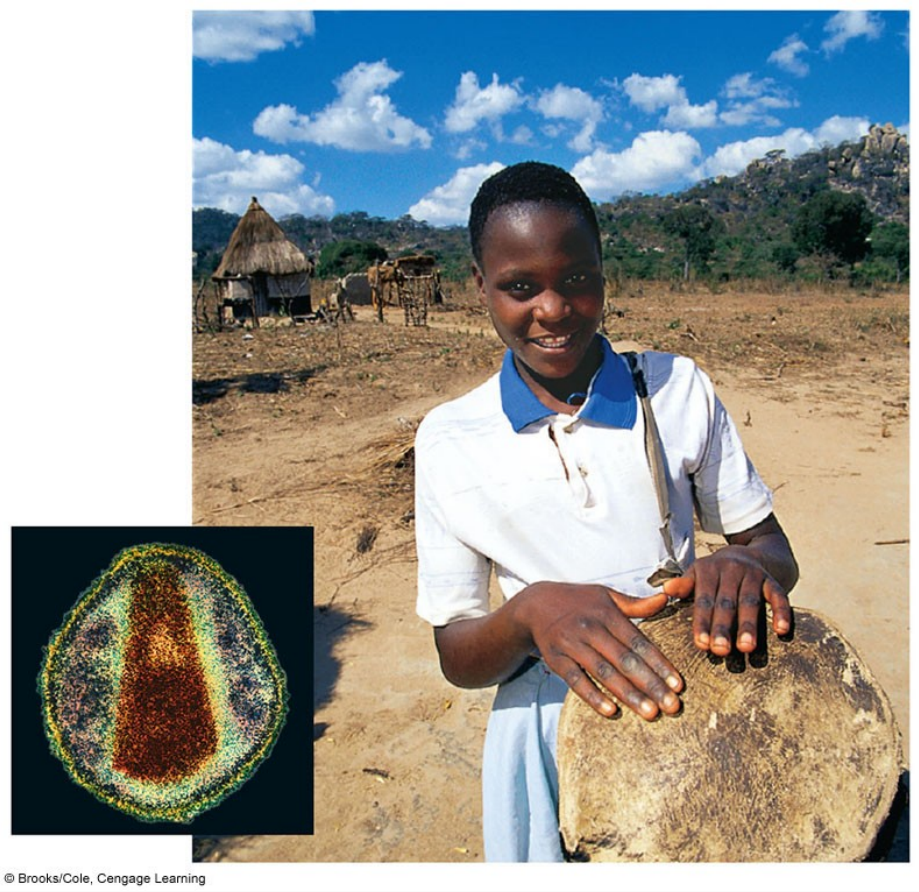
Microbial Life (mostly) – From viruses to prokaryotes to eukaryotes! Domains Bacteria, Archaea, and Eukarya – Kingdom Protista!

Impacts, Issues
The Effects of AIDS

- Some viruses and bacteria help us; others, such as the HIV virus that causes AIDS, can kill



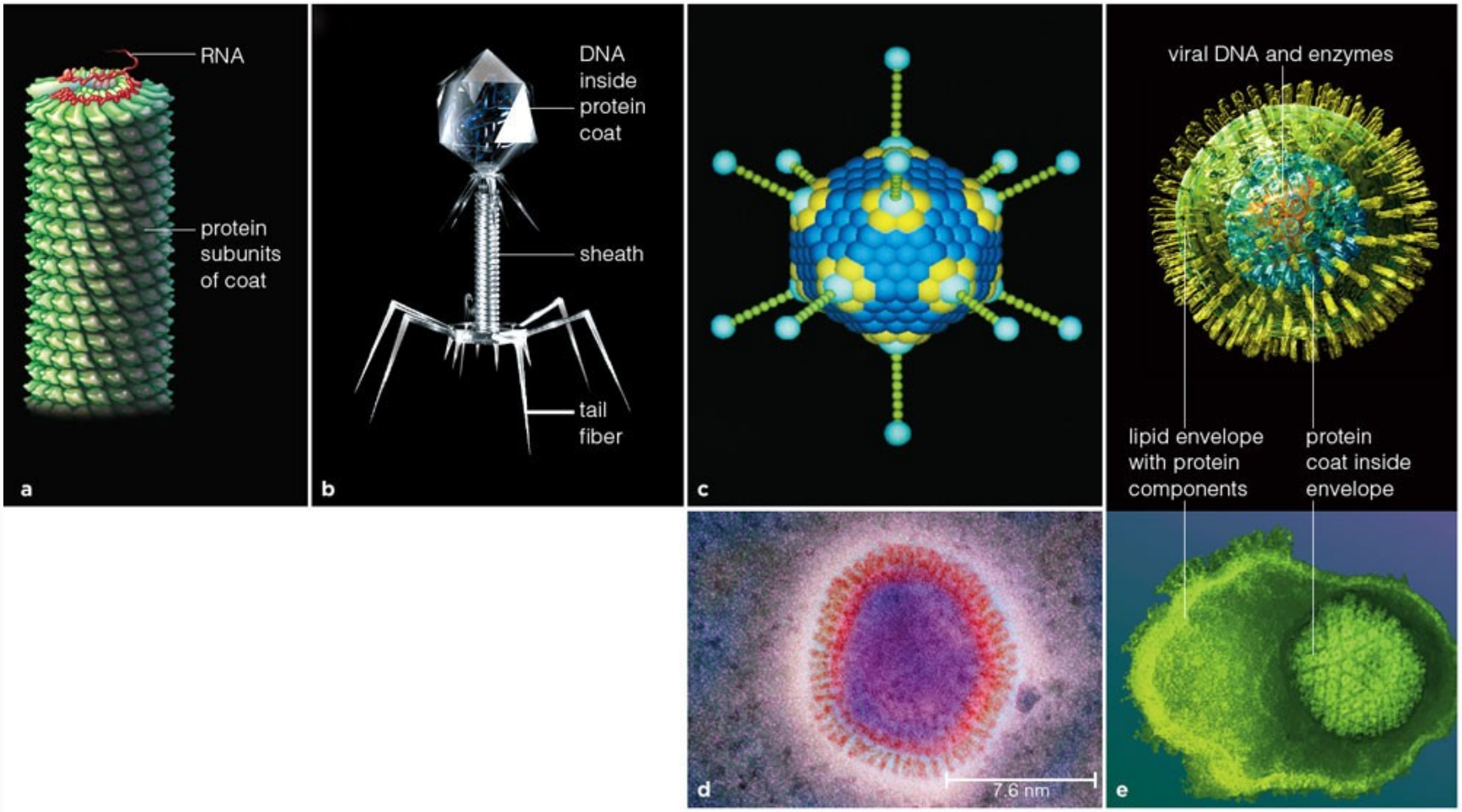
Viral Characteristics and Diversity

- A virus consists of nucleic acid and protein
- A virus is smaller than any cell and has no metabolic machinery of its own

Viruses

- **Viruses**
  - Noncellular infectious particles that multiply only inside living cells
  - Consist of genetic material (DNA or RNA) and a protein coat; some also have a lipid envelope
  - Some viruses cause disease (**pathogens**); others control disease-causing organisms

Examples of Viruses



Viral Origins and Evolution

- Viruses may have descended from cells that were parasites of other cells
- Viruses may be genetic elements that escaped from cells
- Viruses may represent a separate evolutionary branch

Viral Replication

- All viruses replicate only inside host cells, but the details of the process vary among viral groups

Steps in Viral Replication

Table 21.2 Steps in Most Viral Multiplication Cycles

1. Attachment Proteins on viral particle chemically recognize and lock onto specific receptors at the host cell surface.

2. Penetration Either the viral particle or its genetic material crosses the plasma membrane of a host cell and enters the cytoplasm.

3. Replication and synthesis Viral DNA or RNA directs host to make viral nucleic acids and viral proteins.

4. Assembly Viral components assemble as new viral particles.

5. Release The new viral particles are released from the cell.

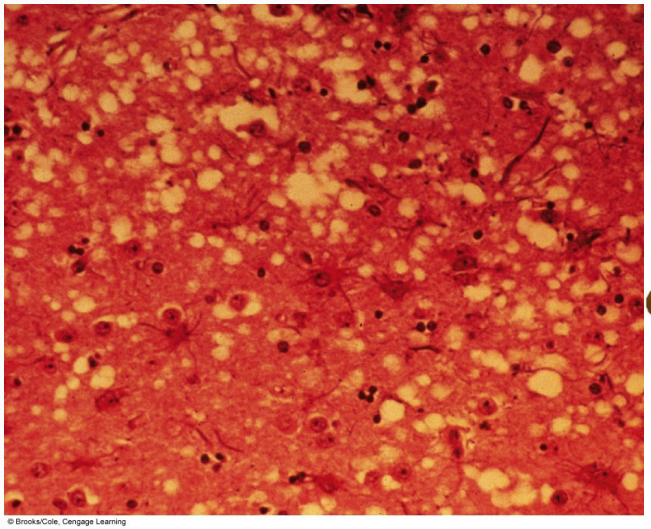
Viroids and Prions

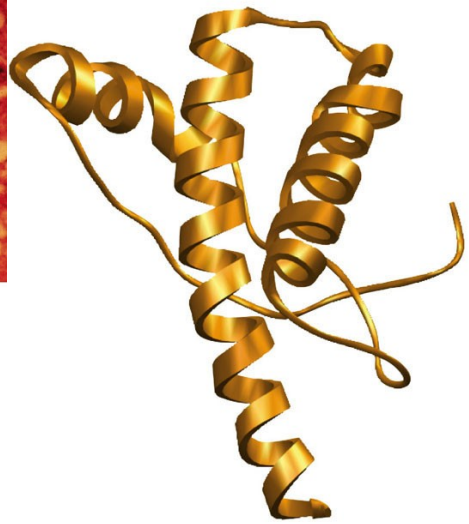
- Viroids and prions are infectious particles that are even simpler than viruses

- **Viroid**
  - Infectious RNA, not surrounded by a protective protein coat

- **Prion**
  - Proteins in the nervous system that can misfold, and cause other prions to misfold

Prion Diseases





- Bovine spongiform encephalopathy (BSE or mad cow disease): Affects cattle that have eaten feed made with infected sheep

http://www.youtube.com/v/w5aAPEYIL9A

Key Concepts: Viruses and Other Noncellular Infectious Particles

- *Viruses are noncellular particles made of protein and nucleic acid; they replicate by taking over the metabolic machinery of a host cell*
- *Viroids are short sequences of infectious RNA*
- *Prions are infectious misfolded versions of normal proteins*

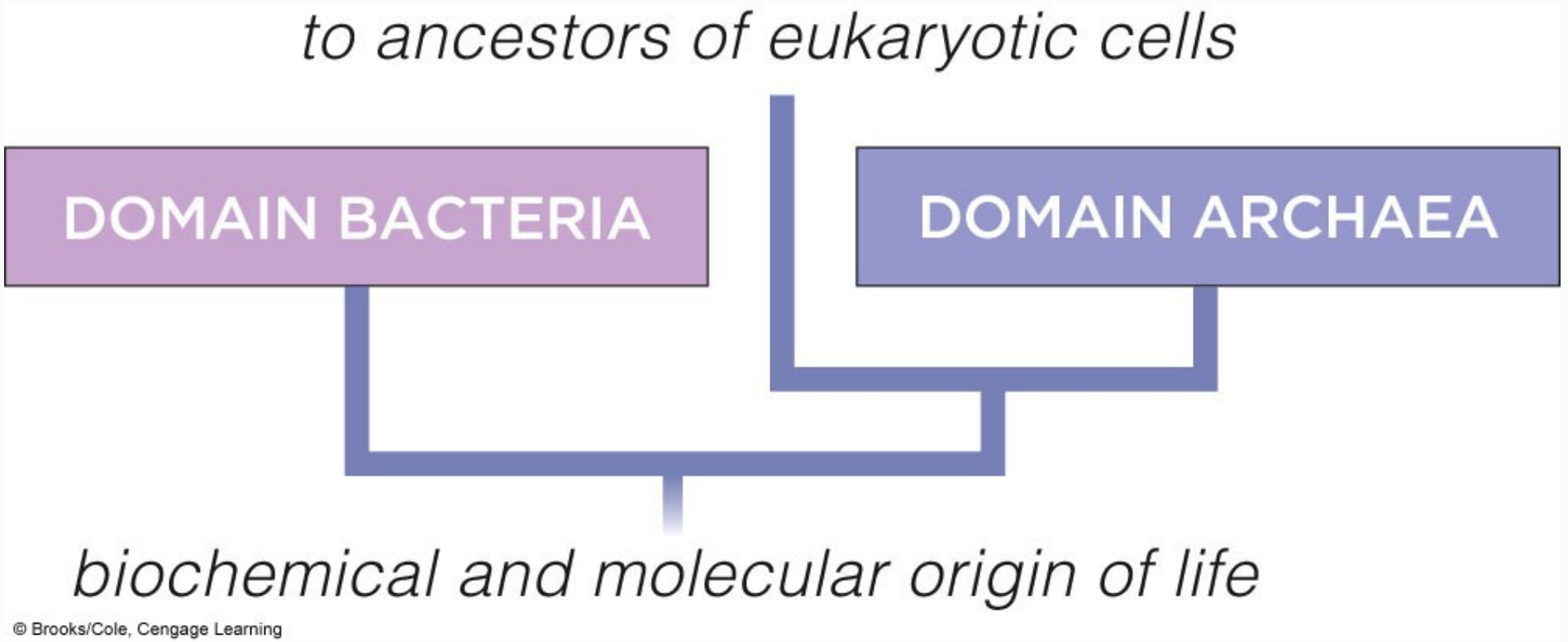
Prokaryotes—Enduring, Abundant, and Diverse

- **Prokaryotes**
  - Structurally simple cells that lack a nucleus
  - Evolved before eukaryotes
  - Earth's most abundant organisms!

