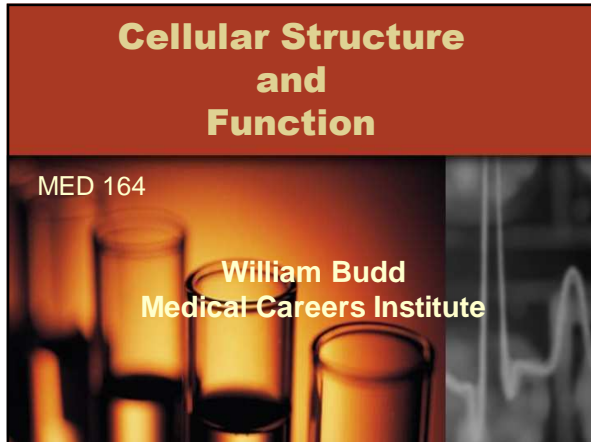


## Cellular Structure and Function

MED 164

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Medical Careers Institute



## Objectives

- Identify the structure of basic cellular organelles
- Describe the function of cellular organelles
- Describe the structure of a cell membrane
- Function of a cell membrane
- Discuss the mechanisms utilized to transport substances in and out of cells
- Discuss cellular division
- Cell disorders

## Objectives

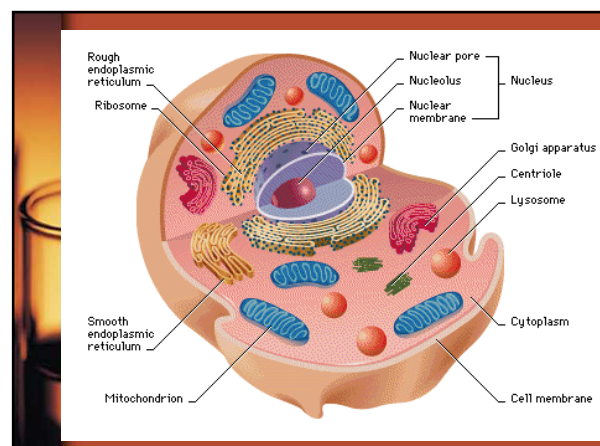
- Expanded cell theory

## What is a cell?

- Cells are basic unit of life
- All living organisms are made of cells
- Cells are usually microscopic
  - On orders of micrometers in length
  - 1 micrometer = 0.000001 meters
  - Take a millimeter and divide it into one thousand pieces, the cell is one of those pieces in length

## Cells

- Eukaryotic cells (complex life forms) are made of a cell membrane and membrane bound organelles
- Cytoplasm
  - Everything from cell membrane to nuclear membrane
  - Organelles
  - Cytosol
    - Fluid made of water, carbohydrates, salts, proteins, and lipids

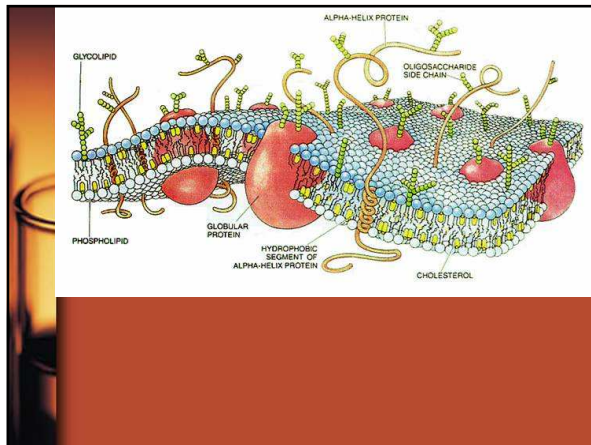


### Cell Membrane

- Cell membrane also called plasma membrane
- Separates cell from its external environment
- Made primarily of phospholipids but contains cholesterol and many proteins

### Cell Membrane

- Phospholipids spontaneously form a bilayer in water with hydrophobic tails sandwiched in middle
- Heads are hydrophilic
- Tails are hydrophobic



### Membrane Proteins

- Help regulate movement of substances in and out of cell
- Essential for transport of hydrophilic materials

### Cytosol

- Provides a location for many of the reactions that are needed by the cell
  - Most metabolic reactions occur in the cytosol

