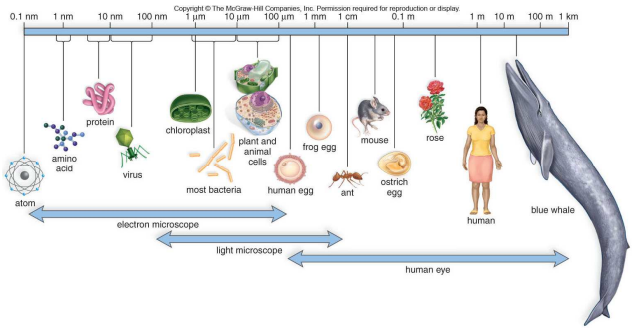
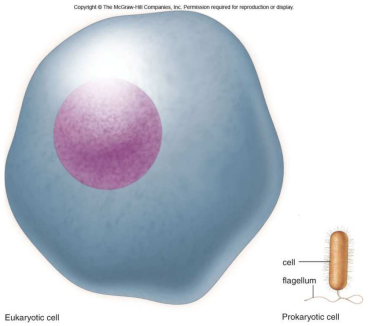
Structure and Function of Cells

ساختمان و عمل سلول‌ها

اندازهٔ چیزهای زنده و اجزای آنها



تئوری سلول:
سلول واحد زیربنایی حیات است.

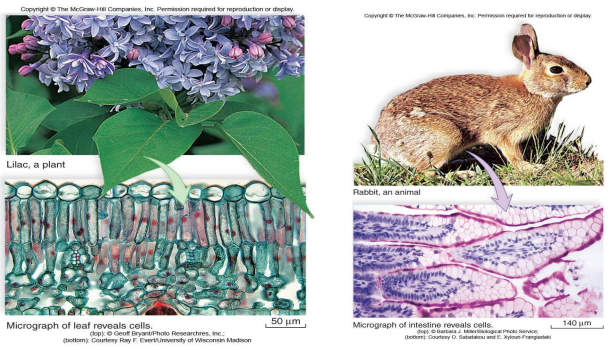


همهٔ موجودات از سلول ساخته شده‌اند

تئوری سلول بیان می‌کند که:

- سلول واحد زیربنایی حیات است
- همهٔ چیزهای زنده از سلول تشکیل شده‌اند
- سلول‌های جدید فقط از سلول‌های از پیش موجود ایجاد می‌شوند
- سلول‌ها از واحدهای اطلاعاتی تشکیل می‌شوند که به اولادشان منتقل می‌شوند.

همهٔ موجودات از سلول ساخته شده‌اند

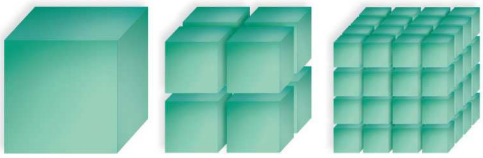


دلیل این که سلول‌ها کوچک‌اند

نسبت سطح به حجم سلول با کاهش اندازه سلول افزایش می‌یابد:

- سلول‌های در حال متابولیسم فعال باید کوچک باشند
- سلول‌هایی که برای جذب ویژه شده‌اند، طوری تغییر یافته‌اند که نسبت سطح به حجم بیشتر گردد

رابطهٔ بینابین سطح به حجم



One 4-cm cube | Eight 2-cm cubes | Sixty-four 1-cm cubes

Total surface area (height × width × number of sides × number of cubes)		
96 cm^2	192 cm^2	384 cm^2
Total volume (height × width × length × number of cubes)		
64 cm^3	64 cm^3	64 cm^3
Surface-area-to-volume ratio per cube (surface area ÷ volume)		
1.5:1	3:1	6:1

میکروسکوپ به ما اجازه می‌دهند تا سلول‌ها را ببینیم

میکروسکوپ نوری مرکب (Compound light microscope)

– عدسی‌های چندگانه قدرت را افزایش می‌دهند

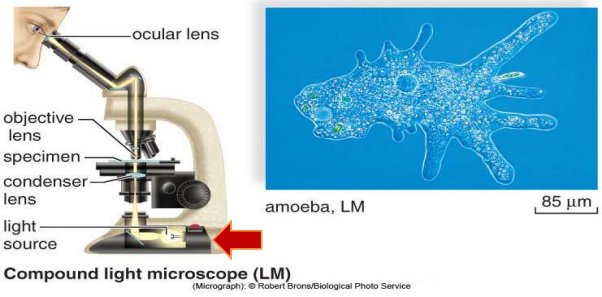
- یک عدسی متراکم کننده نور را از نمونه عبور می‌دهند
- یک عدسی شی ای تصویر نمونه را بزرگ می‌کند
- یک عدسی چشمی تصویر را به چشم می‌رساند

میکروسکوپ الکترونی (Electron microscope)

– **قدرت درشت‌نمایی آن از میکروسکوپ نوری بیشتر است**

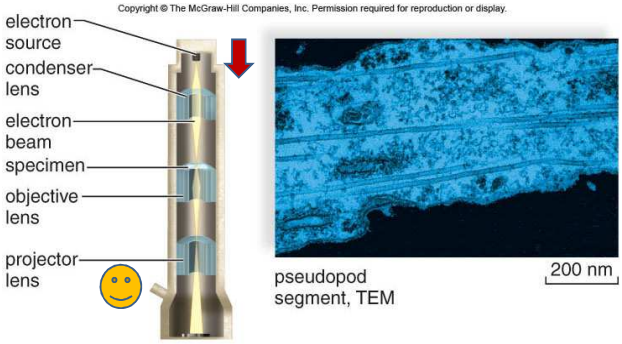
- میکروسکوپ الکترونی انتقالی (Transmission electron microscope (TEM)): الکترون‌ها از نمونه عبور می‌کنند
- میکروسکوپ الکترونی روبنده (Scanning electron microscope (SEM)): الکترون‌های پراکنده شده با نمونه را جمع کرده و متمرکز می‌کند