- Prokaryotes still persist in enormous numbers and show great metabolic diversity

Evolutionary History and Classification

- Automated gene sequencing and comparative biochemistry helps classify species and subgroups (**strains**) of prokaryotes



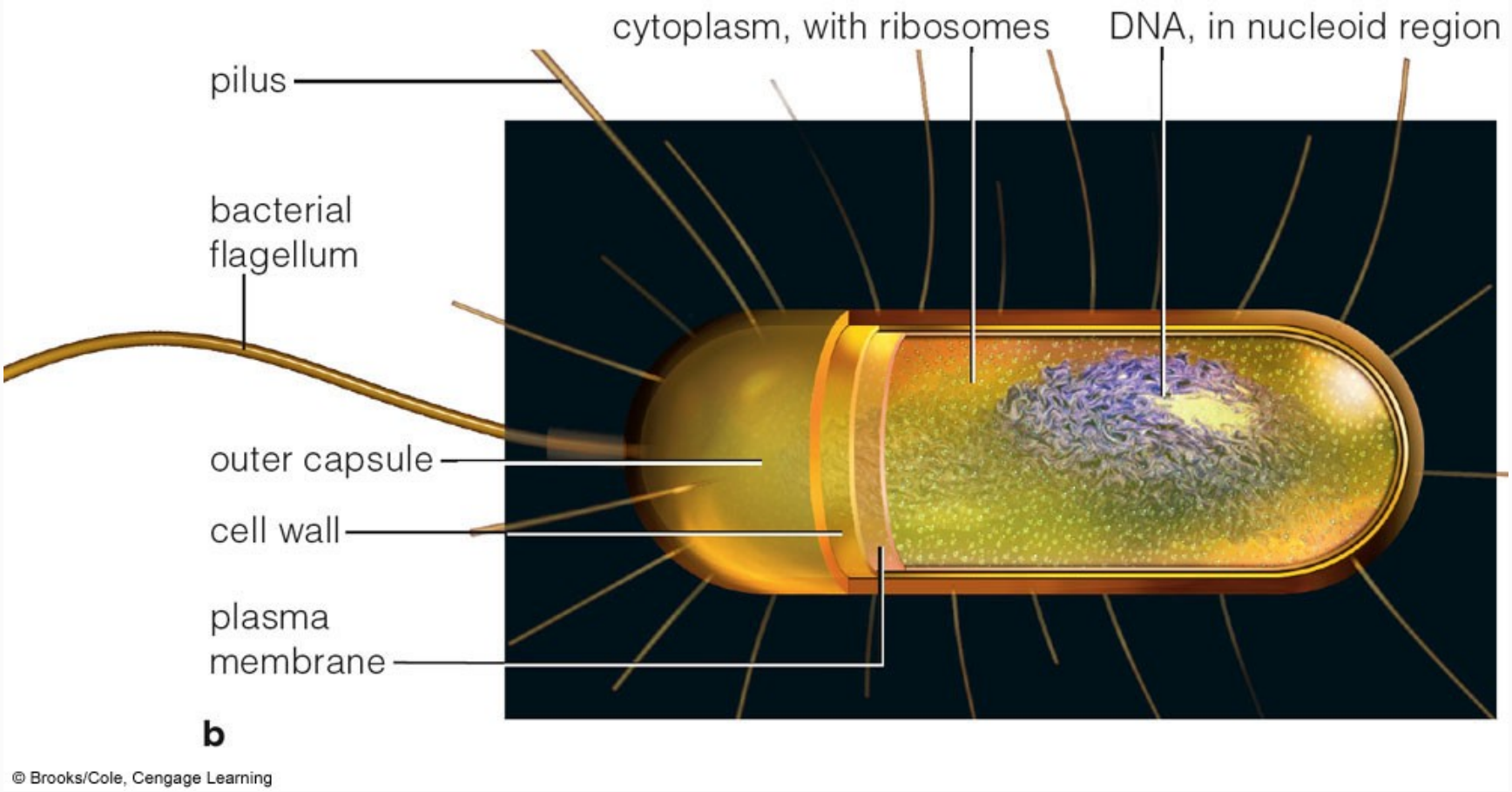
Prokaryotic Structure and Function

- Prokaryotic cells have many structural features that adapt them to their environment
- The typical prokaryote is a walled cell with ribosomes but no nucleus

Prokaryotic Cell Characteristics

- Prokaryotic structure
  - **Nucleoid** region contains a single, circular chromosome
  - **Cell wall** surrounds the plasma membrane, with a slime layer (**capsule**) outside the cell wall
  - **Flagella** rotate like propellers
  - **Pili** extend from the cell surface for adhesion or motion

Prokaryotic Body Plan



Prokaryotic Cell Size and Shape

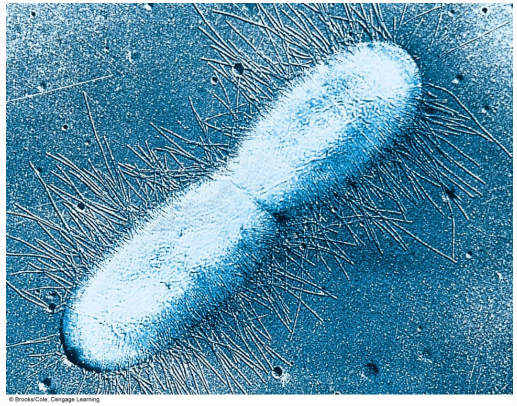
- Prokaryotic cells are much smaller than eukaryotic cells (about the size of mitochondria)

- Prokaryotes have three typical shapes:

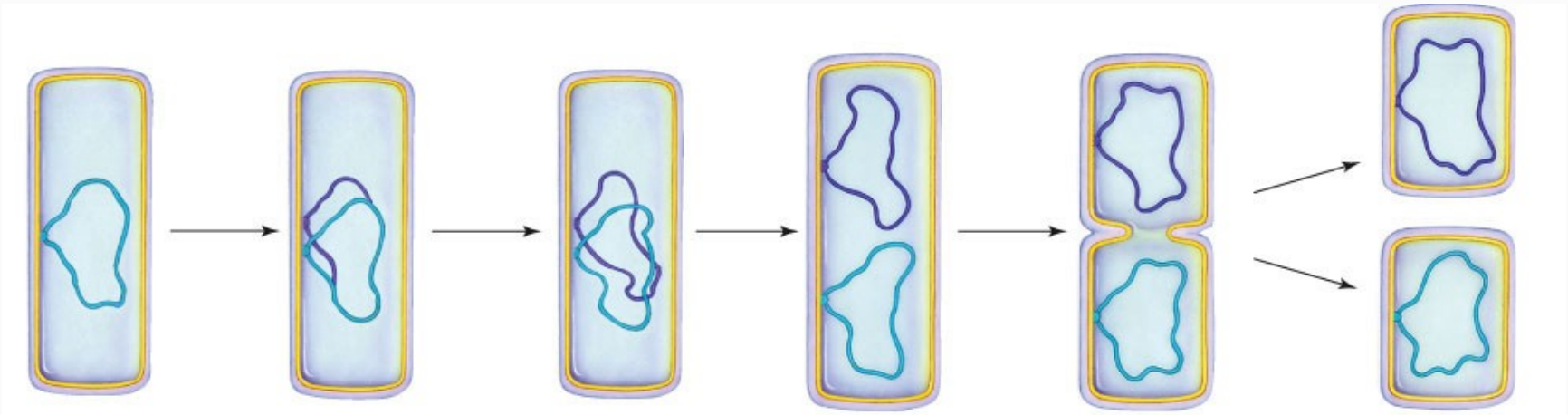
Prokaryotic Reproduction

- **Prokaryotic chromosome**
  - A circular, double-stranded DNA molecule

- **Prokaryotic fission**
  - DNA replicates; parent cell divides in two



Prokaryotic Fission



A The bacterial chromosome is attached to the plasma membrane prior to DNA replication.

B Replication starts and proceeds in two directions from a certain site in the bacterial chromosome.

C The DNA copy becomes attached at a membrane site near the attachment site of the parent DNA molecule.

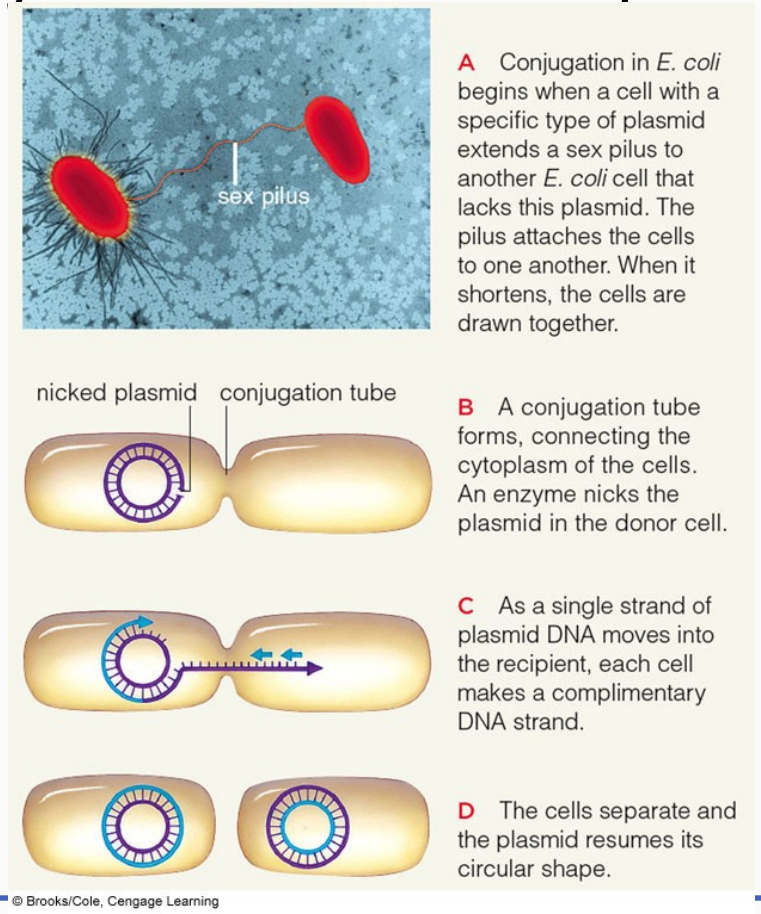
D Then the two DNA molecules are moved apart by membrane growth between the two attachment sites.

E Lipids, proteins, and carbohydrates are built for new membrane and new wall material. Both get inserted across the cell's midsection.

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

Horizontal Gene Transfers

- **Conjugation**
  - Transfer of a **plasmid** (non-chromosomal DNA) between prokaryotic cells via a sex pilus



http://www.youtube.com/v/IYW6wwEAnqs

Key Concepts
Features of Prokaryotic Cells

- *Prokaryotes are single-celled organisms that do not have a nucleus or the diverse cytoplasmic organelles found in most eukaryotic cells*

The Bacteria

- Bacteria are the oldest, most diverse, and most abundant prokaryotic lineage
- Most are harmless or benefit us by releasing oxygen, fixing nitrogen, or cycling nutrients
- Some bacteria cause disease in humans

http://www.youtube.com/watch?v=J6akNYlkehY&feature=related

Key Concepts
The Bacteria

- *Bacteria are the most abundant prokaryotic cells on Earth*
- *Bacteria perform important services such as degrading wastes, adding oxygen to the air, and providing essential nutrients to plants*
- *Nearly all disease-causing prokaryotes are bacteria*

The Archaeans

- Archaeans, the more recently discovered prokaryotic lineage, are the third domain – the closest prokaryotic relatives of eukaryotes

- Archaeans live everywhere – many live in very hot or very salty habitats; some are methanogens (methane producers)

- Hardly any archaeans cause human disease

  http://www.youtube.com/watch?v=IrpKD5L626c

Key Concepts
The Archaeans

- *Archaeans are the more recently discovered, less studied prokaryotic group*
- *Some show a remarkable ability to survive in extreme habitats, but others live in more ordinary places*
- *They play important roles in ecosystems*

Evolution and Infectious Disease

- **Infection** occurs when pathogens enter the internal environment and multiply
- **Disease** follows when the pathogen's activities interfere with normal body functions
- Viruses, bacteria, and other pathogens evolve by natural selection, as do their hosts

Deaths From Infectious Diseases

Table 21.5 Deaths From Infectious Diseases*

Disease	Type of Pathogen	Deaths per year
Acute respiratory infections	Bacteria, viruses	4 million
AIDS	Virus (HIV)	2.7 million
Diarrheas	Bacteria, viruses, protists	1.8 million
Tuberculosis	Bacteria	1.6 million
Malaria	Protists	1.3 million
Measles	Viruses	600,000
Whooping cough	Bacteria	294,000
Tetanus	Bacteria	204,000
Meningitis	Bacteria, viruses	173,000
Syphilis	Bacteria	157,000

* Deaths worldwide, based on The World Health Report for 2004.

