NH_3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO_3^-
Nitrification (procaryotes)

Nitrogen



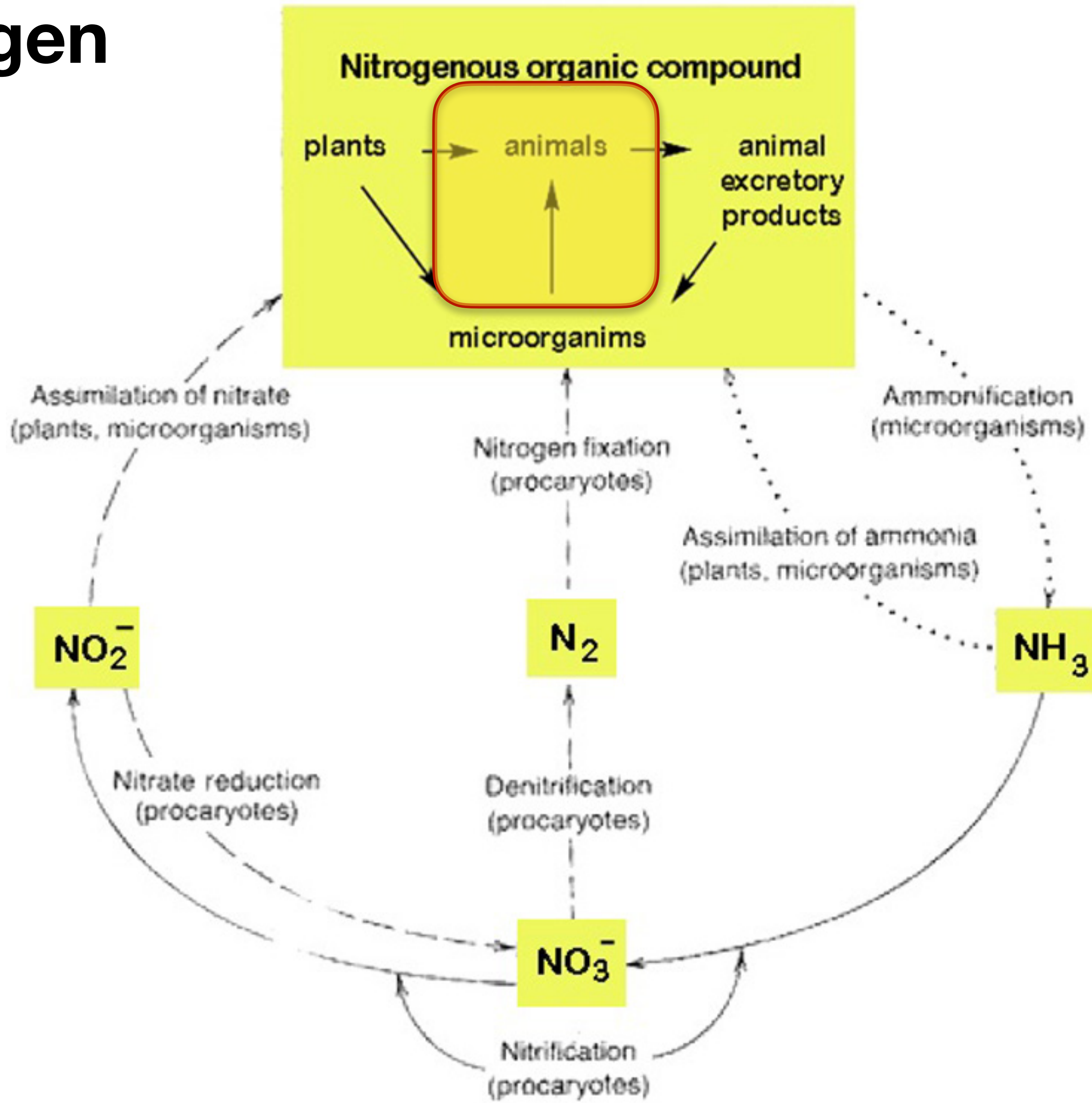
Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Assimilation of ammonia (plants, microorganisms)
Ammonification (microorganisms)
NO_2^-
N_2
NH_3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO_3^-
Nitrification (procaryotes)

Nitrogen



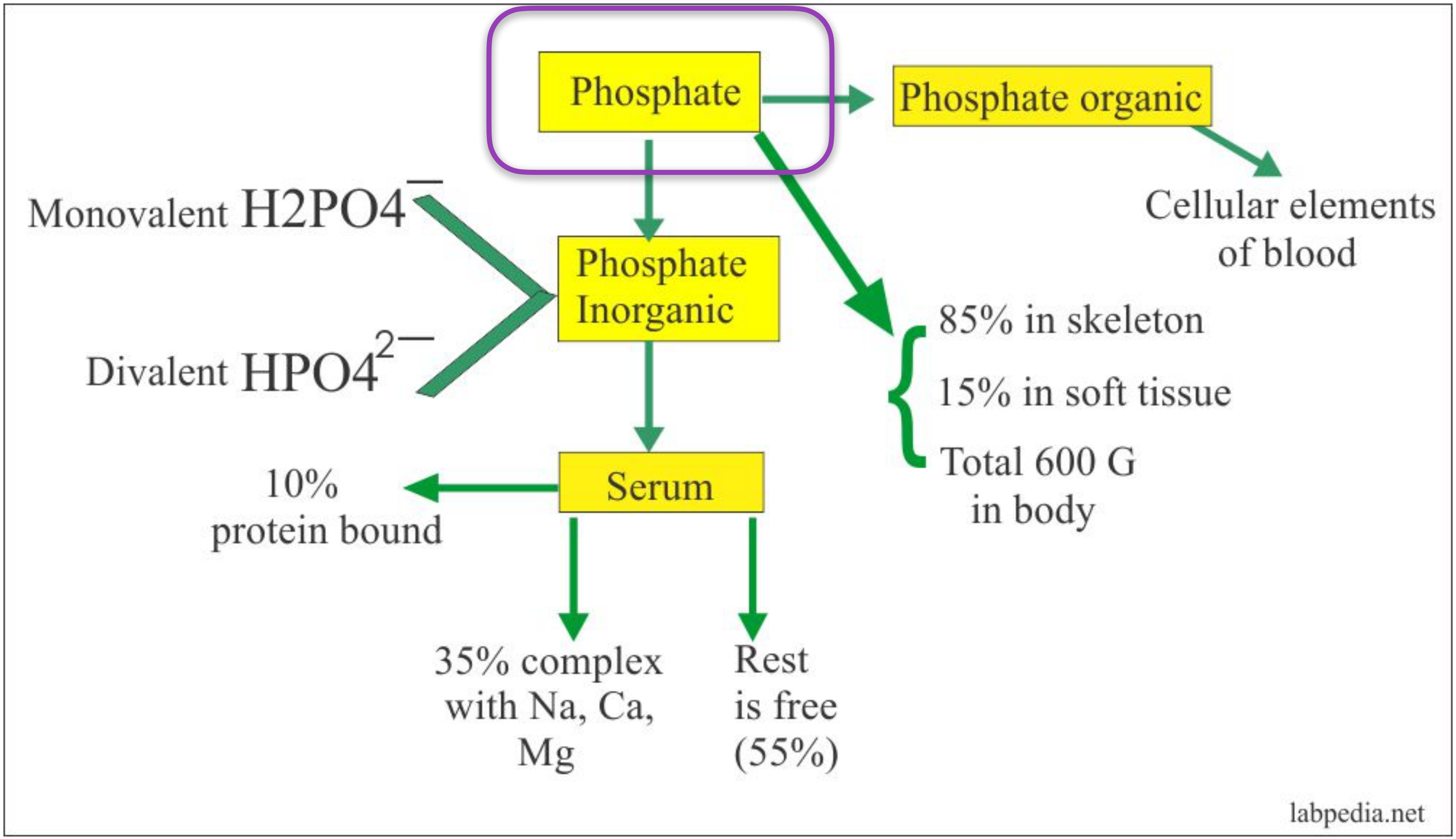
Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Ammonification (microorganisms)
Assimilation of ammonia (plants, microorganisms)
NO2-
N2
NH3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO3-
Nitrification (procaryotes)

Nitrogen

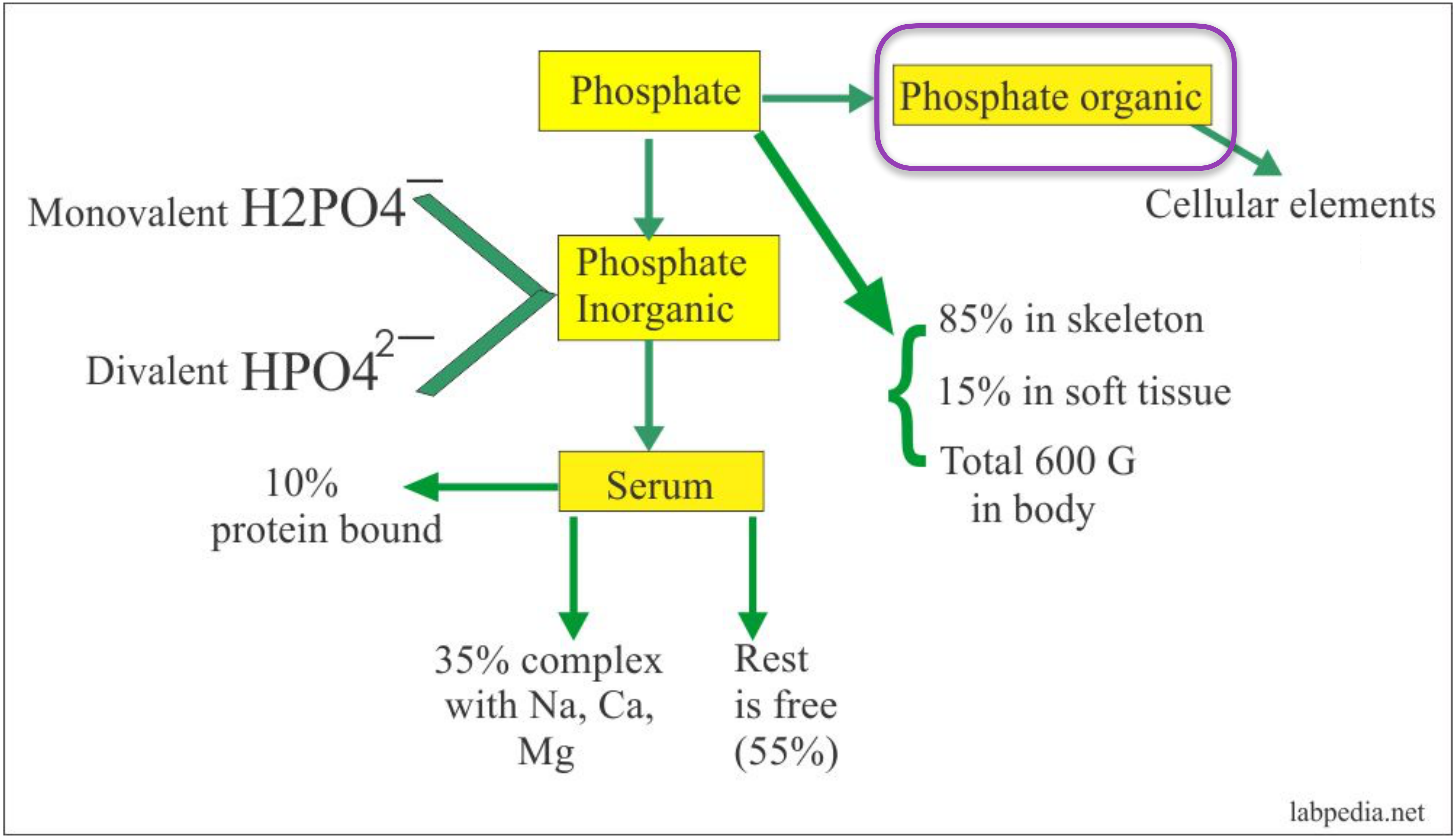


Nitrogenous organic compound
plants
animals
animal excretory products
microorganims
Assimilation of nitrate (plants, microorganisms)
Nitrogen fixation (procaryotes)
Assimilation of ammonia (plants, microorganisms)
Ammonification (microorganisms)
NO_2^-
N_2
NH_3
Nitrate reduction (procaryotes)
Denitrification (procaryotes)
NO_3^-
Nitrification (procaryotes)

Phosphorus -Not really a “cycle” *per se*

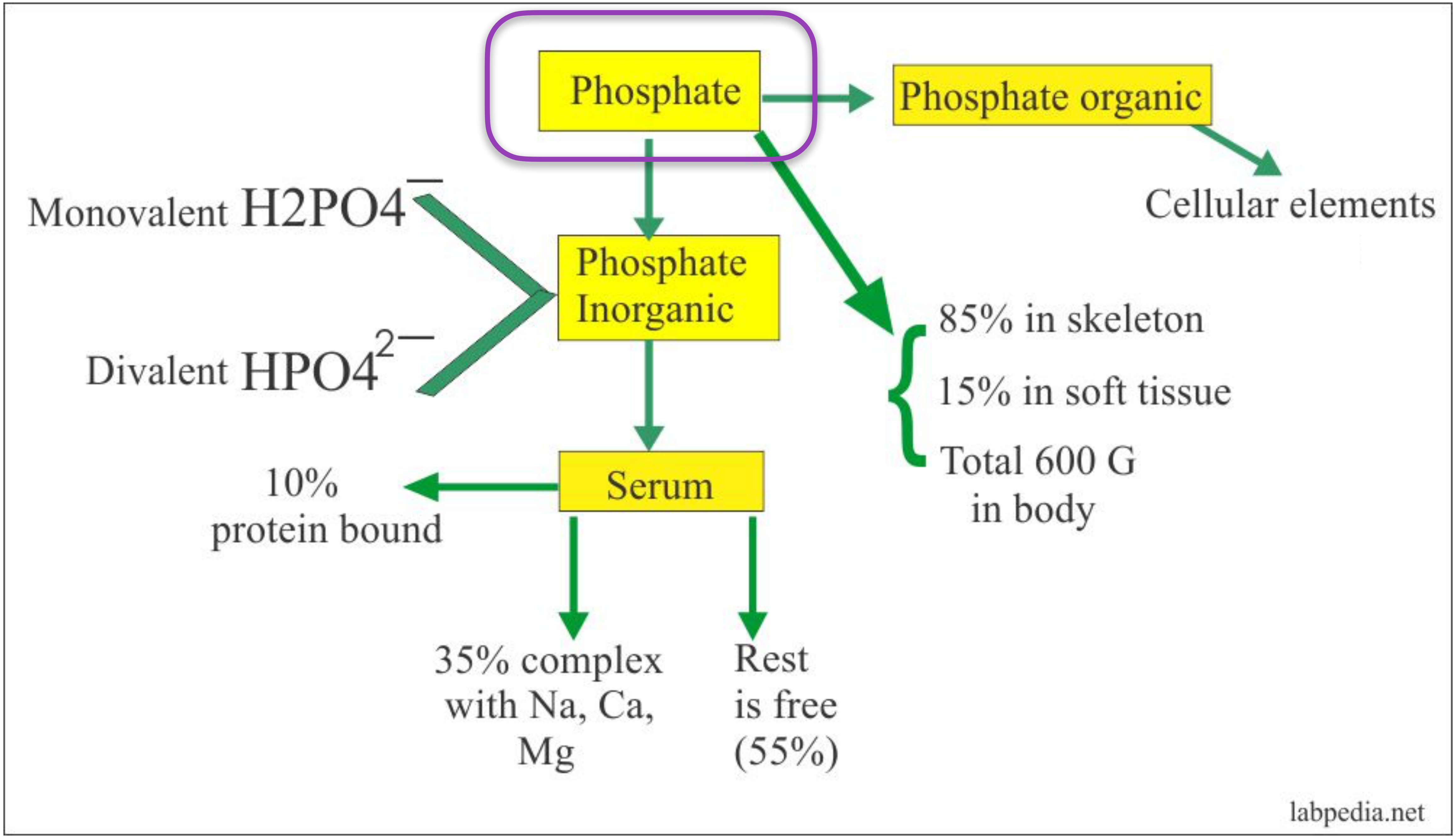


Phosphorus



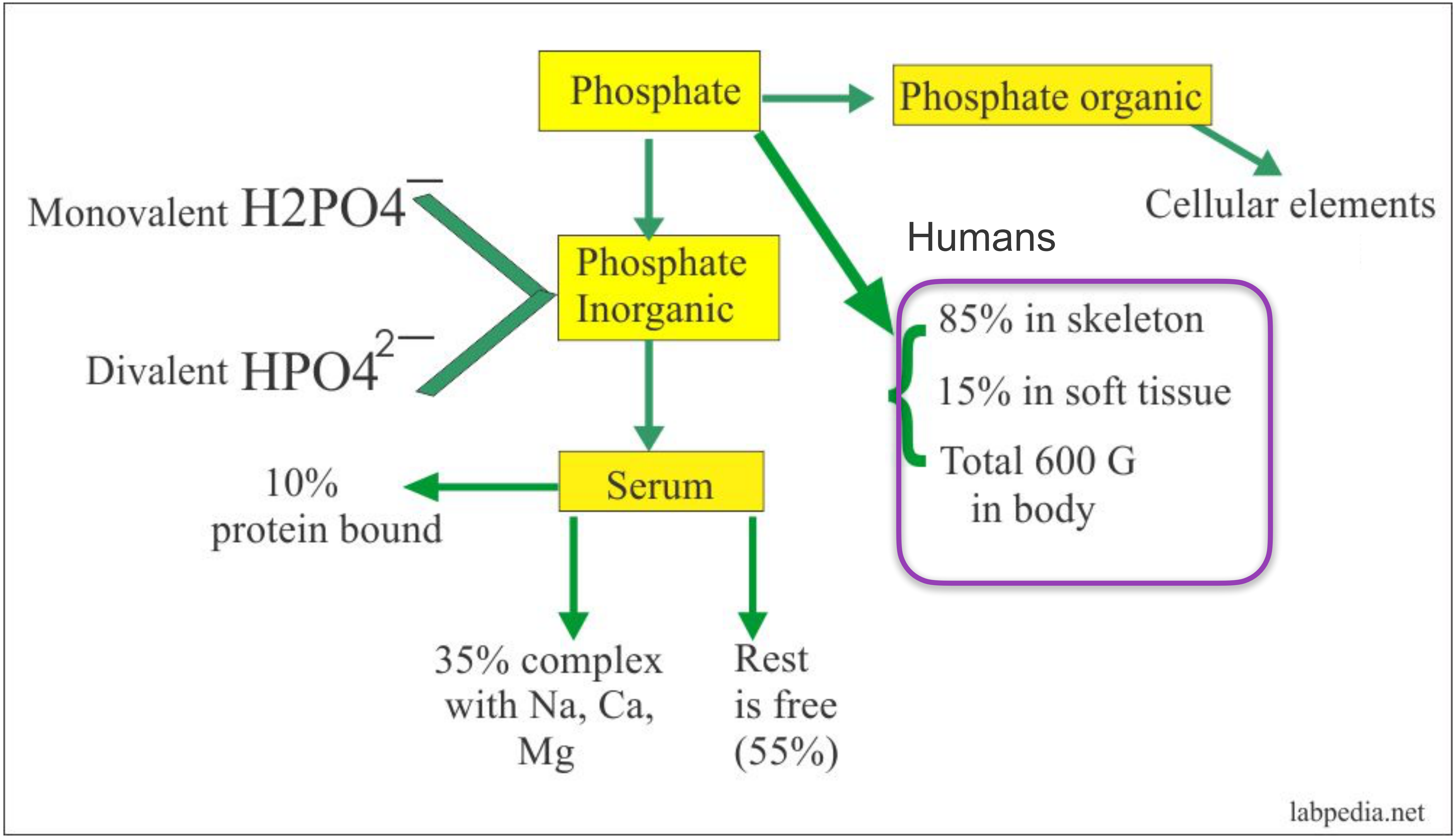
Phosphate
Phosphate organic
Cellular elements
Monovalent H2PO4⁻
Divalent HPO4²⁻
Phosphate Inorganic
85% in skeleton
15% in soft tissue
Total 600 G in body
Serum
10% protein bound
35% complex with Na, Ca, Mg
Rest is free (55%)
labpedia.net

Phosphorus

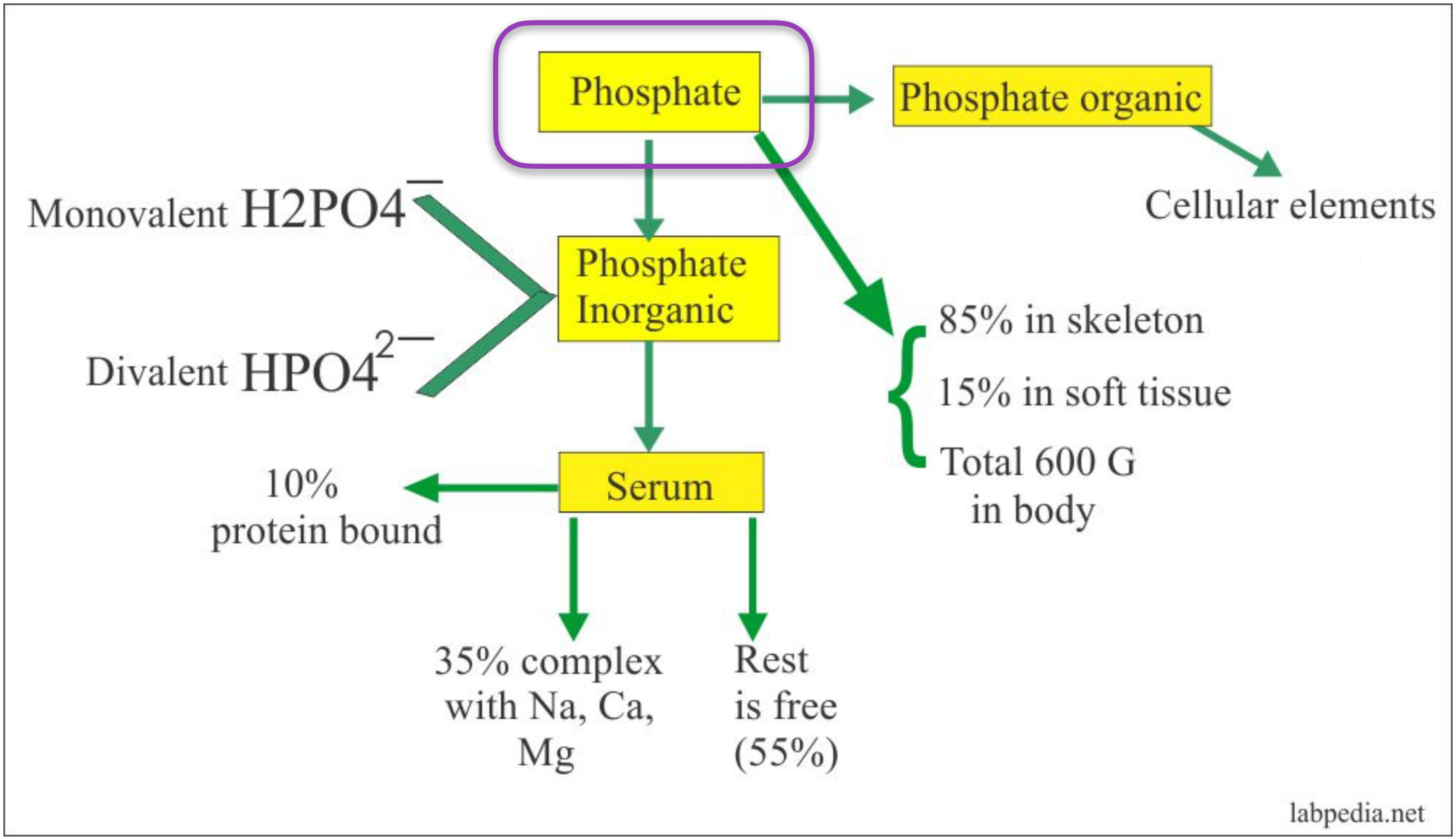


Phosphate
Phosphate organic
Cellular elements
Monovalent H2PO4^{-}
Divalent HPO4^{2-}
Phosphate Inorganic
85% in skeleton
15% in soft tissue
Total 600 G in body
Serum
10% protein bound
35% complex with Na, Ca, Mg
Rest is free (55%)
labpedia.net

