N-3 Anatomy and Physiology
First Semester, AY 2024-2025

# CELLS and TISSUES

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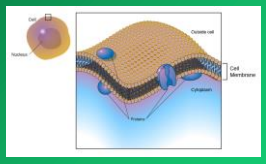
## CELLS

- basic, living, structural, and functional units of the body

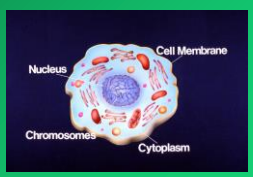



**3 MAIN PARTS**

- **Plasma Membrane**
  - flexible yet sturdy ***outer surface***: separates internal and external environments
  - selective barrier: regulates flow of materials into and out = ✓appropriate environment
  - for communication : identification and signaling

- **Cytoplasm**
  - compartment with all contents between plasma membrane and nucleus
  - 2 components:
    - cytosol *(55% of total cell volume)* - 75-90% water
    - organelles

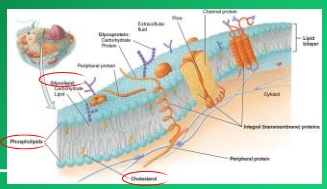
- **Nucleus**
  - large spherical / oval organelle: houses most DNA; *direct activities*

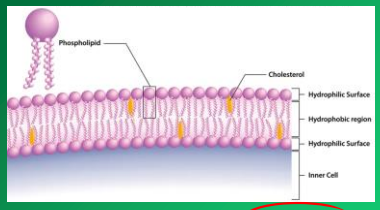



## I. PLASMA MEMBRANE

- FLUID MOSAIC MODEL
  - lipids: passage OR barrier

- basic structural framework: LIPID BILAYER
  - 3 types of lipid molecules
    - phospholipids
    - cholesterol
    - glycolipids

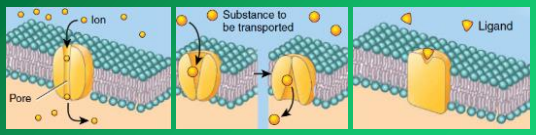




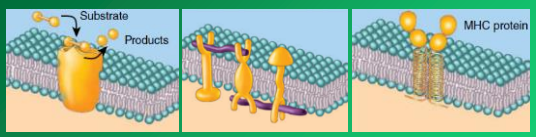

- Lipids are amphipatic molecules
  - polar parts: *hydrophilic* -> cytosol
  - nonpolar parts: *hydrophobic* -> extracellular fluid

***"like seeks like"***

- **MEMBRANE PROTEINS**
  - integral (extend, embedded) OR peripheral (attached)
  - FUNCTIONS:
    - *ion channel* (forms pore)
    - *carrier / transporter* (changes shape)
    - *receptor* (recognizes -> alters function)



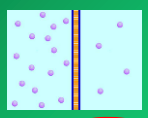

- *enzyme* (catalyzes reaction)
- *linker* (anchors -> stability, shape)
- *identity marker* (distinguishes)




- **SELECTIVE PERMEABILITY**
  - plasma membrane permits **some**
  - greater to more hydrophobic / lipid-soluble substance d/t **hydrophobic interior**

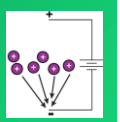
ELECTROCHEMICAL GRADIENT *influences movement*

- **CONCENTRATION GRADIENT**
  - **extracellular fluid**: oxygen and sodium
  - **cytosol**: carbon dioxide and potassium



move: more -> less

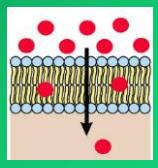
- **ELECTRICAL GRADIENT**
  - **inner**: more (-)
  - **outer**: more (+)



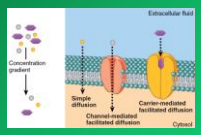
move: (+): -> (-)
(-): -> (+)

