# Chapter 4

# Inside the Cell

## Cytology

- Study of cells
- Cell – basic unit of life
  - Are extremely diverse
  - Most microscopic
  - Each cell is specialized for a particular function
- Light microscope
  - Invented in 17th century – Robert Hooke
  - Limited view of cell due to properties of light
- Electron microscope
  - Invented in 1930s
  - Overcomes limitation of light by using beam of electrons; however cells will be dead

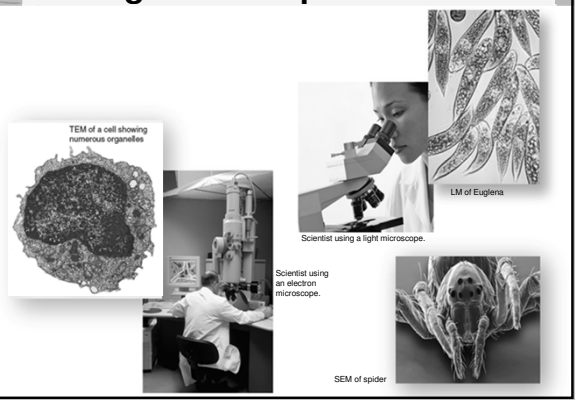
## Tools Used By Biologist

- Microscopes vary in magnification and resolving power.
  - **Magnification** is the ratio of an object's image to its real size. (eyepiece X objective)
  - **Resolving power** is the ability to distinguish 2 points that are close together as 2 separate points.

## Electron Microscopes

- **1. Transmission electron microscopes** (**TEM**) are used mainly to study the internal structure of cells.
- **2. Scanning electron microscopes** (**SEM**) are used to study surface structures.
  - The SEM has an image that seems 3-D

## Using microscopes to see cells




## Why are cells so small?

- Nucleus can only control a small area
- Surface-area-to-volume ratio
  - Need surface areas large enough for entry & exit of materials
  - Small cells have more surface area for exchange.
  - Adaptations to increase surface area
    - Microvilli in the small intestine increase surface area for absorption of nutrients

## Cell theory

- Cells are the basic unit of life
- All organisms composed of cells
- Cells arise from pre-existing cell

## Cell Info

- Largest cells are nerve cells from the giant squid & colossal squid ( 46 feet long)
- Most common example of large cells is ostrich egg
- ALL cells have:
  - A plasma membrane to regulate movement of material
  - Cytoplasm where chemical reactions occur
  - Genetic material for growth and reproduction

## 2 Types of Cells

- **Prokaryotes** – cells without a nucleus and membrane bound organelles, smallest & most abundant cells
  - Domain Archaea & Bacteria
  - **only EX.** bacteria
- **Eukaryotes –** cells with a nucleus and membrane bound organelles
  - **EX.** All life except bacteria

## Cell Differences

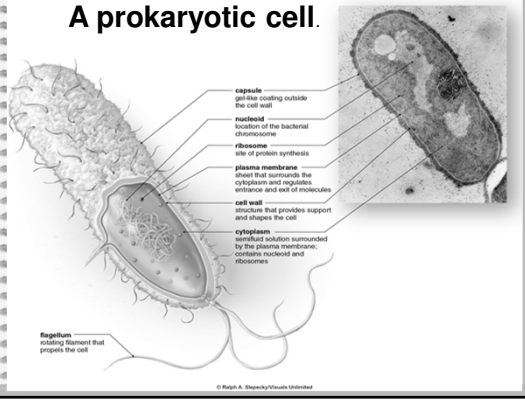
- A major difference between prokaryotic & eukaryotic cells is the location of chromosomes.
- In an eukaryotic cell, chromosomes are contained in a membrane-enclosed structure, the **nucleus.**
- In a prokaryotic cell, the DNA is concentrated in the **nucleoid** w/out a membrane separating it from the rest of the cell.

## Cell Differences

- In eukaryote cells, the chromosomes are contained within a membranous nuclear envelope.
- The region between the nucleus and the plasma membrane is the **cytoplasm**.
- Within the cytoplasm of a eukaryotic cell is a variety of membrane-bounded organelles with a specific function.
  - absent in prokaryotes.



