Biology

Concepts and Applications | 9e
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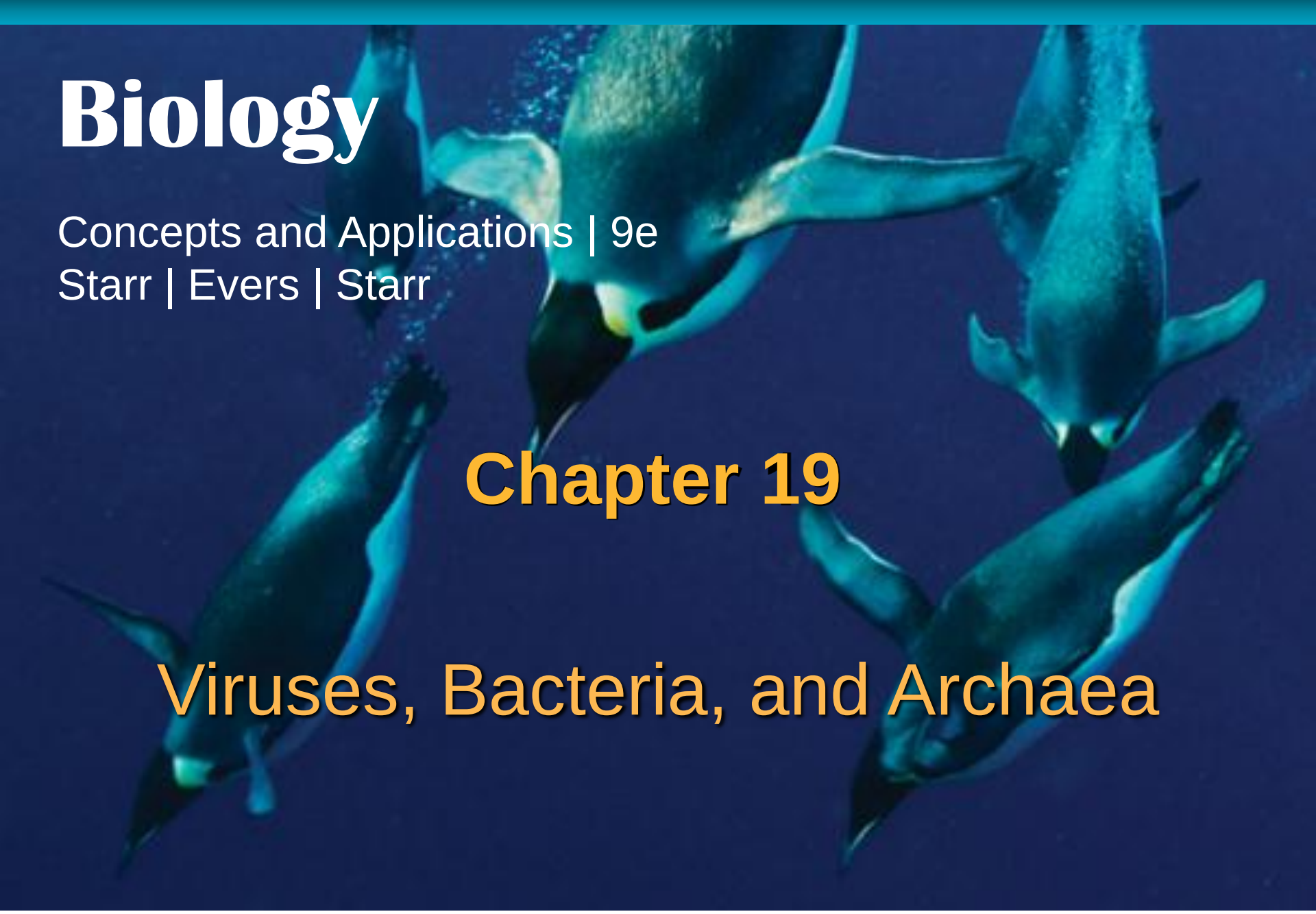


Chapter 19

Viruses, Bacteria, and Archaea

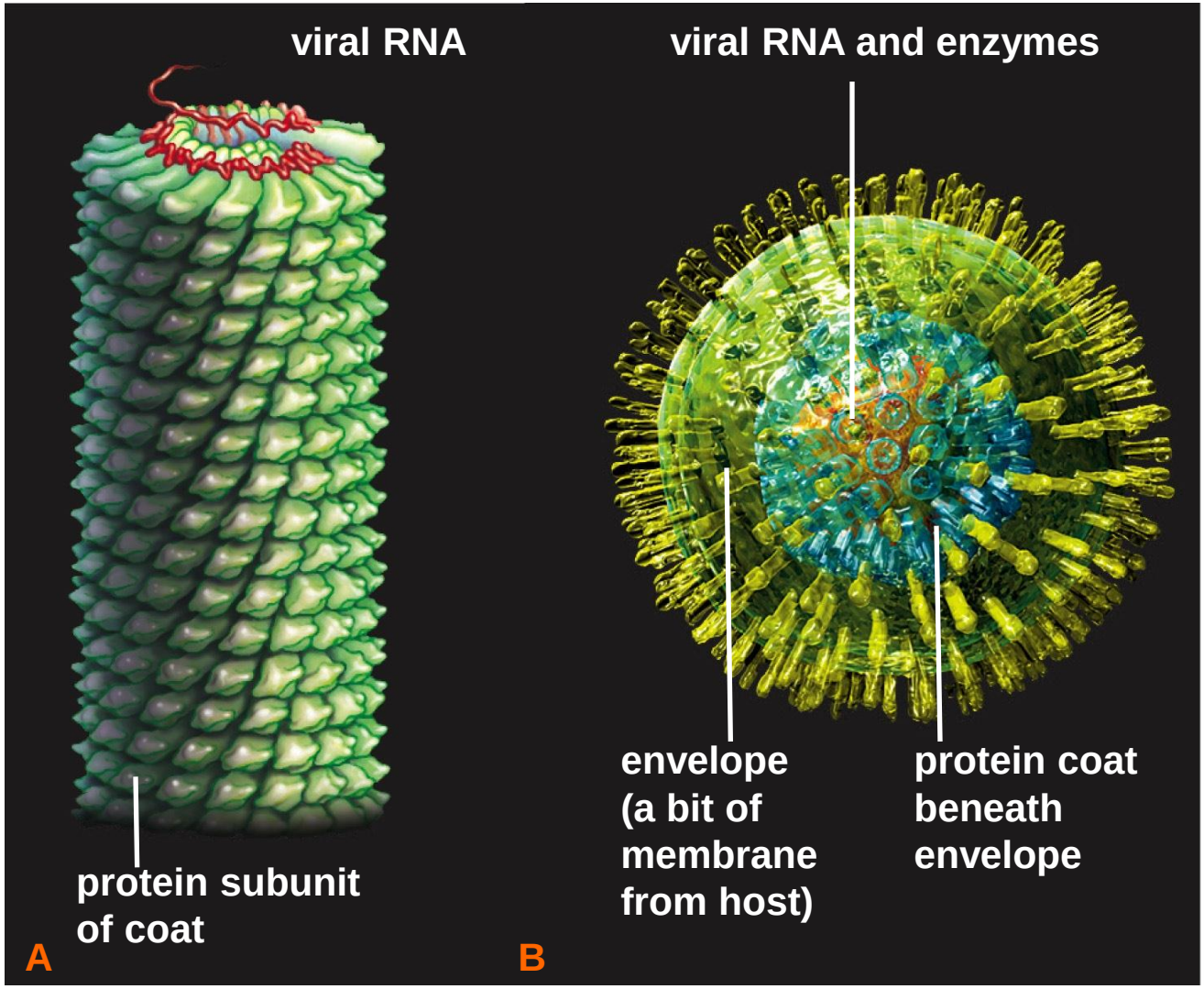
19.1 What Are Viruses?

