Cell Structure & Components

Introduction to Cells

- Cells – the smallest units capable of carrying out life functions using. . .
  - Organelles – “little organs” – carry on essential functions of cells
  - Enzymes – direct chemical reactions in cells which mediate metabolic events within a cell.

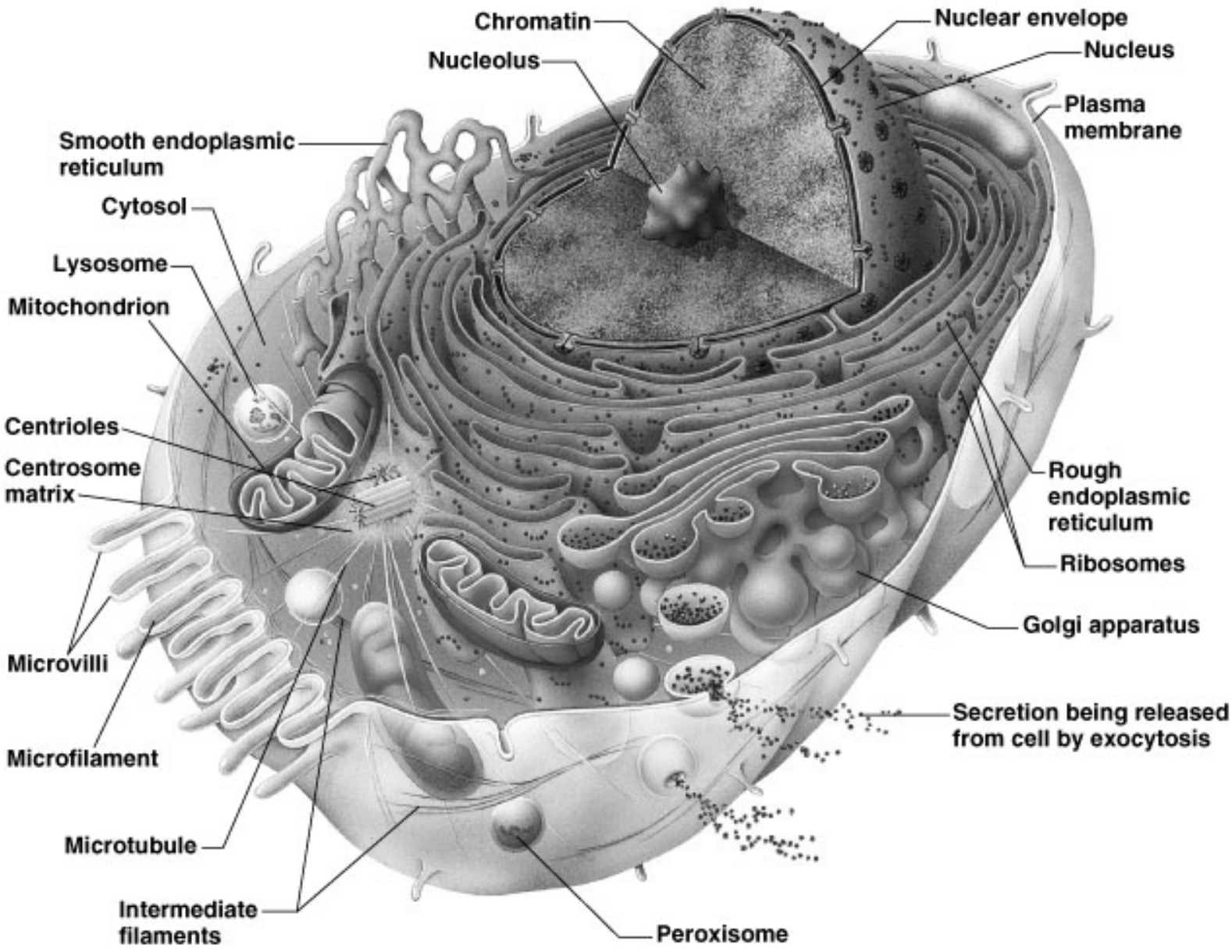
    Metabolism – the sum of all chemical reactions in the cell, may be anabolic or catabolic
  - The organelles, proteins and enzymes present (due to gene expression) determine a cells structure and function
  - About 210 distinct cell types in the human body

