

PowerLecture:
Chapter 4
Cell Structure and Function
Section 4.0: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 4.0 : Red Gold: Anton Van Leeuwenhoek
- Section 4.0 : Robert Hooke's *Micrographia* (1665)
- Section 4.0 : The Remarkable Vision of Robert Hooke (1635-1703): First Observer of the Microbial World. Howard Gest. *Perspectives in Biology and Medicine*, Spring 2005.

How Would You Vote?

The following is the question for this chapter. See national results below.

- Would you support research into creating the “minimal organism”?

Impacts, Issues: Animalcules and Cells Fill'd With Juices

- Nearly all cells are invisible to the naked eye
- Powerful microscopes allow us to see cells with detail

Section 4.1: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 4.1 : NCBI Science Primer
- Section 4.1 : The Incredible Life and Times of Biological Cells (cell theory). Paul Nurse. *Science*, Sept. 8, 2000.

The Cell

- Smallest unit of life
- Can survive on its own or has potential to do so
- Is highly organized for metabolism
- Senses and responds to environment
- Has potential to reproduce

Structure of Cells

All start out life with:

- Plasma membrane
- Region where DNA is stored
- Cytoplasm

Lipid Bilayer

- Main component of cell membranes
- Gives the membrane its fluid properties
- Two layers of phospholipids

Fluid Mosaic Model

- Membrane is a mosaic of
 - Phospholipids
 - Glycolipids
 - Sterols
 - Proteins
- Most phospholipids and some proteins can drift through membrane

Membrane Proteins

- Adhesion proteins
- Communication proteins
- Receptor proteins
- Recognition proteins

Why Are Cells So Small?

- Surface-to-volume ratio
- The bigger a cell is, the less surface area there is per unit volume
- Above a certain size, material cannot be moved in or out of cell fast enough

Surface-to-Volume Ratio

Early Discoveries

- Mid 1600s - Robert Hooke observed and described cells in cork
- Late 1600s - Antony van Leeuwenhoek observed sperm, microorganisms
- 1820s - Robert Brown observed and named nucleus in plant cells

Developing Cell Theory

- Matthias Schleiden
 - Theodor Schwann
 - Rudolf Virchow
- #### Cell Theory

- 1) Every organism is composed of one or more cells

- 2) Cell is smallest unit having properties of life
- 3) Continuity of life arises from growth and division of single cells

Section 4.2: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 4.2 : Nanoworld—Electron/Optical Images
- Section 4.2 : MicroScape—Virtual Microscope
- Section 4.2 : Molecular Expressions
- Section 4.2 : Basics of Light Microscopy. Barbara Foster. *R & D*, Nov. 2001.
- Section 4.2 : Advances in Microscopy (20th century). Michael Root. *BioScience*, Apr. 1991.

Microscopes

- Create detailed images of something that is otherwise too small to see
- Light microscopes
 - Simple or compound
- Electron microscopes
 - Transmission EM or Scanning EM

Limitations of Light Microscopy

- Wavelengths of light are 400-750 nm
 - If a structure is less than one-half of a wavelength long, it will not be visible
 - Light microscopes can resolve objects down to about 200 nm in size
- #### Electron Microscopy
- Uses streams of accelerated electrons rather than light
 - Electrons are focused by magnets rather than glass lenses
 - Can resolve structures down to 0.5 nm

Electron Microscope

Different Microscopes

- Different microscopes reveal different aspects of this Green Algae

Size Comparison

Section 4.3: Weblinks and InfoTrac

See the **latest Weblinks** and **InfoTrac articles** for this chapter online or click **highlighted articles below (articles subject to change)**

- Section 4.3 : Intimate Strangers—Unseen Life on Earth
- Section 4.3 : Microbe World
- Section 4.3 : Prokaryotes. Michael Hoppert et al. *American Scientist*, Nov. 1999.
- Section 4.3 : Why We Need Germs. Garry Hamilton. *The Ecologist*, June 2001.