### Nucleus

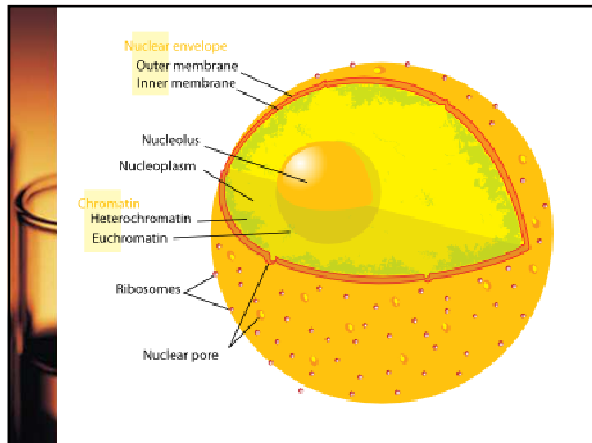
- Contains the genetic material of the cell
  - DNA
- DNA contains the code for instructions needed to assemble all of the proteins needed by the cell
- Some consider the nucleus the brain of the cell
  - Not true, it contains the information center

## Nucleus

- Nucleus contains nucleolus and nucleoplasm
- Nucleolus point of assembly for ribosomal RNA
  - Essential component of another organelle; ribosome
- Nucleoplasm is everything except the nucleolus
  - Thick fluid and chromatin

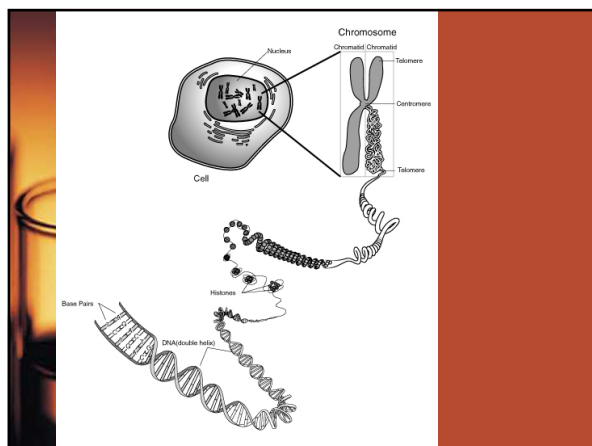
## Nuclear Envelope

- Similar in structure to cell membrane
  - Made of phospholipids and proteins
- Proteins in membrane form many pores
  - Nuclear pores regulate movement of substances in and out of nucleus
    - Protein transcript has to get out of nucleus
    - Signaling molecules need to get into nucleus



## Stages of DNA in Nucleus

- Chromatin – normal arrangement of DNA
  - Loose and diffusely spread out in nucleoplasm
  - Allows access to enzymes for transcription of proteins
- Chromosomes – Condensed rodlike structure of DNA
  - Begin to appear when cell is preparing to divide
  - Human cells have 23 pairs of chromosomes
    - 1 copy comes from Mom 1 copy comes from Dad



## Centrioles

- Barrel shaped organelle that is used during cell division
- Attaches to tubules that help pull chromosomes apart into two separate cells during cellular division

## Endoplasmic Reticulum ER

- Two forms of ER
  - Smooth
    - Involved in cholesterol metabolism
    - Steroid catabolism
    - Fat catabolism
  - Rough
    - Contains ribosomes attached to surface of ER
    - Site of protein translation and modification

## Ribosome

- Complex of ribosomal RNA and protein
- Site of protein translation
- Can be bound to rough ER or free floating in cytoplasm
- Has two sites to bind amino acids
- Catalyzes peptide bond formation

## Mitochondria

- Powerhouse of cell
  - Think Dominion VA Power
- Number of mitochondria varies between cells
  - Active cells have large number of mitochondria
  - Inactive cells have less
  - RBCs have no mitochondria

## Mitochondria

- Responsible for creation of ATP molecules from glucose
- Involved in aerobic metabolism

## Golgi Apparatus

- Modifies and packages proteins for transport from the cell
  - Think UPS Store/ FedEx Kinkos
- Abundant in cells that secrete substances
  - Salivary glands
  - Gastric glands
  - Endocrine glands
  - Pancreatic glands

