

# **Chapter 21:** Prokaryotes & Viruses

# Microorganisms

- Single-celled organisms that are too small to be seen without a microscope
- **Bacteria are the smallest living organisms**
- Viruses are smaller but are not alive

# Prokaryotic Characteristics

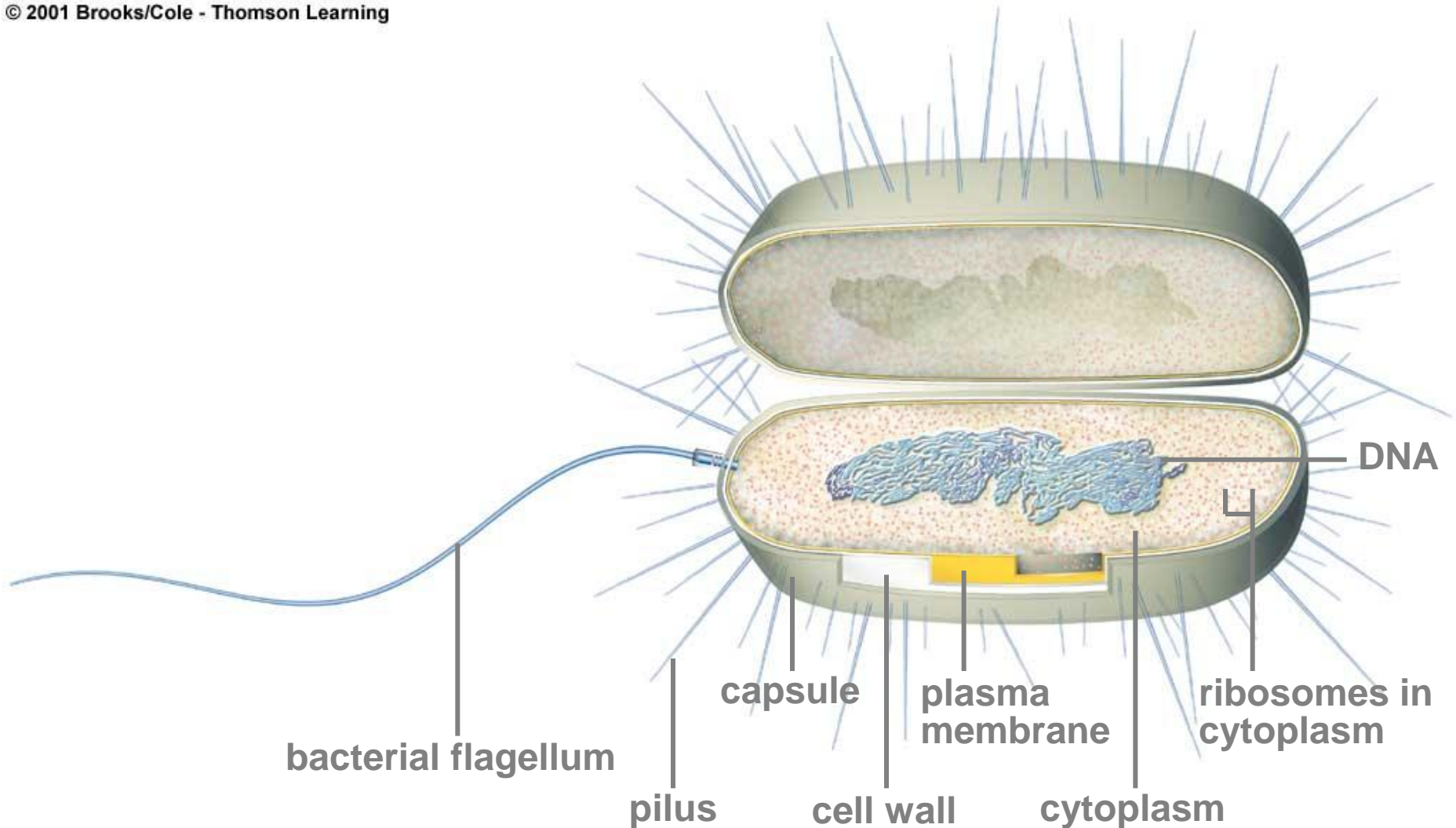
- **No membrane-bound nucleus**
- **Single chromosome**
- **Cell wall (in most species)**
- **Prokaryotic fission**
- **Metabolic diversity**

# The Prokaryotes

- **Archaeobacteria and Eubacteria**
- Arose before the eukaryotes

# Prokaryotic Body Plan

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# Prokaryotic Body Plan

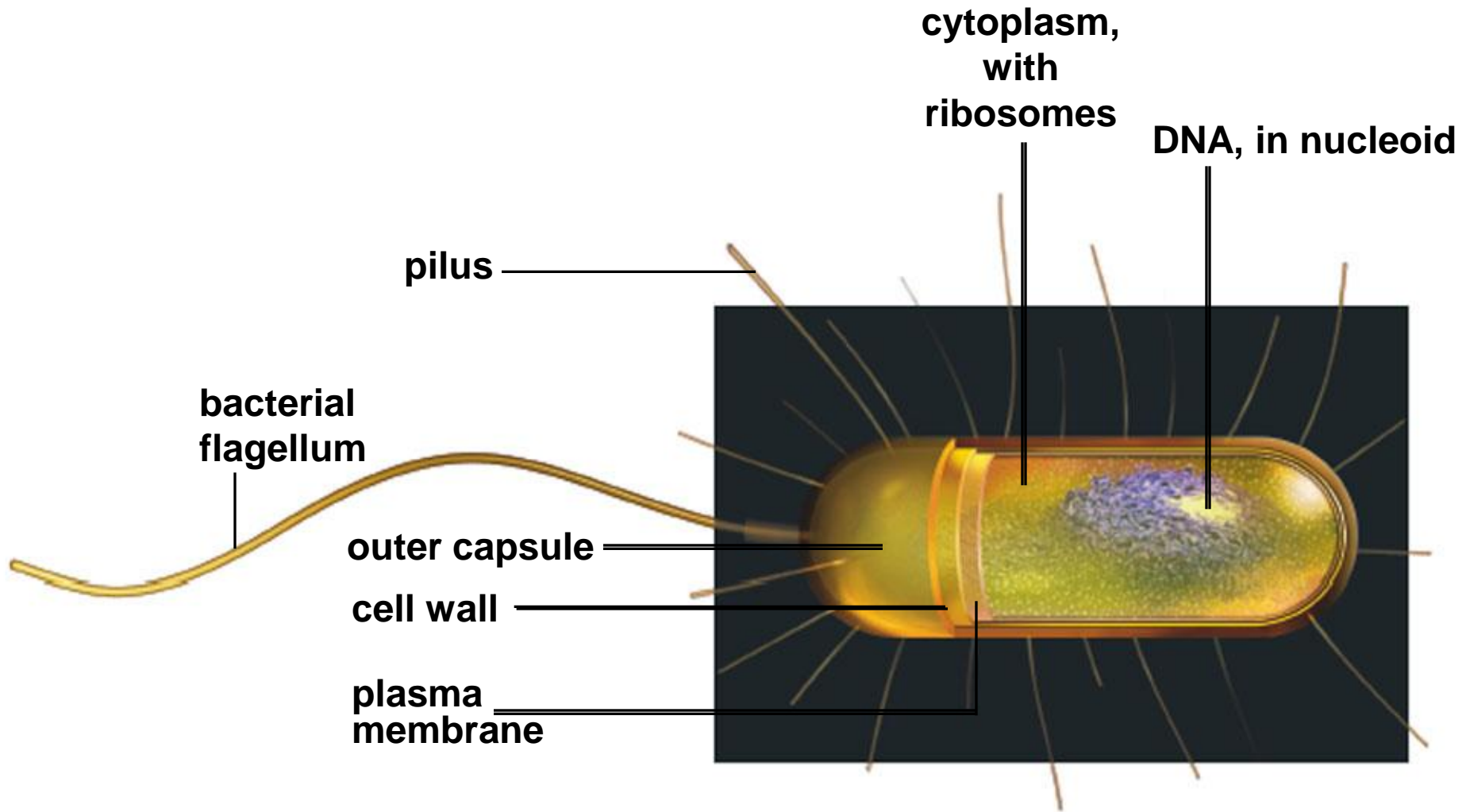
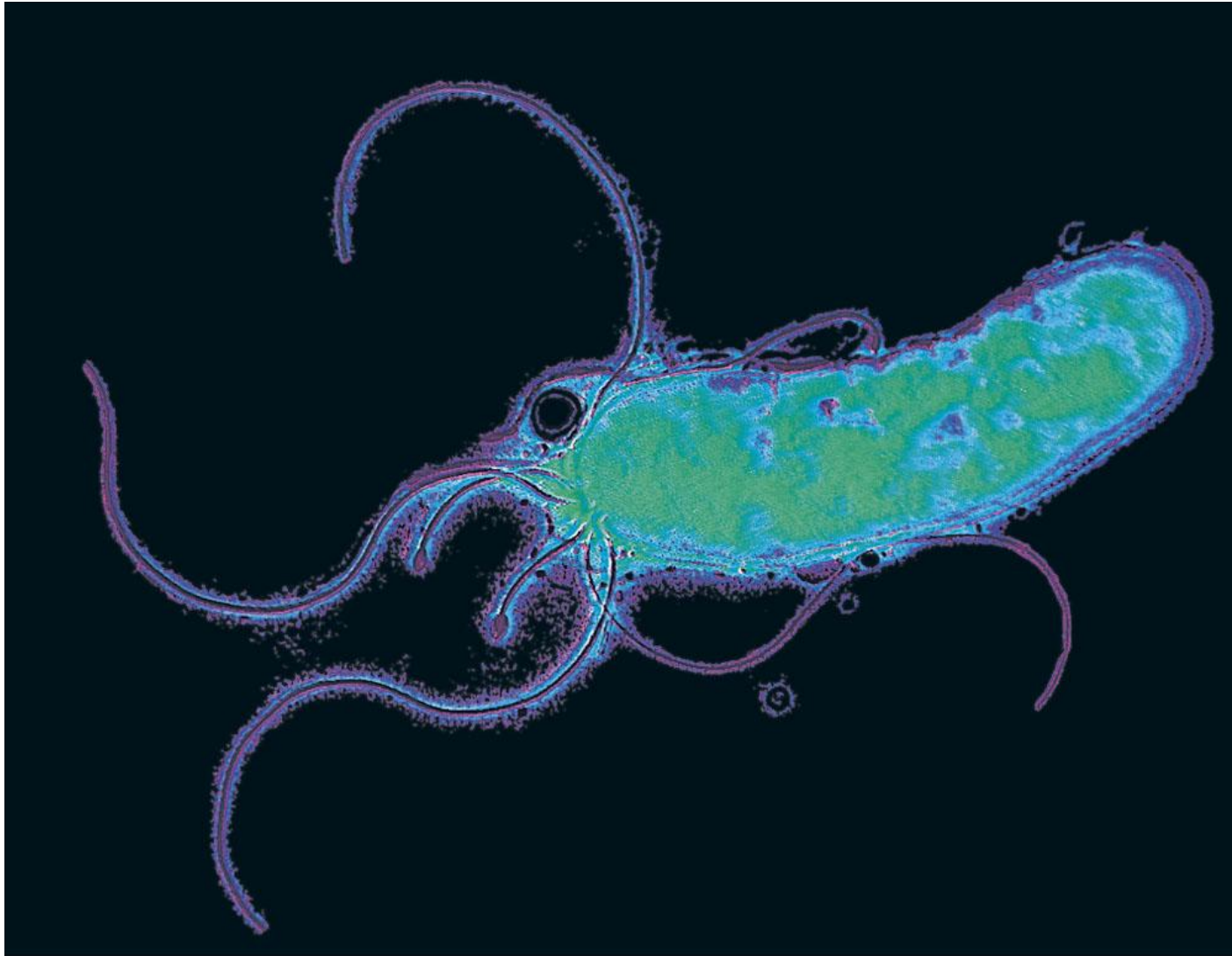