مقایسهٔ سه میکروسکوپ



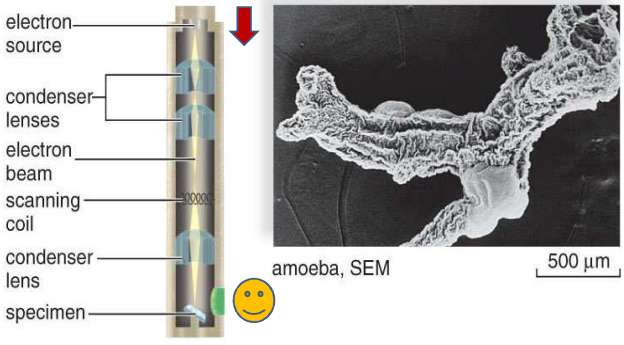
Compound light microscope (LM)

(Micrograph): © Robert Brons/Biological Photo Service



Transmission electron microscope (TEM)

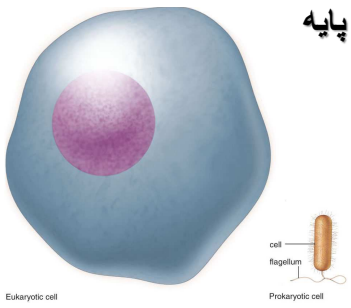
(TEM): © M. Schliwa/Visuals Unlimited

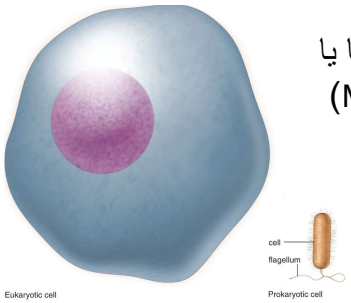


Scanning electron microscope (SEM)

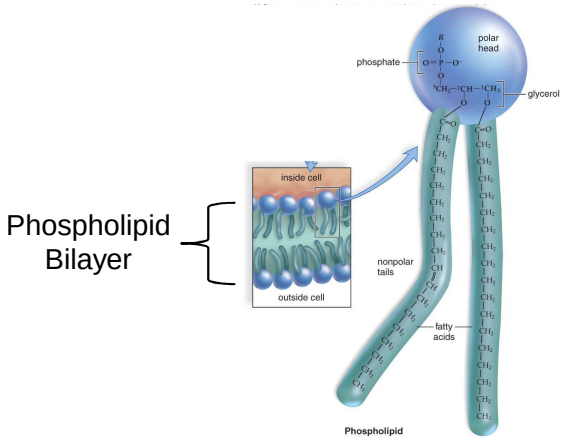
(SEM): © Kessel/Shih/Peter Arnold, Inc.

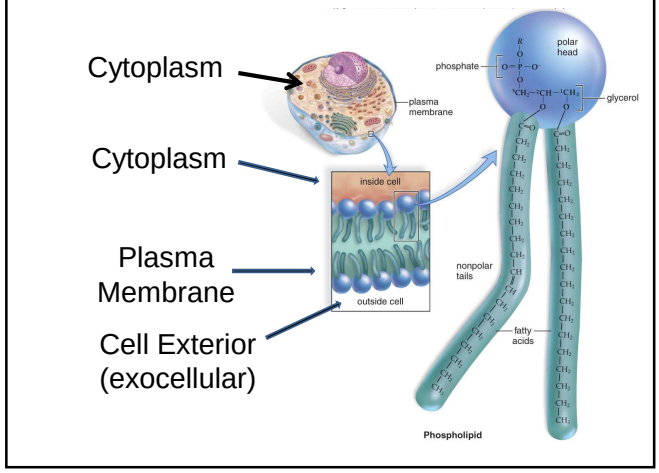
همه سلول‌ها اجزای پایه یکسانی دارند

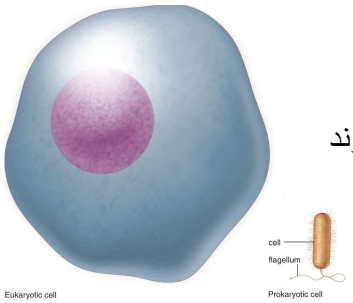




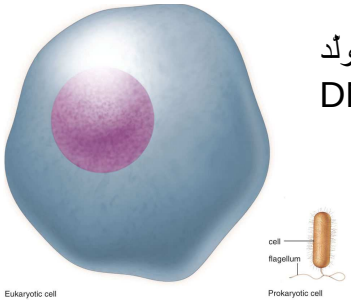
1- همه سلول‌ها غشا یا شامه (Membrane) دارند



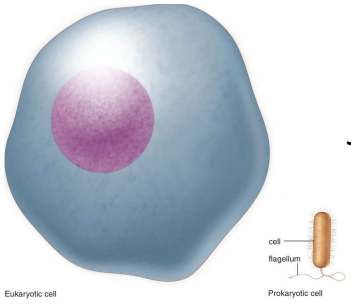




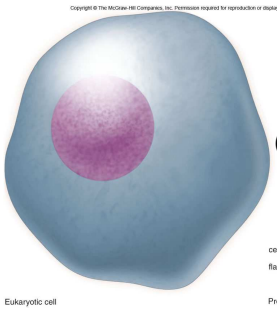
2- همه سلول‌ها سیتوپلاسم (Cytoplasm) دارند