## Lysosomes

- Organelle that contains powerful digestive enzymes
- Binds to old non-functioning organelles for digestion
- Binds to invading pathogens
- Can be used in a cell process called apoptosis
  - Cell suicide

### Peroxisomes

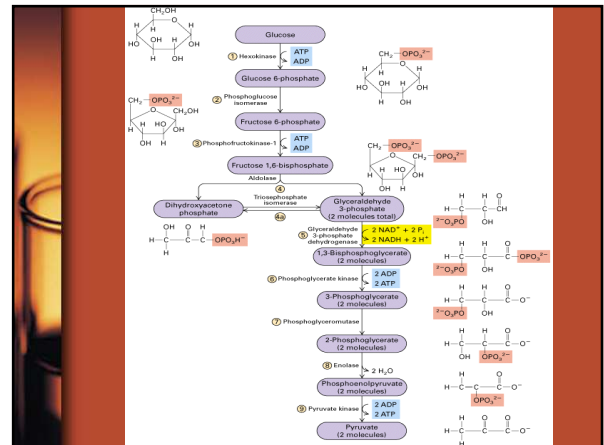
- Organelle that contains sacs that contain oxidative enzymes
- Help to detoxify substances that are toxic to the cell
  - Example peroxide

### Cytoskeleton

- Network of tubules and filaments that give shape to the cell
- Used to help move substances across the cell
- Create a network of “rails” within the cell

### Cellular Metabolism

- Metabolism is series of chemical reactions that maintain life
- Primary reaction glucose converted into adenosine triphosphate (ATP)
  - Glycolysis
  - Oxidative phosphorylation

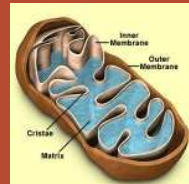


### Glycolysis

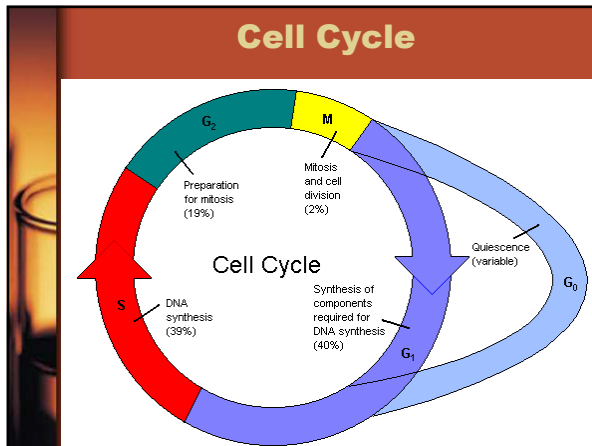
- First step of glucose metabolism
- Occurs in cytosol of cell
- Doesn't require oxygen
- Yields 2 molecules of ATP
- Waste products are pyruvic acid which changes into lactic acid

### Oxidative Phosphorylation

- Occurs in mitochondria of cells
- Requires oxygen
- Total of 32 ATP molecules produced per glucose molecule
- Waste products are water and carbon dioxide



<http://giantsoulders.files.wordpress.com/2007/10/mitochondria.jpg>

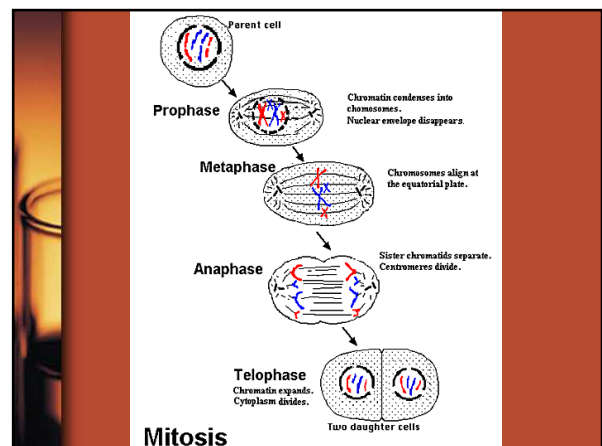


- ### Cell Division (M phase)
- Human cells divide for two purposes
    - Cells can divide for the purpose of sexual reproduction
    - Cells can divide to replace cells that have been damaged
  - Not all cells can undergo cell division
    - They enter the phase G<sub>0</sub>
    - CNS neurons
    - Muscle cells