The Spread of Diseases

- Sporadic diseases
  - Occur irregularly, affect few people
- Epidemic diseases
  - Spread quickly, then subside
- Endemic diseases
  - Occur continually, but don’t spread far
- Pandemic diseases
  - Break out and spread worldwide

An Evolutionary Perspective

- Two barriers prevent pathogens from dominating
  - Species that coevolve with specific pathogens have built-in defenses
  - A pathogen that kills its host too fast might disappear along with the host

Key Concepts
Evolution and Disease

- *An immense variety of pathogens, or disease-causing agents, infect human hosts*

- *Pathogens and their hosts coevolve; each acts as a selective agent on the other*

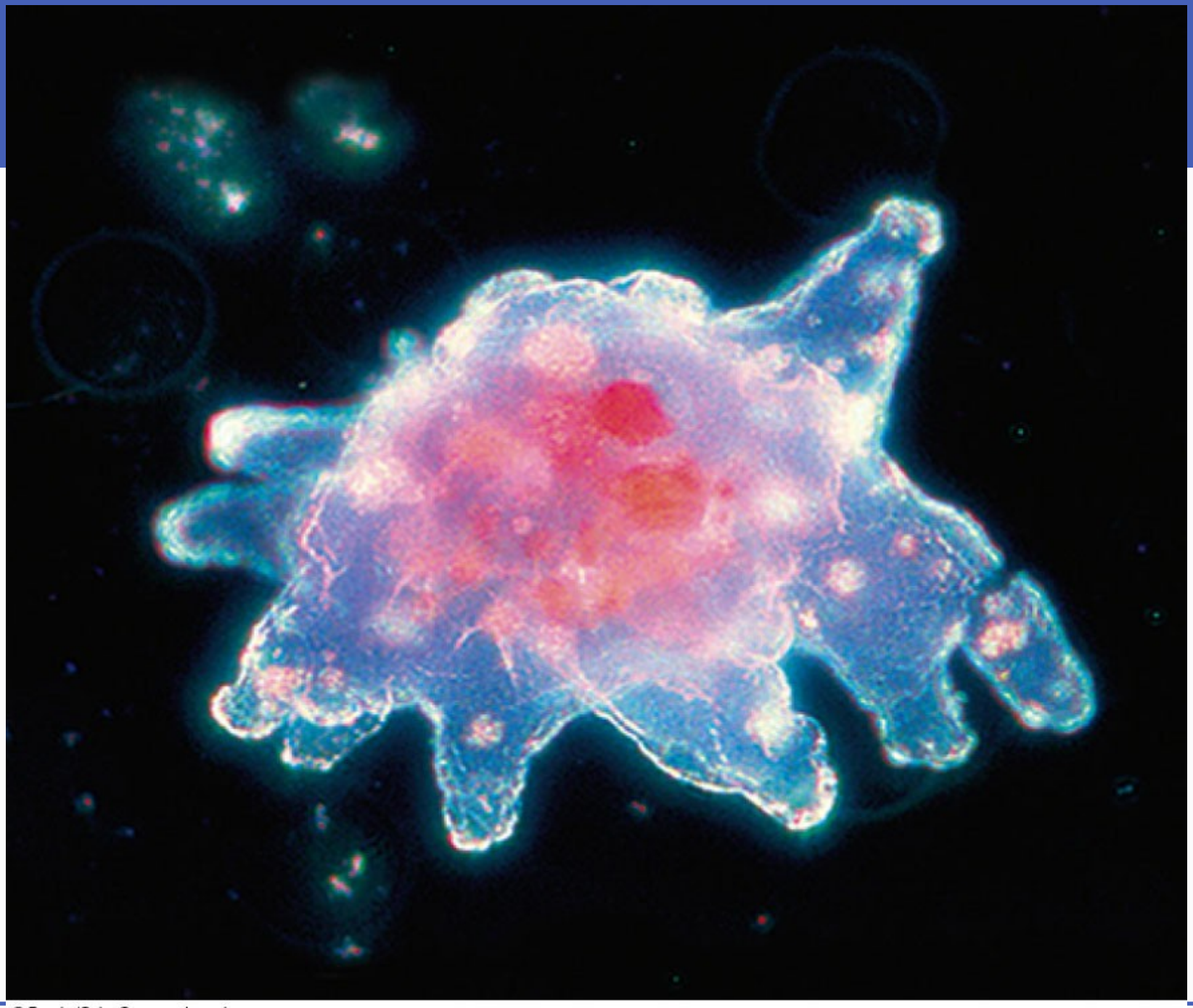
Protists – The Simplest Eukaryotes
Domain Eukarya Kingdom Protista

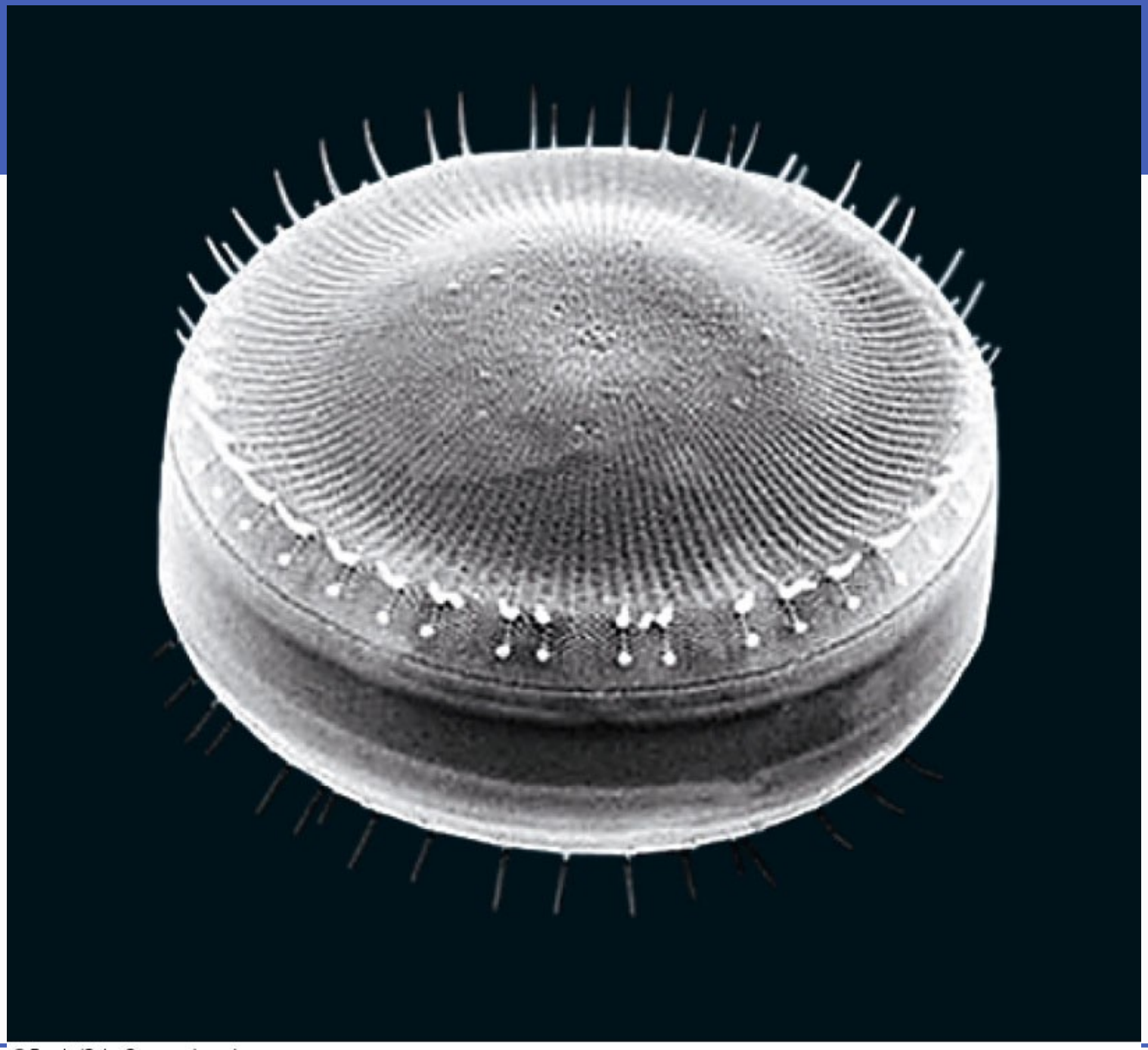
Impacts, Issues
The Malaria Menace

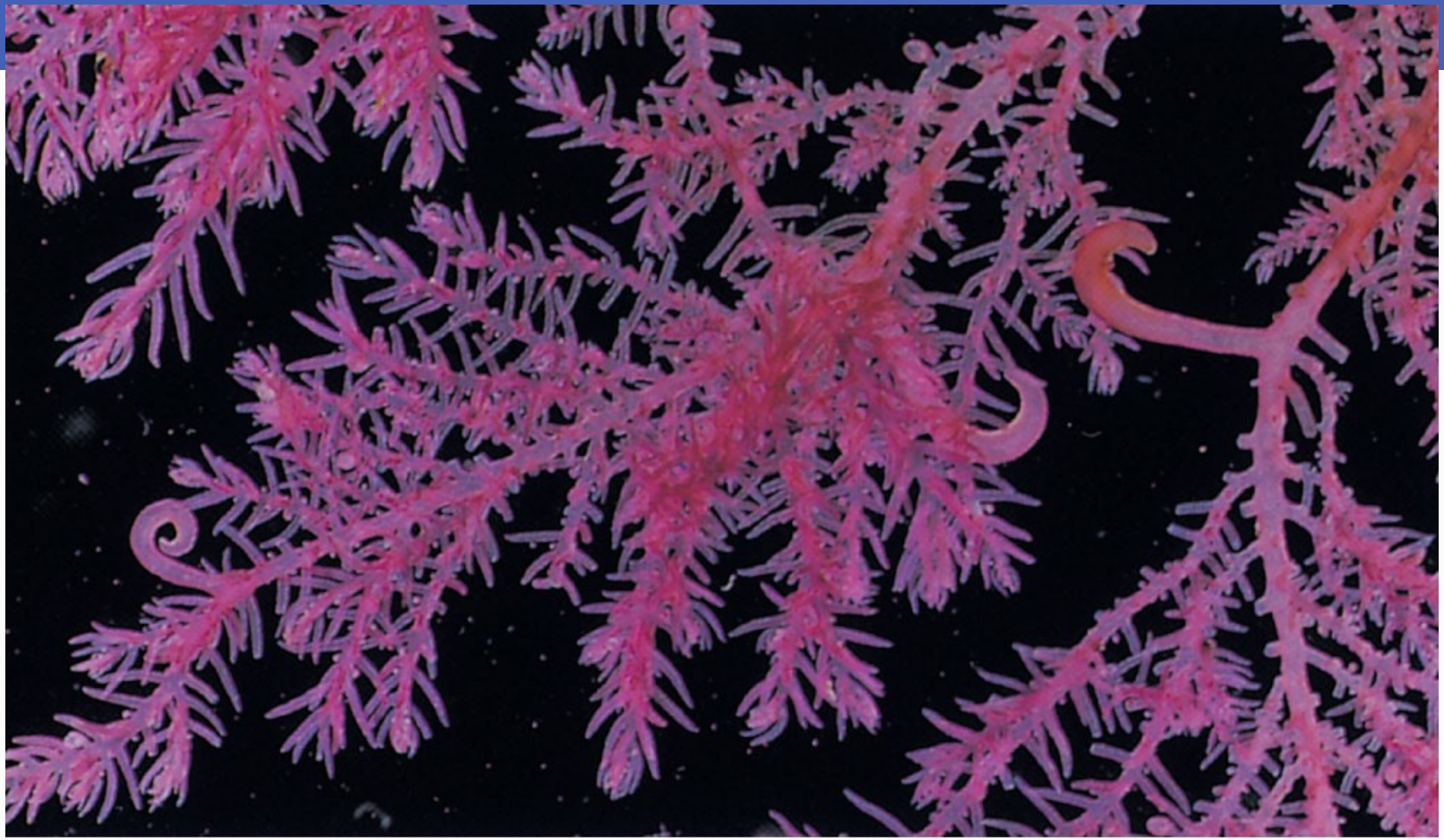
- *Plasmodium*, a single-celled protist, causes malaria – but also manipulates its mosquito and human hosts to maximize its own survival

The Many Protist Lineages

- **Protists** are eukaryotic organisms that are not fungi, plants, or animals
- Protists include many lineages of mostly single-celled eukaryotes, some only distantly related to one another
- No single trait is unique to protists – the “catch-all” kingdom!