Prokaryotic Cells

- Archaea and eubacteria
- DNA is *not* enclosed in nucleus
- Generally the smallest, simplest cells
- No organelles

Prokaryotic Structure

Section 4.4: Weblinks and InfoTrac

See the **latest Weblinks** and **InfoTrac articles** for this chapter online or click **highlighted articles below (articles subject to change)**

- Section 4.4 : The Virtual Cell
- Section 4.4 : Cell Biology Web Pages
- Section 4.4 : Celle Fantasyk. Jennifer Ackerman. *Natural History*, May 2001.

Eukaryotic Cells

- Have a nucleus and other organelles
- Eukaryotic organisms
 - Plants
 - Animals
 - Protistans

● Fungi

Plant Cell Features

Animal Cell
Animal Cell Features

Section 4.5: Weblinks and InfoTrac

See the **latest Weblinks** and **InfoTrac articles** for this chapter online or click **highlighted articles below (articles subject to change)**

- Section 4.5 : The Cell Nucleus
- Section 4.5 : Cell Nucleus Research
- Section 4.5 : Chromatin Structure and Function
- Section 4.5 : Basic Science: DNA Movements in Living Cells. *Applied Genetics News*, Sept. 2001.
- Section 4.5 : The Nuclear Membrane. Colin Dingwall et al. *Science*, Nov. 6, 1992.

Functions of Nucleus

- Keeps the DNA molecules of eukaryotic cells separated from metabolic machinery of cytoplasm
- Makes it easier to organize DNA and to copy it before parent cells divide into daughter cells

Components of Nucleus

- Nuclear envelope
- Nucleoplasm
- Nucleolus
- Chromatin

Nucleus

Nucleus

- Transmission electron micrograph of a pancreatic cell's nucleus

Chromatin

- Cell's collection of DNA and associated proteins
- Chromosome is one DNA molecule and its associated proteins

- Appearance changes as cell divides

Nuclear Envelope

- Two outer membranes (lipid bilayers)
- Innermost surface has DNA attachment sites
- Pores span bilayer

Nuclear Envelope

- Pores of the nuclear envelope

Nucleolus

- Dense mass of material in nucleus
- May be one or more
- Cluster of DNA and proteins
- Materials from which ribosomal subunits are built
- Subunits must pass through nuclear pores to reach cytoplasm

Nuclear DNA

- The changing appearance of a chromosome

Section 4.6: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 4.6 : Life and Discoveries of Camillo Golgi
- Section 4.6 : Coming to Grips with the Golgi. Carol Featherstone. *Science*, Dec. 18, 1998.

Endomembrane System

- Group of related organelles in which lipids are assembled and new polypeptide chains are modified
- Products are sorted and shipped to various destinations

Components of Endomembrane System

- Endoplasmic reticulum
- Golgi bodies
- Vesicles

Endoplasmic Reticulum

- In animal cells, continuous with nuclear membrane
- Extends throughout cytoplasm
- Two regions: rough and smooth

Rough ER

- Arranged into flattened sacs
- Ribosomes on surface give it a rough appearance
- Some polypeptide chains enter rough ER and are modified
- Cells that specialize in secreting proteins have lots of rough ER

Smooth ER

- A series of interconnected tubules
- No ribosomes on surface
- Lipids assembled inside tubules
- Smooth ER of liver inactivates wastes, drugs
- Sarcoplasmic reticulum of muscle is a specialized form

Golgi Bodies

- Put finishing touches on proteins and lipids that arrive from ER
- Package finished material for shipment to final destinations
- Material arrives and leaves in vesicles

Vesicles

- Membranous sacs that move through the cytoplasm
- Lysosomes
- Peroxisomes

Central Vacuole

- Fluid-filled organelle
- Stores amino acids, sugars, wastes
- As cell grows, expansion of vacuole as a result of fluid pressure forces cell wall to expand
- In mature cell, central vacuole takes up 50-90 percent of cell interior

Section 4.7: Weblinks and InfoTrac

See the **latest Weblinks and InfoTrac articles** for this chapter online or click **highlighted articles below (articles subject to change)**

- Section 4.7 : [Mitochondrion Reconstructed by Electron Tomography](#)
- Section 4.7 : [Symbionts and Assassins \(endosymbiont theory\). Guy Brown. *Natural History*, July 2000.](#)

Mitochondria

- ATP-producing powerhouses
- Double-membrane system
- Carry out the most efficient energy-releasing reactions
- These reactions require oxygen

Mitochondria

Mitochondrial Structure

- Outer membrane faces cytoplasm
- Inner membrane folds back on itself
- Membranes form two distinct compartments
- ATP-making machinery is embedded in the inner mitochondrial membrane

Section 4.8: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 4.8 : Virtual [Plant] Cell
- Section 4.8 : What the Heck is a Chloroplast?
- Section 4.8 : Plant Scientists See Big Potential in Tiny Plastids. Josh Gewolb. *Science*, Jan. 11, 2002.