Phosphorus

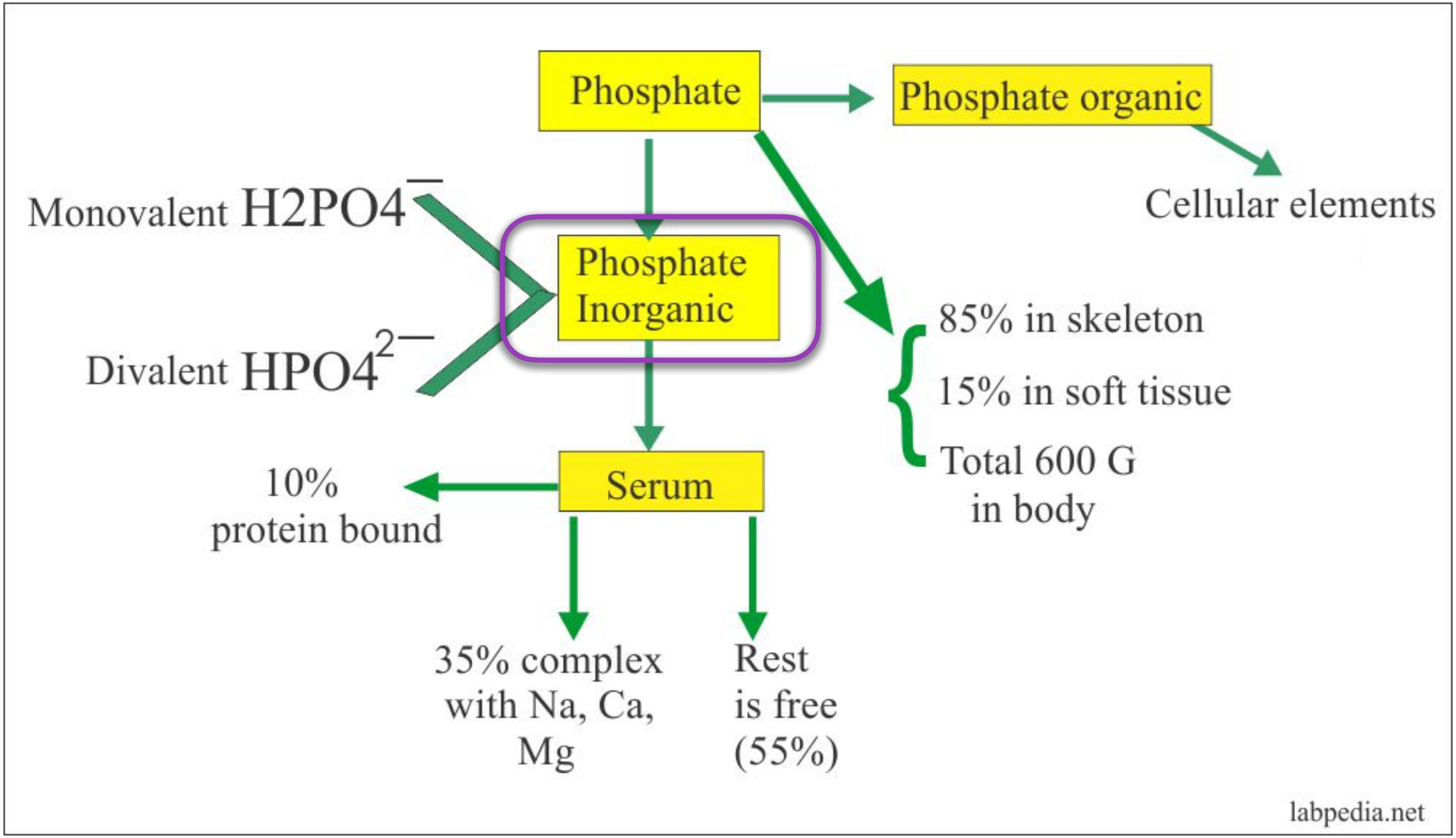

Phosphate
Phosphate organic
Cellular elements
Monovalent H2PO4⁻
Divalent HPO4²⁻
Phosphate Inorganic
Humans
85% in skeleton
15% in soft tissue
Total 600 G in body
Serum
10% protein bound
35% complex with Na, Ca, Mg
Rest is free (55%)
labpedia.net

Phosphorus

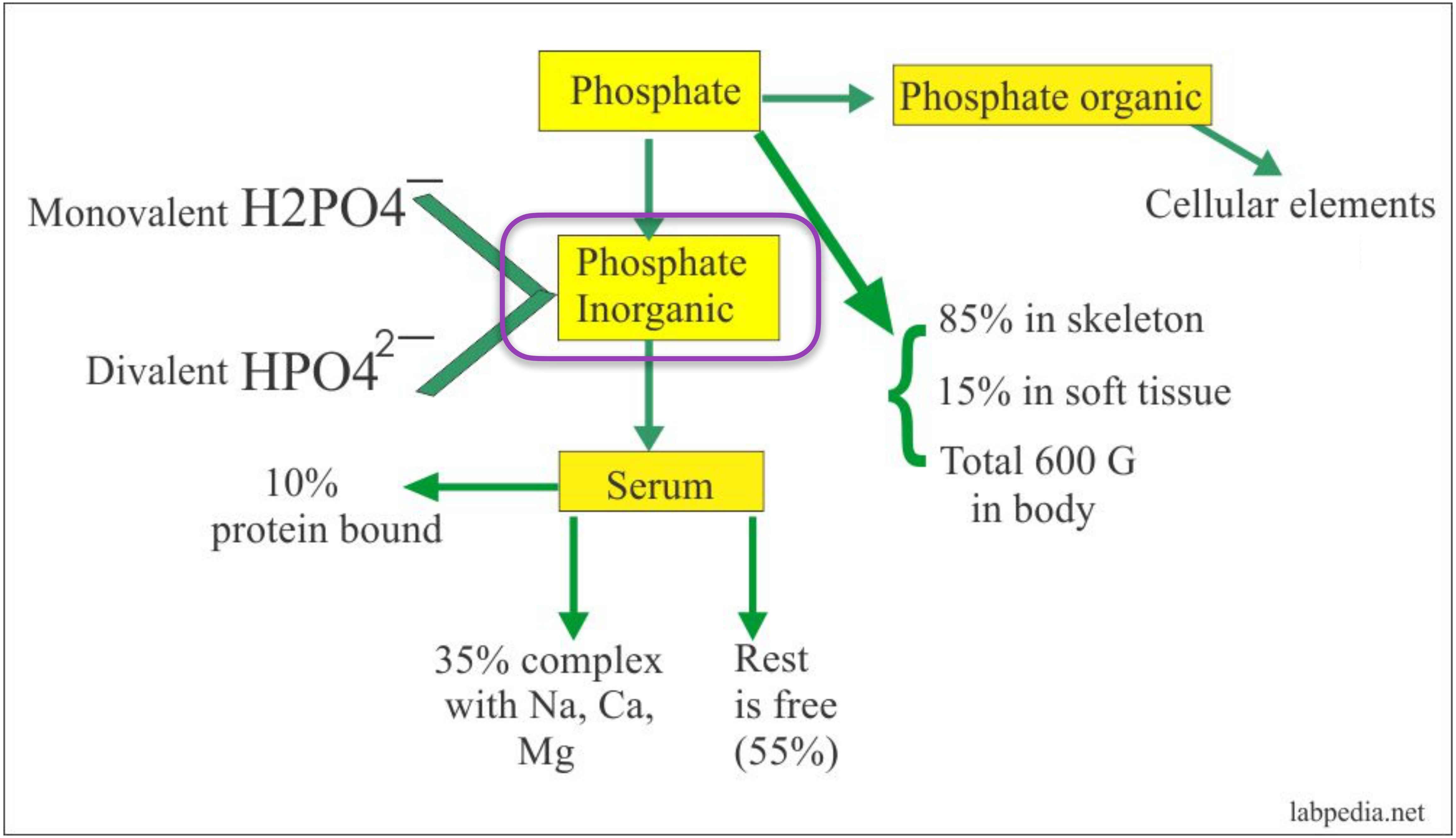

Phosphate
Phosphate organic
Cellular elements
Monovalent H2PO4⁻
Divalent HPO4²⁻
Phosphate Inorganic
85% in skeleton
15% in soft tissue
Total 600 G in body
Serum
10% protein bound
35% complex with Na, Ca, Mg
Rest is free (55%)
labpedia.net

Phosphorus

ATP

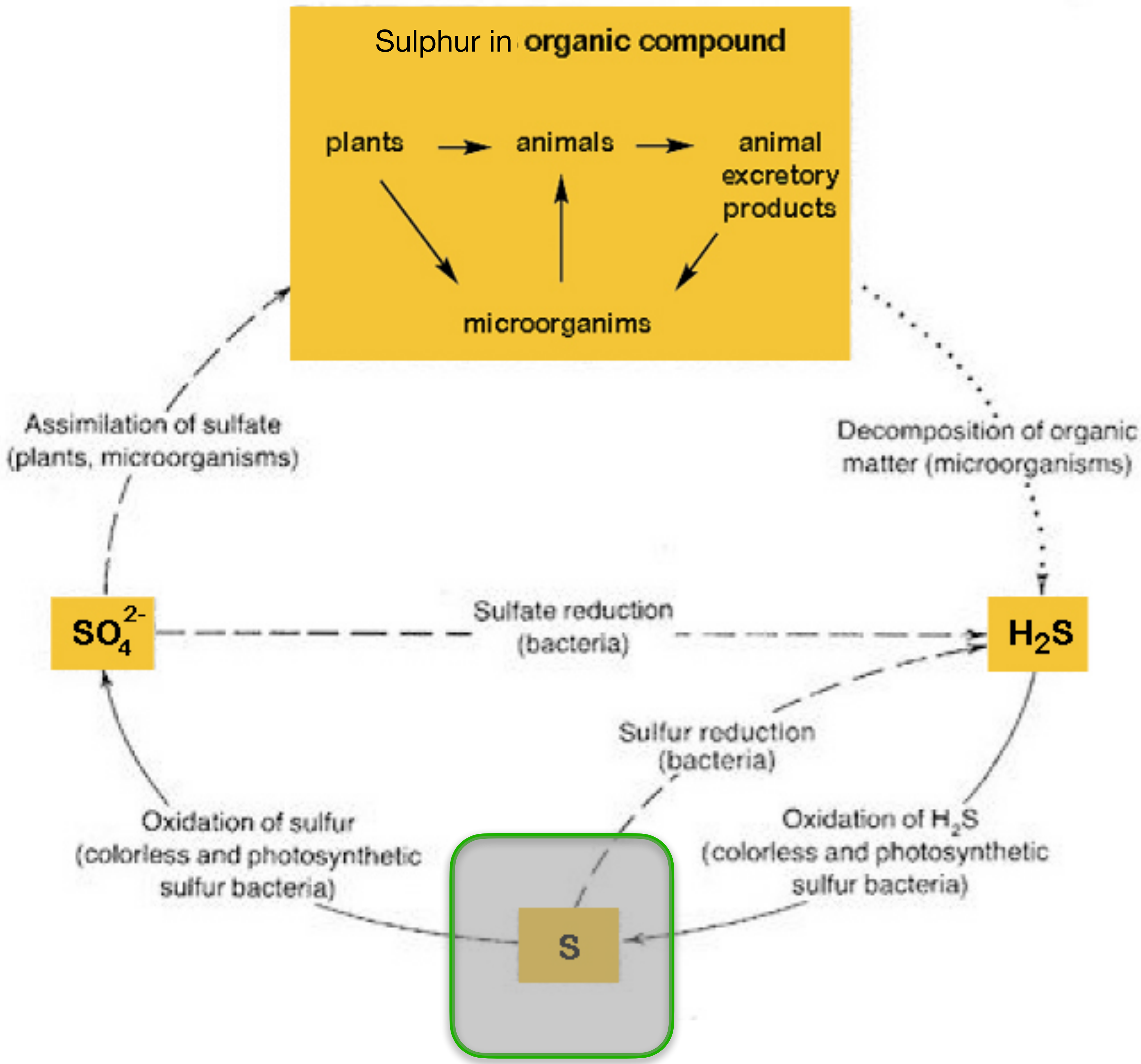


Phosphorus



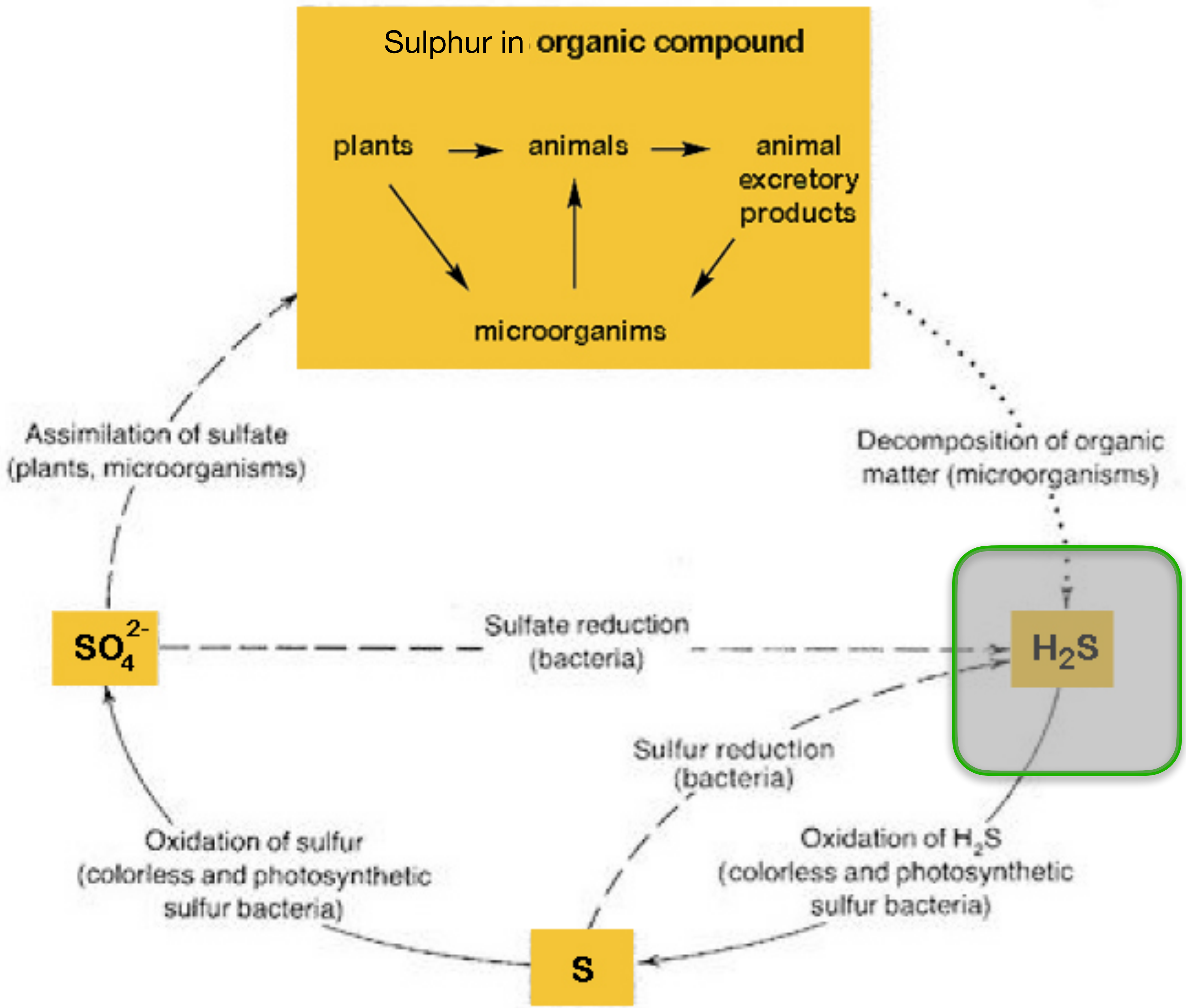
Phosphate
Phosphate organic
Cellular elements
Monovalent H2PO4⁻
Divalent HPO4²⁻
Phosphate Inorganic
85% in skeleton
15% in soft tissue
Total 600 G in body
Serum
10% protein bound
35% complex with Na, Ca, Mg
Rest is free (55%)
labpedia.net

Sulphur



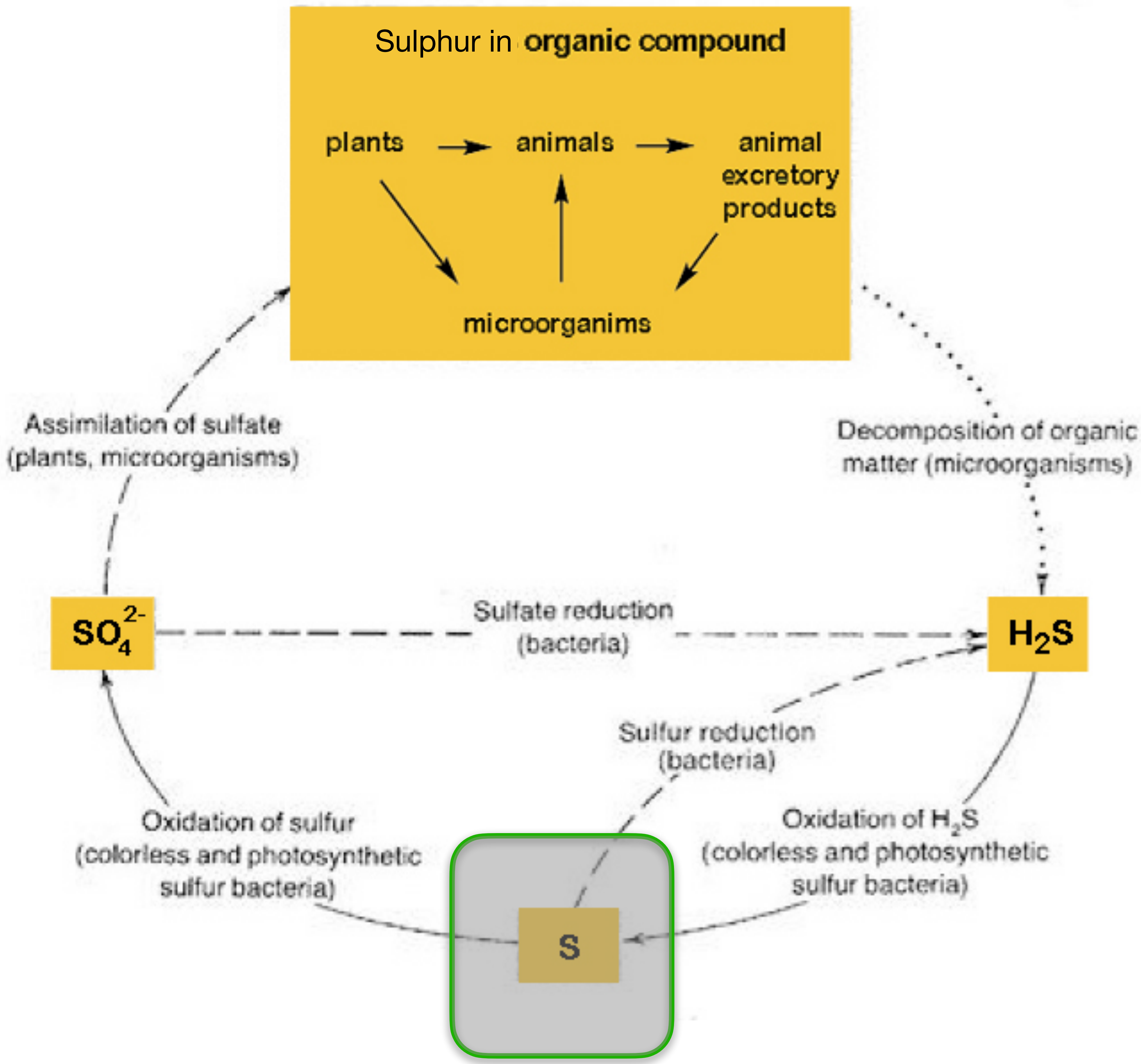
Sulphur in organic compound
plants
animals
animal excretory products
microorganims
Assimilation of sulfate (plants, microorganisms)
Decomposition of organic matter (microorganisms)
SO_4^{2-}
Sulfate reduction (bacteria)
H_2S
Sulfur reduction (bacteria)
Oxidation of sulfur (colorless and photosynthetic sulfur bacteria)
Oxidation of H_2S (colorless and photosynthetic sulfur bacteria)
S

Sulphur



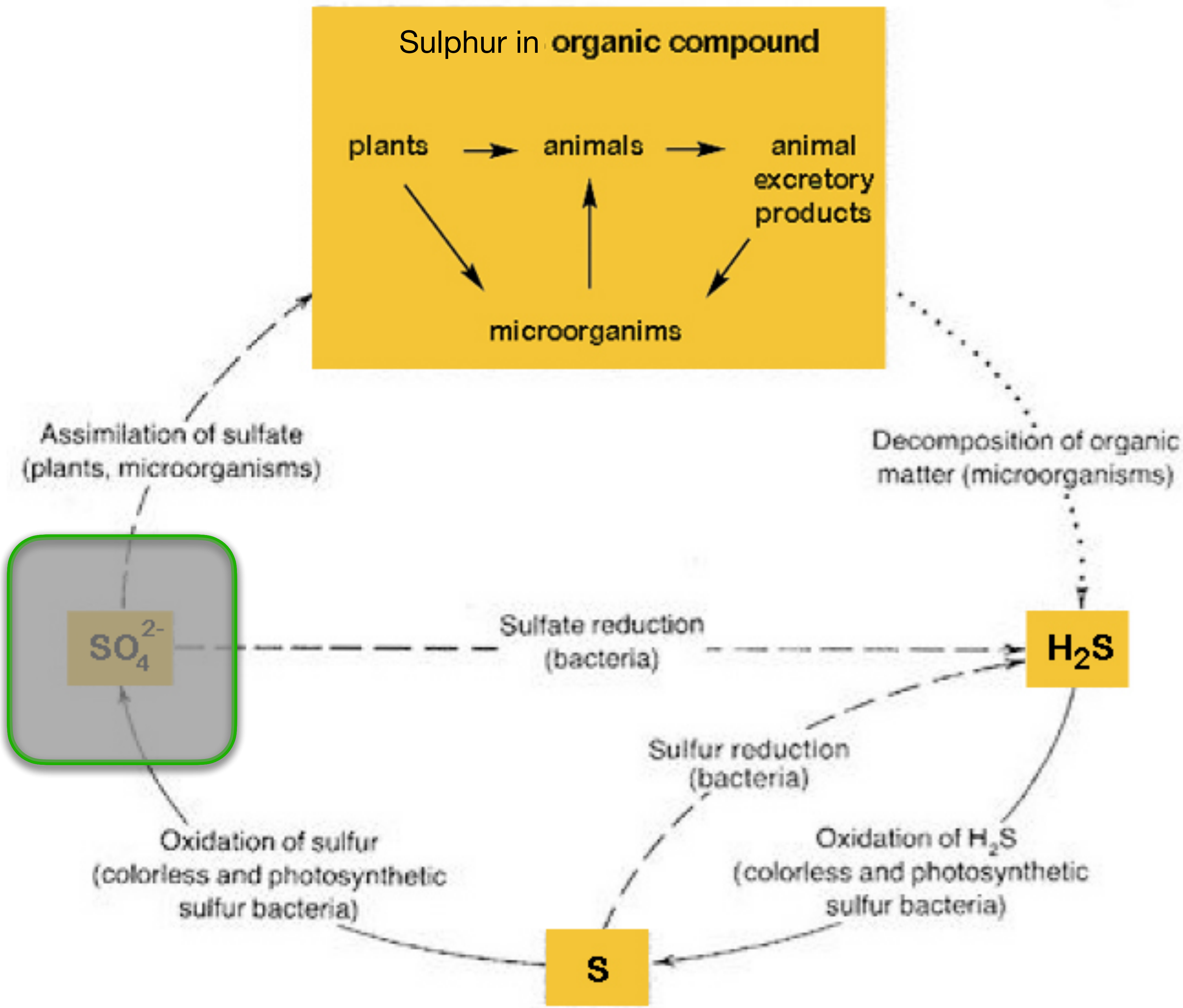
Sulphur in organic compound
plants
animals
animal excretory products
microorganims
Assimilation of sulfate (plants, microorganisms)
Decomposition of organic matter (microorganisms)
SO_4^{2-}
Sulfate reduction (bacteria)
H_2S
Sulfur reduction (bacteria)
Oxidation of sulfur (colorless and photosynthetic sulfur bacteria)
Oxidation of H_2S (colorless and photosynthetic sulfur bacteria)
S