**A prokaryotic cell**.



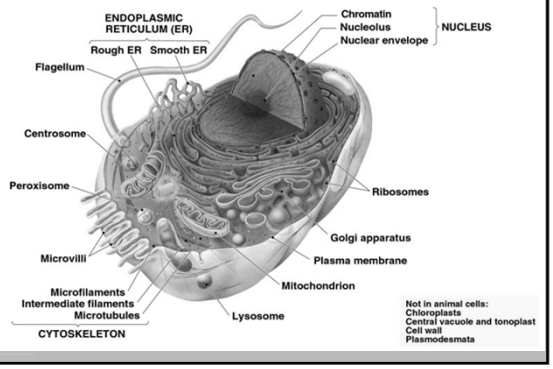
## Bacterial Structures

- Cytoplasm surrounded by plasma membrane & cell wall
  - Sometimes a capsule - protective layer
- Cell wall maintains the shape of a cell
- DNA - single circular chromosome located in nucleoid region - (not membrane enclosed)
- Ribosomes - site of protein synthesis
- Appendages
  - Flagella - movement
  - Fimbriae - attachment to surfaces
  - Conjugation pili - DNA transfer

## Eukaryote Cell Characteristics

- Kingdoms: Protista, Fungi, Plantae, Animalia
- All eukaryotic cells have the following
  - Plasma membranes – outer membrane for protection and support
  - Nucleus – control center
  - Cytoplasm – (cytosol) fluid of the cell
  - Organelles – little organs that have a specific function

## Eukaryotic Animal Cell



## Eukaryotic Plant Cell

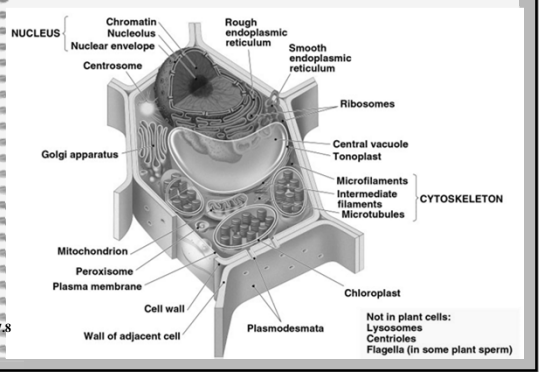



Fig. 7.8

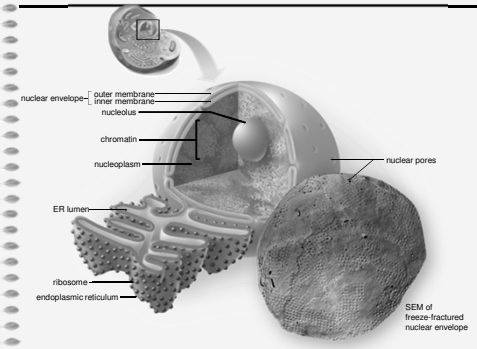
## The nucleus

- **Chromatin** – consist of DNA & proteins and appears as thin strands in the nucleus.
- **Chromosomes** – thick, coiled strand that appear during cell ÷
  - – contains the genes in a eukaryotic cell.
  - – Some genes are located in mitochondria & chloroplasts.
  - – **Somatic cells** have 46 chromosomes
  - – **Gametes** have 23 chromosomes
  - ❖RBC are only **anucleated** cells
- **Nucleoplasm** – fluid material in the nucleus

## The Nucleus

- **Nuclear membrane** or **nuclear envelope**- a double membrane that separates nucleus from the cytoplasm.
- **Nuclear pores** - allows large macromolecules & particles to pass through.
- **Nucleolus** – helps in the production of ribosomes;
  - Cells may have more than 1 (nucleoli);
  - makes **rRNA** (ribosomal RNA)

## Structure of the nucleus



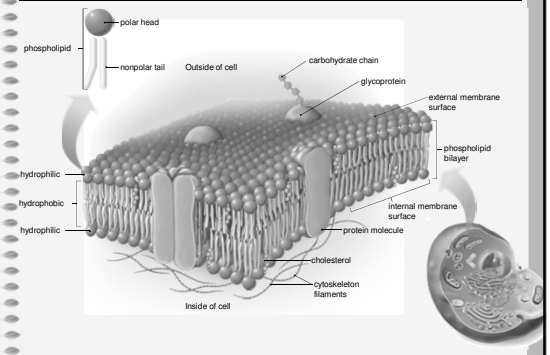

## Eukaryote Cell Characteristics

- The **plasma membrane** functions as a selective barrier that allows passage of oxygen, nutrients, and wastes for the cell.
- Consist of a double layer of **phospholipids** and other diverse **proteins**.