3- همه سلول‌های مولّد دارای RNA و DNA هستند



1- همه سلول‌ها پروتئین، لیپید و کربوهیدرات دارند

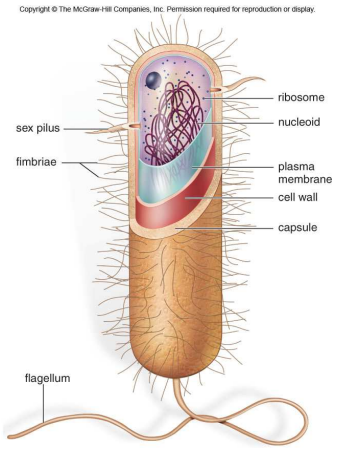


مقایسه اندازه

سلول یوکاریوتی (Eukaryotic Cell)
در برابر
سلول پروکاریوتی (Prokaryotic Cell)

Prokaryotic Cells

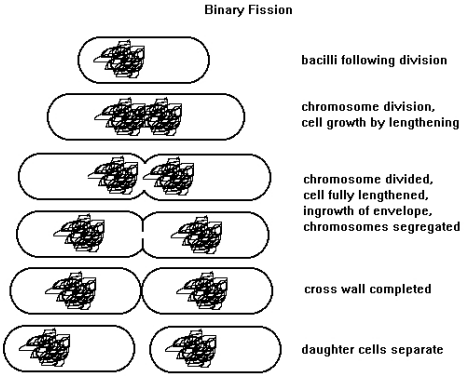
1. فقدان هسته محصور در غشا
2. کوچکتر از سلول‌های یوکاریوتی
3. داشتن یک کروموزوم منفرد (DNA حلقوی)
4. داشتن هزاران ریبوزوم پراکنده در سیتوپلاسم
5. فقدان اندامک در سیتوپلاسم
6. تولید مثل غیرجنسی (تقسیم دوتایی= binary fission)
7. موجود تک سلولی
8. گاهی دارای Pili و Flagellum و کپسول ودیواره

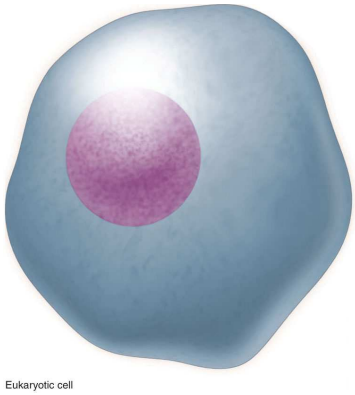


Prokaryotic Cell Structure

Archaea and Bacteria

- دو دومین از سلول‌های پروکاریوتی
- برخی باکتری‌ها بیماریزا هستند
- در بازچرخش مواد غذایی محیط اهمیت دارند
- با تقسیم ساده دوتایی تولید مثل می‌کنند
- معمولاً سریع‌تر از سلول‌های یوکاریوتی تولید مثل می‌کنند





Eukaryotic Cell

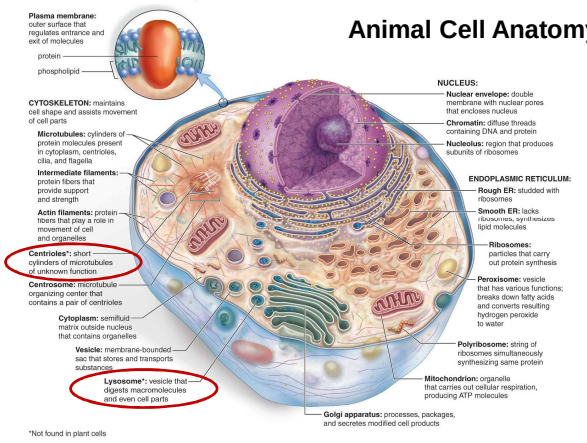
Most kinds of living organisms

- Protozoans
- Algae
- Fungi
- Plants
- Animals

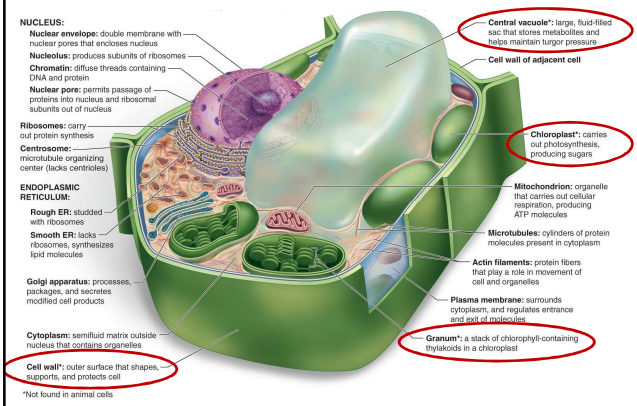
Eukaryotic Cells

1. سلول‌های یوکاریوتی سومین دومین از سلول‌ها هستند
2. داشتن فیبرهای پروتئینی اسکلت سلولی، که شکل سلول را حفظ می‌کنند
3. داشتن هسته محصور در غشا که کروموزومها درون آن قرار دارند (یک یا چند جفت کروموزوم)
4. تولید مثل آنها جنسی یا غیرجنسی است
5. دارای اندامکهای (Organelles) محصور در غشا هستند
   - این اندامکها در سیتوپلاسم قرار گرفته و هر یک ساختمان و عمل ویژه ای دارند

Animal Cell Anatomy



Plant Cell Anatomy



Functions of Cells

1. **سلول‌ها واحد اصلی حیات را تشکیل می‌دهند**
2. **بافت و اندامها را تشکیل می‌دهند**
3. **اعمال ضروری بدن را انجام می‌دهند**
   - آنزیم‌ها و سایر پروتئین‌ها
   - انرژی
   - حرکت (سلول‌های عضله)
   - عمل مغز (سلول‌های عصبی)
   - سم زدایی (سلول‌های کبد)
   - دفع مواد زاید (سلول‌های کبدی و کلیه)

مروری بر سلول

- The cell is the basic unit of structure and function in the body.
  - Prokaryote v. Eukaryote
    - Are smaller than eukaryotic cells
    - Lack internal structures surrounded by membranes
    - Lack a nucleus
- There are three principal parts:
  - plasma membrane (plasmalemma)
  - cytoplasm and organelles
  - nucleus..