Introduction to Cells

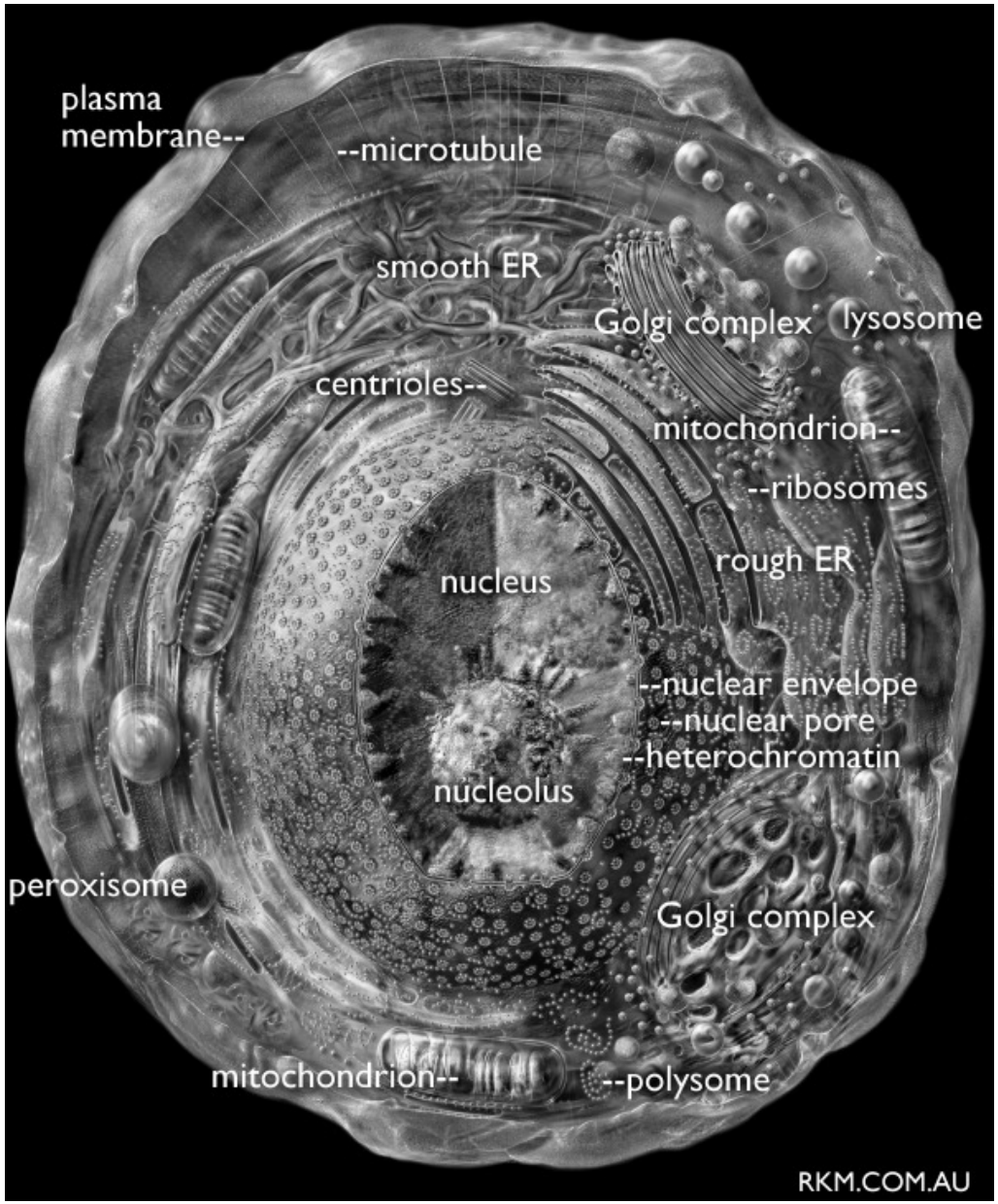
Cells have three main components

1. Plasma membrane
2. Cytoplasm
   A. Organelles
   B. Cytosol
   C. Inclusions
3. Nucleus

Structure of a Generalized Cell

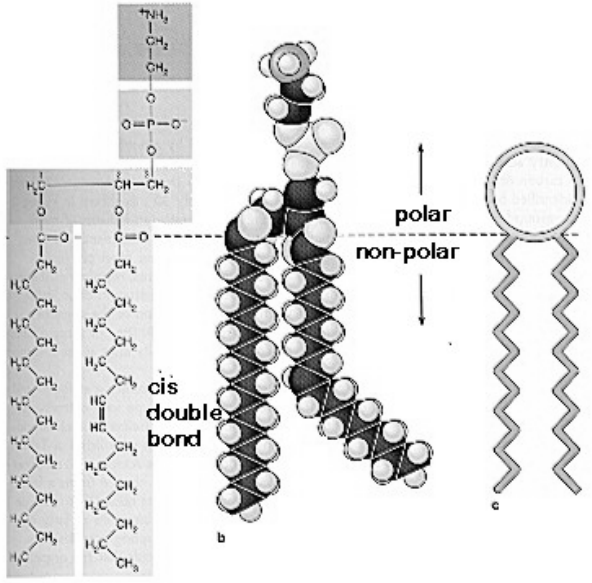


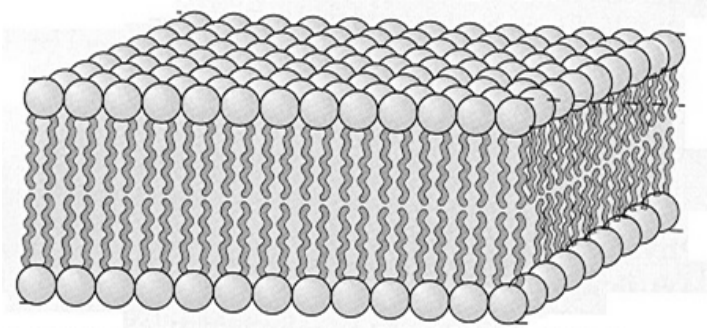
Structure of a Generalized Cell



The Plasma Membrane

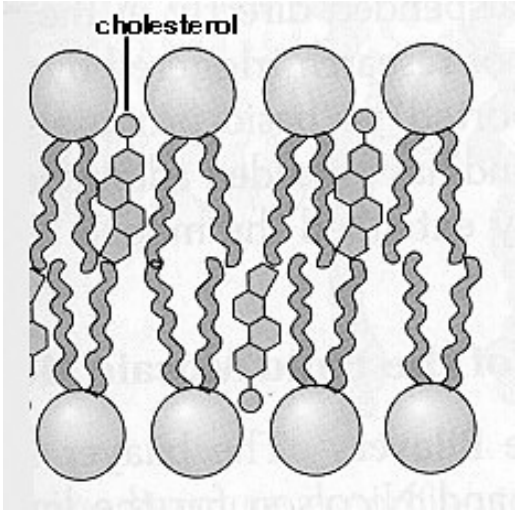
- Structure of membrane
  - Fluid mosaic model contains:
    - Phospholipids – contains both polar & non-polar regions
      - may have glucose chain attached to “head” = glycolipid
      - Glycolipids and glycoproteins form the glycocalyx of a cell.
      - The phospholipids will arrange in a tail-to-tail configuration due to the amphipathic nature of the molecule.



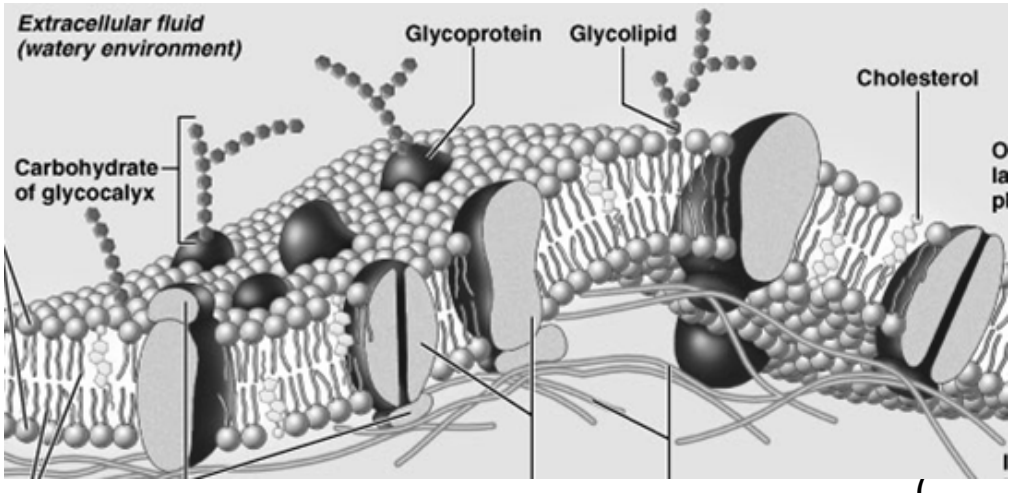


Plasma Membrane cont...

- Cholesterol – provides two important functions due to its structural interactions with the tails of the phospholipids
  - The polar region of the cholesterol is attracted to the polar heads of the phospholipids, making the membrane resilient and less permeable
  - while the tail of the cholesterol remains in the tails of the phospholipids and prevent the crystallization of the long hydrocarbon chains



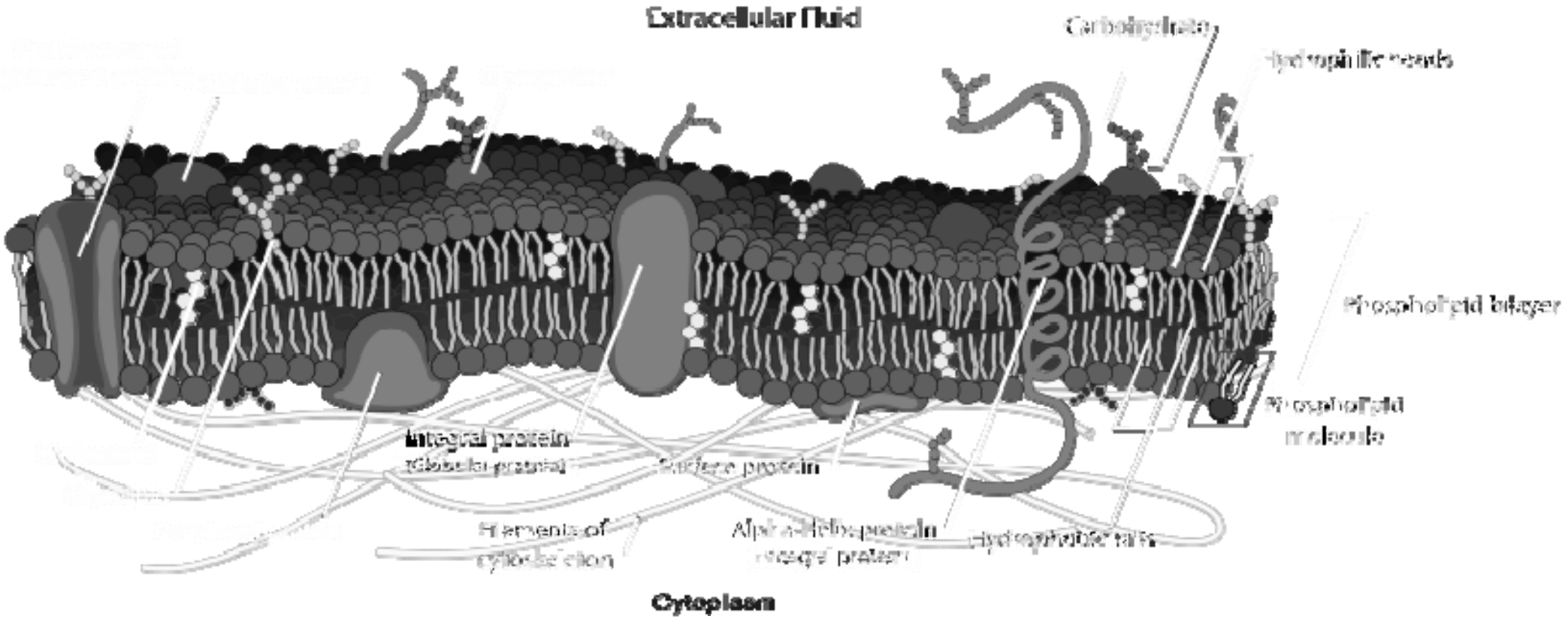
- Membrane proteins
  - Integral proteins – firmly imbedded in, or attached to phospholipid bilayer
  - Peripheral proteins – attach to membrane surface



Plasma Membrane cont...