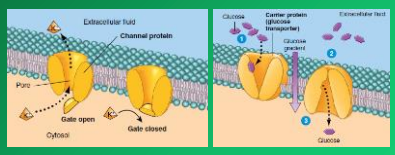
# TRANSPORT ACROSS PLASMA MEMBRANE

- **PASSIVE**: gradient using kinetic energy
  - simple diffusion: **-> lower concentration**
    - **greater difference**
    - **higher temperature** (ex. fever)
    - **smaller mass**
    - **larger surface area** (ex. normal vs emphysema)
    - **shorter distance** (ex. normal vs pneumonia)



  - facilitated diffusion
    - too hydrophilic -> **ion channel**
    - **carrier / transporter** (changes shape)



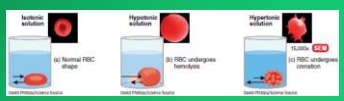




*Permeable to water but not to certain solutes:*

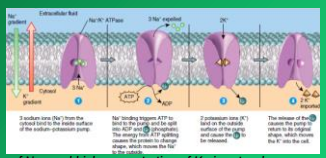
- osmosis: higher water concentration -> lower water concentration
  **lower solute concentration -> higher solute concentration**
  - aquaporins: water channels

**TONICITY** - solution's ability to change cell volume by altering water content

- hypotonic: lower solute concentration -> lysis (rupture) *for dehydration*
- hypertonic: higher solute concentration -> crenation (shrink) *for edema*




- **ACTIVE**: using cellular energy [adenosine triphosphate (ATP)] against gradient
  - **active transport**
    - **pumps**:
      carrier proteins
      that change shape

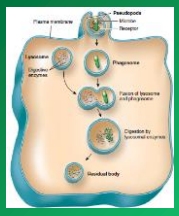



*maintain low concentration of Na+ and high concentration of K+ in cytosol*

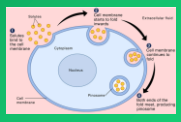
  - **vesicle**
    - endocytosis (detach ← into)
    - exocytosis (merge → release)

transcytosis: endo on one side, move across, exo on opposite

- **phagocytosis**
  - *form of endocytosis*: phagocytes (macrophages and neutrophils) engulf
  - membranes fuse to form vesicle (phagosome), which enters cytoplasm

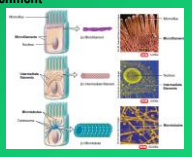


- **pinocytosis**
  - *form of endocytosis*: take droplets of extracellular fluid (*ex. absorptive cells in intestines and kidneys*)



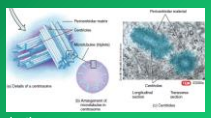
## II. CYTOPLASM

- **Cytoskeleton** - network of protein filaments: extends throughout cytosol
  - 3 types
    - microfilaments: *composed of proteins actin and myosin*
      - **movement** (muscle contraction, cell division) and **support**
    - intermediate filaments: help **stabilization** and **attachment**
    - microtubules: *composed of protein tubulin*
      - help determine cell **shape**



**Organelles**

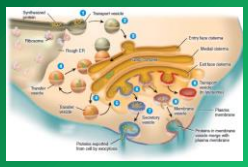
- **Centrosome** - microtubule organizing center
  - **pair of centrioles**
  - **pericentriolar matrix**

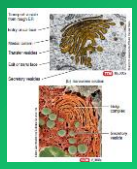


- **Cilia** (move fluids) and **Flagella** (move cell) - motile projections
- **Ribosomes** : protein synthesis

- **Endoplasmic Reticulum** - network of membranes
  - 2 forms:
    - rough - studded with ribosomes; produces **proteins**
    - smooth - synthesize **fatty acids and steroids** (*estrogen and testosterone*)

- **Golgi Complex** - *first step in transport pathway*
  - modifies, sorts, packages, transports proteins from rough ER



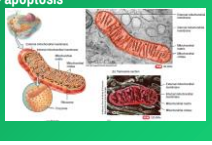


- **Lysosomes** - membrane-enclosed vesicles that form from GC
  - **autophagy**: digest worn-out organelles
  - **autolysis**: digest entiire cell

