

A& P Chapter 1

Branches of Anatomy

GROSS ANATOMY refers to macroscopic study of the whole body...things that can be seen with the naked eye. Within Gross anatomy are REGIONAL ANATOMY which studies the anatomy of body parts (the head, the leg, etc), SYSTEMIC ANATOMY which studies body systems, and SURFACE ANATOMY which studies what is underneath the surface.

MICROSCOPIC ANATOMY refers to the study of anatomy using a microscope. CYTOLOGY is the study of cells and HISTOLOGY is the study of tissues (tissues are groups of cells).

DEVELOPMENTAL ANATOMY studies where things come from, how they develop. This area includes EMBRYOLOGY (the study of embryonic development)

SPECIALIZED ANATOMY areas include PATHOLOGICAL which is the study of disease, RADIOGRAPHIC which studies how anatomy relates to the radiographic techniques, and SURGICAL ANATOMY.

Physiology

Physiology is studied based on organ system subdivisions, though it is important to note that organ systems do not operate independently of one another—they overlap.

Physiology is based on three things:

- 1) Cellular function
- 2) Molecular activity
- 3) Laws of physics

The overarching concept behind physiology is THE PRINCIPLE OF COMPLEMENTARITY OF STRUCTURE AND FUNCTION. This simply means that function follows form...in other words, what a structure can do depends on its design. For example, a Volkswagen is not going to win the Indy 500, because it was not designed to do so. A bicycle is not going to fly, because it was not designed with wings.

Levels of organization

Living organisms are organized from smaller structures to larger structures.

Smallest level	Chemical	Atoms Molecules (atoms build molecules)
Next level	Cellular	Organelles Cells (organelles are part of cells)

Next level	Tissues	groups of cells together
Next level	Organ	Various tissues work together to form organ
Next level	Organ system	11 in the human body
Highest level	Organism	All the organ systems working together

Maintenance of Life

In order to maintain life, an organism must 1) **maintain boundaries** and remain separate from the environment, i.e. skin or cell membrane; 2) be capable of **movement**, which can be internal and external; 3) utilize **responsiveness**, which is the sensing of and response to changes in the environment. This stimuli can be internal and external such as feeling cold or having a thought; 4) be capable of **digestion**, the breakdown of complex foodstuffs into the smallest building block molecules; 5) have a **metabolism**, which encompasses all the chemical process in the body. Catabolism is the breakdown of complex molecules into smaller particles which anabolism is the building of molecules. Cellular respiration, another component of metabolism, is an organism's ability to use oxygen to convert nutrients to ATP; 6) be capable of **excretion**, the removal of wastes from the body. Defecation eliminates unabsorbed food (that never really entered the body!) and urination voids metabolic wastes. Another form of excretion is expiration, which is the rids the body of carbon dioxide via exhalation; 7) undergo **reproduction** at both the cellular and organismal level; and 8) be capable of **growth**, which is usually an increase in the number of cells (though the size of the cells can increase slightly). Growth occurs when anabolic processes dominate over catabolic processes.

Survival Needs

Nutrients: CHO, protein, lipids, minerals, vitamins
Oxygen: Required for oxidation of nutrients into usable energy
Water: Body is 60-80% water - the most abundant substance in the body
Appropriate Temp: Life is driven by enzyme-catalase reactions. Protein enzymes lose their shape when not at the correct temperature and they fail to function.
Appropriate Pressure: Ventilation drives mechanical respiration. Think of Mt. Everest or SCUBA diving.

Homeostasis AKA "Staying the Same"

Homeostasis is the ability of the body to maintain a stable set of internal conditions, such as temperature. It is also referred to as dynamic equilibrium because it doesn't adhere to one strict notion of "normal", yet keeps the body constantly moving toward "normal", within a close range. For example, the body's temperature is not always 98.6, it may fluctuate a bit in either direction throughout the day.

Mechanisms of Homeostasis

The RECEPTOR provides data. It recognizes the stimulus or change in the environment and reports the value, for example...the temperature is 99.2

The CONTROL CENTER decides what to do with this information. An example of a control center is the hypothalamus. It compares the receptor input against the body's set point and decides what adjustments to make (if any).

The EFFECTOR carries out the plan. It is the means of altering organism's function according to control center output.

2 Types of Feedback in Homeostasis

In NEGATIVE FEEDBACK the effector's response opposes or negates the movement of original stimulus. If the original stimulus is saying that it is too cold, then the effector's response will negate the cold. It works to return organism to equilibrium and is the most common type of feedback.

In POSITIVE FEEDBACK the effector's response enhances the original stimulus. In this case, the organism temporarily moved further from equilibrium. One example is childbirth, where contractions get progressively stronger until the baby is born. This type of feedback occurs infrequently. It initiates a set of self-perpetuating events and also includes an event to break the cycle.