- Viruses: noncellular infectious agents
  - Consists of a protein coat around a core of DNA or RNA
    - The coat is enveloped in a bit of plasma membrane derived from a previous host
  - Replicates only in a host cell
  - A virus is far smaller than any cell
  - Has no ribosomes or other metabolic machinery

What Are Viruses? (cont'd.)

- Viral structure
  - Either enveloped or non-enveloped
    - Most animal viruses are enveloped
    - Most plant viruses are non-enveloped
    - Herpes viruses are enveloped DNA viruses
    - HIV is an enveloped RNA virus
    - Tobacco mosaic virus has a helical structure, with coat proteins arranged around RNA to form a rod
  - Many animal viruses have a 20-sided protein coat

What Are Viruses? (cont'd.)



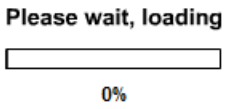
What Are Viruses? (cont'd.)

- Viral replication
  - Each type of virus has structural adaptations that allow it to infect and replicate in hosts of a particular type
  - Replication begins when a virus attaches to membrane proteins on host cell
  - Genetic material enters cell
  - Results in cellular hijacking

What Are Viruses? (cont'd.)

- Bacteriophage (phages)
  - A virus that infects bacteria and archaea
  - Have two replication pathways
    - Lytic: multiplication is rapid, and new viral particles are released by lysis
    - Lysogenic: the virus enters a latent state that extends the cycle

Animation: Bacteriophage multiplication cycles



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What Are Viruses? (cont'd.)

- HIV replication
  - HIV is an enveloped RNA virus that causes the disease AIDS
  - HIV replicates inside human white blood cells
  - Spikes of viral protein attach to proteins in the cell's plasma membrane
  - Drugs that fight HIV interfere with viral binding to the host, reverse transcription, integration of DNA, or formation of viral proteins

What Are Viruses? (cont'd.)

- Nine steps in HIV replication
  1. Virus binds to a host cell
  2. Viral RNA and enzymes enter cell
  3. Viral reverse transcriptase uses viral RNA to make double-stranded viral DNA
  4. Viral DNA integrates into host genome
  5. Transcription produces viral RNA

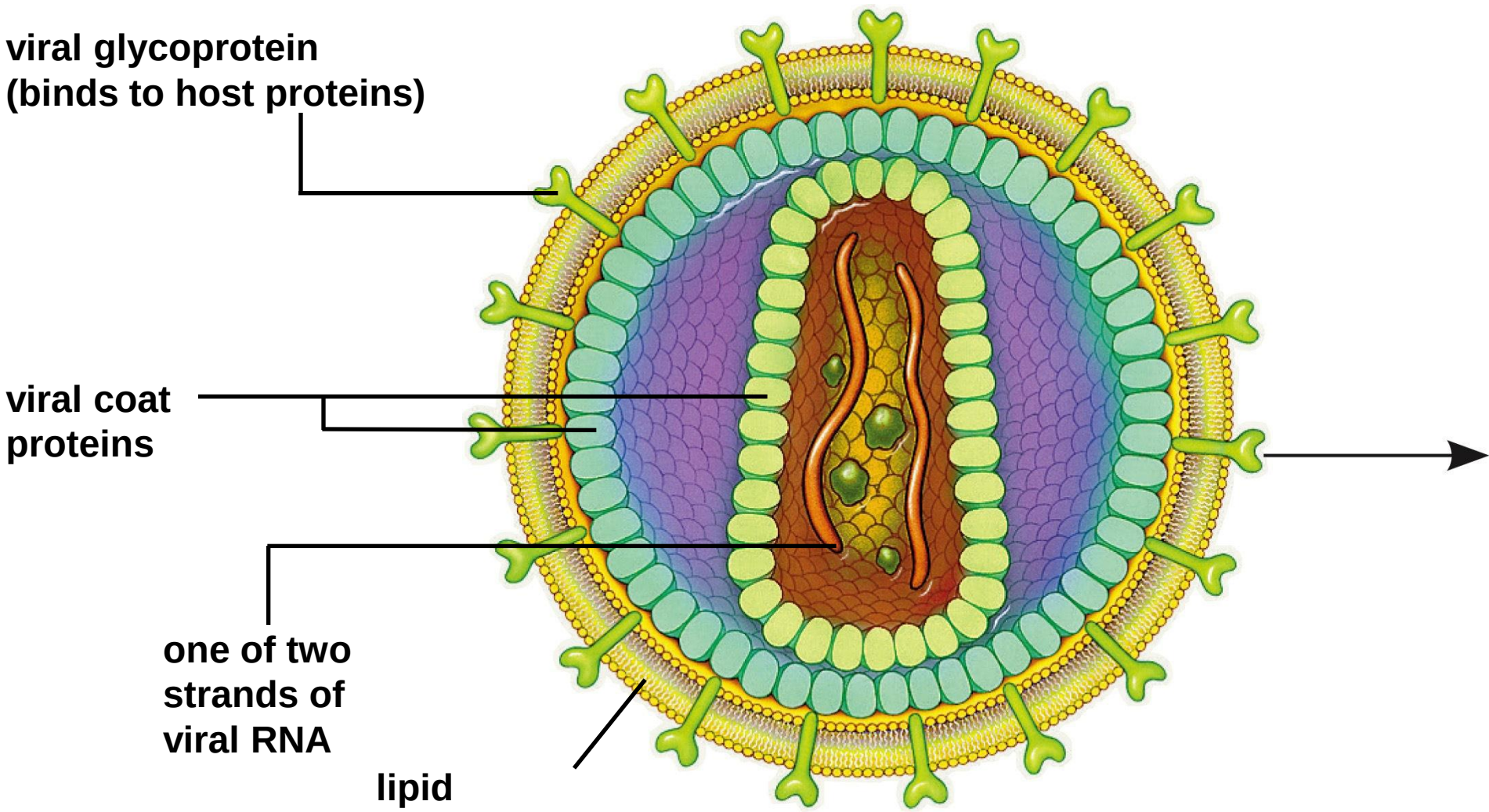
What Are Viruses? (cont'd.)