Sulphur



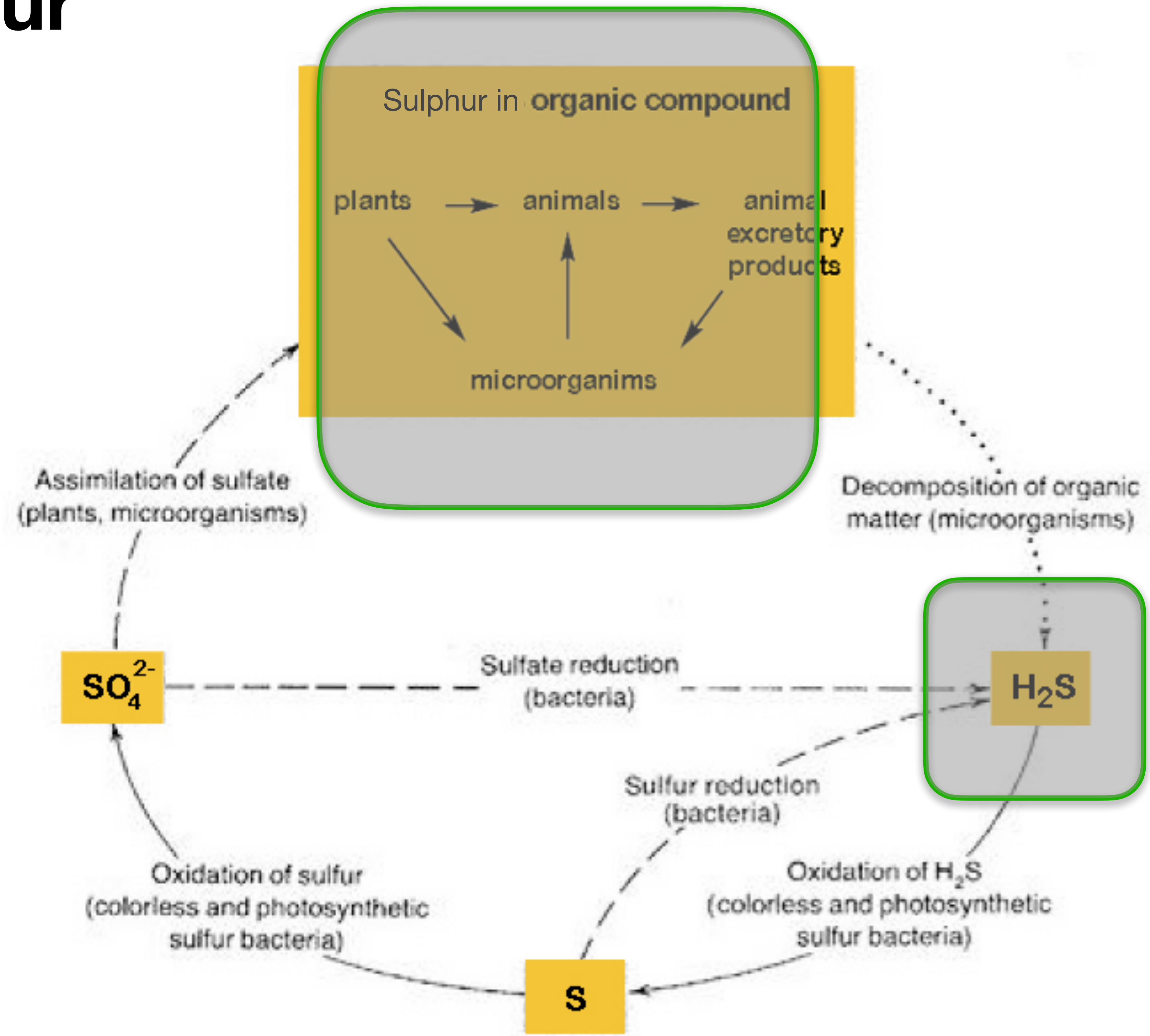
Sulphur in organic compound
plants
animals
animal excretory products
microorganims
Assimilation of sulfate (plants, microorganisms)
Decomposition of organic matter (microorganisms)
SO_4^{2-}
Sulfate reduction (bacteria)
H_2S
Sulfur reduction (bacteria)
Oxidation of sulfur (colorless and photosynthetic sulfur bacteria)
Oxidation of H_2S (colorless and photosynthetic sulfur bacteria)
S

Sulphur



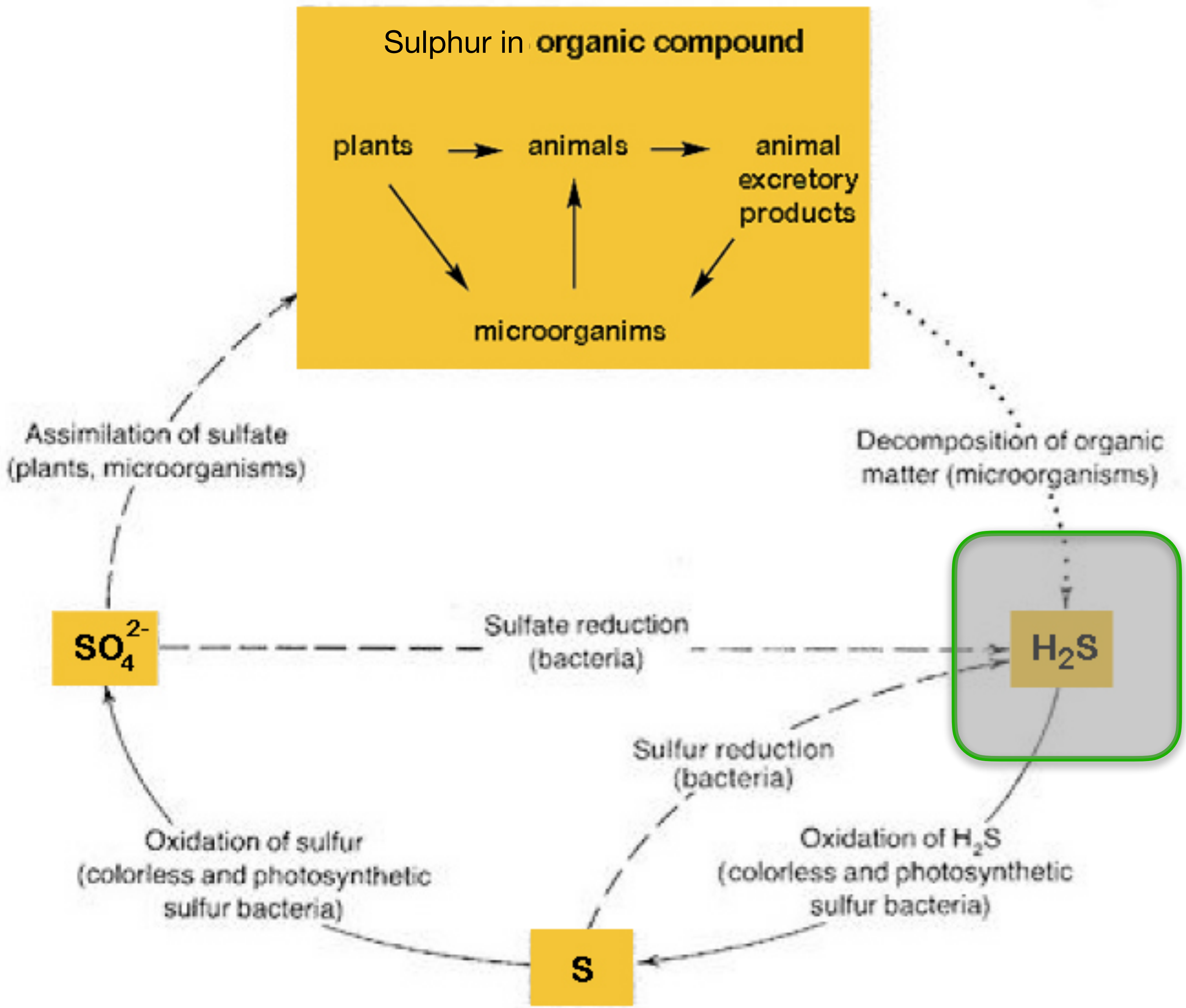
Sulphur in organic compound
plants
animals
animal excretory products
microorganims
Assimilation of sulfate (plants, microorganisms)
Decomposition of organic matter (microorganisms)
SO_4^{2-}
Sulfate reduction (bacteria)
H_2S
Sulfur reduction (bacteria)
Oxidation of sulfur (colorless and photosynthetic sulfur bacteria)
Oxidation of H_2S (colorless and photosynthetic sulfur bacteria)
S

Sulphur

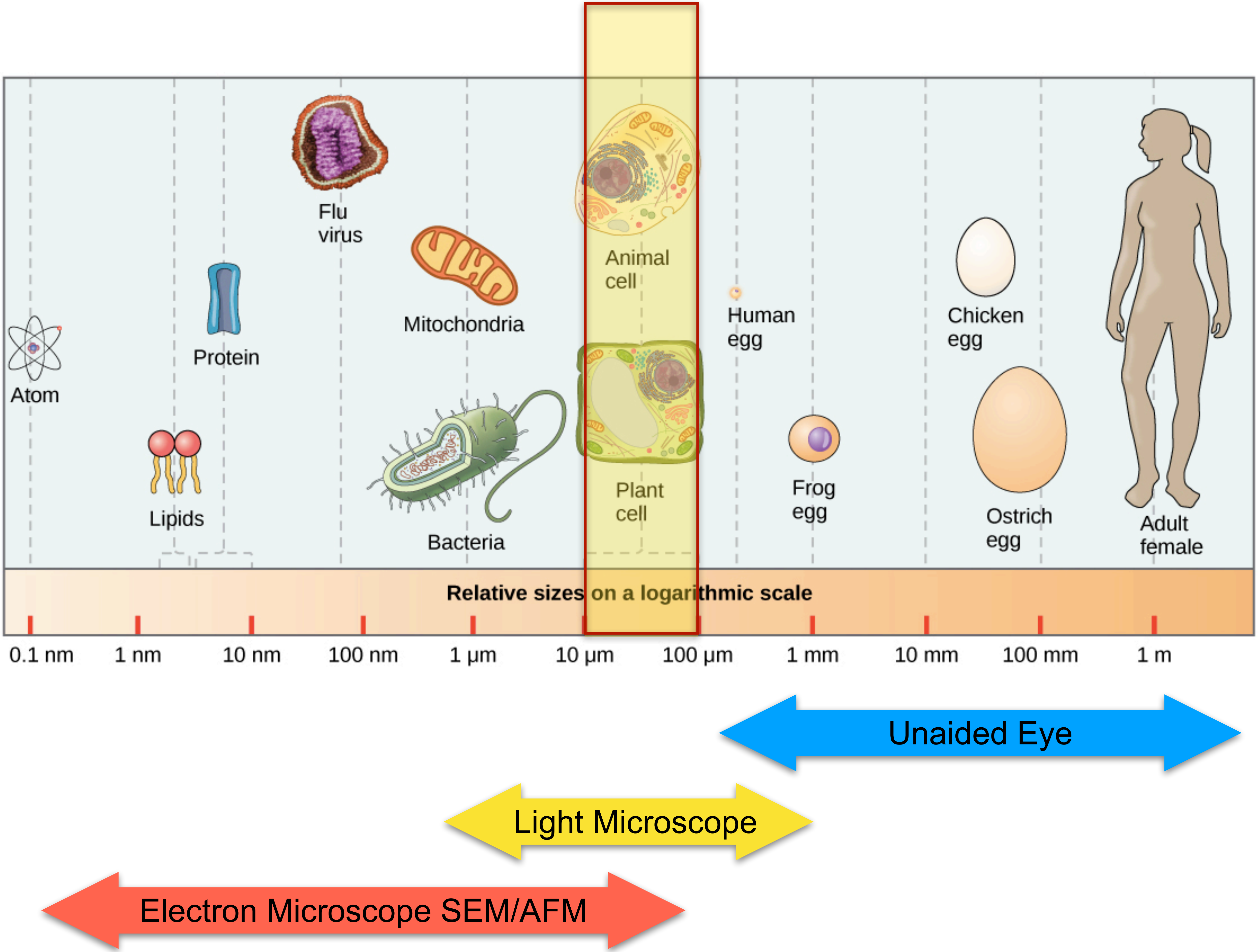


Sulphur in organic compound
plants
animals
animal excretory products
microorganims
Assimilation of sulfate (plants, microorganisms)
Decomposition of organic matter (microorganisms)
SO4 2-
Sulfate reduction (bacteria)
H2S
Sulfur reduction (bacteria)
Oxidation of sulfur (colorless and photosynthetic sulfur bacteria)
Oxidation of H2S (colorless and photosynthetic sulfur bacteria)
S

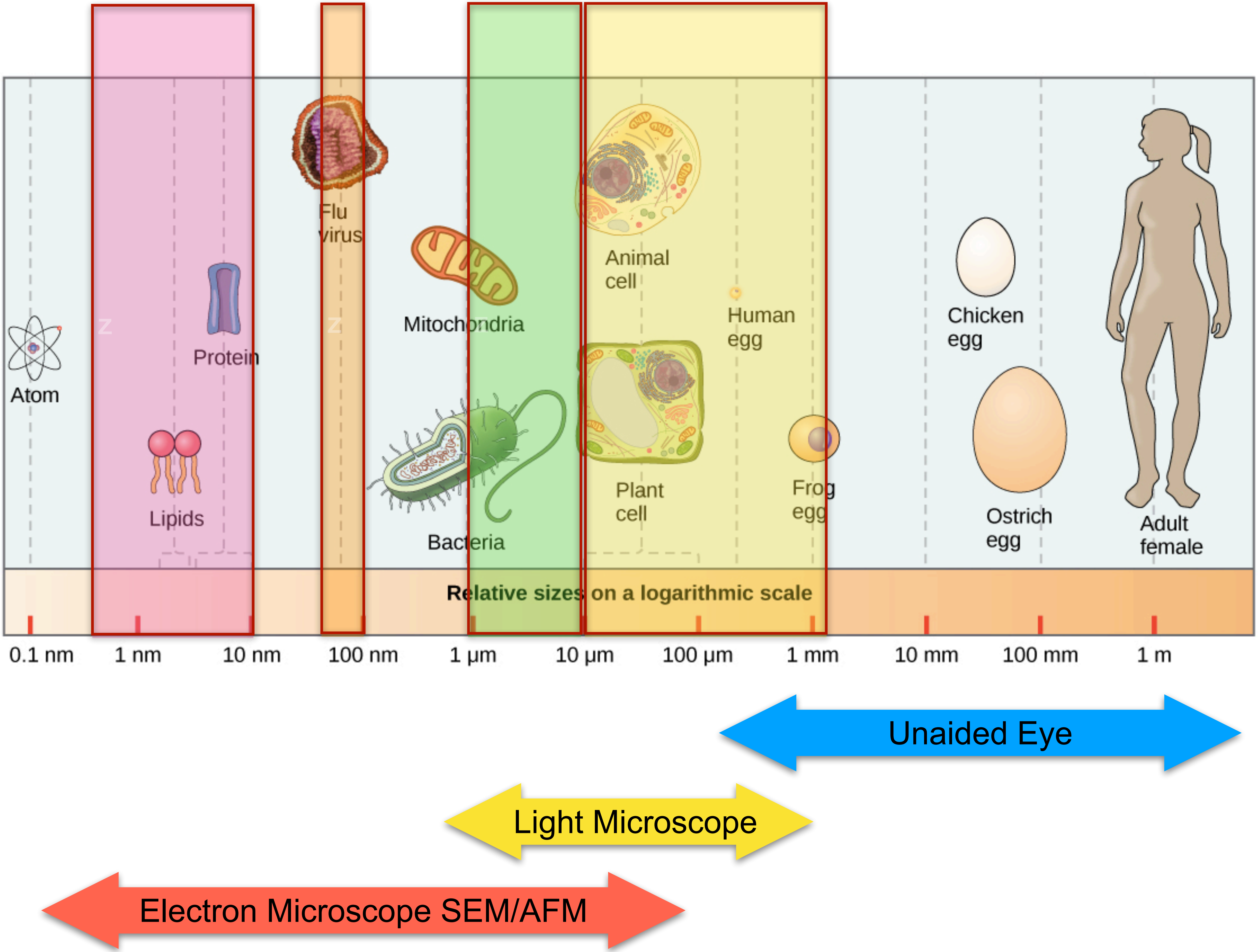
Sulphur



Sulphur in organic compound
plants
animals
animal excretory products
microorganims
Assimilation of sulfate (plants, microorganisms)
Decomposition of organic matter (microorganisms)
SO_4^{2-}
Sulfate reduction (bacteria)
H_2S
Sulfur reduction (bacteria)
Oxidation of sulfur (colorless and photosynthetic sulfur bacteria)
Oxidation of H_2S (colorless and photosynthetic sulfur bacteria)
S



Flu virus
Animal cell
Protein
Mitochondria
Human egg
Chicken egg
Atom
Lipids
Bacteria
Plant cell
Frog egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Unaided Eye
Light Microscope
Electron Microscope SEM/AFM



Atom
Lipids
Protein
Flu virus
Mitochondria
Bacteria
Animal cell
Plant cell
Human egg
Frog egg
Chicken egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Unaided Eye
Light Microscope
Electron Microscope SEM/AFM

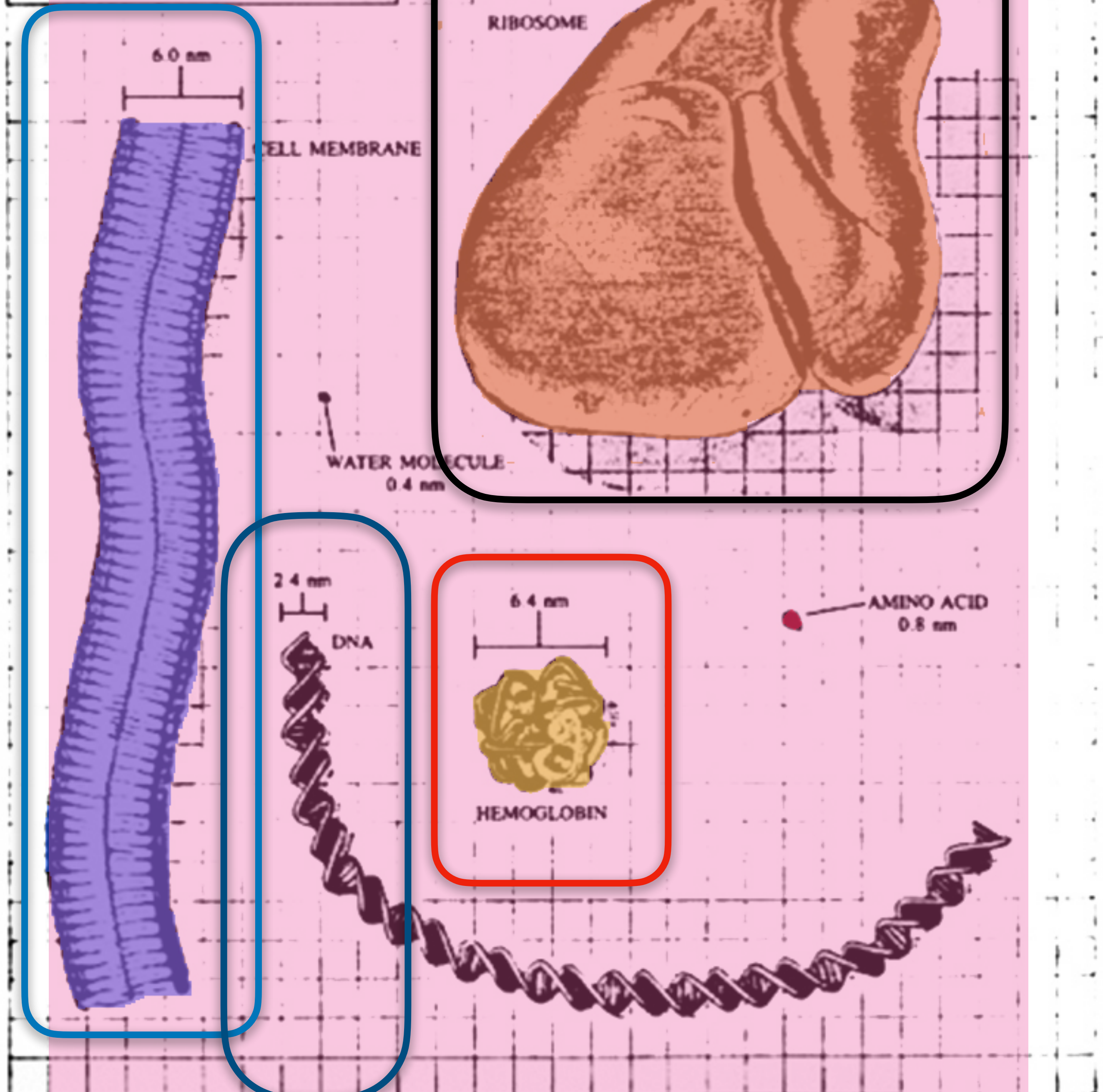
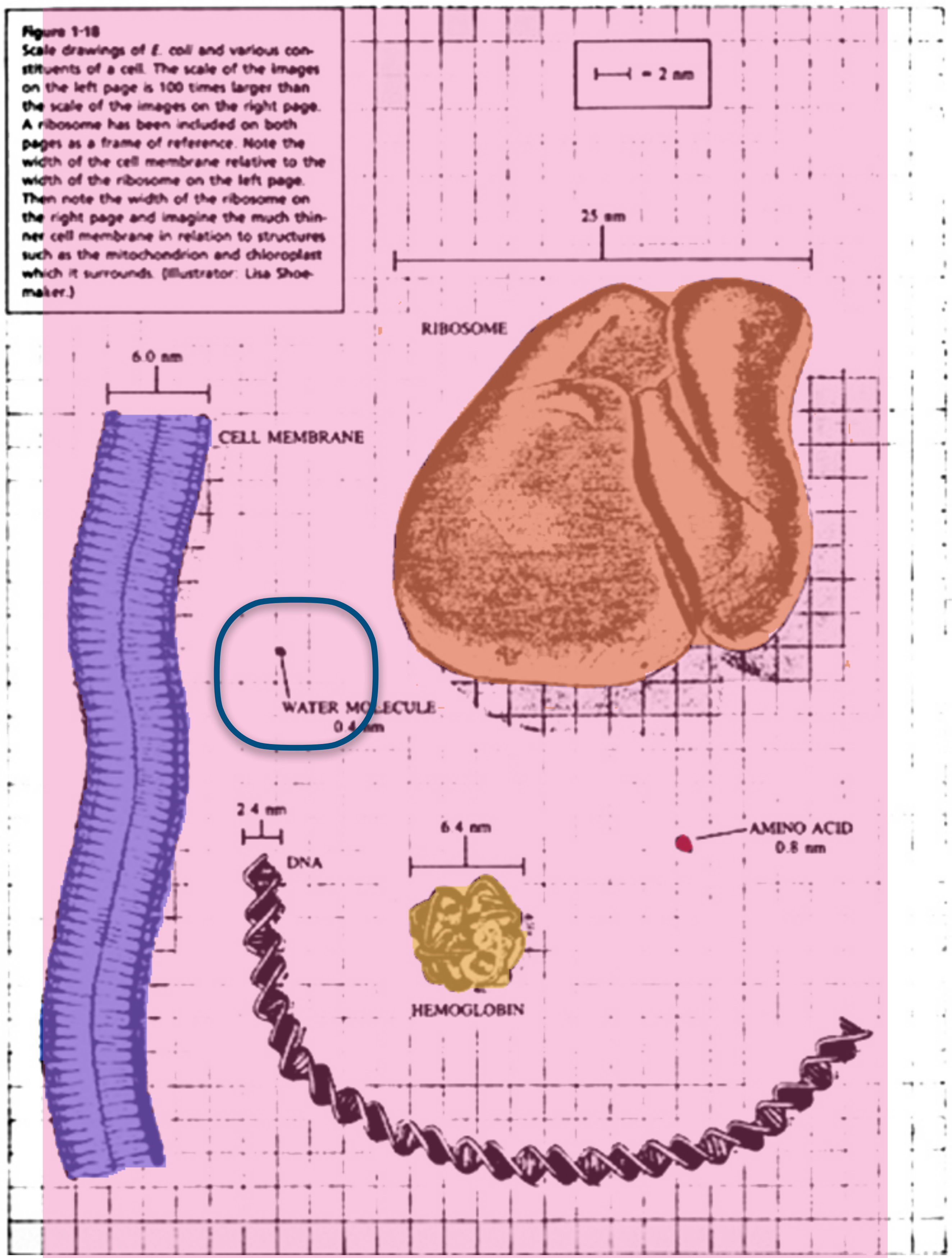
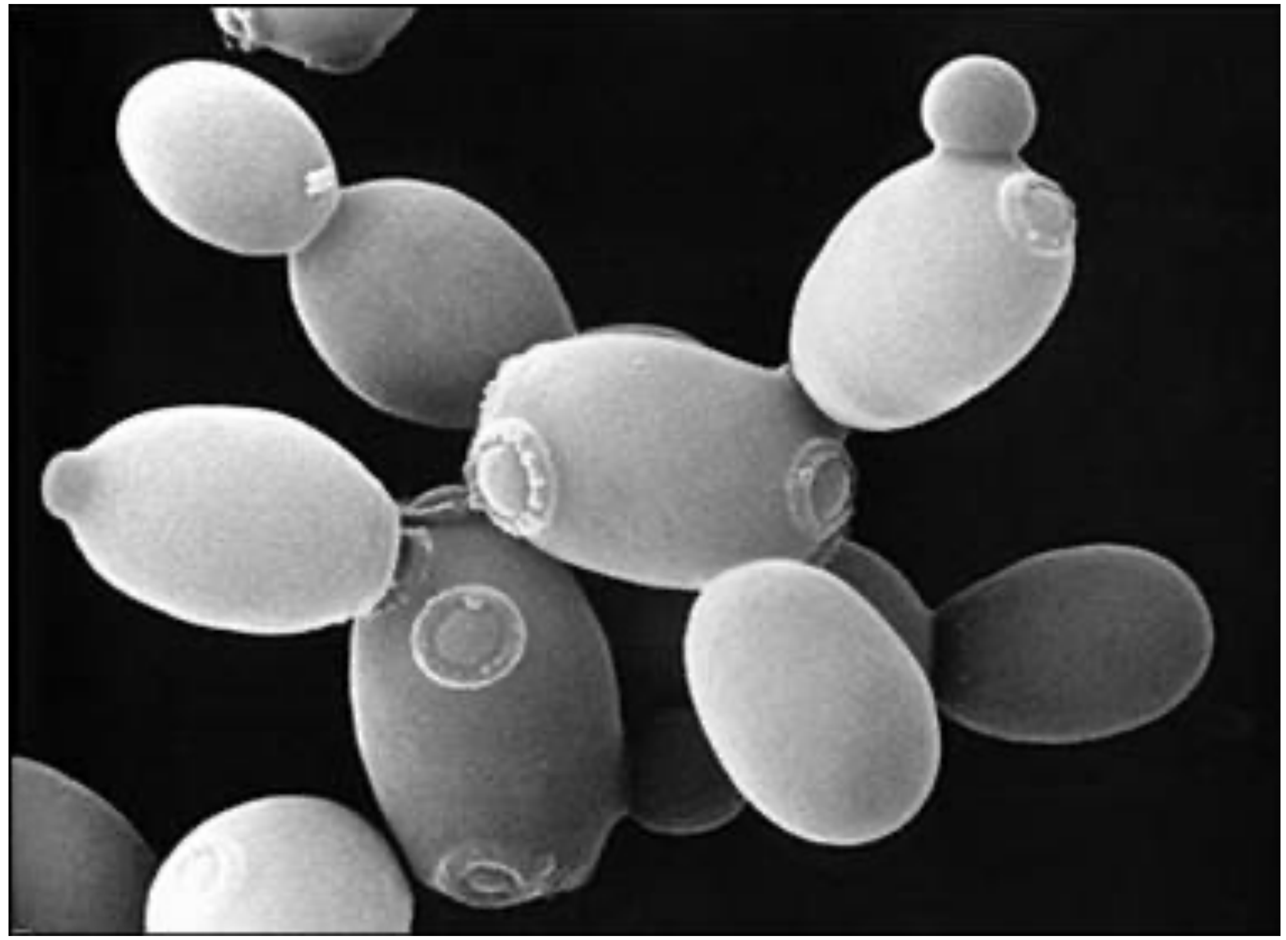