## Plasma Membrane

- Marks outer boundary
- Regulates passage in & out of a cell
- Phospholipid bilayer with embedded proteins
  - Polar heads (hydrophilic) phospholipids face into watery medium
  - Nonpolar tails (hydrophobic) face each other
- Fluid-mosaic model—the structure of the plasma membrane

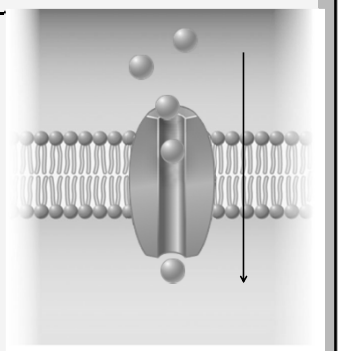
## Model of the plasma membrane




## Functions of Membrane Proteins

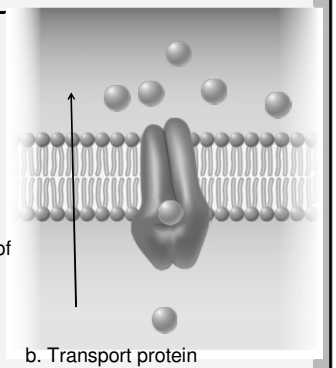
- Channel Proteins
- Transport Proteins
- Cell Recognition Proteins
- Receptor Proteins
- Enzymatic Proteins
- Junction Proteins

- Channel proteins
  - Form tunnel for specific molecules



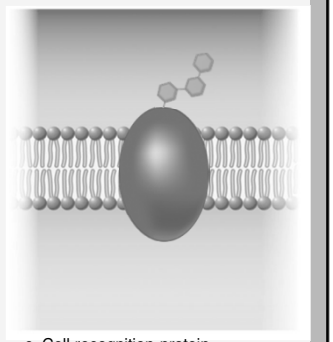
a. Channel protein

- Transport proteins
  - Passage of molecules through the membrane, sometimes requiring input of energy



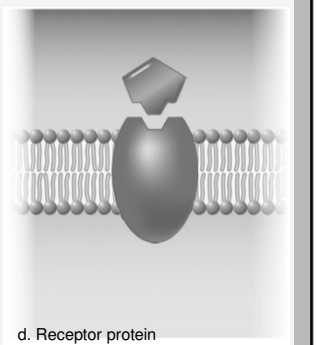
b. Transport protein

- Cell recognition proteins
  - Enables our body to distinguish between our own cells and cells of other organisms



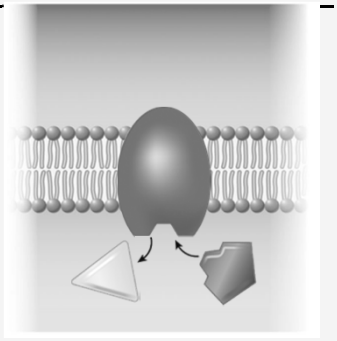
c. Cell recognition protein

- Receptor proteins
  - Allow signal molecules to bind, causing a cellular response



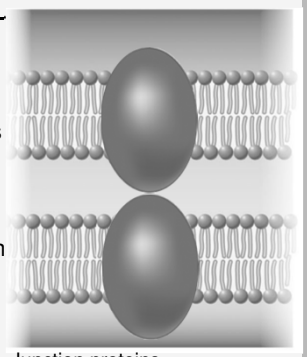
d. Receptor protein

- Enzymatic proteins
  - Directly participate in metabolic reactions



e. Enzymatic protein

- Junction proteins
  - Form junctions between cells
  - Cell-to-cell adhesion and communication



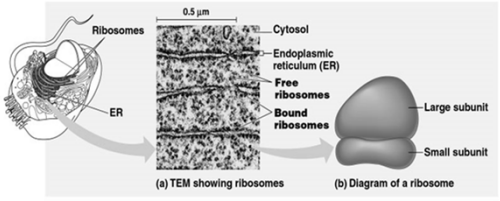
f. Junction proteins

## Introduction to Organelles

- Many of the organelles in a eukaryotic cell are part of the **endomembrane system**.
- These membranes are either in direct contact or connected via transfer of **vesicles**, (sacs).
- The endomembrane system includes the **nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, vacuoles, & the plasma membrane**.