- Nine steps in HIV replication (cont'd.)
  6. Some viral RNA is translated to produce viral proteins
  7. Other viral RNA forms the new viral genome
  8. Viral proteins and RNA self-assemble at the host membrane
  9. New virus buds with an envelope of host membrane

What Are Viruses? (cont'd.)

- RNA viruses that use reverse transcriptase to produce viral DNA in a host are called retroviruses

What Are Viruses? (cont'd.)



Animation: HIV replication cycle

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19.2 How Do Viruses Affect Human Health?

- Viral diseases
  - Pathogens: disease-causing agents
  - Usually produce mild symptoms persist in body for long periods
  - Can be latent and then reawaken

How Do Viruses Affect Human Health? (cont'd.)

CDC/Dr. Hermann

How Do Viruses Affect Human Health? (cont'd.)

- Common viral diseases
  - Nonenveloped viruses:
    - Adenoviruses (colds)
    - Viral gastroenteritis (stomach flu)
    - Human papillomavirus (genital warts, cervical cancer)

How Do Viruses Affect Human Health? (cont'd.)

- Enveloped viruses
  - Herpes viruses (cold sores, genital herpes, infectious mononucleosis, chicken pox)
  - Influenza (flu)
  - Mumps, measles, and German measles

How Do Viruses Affect Human Health? (cont'd.)

- Emerging viral diseases
  - Changes to viral genomes as a result of mutation or gene exchanges can alter the properties of a viral disease
  - A disease that was previously unknown, is new to humans, or has recently begun spreading to a new region

How Do Viruses Affect Human Health? (cont'd.)

- West nile fever
  - An enveloped RNA virus that replicates in birds
  - Mosquitoes carry the virus from host to host (the vector for this virus)
  - Attacks the nervous system and can be fatal
  - An endemic disease throughout the continental United States

How Do Viruses Affect Human Health?

- Ebola hemorrhagic fever
  - Ebola virus is highly contagious to humans
  - Symptoms include fever, muscle pain, and massive internal bleeding
  - Death rate is 90 percent

How Do Viruses Affect Human Health?

- Viral recombination
  - Viruses have genomes that can mutate
  - RNA viruses can mutate quickly
  - Viral genomes can also exchange genes when two viruses infect a host at the same time

How Do Viruses Affect Human Health?

- Viral recombination (cont'd.)
  - Avian influenza H5N1 (bird flu) occasionally infects people who are in contact with birds, and has a high mortality rate
  - Influenza H1N1 (swine flu) first appeared in 2009, can cause severe respiratory symptoms, and is easily transmitted

19.3 How Do Viruses Affect Plant Health?

- Viroids
  - A new type of plant pathogen
  - A small RNA, circular and single-stranded without a protein coat
  - Are ribozymes (RNAs with enzymatic activity)
  - Discovered in 1971
  - Viroids do not encode proteins

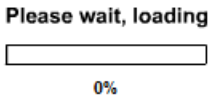
How Do Viruses Affect Plant Health?

(6A) Courtesy D. Shew, Reproduced by permission from Compendium of Tobacco Diseases, 1991, American Phytopathological Society, St. Paul, MN; (6B) Photo by Barry Fitzgerald, Courtesy of USDA

19.4 How Are Bacteria and Archaea Similar?

- Bacteria and archaea
  - Prokaryotes
  - Small, structurally simple and single-celled
  - Three cell shapes
    - Coccus (spherical)
    - Bacillus (rod-shaped)
    - Spirillum (spiral)

Animation: Typical prokaryotic cell



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How Are Bacteria and Archaea Similar?

- Prokaryotic traits
  - No nucleus, endoplasmic reticulum, or Golgi bodies
  - Single chromosome (a circular DNA molecule); many species also contain plasmids
  - Cell wall (in most species)

How Are Bacteria and Archaea Similar? (cont'd.)

- Prokaryotic traits (cont'd.)
  - Ribosomes distributed in the cytoplasm
  - Asexual reproduction by binary fission
  - Capacity for gene exchange among existing cells through conjugation, transduction, and transformation

How Are Bacteria and Archaea Similar? (cont'd.)

- Reproduction and gene exchange
  - Reproduce by *binary fission*:
    - Asexual reproduction
    - Replication of a single, circular chromosome
    - Division of a parent cell into two genetically equivalent descendants

How Are Bacteria and Archaea Similar? (cont'd.)

- Four steps in binary fission
  - Circular chromosome attaches to inside of plasma membrane
  - Cell duplicates chromosome, attaches copy beside the original, and adds membrane and wall material between them
  - When cell has almost doubled in size, new membrane and wall are deposited
  - Two genetically identical cells result

Animation: Prokaryotic fission

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How Are Bacteria and Archaea Similar? (cont'd.)