- The Membrane proteins may have sugars attached to them creating
  - Glycoproteins
    - Receptors, adhesion, hemostasis
- The Lipids may also have sugars attached to them creating
  - Glyoclipids
    - Energy and cell markers (ABO)

Plasma Membrane Surface



The Cytoplasm

- Cytoplasm –
  - lies internal to plasma membrane
  - Consists of cytosol, organelles, and inclusions
- Cytosol (cytoplasmic matrix)
  - Jelly-like fluid in which other cellular elements are suspended
  - Consists of water, ions, and enzymes

Cytoplasmic Organelles

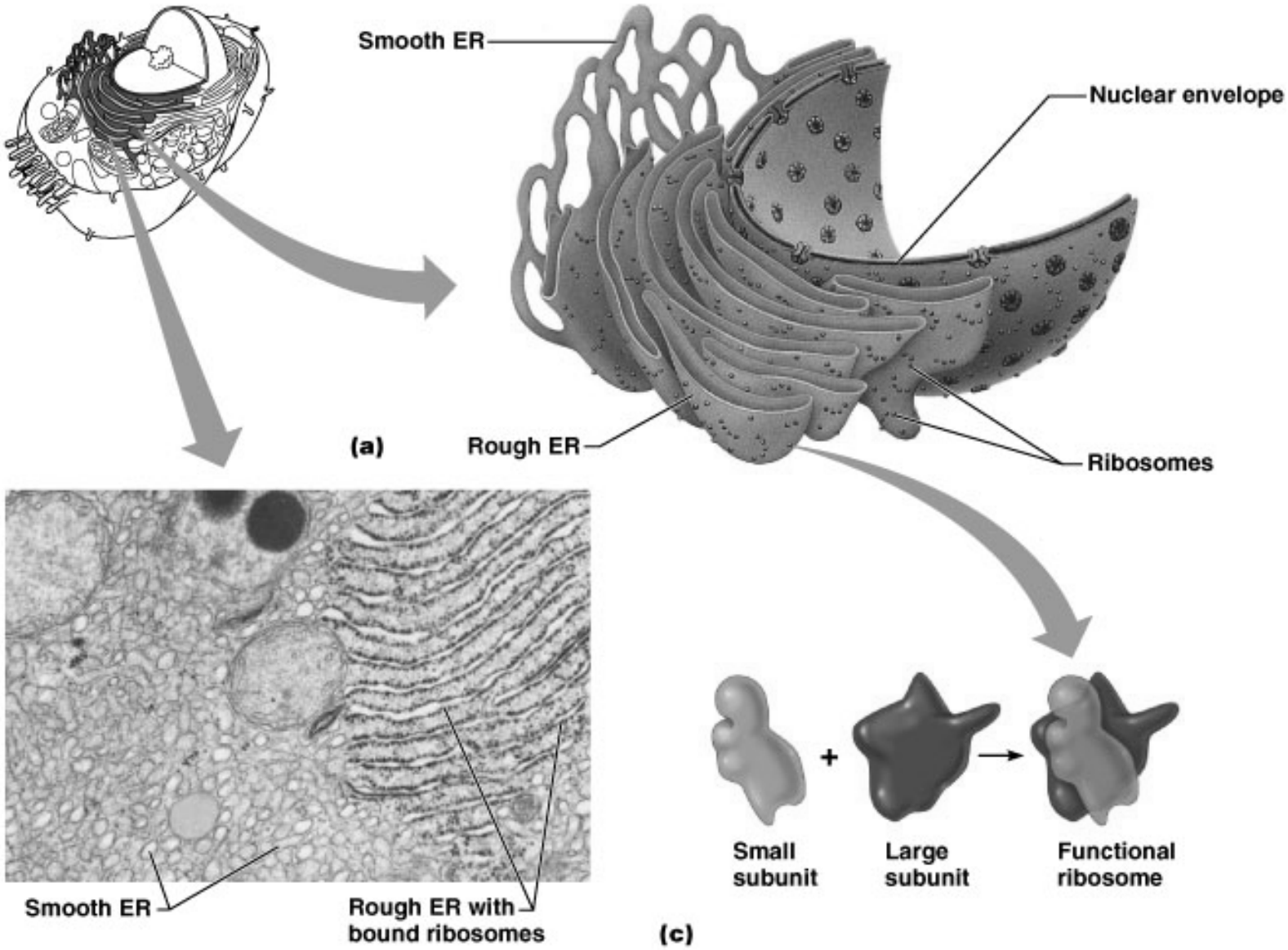
Generally classified as either membrane bound or non-membrane bound

- Membrane Bound Organelles
  - Endoplasmic Reticulum, Golgi Apparatus, Mitochondria, Peroxisomes, Lysosomes, Vesicles
- Non-Membrane Bound Organelles
  - Ribosomes, cytoskeletal components

Cytoplasmic Organelles

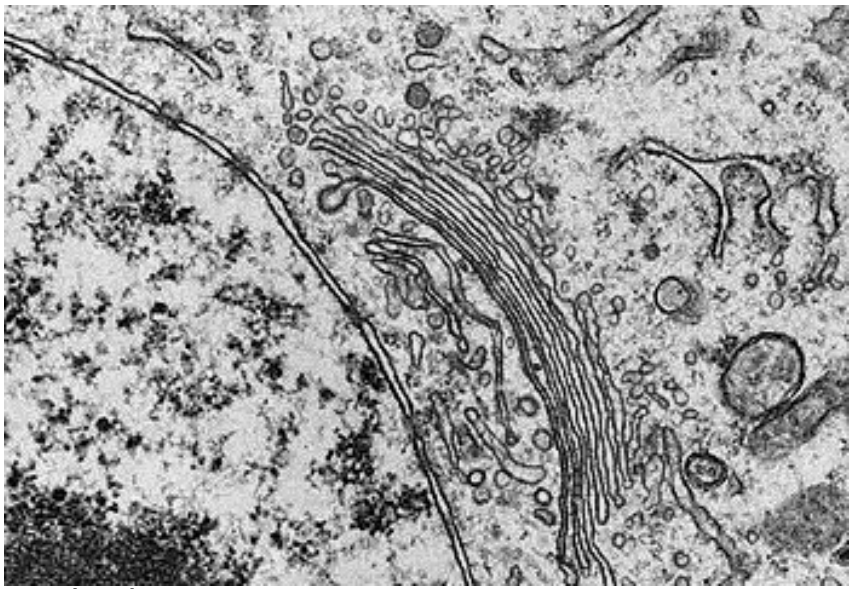
- Endoplasmic reticulum – “network within the cytoplasm”
  - Rough ER – closely associated with the nuclear envelope
    - ribosomes stud the external surfaces
    - Site of protein synthesis
  - Smooth ER – consists of tubules in a branching network
    - No ribosomes are attached; therefore no protein synthesis
    - Site of lipid synthesis

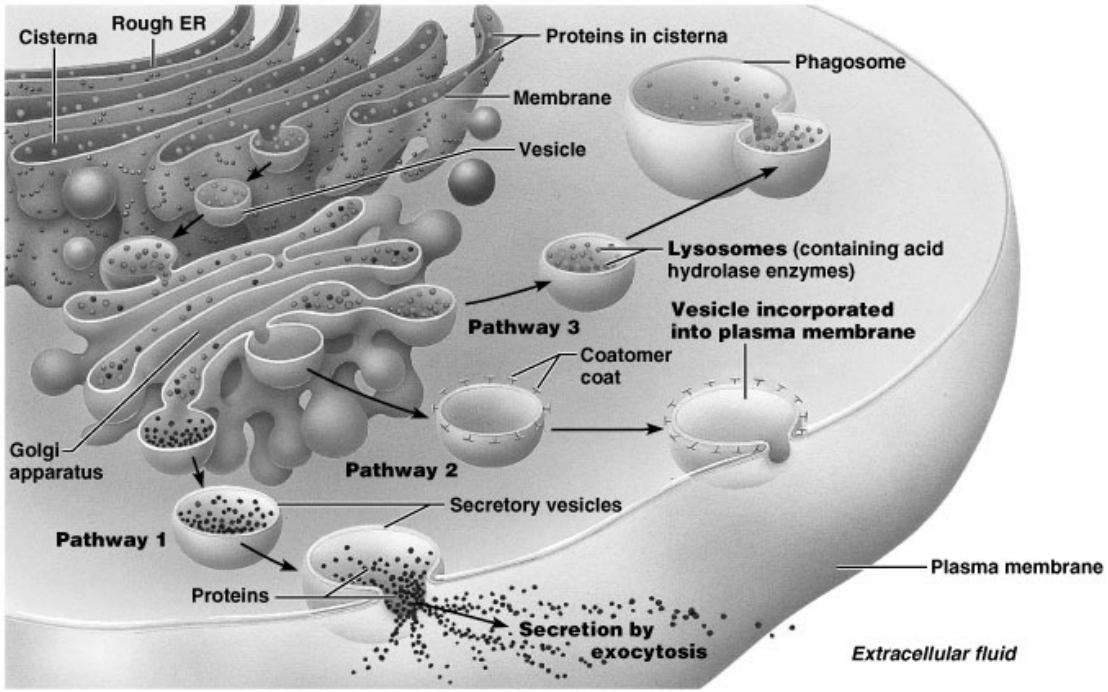
The Endoplasmic Reticulum and Ribosomes



Cytoplasmic Organelles

- Golgi apparatus – a stack of three to ten disk-shaped envelopes
  - Sorts products of rough ER and sends them to proper destination