Fig. 21-2, p.334

# Bacterial Shapes



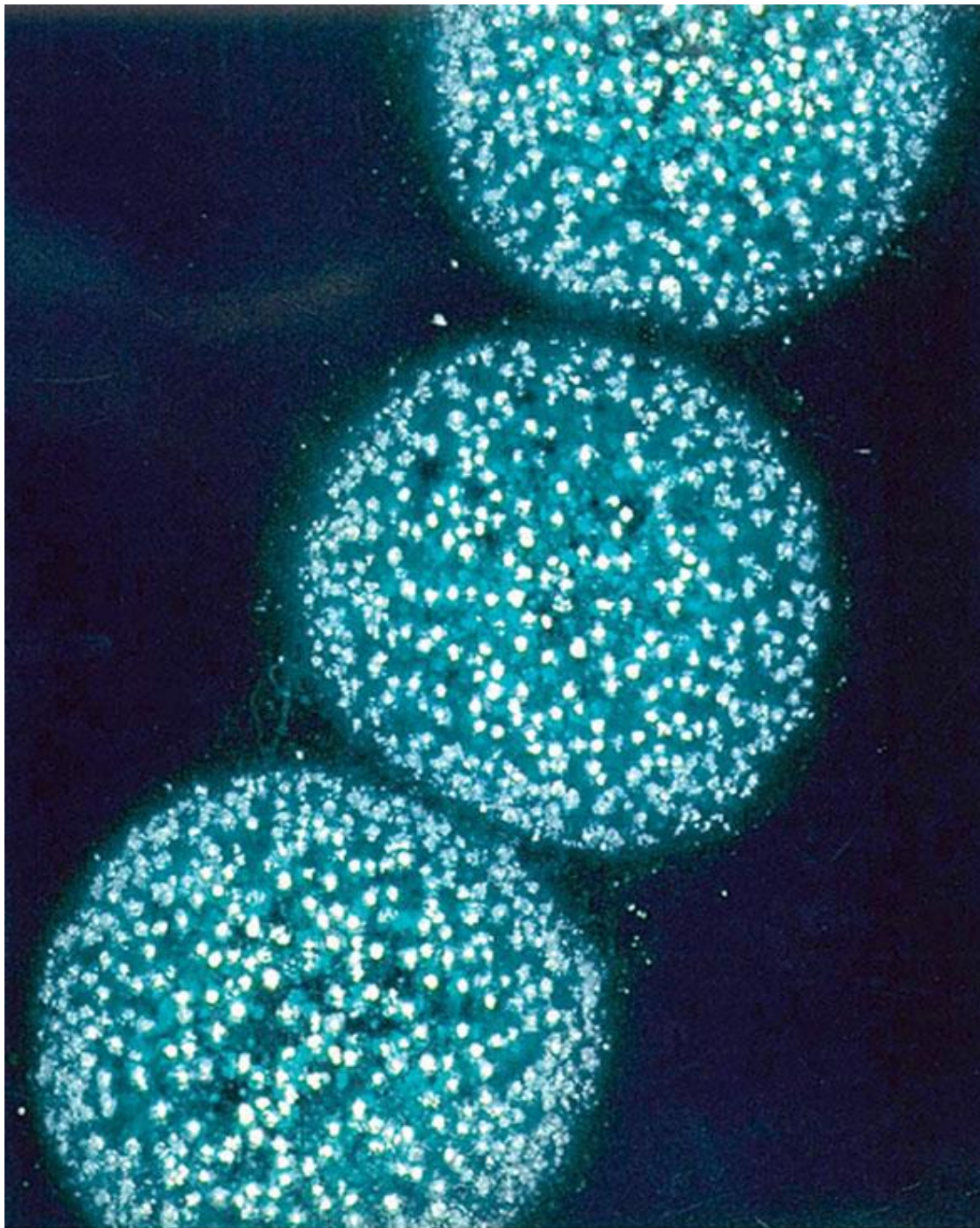
# Bacterial Shapes



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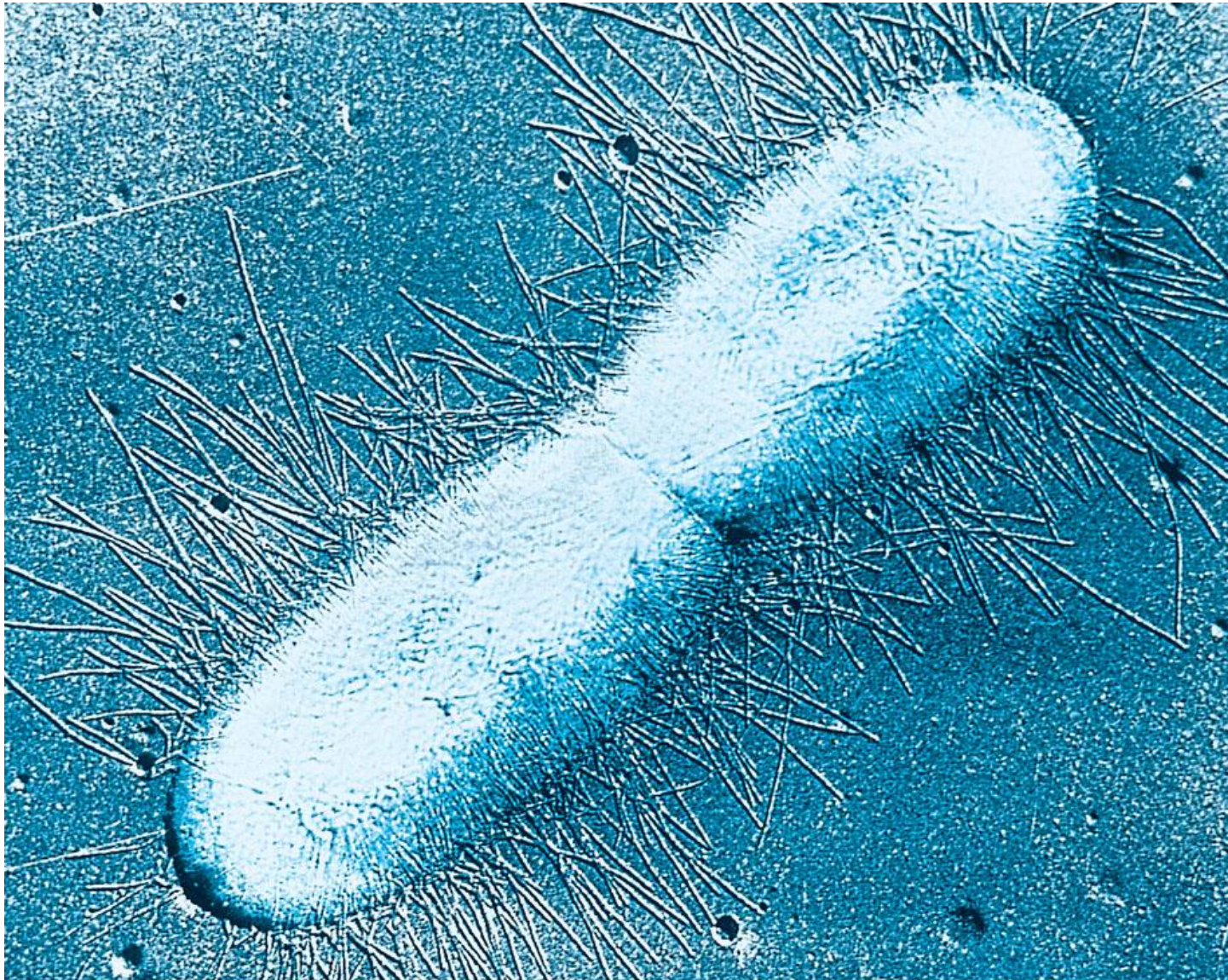


# Bacterial Shapes





# Bacterial Shapes



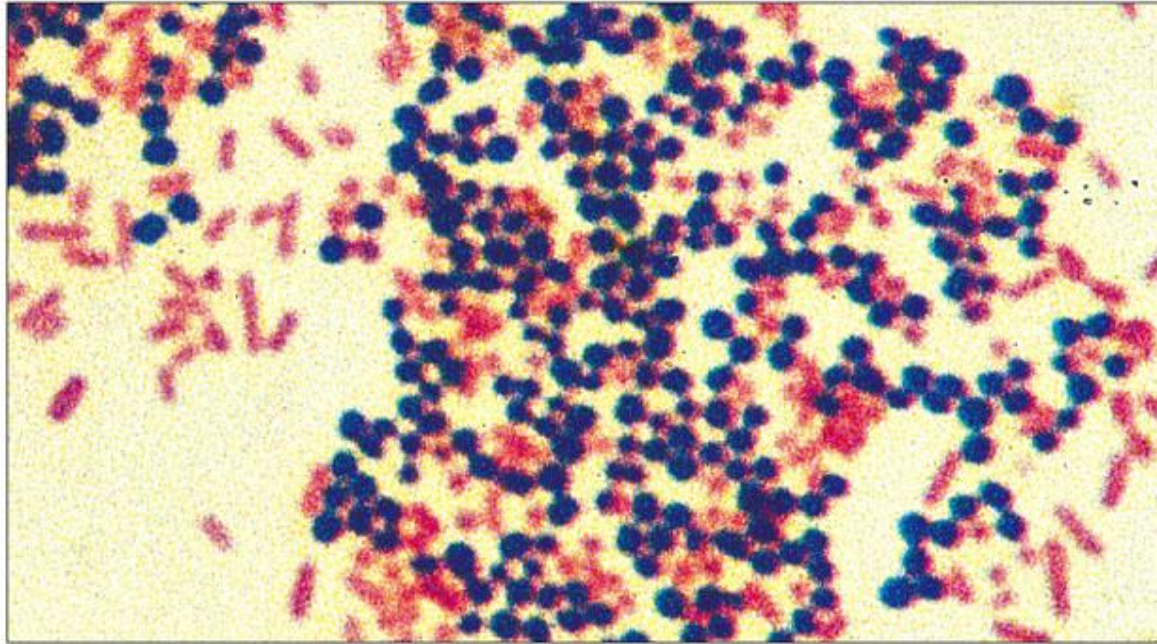
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# Metabolic Diversity

- Photoautotrophs
- Chemoautotrophs
- Chemoheterotrophs



# Gram Stain



- stain with purple dye
- stain with iodine
- wash with alcohol
- counterstain with safranin

# Bacterial Genes

- Bacteria have a single chromosome
  - Circular molecule of DNA
- Many bacteria also have plasmids
  - Self-replicating circle of DNA that has a few genes
  - Can be passed from one cell to another

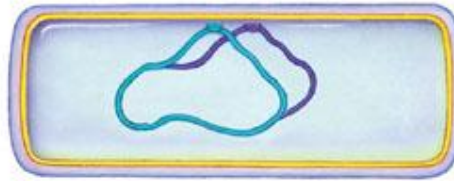
# Bacterial Reproduction

- **Binary fission (splitting into 2) is a type of asexual reproduction**
- **Conjugation is a type of sexual reproduction**

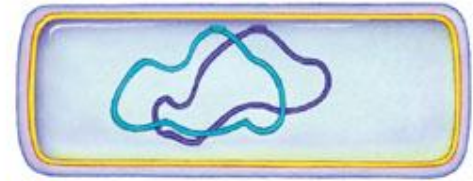
# Prokaryotic Fission



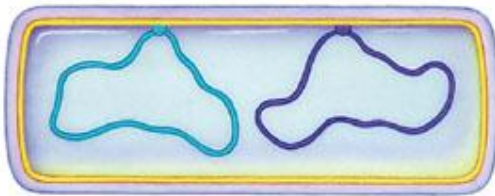
**a** The bacterial chromosome is attached to the plasma membrane before DNA replication.



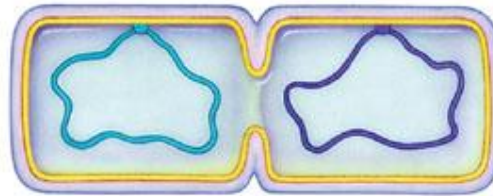
**b** Replication starts and proceeds in two directions from some point in the bacterial chromosome.



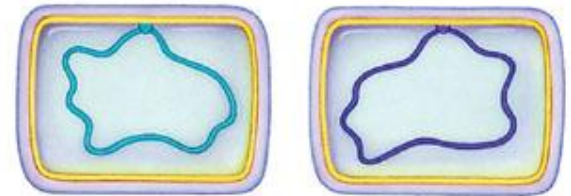
**c** The DNA copy is attached at a membrane site near the attachment site of the parent DNA molecule.



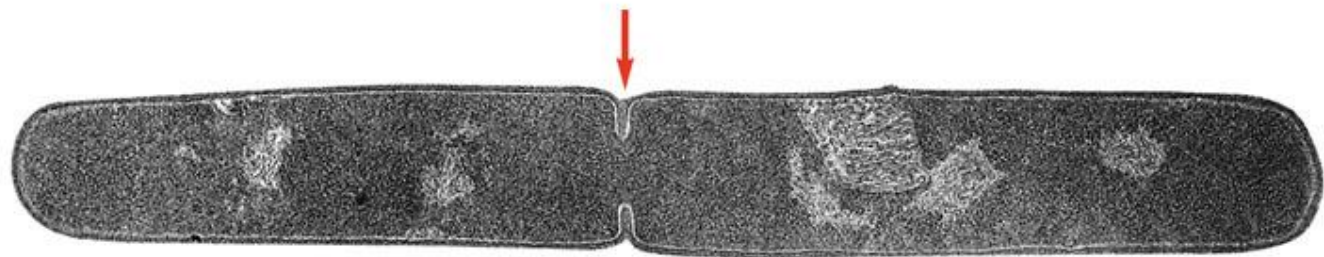
**d** The two DNA molecules are moved apart by membrane growth between the two attachment sites.



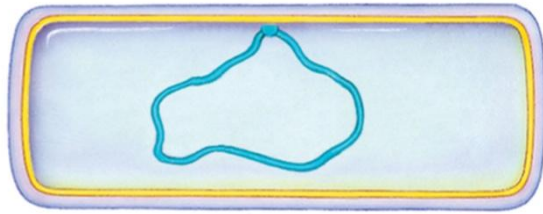
**e** New membrane and new wall material are added transversely, through the cell's midsection.



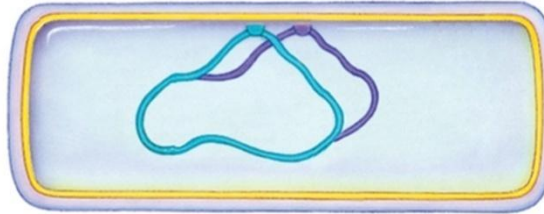
**f** The ongoing, orderly deposition of membrane and wall material at the midsection cuts the cell in two.



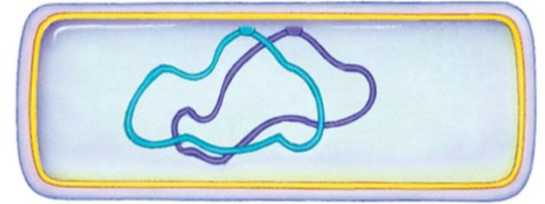




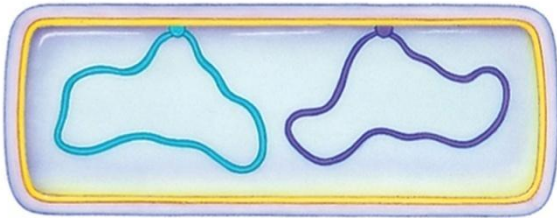
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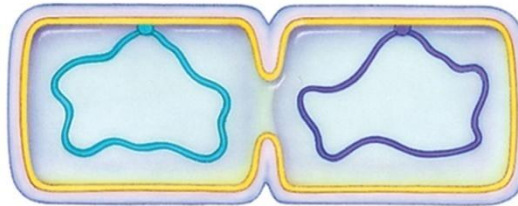
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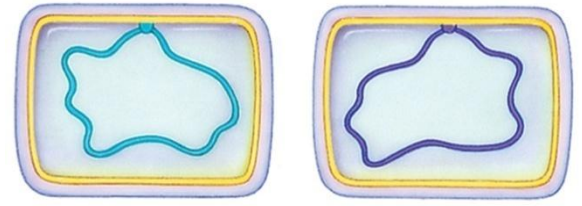
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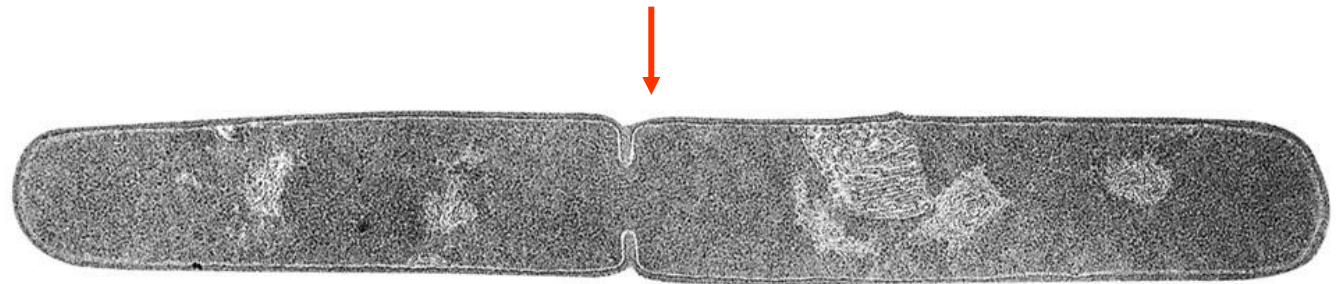
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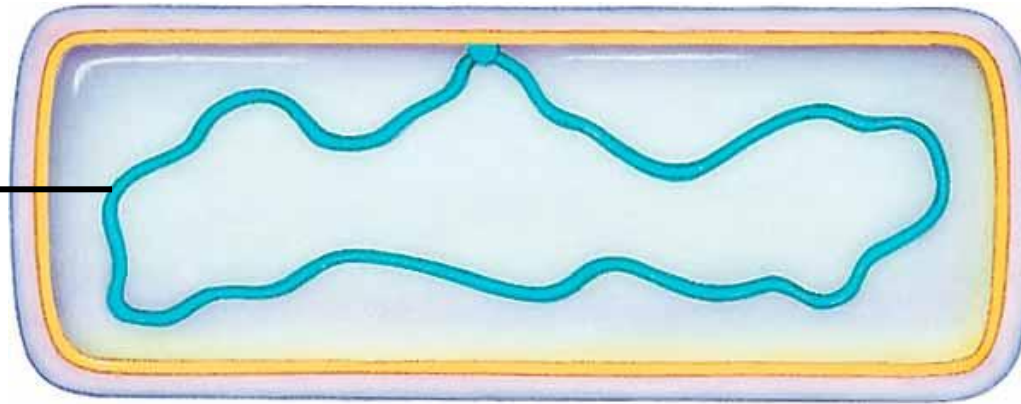
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Fig. 21-5, p.335