Figure 1-18
Scale drawings of *E. coli* and various constituents of a cell. The scale of the images on the left page is 100 times larger than the scale of the images on the right page. A ribosome has been included on both pages as a frame of reference. Note the width of the cell membrane relative to the width of the ribosome on the left page. Then note the width of the ribosome on the right page and imagine the much thinner cell membrane in relation to structures such as the mitochondrion and chloroplast which it surrounds. (Illustrator: Lisa Shoemaker.)

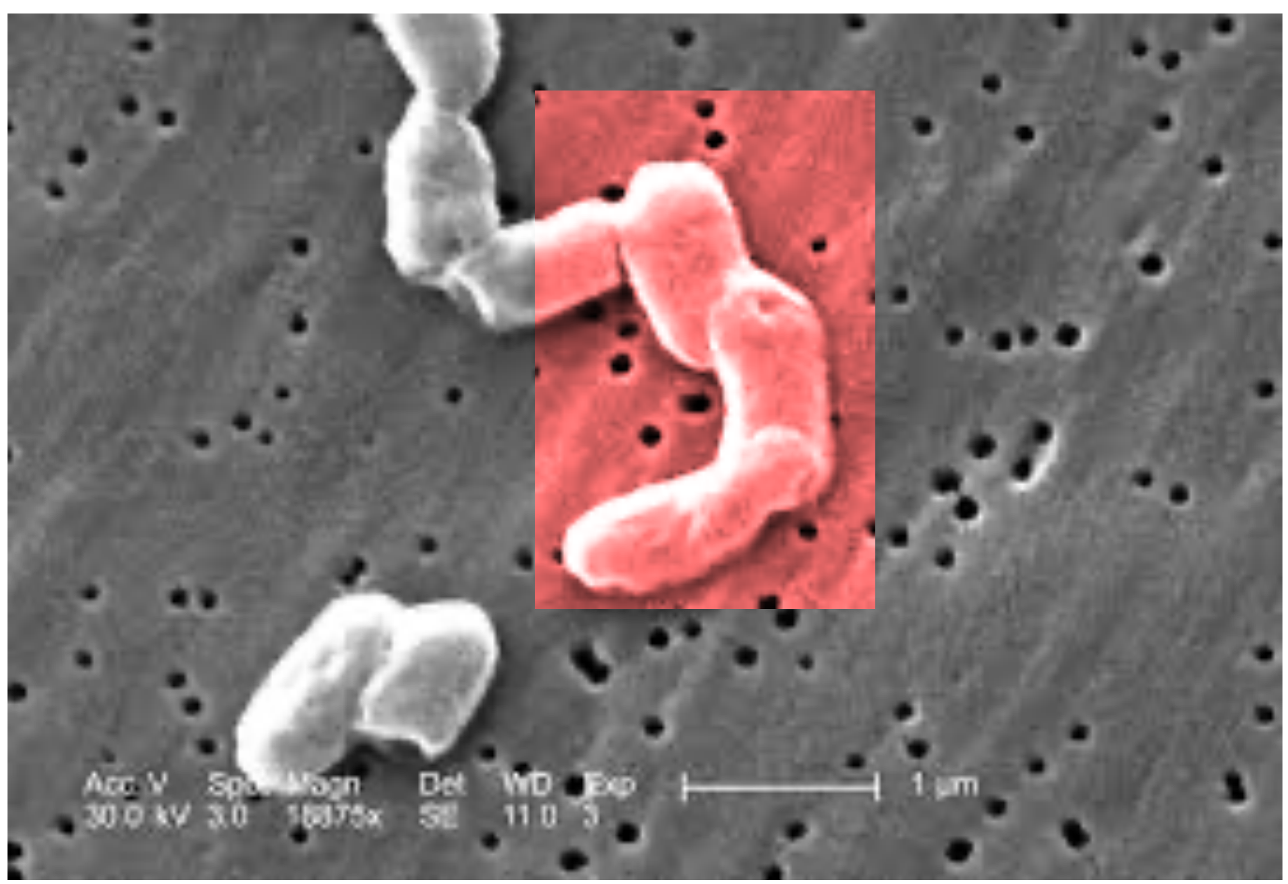
Figure 1-18
Scale drawings of *E. coli* and various constituents of a cell. The scale of the images on the left page is 100 times larger than the scale of the images on the right page. A ribosome has been included on both pages as a frame of reference. Note the width of the cell membrane relative to the width of the ribosome on the left page. Then note the width of the ribosome on the right page and imagine the much thinner cell membrane in relation to structures such as the mitochondrion and chloroplast which it surrounds. (Illustrator: Lisa Shoemaker.)





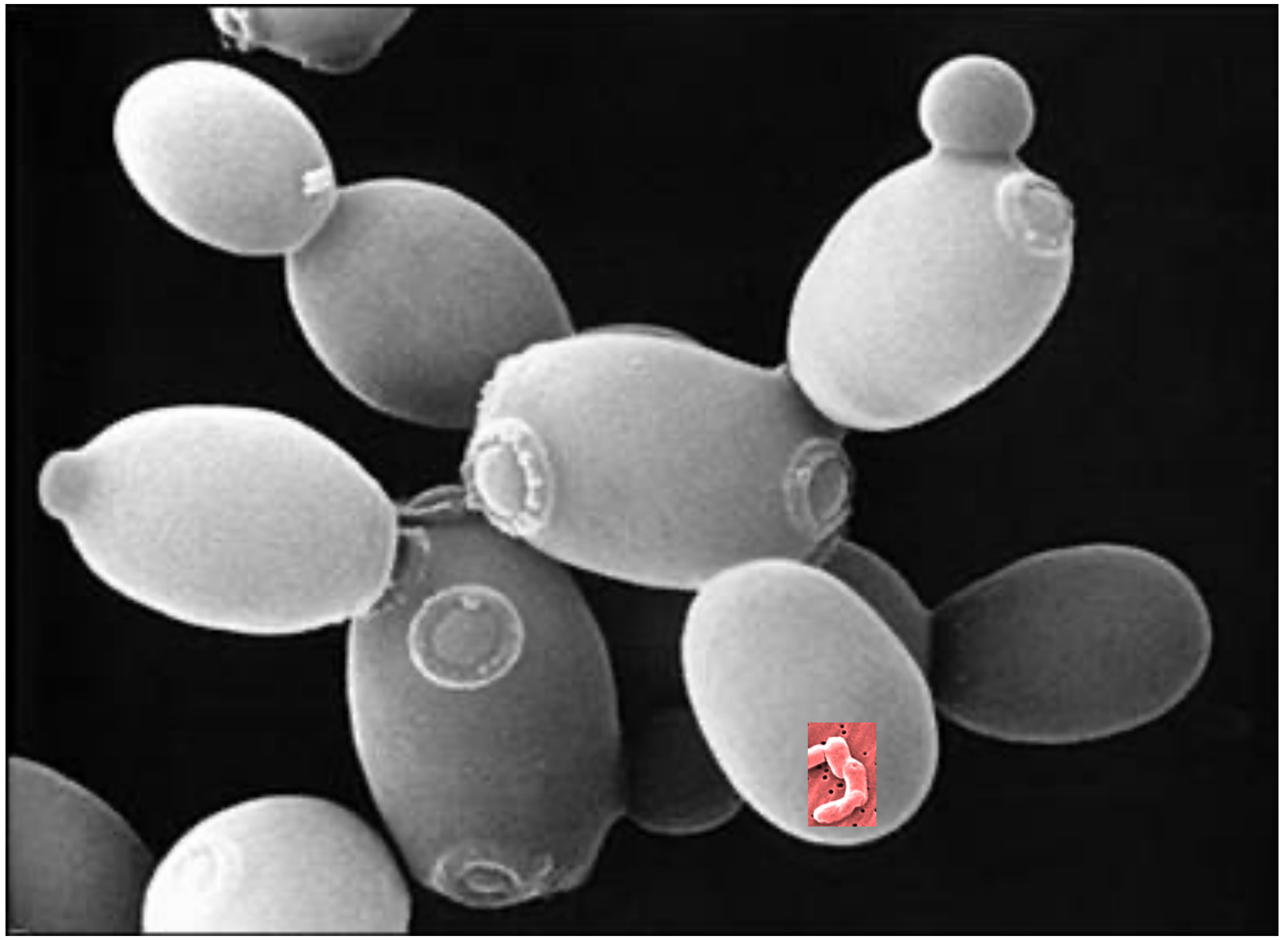
Yeast
S. cerevisiae

(~34 - 45 uM)



Bacterium
E. coli

(~1.5 - 3 uM)



Yeast
S. cerevisiae

(~34 - 45 uM)

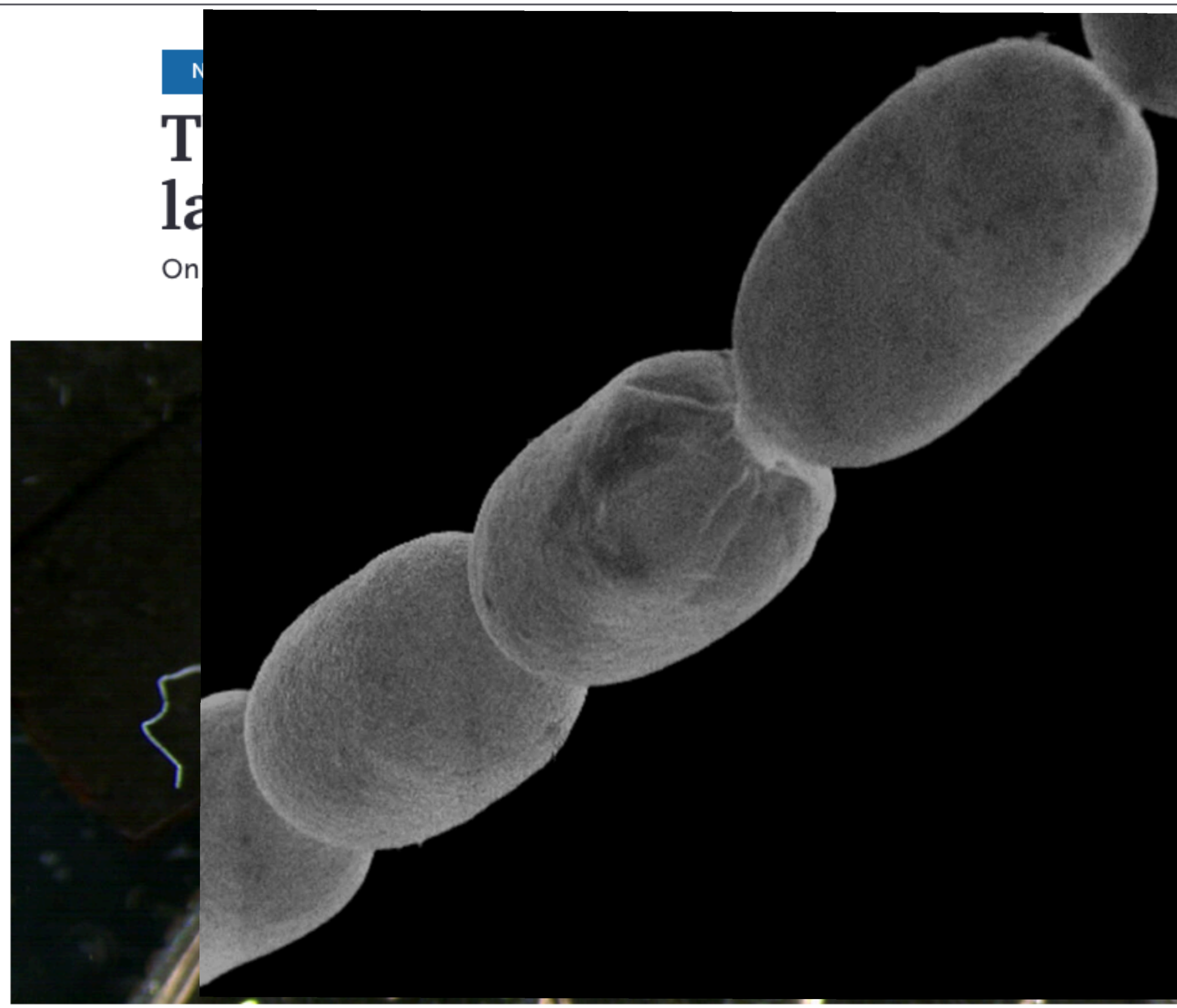
Bacterium
E. coli

(~1.5 - 3 uM)

N

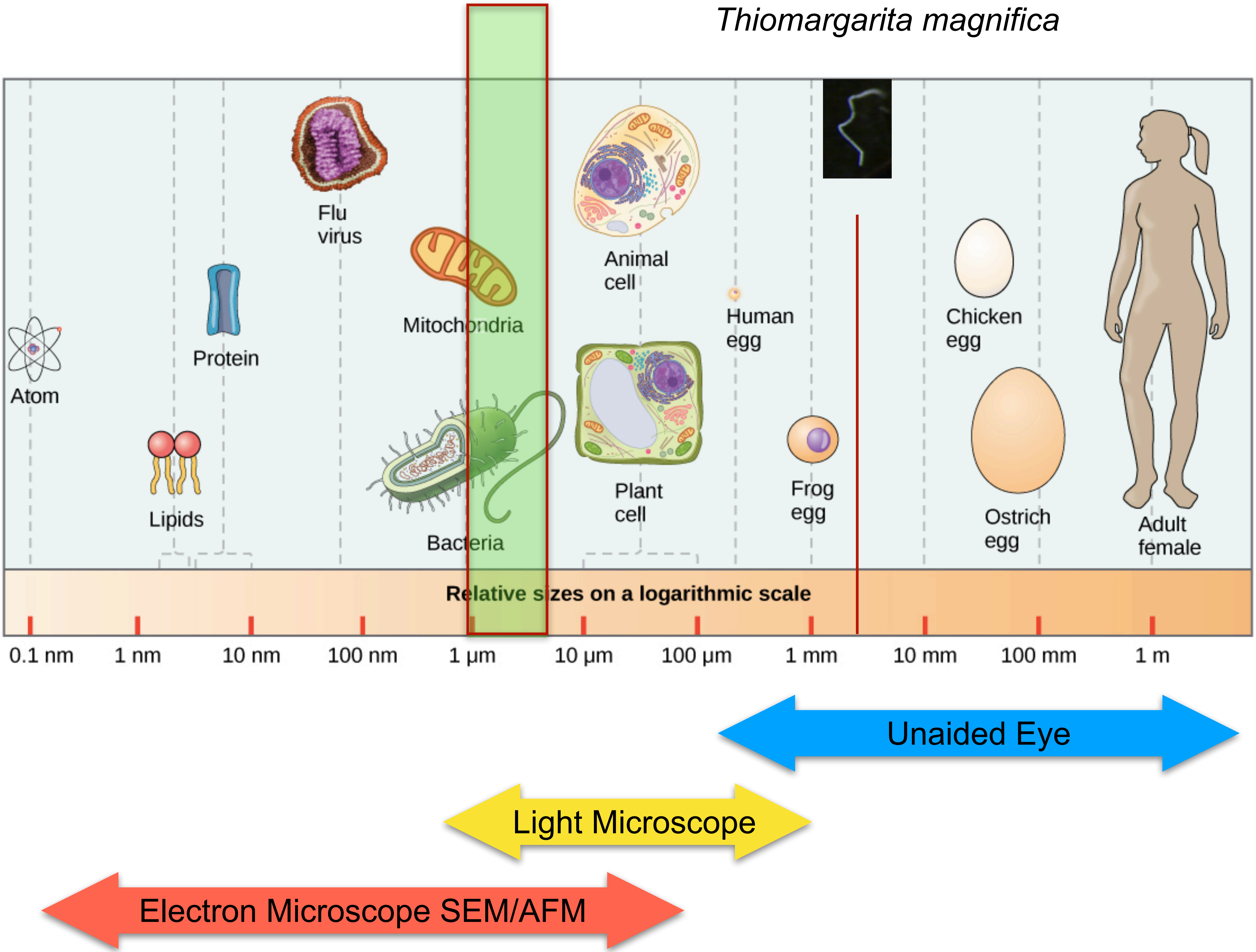
T
la

On

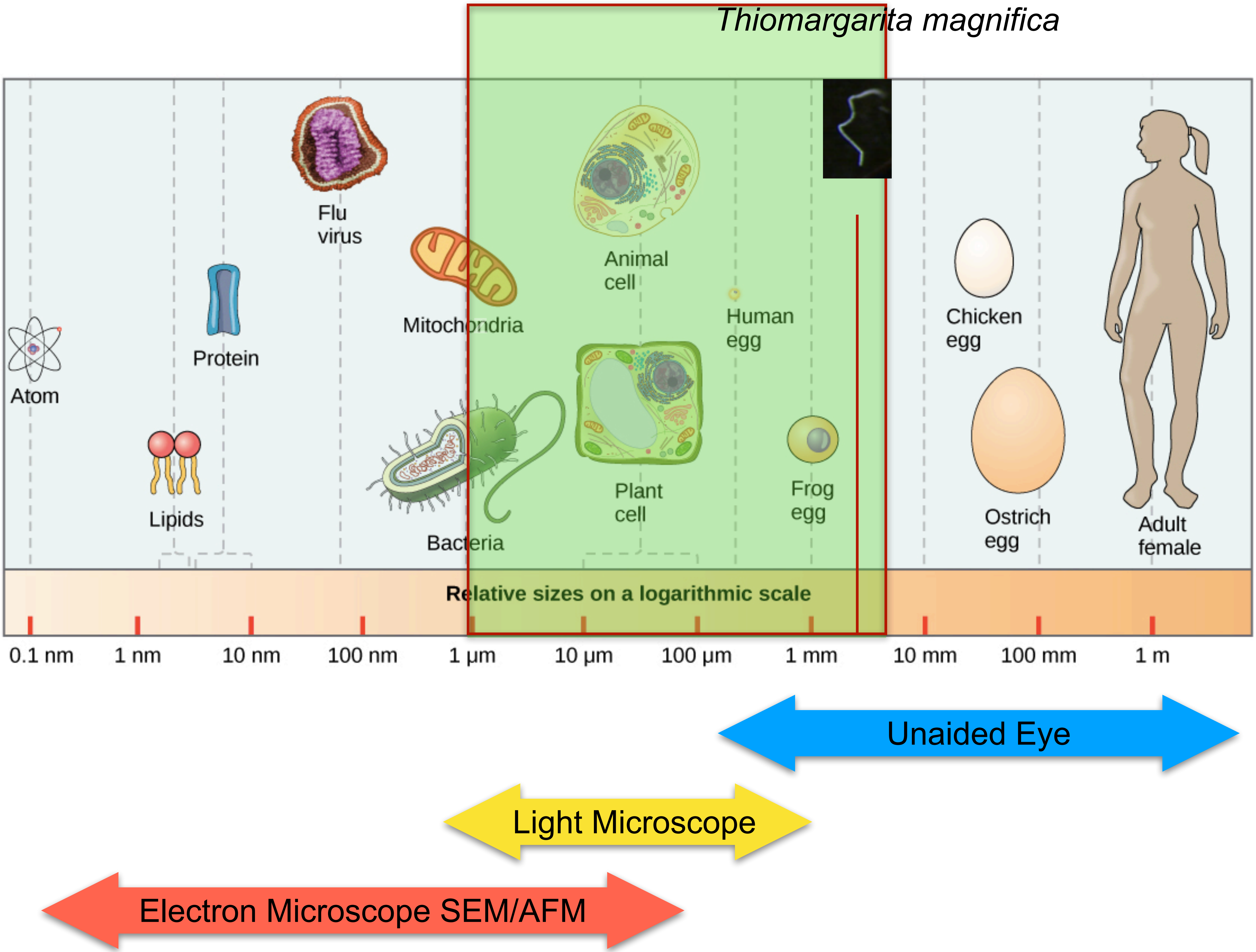


With an average length of 1 centimeter, *Thiomargarita magnifica* bacteria (several pictured) are big enough to see with the naked eye.