Organelles of a Typical Cell

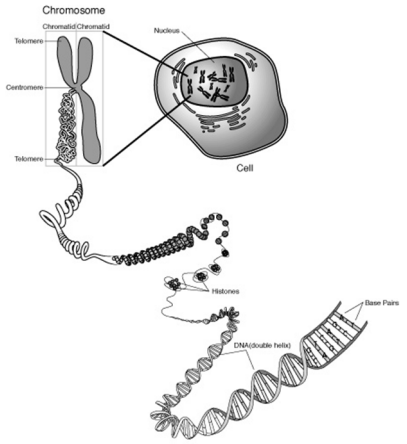
Ribosome	• Production of proteins – located attached to ER or free-floating
Endoplasmic Reticulum (ER) *Rough *Smooth	• Passageway for materials • Produces proteins & processes molecules for secretion • Produces lipids & detoxifies drugs & stores Ca^{++}
Golgi Apparatus	• Packages material for export & processes macromolecules
Vacuole & vesicle	• Storage..

Lysosome	• Contains digestive enzymes. Each contains one specific enzyme.
Chloroplasts	• Carries out photosynthesis: $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$
Mitochondria	• Aerobic cellular respiration: $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + ATP$
Cilia, flagella, microvilli	• Surface projections – increase surface area & produce movement..

The Nucleus Contains the Cell's Genetic Information

Nucleus contains **chromatin,** a network of strands that condenses to form **chromosomes**

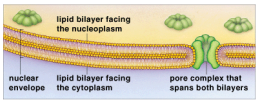
- **Chromosomes** contain DNA which carries genes, the units of heredity



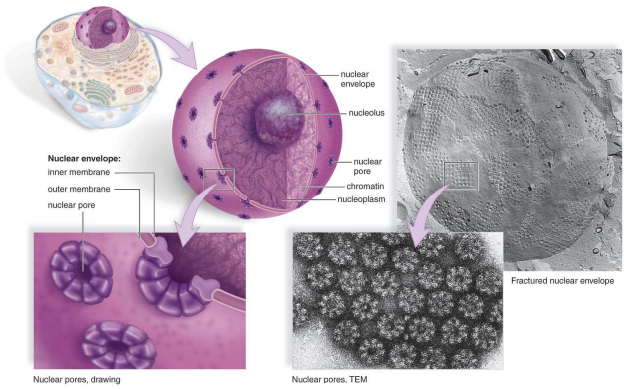
The Nucleus Contains the Cell's Genetic Information

Nucleus contains **chromatin,** a network of strands that condenses to form **chromosomes**

- **Chromosomes** contain DNA which carries genes, the units of heredity
- **Nucleolus** - dark region of chromatin with *ribosomal RNA (rRNA)*
- **Nuclear envelope** separates the nucleus from the cytoplasm, but has **nuclear pores** to permit passage of ribosomal subunits



Anatomy of the Nucleus



Organelles

Endomembrane system:

- Endoplasmic reticulum (smooth and rough)
- Golgi apparatus
- Lysosomes

Energy-related organelles:

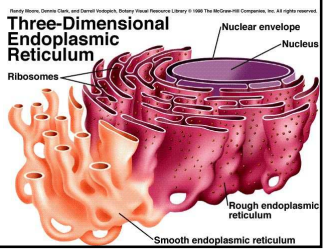
- Mitochondria
- Chloroplasts

Storage organelles:

- Vacuoles
- Leucoplasts

Endoplasmic Reticulum (ER)

- Rough
  - Ribosomes attach
  - Protein synthesis
- Smooth
  - No ribosomes
  - Lipid synthesis
  - Carbohydrate synthesis



Ribosomes

- non-membrane-bound particles
- Synthesize proteins
- On rough ER

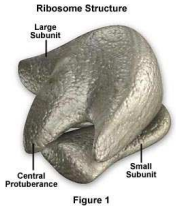
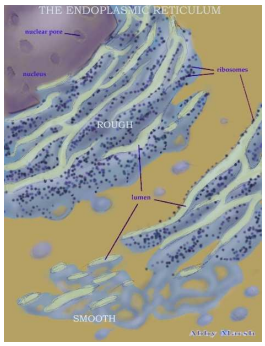
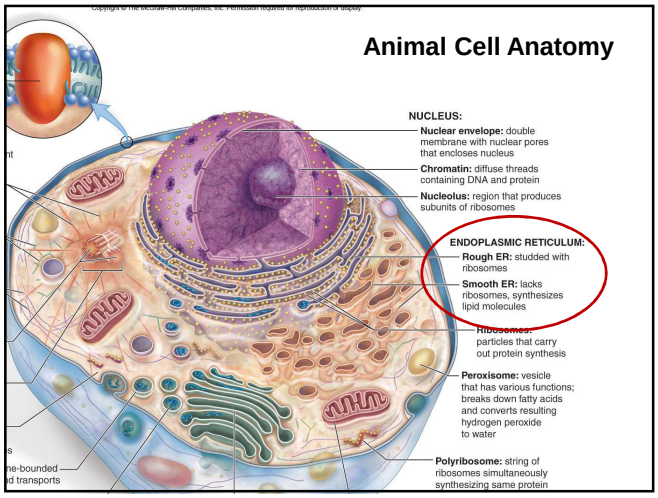
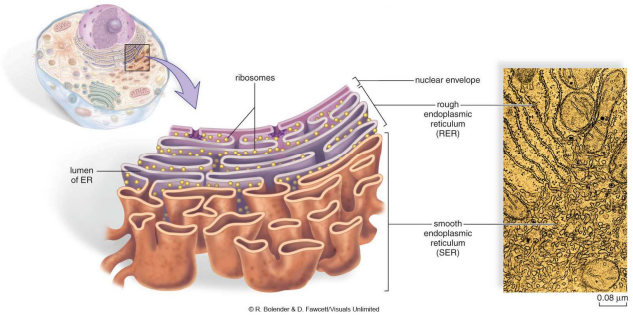