- Horizontal gene transfers
  - Move genes between existing individuals (cells)
- Conjugation
  - One cell gives a plasmid to the other
  - One cell extends a sex pilus out to another cell
  - The cell that made the sex pilus passes a copy of its plasmid to its partner

Animation: Prokaryotic conjugation

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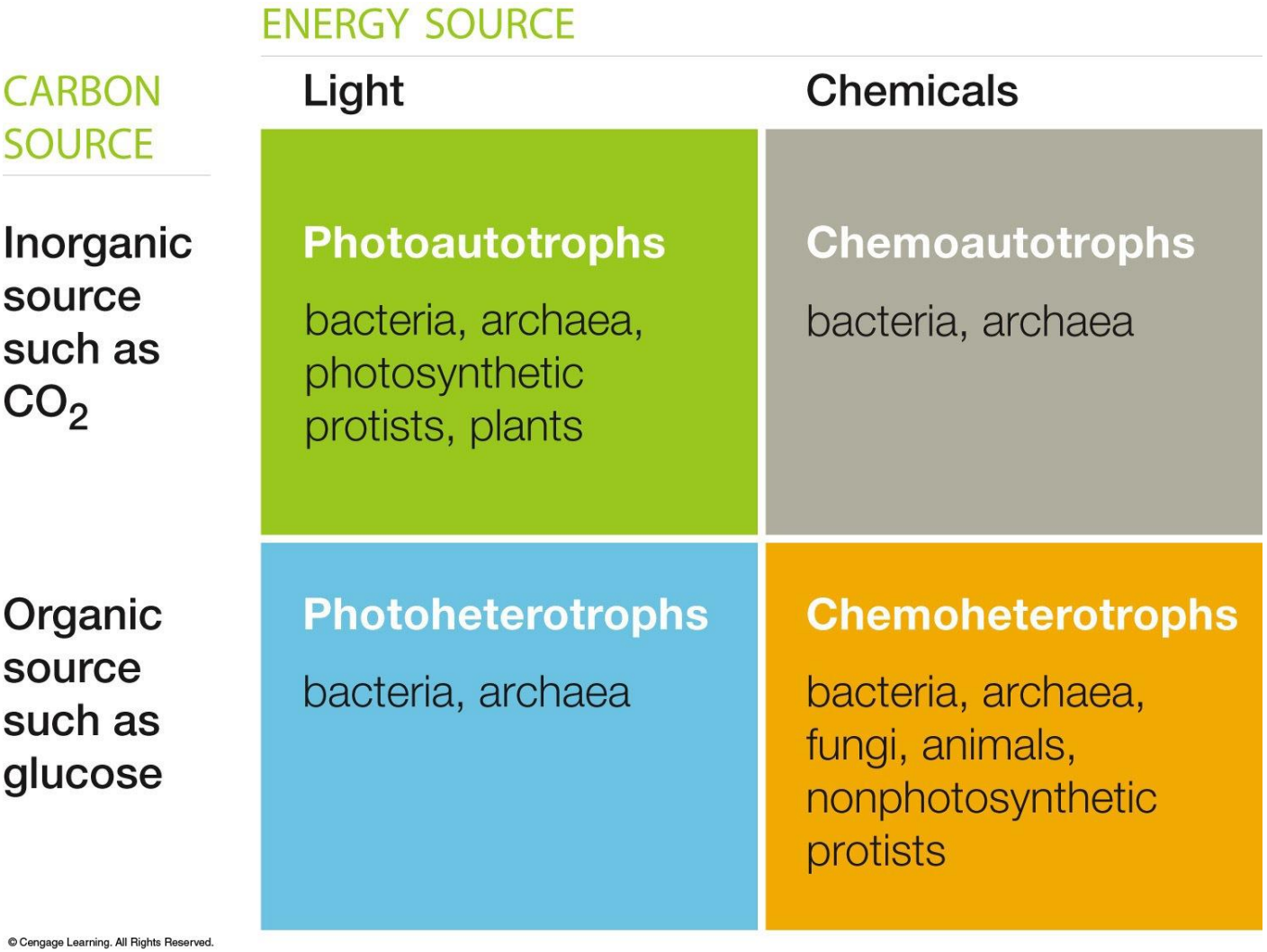
How Are Bacteria and Archaea Similar? (cont'd.)

- Metabolic diversity of prokaryotes

Mode of Nutrition	Energy Source	Carbon Source
Photoautotrophic	Sunlight	Carbon dioxide
Chemoautotrophic	Inorganic substances	Carbon dioxide
Photoheterotrophic	Sunlight	Organic compounds
Chemoheterotrophic	Organic compounds	Organic compounds

How Are Bacteria and Archaea Similar? (cont'd.)



