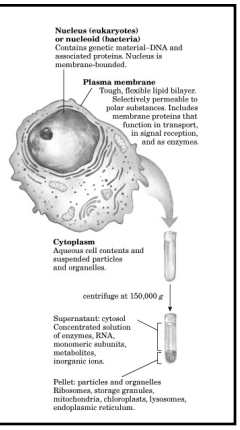
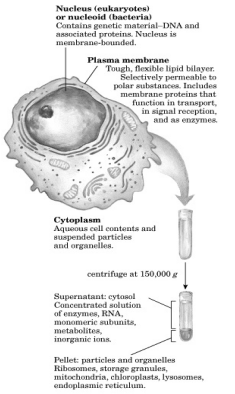
Cells- the functional units of living organisms

- Structural features
  - Plasma membrane
    - Lipid and protein complex
    - Tough, thin, pliable hydrophobic barrier
    - Bars free passage of most inorganic ions (K^+, H^+, etc.)
    - Contains transporter proteins (K^+, glucose, etc.)



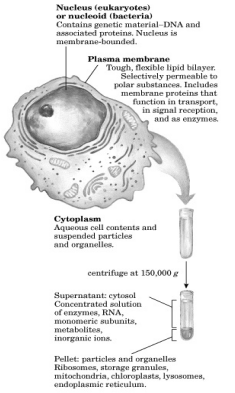
Cytoplasm - the internal cell volume bounded by the plasma membrane

- Two Portions
  - (1) Cytosol
    - Aqueous solution containing enzymes, RNA, metabolites, etc.
  - (2) Organelles
    - Mitochondria, chloroplasts, ER, etc.



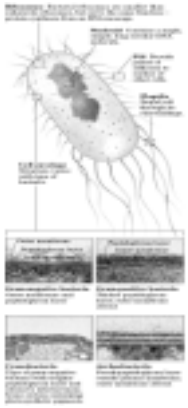
Nucleus (eukaryotes) or Nucleoid (prokaryotes)

- Storage, replication, repair and expression of genetic material (DNA)
- Eukaryotic nucleus is surrounded by a double membrane



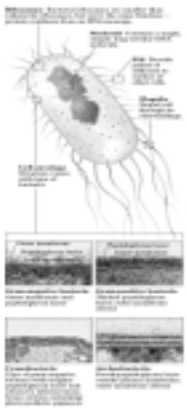
Prokaryotes (Bacterial Cells)

- E.coli features and organization
  - Cell envelope
    - Protective outer membrane
      - Regulates flow of materials
    - Inner plasma membrane
      - Energy metabolism
    - Peptidoglycan layer b/w membranes
      - cross-linked amino acid and carbohydrate polymers



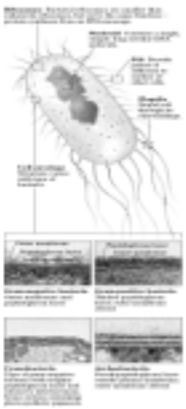
Prokaryotes (Bacterial Cells)

- Pili (short) and Flagella (long)
  - Hair-like protein structures
  - Used for binding to surfaces and propulsion

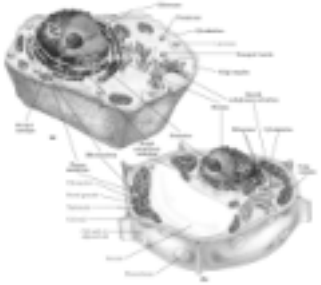


Prokaryotes (Bacterial Cells)

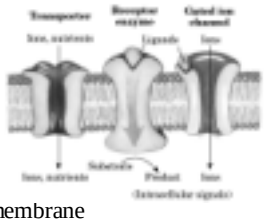
- Cytoplasm
  - Ribosomes (protein synthesis)
  - Enzymes (metabolism, biosynthesis)
  - Ions (H^+, K^+, Na^+, Cl^-, etc.)
- Nucleoid
  - Single circular chromosome (DNA)
  - Associated proteins and RNA
- Plasmids
  - Small, circular DNA molecules
  - Antibiotic resistance