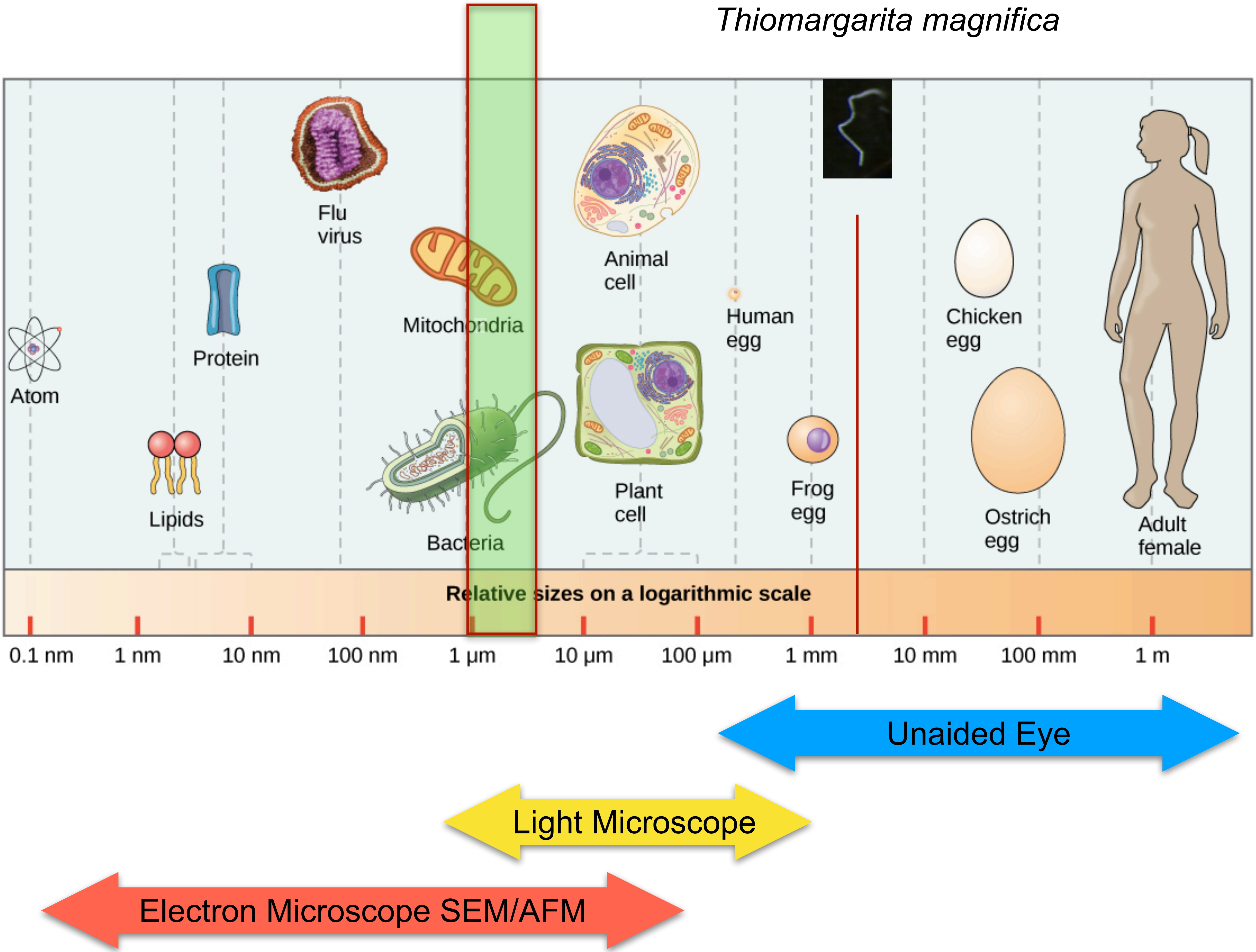
TOMAS TYML



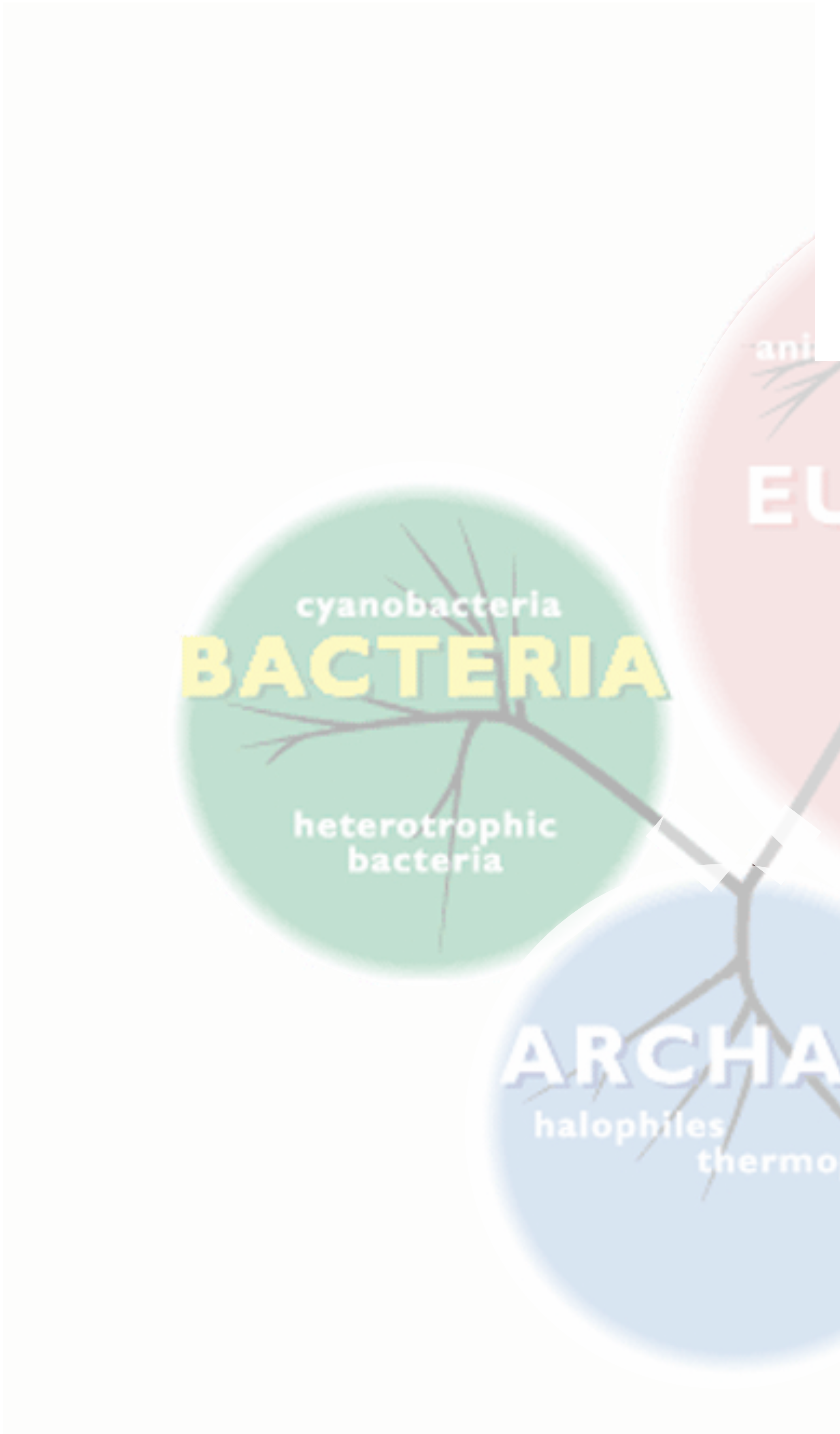
Thiomargarita magnifica
Flu virus
Animal cell
Protein
Mitochondria
Human egg
Chicken egg
Atom
Lipids
Bacteria
Plant cell
Frog egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Unaided Eye
Light Microscope
Electron Microscope SEM/AFM



Thiomargarita magnifica
Flu virus
Protein
Atom
Lipids
Mitochondria
Bacteria
Animal cell
Plant cell
Human egg
Frog egg
Chicken egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Unaided Eye
Light Microscope
Electron Microscope SEM/AFM



Thiomargarita magnifica
Atom
Lipids
Protein
Flu virus
Mitochondria
Bacteria
Animal cell
Plant cell
Human egg
Frog egg
Chicken egg
Ostrich egg
Adult female
Relative sizes on a logarithmic scale
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
10 mm
100 mm
1 m
Unaided Eye
Light Microscope
Electron Microscope SEM/AFM



Eukaryote

Temporal range: Orosirian – Present

1850–0 Ma

Diversity in Eukaryotes

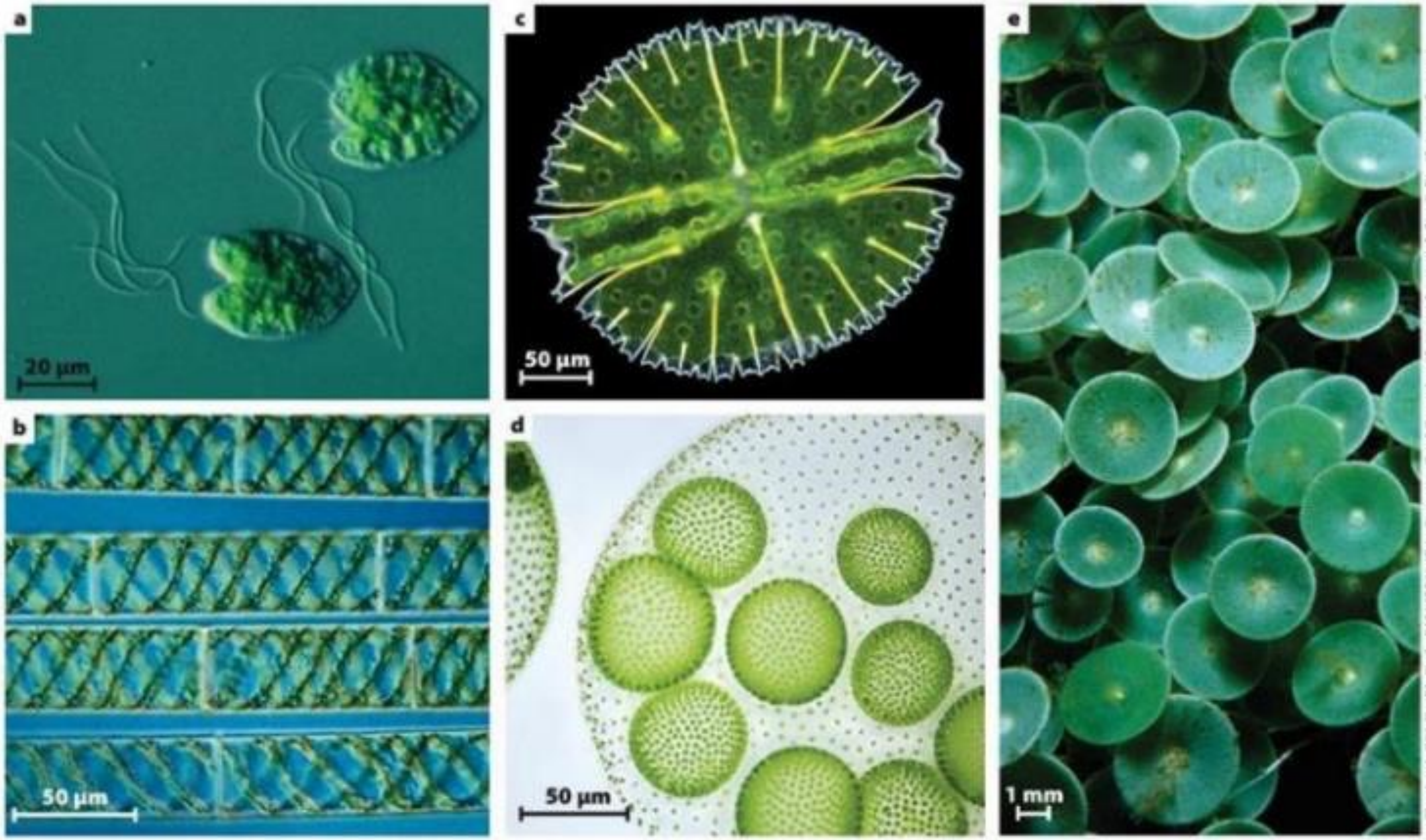
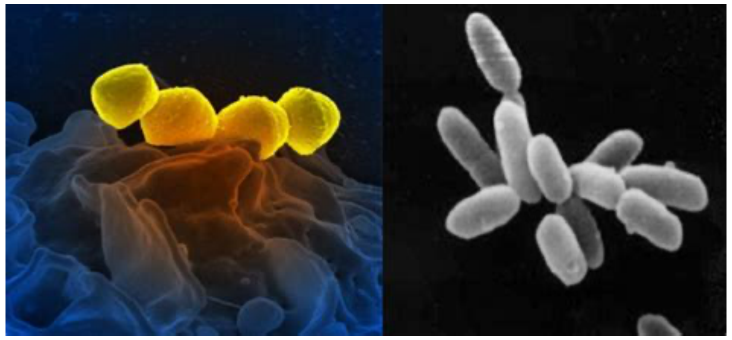
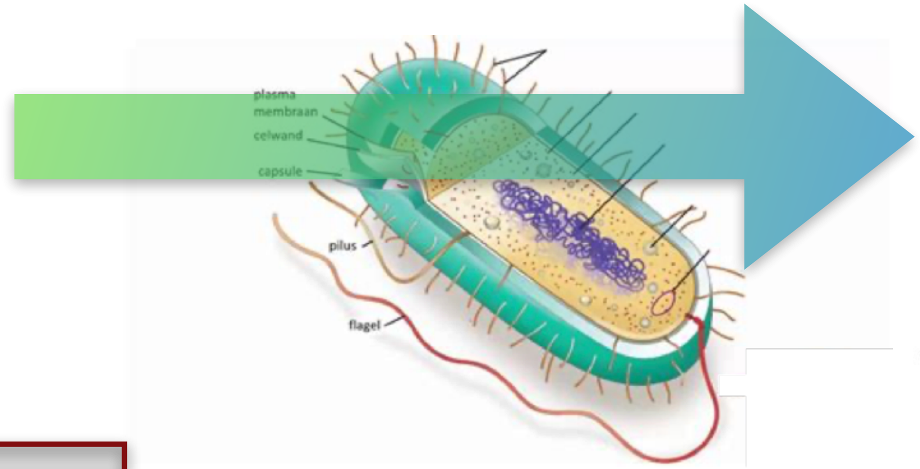


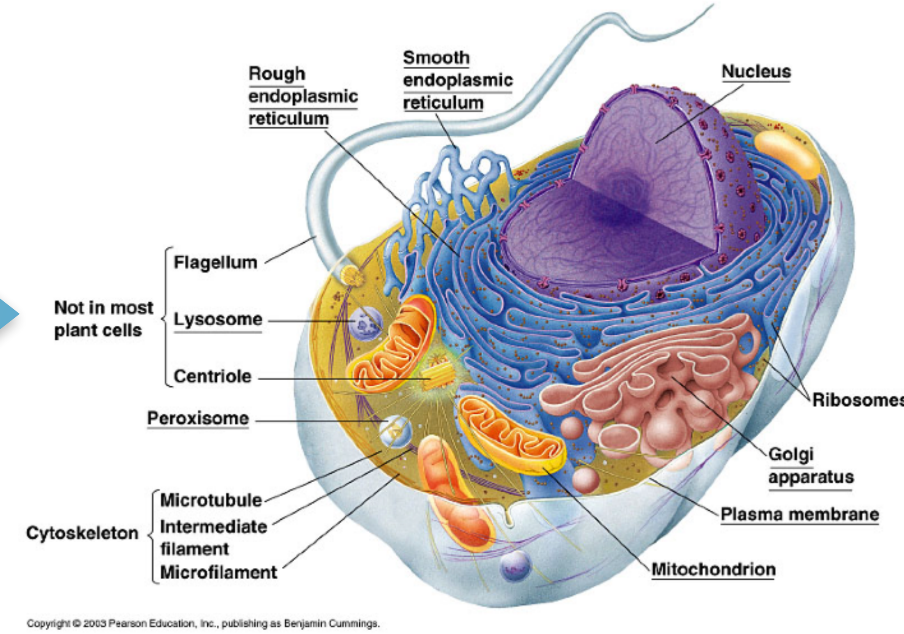
Figure 25.15
Biology: How Life Works, Third Edition

a: Charles J. O'Kelly, Ph.D.; b: DIOMEDIA/Erik Grave; c: Gerd Guenther/Science Source; d: Frank Fox/Science Source; e: Wolfgang Poelzer/Wa/AGE Fotostock

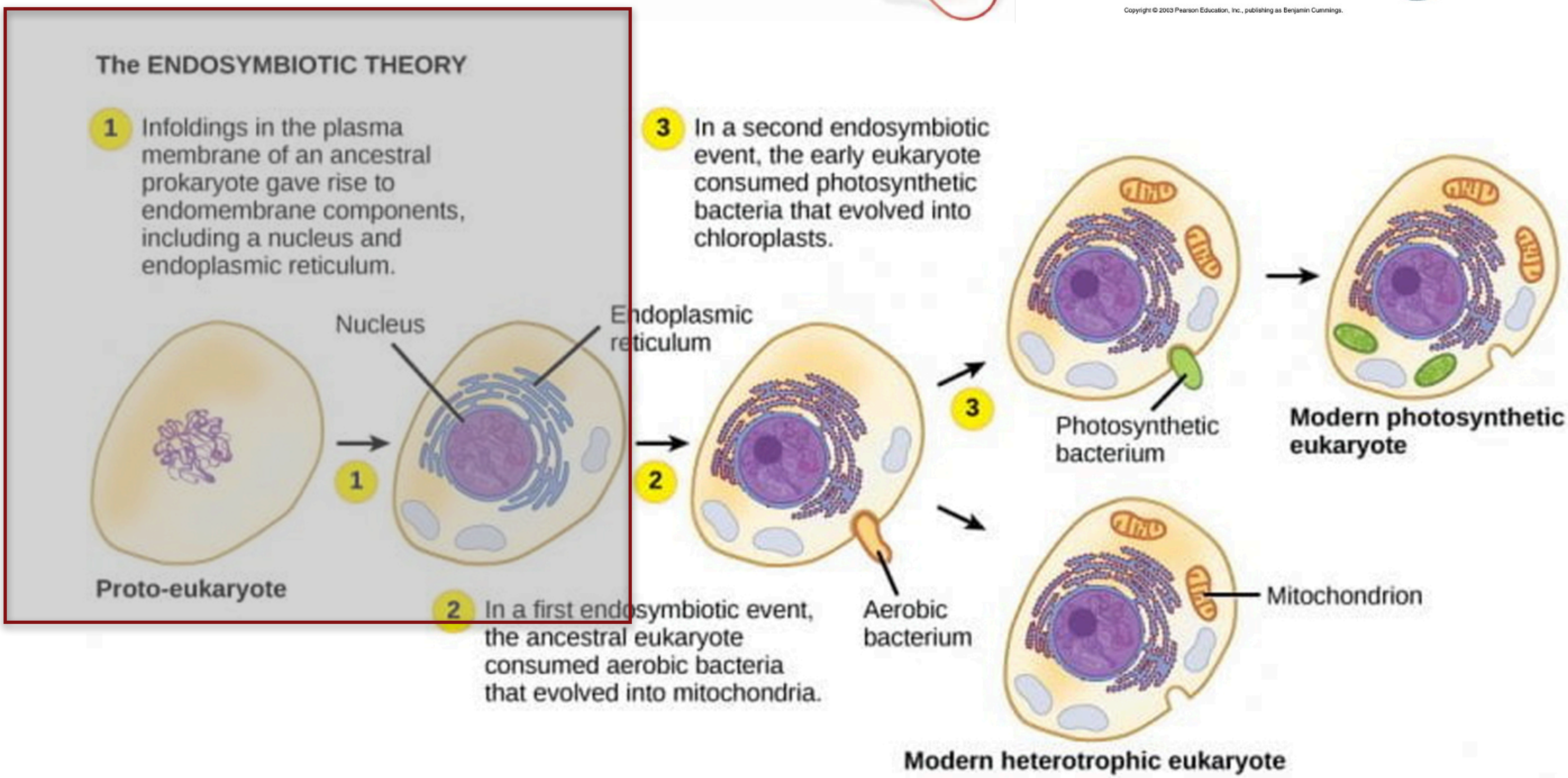


Archaea

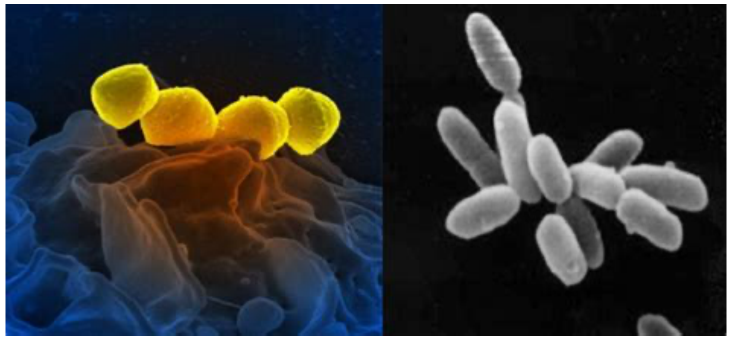


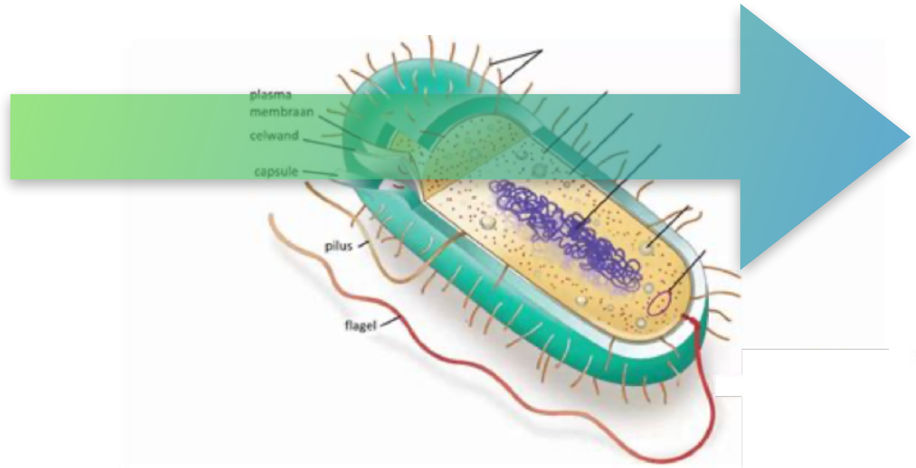


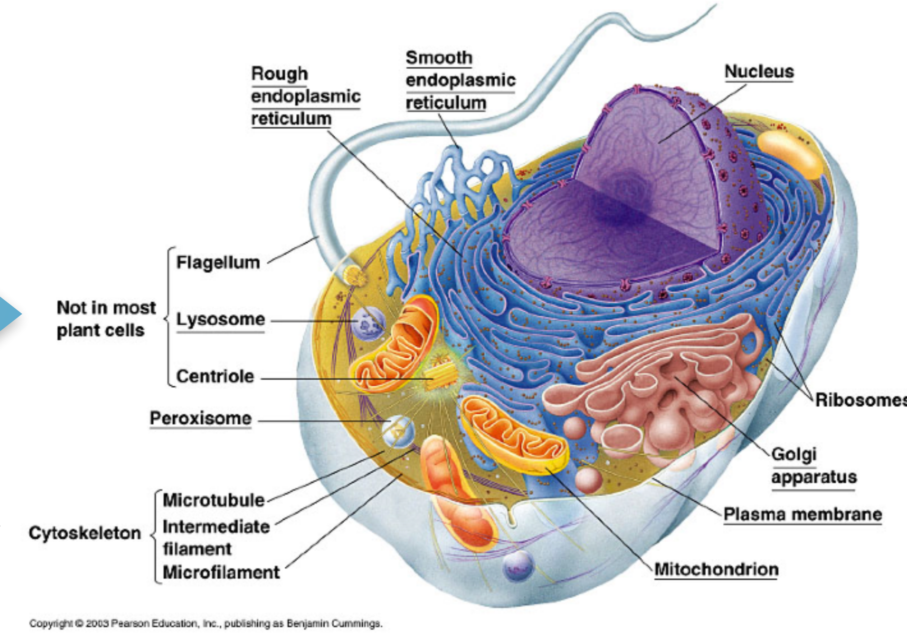
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Nucleus
Flagellum
Not in most plant cells
Lysosome
Centriole
Peroxisome
Ribosomes
Golgi apparatus
Cytoskeleton
Microtubule
Intermediate filament
Microfilament
Plasma membrane
Mitochondrion
Copyright © 2003 Pearson Education, Inc., publishing as Benjamin Cummings.