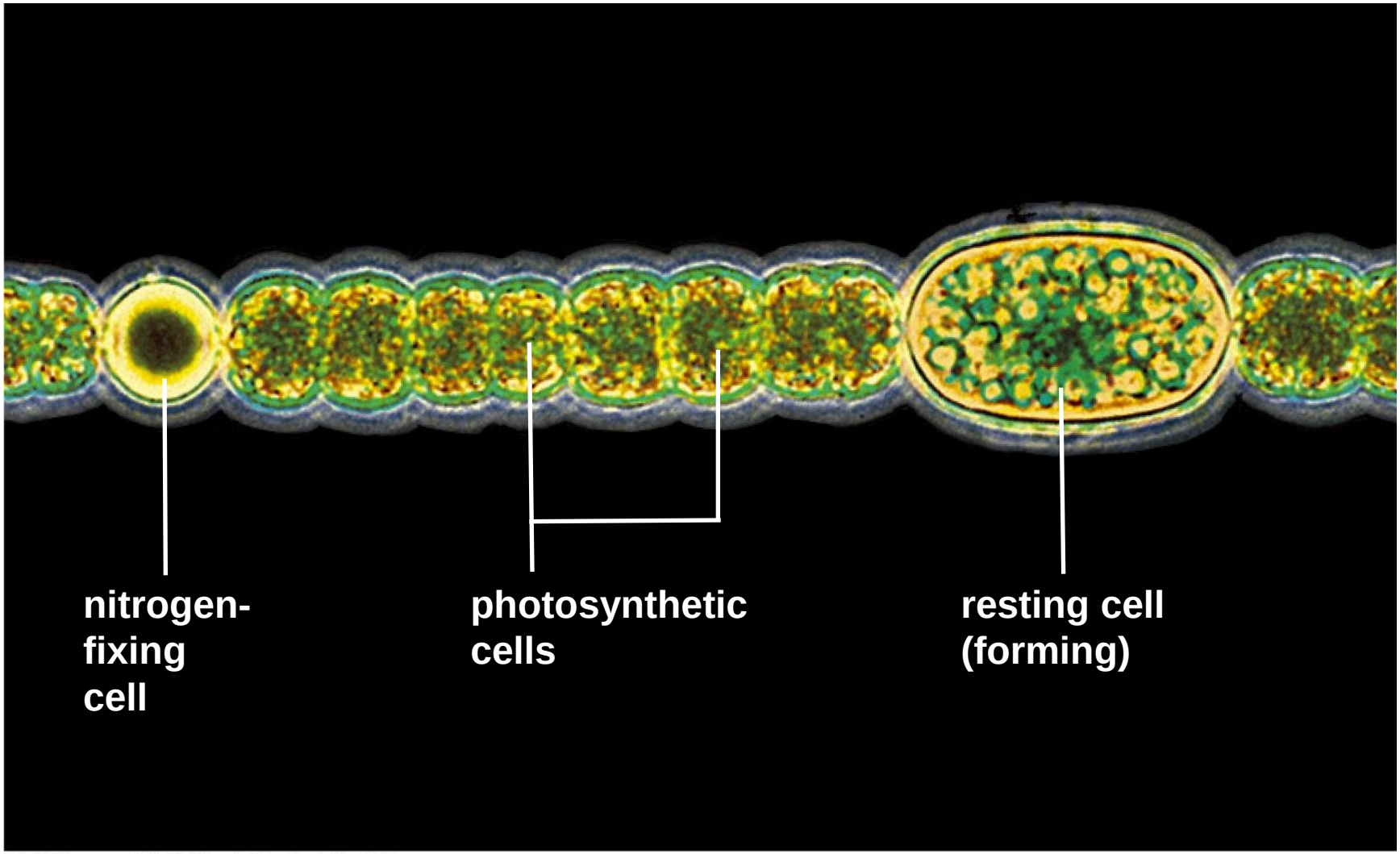
19.5 What Are Some Major Bacterial Lineages?

- Bacteria are widespread, abundant, and diverse
  - Most either harmless or beneficial
- Many bacteria have essential ecological roles:
  - Decomposers
  - Cycle nutrients
  - Form partnerships with other species

What Are Some Major Bacterial Lineages? (cont'd.)

- Cyanobacteria
  - Produce oxygen during photosynthesis
  - Carry out *nitrogen fixation*, producing ammonia that algae and plants need as a nutrient
  - Partner with fungi and form lichens
  - Spirulina is grown commercially

What Are Some Major Bacterial Lineages? (cont'd.)



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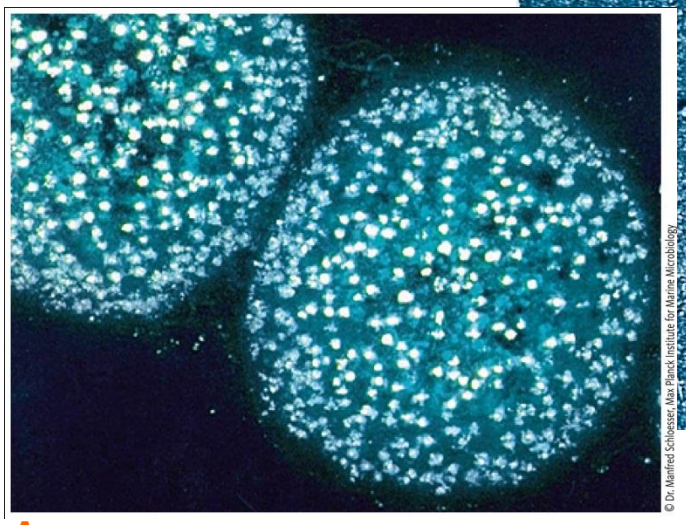
What Are Some Major Bacterial Lineages? (cont'd.)

- Proteobacteria are the largest bacterial lineage
  - Some are nitrogen-fixers (*Rhizobium*)
  - Myxobacteria show remarkable cooperative behavior (multicelled fruiting bodies with spores)
  - *Escherichia* coli are part of our normal flora

What Are Some Major Bacterial Lineages? (cont'd.)

- *Thiomargarita namibiensis*
  - The largest known bacterium
  - Has an enormous vacuole that holds sulfur and nitrate
- Some important pathogens: *Salmonella*, *Campylobacter*, *Helicobactor pylori*, *Vibrio cholerae*
- *Rickettsias* (intracellular parasites) are the closest relatives of mitochondria

What Are Some Major Bacterial Lineages? (cont'd.)