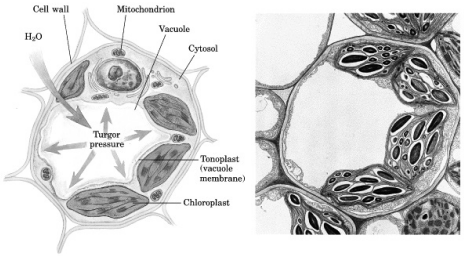
Eukaryotic Cells - 1000's x larger than bacteria



- Major structural features - Nucleus
  - DNA storage, replication, repair and expression
  - Complex structure surrounded by double membrane

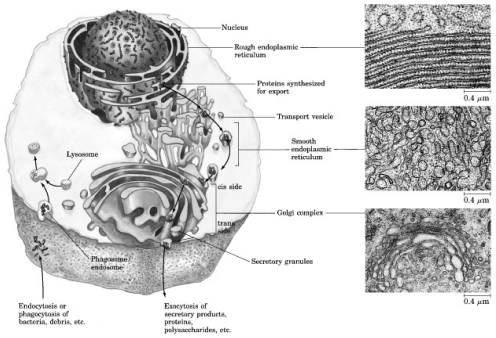


- Plasma membrane
  - Protein and lipid (fat) complex
    - Transporter proteins - import/export of nutrients and waste
    - Signal receptor proteins - respond to external stimuli (hormones, neurotransmitters, etc.)
    - Ion channels - permit exit/entry of specific ions (H^+, K^+, etc.)



Plant cells also have cell walls in addition to plasma membranes; tough protective shells of cellulose and lignin (phenolics)

The Endomembrane system



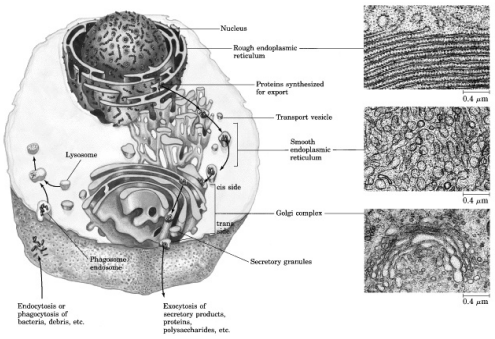
<u>The endomembrane system</u>

- Membrane-enclosed vesicles
- Import/export of proteins and particulate matter
  - (endocytosis/exocytosis)
- Buds form from one membrane system and fuse to another in import/export
- Examples: Endoplasmic reticulum (smooth and rough), Golgi complex, lysosomes, peroxisomes, glyoxysomes (plants)

Rough endoplasmic reticulum (ER)

- Highly convoluted
- Heavy attachment of ribosomes (protein synthesis complexes of protein + RNA)
- Site of modification of nascent proteins destined for export (addition of carbohydrate, lipid, acetyl groups, etc.)

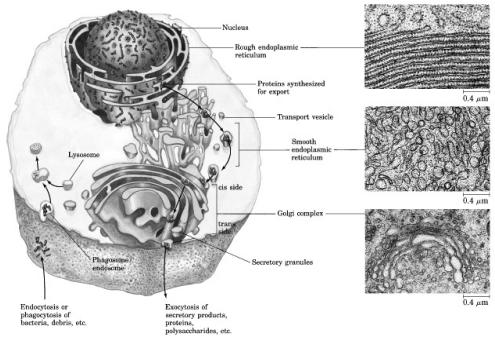
The Endomembrane system - Smooth ER



Smooth Endoplasmic Reticulum

- Physically continuous with Rough ER
- Lacks ribosomes
- Site of lipid (fat) biosynthesis
- Site of certain drug and toxin metabolism
- Ca^{2+} storage (Muscle contraction, enzyme activation)