- **Peroxisomes / microbodies** - contain **oxidases** and **catalase**
  - abundant in liver (*detoxification*); protect from hydrogen peroxide

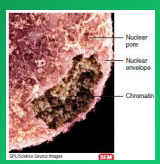
- **Proteasomes** - *proteases*: destruction of proteins (*unneeded, damaged, faulty*)

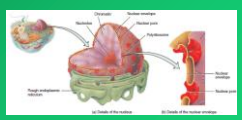
- **Mitochondria** - '*powerhouse*': generate most ATP through aerobic respiration
  - **muscles, liver, kidneys** have large number *(use ATP at high rate)*
  - *initiate cascade of activation* -> **apoptosis**



## III. NUCLEUS

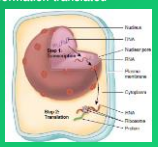
- **Nuclear envelope** - *double bilayer*; continuous with rough ER
  - **separates** nucleus from cytoplasm
- **Nuclear pores** - **control movement** of substances
- **Nucleoli** - **produce ribosomes**
  - cluster of protein, DNA, RNA
  - prominent in **muscle and liver cells**
- **Genes** - hereditary units
  - 46 chromosomes: *long molecules of DNA*
- **Chromatin** - complex of DNA, proteins, RNA



## PROTEIN SYNTHESIS

- **PROTEINS** - determine cell characteristics
- **GENE EXPRESSION** : uses gene's DNA as template for protein synthesis
  - **transcription** (in nucleus) : information transcribed (copied) -> ribonucleic acid
  - **translation** (in cytoplasm) : RNA attaches to ribosome : information translated -> sequence of amino acids -> protein molecule



## TRANSCRIPTION

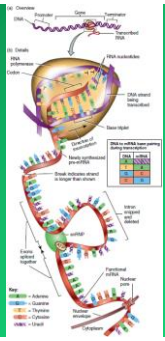
DNA template -> 3 types of RNA:

- messenger (mRNA) - directs protein synthesis
- ribosomal (rRNA) - joins ribosomal proteins => ribosomes
- transfer (tRNA) - binds to amino acid

>>> begins at PROMOTER (*nucleotide sequence*):
RNA polymerase attaches to DNA

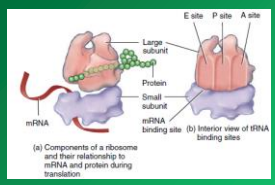
>>> DNA to mRNA base pairing:

| | |
|---|---|
| adenine - uracil | thymine - adenine |
| guanine - cytosine | cytosine - guanine |



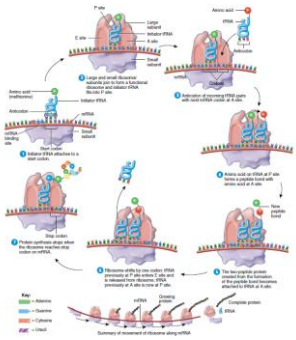
## TRANSLATION

- mRNA binds to ribosome
- mRNA nucleotide sequence specifies *amino acid sequence of protein*




- initiator tRNA binds to start codon (AUG)
- tRNA anticodon (UAC) attaches to mRNA codon (AUG)

- small and large ribosomal subunits
  - join to form a **functional ribosome**
  - separate when process is complete

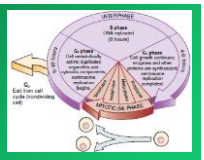


## CELL DIVISION

- process for cells to reproduce

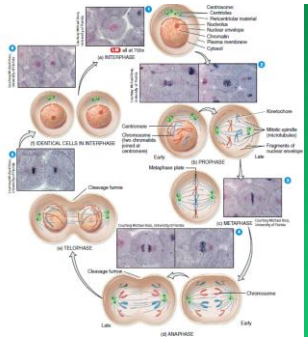
- 2 types
  - somatic => 2 genetically identical cells (same number & kind)
    - nuclear division (mitosis) - distribute 2 sets of chromosomes into separate nuclei
    - cytoplasmic division (cytokinesis) - cleavage furrow forms; completed after telophase; *divides cytoplasm into separate and equal portions*
  - reproductive => gametes (sperm or oocyte)
    - meiosis => half number of chromosomes in nucleus