Figure 1

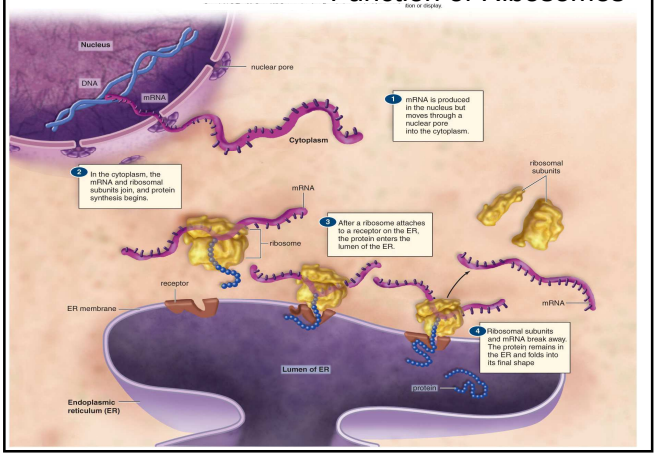




Rough ER (RER) and Smooth ER (SER)



Function of Ribosomes



The Endoplasmic Reticulum Synthesizes and Transports Proteins and Lipids

The ER attaches to the nuclear envelope

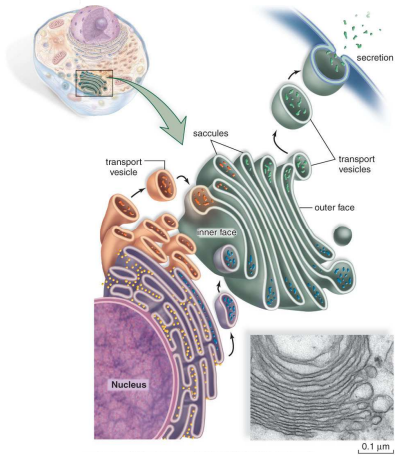
> **Rough ER** is studded with ribosomes that synthesize proteins

> **Smooth ER** lacks proteins and is where lipids are made

Transport vesicles carry proteins and lipids to Golgi apparatus for modification

The **Golgi Apparatus** modifies and repackages proteins for distribution

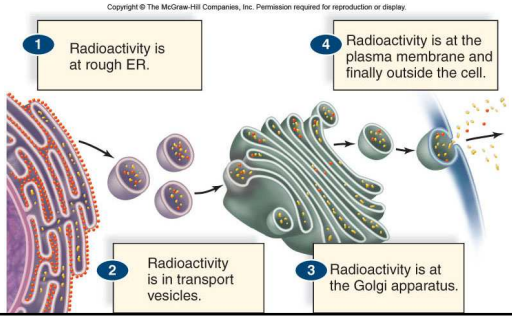
- Golgi Body/Apparatus
  - Package and process proteins & lipids
  - "Warehouse & finishing factory"
  - Receives vesicles from ER → toward cytoplasm
  - Produces vesicles for finished products (proteins and lipids)
    - Vesicles are secreted from the cell membrane via ***exocytosis***



Golgi Apparatus (gray-green) and transport vesicles

Pulse-labeled experiment - placed radioactive amino acids in the rough ER and observes the pathway of protein secretion

Endomembrane system
- Interconnecting membrane system
- Nuclear membrane → Rough ER → Smooth ER → Golgi apparatus → lysosomes/vacuoles → plasma membrane

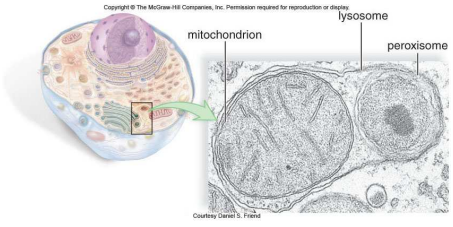


Vesicles

- Vesicles—sacs containing enzymes
  - Lysosomes
    - Intracellular digestion
    - Destroy bacteria in white blood cells
    - Breaks down damaged organelles
  - Peroxisomes
    - Break down fatty acids & proteins
    - Detoxify alcohol & other toxic substances
- Vacuoles—large vesicles for storing food & water
  - Only some eukaryotes

Lysosomes digest macromolecules and cell parts

Lysosomes - membrane-bound vesicles produced by the Golgi apparatus
- Important in recycling cellular material and digesting worn-out organelles
- Tay Sachs disease – when a particular lysosomal enzyme is nonfunctional