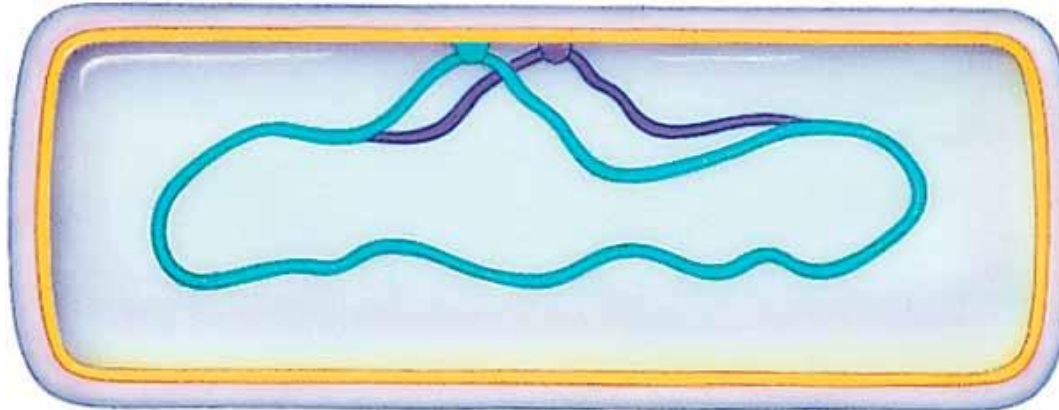


**bacterial  
chromosome**



**Bacterium before  
DNA replication**

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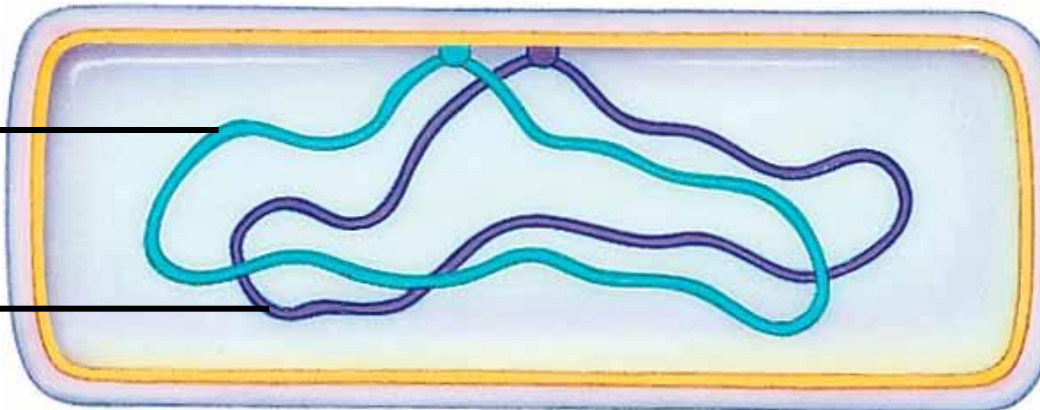


**DNA replication  
begins**

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**parent DNA  
molecule**

**DNA copy**

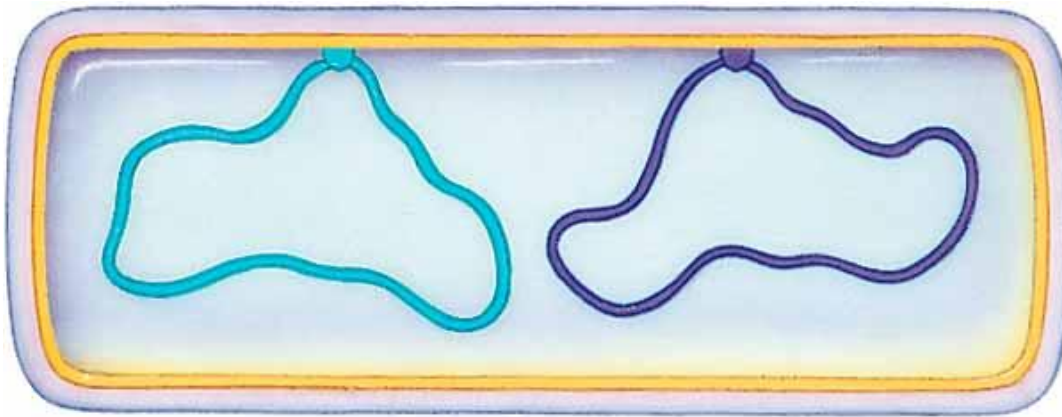


**DNA replication  
completed**

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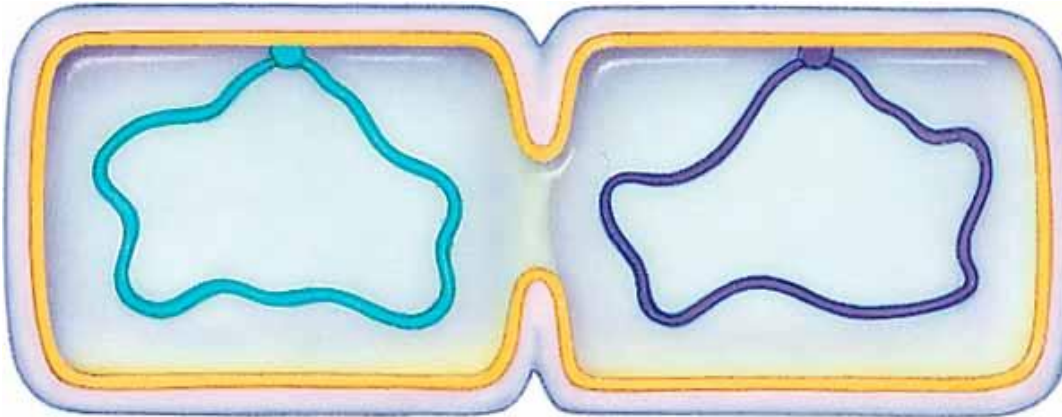
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**Fig. 21-5a-c, p.336**



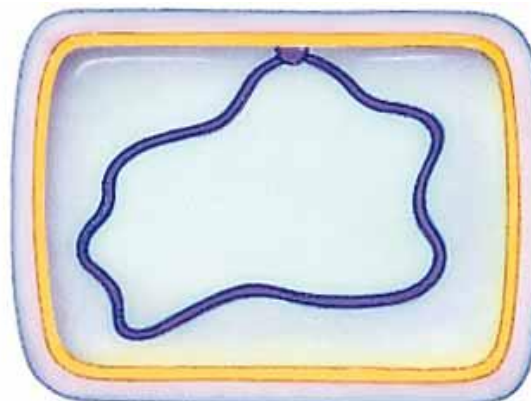
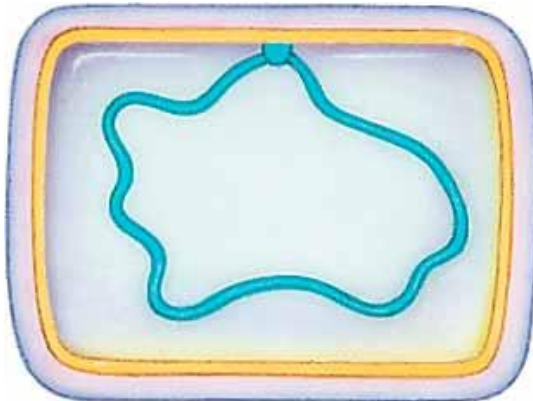
**Membrane growth  
moves DNA  
molecules apart**

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**New membrane and  
cell-wall material  
deposited**

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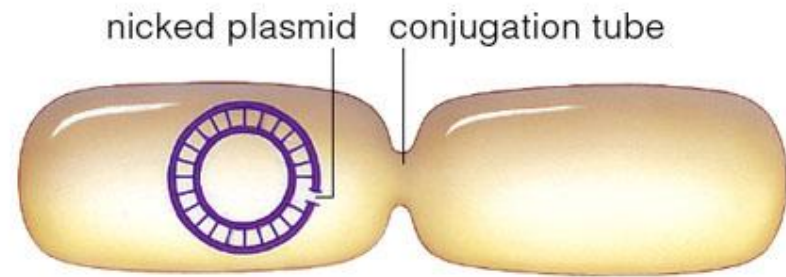
**Cytoplasm  
divided in two**

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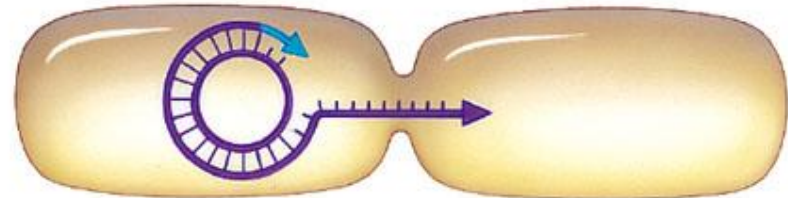
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**Fig. 21-5d-f, p.336**

# Conjugation

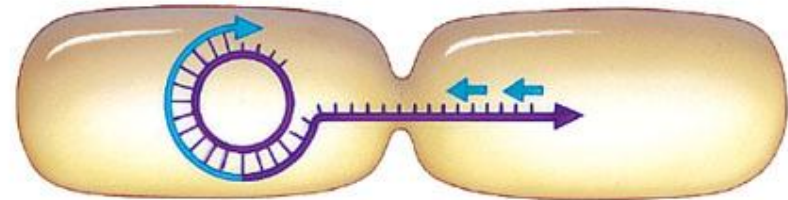
## Transfer of plasmid



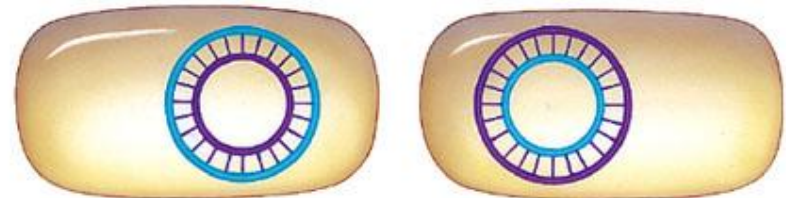
**a** A conjugation tube has already formed between a donor and a recipient cell. An enzyme has nicked the donor's plasmid.



**b** DNA replication starts on the nicked plasmid. The displaced DNA strand moves through the tube and enters the recipient cell.

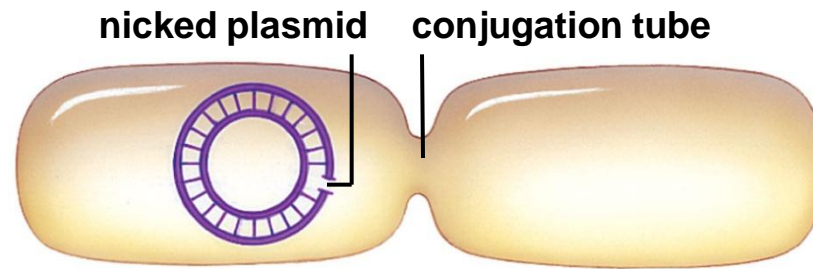


**c** In the recipient cell, replication starts on the transferred DNA.

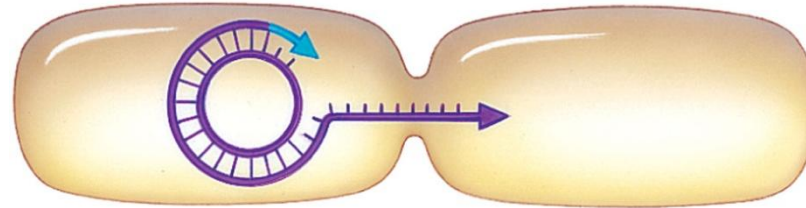


**d** The cells separate from each other; the plasmids circularize.

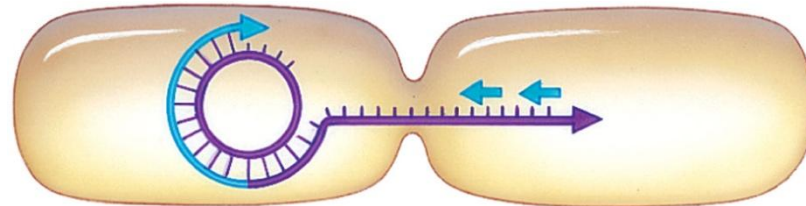




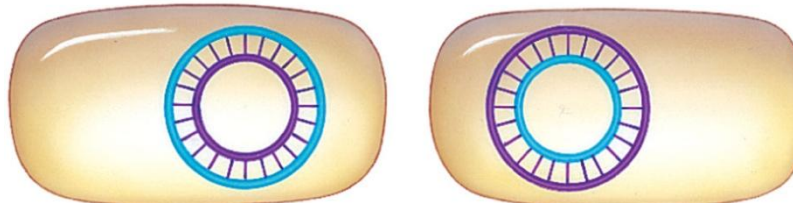
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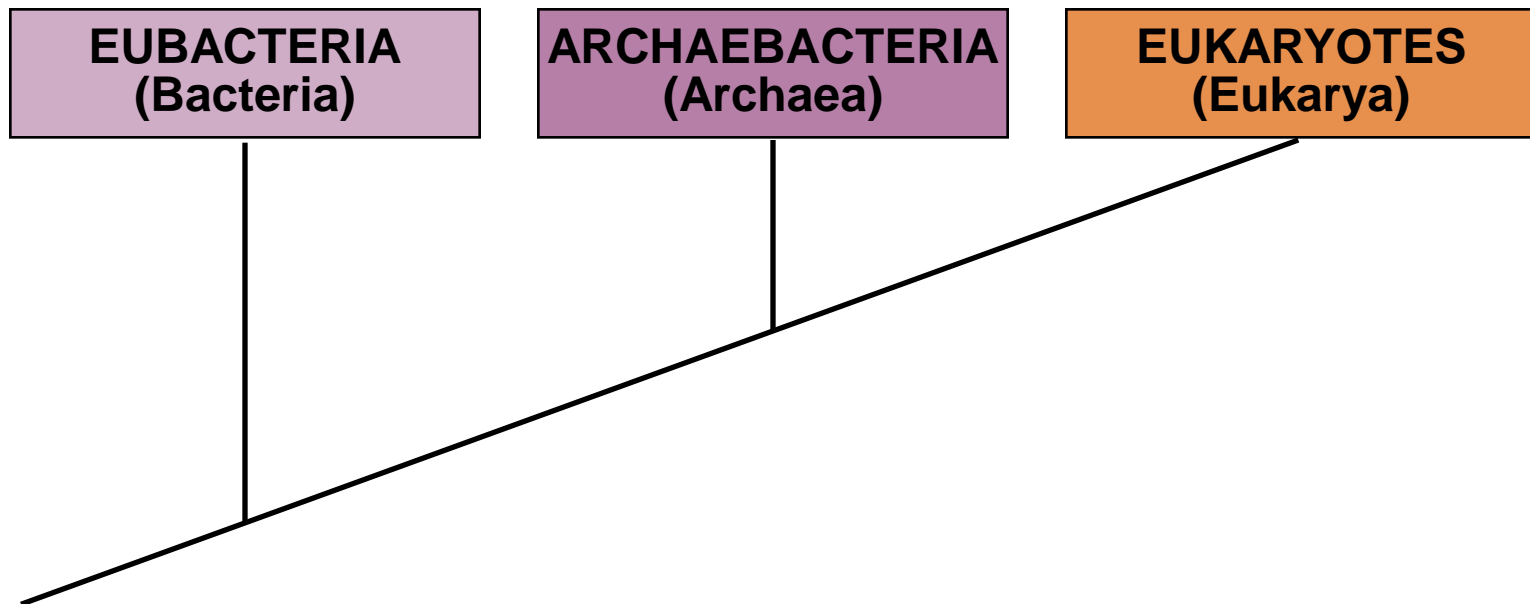