**SOMATIC: G1 -> S -> G2 -> mitosis -> cytokinesis**



2 major periods of cell cycle

- **Interphase** - *not dividing; does most of growing*
  - **G1** - replicates most organelles & cytosolic components
  - **S** - DNA synthesis
  - **G2** - synthesis of enzymes & other proteins; complete centrosome replication
- **Mitotic (M) phase** - *dividing*
  - Prophase: centromere holds chromatid pair (identical strands) together
    - centromeres pushed to poles
    - mitotic spindle –– separation of chromatids to opposite poles
    - nucleolus disappears, nuclear envelope breaks down

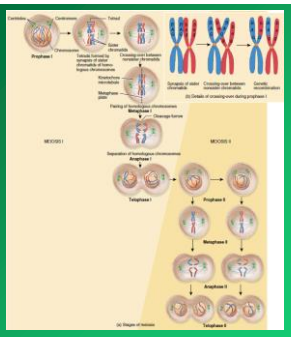


- **Metaphase**: microtubules of mitotic spindle align the centromeres of the chromatid pairs at the exact center of the mitotic spindle
- **Anaphase**: centromeres split, members of chromatid pair move toward poles => ***chromosomes***
- **Telophase**: chromosomal movement stops; identical chromosomes uncoil; nuclear envelope forms; nucleoli reappears; mitotic spindle breaks

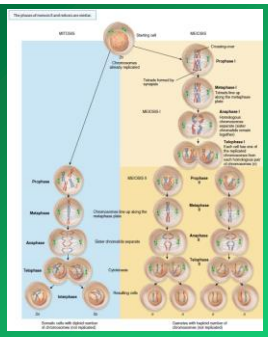
**REPRODUCTIVE**

2 successive stages of Meiosis:

- **Meiosis I** => **haploid number** (*only 1 of each pair of homologous chromosomes*)
  - Prophase I: chromosomes shorten & thicken; nuclear envelope & nucleoli disappear; mitotic spindle forms
  - Metaphase I: tetrads (4 chromatids) line up
  - Anaphase I: members of chromosomes pulled to poles
  - Telophase I & Cytokinesis: similar to mitosis
- **Meiosis II**
  - Prophase II, Metaphase II, Anaphase II, Telophase II: similar to mitosis
    - centromeres split, sister chromatids separate and move to poles
  - each of two haploid cells divides => **4 haploid gametes (genetically different from original diploid)**



| POINT OF COMPARISON | MITOSIS | MEIOSIS |
|---|---|---|
| **Cell type** | Somatic. | Gamete. |
| **Number of divisions** | 1 | 2 |
| **Stages** | Interphase.<br>Prophase.<br>Metaphase.<br>Anaphase.<br>Telophase. | Interphase I only.<br>Prophase I and II.<br>Metaphase I and II.<br>Anaphase I and II.<br>Telophase I and II. |
| **Copy DNA?** | Yes, interphase. | Yes, interphase I; No, interphase II. |
| **Tetrads?** | No. | Yes. |
| **Number of cells** | 2. | 4. |
| **Number of chromosomes per cell.** | 46, or two sets of 23; this makeup, called diploid (2n), is identical to the chromosomes in the starting cell. | One set of 23; this makeup, called haploid (n), represents half of the chromosomes in the starting cell. |



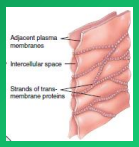
## TISSUES

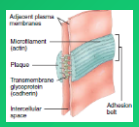
4 basic types (structure & function)

- Epithelial - covers surfaces; lines hollow organs, cavities, ducts; forms glands
  - allows to interact with environments
- Connective - protects & supports: binds organs; stores energy reserves
  - helps provide immunity
- Muscular - contraction & generation of force and heat
- Nervous - detects changes -> generates signals -> muscular contractions, glandular secretions