Peroxisomes break down long-chain fatty acids

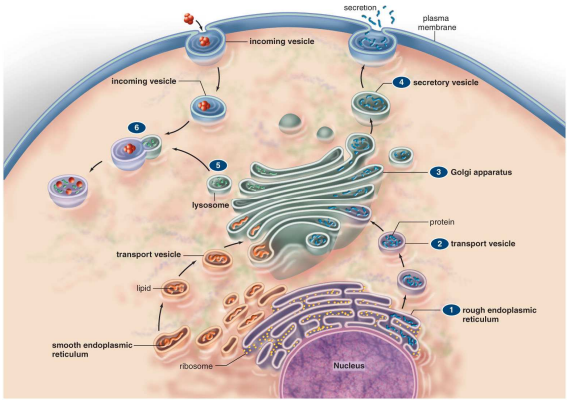
- **Peroxisomes** - small, membrane-bound organelles resembling empty lysosomes
- Contain enzymes to digest excess fatty acids
  > Produces products used by mitochondria to make ATP
- Produce cholesterol and phospholipids found in brain and heart tissue

The Organelles of the Endomembrane System Work Together

Endomembrane System is a series of membranous organelles that work together and communicate via transport vesicles

Includes: ER (rough & smooth)
Transport Vesicles
Golgi Apparatus
Lysosomes

The Organelles of the Endomembrane System

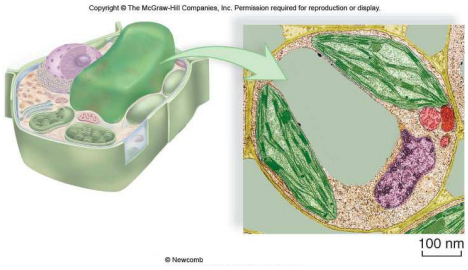


Vacuoles
Various functions in protists and plants

- **Vacuoles –** membranous sacs larger than vesicles and usually store substances
  Examples:
  - toxic substances used in plant defense
  - trap and export waste
  - pH buffers
  - store various small molecules needed by plant
  - 'protein bodied' in seeds
    (needed for germination)

Vacuoles have varied functions in protists and plants

- **Central vacuole** – found in plants, contains
  - watery sap and maintains turgor pressure,
  - Storage (amino acids, sugars, ions, wastes)

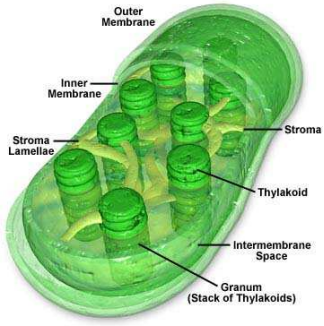


Cells Carry Out Energy Transformations

All actively metabolizing cells carry out energy transformation

Eukaryotes (plants)

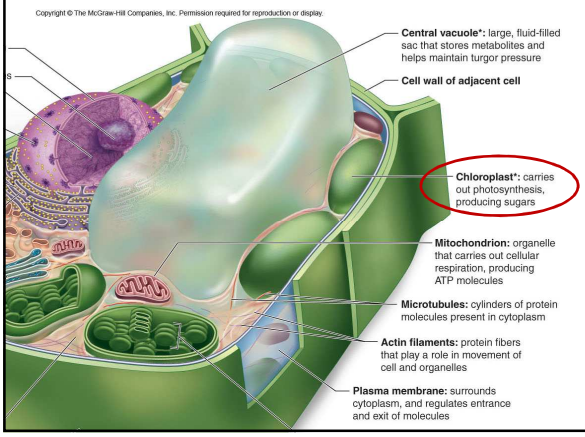
- Plastids
  - Chlorloplasts
    - Photosynthesis (energy from light)
    - Only in plant cells
  - Leucoplasts
    - Store starches, est..
    - Specialized chloroplast
  - Like mitochondria, may be artifact of ancient symbiotic relationship between prokaryotes & eukaryotes



Plastids:

1. Chloroplasts
   - site of photosynthesis
2. Leucoplasts
   - site of energy storage

Plant Cell Anatomy



Chloroplasts capture solar energy and produce carbohydrates

Chloroplasts - type of **plastid,** an organelle bounded by a double membrane with a series of internal membranes separated by a ground substance

Some algae have 1, some plant cells have 100.

Sight of photosynthesis

Leucoplasts are also type of plastid

Different types of **Leucoplasts:**

1. Site for storage of starch (amyloplasts), lipids (oleoplasts), proteins (proteinoplast)
   - Starch stored for energy by plants that do not actively do photosynthesis year round
2. Site for synthesis of amino acids and some lipids

eukaryotes

- Mitochondria
  - Forms ATP (energy) from carbohydrates
  - Requires oxygen
  - Site of cellular respiration
  - Similar to bacteria: have their own DNA & ribosomes
    - May be artifact of ancient symbiotic relationship between prokaryotes & eukaryotes

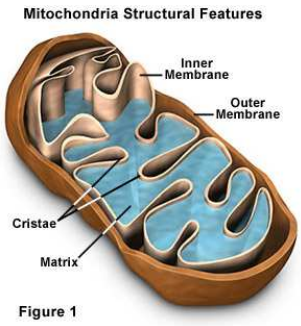


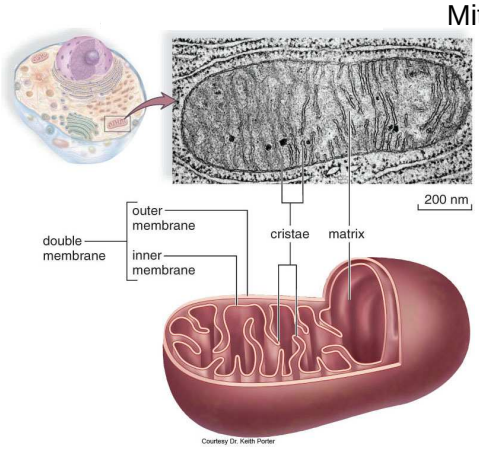
Figure 1

Mitochondria break down carbohydrates and produce ATP

Mitochondria have a double membrane (as do some bacteria)

- Often called the powerhouse of the cell because they produce most of the ATP
- Cells that have high energy requirements (e.g., muscle) have high concentration of mitochondria

Mitochondrion structure



Mitochondria in Muscle Tissue

Mitochondria also contain DNA (mtDNA)
About 16,000 base pairs

Function of this DNA … ???