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Fig. 21-6, p.337

# Prokaryotic Classification



- Traditionally classified by numerical taxonomy
- Now increased use of comparative biochemistry

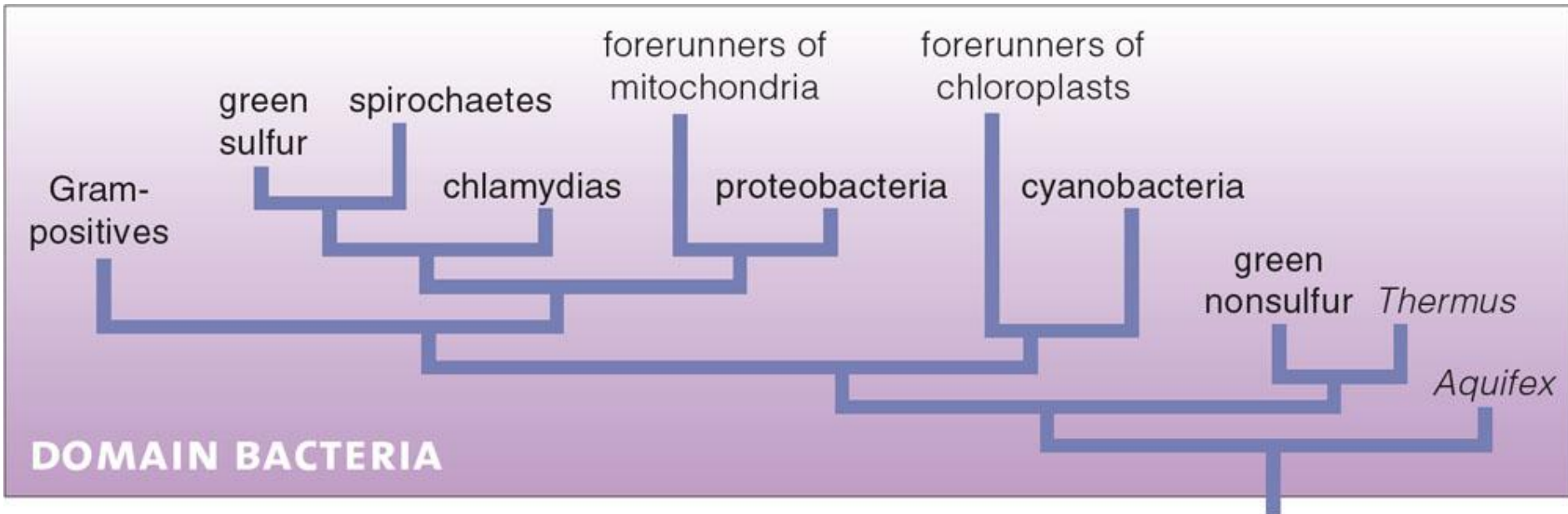
# Eubacteria

- Includes most familiar bacteria
- Have fatty acids in plasma membrane
- Most have cell wall; always includes peptidoglycan
- Classification based largely on metabolism

# Eubacterial Diversity

- **Photoautotrophic**
  - Aerobic (Cyanobacteria)
  - Anaerobic (Green bacteria)
- **Chemoautotrophic**
  - Important in nitrogen cycle
- **Chemoheterotrophic**
  - Largest group

# Eubacterial Diversity



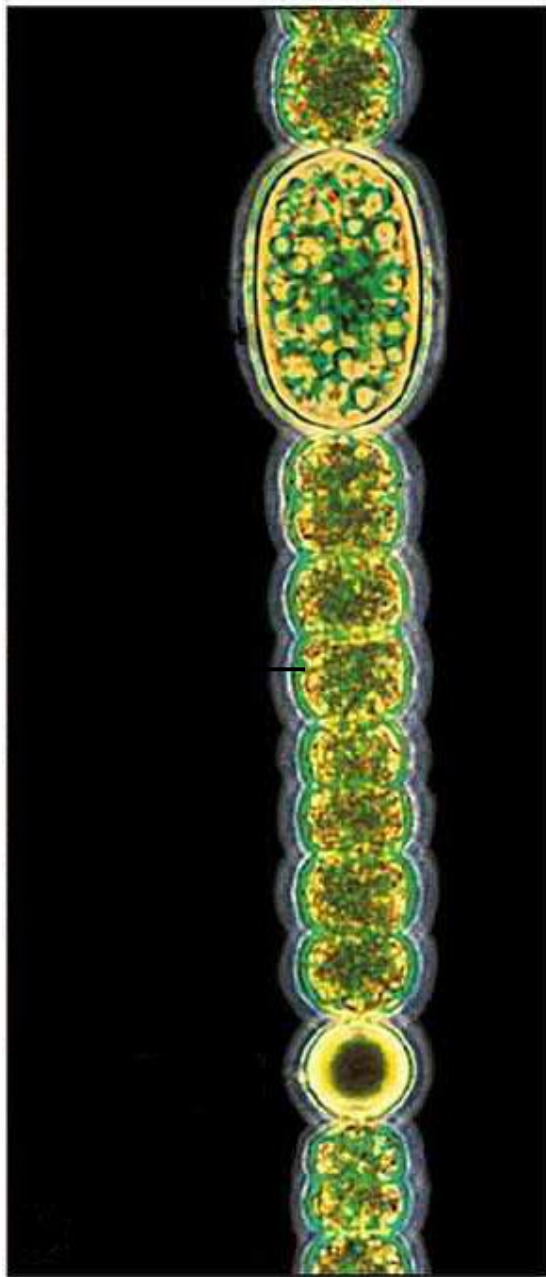
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# Some Pathogenic Eubacteria

- Most are chemoheterotrophs
  - *E. coli* strains
  - *Clostridium botulinum*
  - *Clostridium tetanus*
  - *Borrelia burgdorferi*
  - *Rickettsia rickettsii*

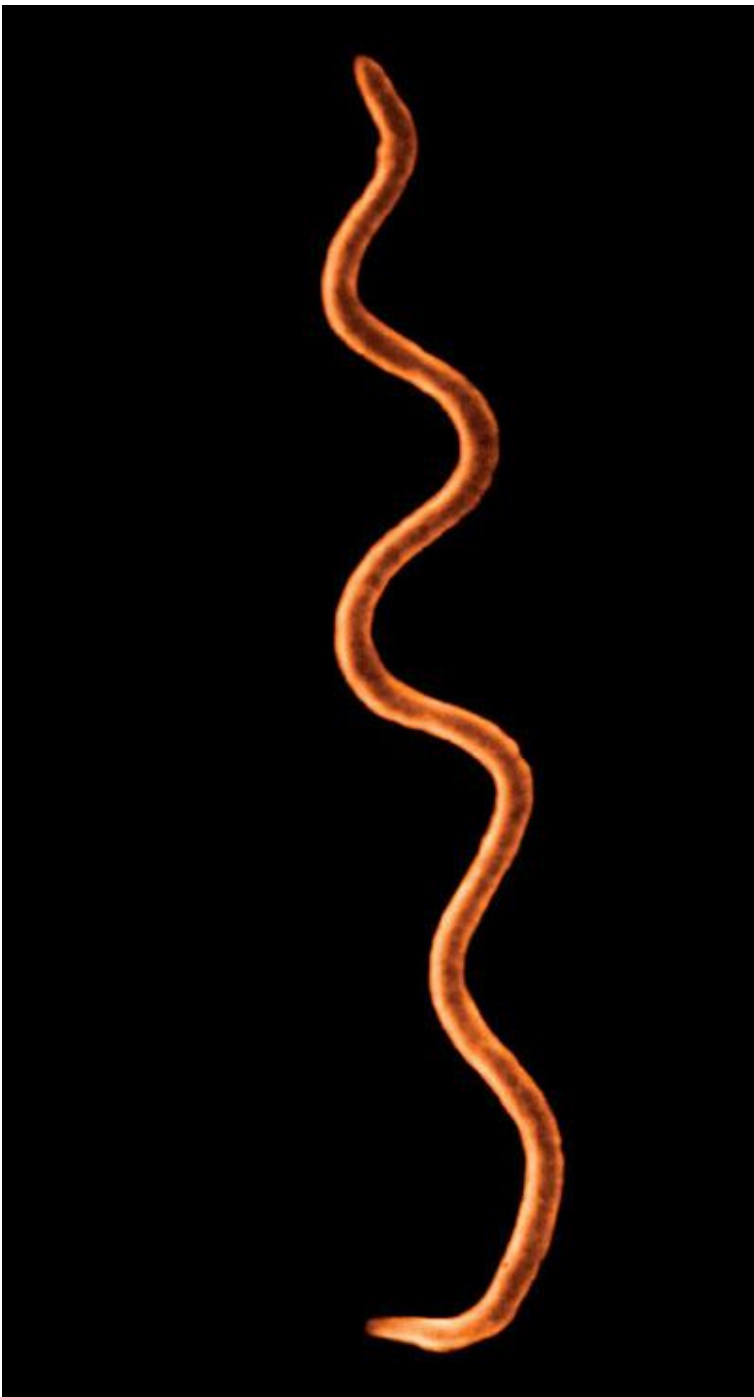
# Some Pathogenic Eubacteria



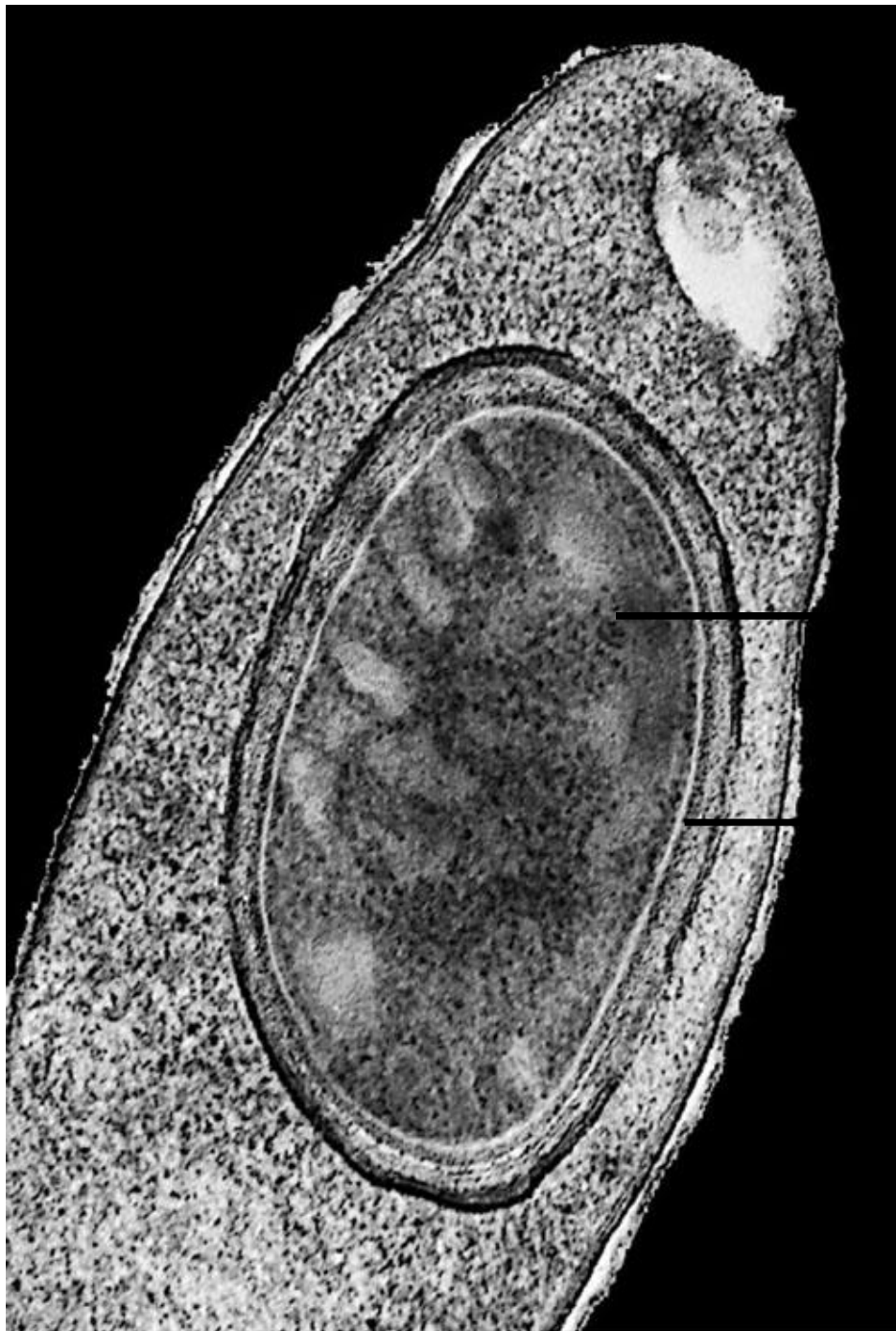
# Some Pathogenic Eubacteria



# Some Pathogenic Eubacteria



# Some Pathogenic Eubacteria



DNA

spore  
coat

capsule  
around cell  
wall

# Bacterial Behavior

- Bacteria move toward nutrient-rich regions
- Aerobes move toward oxygen; anaerobes avoid it
- Photosynthetic types move toward light
- Magnetotactic bacteria swim downward
- Myobacteria show collective behavior



