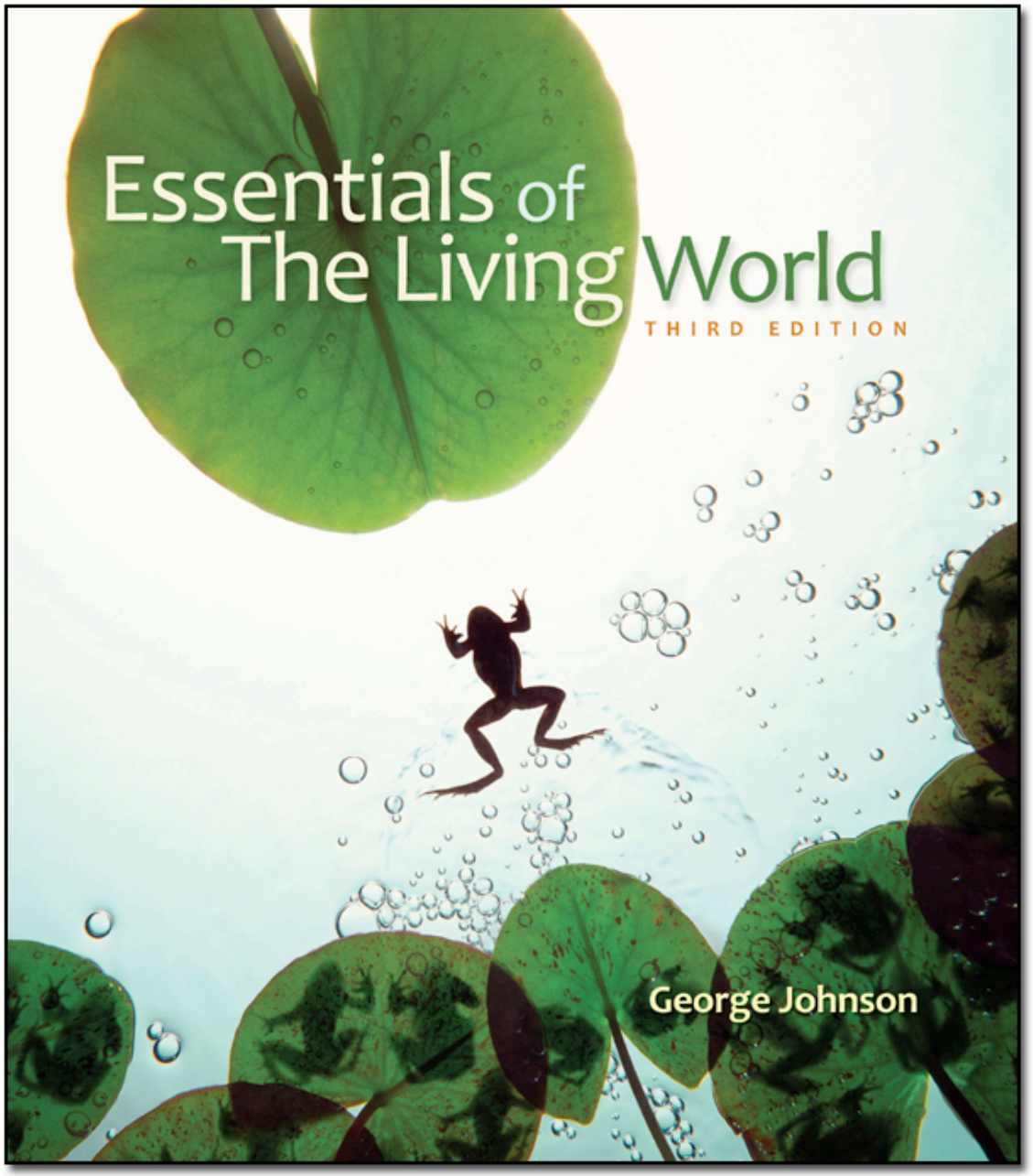
Chapter 16 Lecture Slides



16.1 How Cells Arose

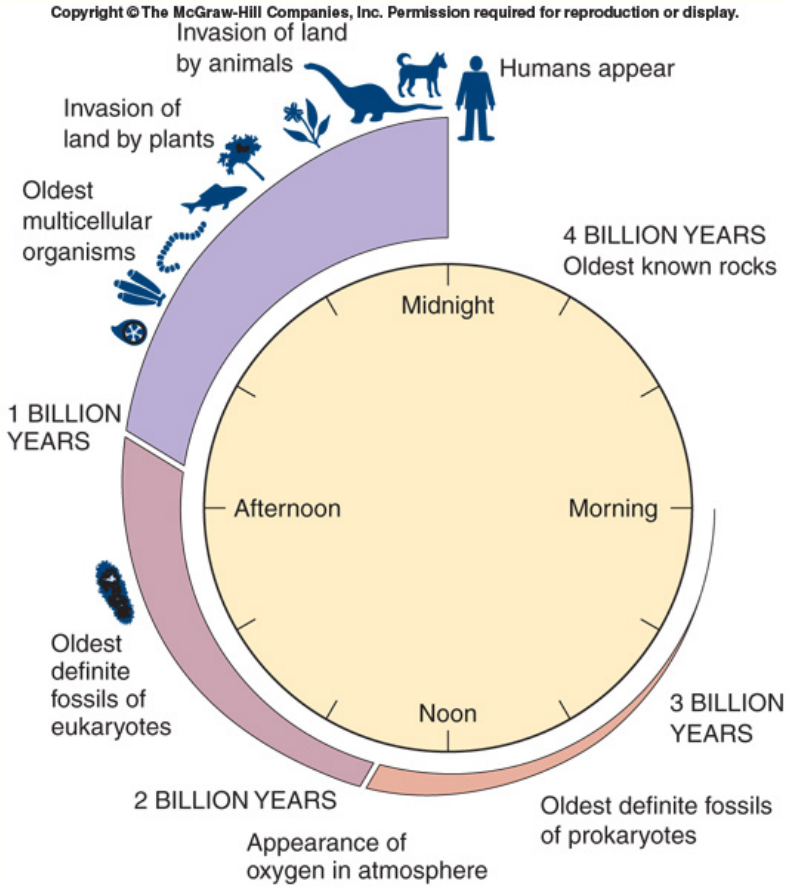
- No one knows for sure where the first organisms (thought to be like today's bacteria) came from

- There are several possibilities for the origin of life on earth, such as
  - **extraterrestrial origin**
  - **special creation**
  - **evolution**
- Evolution and extraterrestrial origin permits testable hypotheses and are the only scientific explanations

16.1 How Cells Arose

- The earth formed 4.5 billion years ago
- The first life originated around 2.5 billion years ago

Figure 16.1 A clock of biological time



16.1 How Cells Arose

- When life formed, the earth's atmosphere contained little or no oxygen but contained lots of hydrogen-rich gases, such as hydrogen sulfide (H_2S), ammonia (NH_3), and methane (CH_4)