Mitochondria

- Mitochondria – generate most of the cell's energy; most complex organelle
  - Consists of an outer membrane and a highly convoluted inner membrane
  - Also contains mitochondrial DNA
  - Enzymes present for production of energy (ATP)

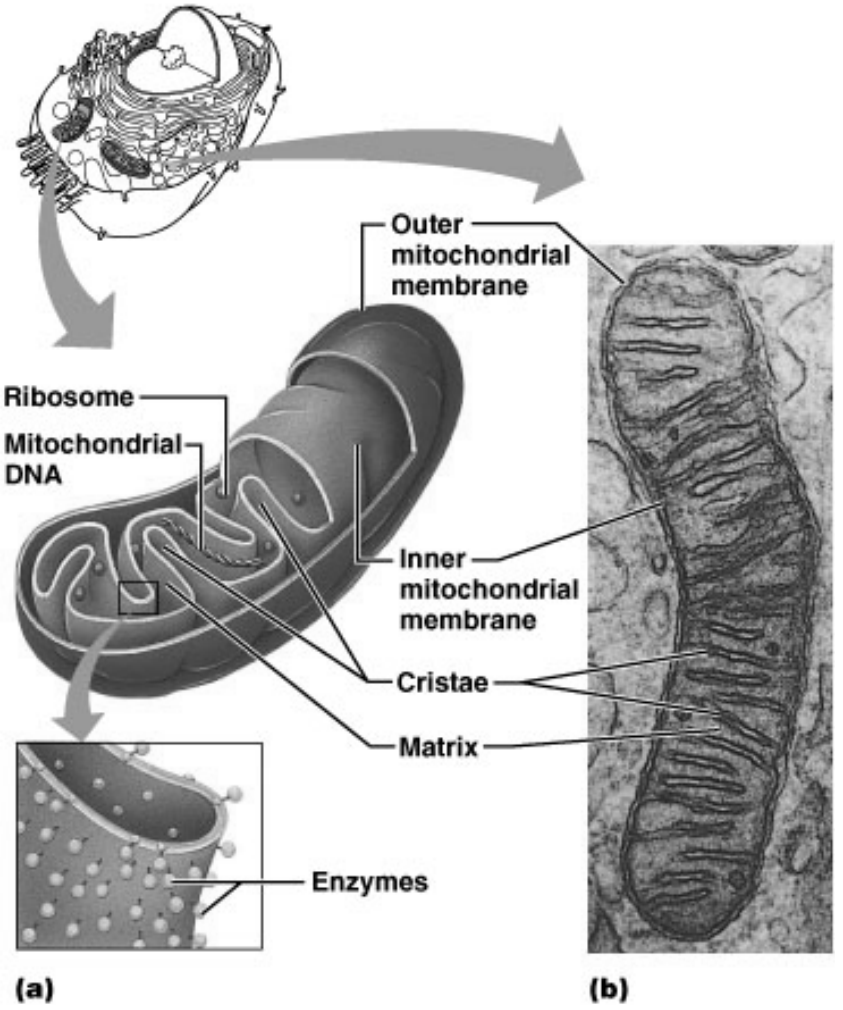


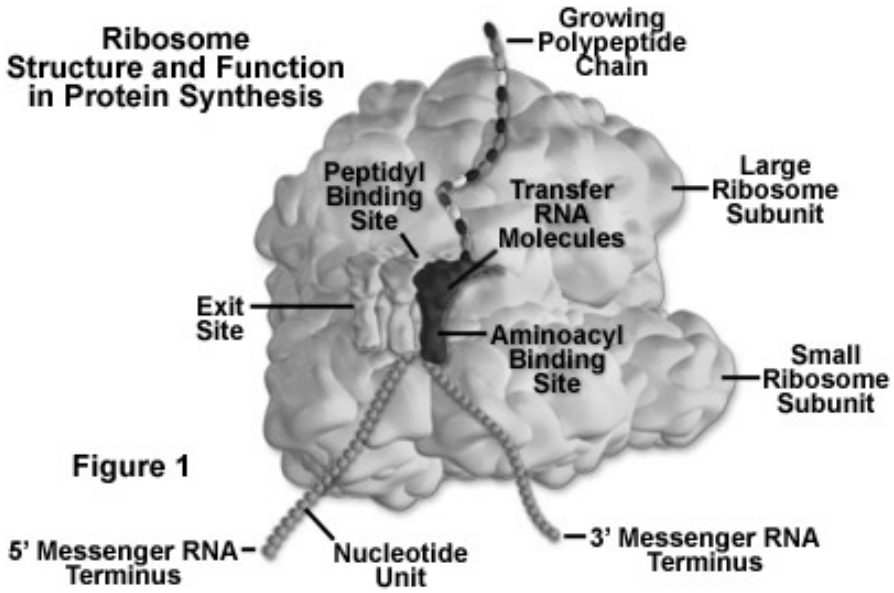
Figure 2.9

Cytoplasmic Organelles

- Lysosomes – membrane-walled sacs containing digestive enzymes
  - Digest unwanted substances
- Peroxisomes – membrane-walled sacs of oxidase enzymes
  - Enzymes neutralize free radicals and break down poisons
  - Break down long chains of fatty acids
  - Are numerous in the liver and kidneys

Cytoplasmic Organelles

- Ribosomes – constructed of proteins and ribosomal RNA
  - Site of protein synthesis
  - May be free in cytoplasm, or associated with endoplasmic reticulum



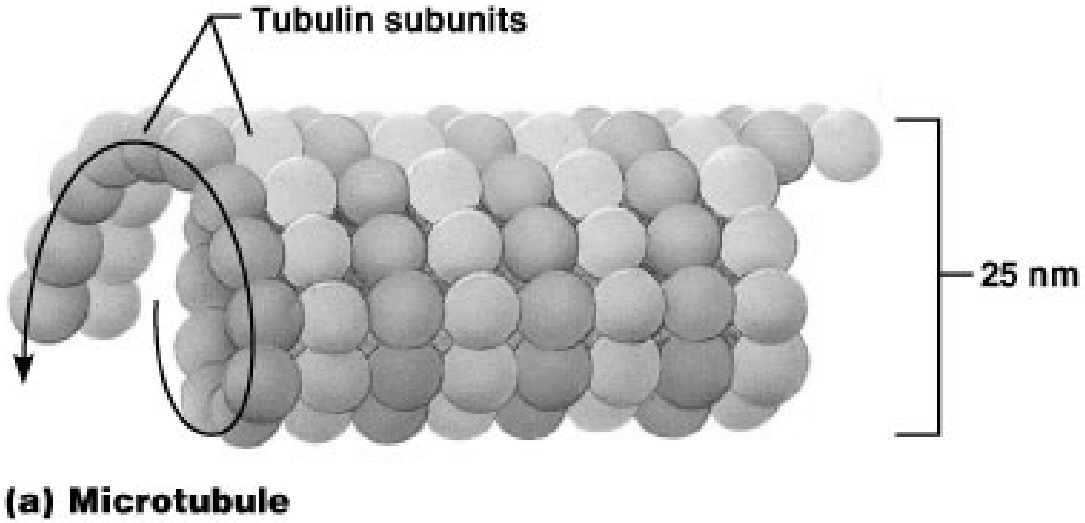
Cytoplasmic Organelles

Non-membrane bound organelles

- Cytoskeleton – “cell skeleton” – an elaborate network of rods
  - Contains three types of rods
    - Microtubules – cylindrical structures made of proteins, 25 nm in diameter
    - Microfilaments – filaments of contractile protein actin, 7 nm in diameter
    - Intermediate filaments – protein fibers, 10 nm in diameter