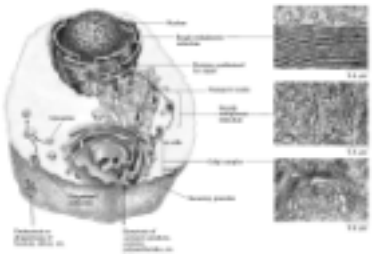
Golgi Complex



Golgi complex

- Stacks of membraneous "sacks"
- "Cis-" and "trans-" nomenclature (face direction)
  - Cis side- faces towards rough ER
  - Trans side- faces plasma membrane of cell
- Contains enzymes which modify proteins for export (add sulfate, carbohydrate, lipid etc. groups)
- Protein modification serves to "address" proteins (organelle destination or export)

Lysosomes



Contain enzymes capable of degrading proteins, polysaccharides, nucleic acids and lipids - monomeric components may be recycled

Unique "safety" feature - pH lower than cytosol - required for enzymatic activity - enzymes inactivated in case of rupture

Other organelles of the endomembrane system

Peroxisomes

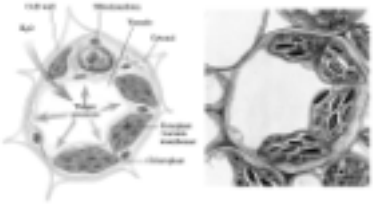
- Specialized enzymes (catalase) which neutralize free radicals (H_2O_2, etc.) - reactive metabolic byproducts

Glyoxysomes (Plants)

- Glyoxylate cycle enzymes
  - Convert fats to carbohydrate

Lysosomes, peroxisomes and glyoxysomes are referred to as "microbodies"

Vacuoles (Plants)

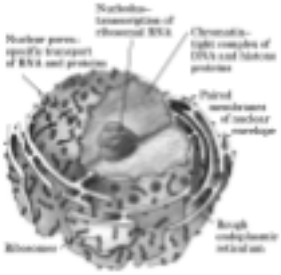


- Functions similar to lysosome
- pH difference with cytosol
- Pigments (flower color)
- Physical support -Turgor pressure

Nucleus - Storage and expression of the genome

Nuclear envelope - two membane bilayers
- Continuous with rough ER

Envelope pinched to form pores
- Movement of specific proteins and RNA

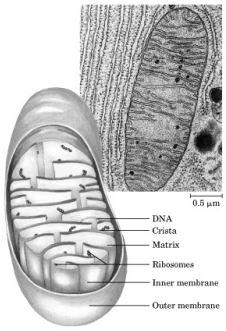


Nucleus filled with chromatin

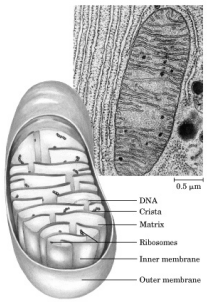
- Diffuse association of protein and DNA
  - DNA (-) wound tightly around Histone protein (+)
  - Nucleosomes (DNA + Histones)
  - Ordered, not random association
- Chromatin fibers condense further into looped regions
- Usually invisible
- Dense condensation prior to cell division

Mitochondria - Cellular Power Plants

- Each mitochondrion has 2 membranes:
  - Outer, unwrinkled surrounding membrane
  - Inner, convoluted membrane. Infoldings (christae) provide more surface area for enzymatic reactions



Inner membrane surrounds the matrix - concentrated solution of enzymes involved in energy metabolism



Chemical energy released in mitochondria used to generate ATP, The biological "currency" of chemical energy

Unlike other organelles, new mitochondria are produced by division from "mother" organelles

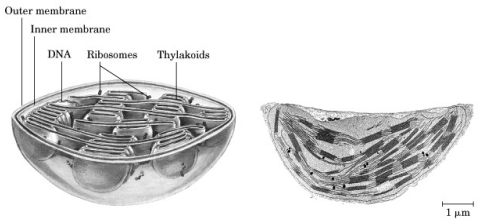
Each mitochondria contains its own DNA, RNA and ribosomes (protein synthesis)