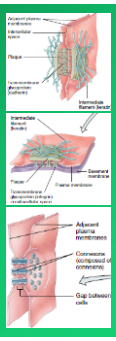
## CELL JUNCTIONS

- contact points between plasma membranes of tissue cells
- 5 types:
  - **Tight junctions**: weblike strands
    - epithelial: stomach, intestines, urinary bladder
    - inhibit passage, prevents leaking
  - **Adherens junctions**: cadherins inserts, crosses, connects
    - epithelial: resist separation (contractile, food in intestines)



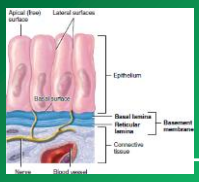



- **Desmosomes**: plaque attaches to intermediate filaments
  - stability: epidermis, cardiac muscle cells
  - prevents separation (tension, contraction)
- **Hemidesmosomes**: integrins attach to intermediate filaments
  - anchor cells to basement membrane
- **Gap junctions**: connexins form connexons --- allow diffusion
  - very narrow intercellular gap
  - enable nerve or muscle impulses to spread rapidly



# I. EPITHELIAL TISSUE

- *cells arranged in continuous sheets*
- types: covering and lining (surface); secreting portions of glands (glandular)




- apical - faces surface, cavity, lumen, duct
- lateral - faces adjacent cells
- basal - adhere to extracellular materials
- basement membrane: migration, restrict passage, filtration
  - basal lamina - to epithelial cells
  - reticular lamina - to connective tissue

## CLASSIFICATION

I. Arrangement of cells in layers
- Simple - single: diffusion, osmosis, filtration, secretion, absorption
- Pseudostratified - nuclei lie at different levels
- Stratified - 2 or more: protect from wear and tear

II. Cell shapes
- Squamous - thin: rapid passage of substances
- Cuboidal - tall as wide: secretion, absorption
- Columnar - taller than wide: protect, secretion, absorption
- Transitional - change squamous to cuboidal: urinary bladder


## I. COVERING AND LINING EPITHELIUM

A. **Simple squamous** - tiled floor --- *filtration, diffusion, secretion*
- **endothelium**: cardiovascular, lymphatic
- **mesothelium**: serous membranes (peritoneum, pleura, pericardium)

B. **Simple cuboidal** --- *secretion, absorption*
- ovary, lens, retina, kidney tubules, thyroid gland, pancreas

C. **Nonciliated simple columnar** --- *secretion, absorption*
- gastrointestinal tract, ducts, gallbladder

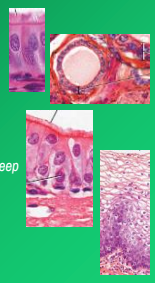
**(cont.) COVERING AND LINING EPITHELIUM**

D. **Ciliated simple columnar** --- *moving mucus, oocytes*
- bronchioles, fallopian tubes, uterus, sinuses

E. **Nonciliated pseudostratified columnar** --- *absorption, secretion*
- epididymis, larger ducts, male urethra

F. **Ciliated pseudostratified columnar** --- *mucus to trap, cilia to sweep*
- upper respiratory tract airways

G. **Stratified squamous** --- *protection, first line of defense*
- superficial skin, mouth lining, esophagus, vagina, tongue

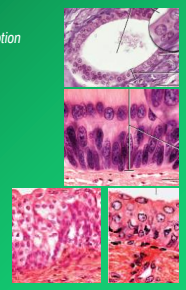


**(cont.) COVERING AND LINING EPITHELIUM**

H. **Stratified cuboidal** --- *protection, limited secretion & absorption*
- ducts of adult sweat & esophageal glands, male urethra

I. **Stratified columnar** --- *protection, secretion*
- urethra, esophageal glands, conjunctiva

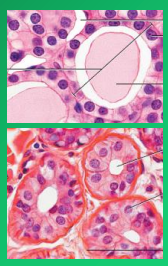
J. **Transitional** --- *stretch, maintain protective lining*
- urinary bladder, ureter, urethra