- Electrons of these gases would have been frequently pushed to higher energy levels by photons from the sun or by electrical energy in lightning

16.1 How Cells Arose

- **Stanley Miller** and **Harold Urey** reconstructed the oxygen-free atmosphere of the early earth in their laboratory
- They subjected it to the lighting and UV radiation that it would have experienced then
- They found that many of the building blocks of organisms formed spontaneously
- They concluded that life may have evolved in a "**primordial soup**" of biological molecules formed in the early earth's oceans

16.1 How Cells Arose

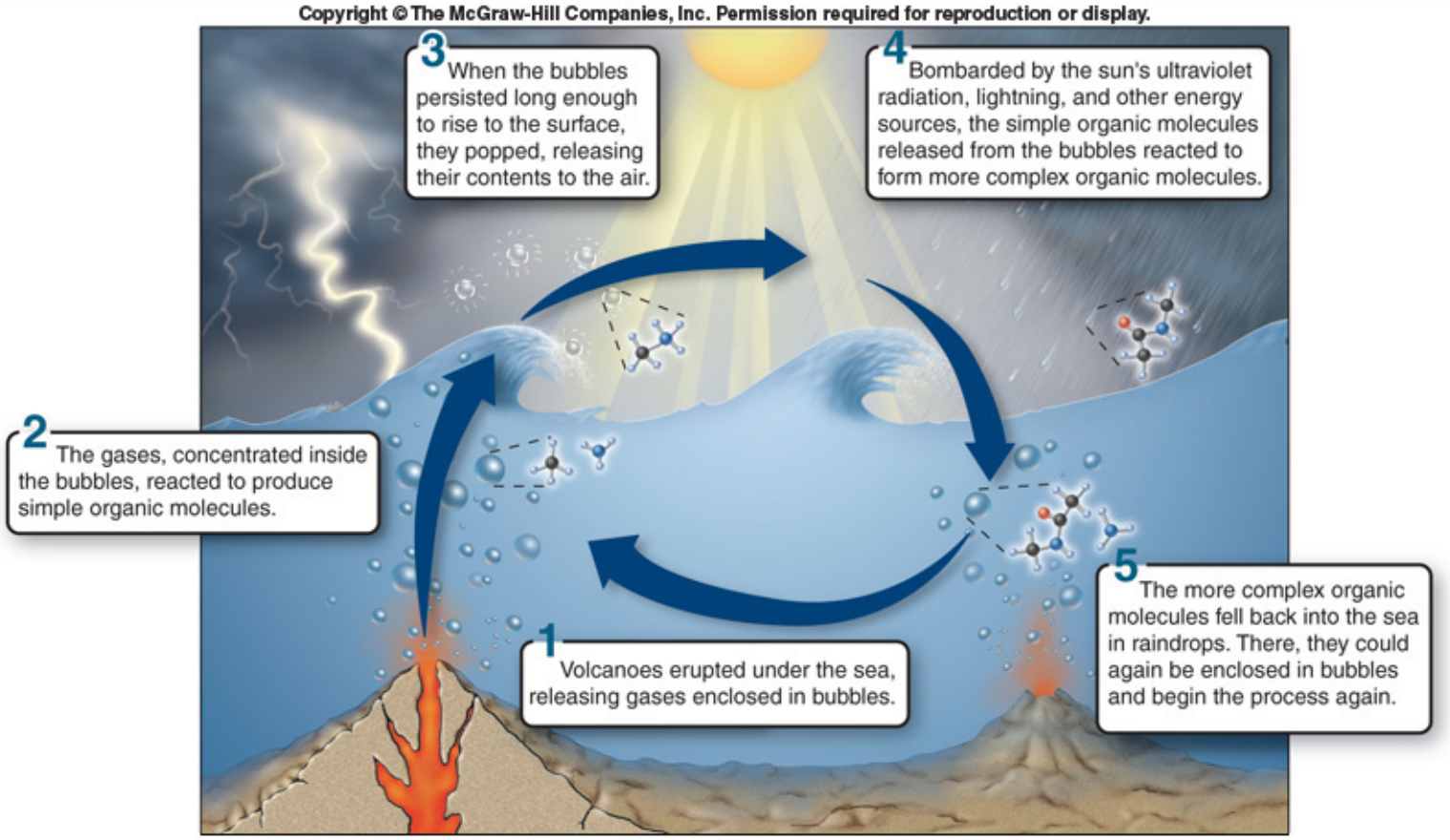
- Critics of the Miller-Urey experiment say that because there was no oxygen in the early atmosphere, there would have been no protection from ozone against UV

- The UV radiation would have destroyed ammonia and methane in the atmosphere, without which, the building blocks cannot be synthesized

16.1 How Cells Arose

- The **bubble model** proposes that life's building blocks could have formed within bubbles on the ocean's surface
  - the bubbles were produced by wind, wave action, the impact of rain drops, and volcanic action
  - chemical reactions would proceed fast inside the bubbles where polar reactants would be concentrated
  - the bubbles would also provide protection from UV radiation

Figure 16.2 A chemical process involving bubbles may have preceded the origin of life



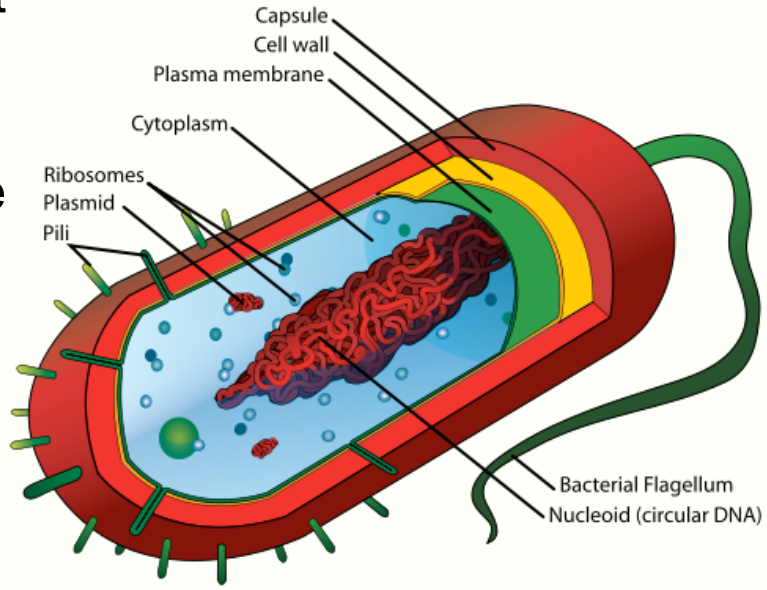
16.1 How Cells Arose

- Most scientists assume the first cells aggregated spontaneously
- When organic molecules are present in water, they tend to cluster together in structures called **microspheres**
  - these microspheres have many cell-like properties

- The first cells could have formed similar to the way microspheres form
- The first macromolecules to form might have been RNA because RNA can be an enyzme as well as genetic material

16.2 The Simplest Organisms

- Prokaryotes are the simplest and most abundant organisms on earth
- There are two types: ??
- Prokaryotes play important roles in the biosphere
  - cycling minerals
  - creating oxygen in earth's atmosphere
  - cause many diseases



16.2 The Simplest Organisms

- Prokaryotes are small, simply organized, single cells that lack a nucleus
  - There are many ways in which prokaryotes differ from eukaryotes
- The prokaryotic cell's plasma membrane is encased within a cell wall
  - the cell wall of bacteria is different than that of archaea and those found in eukaryotes
  - in bacteria, the cell wall is made of_____?