## Organelles

- **Ribosome** is composed of two subunits that combine to carry out protein synthesis.
- Can be attached to the ER or free in the cytoplasm.



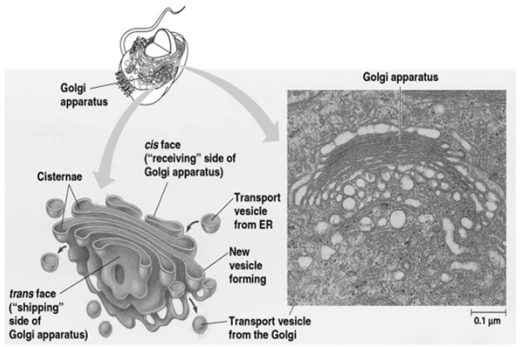

## Organelles

- The **endoplasmic reticulum** (**ER**) accounts for half the membranes in a eukaryotic cell.
- Includes membranous tubes for the transport of material
- 2 types of ER
  - **Smooth ER** lacks ribosomes.
    - synthesize lipids, (oils, phospholipids, & steroids)
    - rich in enzymes; plays a role in a variety of metabolic processes
  - **Rough ER** ribosomes are attached to the outside,. Transports materials

## Organelles

- The **Golgi apparatus** - modifies, stores, sorts, and ships materials made by the cell.
- Consists of flattened, curved membranous sacs.
- Materials are released in membrane bound packages called **vesicles.**
- Many vesicles from the ER travel to the **Golgi apparatus** for modification of their contents.

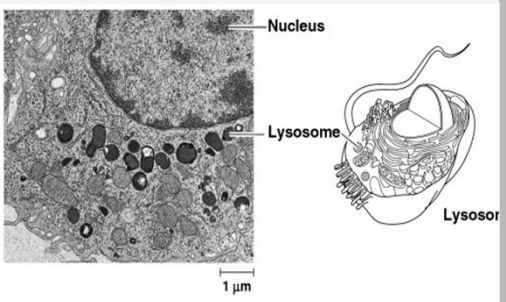
## Organelles




## Organelles

- **Lysosome** is a sac of hydrolytic enzymes that digests macromolecules.
- Massive leakage from lysosomes can destroy a cell by auto-digestion
- Some diseases affect lysosomal metabolism.
  - Individuals lack a functioning hydrolytic enzyme.
  - Pompe's disease in the liver(can't break down glycogen)
  - Tay-Sachs disease in the brain(can't break down lipids).

## Organelles




(a) Lysosomes in a white blood cell

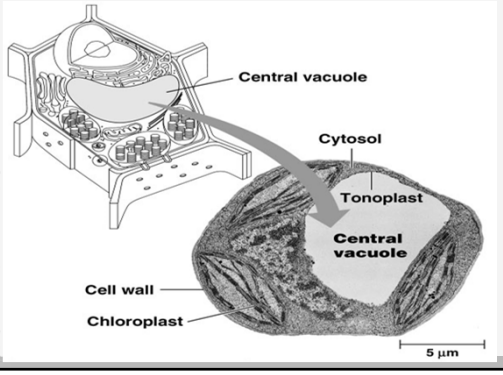
## Organelles

- **Peroxisomes** contain enzymes that break down toxins by transferring **H** from various substrates to **O**. Creates hydrogen peroxide ($H_2O_2$).
  - The peroxisome has another enzyme that converts $H_2O_2$ to water.
  - Detoxify alcohol and other harmful compounds.

## Organelles

- **Vacuoles** are membrane-bound sacs with varied functions such as storing water, food or waste. Larger than vesicles
  - **Food vacuoles** -fuse with lysosomes to digest food.
  - **Contractile vacuoles** - pump excess water out of the cell.
  - **Central vacuoles** -largest structure in plant cell. Stores water & other metabolic byproducts

## Organelles



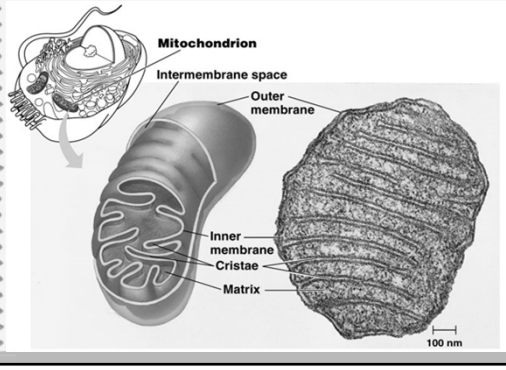
## Organelles

- Inside the chloroplast is a fluid-filled space, the **stroma**, in which float sacs containing chlorophyll, the **thylakoids**.
  - The stroma contains DNA, ribosomes, and enzymes for photosynthesis.
  - The thylakoids are stacked into **grana** and are critical for converting light to chemical energy.