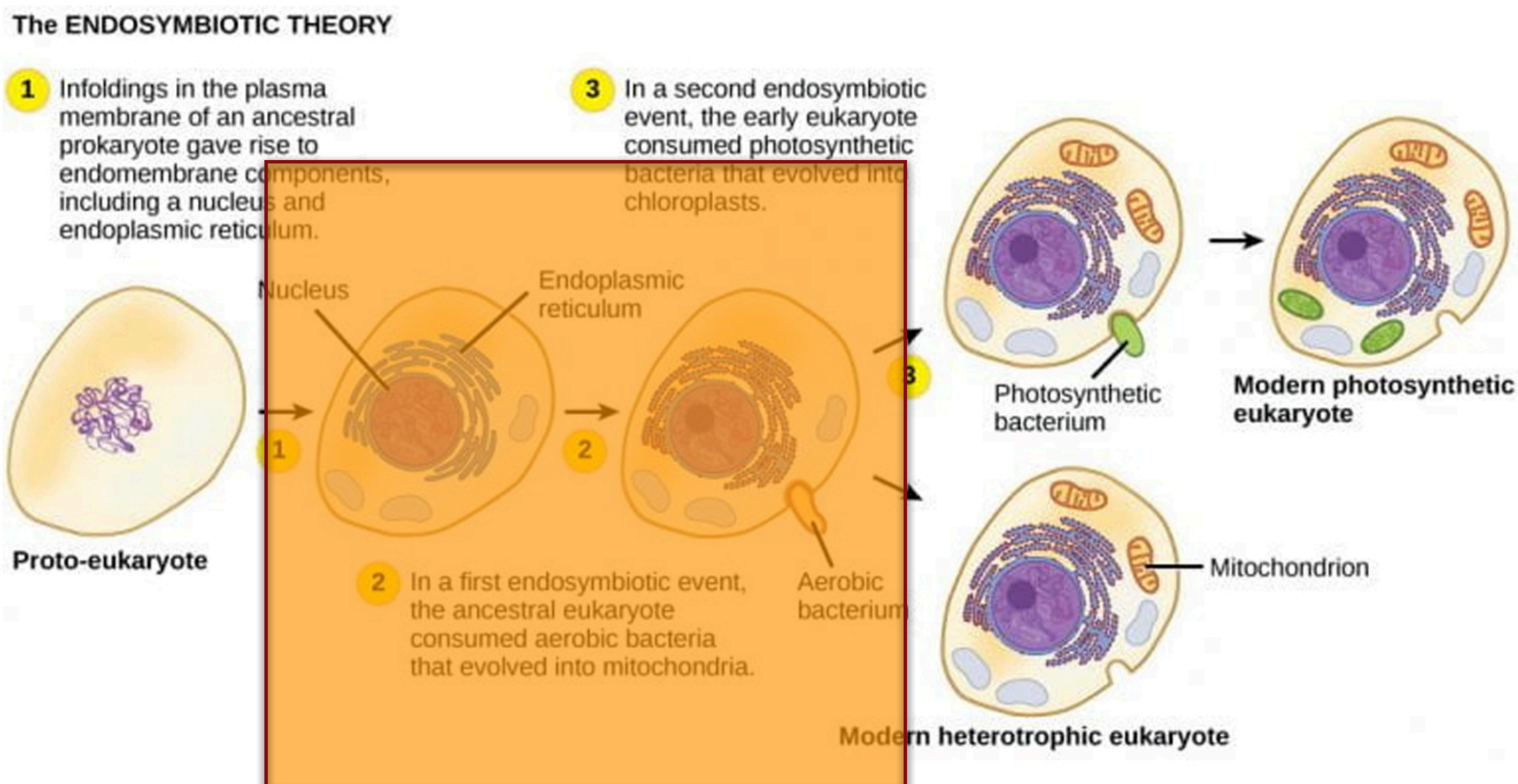


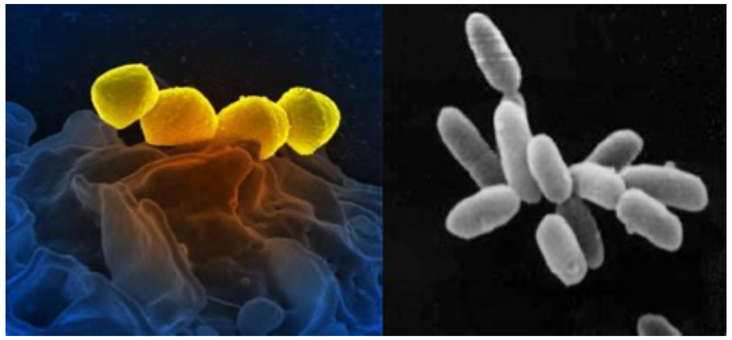
The ENDOSYMBIOTIC THEORY
1 Infoldings in the plasma membrane of an ancestral prokaryote gave rise to endomembrane components, including a nucleus and endoplasmic reticulum.
Nucleus
Endoplasmic reticulum
Proto-eukaryote
1
2
2 In a first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria that evolved into mitochondria.
Aerobic bacterium
3 In a second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria that evolved into chloroplasts.
3
Photosynthetic bacterium
Modern photosynthetic eukaryote
Mitochondrion
Modern heterotrophic eukaryote

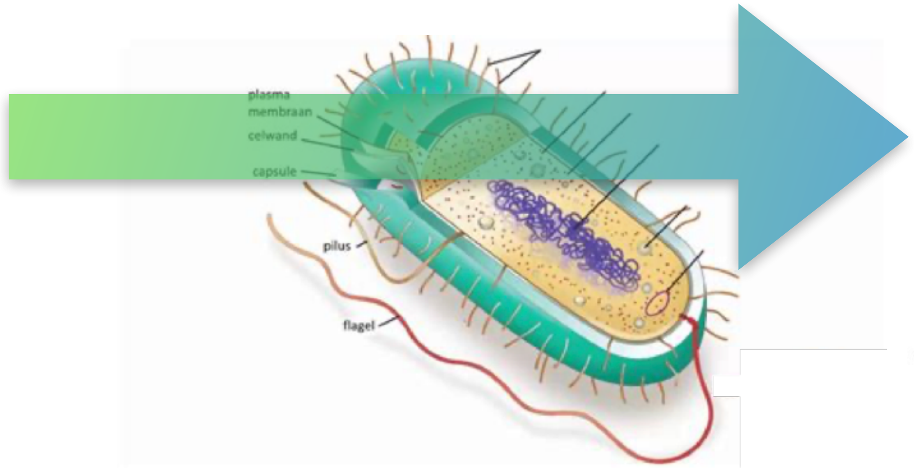


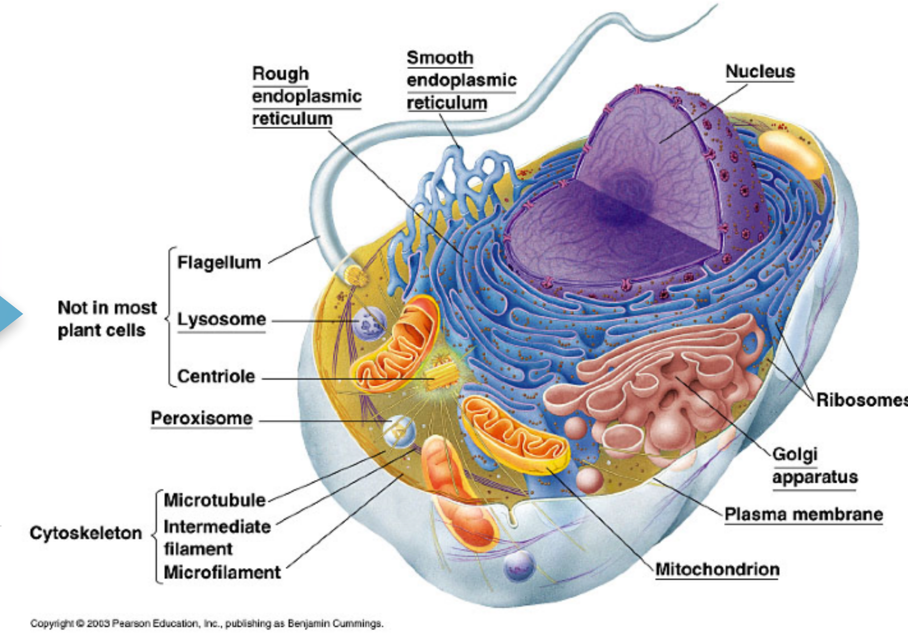


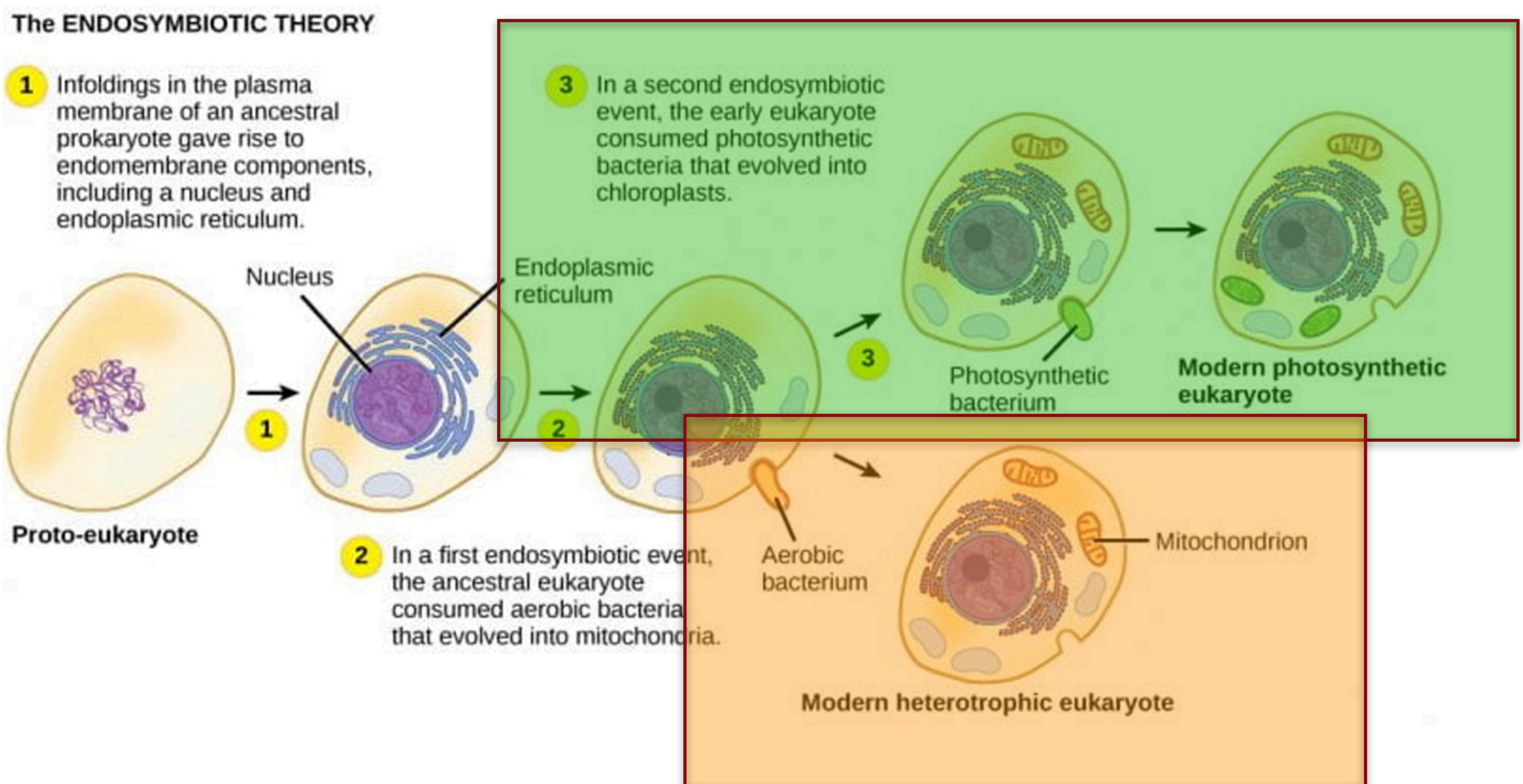

Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Nucleus
Flagellum
Not in most plant cells
Lysosome
Centriole
Peroxisome
Ribosomes
Golgi apparatus
Cytoskeleton
Microtubule
Intermediate filament
Microfilament
Plasma membrane
Mitochondrion
Copyright © 2003 Pearson Education, Inc., publishing as Benjamin Cummings.


The ENDOSYMBIOTIC THEORY
1 Infoldings in the plasma membrane of an ancestral prokaryote gave rise to endomembrane components, including a nucleus and endoplasmic reticulum.
3 In a second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria that evolved into chloroplasts.
Nucleus
Endoplasmic reticulum
Proto-eukaryote
1
2
3
Photosynthetic bacterium
Modern photosynthetic eukaryote
Mitochondrion
2 In a first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria that evolved into mitochondria.
Aerobic bacterium
Modern heterotrophic eukaryote




pilus
flagel


Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Nucleus
Flagellum
Not in most plant cells
Lysosome
Centriole
Peroxisome
Ribosomes
Golgi apparatus
Cytoskeleton
Microtubule
Intermediate filament
Microfilament
Plasma membrane
Mitochondrion
Copyright © 2003 Pearson Education, Inc., publishing as Benjamin Cummings.


The ENDOSYMBIOTIC THEORY
1 Infoldings in the plasma membrane of an ancestral prokaryote gave rise to endomembrane components, including a nucleus and endoplasmic reticulum.
3 In a second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria that evolved into chloroplasts.
Nucleus
Endoplasmic reticulum
1
2
3
Photosynthetic bacterium
Modern photosynthetic eukaryote
Proto-eukaryote
2 In a first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria that evolved into mitochondria.
Aerobic bacterium
Mitochondrion
Modern heterotrophic eukaryote

Prokaryotic Phylogeny

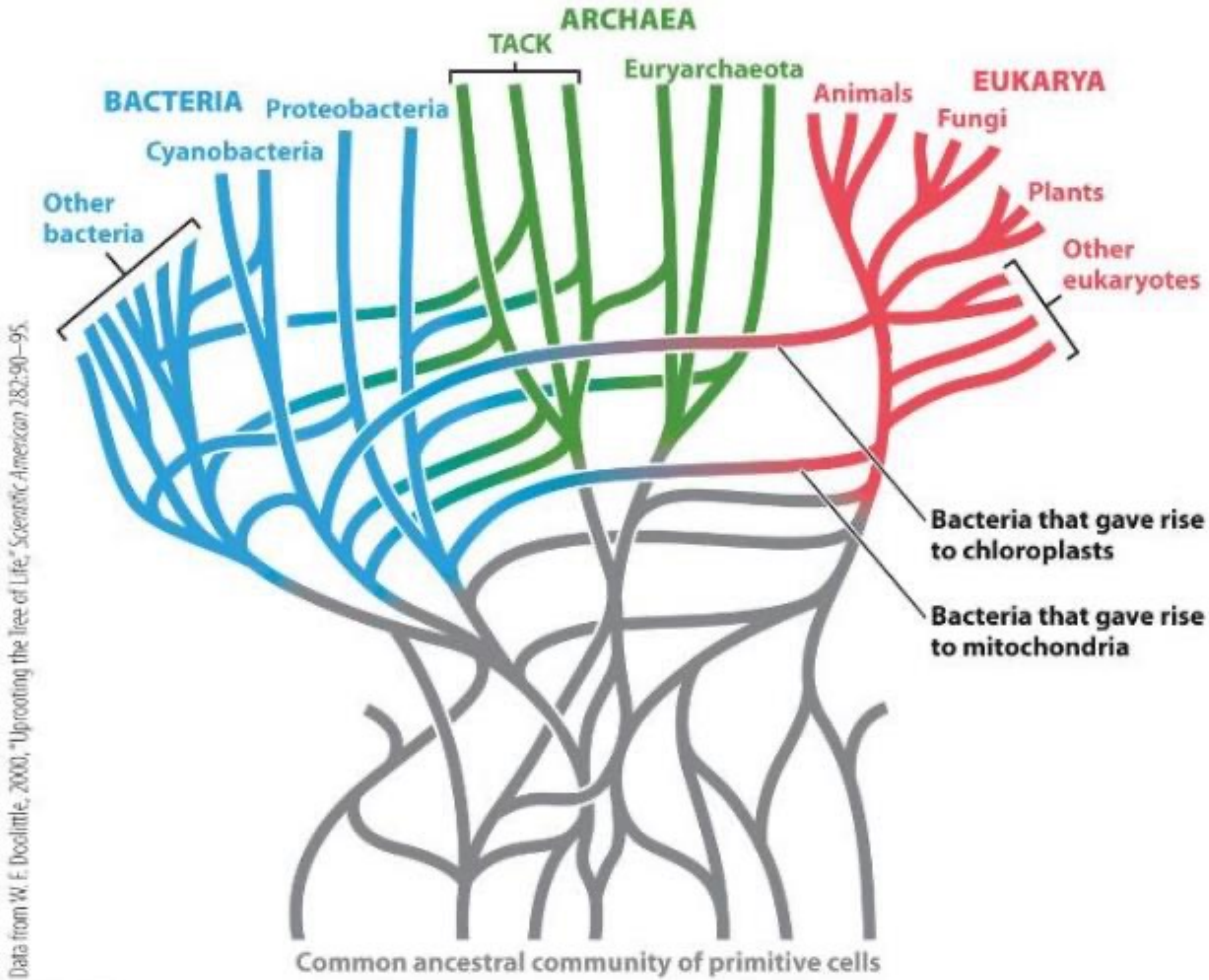


Figure 24.15
Biology: How Life Works, Third Edition

Origins of Eukaryotic Cells

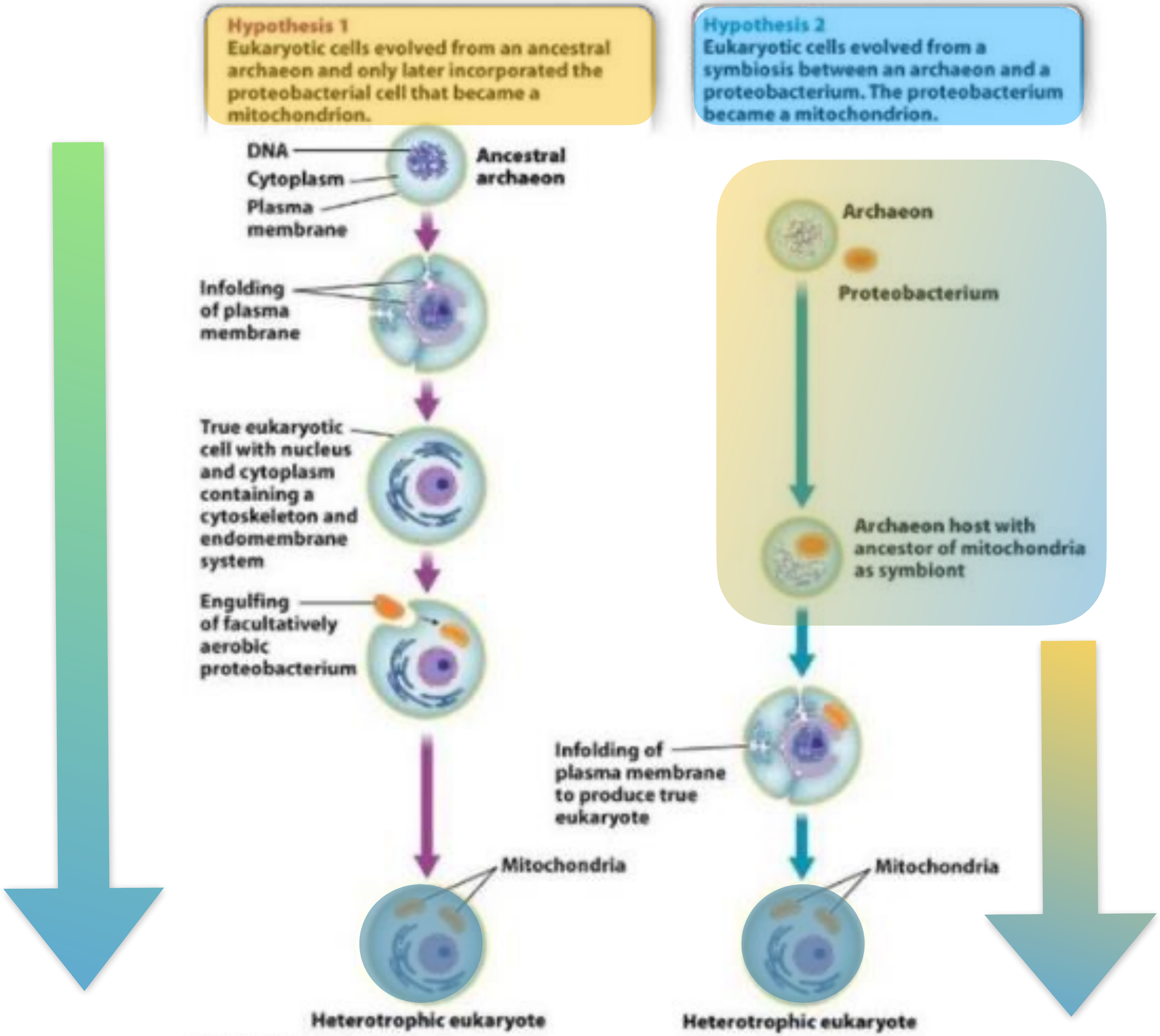
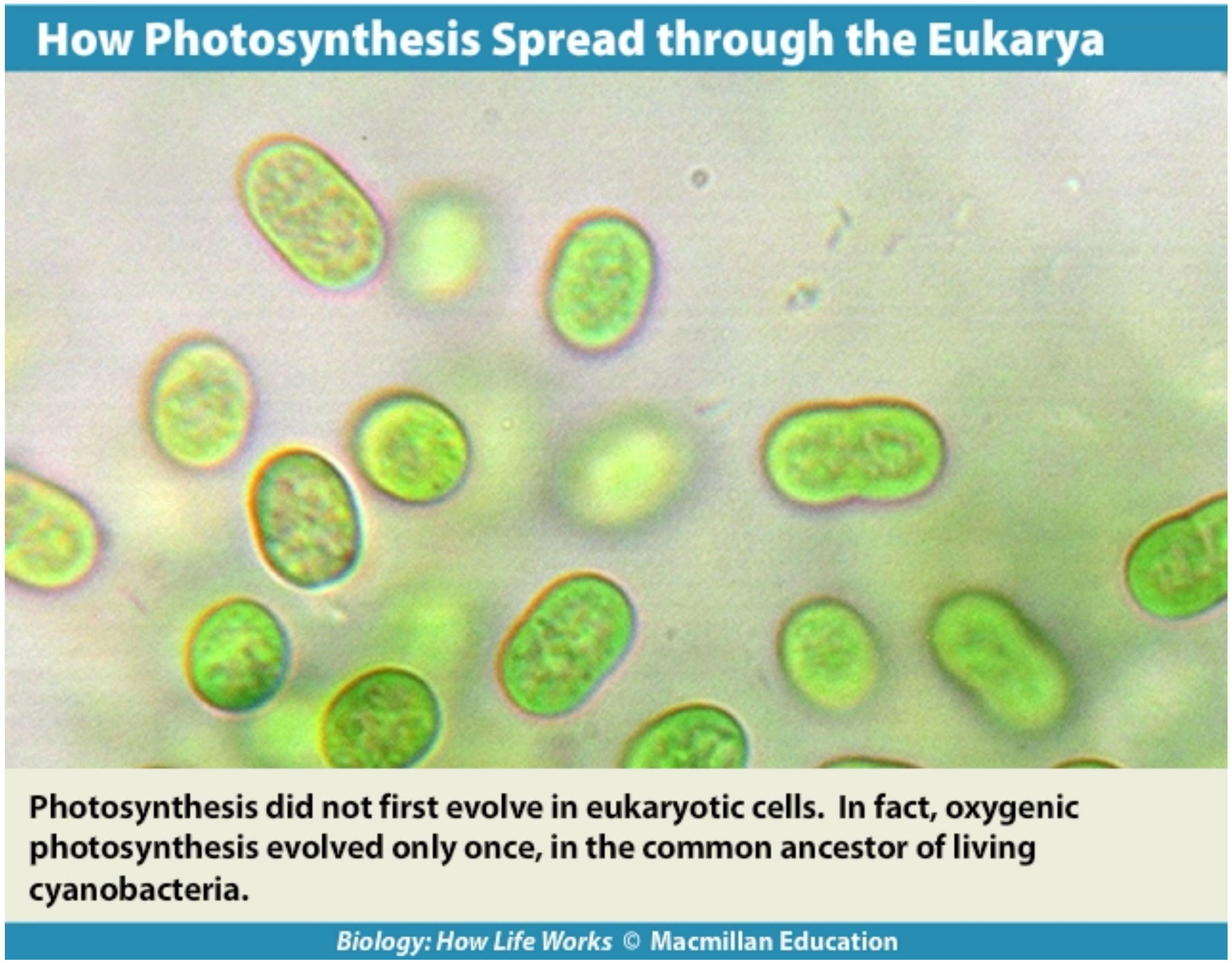