# Bacterial Behavior

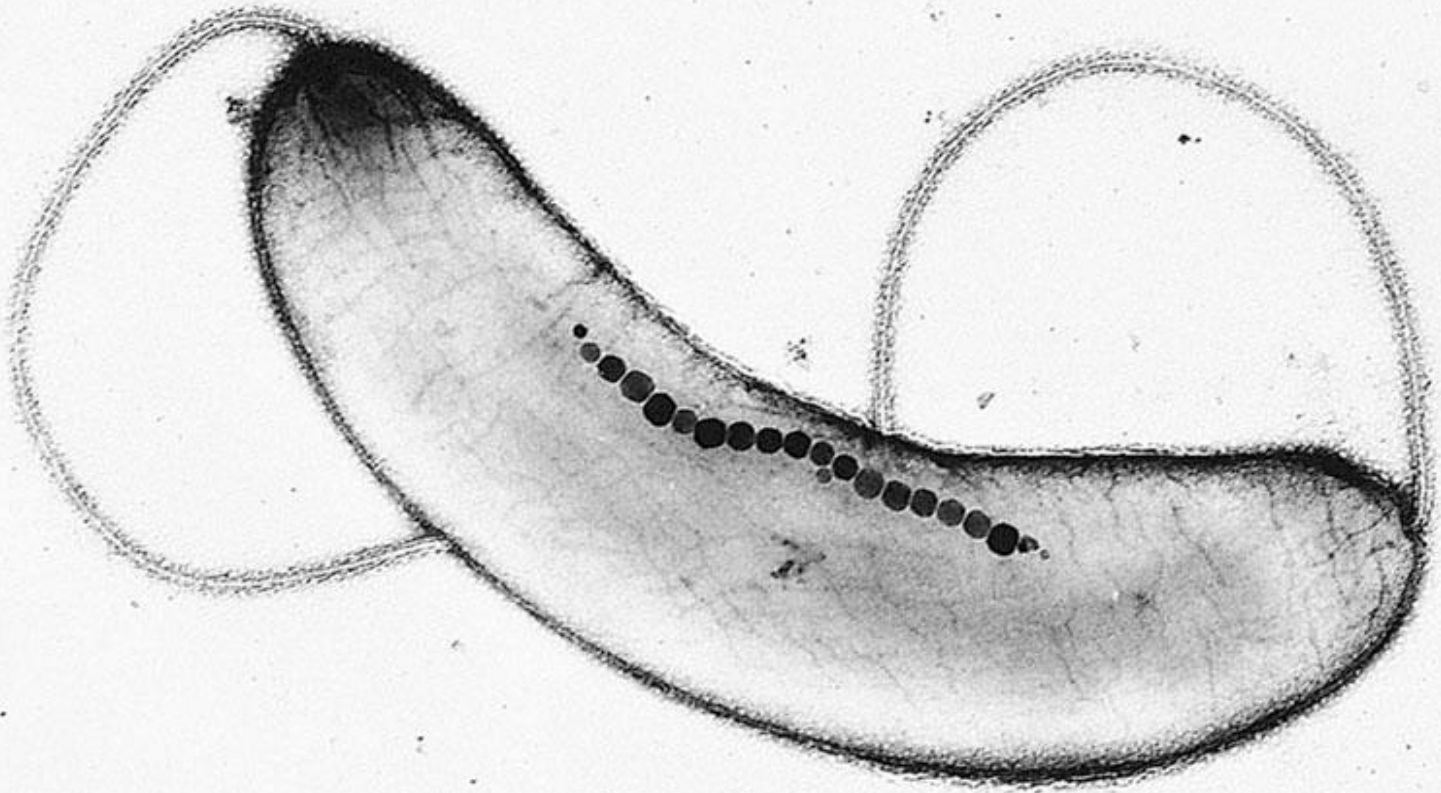
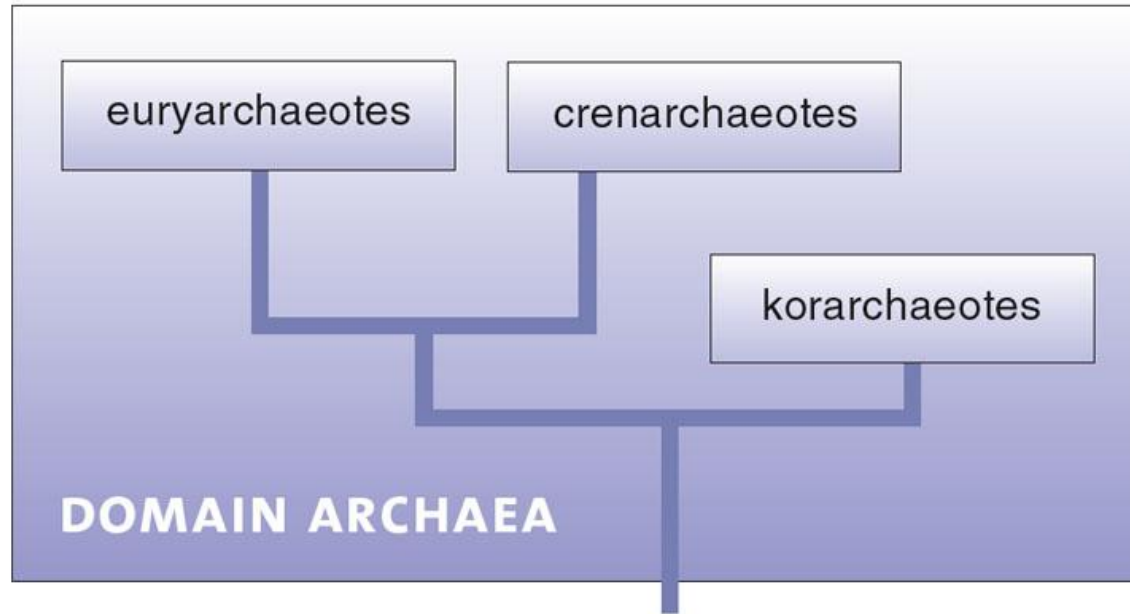


Fig. 21-9, p.339

# Archaeobacteria



Euryarchaeotes	Methanogens, extreme halophiles, sulfate reducers, unwalled archaeans (e.g., <i>Methanococcus</i> , <i>Thermoplasma</i> , <i>Methanobacterium</i> , <i>Halobacterium</i> )
Crenarchaeotes	Extreme thermophiles, marine cryophiles (e.g., <i>Thermoproteus</i> , <i>Sulfolobus</i> )
Korarchaeotes	Newly discovered extreme thermophiles



# **Archaeobacteria**

**Methanogens**

**Extreme halophiles**

**Extreme thermophiles**

# Methanogens



# Methanogens





# Extreme Halophiles



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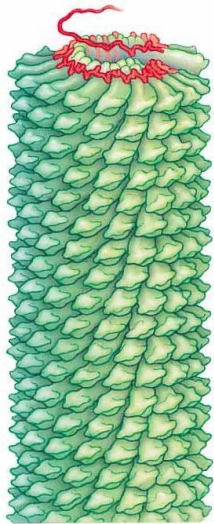
# Extreme Thermophiles





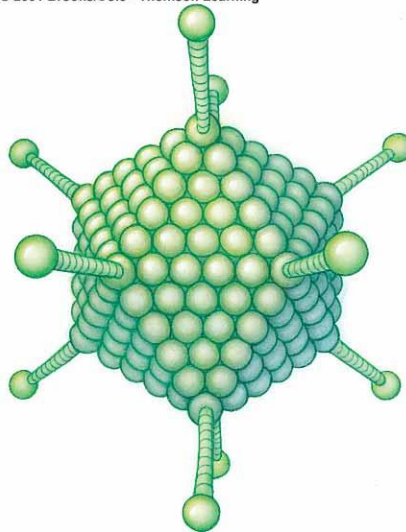
# Viral Body Plans

- Genetic material is DNA or RNA
- Coat is protein



Helical virus

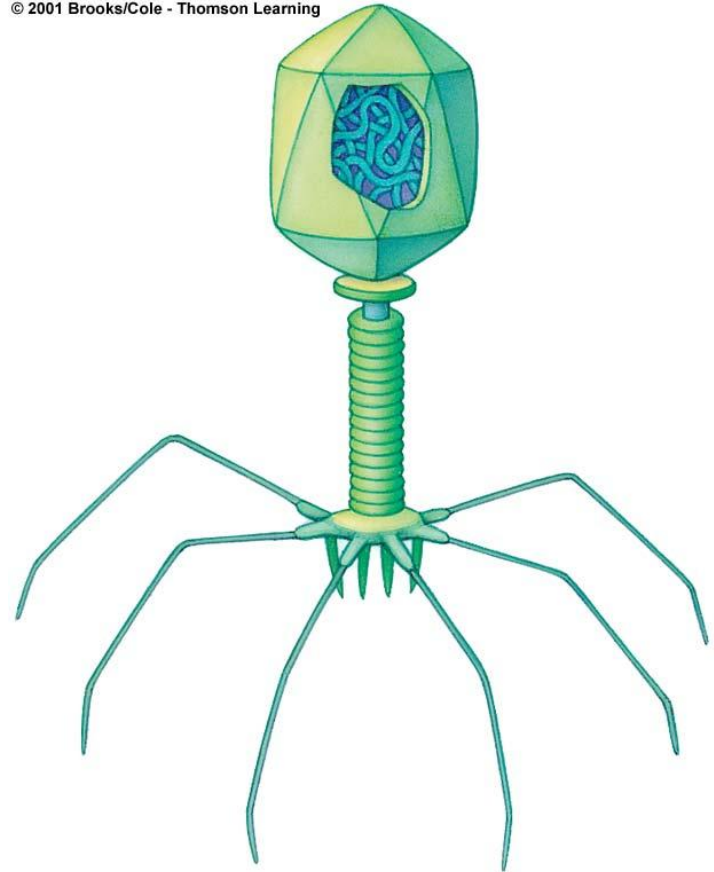
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Polyhedral virus

Complex virus  
(bacteriophage)

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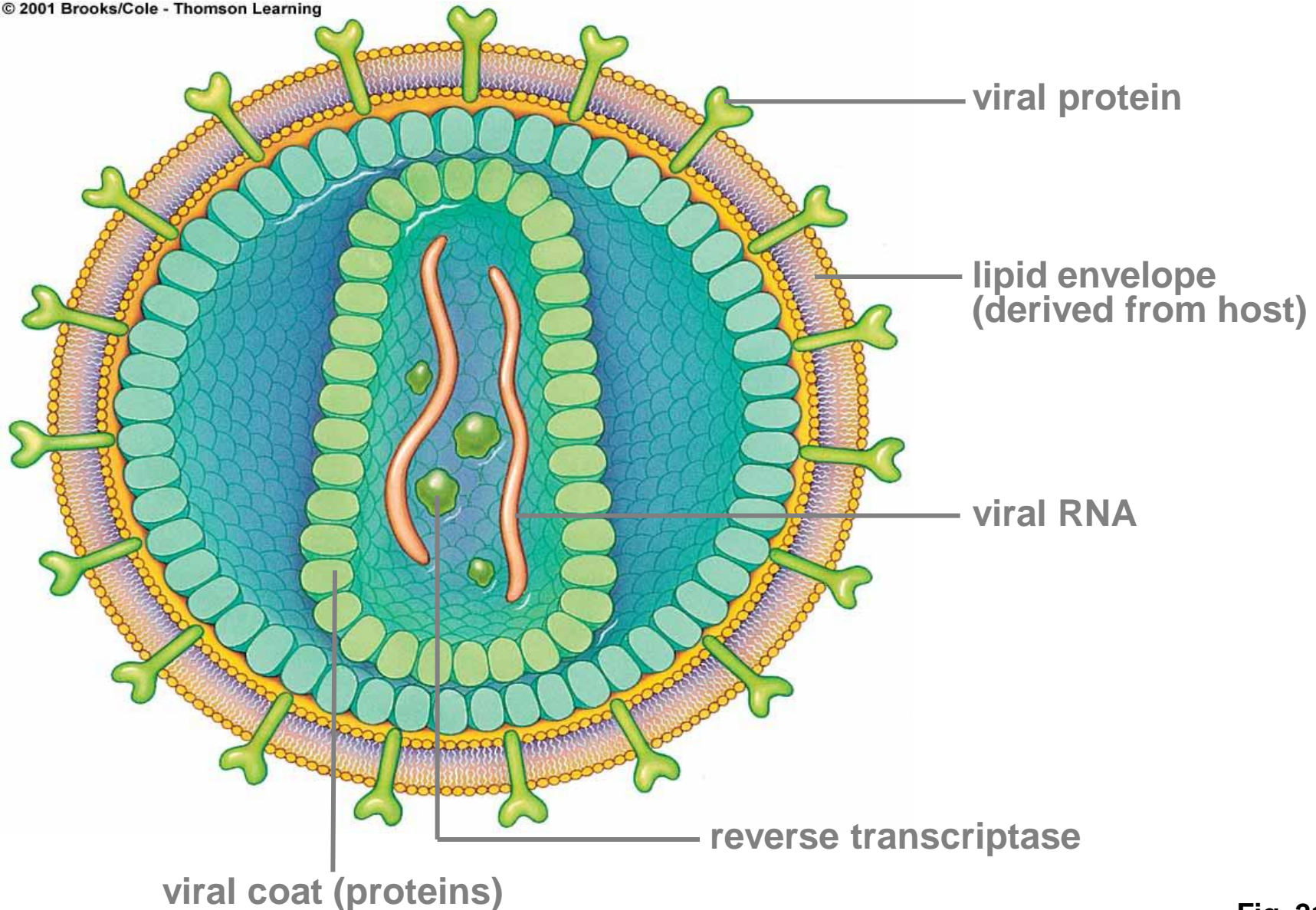


# Virus

- Noncellular infectious agent
- Protein wrapped around a nucleic acid core
- Cannot reproduce itself; can only be reproduced using a host cell

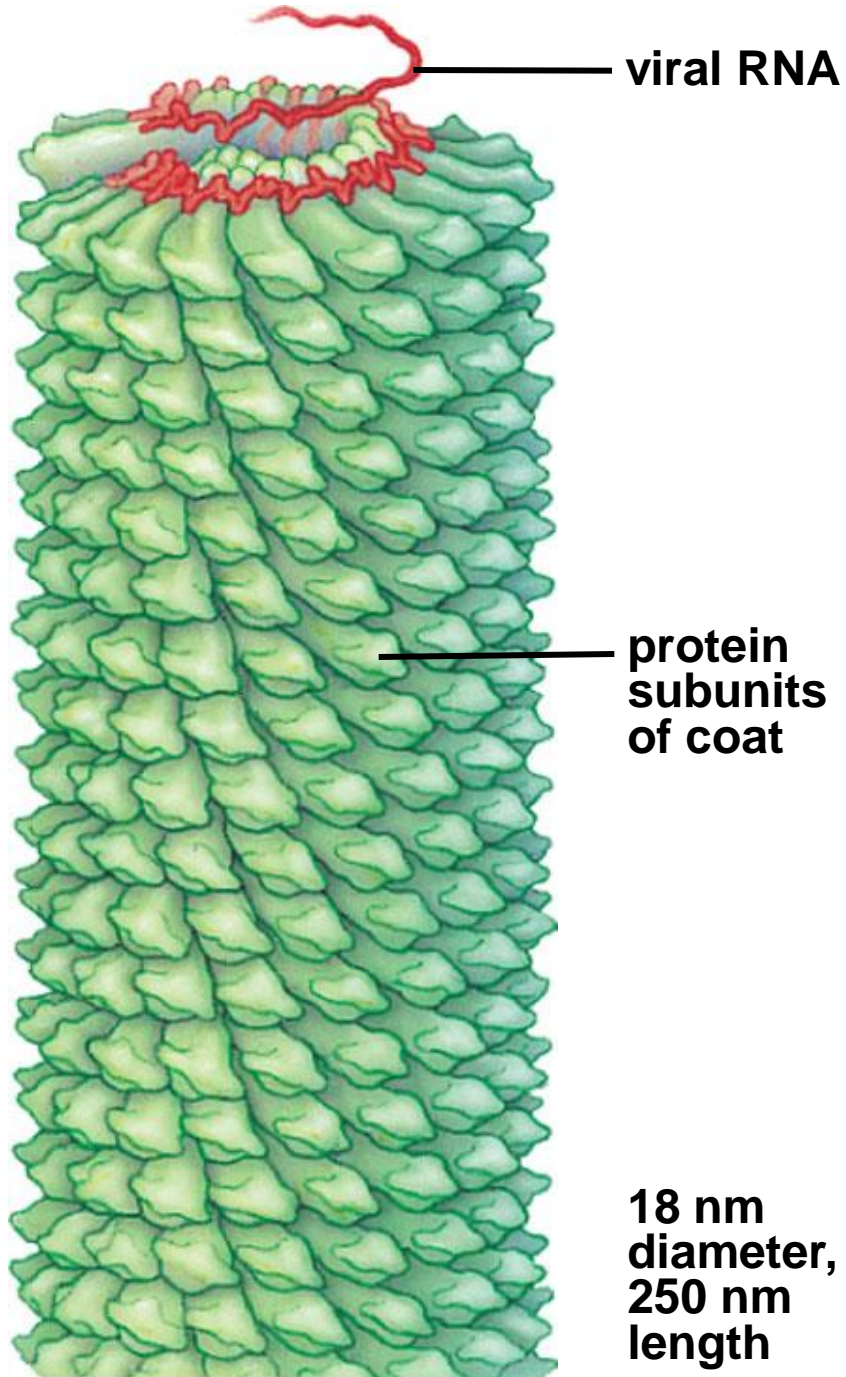
# Enveloped Virus (HIV)