Perhaps contribute important genes for mitochondrial specific proteins.

Malfunctioning mitochondria can cause human diseases

- Inadequate energy production, cause energy loss of organism
- DNA damage may causes disease

Bi-products of ATP formation can damage mtDNA

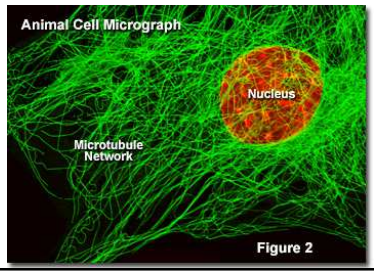
mtDNA mutations can be inherited

Mutations in mitochondrial DNA (mtDNA) have been linked to diseases:

Ex: Parkinsons or Alzheimer patients have more mtDNA mutations

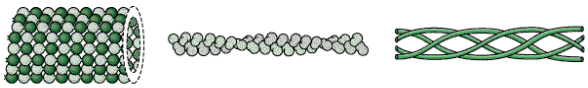
Cytoskeleton

- Maintains Cell Shape (Internal shape & organization) and Assists Movement
- Protein filaments between nucleus & plasma membrane
- Can be permanent or temporary



Cytoskeleton

- Microtubules
  - Keep organelles & cell structures in place or move them
  - Centrioles
  - Compose cilia & flagellae
- Intermediate filaments
  - Ropelike structure
  - Reinforce cell shape
  - Anchor some organelles
  - More permanent than other cytoskeleton
- Microfilaments
  - Thin filaments
  - Help in cell division (contracts midsection)
  - Anchor membrane proteins
  - Help support cell shape
  - Muscle contraction (actin filaments)



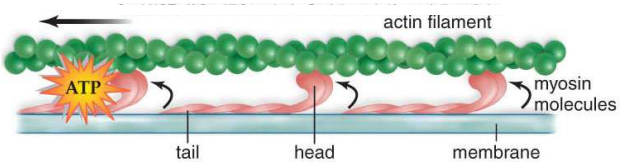
microtubule microfilament intermediate filament

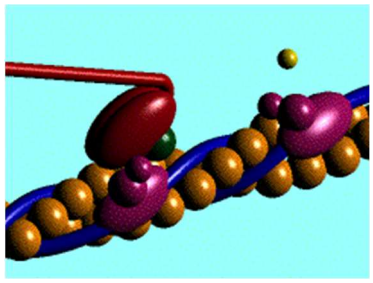
The Cytoskeleton consists of Filaments and Microtubules

Actin Filaments - long, thin flexible fibers in bundled or mesh-like networks

- Play a structure role in the plasma membrane
- Creates **pseudopods** amoebas to crawl

Actin Filaments interact with **motor molecules**; proteins that attach, detach, and reattach causing movement



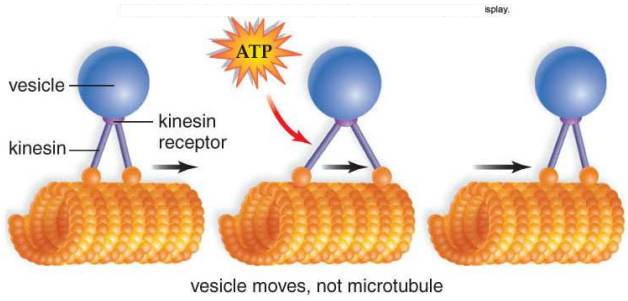


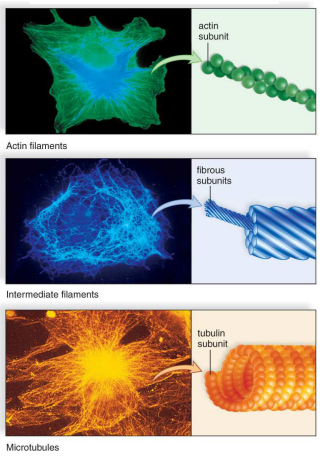
Intermediate Filaments - size between actin filaments and microtubules

> Support nuclear envelope or plasma membrane and are in cell-to-cell junctions

Microtubules – made of globular protein tubulin

> Radiate from centrosome and maintain cell shape and create tracks along which organelles move

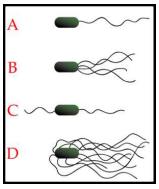


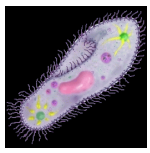


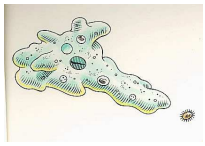
The three types of protein components of the cytoskeleton

Movement

- Motor proteins move things within cells
- Flagella—long outer structures for movement
  - Usually only a few
- Cilia—short outer structures for movement
  - Usually many
- Pseudopod
  - "False foot"