Figure 25.7
Biology: How Life Works, Third Edition

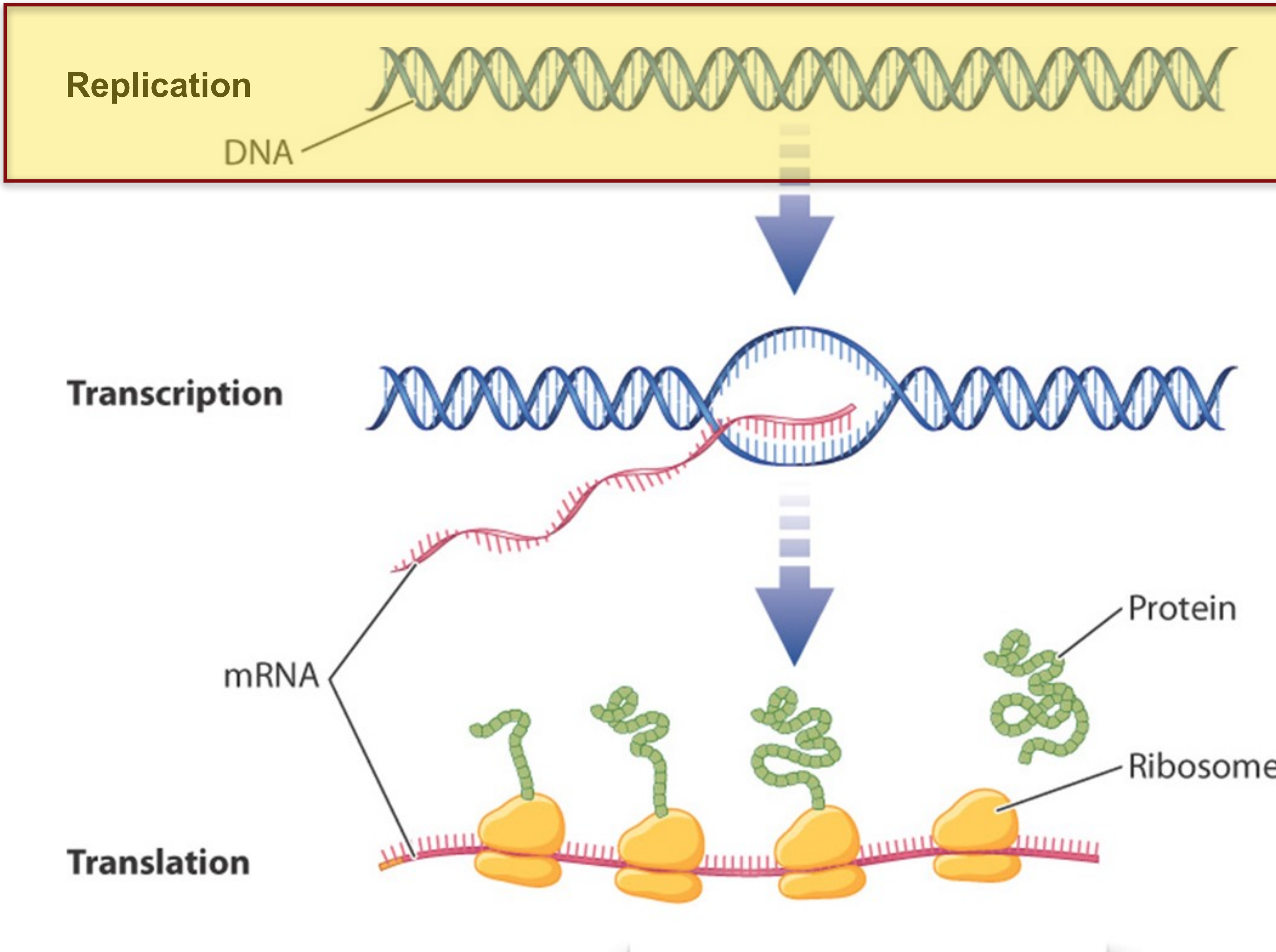
How Photosynthesis Spread through the Eukarya



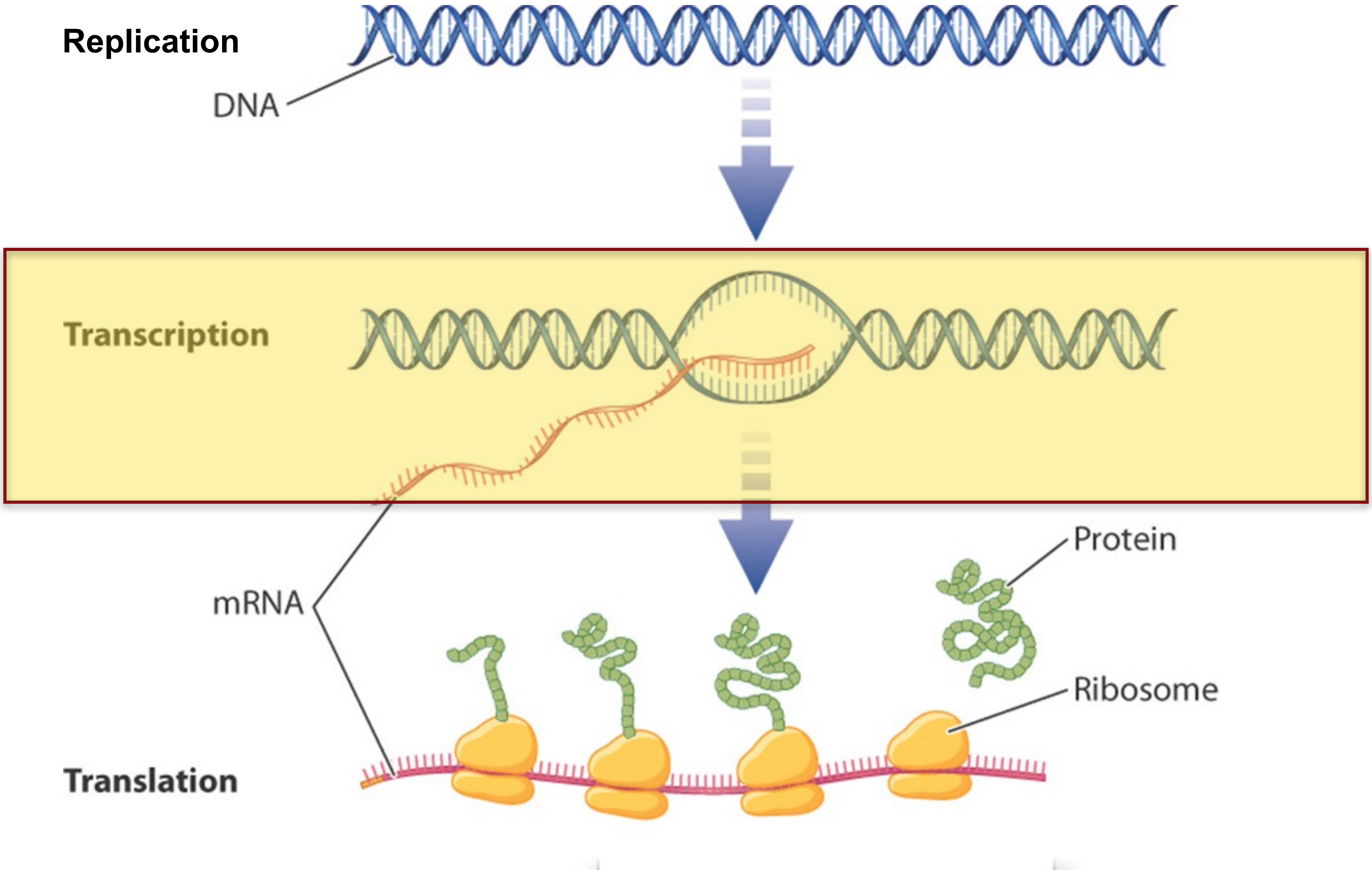
[View Transcript Link]

Photo credit: Cyanobacteria: Dr. Ralf Wagner

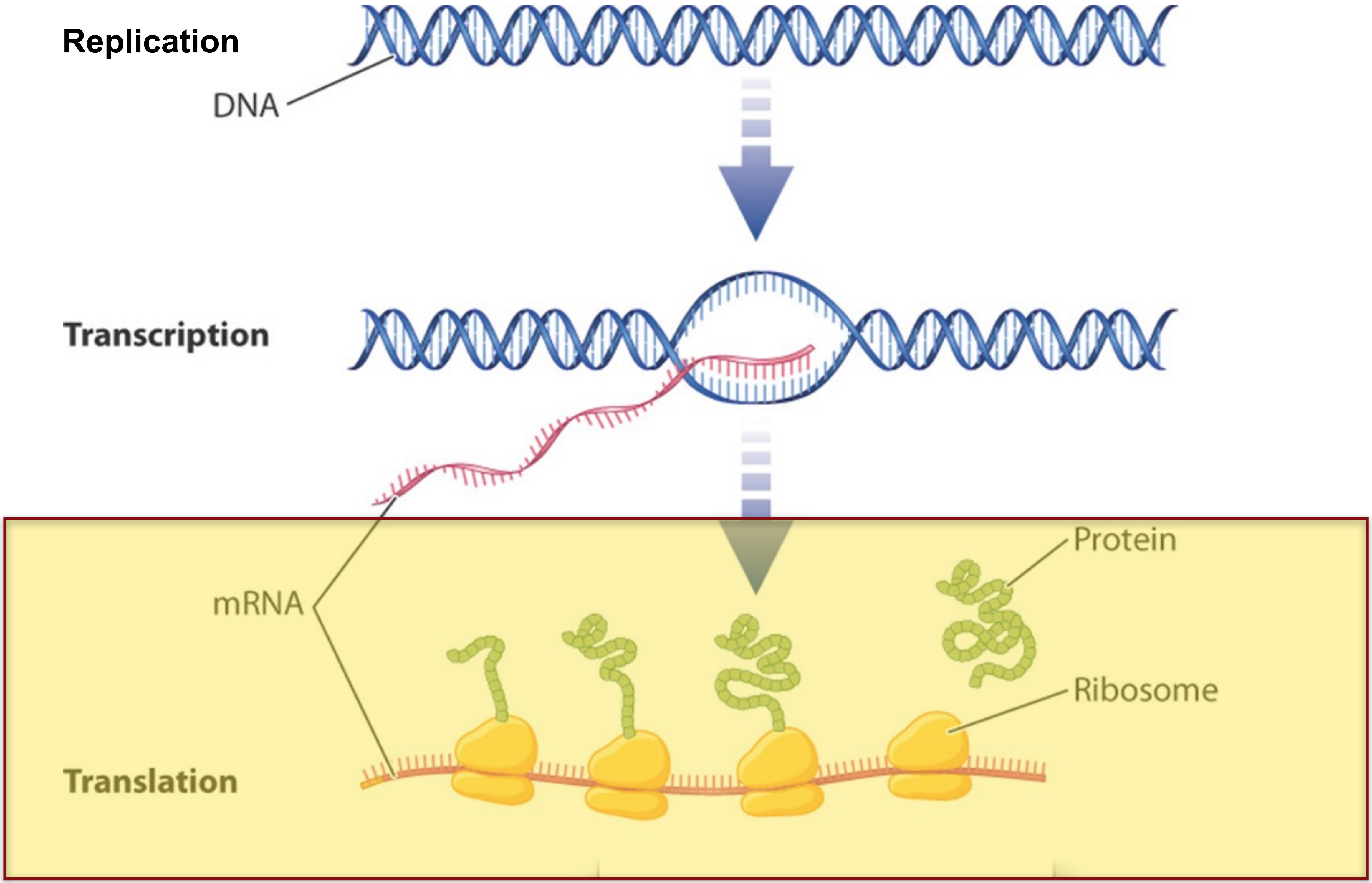
Central Dogma

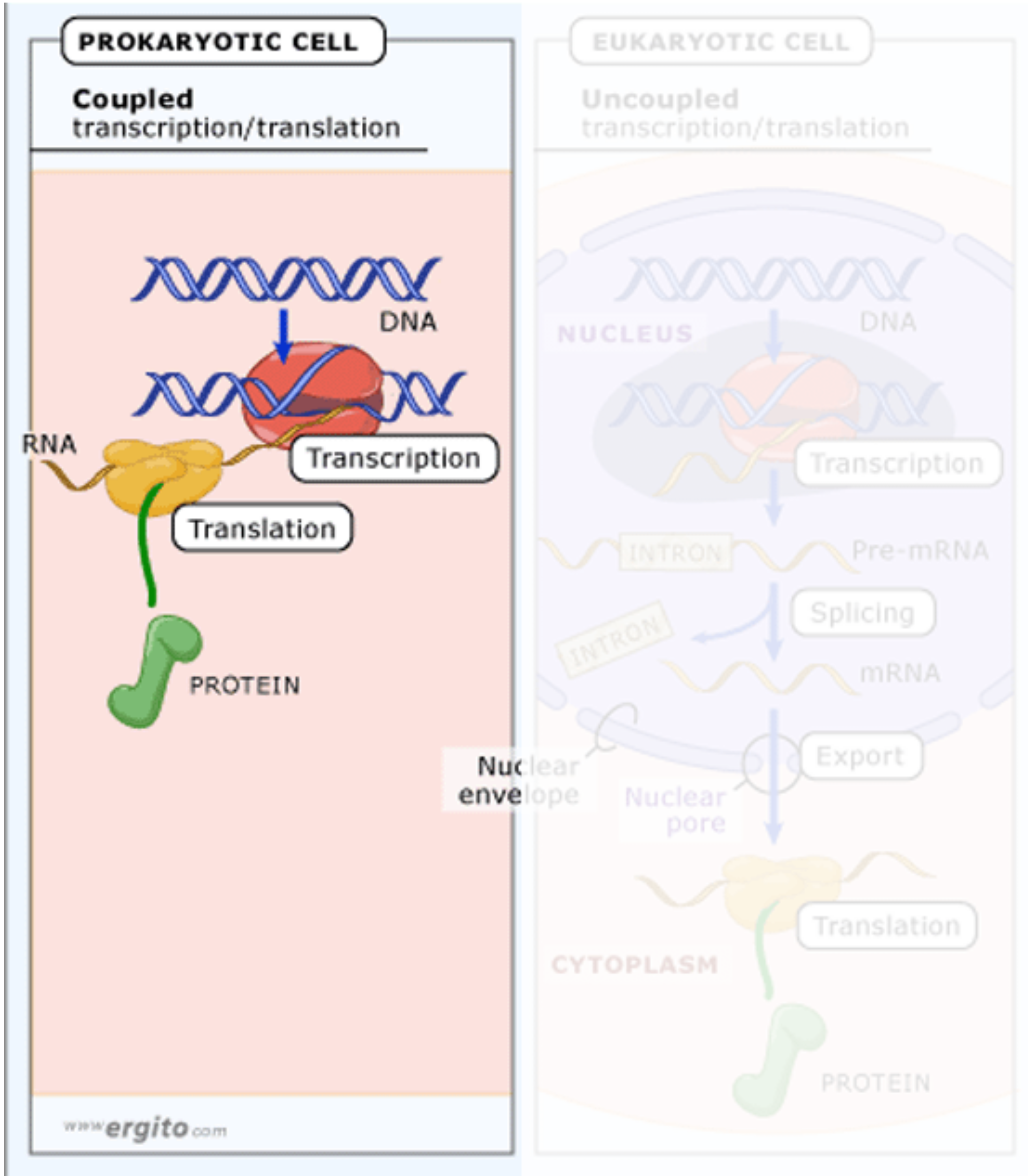


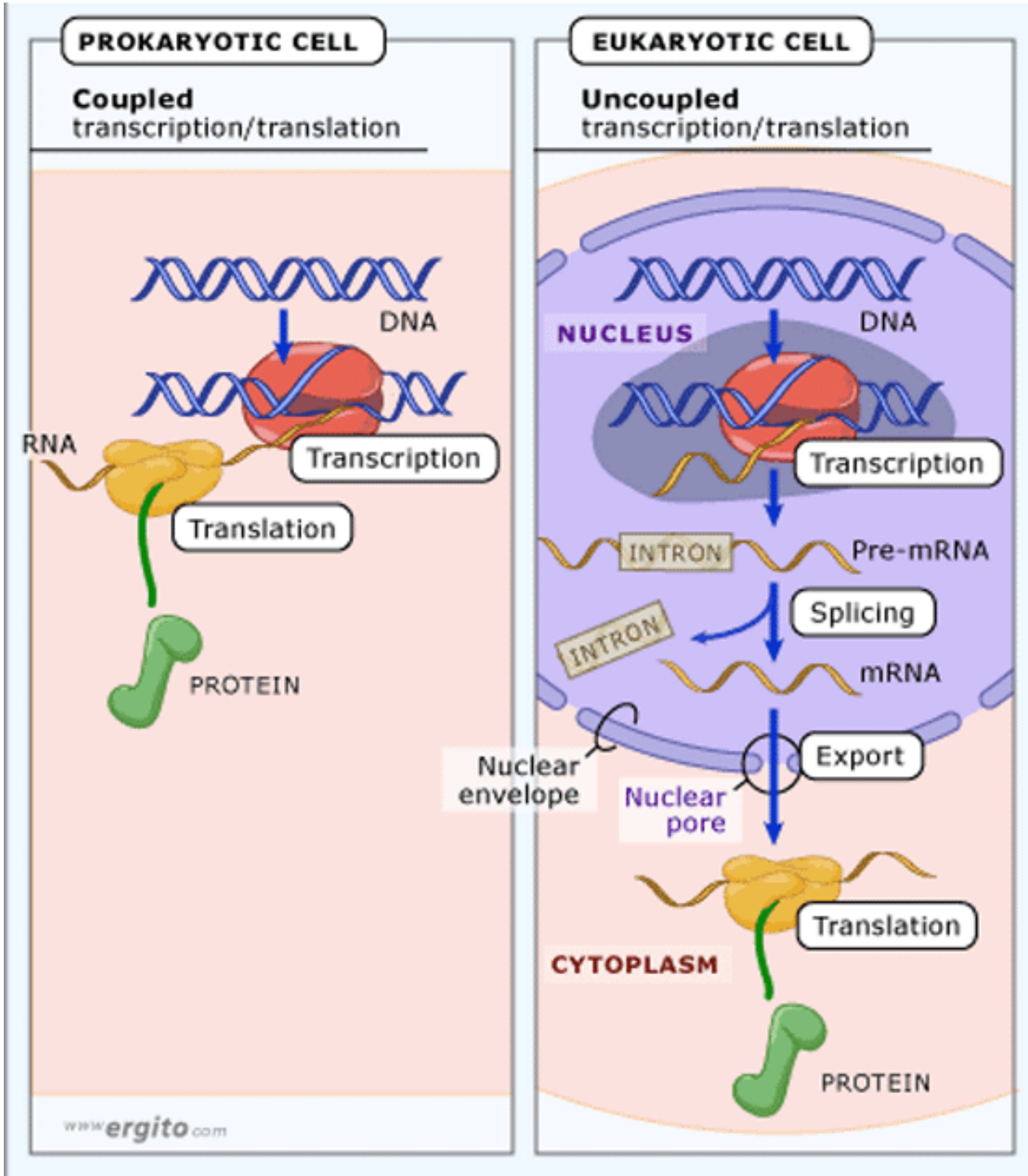
Central Dogma



Central Dogma




PROKARYOTIC CELL
Coupled
transcription/translation
DNA
RNA
Transcription
Translation
PROTEIN
www.ergito.com
EUKARYOTIC CELL
Uncoupled
transcription/translation
NUCLEUS
DNA
Transcription
INTRON
Pre-mRNA
Splicing
INTRON
mRNA
Nuclear
envelope
Export
Nuclear
pore
Translation
CYTOPLASM
PROTEIN



PROKARYOTIC CELL
Coupled
transcription/translation
DNA
RNA
Transcription
Translation
PROTEIN
www.ergito.com
EUKARYOTIC CELL
Uncoupled
transcription/translation
NUCLEUS
DNA
Transcription
INTRON
Pre-mRNA
Splicing
INTRON
mRNA
Nuclear
envelope
Export
Nuclear
pore
Translation
CYTOPLASM
PROTEIN

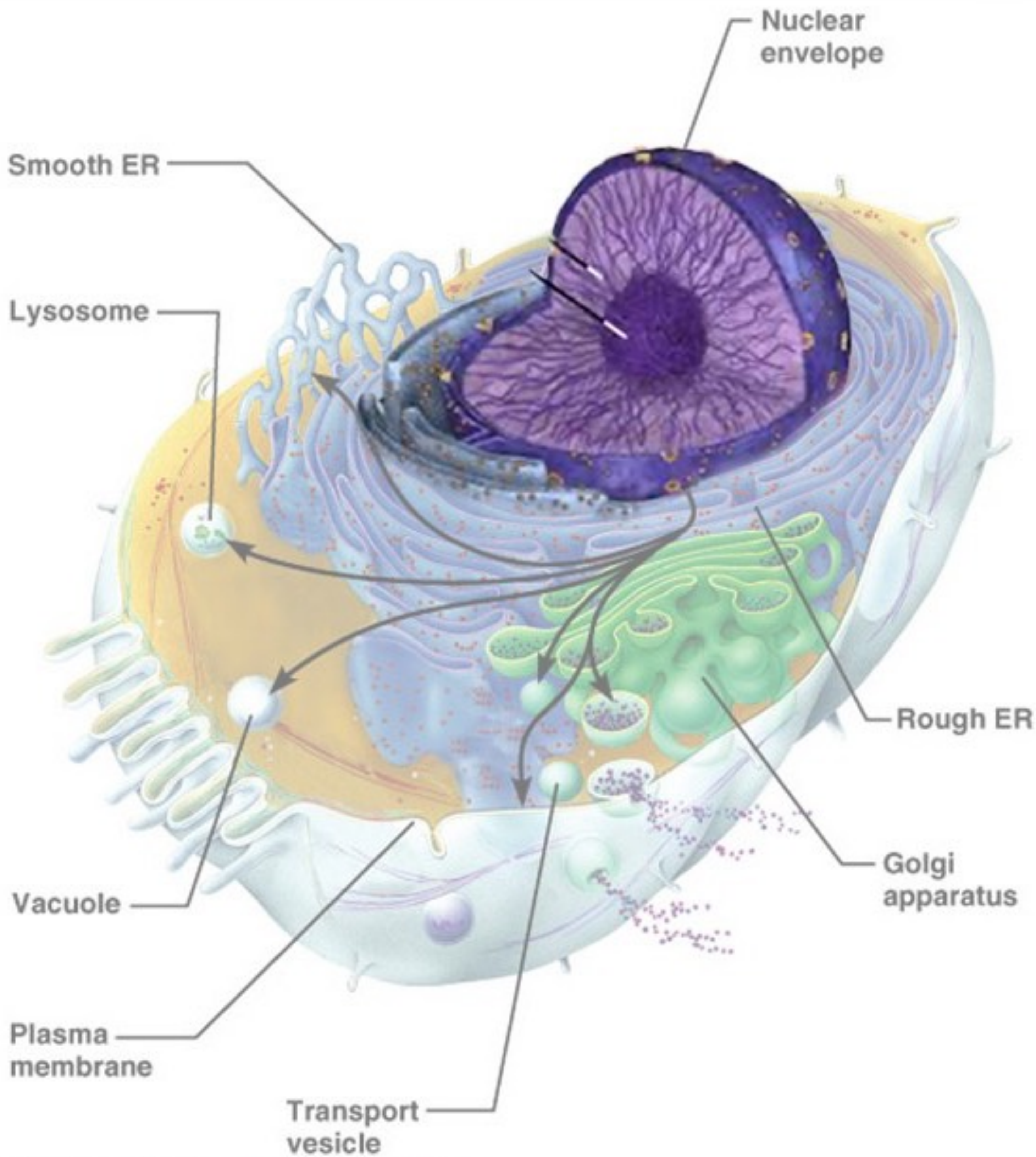

Nuclear envelope
Smooth ER
Lysosome
Rough ER
Golgi apparatus
Vacuole
Plasma membrane
Transport vesicle