Cytoskeleton: Microtubule

Microtubules – found in cilia and flagella, centrosomes, spindle apparatus…



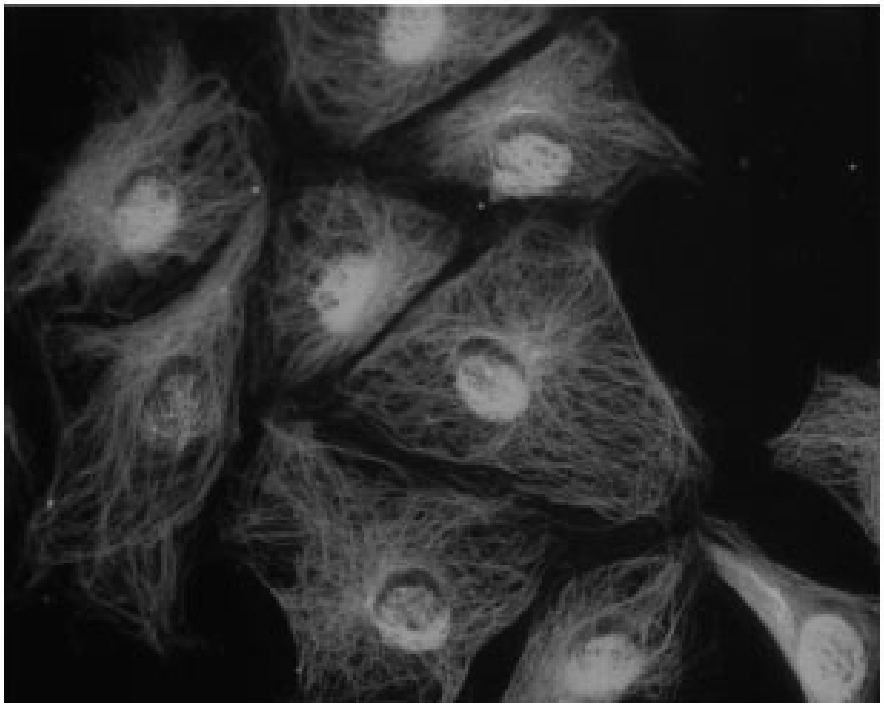


Figure 2.11a

Cytoskeleton: Microfilament

Actin – forms the “thin filament” of muscle

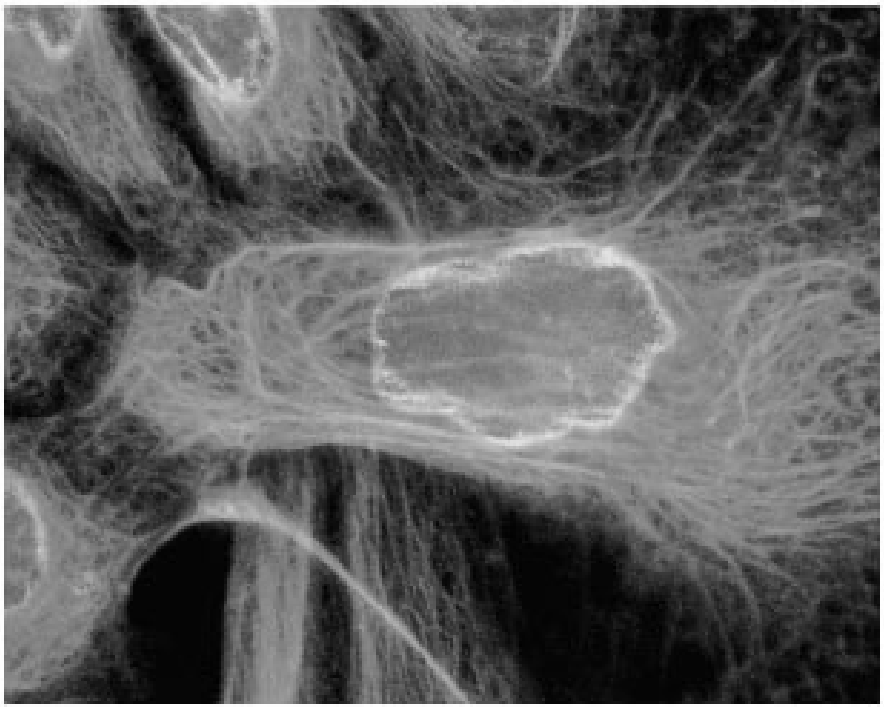
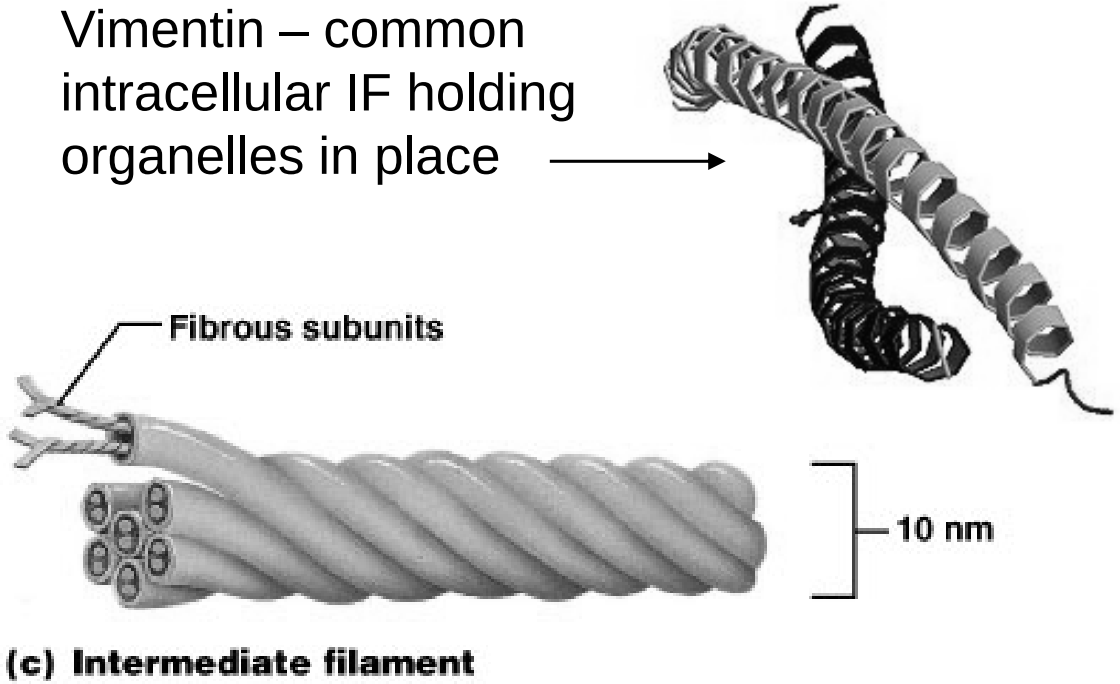