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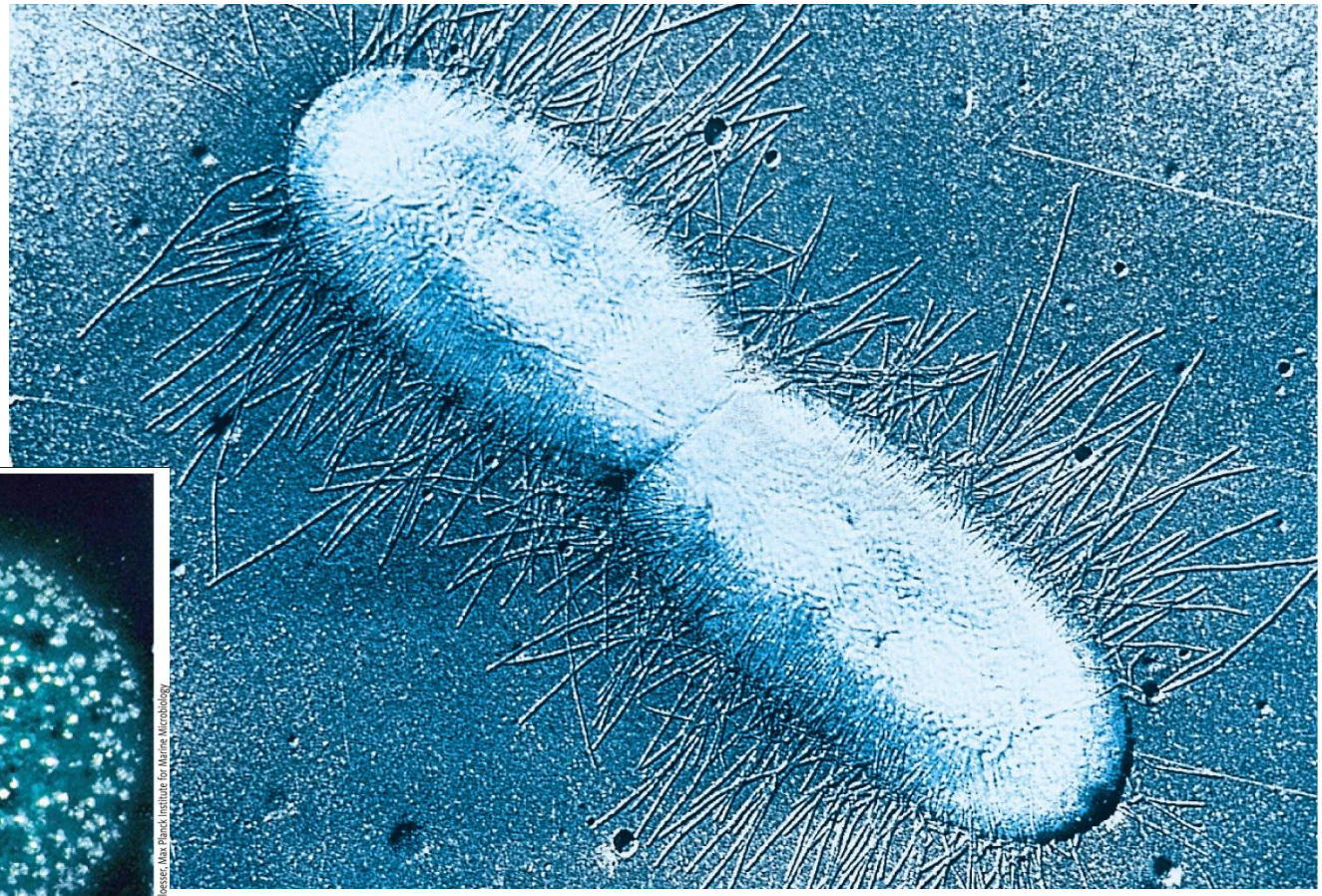

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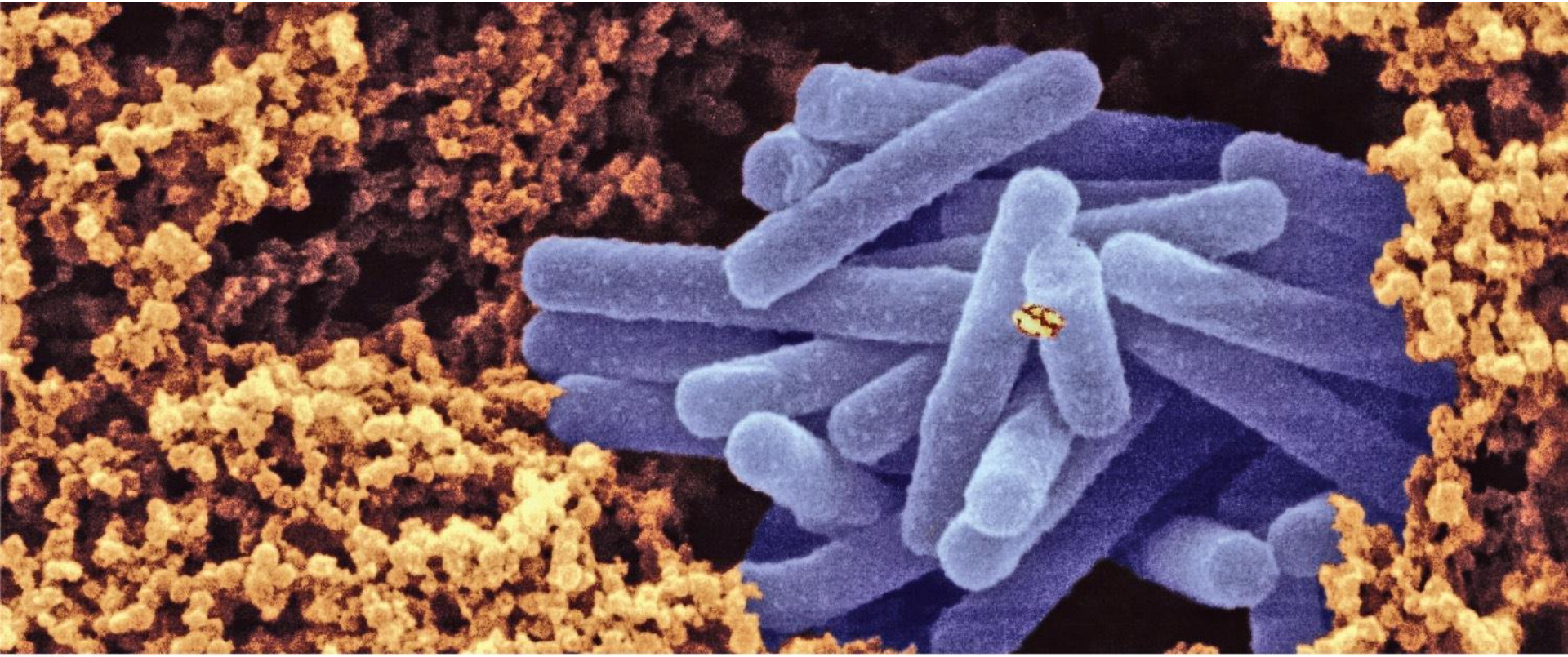
What Are Some Major Bacterial Lineages? (cont'd.)

- Gram staining
  - Method used to prepare bacteria for examination under a microscope
  - Process used to distinguish groups based on cell wall structure
    - Thick-walled Gram-positive bacteria are tinted purple
    - Thinner-walled Gram-negative bacteria such as cyanobacteria and proteobacteria are stained pink

What Are Some Major Bacterial Lineages? (cont'd.)