Figure 3.23

Eukaryotic Life Cycles

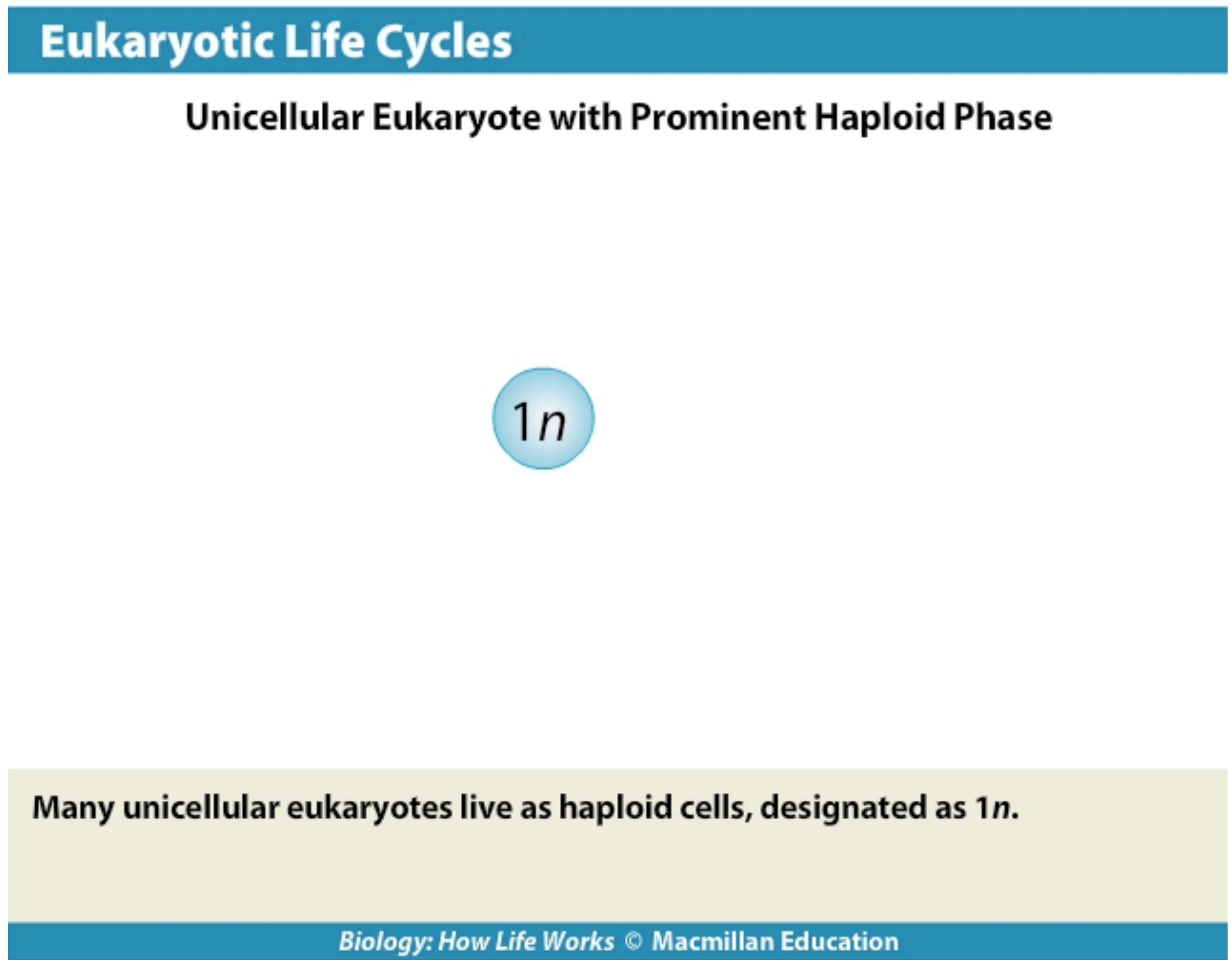
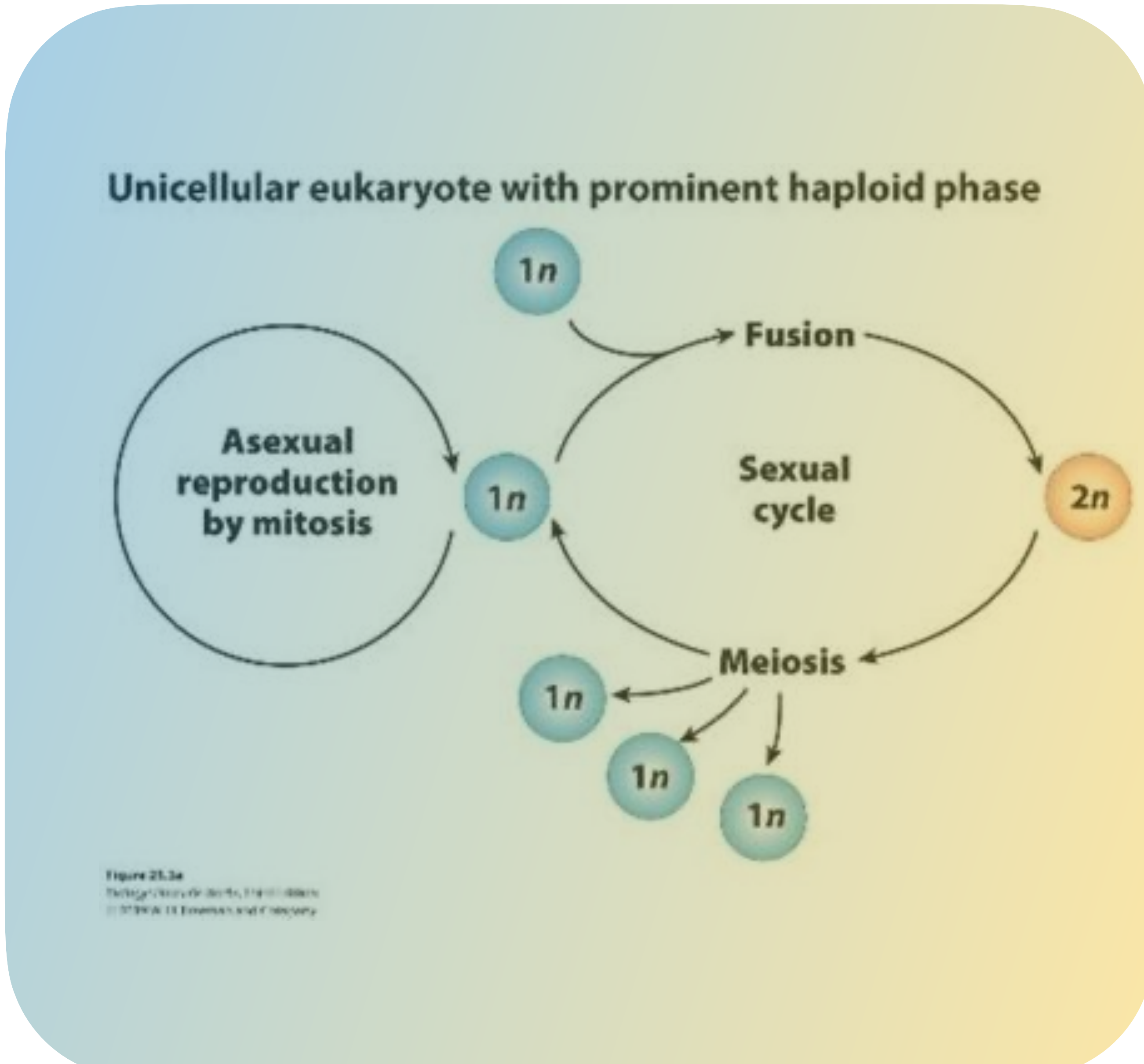
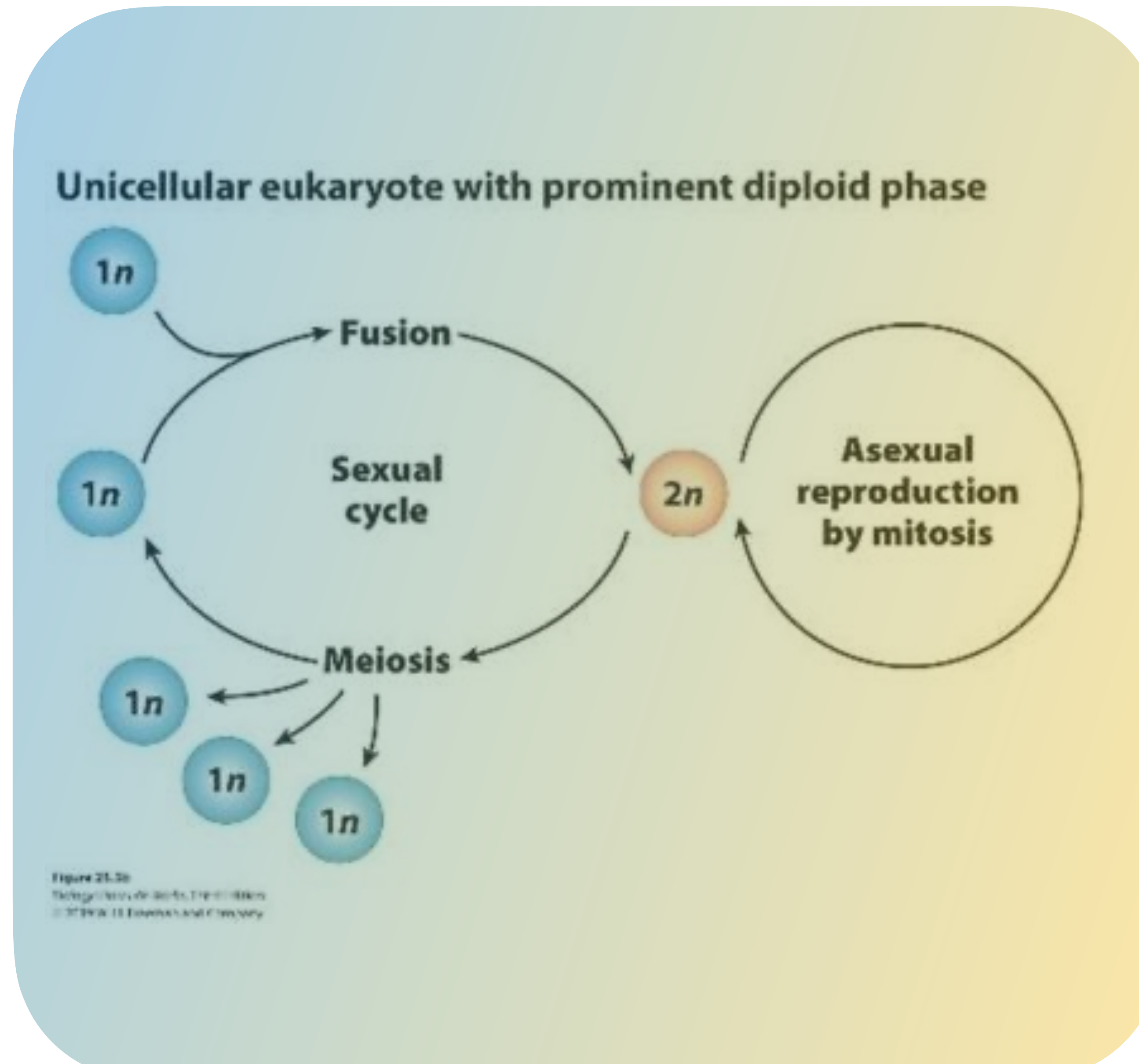


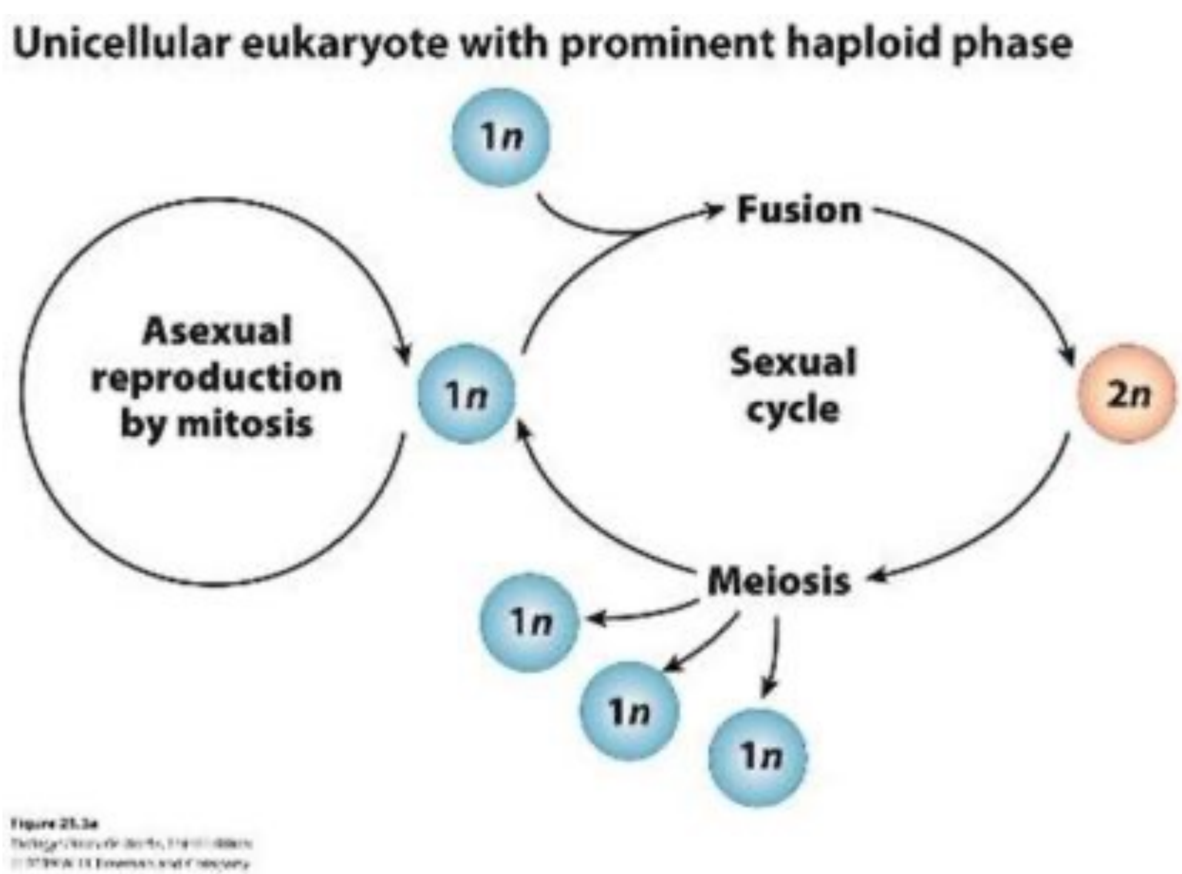
Photo credits: Chlamydomonas: Andrew Syred/Science Source; Diatom: Steve Gschmeissner/Science Source

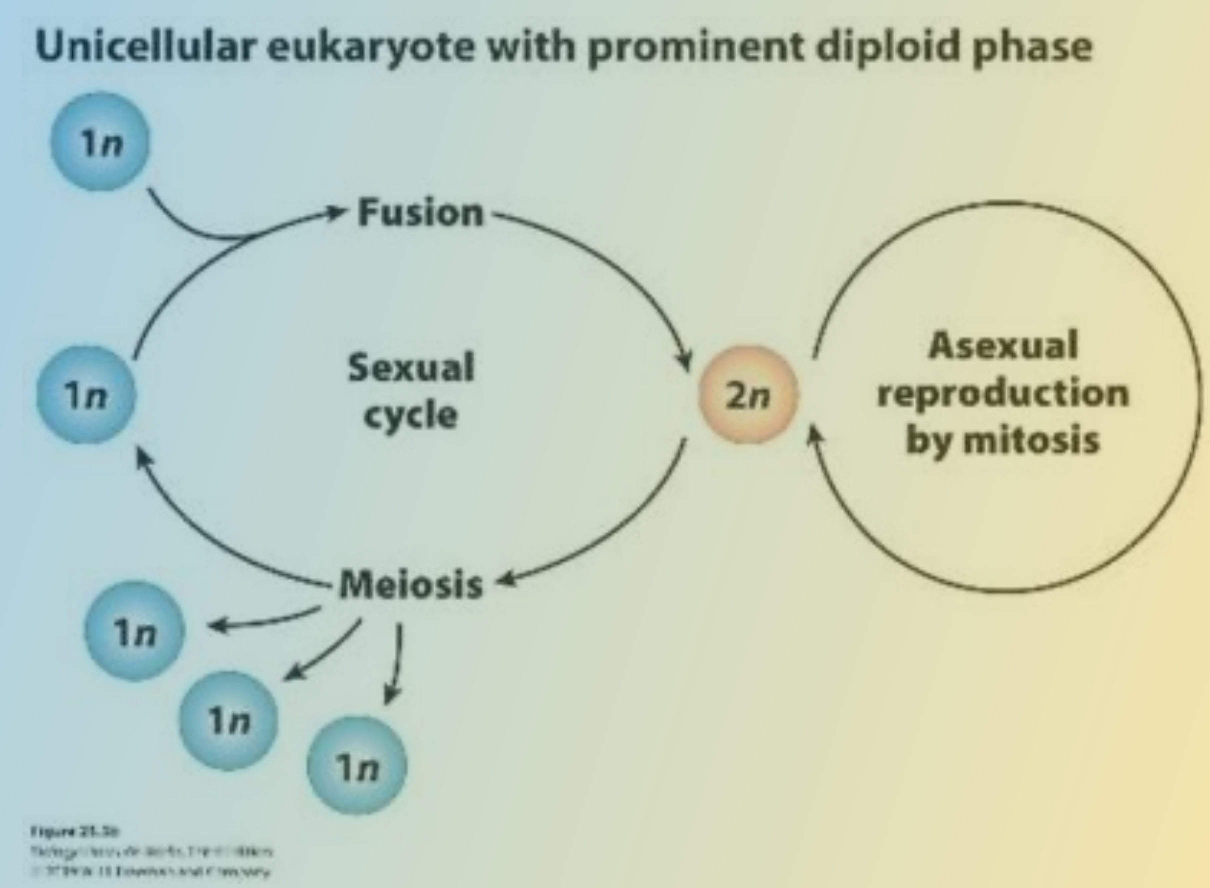
Eukaryotic Life Cycles (1/2)





Eukaryotic Life Cycles (1/2)





Eukaryotic Life Cycle in Animals

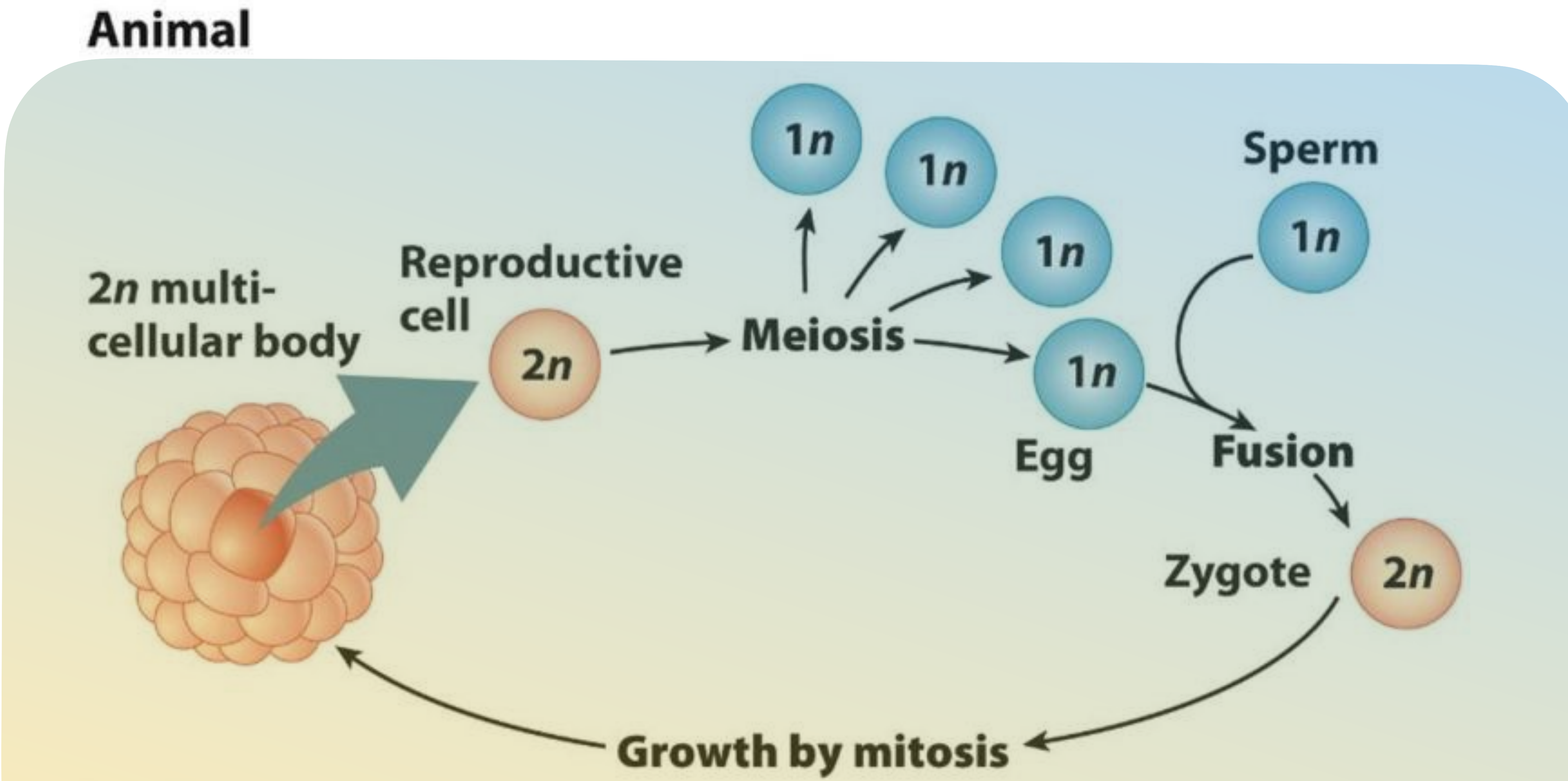


Figure 25.3c
Biology: How Life Works, Third Edition

Eukaryotic Life Cycle in Plants