16.2 The Simplest Organisms

- In many bacteria, called **Gram-negative** bacteria, a thinner cell wall is surrounded by an outer membrane
  - the outer membrane prevents the cell wall from taking up a type of stain called a Gram stain
  - Gram-negative bacteria are more resistant to antibiotics
- In **gram-positive** bacteria, there is no outer membrane and the cell wall is much thicker
  - without the outer membrane, these bacteria take up the Gram stain

16.2 The Simplest Organisms

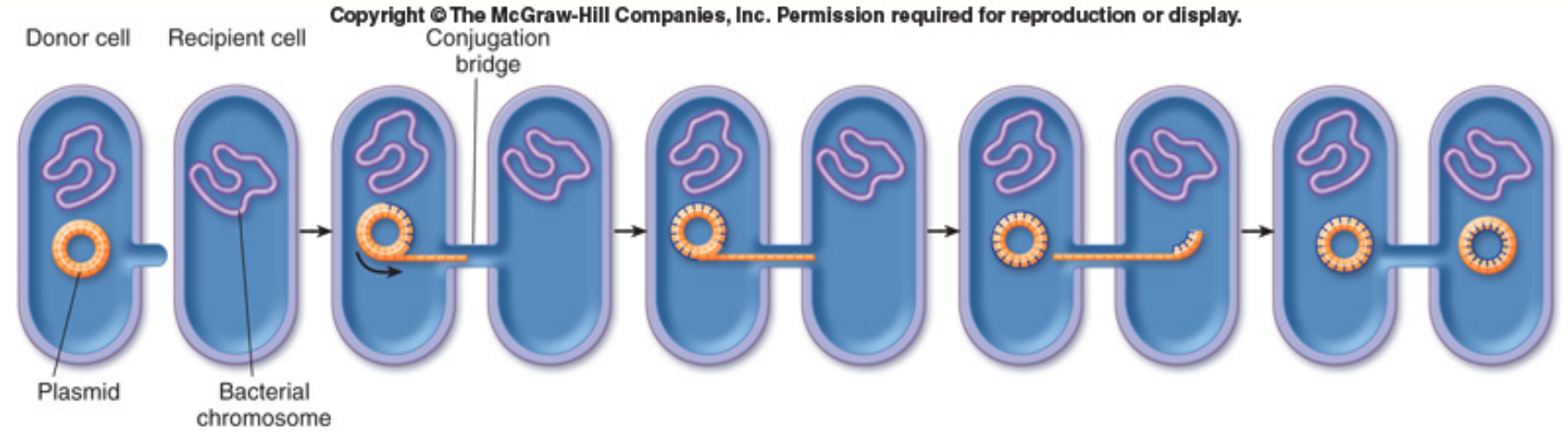
- Additional features of some bacteria include
  - **flagella**: long strands of protein used in swimming
  - **pili:** shorter strands that act as docking cables
  - **endospores**: thick-walled enclosures of DNA and a small bit of cytoplasm that are extremely resistant to environmental stress

16.2 The Simplest Organisms

- All prokaryotes can reproduce via **binary fission**
  - after replicating DNA, the plasma membrane and cell wall grow inward and eventually divide the cell

- Some bacteria can exchange genetic information via plasmids passed from one cell to another
  - this process is called **conjugation** and occurs through a special connection that forms between bacterial cells called a **conjugation bridge**