## Organelles

- **Mitochondria** - site of cellular respiration, ATP produced from the catabolism of sugars, fats, and other fuels in the presence of **O**.
- Have small quantities of DNA
- Mitochondria have folded inner membrane, the **cristae**.
  - increases surface area for the enzymes that synthesize ATP.

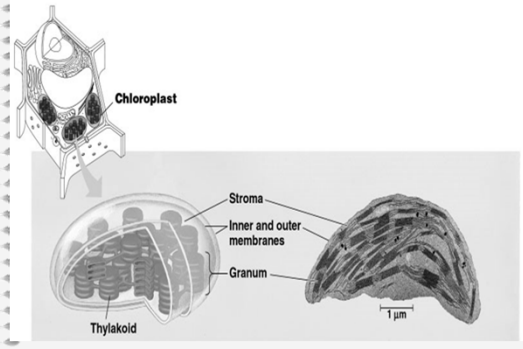
## Organelles



## Organelles

- **Plastids** – organelles found only in plant
  - **Chloroplast -**site of photosynthesis. They convert solar energy to chemical energy and synthesize glucose from $CO_2$ and $H_2O$.
  - **Amyloplasts** or **Leucoplast -** store starch in roots & tubers.
  - **Chromoplasts** -store accessory pigments for fruits & flowers.

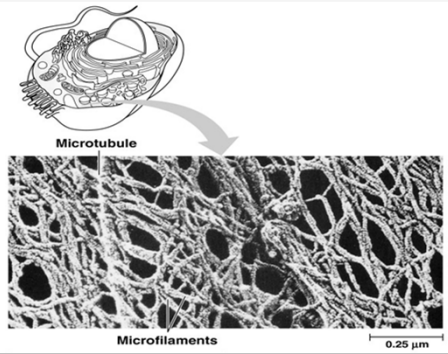
## Organelles




## Organelles

- The **cytoskeleton** is a network of fibers extending throughout the cytoplasm.
- Provides support & maintains shape for cell.
- Plays a major role in cell motility.
- There are 3 types of fibers in the cytoskeleton: **microtubules**, **microfilaments**, & **intermediate filaments**.

## Organelles - cytoskeleton

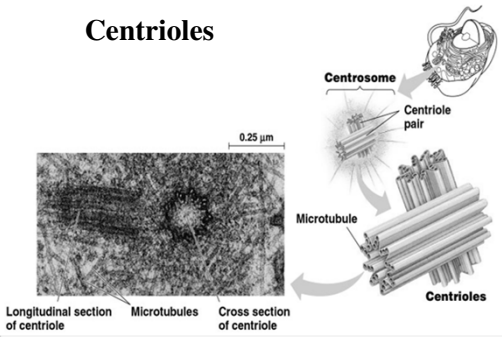



## Organelles

- **Microtubules**, thick, hollow tubes made of tubulin
- Give support & helps maintain cell shape
- Move chromosomes during cell ÷.
- In animal cells, the **centrosome** has a pair of **centrioles**, each with 9 triplets of microtubules arranged in a ring.
- Microtubules form **cilia** and **flagella**.
  - Cilia – short; large numbers on cell membrane
  - Flagella – long; few attached to cell membrane

## Organelles

**Centrioles**



## Organelles

- **Microfilaments**, the thinnest, are made of **actin**.
- Microfilaments divide the cytoplasm of animals cells during cell ÷.
- They cause **cytoplasmic streaming**- circular flow of cytoplasm in the cell.
  - This speeds the distribution of materials within the cell.