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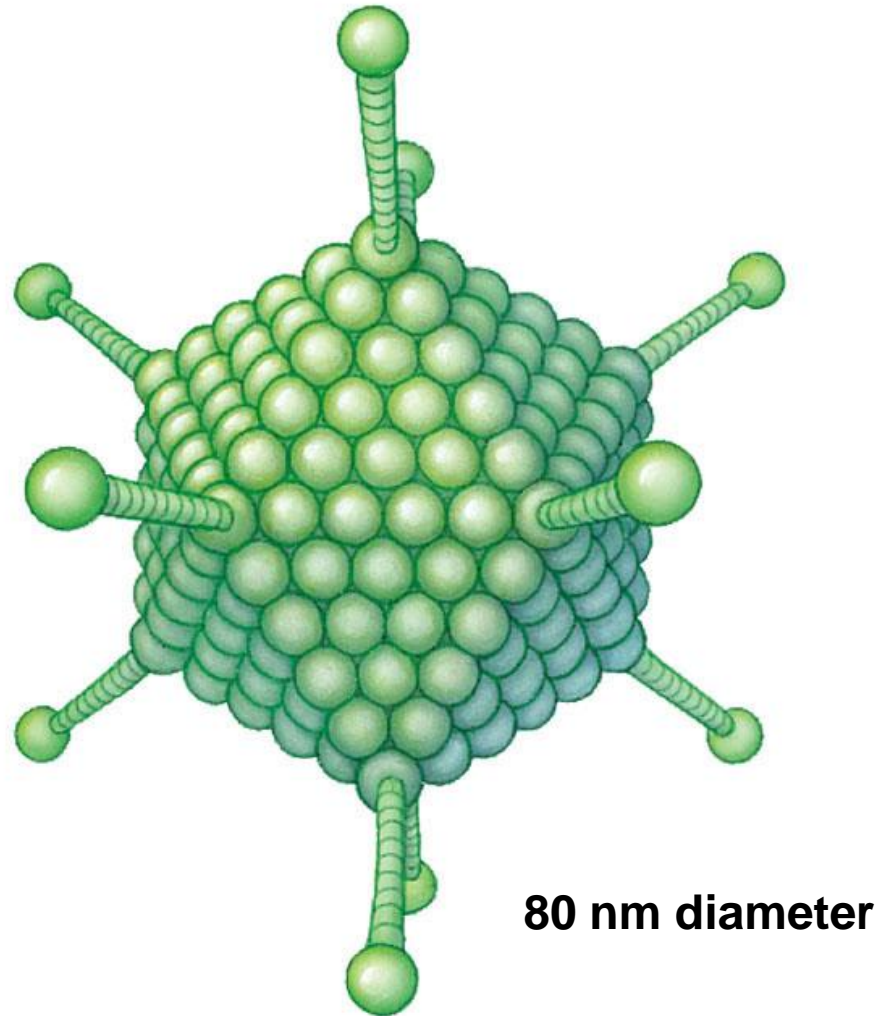




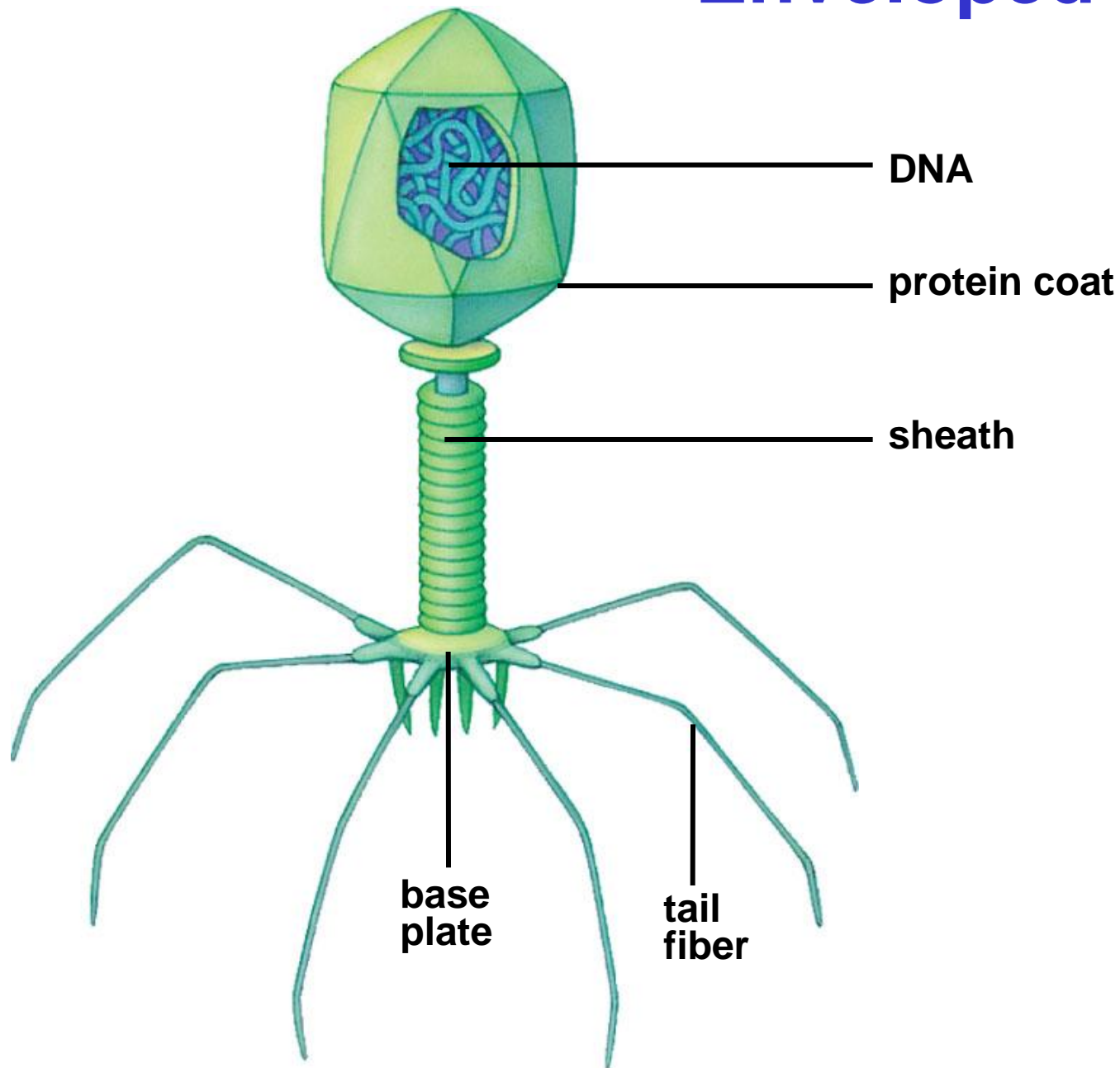
# Enveloped Virus (HIV)



# Enveloped Virus (HIV)

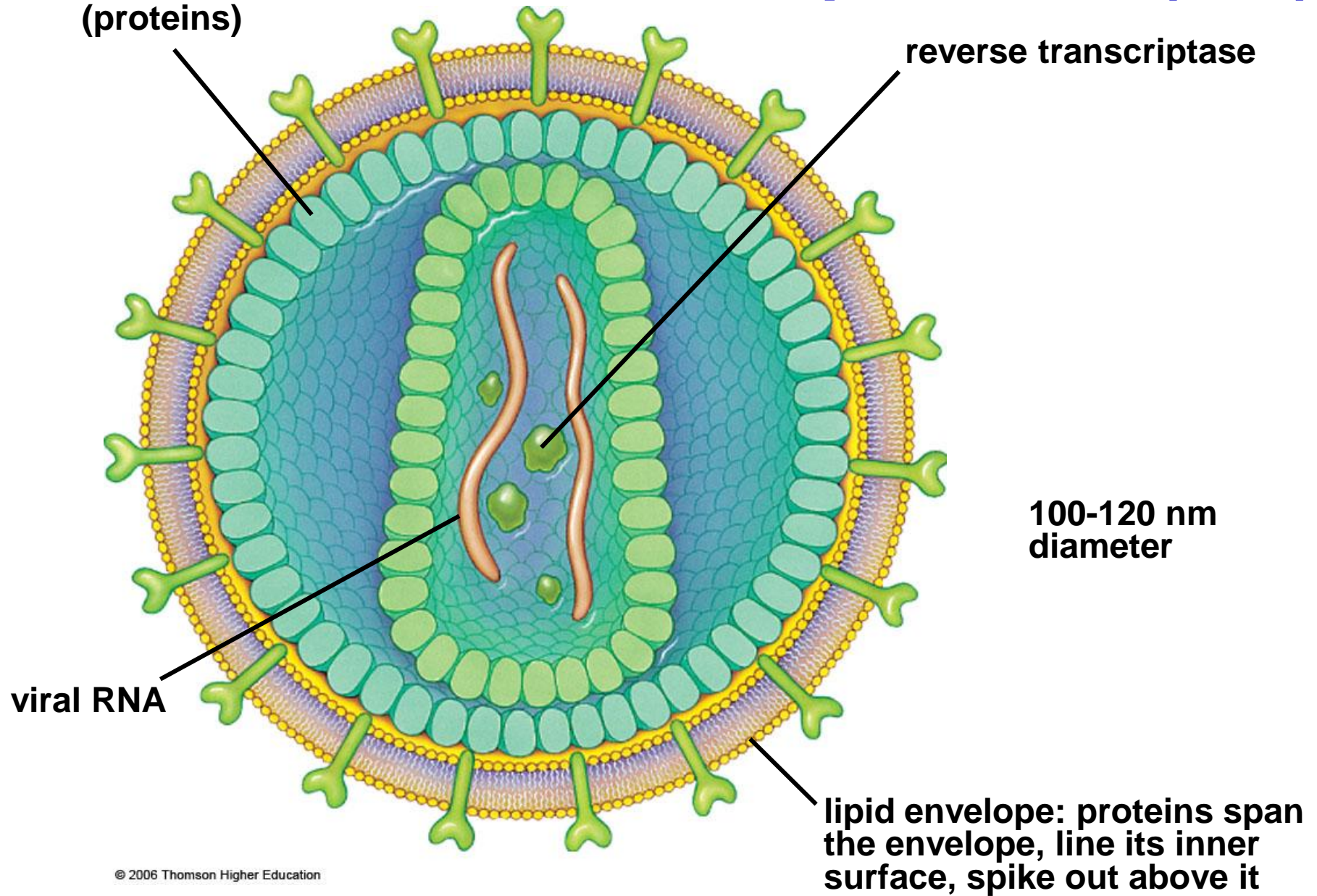


# Enveloped Virus (HIV)





# Enveloped Virus (HIV)



**Table 21.2 Classification of Some of the Major Animal Viruses**

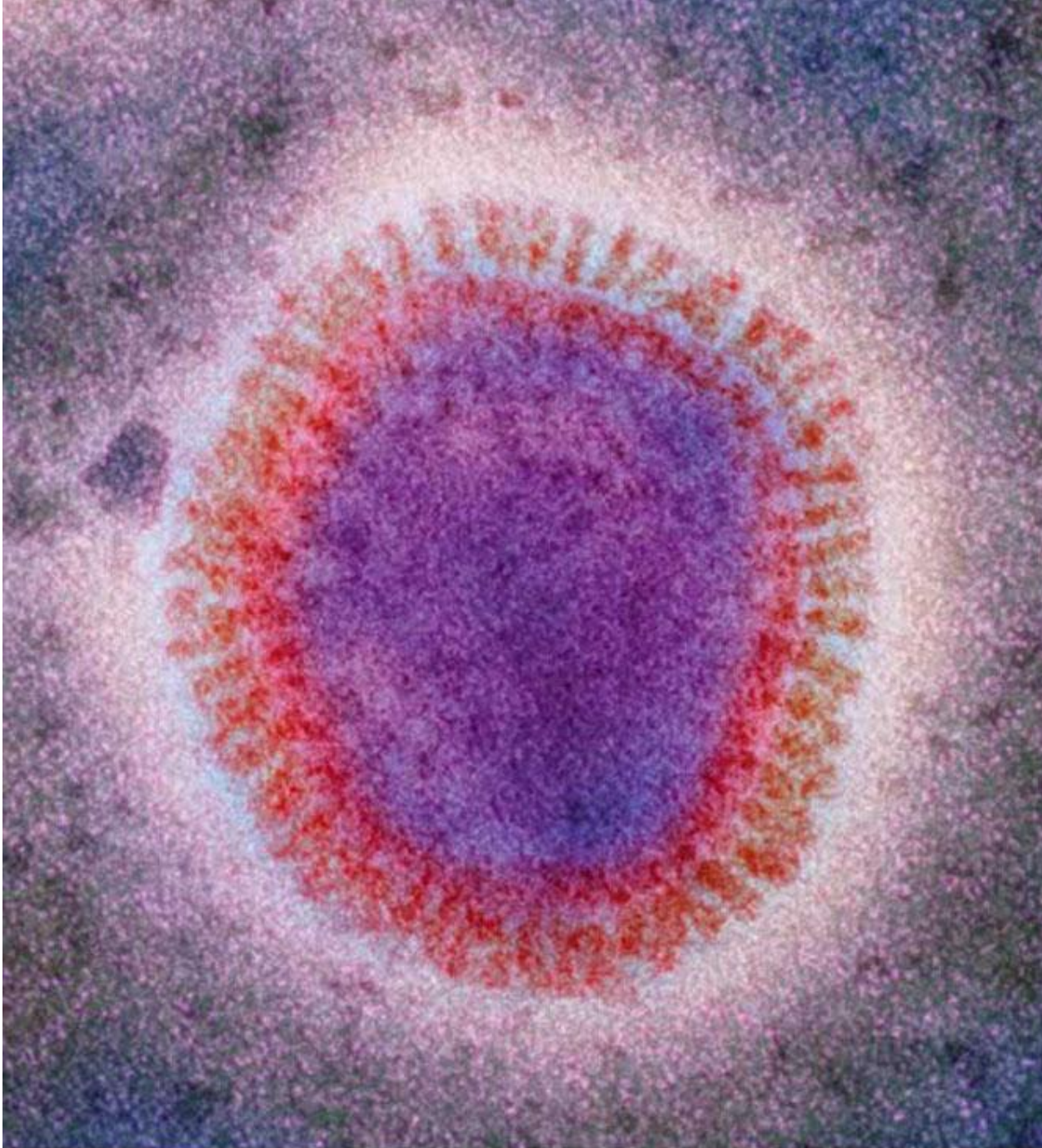
DNA Viruses	Some Diseases and Outcomes
Parvoviruses	Gastroenteritis; roseola (fever, rash) in small children; aggravation of symptoms of sickle-cell anemia
Adenoviruses	Respiratory infections (fever, cough, sore throat, rash), diarrhea in infants, conjunctivitis (inflamed, pebbly eye membranes); some cause tumors
Papovaviruses	Benign and malignant warts
Orthopoxviruses	Smallpox, cowpox, monkeypox
Herpesviruses:	
<i>H. simplex</i> type I	Oral herpes, cold sores
<i>H. simplex</i> type II	Genital herpes (Section 44.8)
Varicella–zoster	Chicken pox, shingles
Epstein–Barr	Infectious mononucleosis; cancers of skin, liver, cervix, pharynx; Burkitt's lymphoma (malignant tumor of jaw, face)
Cytomegalovirus	Hearing loss, mental impairment
Hepadnavirus	Hepatitis B (severe liver infection)