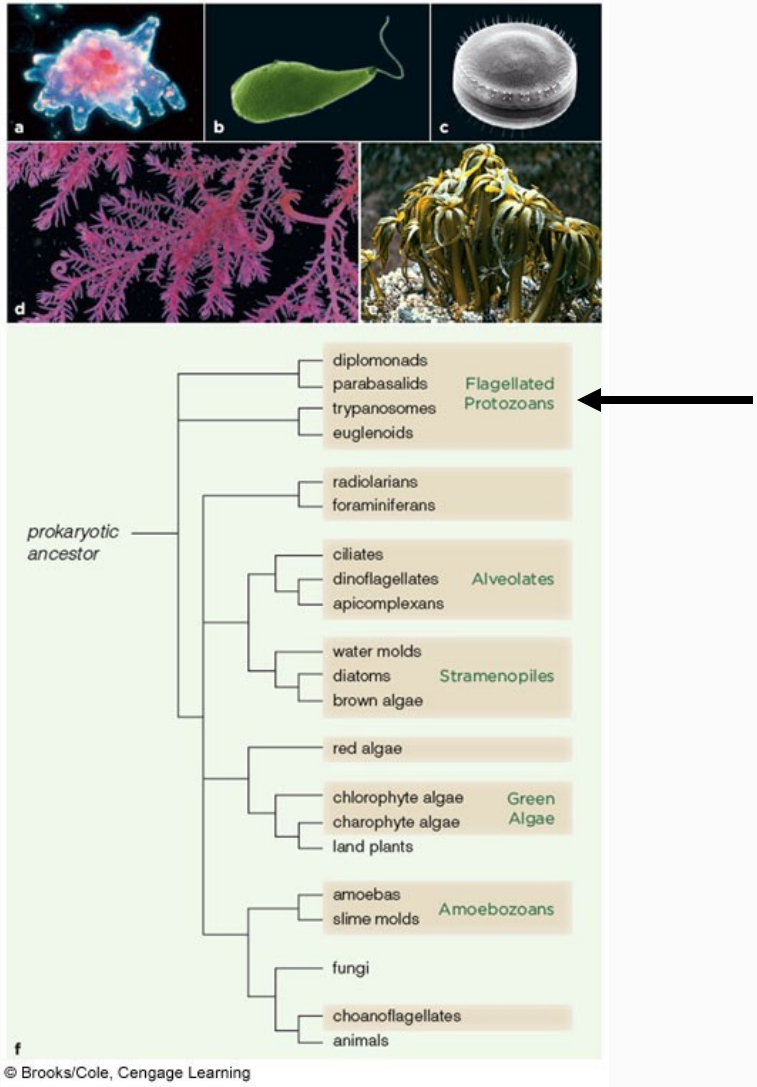




Protist Organization, Nutrition, & Reproduction

- Most protists are single-celled, but some are colonial or multicelled
- Protists can be autotrophs or heterotrophs, and a few can switch between modes
- Protists show great diversity in life cycles; most reproduce both sexually and asexually

Classification and Phylogeny



Flagellated Protozoans

Know the types of organisms in each group!!!

- **Flagellated protozoans** are single-celled protists
- They swim in lakes, seas, and the body fluids of animals
- They are typically heterotrophic and reproduce asexually by **binary fission**

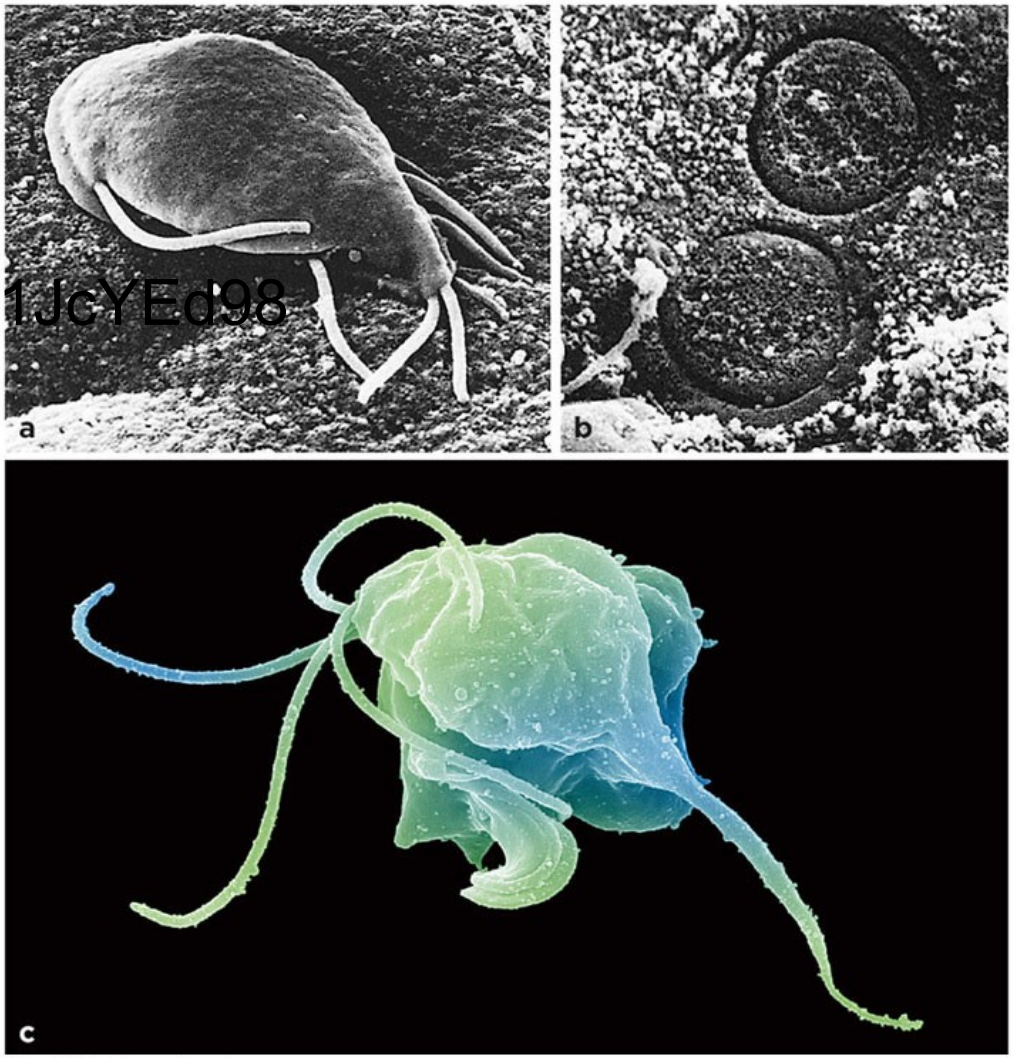
The Anaerobic Flagellates

- Diplomonads and parabasalids have multiple flagella and live in oxygen-poor waters

- Some infect humans and cause disease
  - *Giardia lamblia* is an intestinal parasite
  - *Trichomonas vaginalis* causes a sexually transmitted disease

Giardia and *Trichomonas*

http://www.youtube.com/v/byJ1JcYEd98



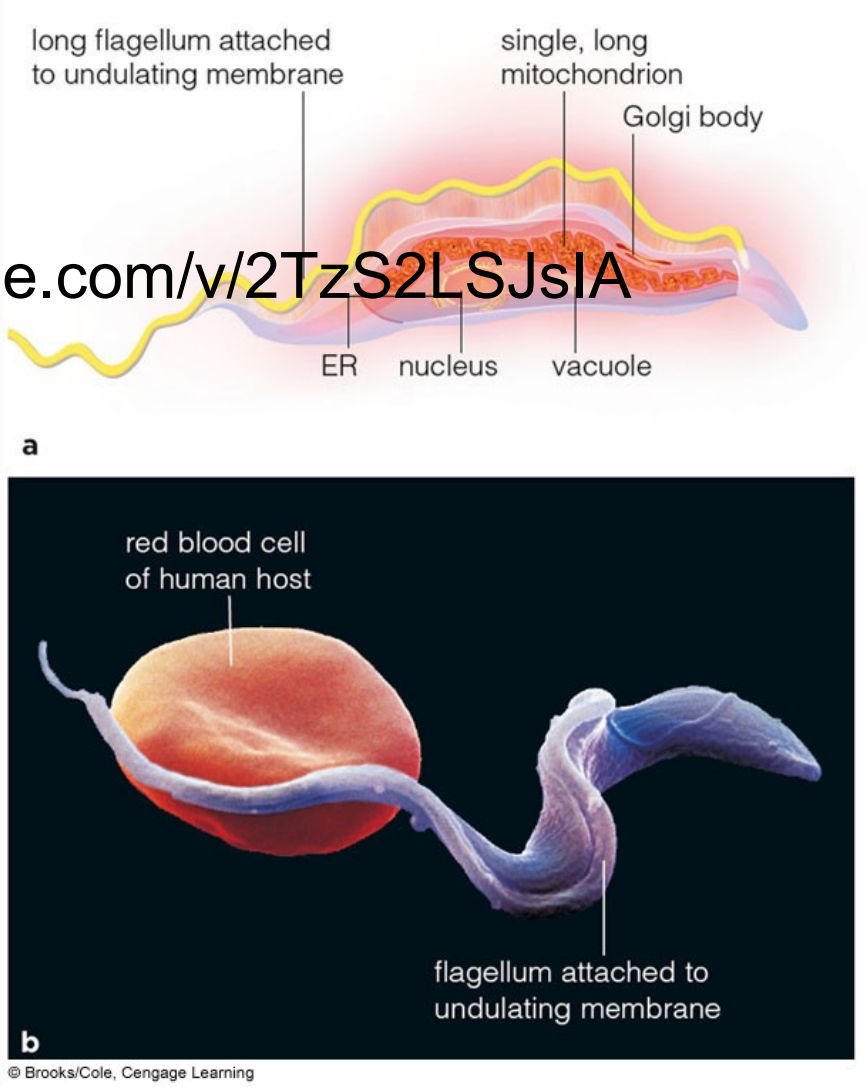
Trypanosomes and Other Kinetoplastids

- **Kinetoplastids** are flagellated protozoans with a single large mitochondrion

- **Trypanosomes** are a type of kinetoplastid that includes human pathogens that are transmitted by insects
  - African sleeping sickness (*T. brucei*) is spread by tsetse flies