The Language of Anatomy

Anatomical position refers to standard body position...face forward, feet forward, arms at sides with palms turned forward.

Directional terms describe the relationships of anatomical structures.

Superior / Inferior = Above / Below

Ex: The head is superior to the chest
The umbilical region is inferior to the neck

Anterior / Posterior = Front / Back (also Ventral / Dorsal)

Ex: The heart is anterior to the spine
The heart is posterior to the breast bone

Medial / Lateral = Toward midline / Toward side

Ex: The heart is medial to the arm
The arms are lateral to the heart

Superficial / Deep = Toward surface / Away from surface (inward)

Ex: The epidermis is superficial to the skeleton
The lungs are deep to the skin

Proximal / Distal = Closer to midline or point of region / Farther away

Ex: The elbow is proximal to the wrist
The wrist is distal to the shoulder

Regional Terms

Regional terms designate specific areas of the body, such as the nasal region, and occipital region.



Body Cavities

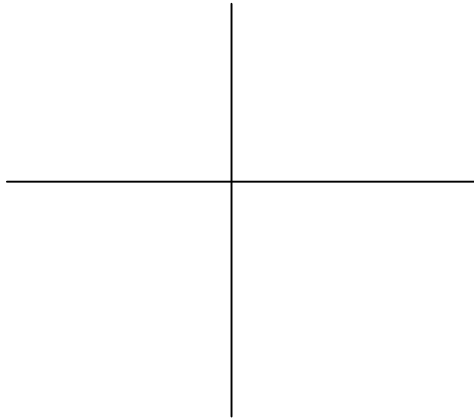
There are two major cavities in the body. They contain the internal organs and are subdivided into smaller cavities.

Two main cavities are the Dorsal Body Cavity and the Ventral Body Cavity.

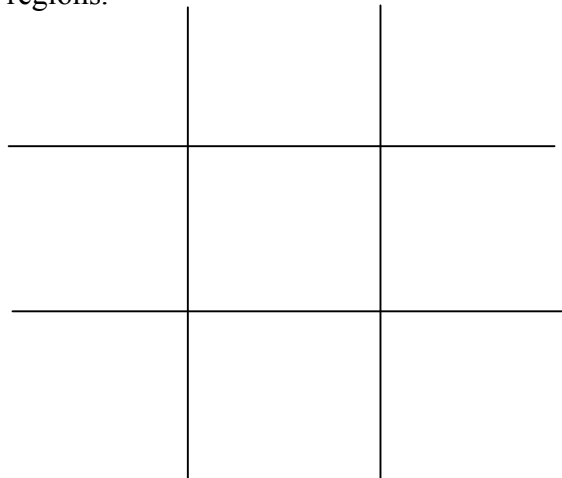
1. Dorsal Body Cavity
 - A. Cranial Cavity
 - B. Spinal Cavity
2. Ventral Body Cavity
 - A. Upper Thoracic Cavity
 - a) Two Pleural Cavities (lungs in each)
 - b) Mediastinum
 - 1) Pericardial Cavity (includes heart)
 - B. Abdominopelvic Cavity
 - a) Abdominal Cavity
 - b) Pelvic Cavity

Abdominopelvic Regions

In general terms, the abdominopelvic region can be divided into four regions, which form a + at the belly button.



In more detail, the area is divided into nine regions.



Chapter 2 Biochemistry

ORGANIC MOLECULES

There are four classes of organic molecules:

- 1-Carbohydrates
- 2-Lipids
- 3-Proteins
- 4-Nucleic Acids

CARBOHYDRATES are basically hydrated carbon. They are molecules composed of carbon, oxygen & hydrogen...with the hydrogen and oxygen in 2:1 ratio (most have this ratio)

The monomers of carbohydrates are **MONOSACCHARIDES**.
MONOSACCHARIDES are chains of 3 to 7 carbons, and each carbon is bonded to a hydrogen (-H) and a hydroxy group (-OH).
The chains cyclize in aqueous solutions, which means they form a ring structure when in water.

Glucose is the
KING of CHOs!

The common monosaccharides are the 6-carbon (hexoses),
glucose, galactose and fructose

... and the 5-carbon (pentoses),
ribose and deoxyribose (nucleic acids)

DISACCHARIDES are molecules formed by the dehydration of two monosaccharides
(remove the water from two monosaccharides and you get a disaccharide)

Common disaccharides:

- sucrose (glucose + fructose)
- maltose (glucose + glucose)
- lactose (glucose + galactose)

POLYSACCHARIDES are the polymers of many monosaccharides. They form long, branching chains. They are typically storage forms

Common polysaccharides:

- glycogen (animal storage form for glucose)
- starch (plant storage form for glucose)
- cellulose (structured, fibrous polysaccharide in plants that is indigestible by most animals)

PRIMARY FUNCTION OF CARBOHYDRATES is energy! Most forms are digested down and/or converted to glucose, which is oxidized within cells to produce ATP.