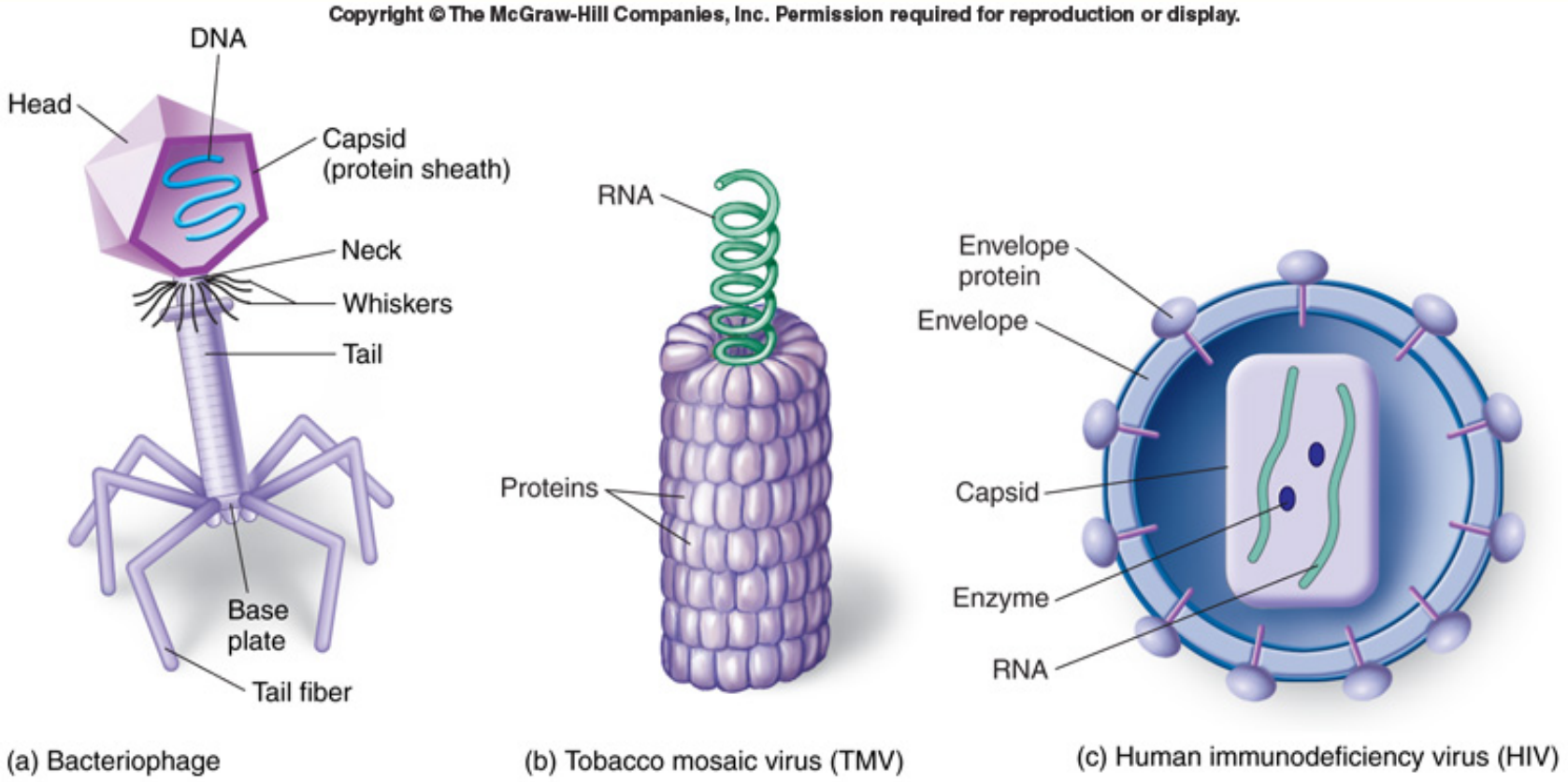
Figure 16.2 Bacterial conjugation



16.3 Viruses Infect Organisms

- **Viruses** are parasitic chemicals, segments of DNA (or sometimes RNA) wrapped in a protein coat called a *capsid*
  - they cannot reproduce on their own
  - they infect in all organisms
    - bacterial viruses are called **bacteriophages**
  - the capsid may be encased by a membranelike *envelope* rich in proteins and lipids
  - there is considerable difference in the details of structure among different types of viruses

Figure 16.4 The structure of bacterial, plant, and animal viruses



(a) Bacteriophage

(b) Tobacco mosaic virus (TMV)

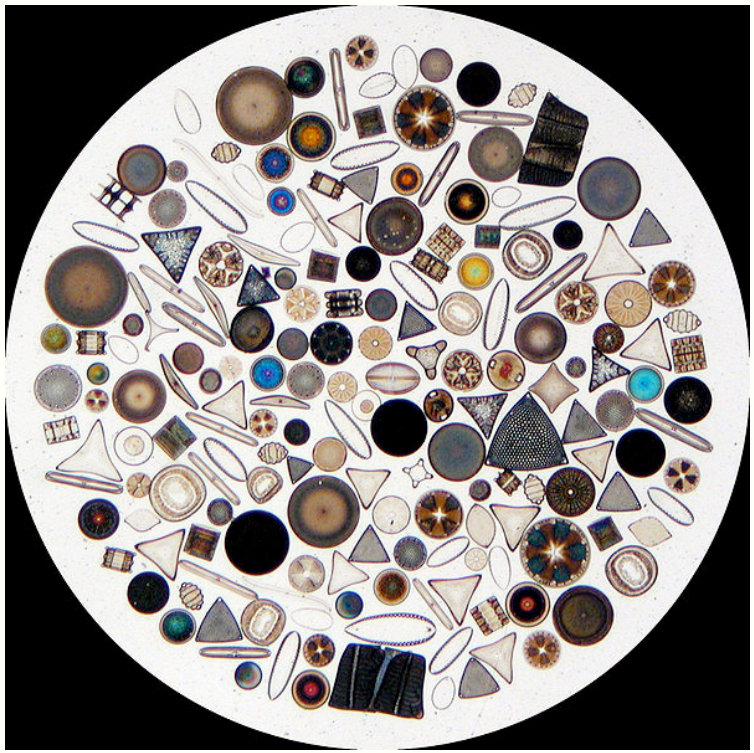
(c) Human immunodeficiency virus (HIV)

16.3 Viruses Infect Organisms

- Viruses that arise in one species may pass to another, causing a new disease
  - the influenza virus has been one of the most lethal viruses in human history – mainly a bird virus
  - AIDS (HIV) is derived from a virus that originated in Central Africa in chimpanzees and monkeys
  - Ebola viruses also arose in Central Africa and attack human connective tissues
  - SARS, severe acute respiratory syndrome, originated from a virus that infects the Chinese horseshoe bat
  - West Nile virus is a mosquito-borne virus that is common among birds

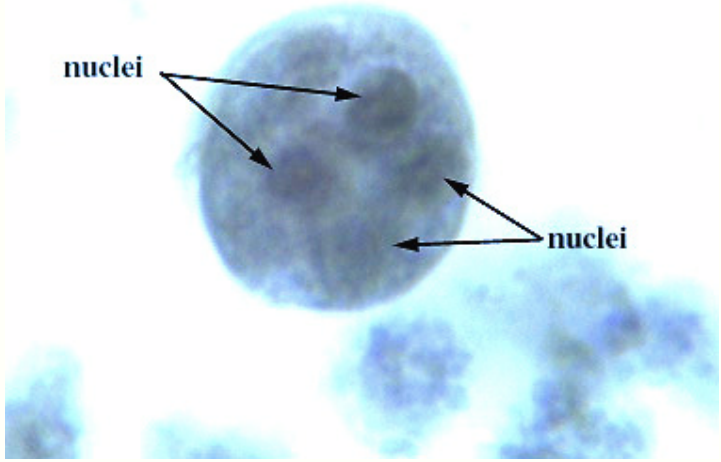
16.4 General Biology of Protists

- The only unifying thing about protists is that they are not fungi, plants, or animals
  - otherwise, they are extremely variable eukaryotes
    - protists have varied types of cell surfaces
      - – all have a cell membrane but many have cell walls or glass shells
    - movement in protists is accomplished by diverse mechanisms – will observe this today in lab
      - – cilia, flagella, or pseudopods



16.4 General Biology of Protists

- Some protists can survive harsh environmental conditions by forming **cysts**
  - cysts are dormant forms of cells with a resistant outer covering in which cell metabolism is more or less completely shut down – what is this comparable to in prokaryotes?



16.4 General Biology of Protists

- Protists employ every form of nutritional acquisition except chemoautotrophy
  - **phototrophs** are photosynthetic autotrophs
  - among heterotrophic forms,
    - **phagotrophs** ingest visible particles of food – what's this process called?
      - – the ingested food is put into intracellular vesicles called **food vacuoles** that are then broken down by lysosomes
    - **osmotrophs** ingest food in soluble form – what's this process called?