RNA Viruses	Some Diseases and Outcomes
Picornaviruses:	
Enteroviruses	Polio, hemorrhagic eye disease, hepatitis A (infectious hepatitis)
Rhinoviruses	Common cold
Hepatitis A virus	Inflammation of liver, kidneys, spleen
Togaviruses	Forms of encephalitis (inflammation in the brain), rubella
Flaviviruses	Yellow fever (fever, chills, jaundice), dengue (fever, severe muscle pain), St. Louis encephalitis
Coronaviruses	Upper respiratory infections, colds
Rhabdoviruses	Rabies, other animal diseases
Filoviruses	Hemorrhagic fevers, as by <i>Ebola</i> virus (Section 21.8)
Paramyxoviruses	Measles, mumps, respiratory ailments
Orthomyxoviruses	Influenza
Bunyaviruses	
Bunyamwera virus	California encephalitis
Phlebovirus	Hemorrhagic fever, encephalitis
Hantavirus	Hemorrhagic fever, kidney failure
Arenaviruses	Hemorrhagic fevers
Retroviruses:	
HTLV-I, HTLV-II*	Adult T-cell leukemia
HIV	AIDS
Reoviruses	Respiratory and intestinal infections

\* Human T-cell leukemia virus.

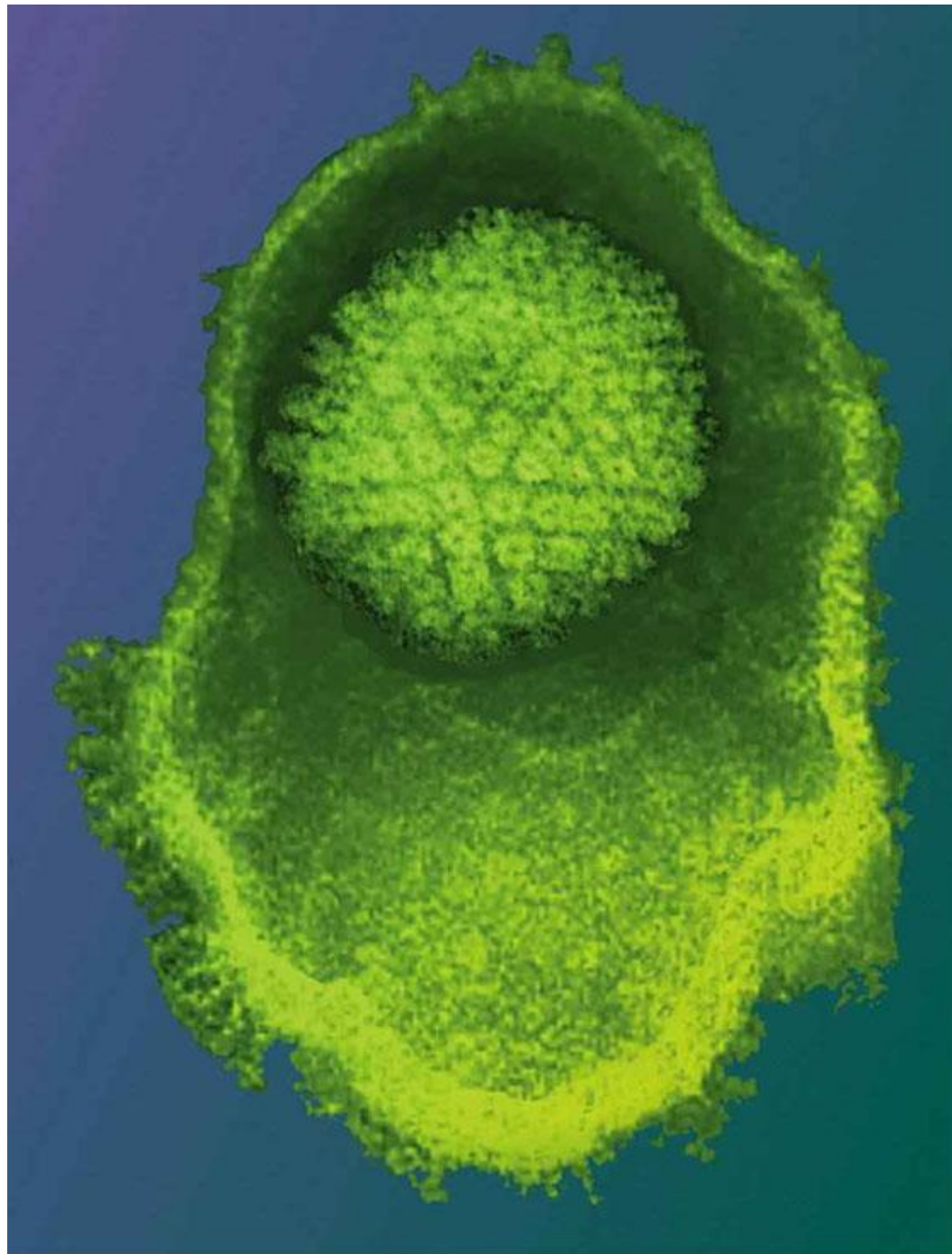


# Viruses





# Viruses



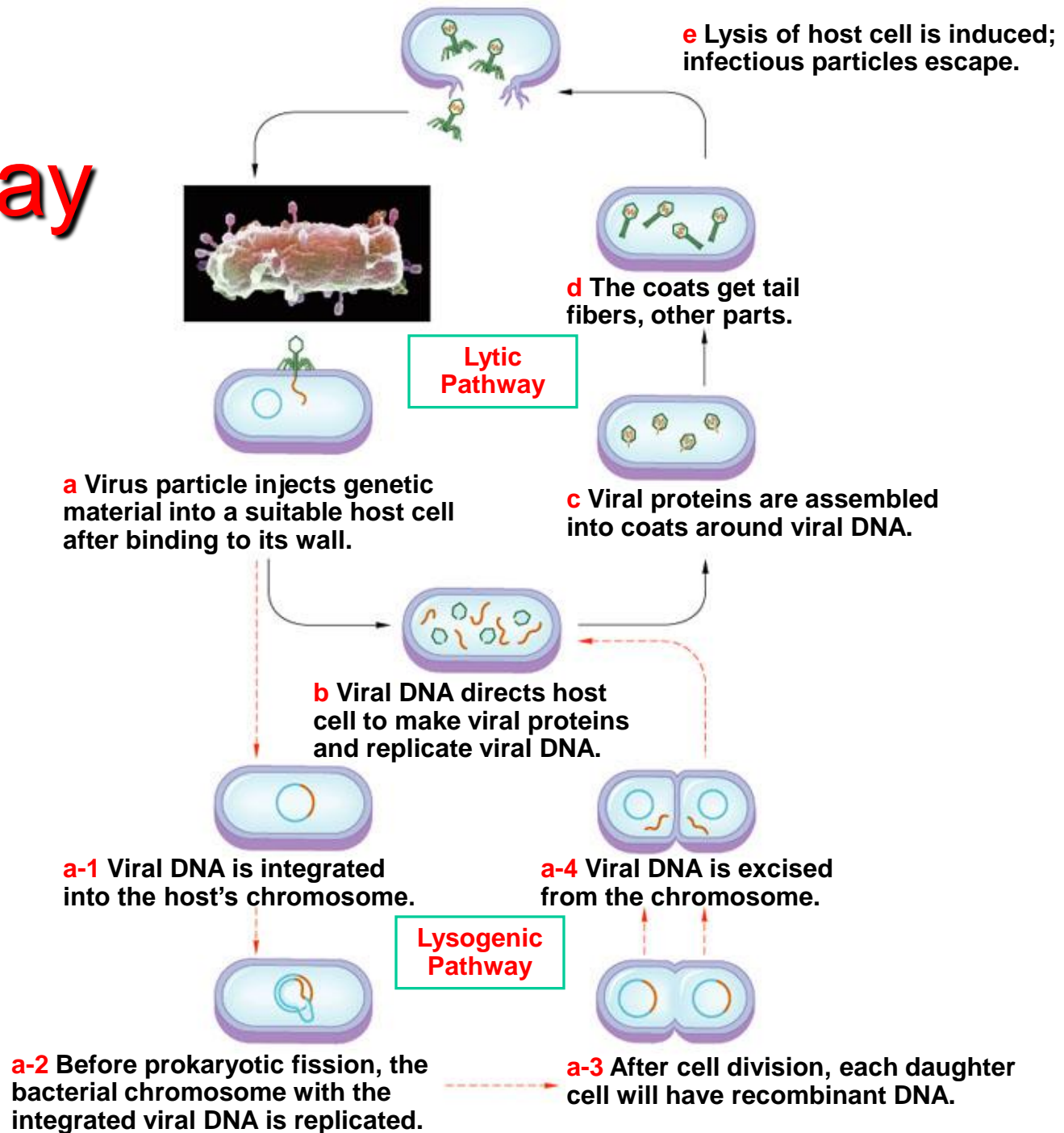
# Viruses



# Viral Multiplication - Basic Steps

- Attach to host cell
- Enter host (virus or just genetic material)
- Direct host to make viral genetic material and protein
- Assemble viral nucleic acids and proteins
- Release new viral particles

# Lytic Pathway



# Lytic Pathway

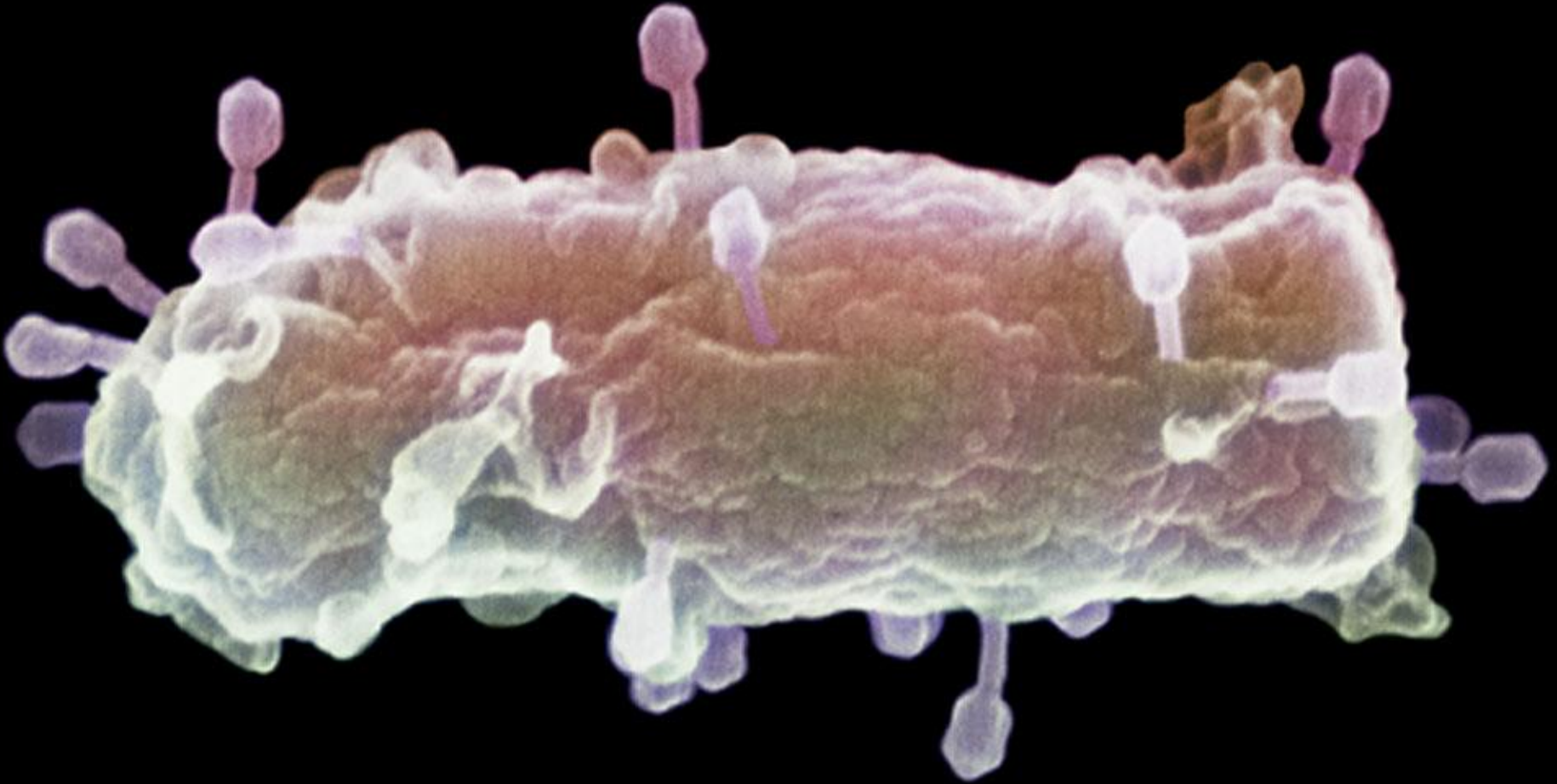
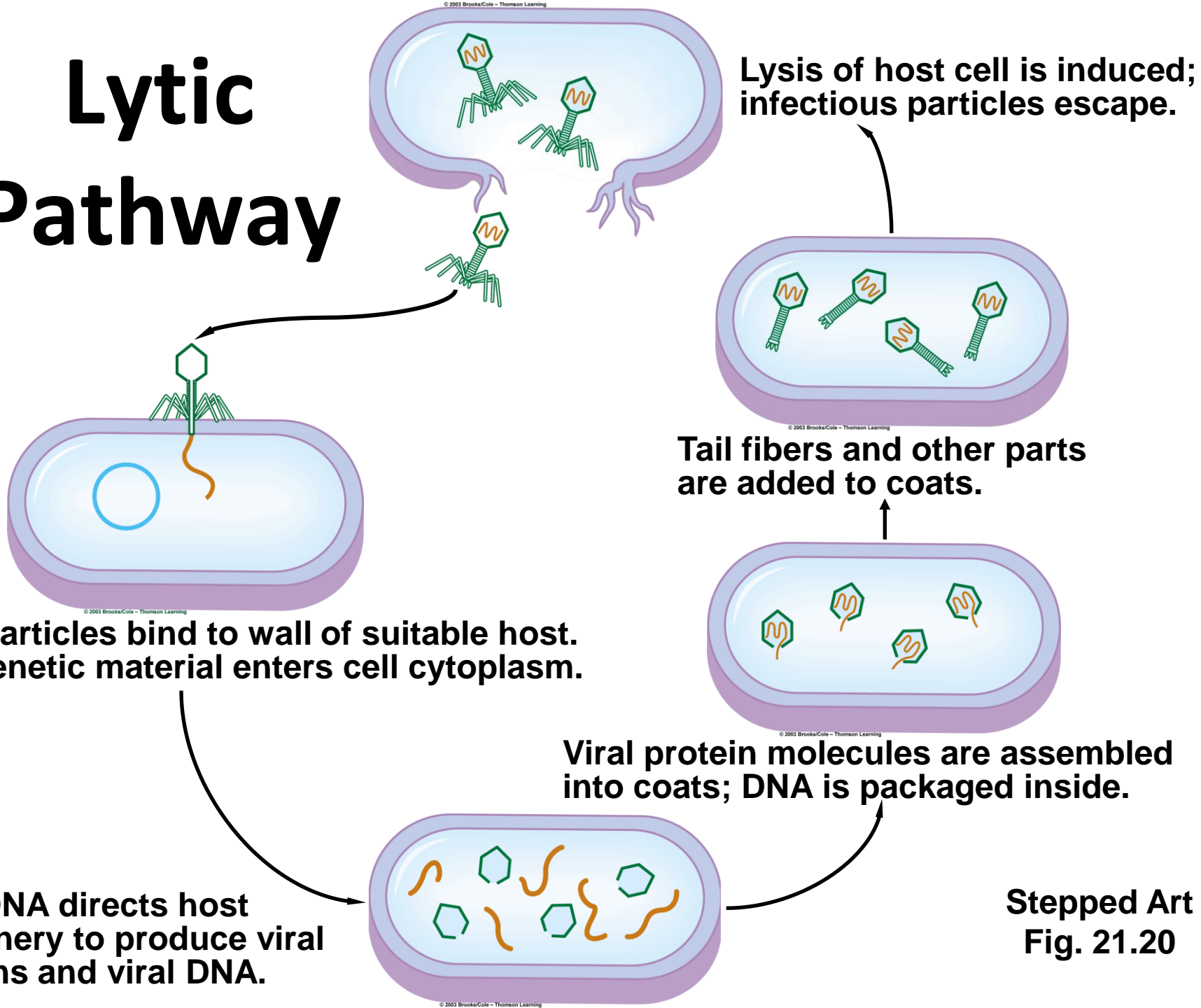