- Gram-positive bacteria have thick walls
- Gram-negative bacteria have thinner walls
- Some Gram-positive soil bacteria (*Clostridium*, *Bacillus*) produce endospores
  - Allow them to survive
    - Boiling, freezing, radiation, and disinfectants

What Are Some Major Bacterial Lineages? (cont'd.)

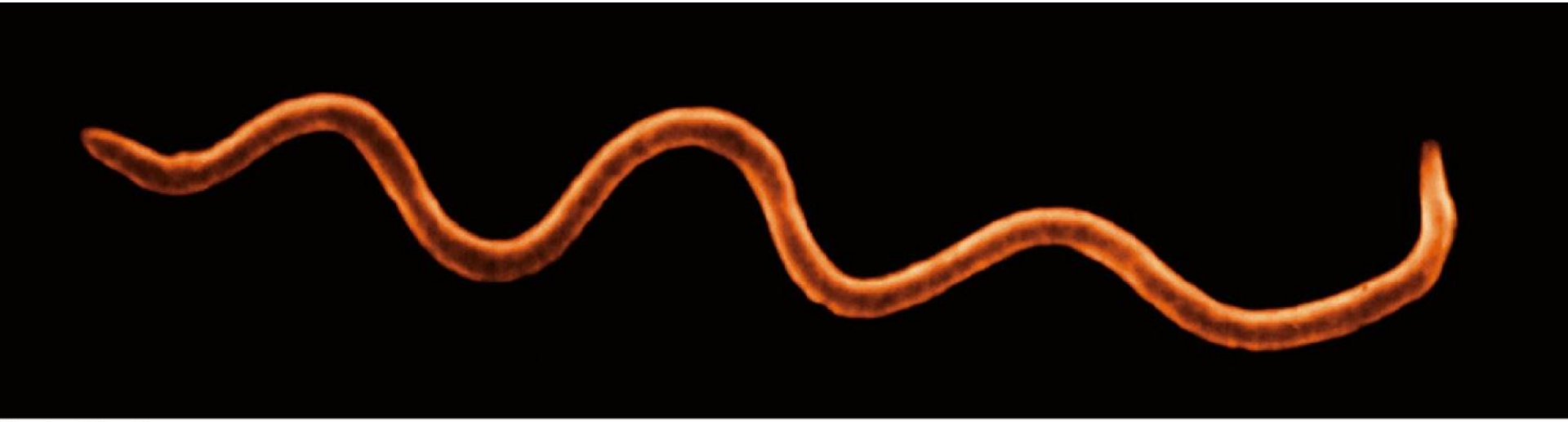


SciMAT/Science Source

What Are Some Major Bacterial Lineages? (cont'd.)

- Spirochetes
  - Spiral-shaped bacteria
  - Include aquatic decomposers, nitrogen fixers, and bacteria that live in cattle gut and break down cellulose
  - Some are pathogens
    - Cause of sexually-transmitted disease syphilis
    - Cause of Lyme disease, transmitted by ticks

What Are Some Major Bacterial Lineages? (cont'd.)



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19.6 How Do Bacteria Affect Human Health?

- Normal flora
  - Normally harmless or beneficial microorganisms that typically live in or on a body
- Some endospore-forming bacteria make deadly toxins:
  - *Bacillus anthracis*: anthrax
  - *Clostridium tetani*: tetanus
  - *C. botulinum*: botulism

How Do Bacteria Affect Human Health? (cont'd.)

- Dangerous infections:
  - *Mycobacterium tuberculosis*: tuberculosis
  - *Streptococcus*: strep throat, "flesh-eating bacteria"
  - *Staphylococcus*: Antibiotic-resistant staph infections

How Do Bacteria Affect Human Health? (cont'd.)

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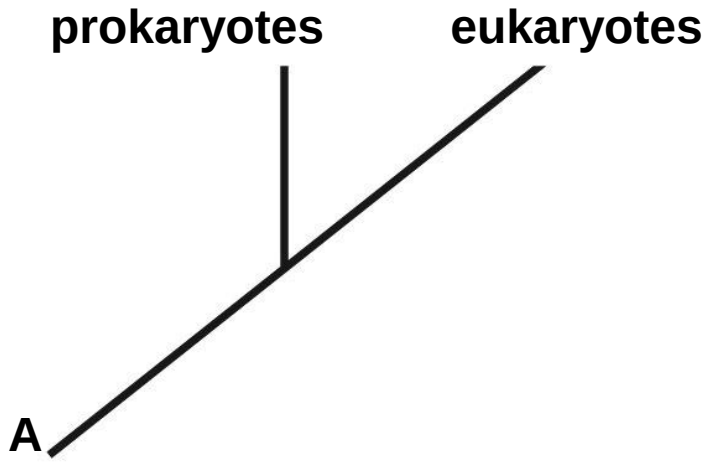
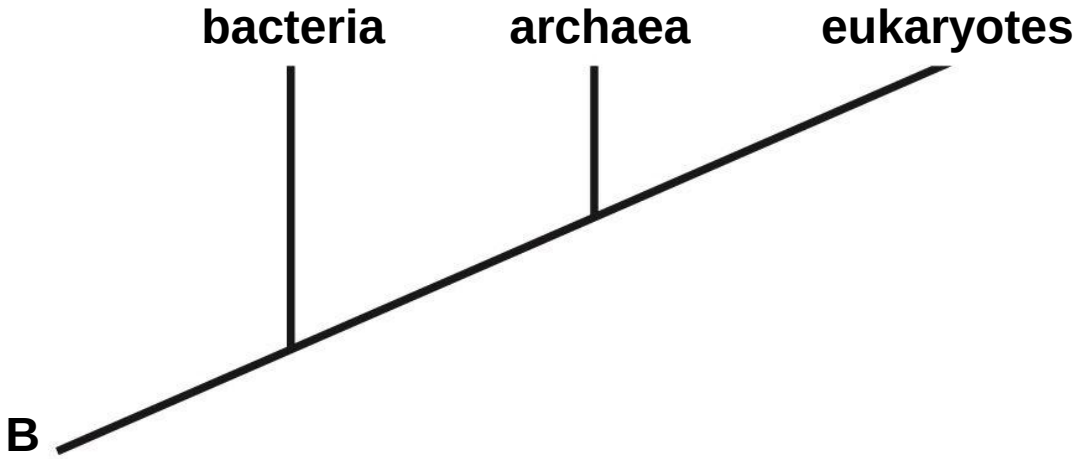
19.7 How Were Archaea Discovered?