Figure 2.11b

Cytoskeleton: Intermediate Filament

Vimentin – common intracellular IF holding organelles in place



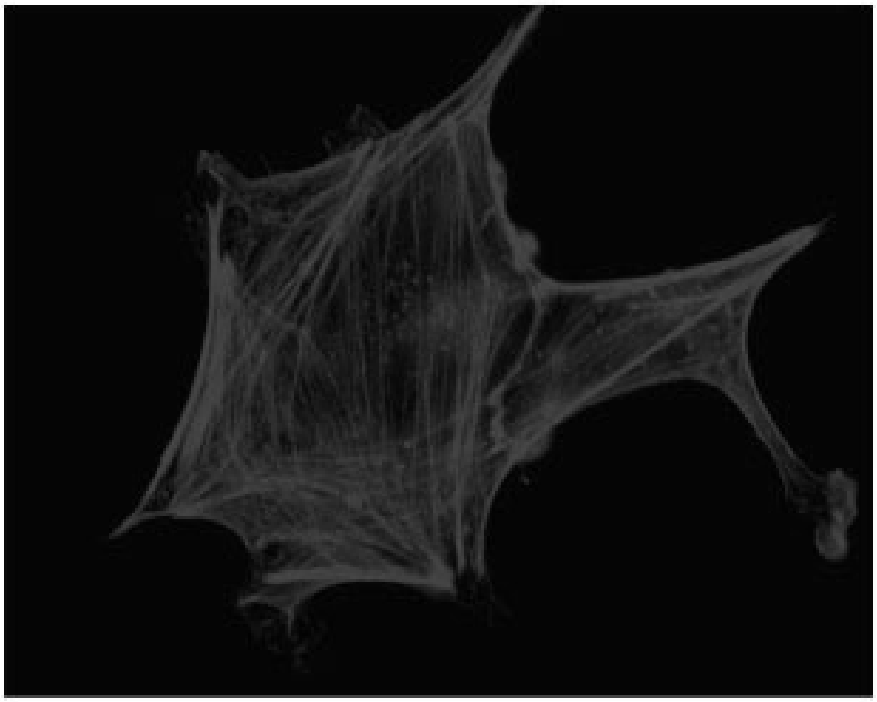
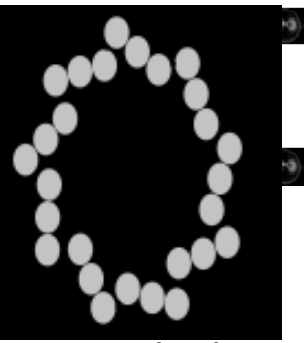
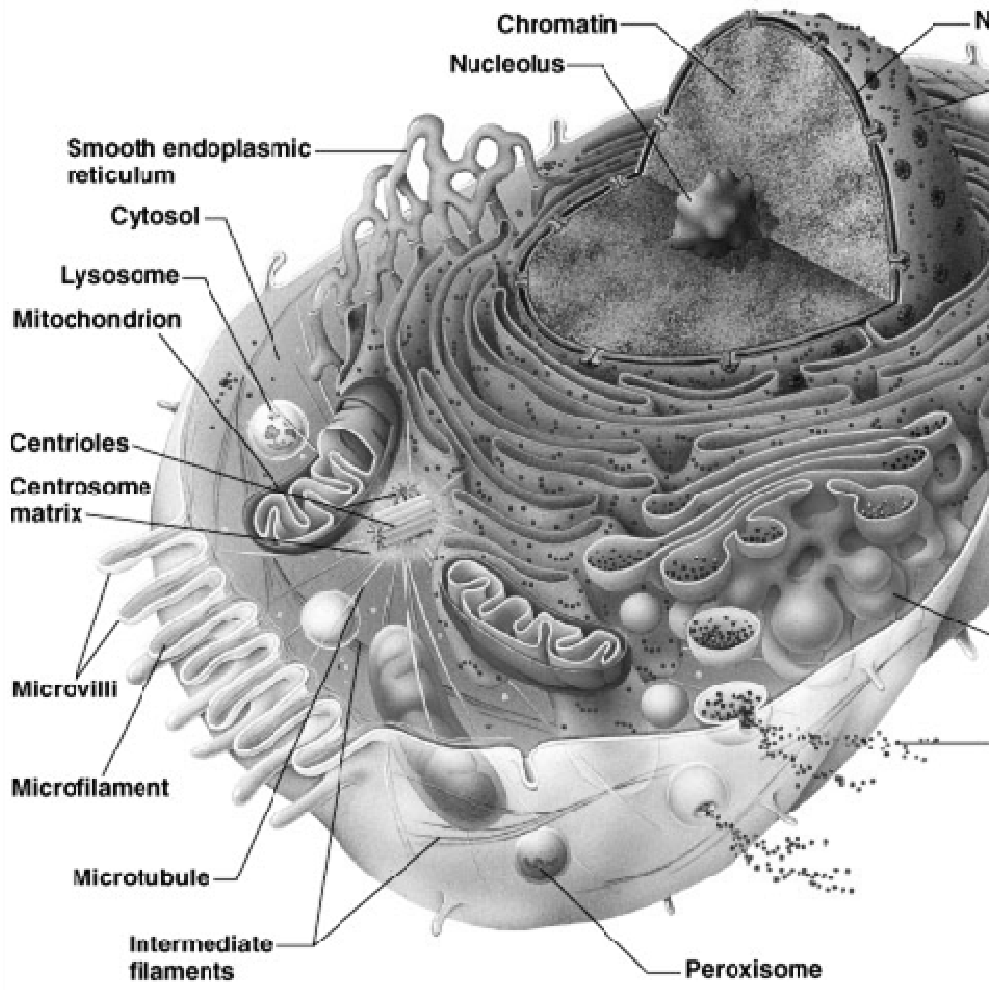


Figure 2.11c

Cytoplasmic Organelles

- centrosomes and centrioles
  - Centrosome – a spherical structure in the cytoplasm
    - Composed of centrosome matrix (PCM – pericentriolar material) and centrioles
  - Centrioles – paired cylindrical bodies
    - Consists of 27 short microtubules
    - Act in forming microtubules for cilia, flagella, spindle apparatus

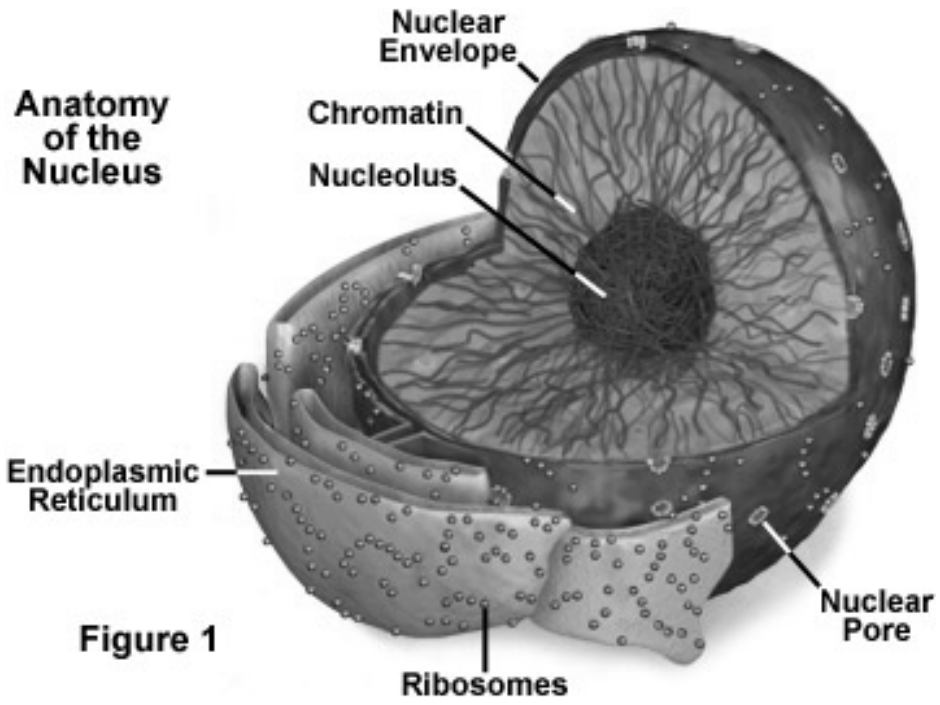




Cytoplasmic Inclusions

- Temporary structures – not present in all cell types
- May consist of pigments, crystals of protein, and food stores such as...
  - Lipid droplets – found in liver cell and fat cells
  - Glycosomes – store sugar in the form of glycogen

The Nucleus



- The nucleus – "central core" or "kernel" – control center of cell
  - DNA directs the cell's activities

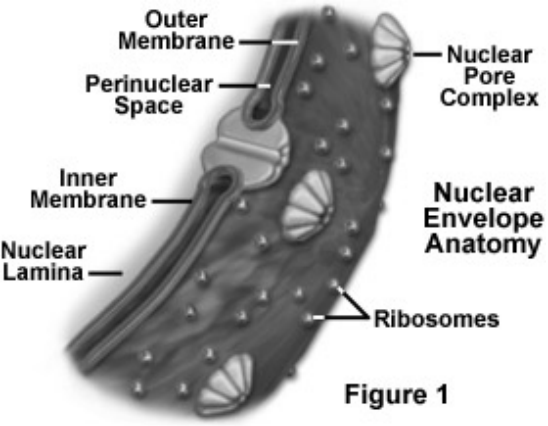
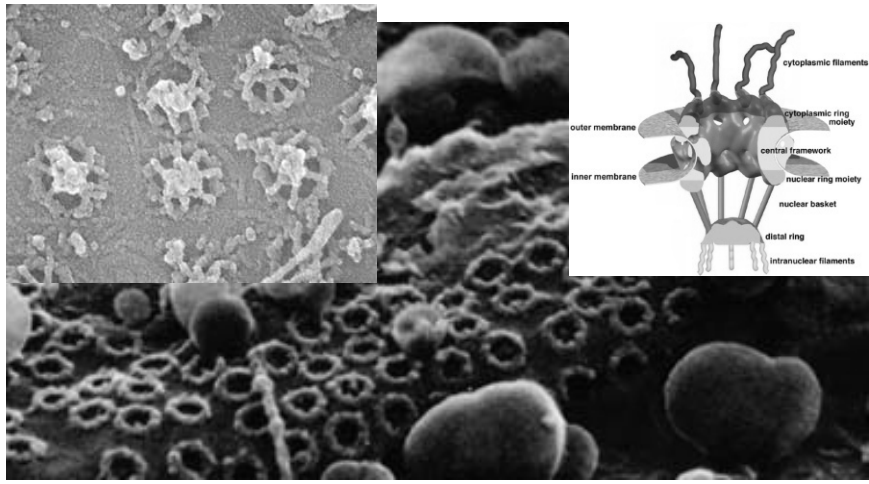