16.4 General Biology of Protists

- Protists typically reproduce asexually, most reproducing sexually only in times of stress
  - fission and budding are common forms of asexual reproduction
  - sexual reproduction occurs only rarely by exchanging nuclei

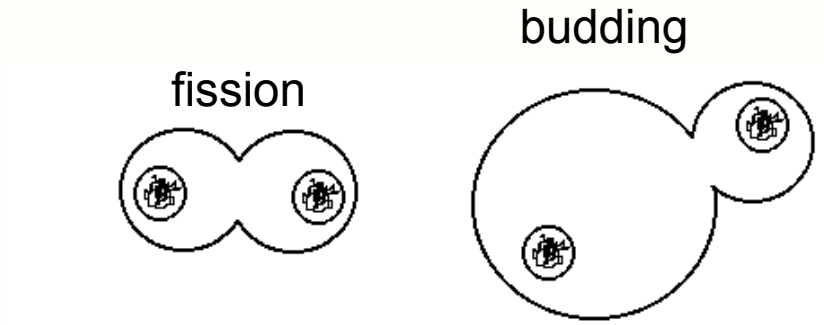
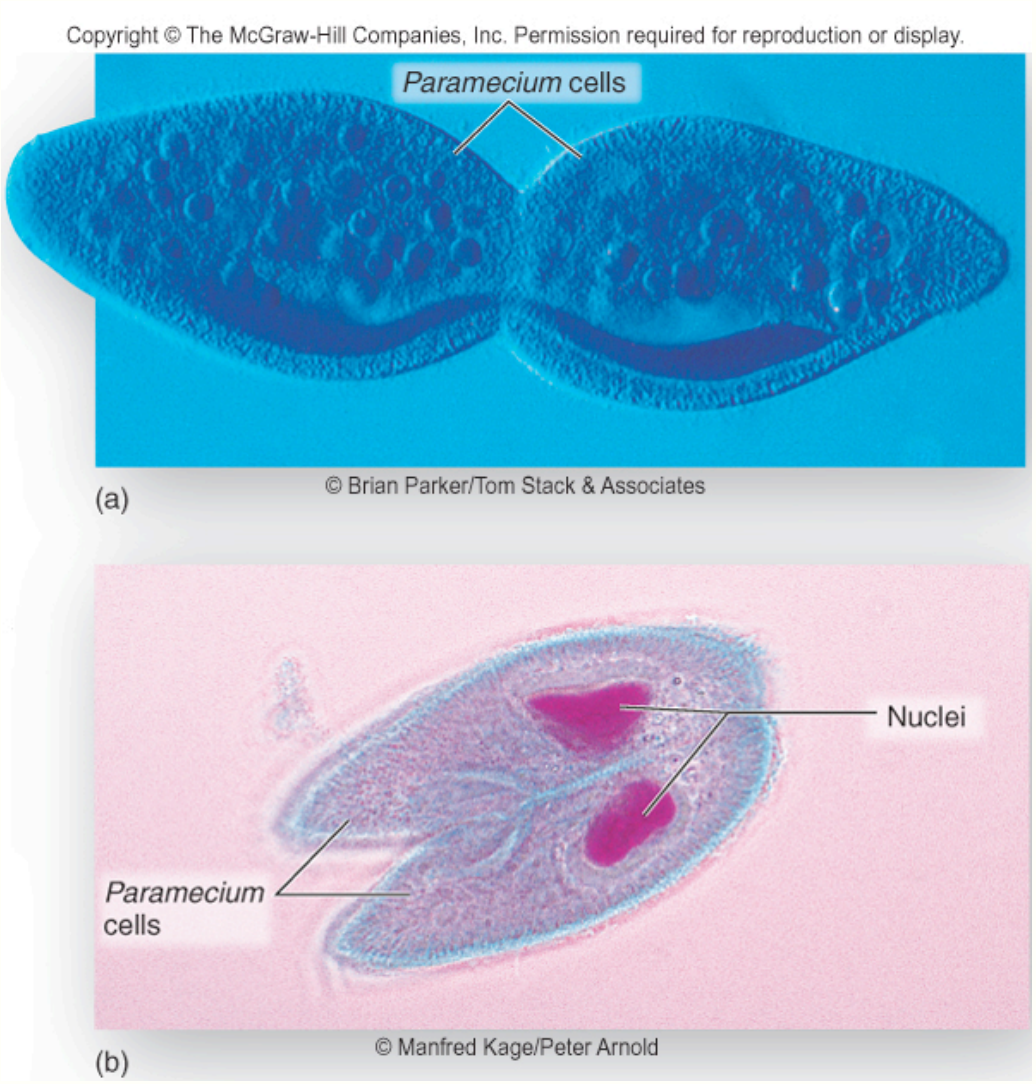
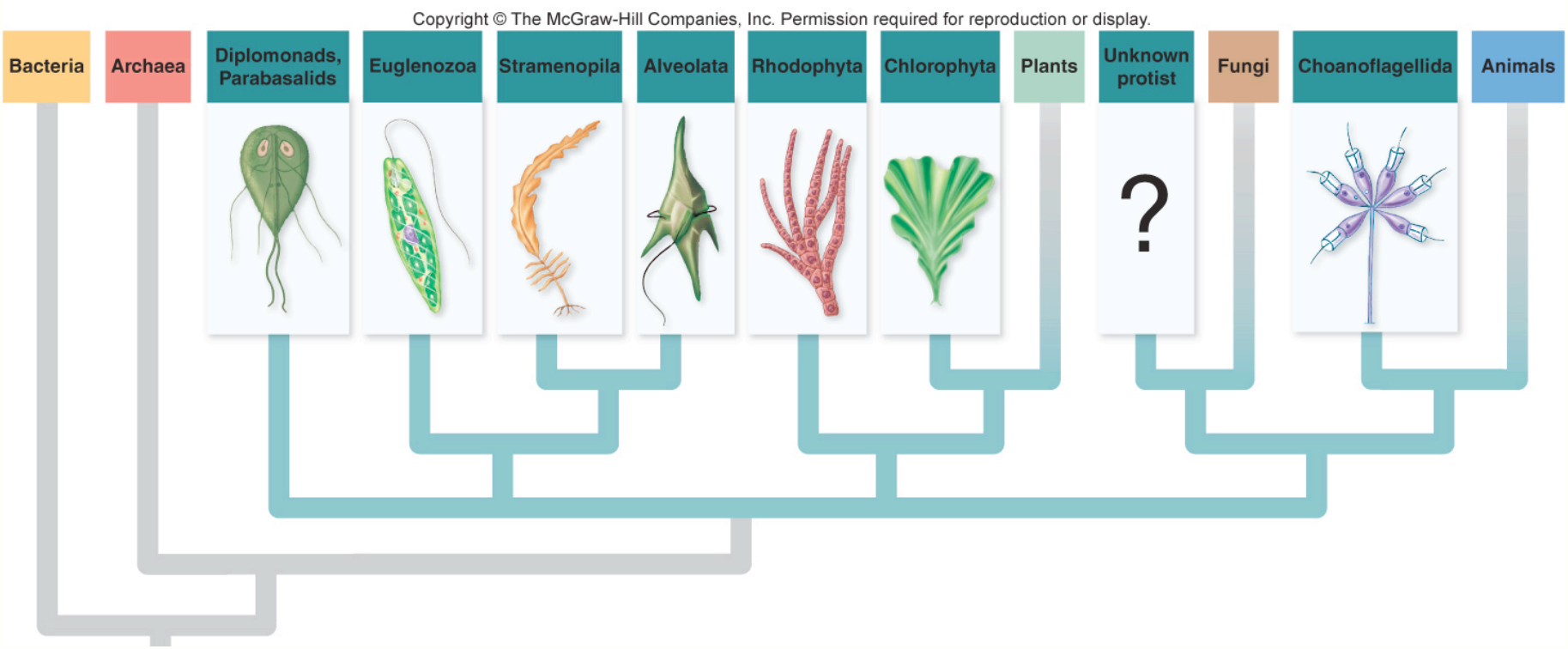