Trypanosoma brucei

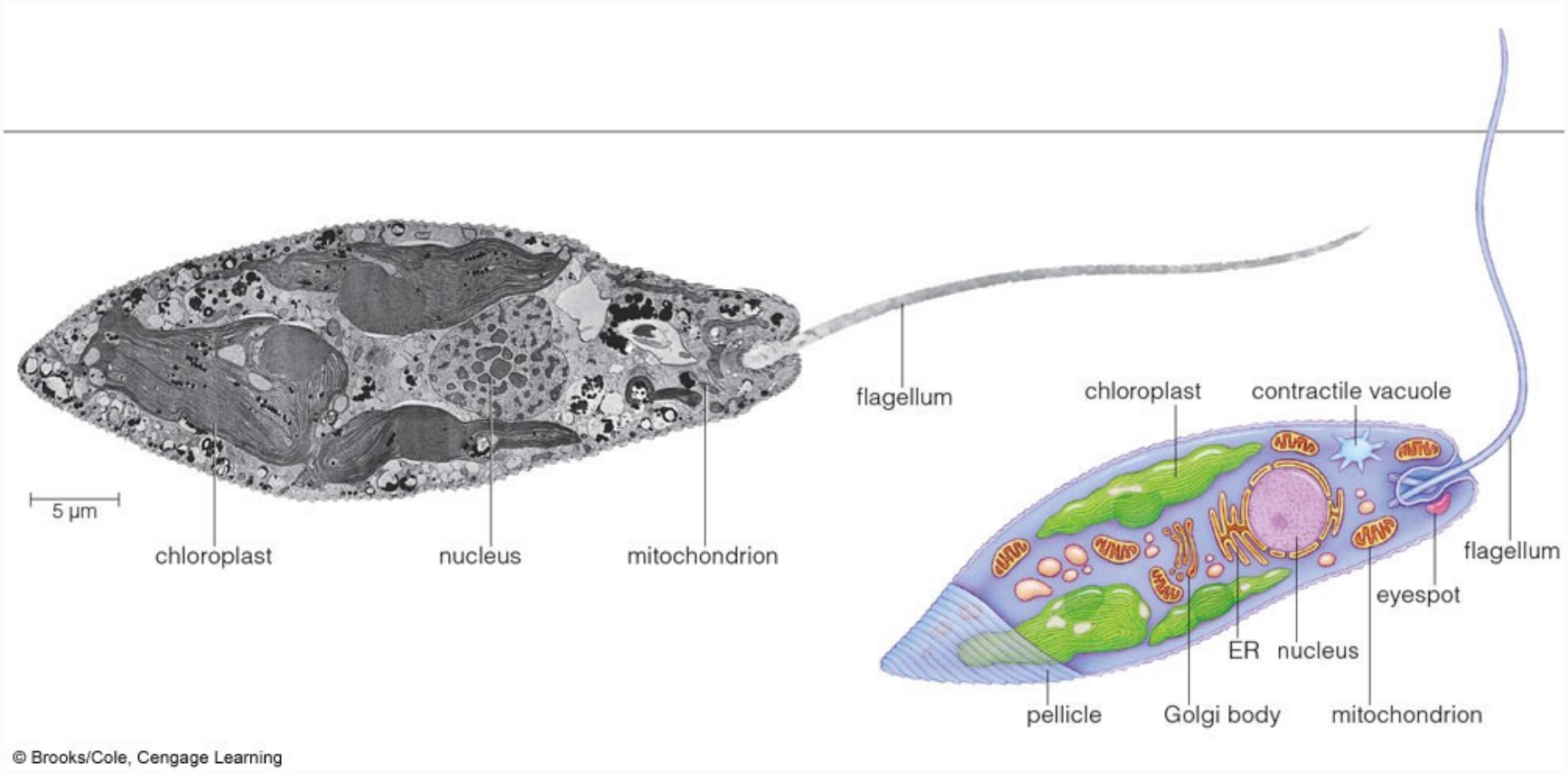
http://www.youtube.com/v/2TzS2LSJsIA



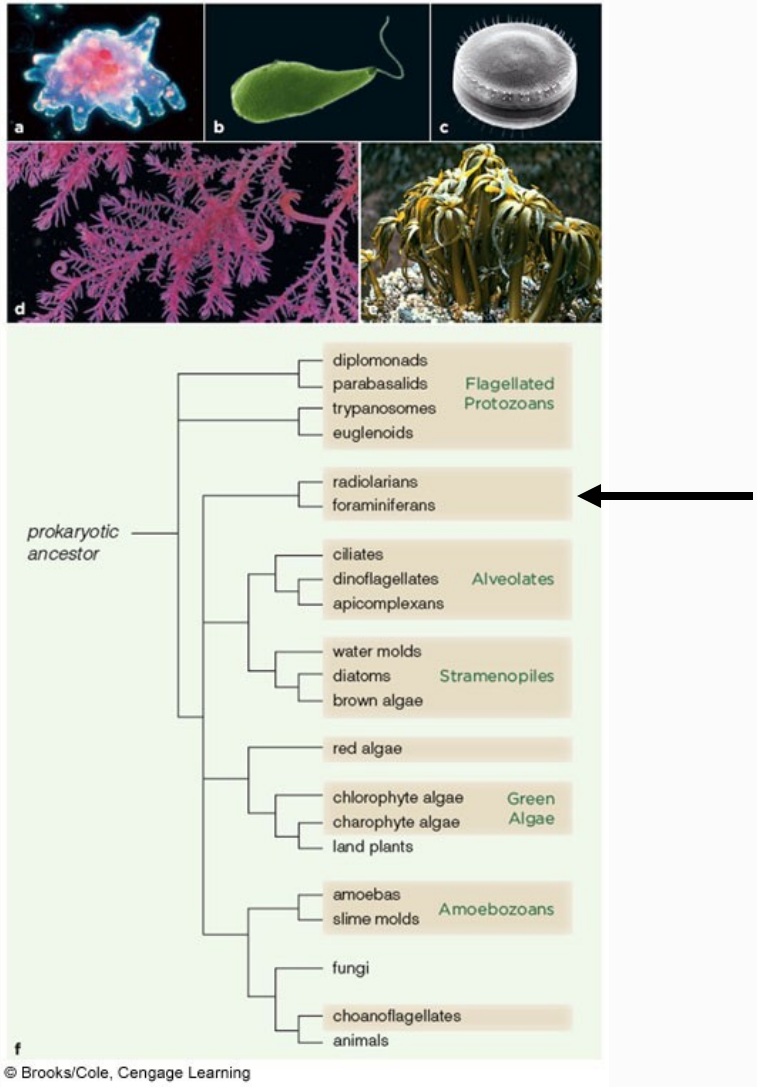
The Euglenoids

- **Euglenoids** are flagellated protists related to kinetoplastids that do not infect humans
  - Most prey on bacteria
  - Some have chloroplasts that evolved from green algae and can detect light with an eyespot
  - Most live in freshwater and have contractile vacuoles that expel excess water

A Euglenoid: *Euglena gracilis*

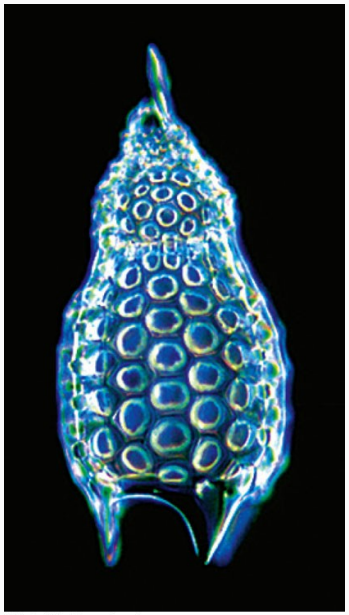


Classification and Phylogeny



Foraminiferans and Radiolarians – protists with a shell

- Heterotrophic single cells with chalky or glassy shells live in great numbers in the world's oceans; cytoplasm extends through many pores



Chalky-Shelled Foraminiferans

- Foraminiferans are single celled protists that make calcium carbonate shells from CO_2
  - Helps stabilize atmospheric CO_2 levels and buffers pH of seawater
  - Shells accumulate as chalk or limestone

- Most forams live on the seafloor; others drift as part of the **plankton**

  http://www.youtube.com/v/9Lm9hUj2h_0

White Cliffs of Dover

- Chalky remains of foraminiferans and other organisms with calcium-carbonate shells

Glassy-Shelled Radiolarians

- Radiolarians are heterotrophic protists with silica shells beneath their plasma membrane

- Most are part of the marine plankton – vacuoles filled with air keep radiolarians afloat

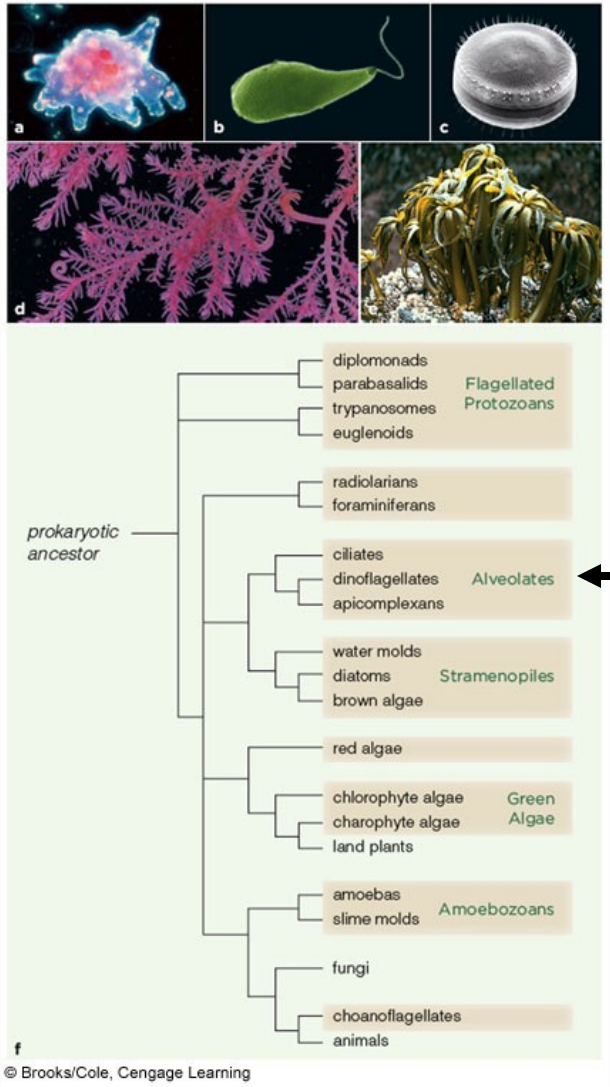
http://www.youtube.com/v/OcOKzxpLkpE

Key Concepts
Flagellated Protozoans and Shelled Cells

- *Flagellated protozoans include single-celled predators and some human parasites*

- *Foraminiferans and radiolarians are shelled, single-celled heterotrophs; most live in seas*

Classification and Phylogeny



Alveolates

- Three groups of protists characterized by tiny sacs beneath their plasma membrane
  - Ciliates
  - Dinoflagellates
  - Apicomplexans

The Ciliates

- **Ciliates** are heterotrophic single cells that move about with the help of cilia

- Ciliates reproduce asexually by binary fission or sexually by conjugation

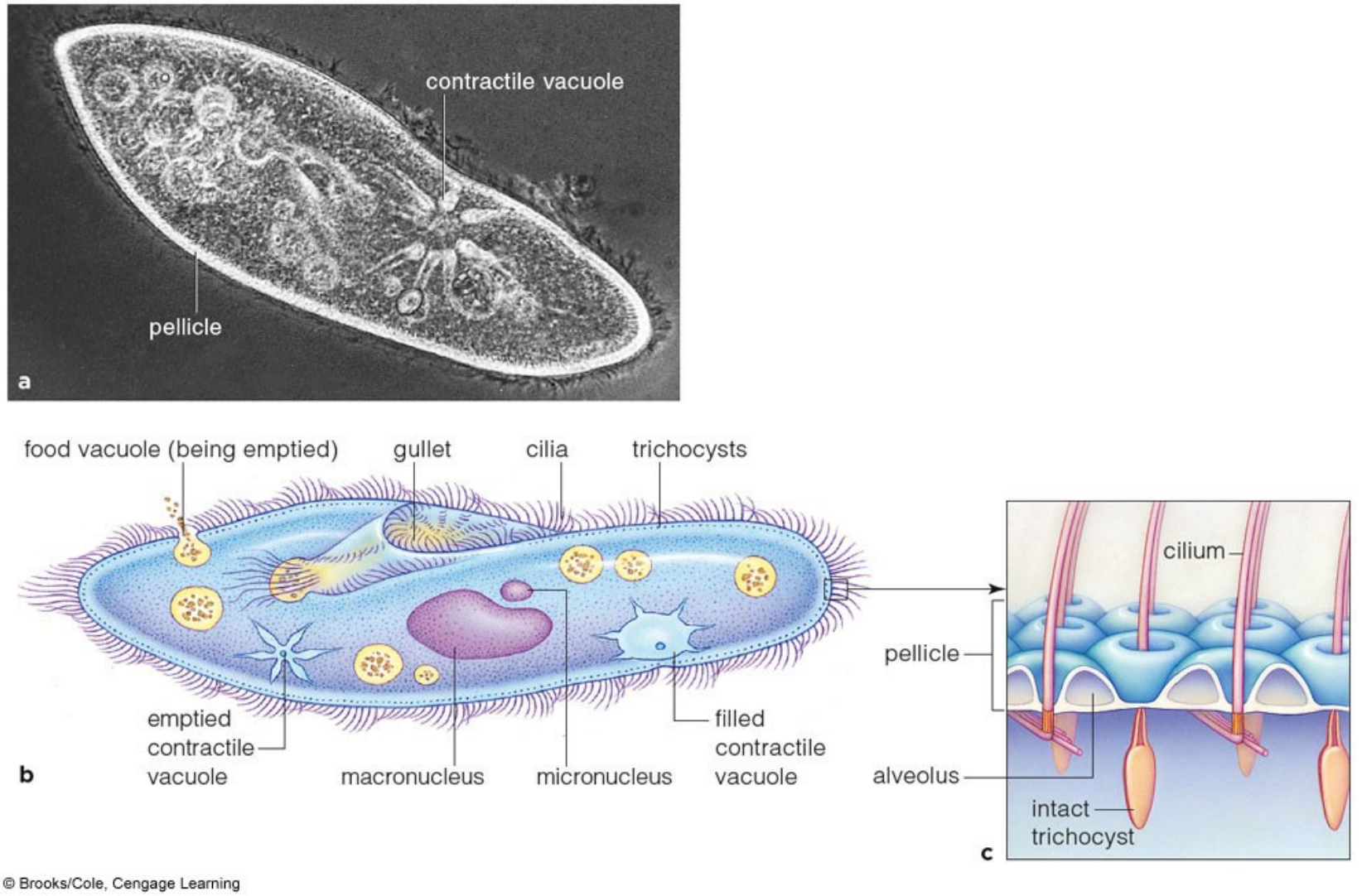
Ciliate Lifestyles

http://www.youtube.com/v/HlHihxqqXOE

- Most ciliates are free-living predators that hunt bacteria, other protists, and one another in freshwater habitats and the oceans
  - *Example: Paramecium*