- Biologists historically divided all life into two groups, prokaryotes and eukaryotes
- New evidence revealed differences in structure, organization, and gene sequences between bacteria and archaeans
- The three domain model is now considered correct

How Were Archaea Discovered? (cont'd.)





How Were Archaea Discovered? (cont'd.)

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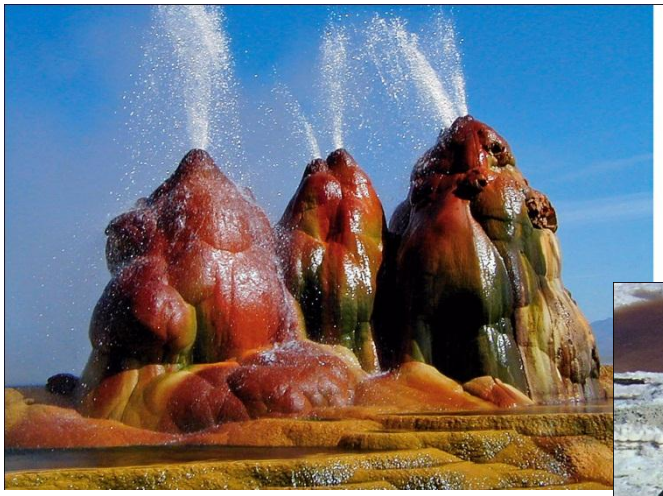
19.8 Where Do Archaea Live?

- Archaeans are more diverse and widely distributed than previously thought
  - Many archaeans are:
    - Methanogens (methane makers)
    - Extreme halophiles (salt lovers)
    - Extreme thermophiles (heat lovers)
- Archaeans coexist with bacteria in many habitats and can exchange genes with them

Where Do Archaea Live? (cont'd.)



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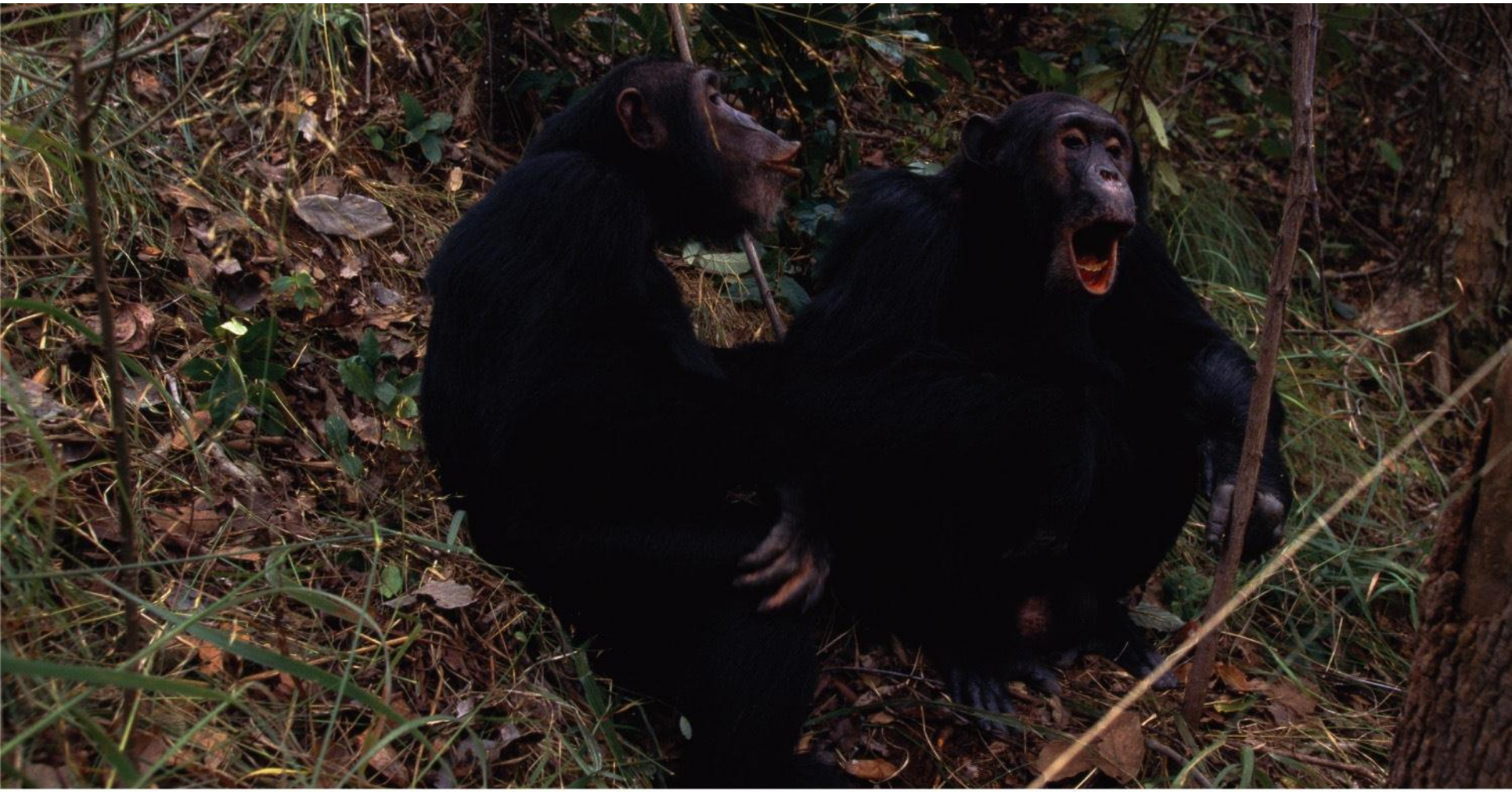
19.9 Sharing Viruses

- Scientists use the knowledge of evolution to investigate how a new disease such as AIDS can arise and spread in the human population
  - By sequencing the HIV-1 genome and comparing it to genomes of primate viruses, researchers found that the human virus evolved from simian immunodeficiency virus (SIV), which infects wild chimpanzees

Sharing Viruses (cont'd.)



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