However, these are not sufficient to code or produce all the enzymes found in the mitochondrion

Chloroplasts

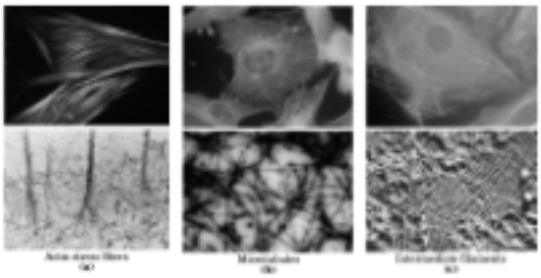
- Photosynthetic cells of plants and algae
- "Powerplants", similar to mitochondria
- Pigment molecules absorb sunlight, transfer energy to molecular machinery for synthesis of ATP and carbohydrates
- High concentration of chlorophyll pigment gives photosynthetic tissue green color

Chlorophyll and other pigments localized in stack of internal membranes (thylakoids)



Like mitochondria, chloroplasts contain their own DNA, RNA and ribosomes

The cytoskeleton



Cell shape, internal organization and motility

The Cytoskeleton

Protein network stabilizes cell shape, organizes cytoplasm and cell motility

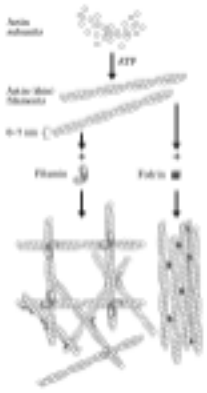
3 types of protein filaments:

- Actin
- Microtubules
- intermediate filaments

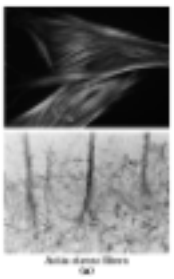
differ in width, composition and specific function

Filaments are formed by the reversible polymerization of protein subunits

Reversible polymerization confers flexibility required for cellular and organelle motility and growth



Actin filaments form cell "frame" by binding to proteins just below the cell surface



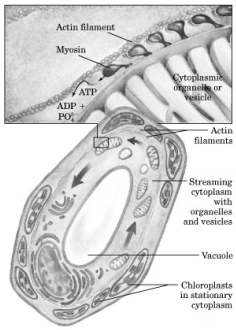
Confers shape and rigidity to the cell surface

Actin filaments can bind to proteins called myosin

Myosin can convert ATP to mechanical work

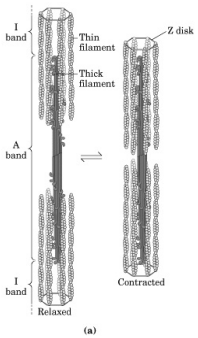
Myosin binds and moves along an actin filament, driven by the breakdown of ATP

Net result: movement of organelles and mixing of cytoplasm (nutrients, O_2, ions, etc.)



Muscle cells are filled with arrays of actin and myosin filaments

Muscle contraction, cilia/flagelae motion, transport of organelles, cytoplasmic streaming all rely on breakdown of ATP for their operation

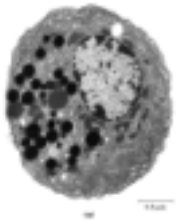


Myosin - thick
Actin - thin

The cytoplasm is crowded, highly ordered and dynamic

- Criss-crossed by a meshwork of structural fibers
- Filaments dissemble and re-assemble
- Complex system of membrane-bound organelles with specific metabolic functions
- Organelles move through cytoplasm along protein filaments
- Membraneous vesicles bud from one organelle to fuse with another on path to export

Endomembrane system of organelles:
-seperates metabolic processes
- increases efficiency of chemical reactions
(pH, concentration of reactants, enzyme isolation)