**II. GLANDULAR EPITHELIUM**
- secretion

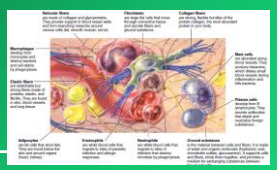
A. **Endocrine glands** --- *hormones (without flowing through duct)*
- pituitary, pineal, thyroid, parathyroid, adrenal, pancreas

B. **Exocrine glands** --- *into duct (skin, lumen)*
- sweat, oil, earwax, salivary, pancreas

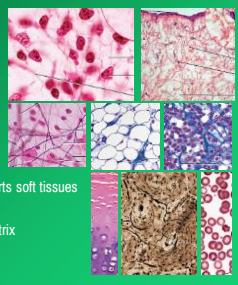


## II. CONNECTIVE TISSUE
- 2 elements: extracellular matrix (*between*) and cells
- highly vascular: has rich blood supply (*except cartilage, tendon*)

- Fibroblast - large, flat
- Macrophage - phagocyte
- Plasma cell - gastrointestinal, respiratory
- Mast cell - inflammatory
- Adipocyte - store triglyceride
- Leukocyte - gather at infection, invasion



## CLASSIFICATION



I. Embryonic - in embryo / fetus
- Mesenchyme - skin, developing bones
- Mucous connective tissue - umbilical cord

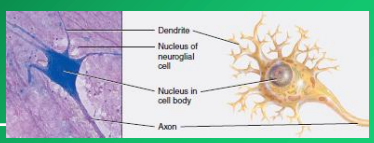
II. Mature - at birth, throughout life
- Connective tissue proper - flexible
  - areolar, adipose, reticular
- Supporting connective tissue - protects & supports soft tissues
  - cartilage, bone
- Liquid connective tissue - liquid extracellular matrix
  - blood, lymph

## III. MUSCULAR TISSUE

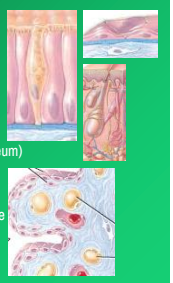
- consists of myocytes
- 3 types
  - **skeletal**: long, cylindrical, striated --- *motion, posture, heat, protection*
    - attached to bones by tendons
  - **cardiac**: branched, striated --- *pumps blood*
    - heart wall
  - **smooth**: nonstriated --- motion (constriction, propulsion, contraction)
    - iris, blood vessel walls, airways, stomach, intestines

## IV. NERVOUS TISSUE

2 types
- **neuron**: stimuli -> nerve action potentials / impulses
  - cell body (*nucleus, organelles*), dendrites (*input*), axons (*output*)
- **neuroglia**: can multiply & divide in mature nervous system




## MEMBRANES



- flat sheets of pliable tissue (covering, lining)

I. **Epithelial**
- Mucous - lines cavity (digestive, respiratory, reproductive, urinary)
- Serous - covers organs within cavity (pleura, pericardium, peritoneum)
- Cutaneous - covers entire surface of body

II. **Synovial** - lines joints; synovial fuid lubricates and nouishes cartilage

## EXCITABLE CELLS

- neurons and muscle fibers: exhibit **electrical excitability**
  - respond to stimuli by producing electrical signals
    - neurons release neurotransmitters for communication

## TISSUE REPAIR: Restoring Homeostasis

- replace *worn-out, damaged, dead cells*
- Stem cells - *immature, undifferentiated cells*
  - divide to replace lost or damaged cells
- **3 factors affect tissue repair**
  - **nutrition** (*adequate protein — structural component*)
  - **blood circulation** (*transport oxygen, nutrients, antibodies*)
  - **age** (*changes in tissue components*)

**N-3 Anatomy and Physiology**
First Semester, AY 2024-2025

# CELLS and TISSUES

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