Fig. 21-15a, p.344

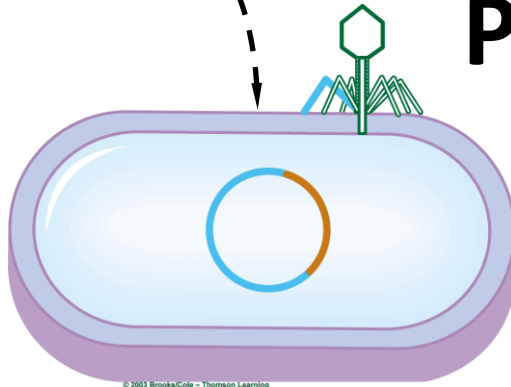


# Lytic Pathway

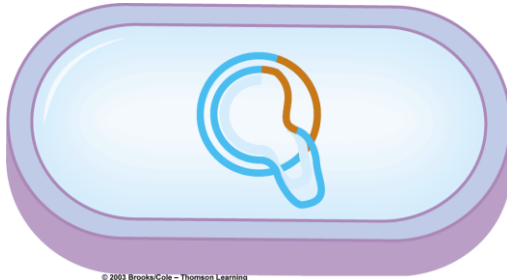


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Fig. 21.20

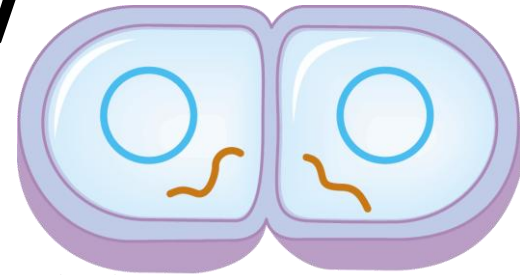
# Lysogenic Pathway



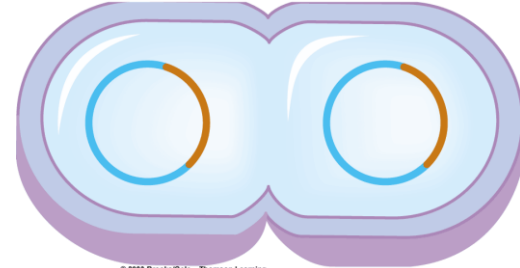
**Viral DNA usually becomes integrated into the bacterial chromosome.**



**Prior to prokaryotic fission, the chromosome and integrated viral DNA are replicated.**



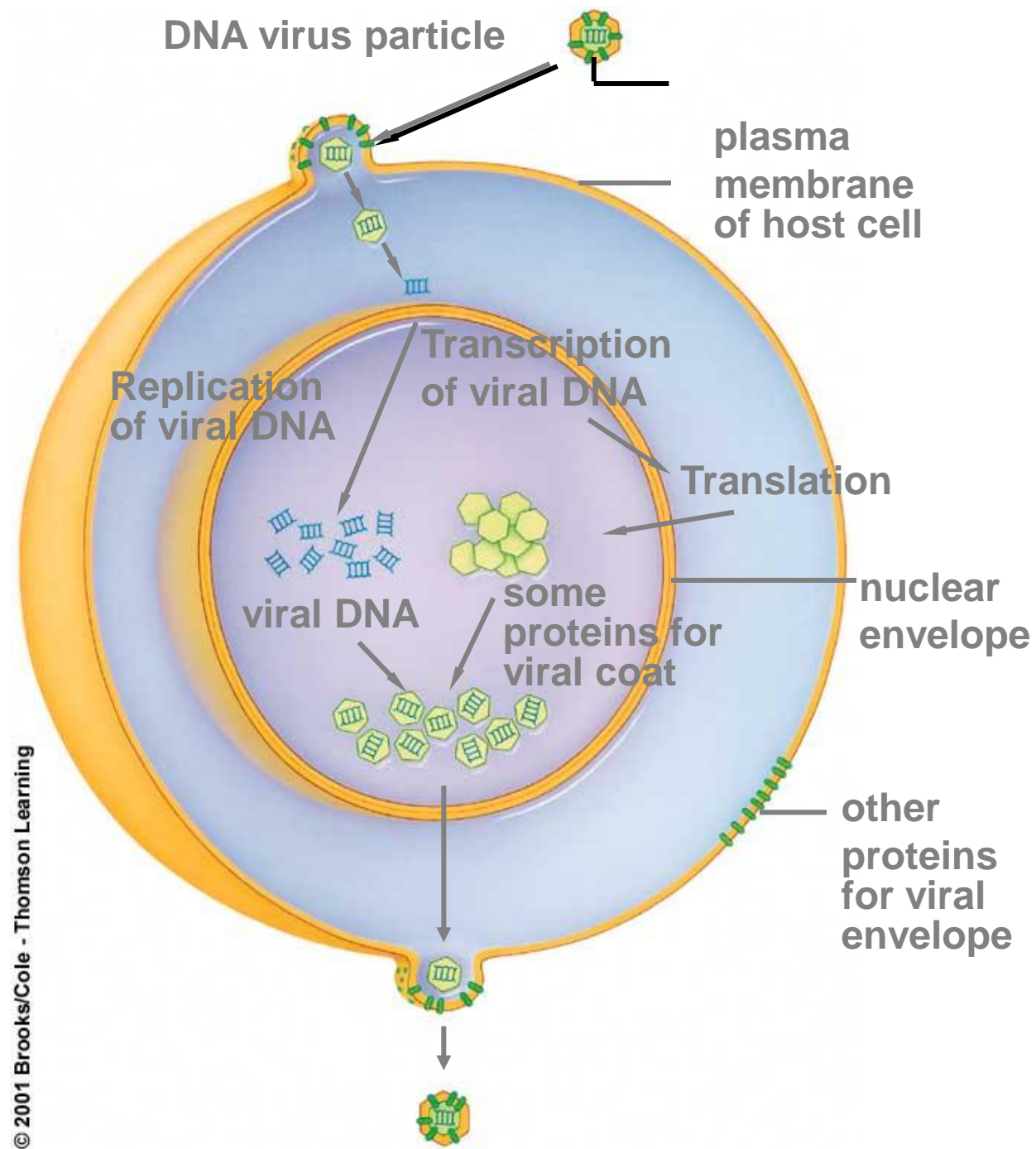
**Viral DNA is excised from chromosome and cell enters lytic pathway.**



**After binary fission, each daughter cell will have recombinant DNA.**

**Stepped Art  
Fig 21.20 (2)**

# Replication of an Enveloped Virus



# Nature of Disease

- Contagious disease pathogens must directly contact a new host
- Epidemic
- Pandemic (AIDS)
- Sporadic
- Endemic

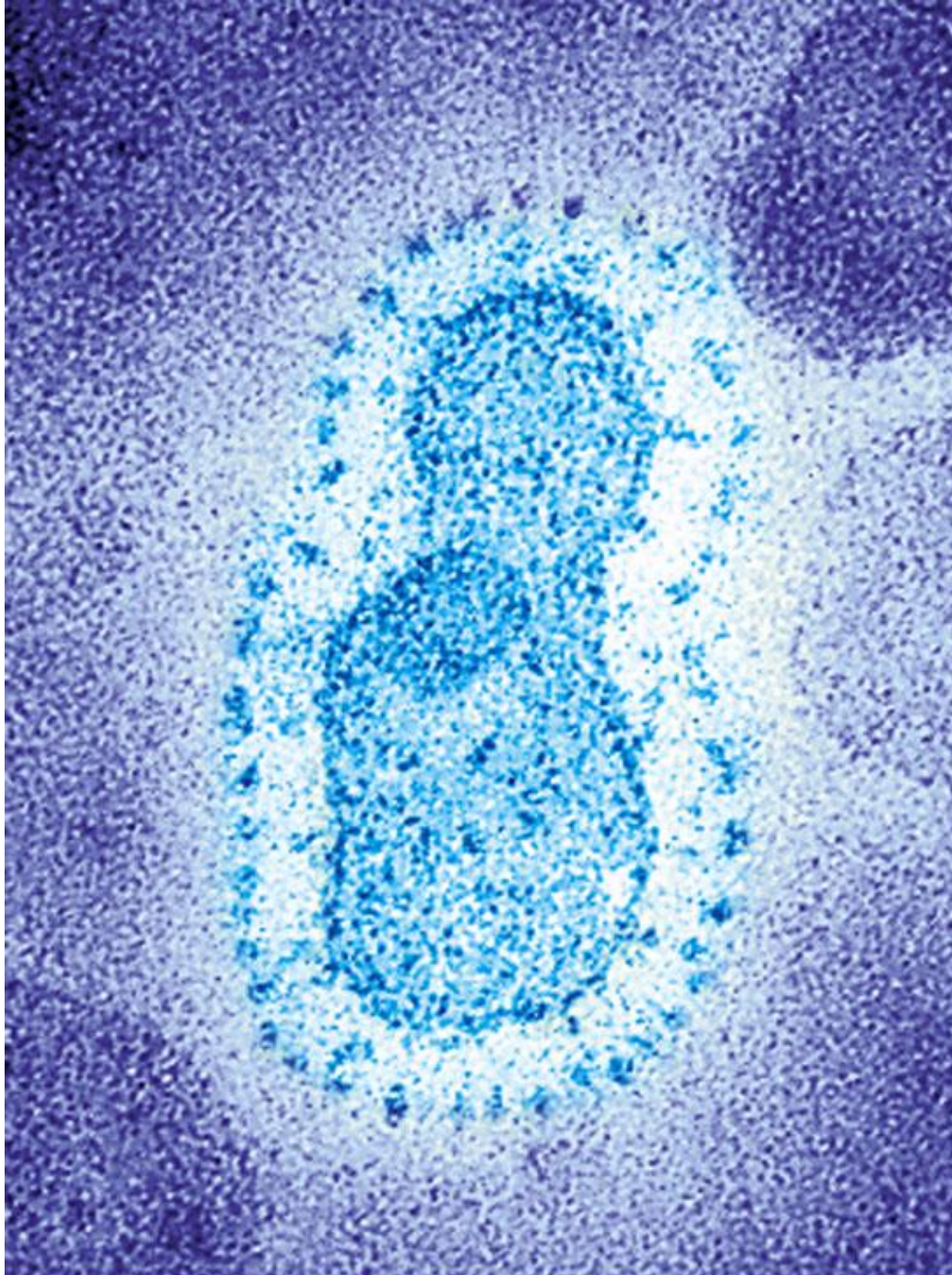
# Evolution and Disease

- Host and pathogen are coevolving
- If a pathogen kills too quickly, it might disappear along with the individual host
- Most dangerous if pathogen
  - Is overwhelming in numbers
  - Is in a novel host
  - Is a mutant strain





***Mycobacterium  
tuberculosis***



**SARS virus**



**Table 21.3    The Eight Deadliest Infectious Diseases**

Disease	Main Agents	Estimated New Cases per Year	Estimated Deaths per Year
Acute respiratory infections*	Bacteria, viruses	1 billion	4.7 million
Diarrheas**	Bacteria, viruses, protozoans	1.8 billion	3.1 million
Tuberculosis	Bacteria	9 million	3.1 million
Malaria	Sporozoans	110 million	2.5–2.7 million
AIDS	Virus (HIV)	5.6 million	2.6 million
Measles	Viruses	200 million	1 million
Hepatitis B	Virus	200 million	1 million
Tetanus	Bacteria	1 million	500,000

\* Includes pneumonia, influenza, and whooping cough.

\*\* Includes amoebic dysentery, cryptosporidiosis, and gastroenteritis.