Positioning of organelles and cytoskeletal filaments is organized and tightly regulated

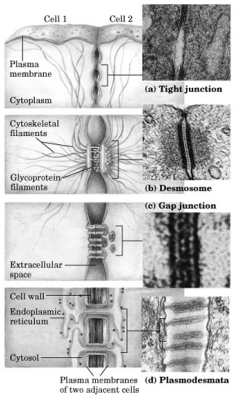
Multicellular organisms

- Advantages
  - Motility
  - Efficiency
  - Reproductive success

Permanent assocications led to specialization:
- Sensory functions (temperature, chemical environment)
- Digestive
- Photosynthetic
- Reproductive
- Etc.

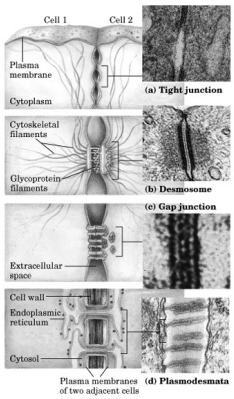
Cellular connections and communication

- Animal cells
  - Tight junctions
    - Close attachment of membranes
  - Desmosomes
    - Fibrous plaques of glycoproteins
  - Gap junctions
    - Small, reinforced openings
    - Allows passage of ions and other small molecules



Cellular connections and communication

- Plant cells
  - Plasmodesmata
    - Similar to gap junctions
    - Path through cell wall and plasma membrane
    - Movement of metabolites and even small proteins



Viruses - parasites of cells

- DNA or RNA genome
  - protective protein or membrane coat
- Non-living outside of host cell (virion)
- Viral genetic message and proteins covert host cell enzymes and resources to production of new viral particles

Viruses can cause cell lysis as they are released
- Pathology associated with viral disease

Some viruses have DNA become incorporated into host cell genome - dormant until conditions are ripe for new particle production

Diverse array of sizes and structures

Often target specific cells (AIDS - T lymphocytes of Immune system)

Study of viruses has provided a great deal of information on DNA and RNA structure, protein synthesis and the mechanisms of gene expression

Summary

- All cells share certain features
  - DNA (genetic information)
  - Ribosomes
    - (RNA and protein complexes for the synthesis of proteins)
  - Plasma membrane
    - Tough, flexible permeability barrier
    - Comprised of lipid and several types of proteins (receptors, transporters and channels)
  - Cytoplasm
    - Cytosol and organelles
      - Cytosol (solution of proteins, RNA, metabolites, ions, co-factors)
      - Organelles (lacking in prokaryotes (bacteria)

Organelles of the endomembrane system

- Nucleus
  - Chromatin: highly organized DNA/protein association
- Rough and Smooth Endoplasmic Reticulum
  - Protein modification for export
- Golgi complex
  - Protein "addressing"
- Lysosomes
  - Degradation of proteins, polysaccharides, nucleic acids
- Mitochondria
  - Cellular "power plants" (production of ATP)

Organelles of the endomembrane system

Specialized plant organelles:

- Vacuoles
  - Degradative reactions, pigments, cell turgor
- Chloroplasts
  - Energy metabilism (ATP synthesis)
- Glyoxysomes
  - Conversion of fat to carbohydrate

Cytoskeleton

- Dynamic network of protein filaments
  - Actin
  - Microtubules
  - Intermediate filaments
- Reversible polymerization confers great flexibility in structure
- Provides shape and aids cellular and organelle movement

Cellular connections and communications

- Strengthen associations within multicellular organisms
  - Tight junctions, desmosomes
- Allow for exchange of materials
  - Gap junctions (animals)
  - Plasmodesmata (plants)

Viruses

- Parasites of living cells
- Non-living outside of host cells
- Subvert cellular machinery and materials for own replication
- Target specific cells
- Responsible for a number of serious diseases in plants, animals and humans