## Organelles

- **Intermediate filaments**, are made up of different keratins.
- They reinforce cell shape and fix organelle location.
  - Ex. Keep nucleus in the center of the cell

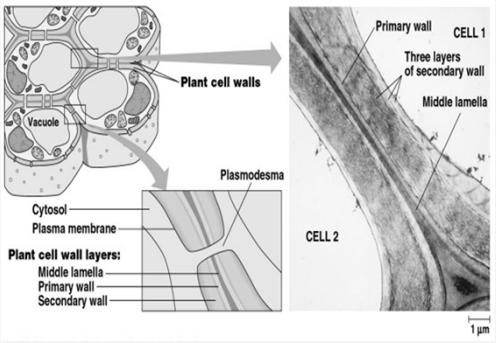
## Outside the Eukaryotic Cell

- The **cell wall**, found in prokaryotes, fungi, & algae, has multiple functions.
- In plants, the cell wall protects the cell, maintains its shape, supports the plant against the force of gravity, & prevents excessive uptake of water.
- The chemical composition of cell walls differs from species to species.
  - Plants - cellulose
  - Fungi - chitin
  - Algae - varies

## Plant Cell Wall

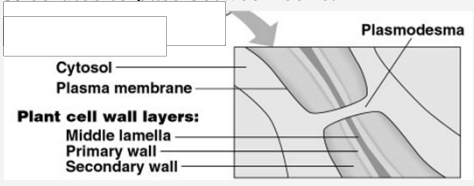
- **Cell wall** consists of cellulose embedded in a matrix of proteins & other polysaccharides.
- A mature cell wall consists of a **primary cell wall,** a **middle lamella** with sticky polysaccharides that holds 2 cells together, and layers of **secondary cell wall.**

## Plant Cell Wall




## Plant cell Walls

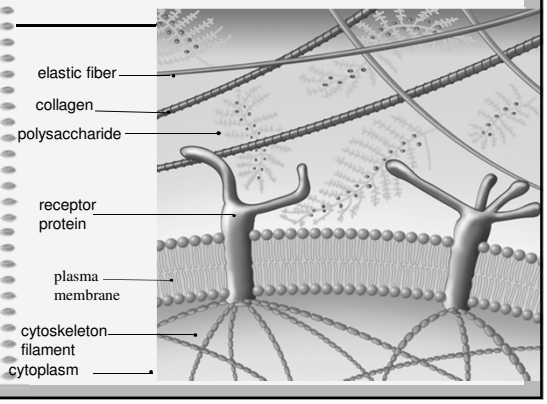
- Neighboring cells interact & communicate through direct physical contact.
- Plant cells are perforated with **plasmodesmata**, channels allowing cysotol & solutes to pass between cells.



## Exterior Surfaces in Animal Cell

- Extracellular Matrix – network of proteins fibers & polysaccharides just outside the cell membrane
  - Collagen & elastin allow for flexibility of cell

## Animal cell extracellular matrix



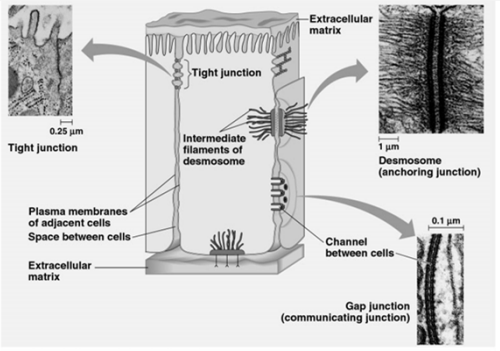

## Exterior Surfaces in Animal Cell

- Animal have 3 types of intercellular links: **tight junctions, desmosomes, & gap junctions**.
- **Adhesion junctions** fasten cells together into strong sheets. (Rivets)
  - Prevent cells from being pulled apart
    - EX. Muscles & skin
- In **tight junctions**, membranes of adjacent cells are fused. (Zipper)
  - This prevents leakage of extracellular fluid.
    - EX. Intestinal cells

## Exterior Surfaces in Animal Cell

- **Gap junctions** provide channels between adjacent cells. Allows cells to communicate
  - Special membrane proteins,called **Connexons,** surround these pores.
  - Salt ions, sugar, amino acids, and other small molecules can pass.
  - Ex. Embryonic cells, heart, smooth muscle

## Organelles




## Summary

- While the cell has many structures with specific functions, they must all work together.
- The enzymes of the lysosomes & proteins of the cytoskeleton are synthesized at the ribosomes.
- The information for these proteins comes from genetic messages sent by DNA in the nucleus to the ribosomes.
- All of these processes require energy in the form of ATP, most of which is supplied by the mitochondria.