Chloroplasts

Convert sunlight energy to ATP through photosynthesis

Chloroplast

Structure of a Chloroplast

- Two outer membranes around semifluid interior (stroma) – bathes inner membrane
- Often, this single membrane is folded back on itself as a series of stacked, flattened disks
- Each stack is called a thylakoid, which contains chlorophylls and other substances involved in photosynthesis

Like Bacteria?

- Both mitochondria and chloroplasts resemble bacteria
- Have own DNA, RNA, and ribosomes

Section 4.9: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

- Section 4.9 : Plant Cell Walls
- Section 4.9 : UC Davis Plasmodesmata Lab
- Section 4.9 : Cell Junctions

➤ Section 4.9 : Tiny Conspiracies (quorum sensing in bacteria). Bonnie Bassler. *Natural History*, May 2001.

➤ Section 4.9 : Biological Ties that Bind (extracellular matrix). Carolyn Strange. *BioScience*, Jan. 1997.

Cell Wall

- Structural component that wraps around the plasma membrane
- Occurs in plants, some fungi, some protists

Plant Cell Walls

Plant Cuticle

- Cell secretions and waxes accumulate at plant cell surface
- Semi-transparent

- Restricts water loss

Matrixes between Animal Cells

- Animal cells have no cell walls
- Some are surrounded by a matrix of cell secretions and other material

Cell Junctions

- Plants

- Plasmodesmata

- Animals

- Tight junctions
- Adhering junctions
- Gap junctions

Cell Junctions

Animal Cell Junctions

Section 4.10: Weblinks and InfoTrac

See the latest Weblinks and InfoTrac articles for this chapter online or click highlighted articles below (articles subject to change)

➤ Section 4.10 : Cytoskeleton, Cell Motility, and Motors

➤ Section 4.10 : Small Wonder. Alice Fulton. *The Sciences*, May–June 1993.

Cytoskeleton

- Present in all eukaryotic cells
- Basis for cell shape and internal organization

- Allows organelle movement within cells and, in some cases, cell motility

Cytoskeletal Elements

Microtubules

- Largest elements
- Composed of the protein tubulin
- Arise from microtubule organizing centers (MTOCs)
- Polar and dynamic
- Involved in shape, motility, cell division

Microfilaments

- Thinnest cytoskeletal elements
- Composed of the protein actin
- Polar and dynamic
- Take part in movement, formation and maintenance of cell shape

Actin Filaments

Accessory Proteins

- Attach to tubulin and actin
- Motor proteins
- Crosslinking proteins

Intermediate Filaments

- Present only in animal cells of certain tissues
- Most stable cytoskeletal elements
- Six known groups
 - Desmins, vimentins, lamins, etc.
- Different cell types usually have 1-2 different kinds

Intermediate Filaments

Section 4.11: Weblinks and InfoTrac

See the **latest Weblinks** and **InfoTrac articles** for this chapter online or click **highlighted articles below (articles subject to change)**

- Section 4.11 : Cilia vs. Flagella

- Section 4.11 : Top Bug (predatory bacteria). Lori Oliwenstein. *Discover*, Mar. 1993.

Mechanisms of Movement

- Length of microtubules or microfilaments can change
- Parallel rows of microtubules or microfilaments actively slide in a specific direction
- Microtubules or microfilaments can shunt organelles to different parts of cell

Flagella and Cilia

- Structures for cell motility
- 9 + 2 internal structure

False Feet

- Some free-living cells, such as amoebas, form pseudopods (“false feet”)

- These temporary, irregular lobes project from the cell and function in locomotion and prey capture
- Pseudopods move as microfilaments elongate inside them – motor proteins attached to the microfilaments drag the plasma membrane with them

Flagellum