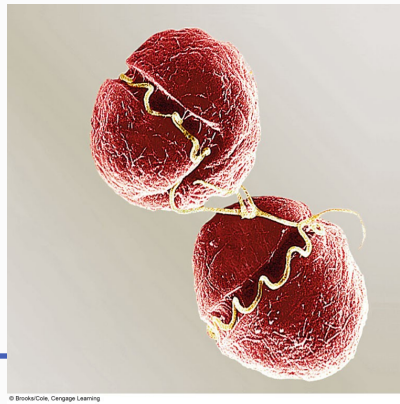
- Some ciliates are parasites of animals
  - *Balantidium coli* is a parasite of humans

Ciliate Structure: *Paramecium*

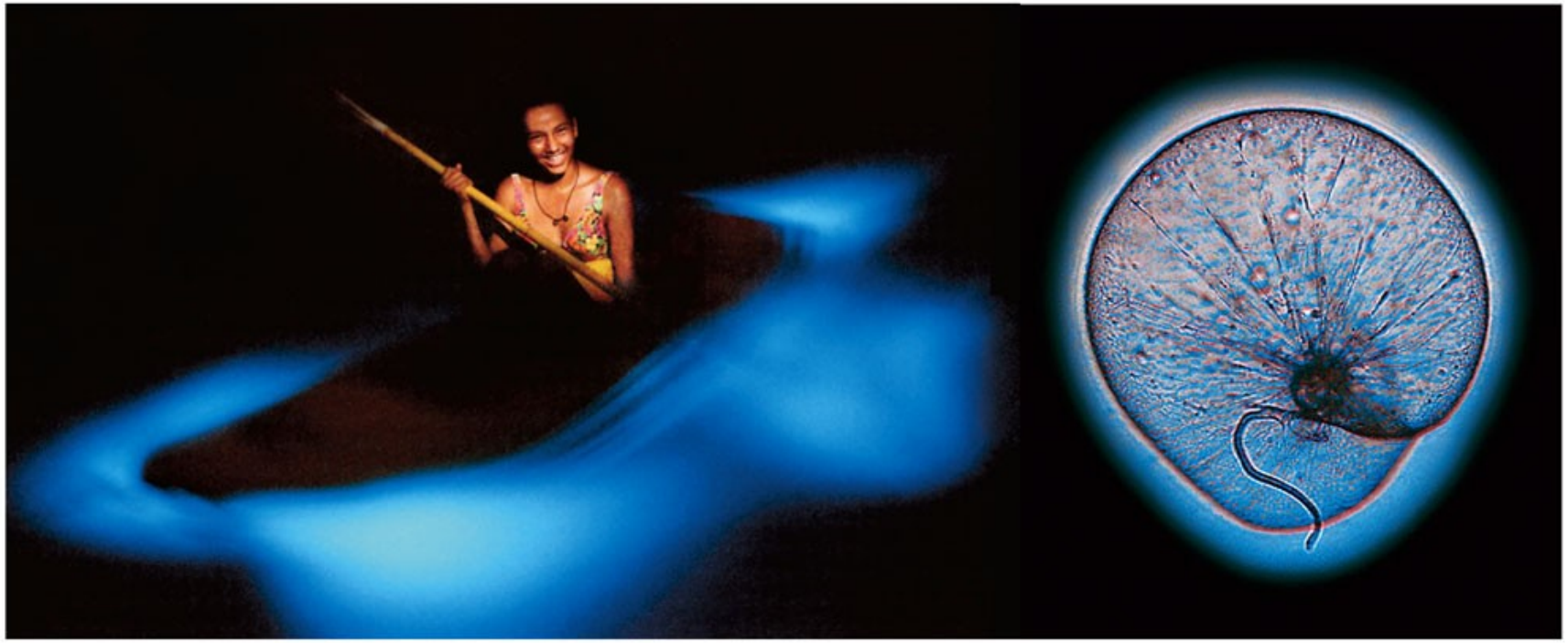


Dinoflagellates

- **Dinoflagellates** ("whirling flagellates") are mostly marine single-celled alveolate protists
- Some are predators or parasites; others are photosynthetic members of the plankton or symbionts in corals
- Are responsible for red tides



Bioluminescent Dinoflagellates



http://www.youtube.com/watch?v=T2xh9-UPSIU&feature=related

The Cell-Dwelling Apicomplexans

- **Apicomplexans** are parasitic alveolates that spend part of their life inside host cells
  - *Plasmodium* causes malaria
  - *Toxoplasma gondii* causes toxoplasmosis
- Apicomplexans infect a variety of animals from worms to insects to humans
  - Life cycle may involve more than one species

Video: Malaria

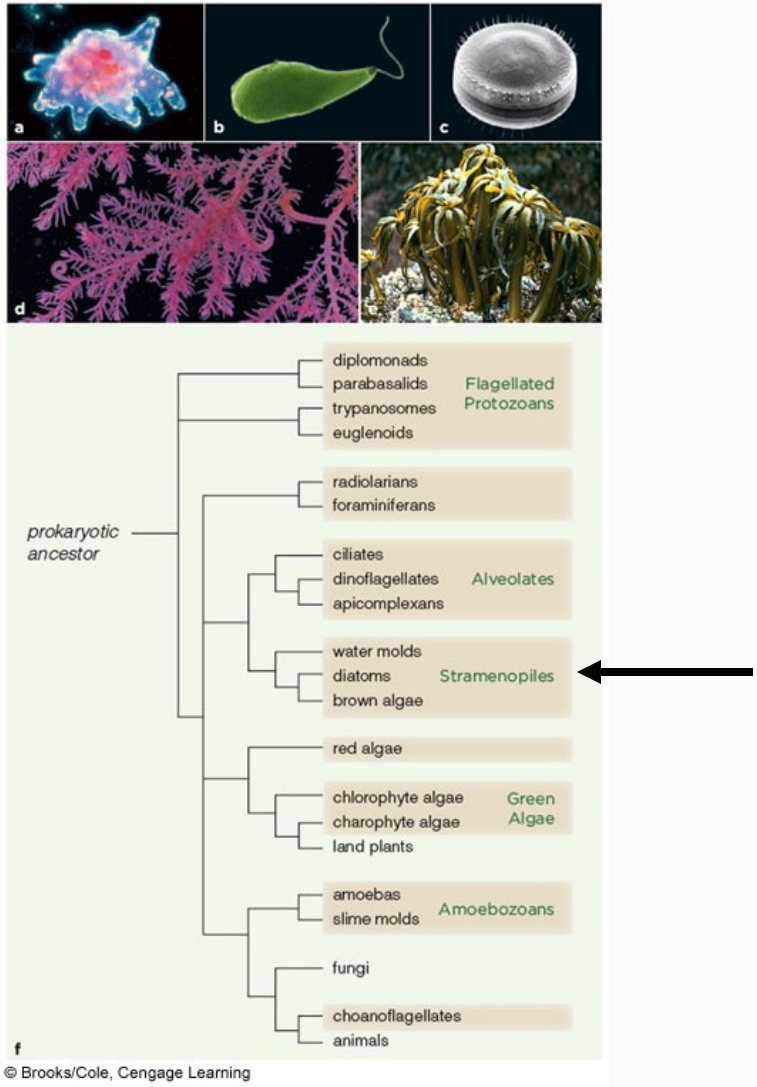
http://www.youtube.com/v/F_Xi3hnhtbg

Key Concepts
The Alveolates

- *Ciliated protozoans, dinoflagellates, and apicomplexans are single-celled photoautotrophs, predators, and parasites*

- *Their shared trait is a unique layer of sacs under the plasma membrane*

Classification and Phylogeny



The Stramenopiles

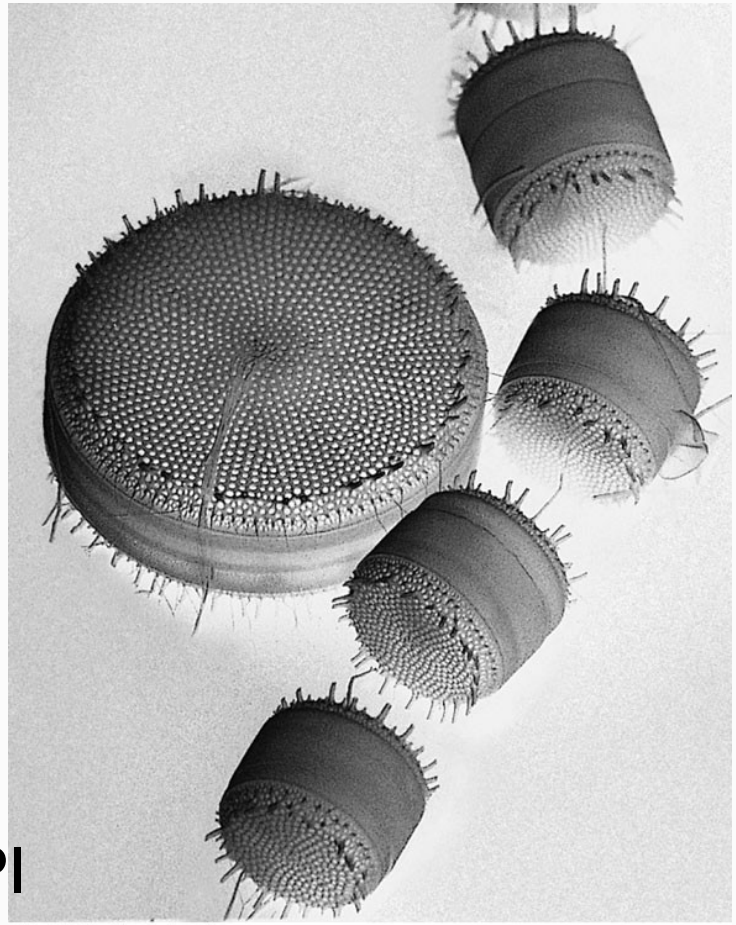
- **Stramenopiles**
  - Colorless filamentous molds, photosynthetic single cells, and large seaweeds belong to the stramenopile lineage – all have hairs on their flagella

The Diatoms

- **Diatoms** are single-celled or colonial protists that have a two-part silica shell
  - Shells accumulate on the seafloor (diatomaceous earth)

- Most are photosynthetic, with a brown accessory pigment (fucoxanthin)
  - Major components of phytoplankton

Diatoms



http://www.youtube.com/v/JYB5529hDPI

The Multicelled Brown Algae

- **Brown algae** are multicelled protists that live in temperate or cool seas; ranging from microscopic filaments to giant kelp

- Some brown algae are used commercially
  - Thickeners (algins), food, fertilizer, herbal supplements (bladderwrack)

Kelps

- Giant kelp (*Macrocystis*) is the largest protist
  - Life cycle: alternation of generation with multicellular haploid and diploid bodies and a dominant sporophyte generation
  - Ecologically important kelp forests (Pacific)

- *Sargassum* forms large floating mats
  - Important Atlantic habitat (Sargasso Sea)

http://www.youtube.com/v/9GVxUDCCNvI

The Heterotrophic Water Molds

- **Water molds** (oomycotes) form a mesh of filaments made up of diploid cells with cellulose cell walls

- Water molds decompose organic matter in aquatic habitats, are aquatic parasites (*Saprolegnia*), or infect plants