- ### Cell Division (M phase)
- Goals of the 2 types of division are different
  - Reproductive goals result in half the number of chromosomes 23
    - Accomplished by meiosis
  - Replicative goals result in the same number of chromosomes 46
    - Accomplished by mitosis

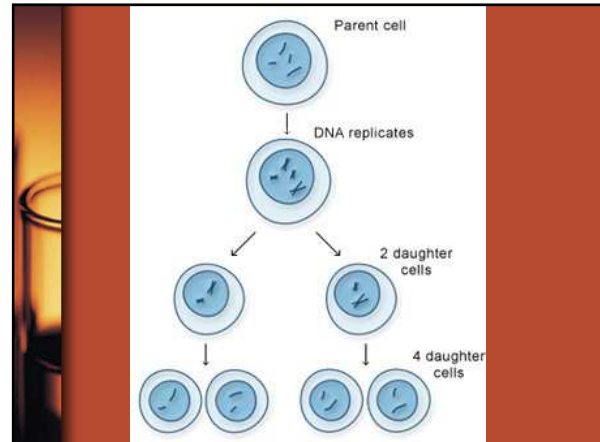
- ### Mitosis
- Orderly, well defined series of steps in which chromosomes are separated into two cells
  - Shortest phase of cell cycle
  - Most cells can divide in 30 minutes or less
  - Mitosis occurs in 4 phases
    - Prophase
    - Metaphase
    - Anaphase
    - Telophase

- ### Mitosis
- When cell is not dividing, it is in interphase
  - Interphase is the “non replicative” phase
  - Cell is undergoing its normal metabolic activities
  - DNA replication occurs during the S phase of the cell cycle

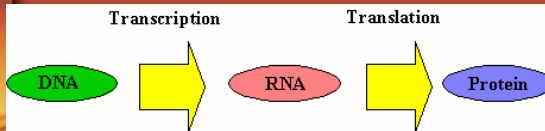


## Meiosis

- Forms gametes
  - Cells with half the number of chromosomes
- Copies of inherited chromosomes randomly segregate into sex cells
- Forms a new cell with some of your mom's genes and some of your dad's genes
- Cross over b/w genes creates new variations that were not present in your parents



## Central Dogma of Biology



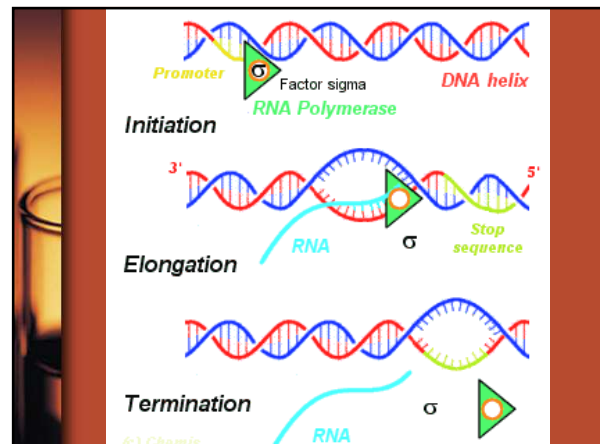
- All visible differences in humans come from this central dogma
- Also diseases arise from alterations in any of these processes
- Most of a cell's life revolves around protein synthesis

## Protein Synthesis

- Two phase process that takes genetic code and creates a protein
- First part is transcription
  - Occurs in nucleoplasm
- Second part is translation
  - Occurs in cytoplasm on a ribosome
- Some proteins undergo post-translational modifications