Figure 1

The Nucleus

- Nuclear envelope – two parallel membranes separated by fluid-filled space
  - Pores allow for transfer of material
  - 3,000 – 4,000 pores in typical mammalian nucleus
    - ~20,000 ribosomes/min can pass through
    - Up to 30,000 histones/min can pass through
  - Outer membrane continuous with the RER membrane



- Chromatin – composed of DNA and histone proteins
  - Condensed chromatin – contains tightly coiled strands of DNA
  - Extended chromatin – contains uncoiled strands of DNA
    - DNA's genetic code is copied onto mRNA (transcription)

The Nucleus

- Chromosomes – highest level of organization of chromatin
  - Contains a long molecule of DNA
- Nucleolus – “little nucleus” – in the center of the nucleus
  - Contains parts of several chromosomes
  - Site of ribosome subunit manufacture

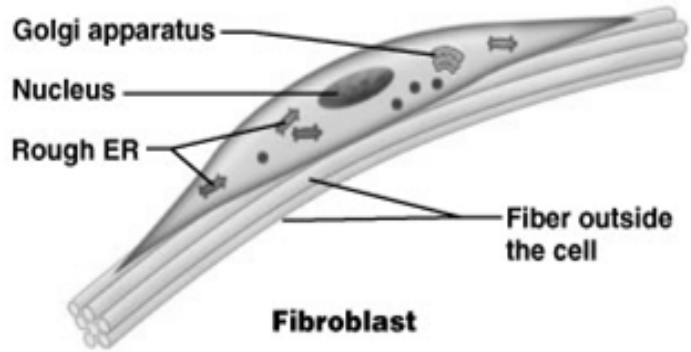
Cellular Diversity

- Specialized functions of cells relates to:
  - Shape of cell
  - Arrangement, type and quantity of organelles

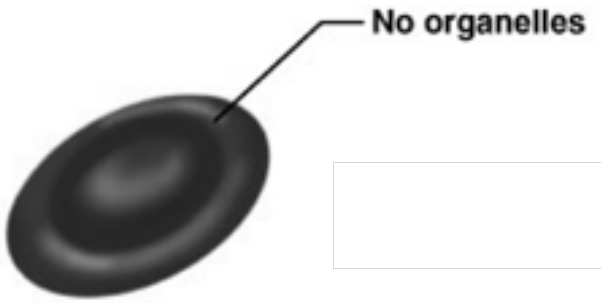
    (i.e. a muscle cell should have more mitochondria than a simple skin epithelial cell)

Cellular Diversity

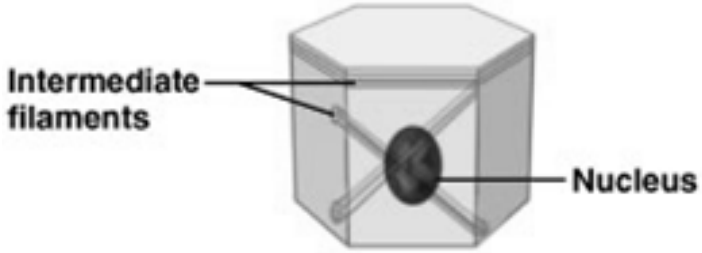
- Cells that connect body parts or cover organs
  - Fibroblast – makes and secretes protein component of fibers
  - Erythrocyte – concave shape provides surface area for uptake of the respiratory gases
  - Epithelial cell – hexagonal shape allows maximum number of epithelial cells to pack together



Fibroblast



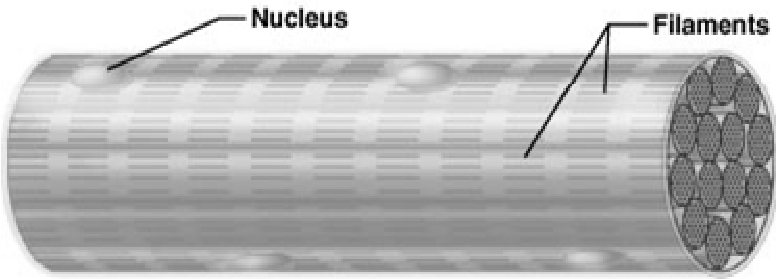
Erythrocyte (red blood cell)



Epithelial cell

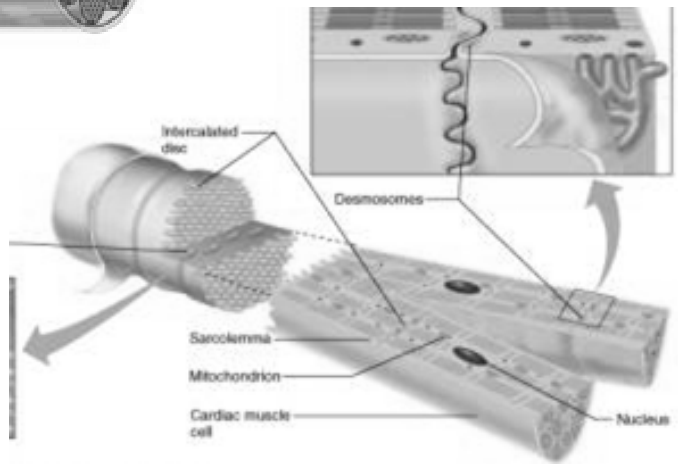
Cellular Diversity

- Cells that move organs and body parts
  - Skeletal, cardiac and smooth muscle cells
    - Elongated and filled with actin and myosin
    - Contract forcefully



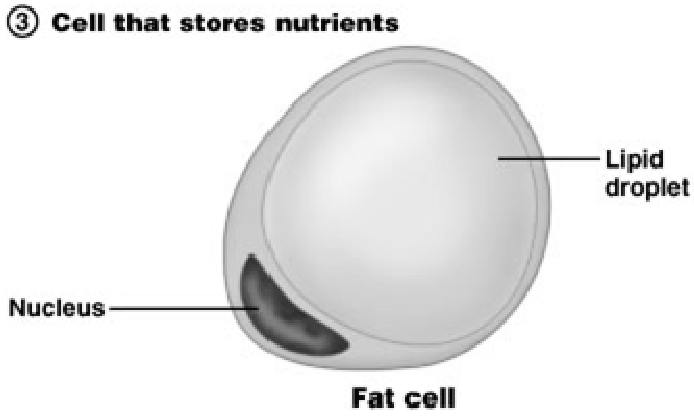
Skeletal muscle cell

Smooth muscle cell

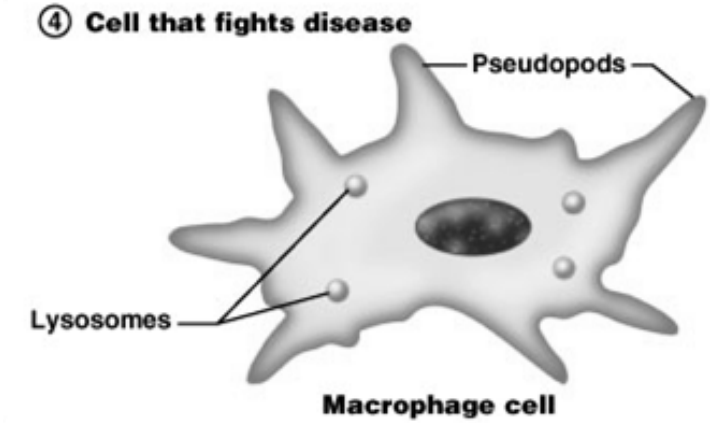


Cellular Diversity

- Cells that store nutrients
  - Fat cell (adipocyte) – shape is produced by large fat droplet in its cytoplasm



- Cells that fight disease
  - Macrophage – moves through tissue to reach infection sites