Figure 16.6 Reproduction among paramecia: (a) asexual reproduction; (b) sexual reproduction



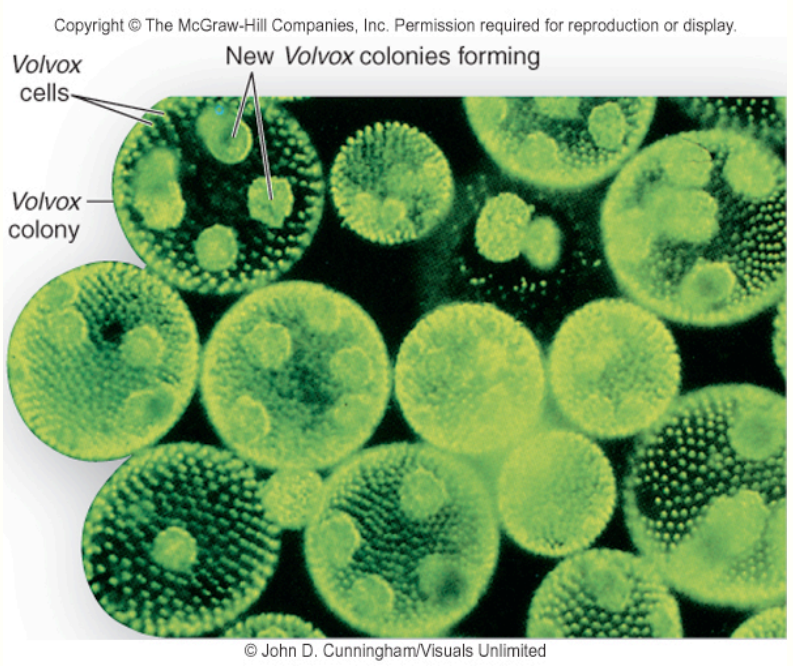
Is this fission or budding?

Figure 16.9 A phylogenetic tree for the protists



16.4 General Biology of Protists

- The evolution of multicellularity solved the problem of surface area-to-volume ratio that occurs as cells increase in size
- The key advantage to multicellularity is that it allows for specialization of cells
- Some protists form colonial assemblies
  - a colonial organism is a permanent collection of cells that show little or no integration of cellular activities
- In true multicellularity, the activities of individual cells are coordinated
  - multicellularity has evolved in three groups of protists: the brown algae, green algae, and red algae



16.5 Kinds of Protists

- The protists are the most diverse of the four kingdoms in the domain Eukarya
  - there are about 200,000 forms, including many unicellular, colonial, and multicellular groups
- Although protists are currently grouped into one kingdom, it is an artificial grouping
- Some types of protists can cause serious diseases in humans, such as malaria; many others have industrial applications

16.6 A Fungus Is Not a Plant

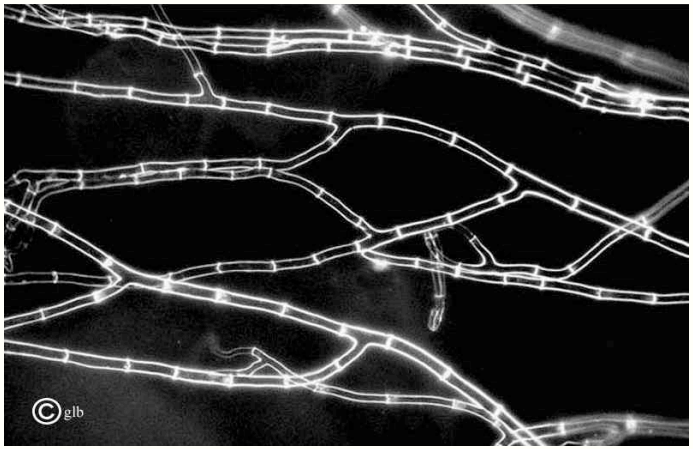
- Fungi lack chlorophyll and resemble plants only because of their general appearance and lack of mobility
- Fungi differ from plants in significant ways, in that fungi
  - are heterotrophs
  - have filamentous bodies
  - have nonmotile sperm
  - have cell walls made of chitin
  - have nuclear mitosis

Figure 16.10 Mushrooms

(a) (b)

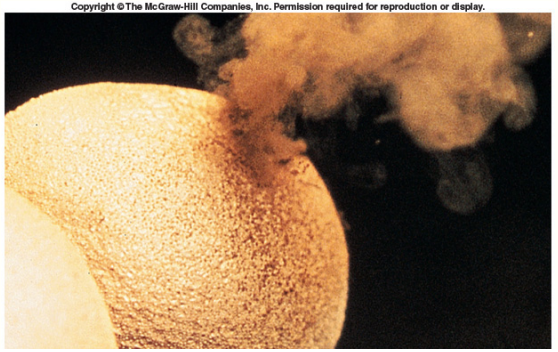
16.6 A Fungus Is Not a Plant

- Fungi exist mainly in the form of slender filaments called **hyphae** (singular, **hypha**)
  - different hyphae then associate with each other to form much larger structures
  - a mass of hyphae is called a **mycelium** (plural, **mycelia**)
  - fungal cells are able to exhibit a high degree of communication within a mycelium
    - cytoplasm is able to cross between adjacent hyphal cells by a process called **cytoplasmic streaming**
    - multiple nuclei can be connected through the shared cytoplasm



16.6 A Fungus Is Not a Plant

- Fungi reproduce both asexually and sexually
  - Spores are a common means of asexual reproduction
  - In sexual reproduction, hyphae of two different mating types come together
    - the nuclei often do not immediately fuse but instead coexist in a common cytoplasm; this type of hyphae is called **dikaryotic**
    - the nuclei in certain cells can fuse and form a zygote