Parasitic Water Molds

- Filaments of *Saprolegnia* infect fish in aquaria

The Plant Destroyers

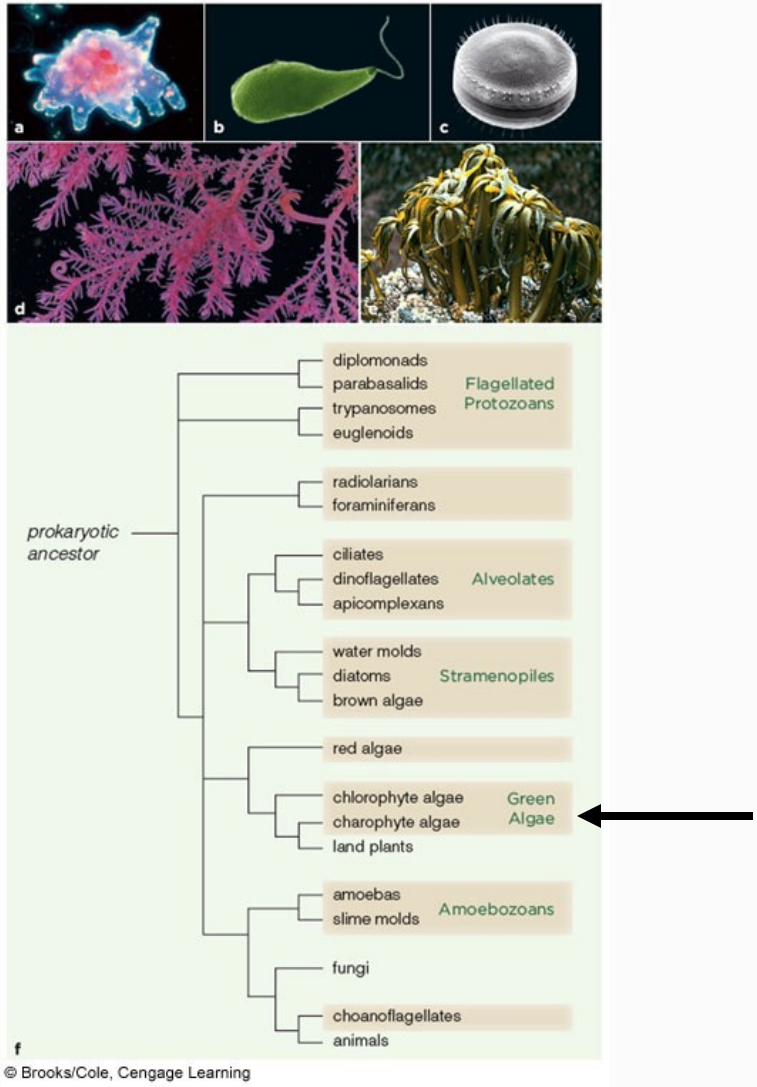
- Water molds include economically and ecologically important plant pathogens that infect a wide variety of crop plants, as well as forest trees
  - *Phytopthora infestans* ruined Irish potato crops
  - *Phytopthora ramorum* recently infected North American forests

Key Concepts
The Stramenopiles

- *Diatoms and brown algae are stramenopiles, most of which are photoautotrophs*

- *The colorless water molds, which include major plant pathogens, are also stramenopiles*

Classification and Phylogeny



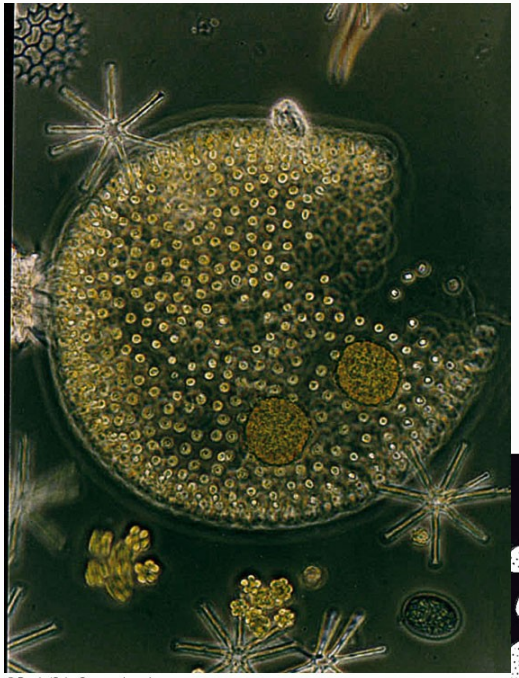
Green Algae

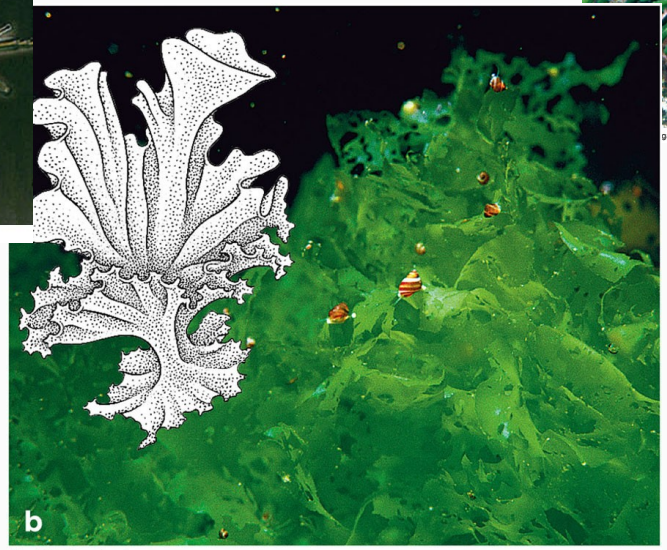
- Green algae are photosynthetic single-celled and multicelled protists
- Like land plants, they have cellulose in their cell walls, store sugars as starch, and have chloroplasts descended from cyanobacteria

The Chlorophytes

- Most green algae are **chlorophytes**
  - *Chlorella*: Single celled, grown as health food
  - *Chlamydomonas*: Single celled, freshwater alga
  - *Volvox*: Colonial, freshwater alga
  - *Cladophora*: Forms long filaments
  - *Ulva*: “Sea lettuce”
  - *Codium fragilis*: Branching marine alga

Chlorophyte Algae

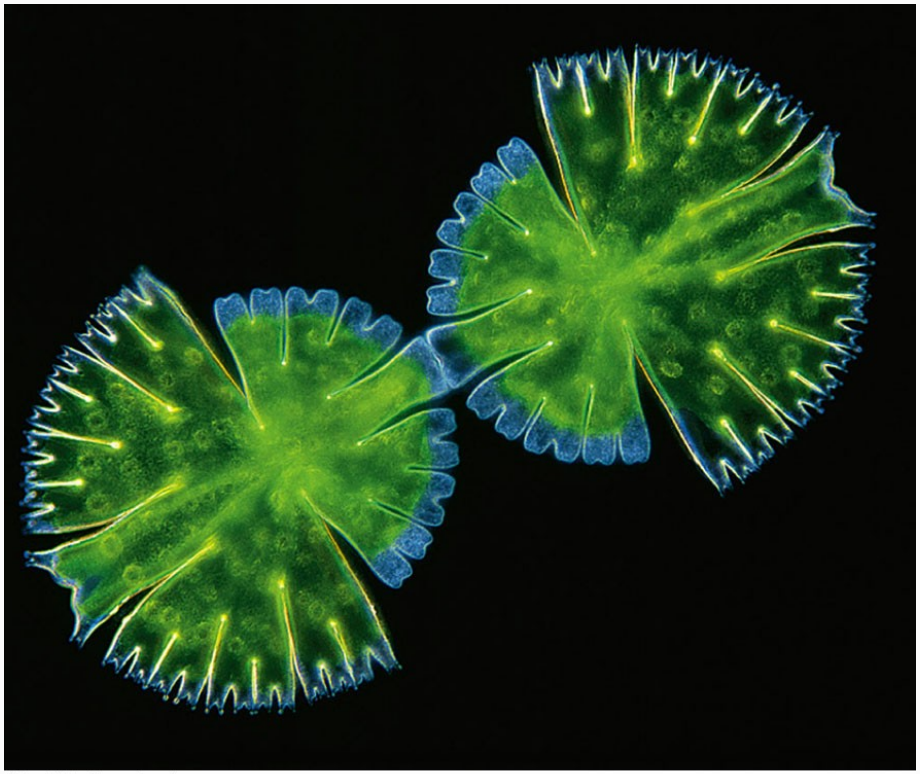


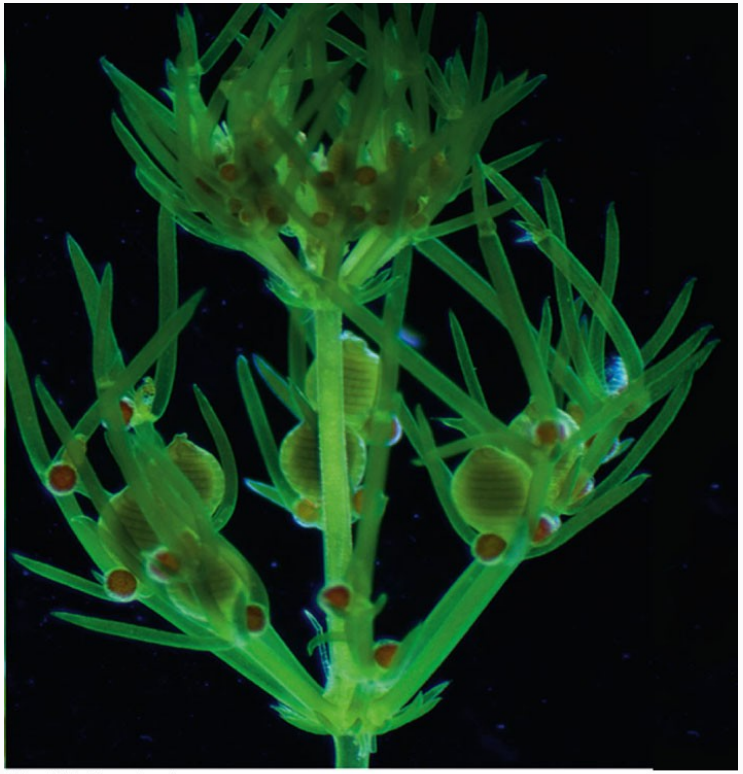


Charophyte Algae

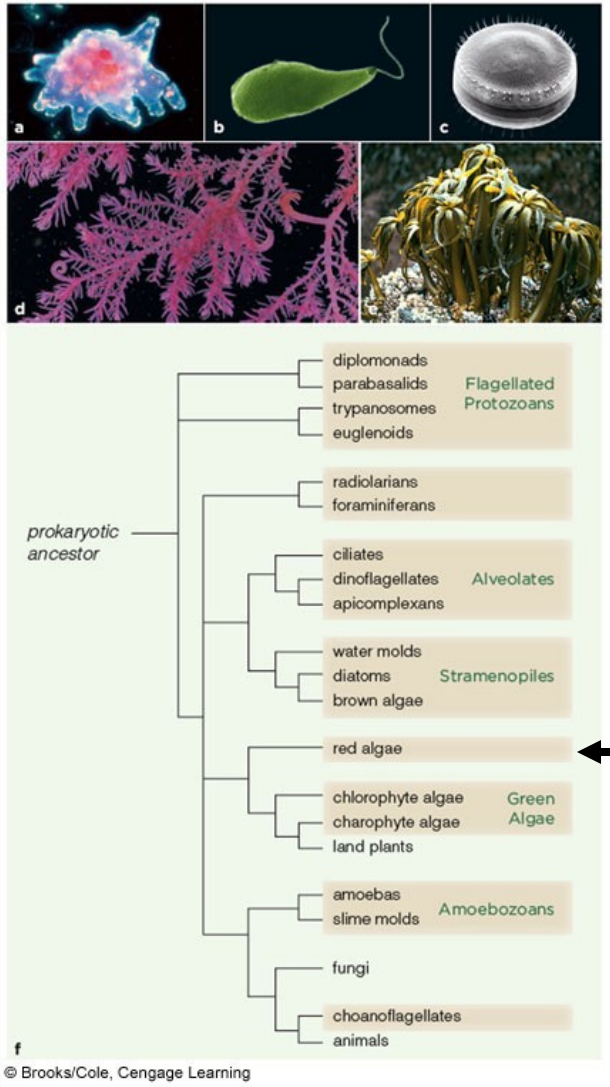
- **Charophyte algae** include several lineages that form a clade with land plants
  - Desmids: A single-celled, freshwater group
  - *Spirogyra*: Forms long filaments
  - Stoneworts (*Chara*): Closely related to land plants