Cellular Diversity

- Cells that gather information
  - Neuron – has long processes for receiving and transmitting messages

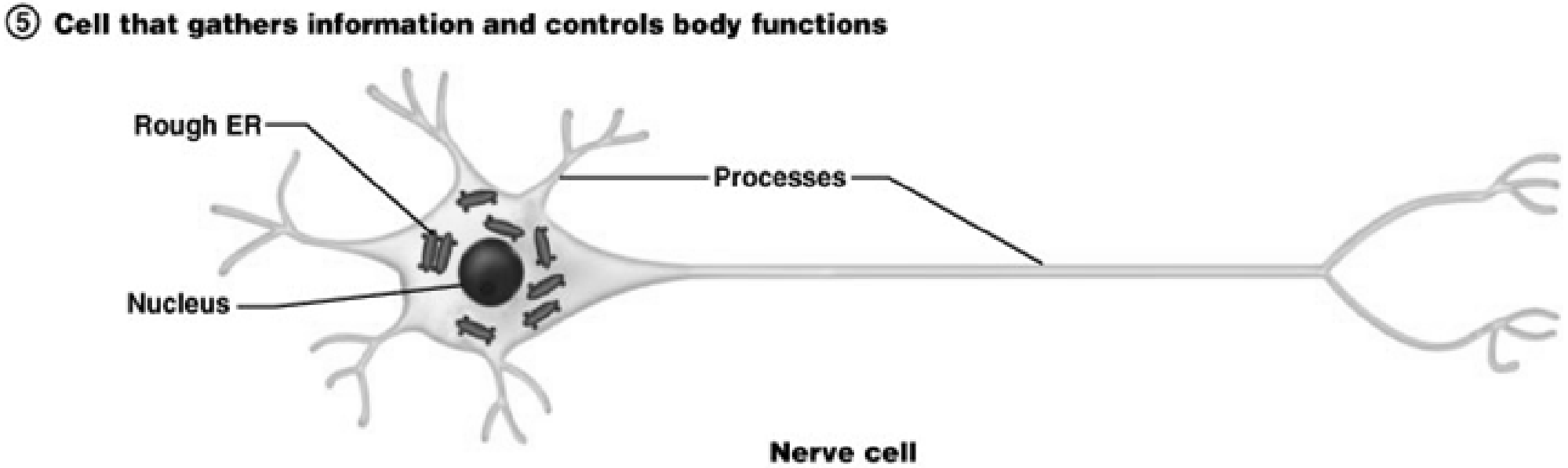
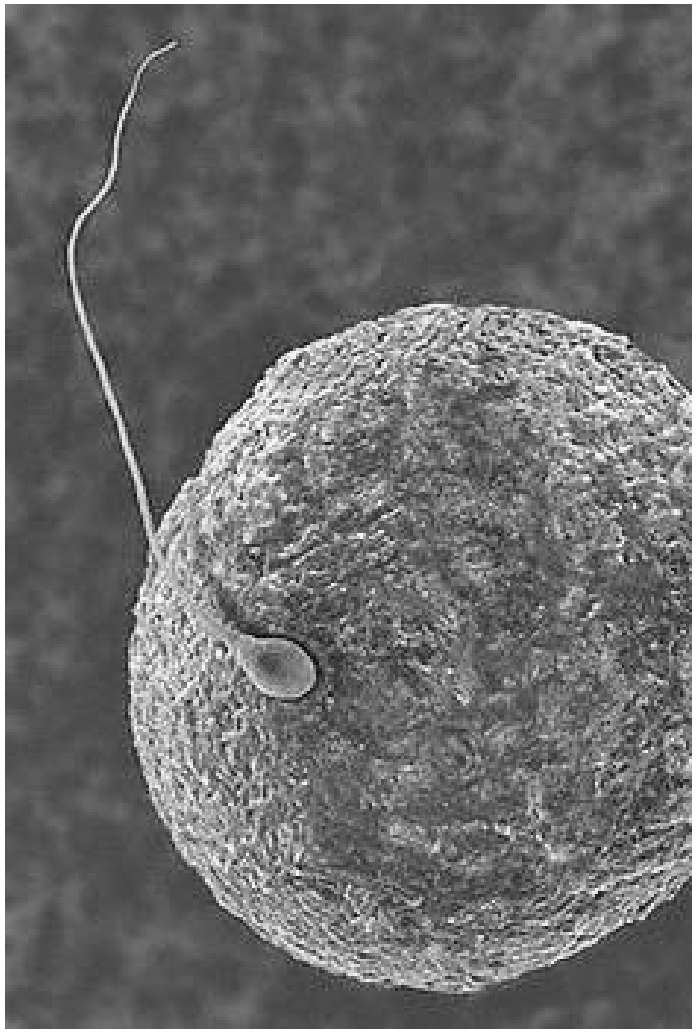


Figure 2.18 (5)

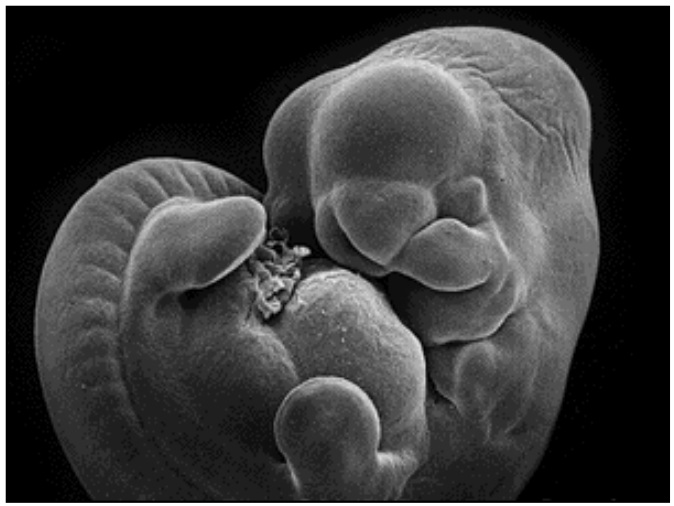
Cellular Diversity

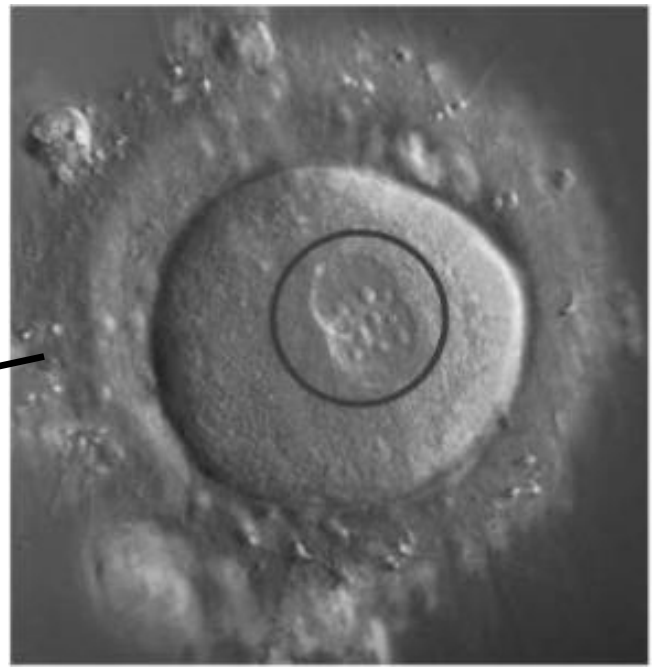
- Cells of reproduction
  - Oocyte (female) – largest cell in the body
    - Contains many copies of organelles for distribution to daughter cells
  - Sperm (male) – possesses long tail for swimming to the egg for fertilization



Developmental Aspects of Cells

- begin as a fertilized egg = Zygote
  - Cells in embryo
    - Exposed to chemical signals
    - Chemicals channel cells into specific pathways of development
  - Cell specialization leads to structural variation of cell types





Developmental Aspects of Cells

- Aging – a complex process caused by a variety of factors
  - Free radical theory
    - Damage from byproducts of cellular metabolism
    - Radicals build up and damage essential molecules of cells
  - Mitochondrial theory – a decrease in production of energy by mitochondria weakens and ages our cells
  - Neurodegenerative disorders have been linked (recently) to nuclear pore aging. *http://www.sciencenews.org/view/generic/id/40136/title/As_cells_age,_the_nuc*

Developmental Aspects of Cells

- Genetic theory – proposes that aging is programmed by genes
  - Telomeres – “end caps” on chromosomes
  - Telomerase – prevents telomeres from degrading