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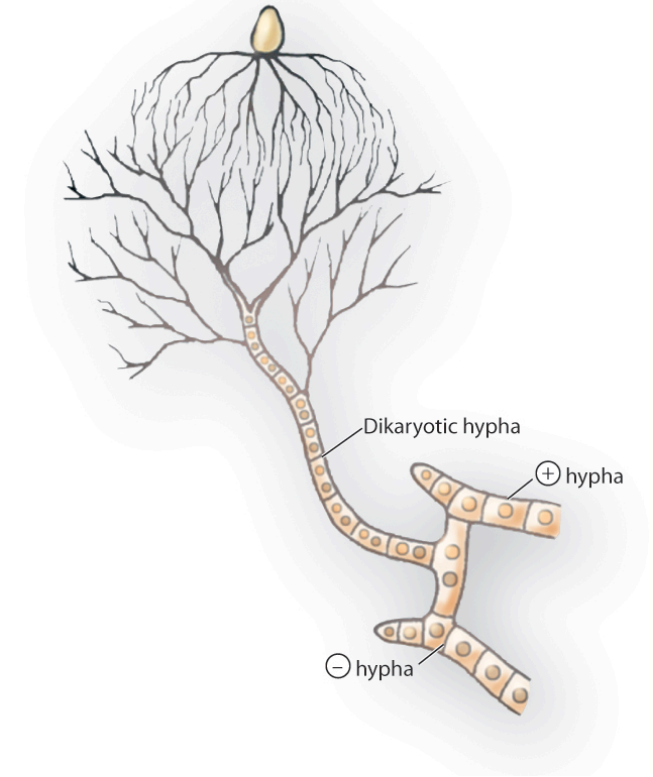


16.6 A Fungus Is Not a Plant

- All fungi are heterotrophs and externally digest food by secreting enzymes into their surroundings and then absorbing the nutrients back into the fungus
  - some fungi are predatory, such as the oyster fungus

16.7 Kinds of Fungi

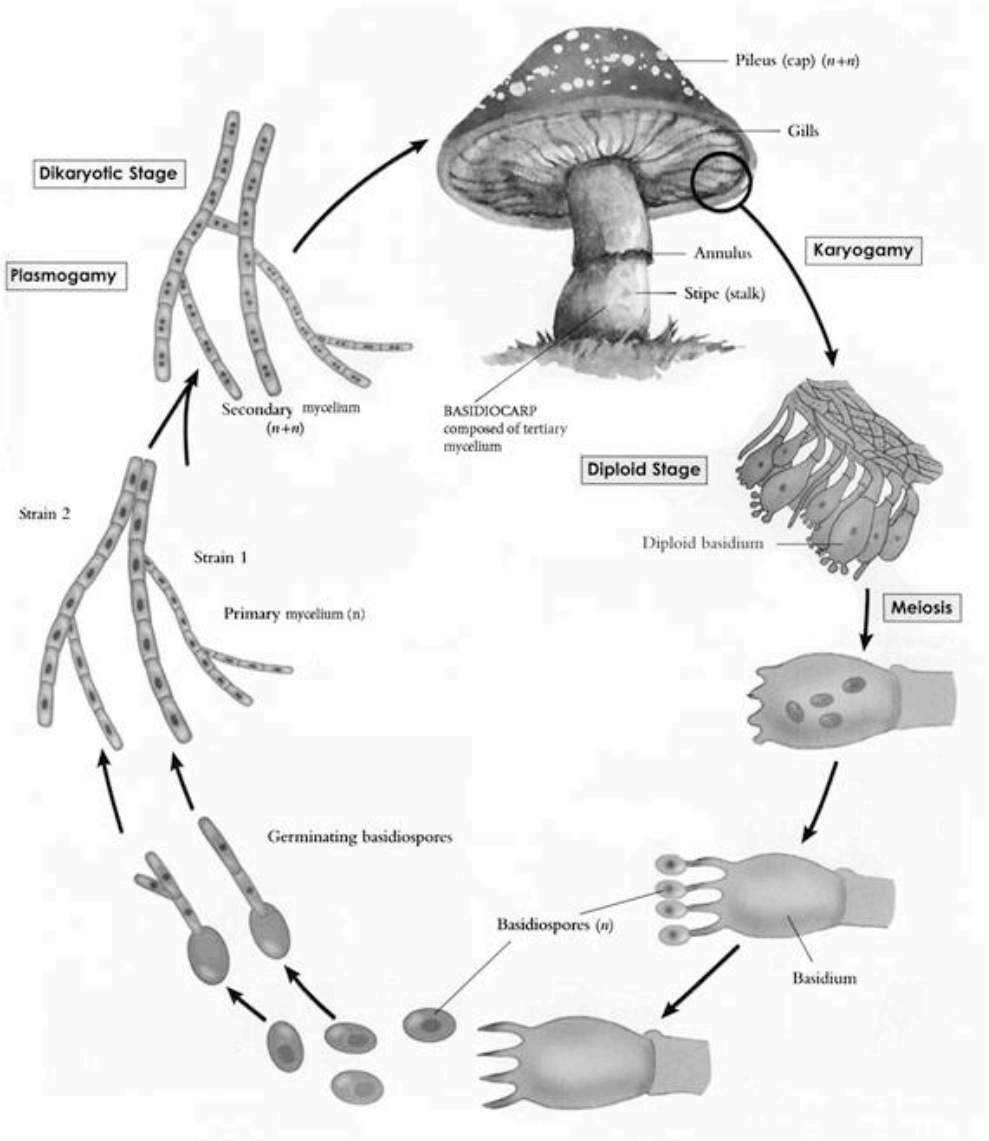
- There are nearly 74,000 described species of fungi
  - the four fungal phyla are distinguished by their mode of sexual reproduction
  - a fifth group, called the **imperfect fungi,** are fungi in which sexual reproduction has not been observed