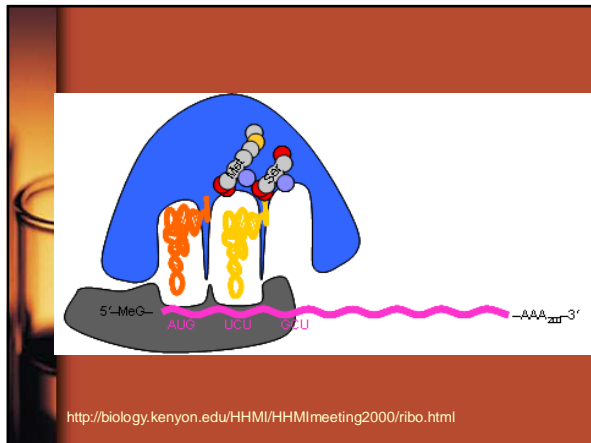
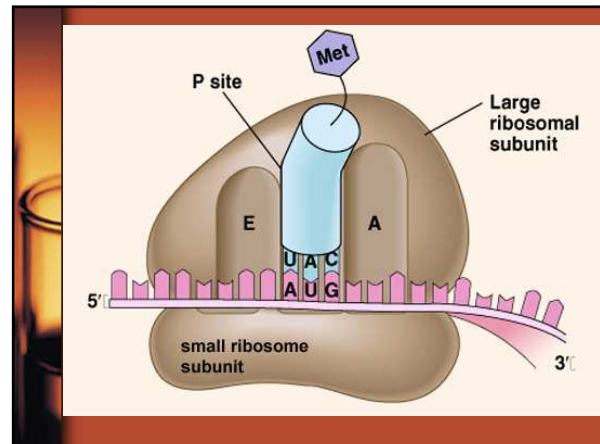
## Protein Synthesis Transcription

- DNA double helix is unwound and strands are separated
- RNA polymerase binds to initiation sequence
- Complementary strand of RNA is created called mRNA
- Transcript is extended until stop sequence is encountered



## Protein Synthesis Translation

- Following creation of transcript, the mRNA is transported into the cytosol and binds a ribosome
- The first three nucleotides enter the P site and a charged tRNA molecule attaches
- The second three molecule enter A site and a charged tRNA molecule enter
- Peptide bond forms between two amino acids



## Post-translation

- Following translation, peptide enters ER and folds into its secondary and tertiary structure
- In the ER, proteins may be modified by adding other organic compounds to them
  - Glycosylation (Adding sugars)
  - Phosphorylation (Adding phosphate groups)
  - Cross bridge formation between peptides

## Protein Export

- Following translation and modification, the protein may be exported from the cell
- The protein travels to the Golgi body and is packaged in a vesicle for cellular export

## Cellular Transport Mechanisms

- In all living organisms, cells must have a manner to bring in substances from environment and eliminate substances back to the environment
- Cell transport is complicated because of the nature of the membrane and the surrounding environment

## Ways things move in and out of cells?

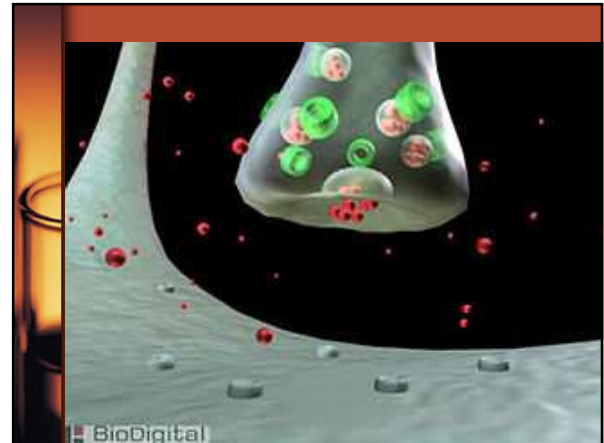
- Endocytosis
- Exocytosis
- Diffusion
  - Simple
  - Facilitated
- Osmosis
- Active Transport

## Endocytosis

- Includes processes to bring in solid and liquid forms of matter
- Phagocytosis brings in solid forms; sometimes called “cell eating”
- Cells that eat a lot are called phagocytes
  - Ex: White blood cells
- Pinocytosis brings in liquid forms of matter

## Exocytosis

- Mechanism in which cell generates secretory vesicles that will leave the cell
- Substance is packaged by Golgi body into a secretory vesicle and the vesicle fuses with the membrane and substance leaves the cell



## Cell Movement Experiments

- See attached handout