Charophyte Algae





Classification and Phylogeny

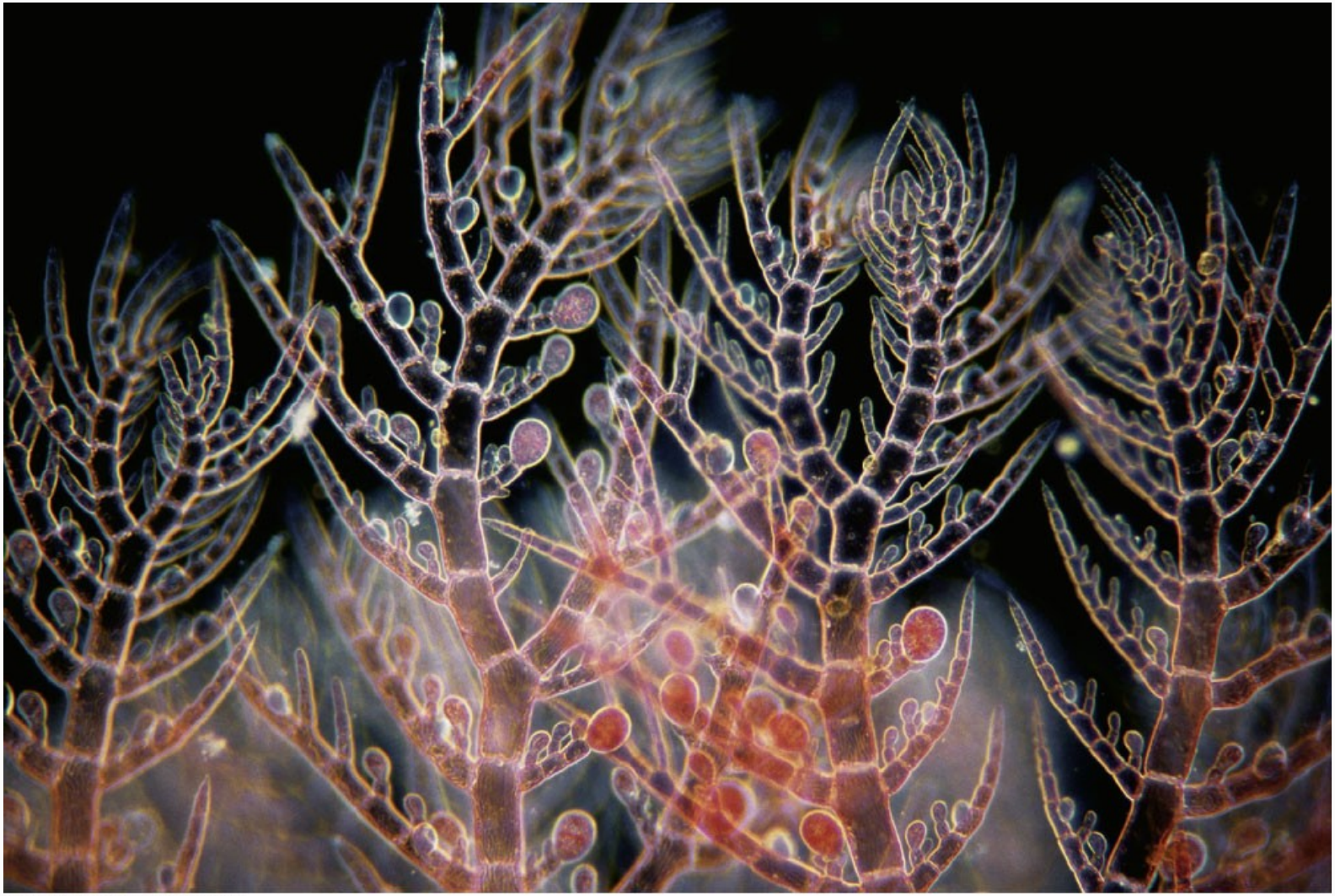


Red Algae Do It Deeper

- **Red algae** are mostly multicelled marine algae that live in clear, warm waters

- Red accessory pigments (phycobilins) allow red algae to live at greater depths than other algae

Red Alga *Antithamnion plumula*

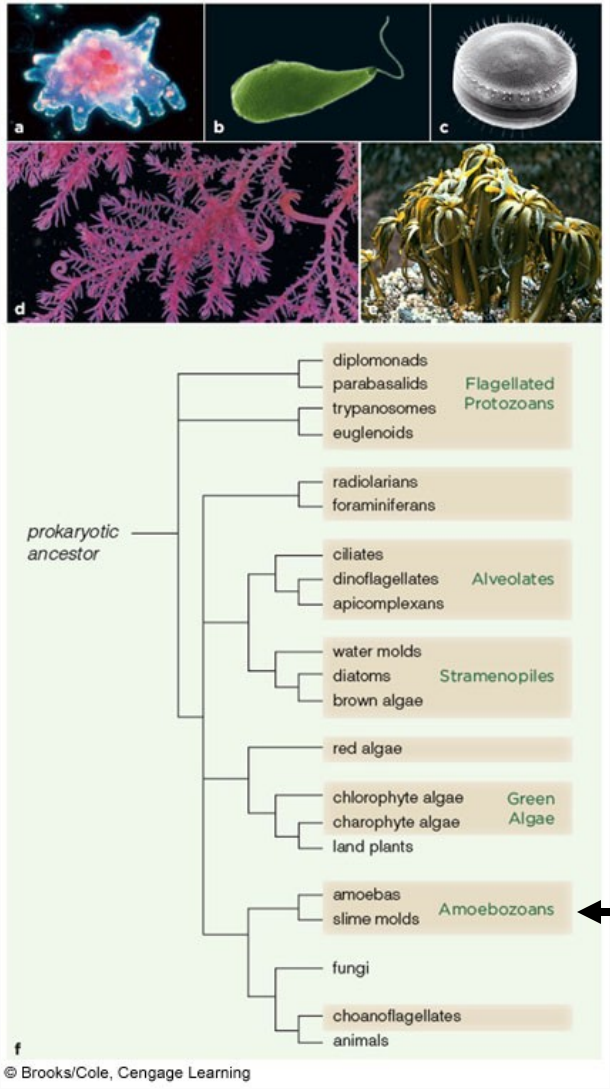


http://www.youtube.com/v/CbWjM79gbi0

Key Concepts
The Closest Relatives of Land Plants

- *Red algae and green algae are photosynthetic single cells and multicelled seaweeds*
- *One lineage of multicelled green algae includes the closest living relatives of land plants*

Classification and Phylogeny



Amoebozoans

- Amoebozoans send out pseudopods, move about, and capture food
  - Most have no cell walls, shell, or pellicles

- **Amoebas** live as single cells
  - *Example: Amoeba proteus*, a freshwater predator

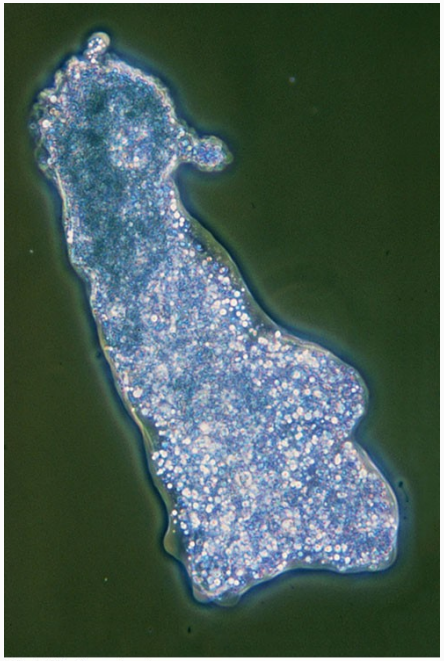
- **Slime molds** are “social amoebas”
  - Plasmodial and cellular slime molds

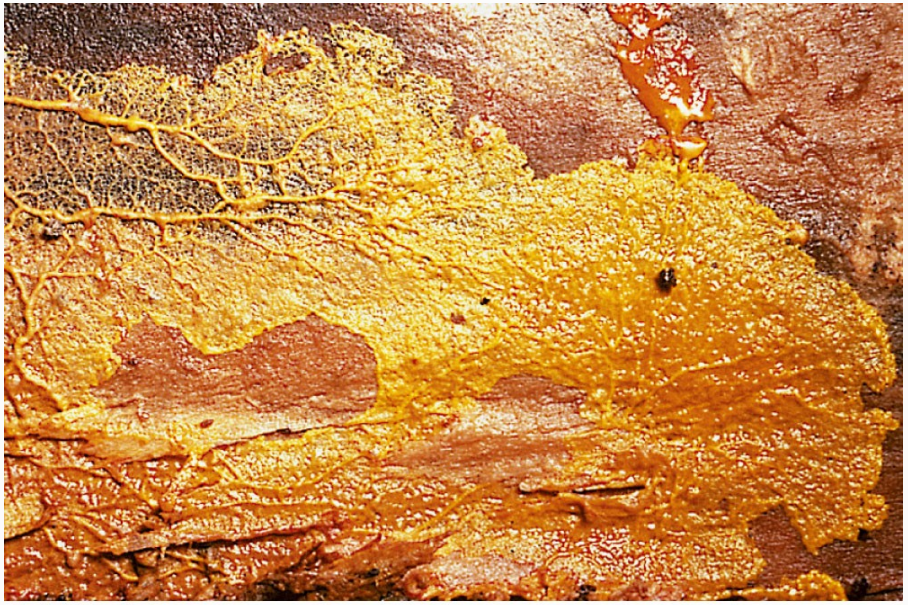
http://www.youtube.com/v/7pR7TNzJ_pA

Plasmodial Slime Molds

- **Plasmodial slime molds** spend most of their lives as a plasmodium
  - A streaming multinucleated mass that feeds on microbes and organic matter
  - Undergoes mitosis many times without cell division
  - Develops into spore-bearing fruiting bodies

Amoeba and Plasmodial Slime Mold





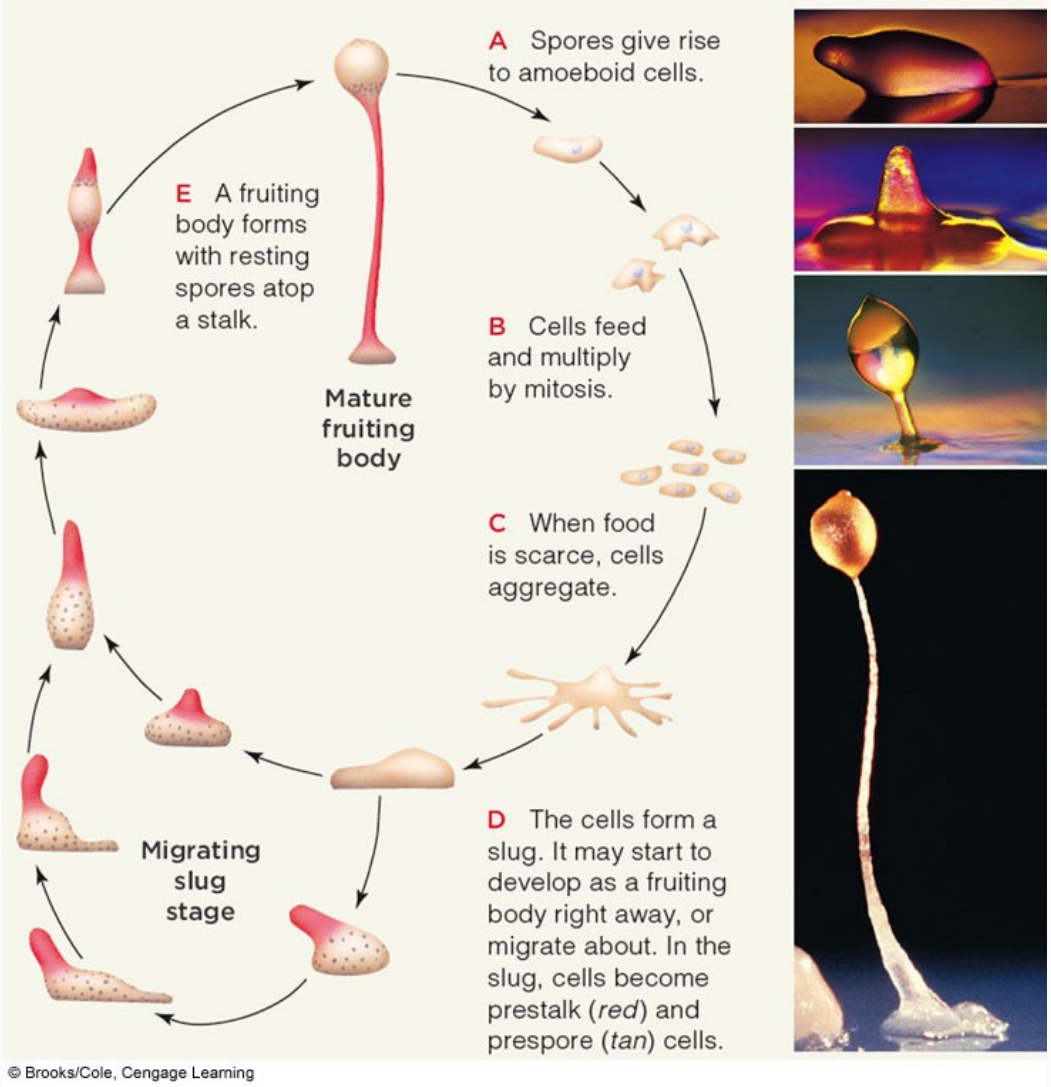
Cellular Slime Molds

- **Cellular slime molds** spend most of their lives as individual amoeboid cells that feed on bacteria and reproduce by mitosis

- When food runs out, thousands of cells form a "slug" that migrates, forms a fruiting body, and produces spores and new diploid amoeboid cells
  - *Example: Dictyostelium discoideum*

http://www.youtube.com/v/bkVhLJLG7ug

Cellular Slime Mold Life Cycle: *Dictyostelium discoideum*



Key Concepts
Relatives of Fungi and Animals

- *A great variety of amoeboid species formerly classified as members of separate lineages are now united as the amoebozoans*

- *They are the closest living protistan relatives of fungi and animals*