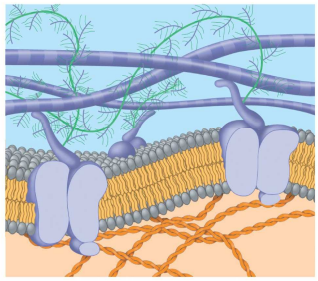
Cilia and Flagella contain Microtubules

Cilia and Flagella - whiplike structures of cells

- Some microbes use them to move
- In our bodies:
  - > cilia remove debris from respiratory tract
  - > move eggs along oviduct
  - > move digest through the digestive tract

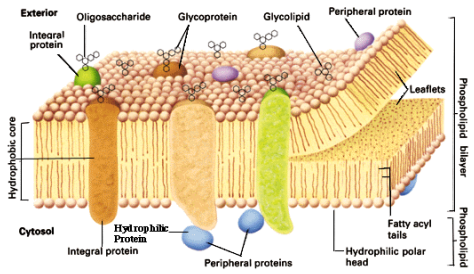
Extracellular matrix

- Structures outside of the plasma membrane
- Holds cells together in tissues
- Protects & supports plasma membrane
- Collagen
  - Glycoproteins
  - Strong fibers



Eukaryote surface

- Plasma (cell) membrane
  - Regulates movement of "stuff" in and out of cell
  - Phospholipid bilayer



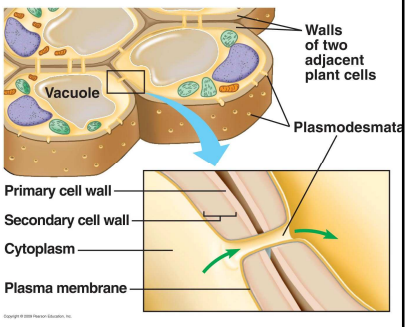
Cells have Many Specializations of Structure for their Particular Functions

- Red blood cells lack a nucleus allowing more room for molecules of hemoglobin, the molecule that transports oxygen in the blood
- Muscle cells are tubular and specialized to contract
- Nerve cells have very long extensions that facilitate the transmission of impulses

In Multicellular Organisms, Cells Join Together

Eukaryote Surface

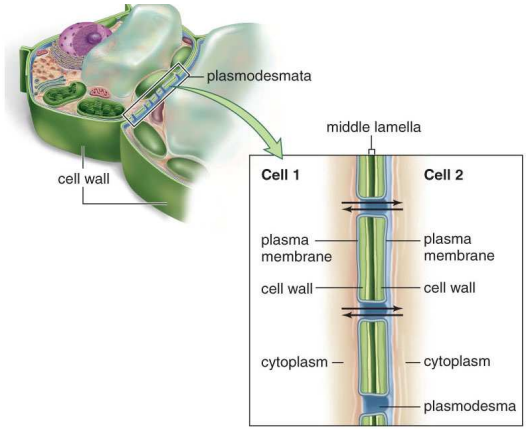
- Cell wall
  - Strong, gives permanent shape to cell
  - Bacteria, protists, fungi, plants
  - Not found in animals
- Plasmodesmata
  - Junctions between plant cell walls
  - Circulation and communication between cells



Plants have a primary cell wall of cellulose microfibrils and a middle lamella of pectin

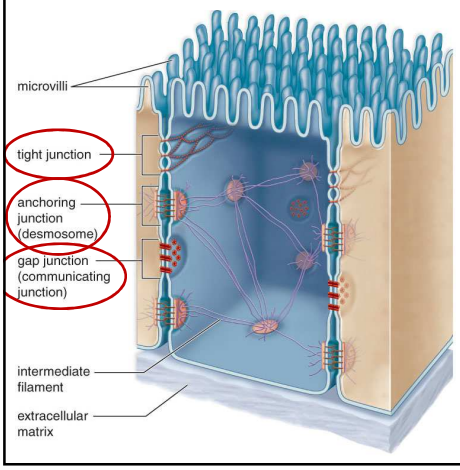
- Channels, **plasmodesma,** connect adjacent cells allowing water and solutes through

Plant cells are joined by Plasmodesmata



Animals cells have junctions between plasma membranes:

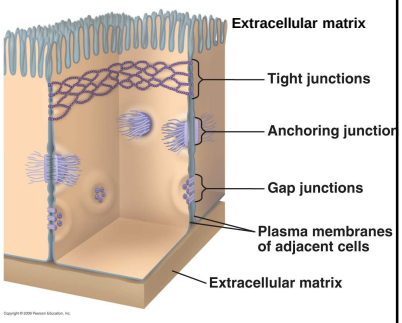
- **Anchoring Junctions** prevent leakage
- **Tight Junctions** seal in digestive juices
- **Gap Junctions** allow cells to communicate



Animal cells are joined by three different types of junctions

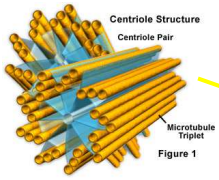
Eukaryote surface

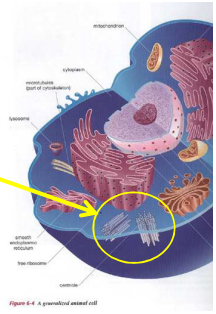
- Animal Cell Junctions
  - Tight junctions
    - Tight seal, prevents leakage of fluids
  - Anchoring junctions
    - Rivets
    - Fasten cells together
  - Gap junctions
    - Channels, pores
    - Allow small molecules to travel between neighboring cells
    - Cell-to-cell communication
    - Nutrient & waste transfer



Eukaryotes (animals)

- Centrioles—produce microfilaments during cell division.





Summary

Eukaryotic cells contain several types of organelles.

Not all eukaryotic cells contain every type of organelle.

Different organelles serve different functions.

Cytoskeleton proteins together with other proteins and carbohydrates serve important roles in motility, transport, cell structure, and tissue integrity.