Table 16.3 Fungi

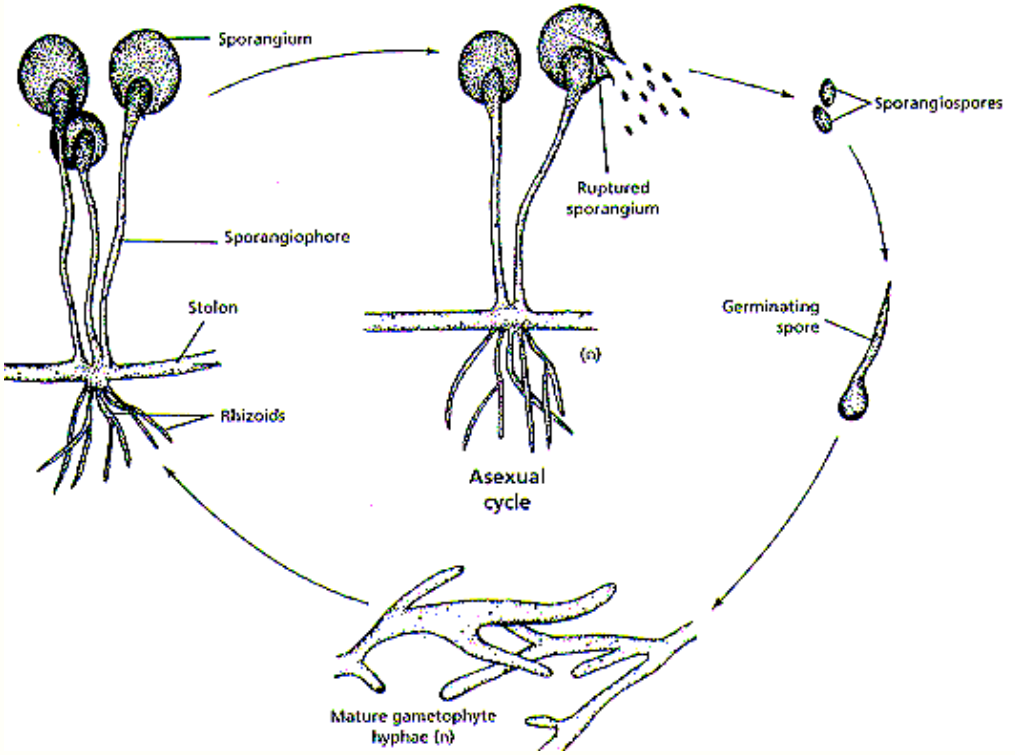
TABLE 16.3 Fungi

Phylum	Typical Examples		Key Characteristics
Zygomycota	*Rhizopus* (black bread mold)		Reproduce sexually and asexually; multinucleate hyphae lack septa except for reproductive structures; fusion of hyphae leads directly to formation of a zygote, in which meiosis occurs just before it germinates
Ascomycota	Yeasts, truffles, morels		Reproduce by sexual means; ascospores are formed inside a sac called an ascus; asexual reproduction is also common
Basidiomycota	Mushrooms, toadstools, rusts		Reproduce by sexual means; basidiospores are borne on club-shaped structures called basidia; the terminal hyphal cell that produces spores is called a basidium; asexual reproduction occurs occasionally
Chytridiomycota	*Allomyces*		Produce flagellated gametes (zoospores); predominately aquatic, some freshwater and some marine; oldest group of fungi

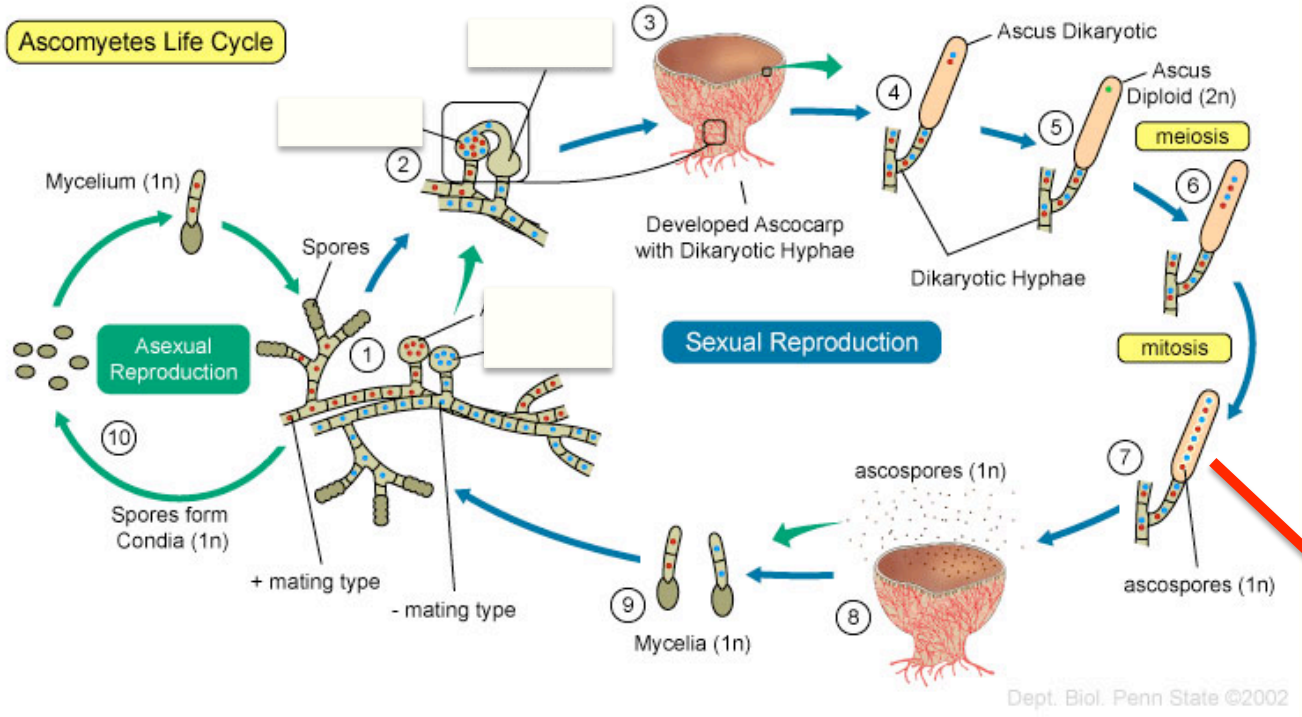
Basidiomycota



Zygomycota


Sporangium
Sporangiophore
Stolon
Rhizoids
Ruptured sporangium
Sporangiospores
Germinating spore
(n)
Asexual cycle
Mature gametophyte hyphae (n)

Ascomycota


Ascomyetes Life Cycle
Mycelium (1n)
Spores
Asexual Reproduction
Spores form Condia (1n)
+ mating type
- mating type
Developed Ascocarp with Dikaryotic Hyphae
Ascus Dikaryotic
Ascus Diploid (2n)
meiosis
Dikaryotic Hyphae
Sexual Reproduction
mitosis
ascospores (1n)
ascospores (1n)
Mycelia (1n)
Dept. Biol. Penn State ©2002

Chytridiomycota

- Predominately aquatic
- Sexually reproduce by produce motile gametes
- Largely responsible for amphibian decline worldwide

16.7 Kinds of Fungi

- Together with bacteria, fungi are the principal decomposers in the biosphere
  - fungi often act as disease causing organisms for both plants and animals
  - fungi are the most harmful pests of living plants as well as stored food products
- Many fungi are used commercially, such as for making bread rise, producing alcohol in beverages, or imparting special flavors to cheese
- Many antibiotics are derived from fungi

16.7 Kinds of Fungi

- Two kinds of mutualistic associations between fungi and autotrophic organisms are ecologically important
  - **mycorrhizae** are fungal/plant associations
    - these interactions expedite the plant's absorption of essential nutrients, such as phosphorus, in the roots
  - **lichens** are fungal/algal or fungal/cyanobacterial associations
    - these can grow in harsh habitats, such as bare rock
- In each of these associations, a photosynthetic organism fixes atmospheric CO_2 and makes organic material available to fungi