Other functions of CHOs include forming part of nucleic acids and attaching to proteins on cell membrane (glycocalyx?)

LIPIDS come in several varieties:

Neutral fats (triglycerides, triglycerols)
Phospholipids
Steroids
Eicosanoids

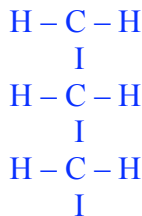
NEUTRAL FATS are the triglycerides. These are the fats that exist as fats (solids) and as oils (liquids). The monomers of triglycerides are:

- glycerol (modified simple 3-carbon sugar)
- 3 fatty acids (long hydrocarbon chain with a carboxyl acid group at one end)

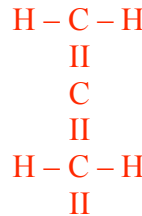
Fat and water don't mix! This is because fatty acids are non-polar and water is polar (+, -) with no internal separation of charges. Fatty acids make neutral fats **HYDROPHOBIC** and they do not dissolve in aqueous solutions.

CRITICAL THINKING: How are lipids transported in blood?

The degree to which fatty acid carbons are loaded with hydrogen is **SATURATION**. Saturated fatty acids are bad. Carbons form **single (covalent) bonds** with other carbons. This creates straight chains that pack tightly to create solids (fats). Unsaturated fatty acids are the good ones. In this type of fatty acid, there is one or more **double bond** between carbons. This creates "kinks" in long chains which keeps them from packing together tightly, so they form liquids (oils). Trans-fats straighten these chains out artificially, so they are solid...very bad!



In saturated fats, every carbon has a hydrogen. These straight chains can cluster tightly to create solids.



In unsaturated fats, double bonds make the chain kinked and can't pack so tightly. The form is liquid

Phospholipids are similar to triglycerides. They have a fatty acid chain, but one of the fatty acids is replaced by phosphorous containing group. This phosphate group is polar. This creates a hydrophilic head region. Because of this phospholipids may interact with water. The fatty-acid "tail" is still hydrophobic.

Steroids are large flat molecules with four interlocking hydrogen rings. The most significant of these is **CHOLESTEROL**.

Eicosanoids are a diverse group derived from arachadonic acid. The most significant of these is prostaglandin, though not much is known about this group.

THE FUNCTION OF LIPIDS is to provide energy (9kcal/gram— a very efficient storage form. It is used in structure of cell membranes, and fats insulate against heat and cooling. Lipids are also involved in metabolic activity...steroids and eicosanoids have hormonal activity.

PROTEINS are the monomers of amino acids. There are twenty common AAs utilized by all living things. The structure of amino acids includes a central carbon with four functional groups attached. ...a hydrogen, an amino group, a carboxyl acid group and a variable R group. Each R group has different functions and characteristics.

Amino Acid Structure

Some characteristics of R groups:

- Simple hydrogen
- Acidic
- Basic
- Sulfur-containing
- Complex hydrocarbon ring

PROTEINS are made up of amino acids that are linked together by peptide bonds. The links are created by the dehydration synthesis of carboxy and amino groups.

A dipeptide is two linked amino acids.

A polypeptide (aka peptide) is a chain of 10-50 amino acids (small proteins)

A protein is a chain of 100 to 10,000 amino acids.

The structural levels of proteins range from PRIMARY to QUATERNARY.

PRIMARY - Specific amino acid sequence
 - Determines all higher levels

SECONDARY - 3-D arrangement of primary structure
 - Alpha helix (coils stabilized by hydrogen bonds...the polar molecules interact) most common
 - Beta pleated sheet (accordian-like...chains hydrogen bond to self and others)
 - EVERY PROTEIN HAS AT LEAST A SECONDARY STRUCTURE

TERTIARY - Unique 3-D folding of the secondary structure
 - This configuration is held in place by hydrogen bonds, disulfide bonds, ionic bonds, and hydrophobic interactions.

- Most proteins have tertiary structure
- TERTIARY STRUCTURE IS CRITICAL FOR ENZYME FUNCTION!**

- QUARTERNARY**
- This is an aggregation and interaction of several tertiary structures
 - EX: Hemoglobin consists of two alpha and two beta chains

FUNCTIONAL TYPES OF PROTEINS

Fibrous proteins are long strands (such as hair) that typically only have an alpha-helix secondary structure. They may aggregate. Some examples include collagen, elastin, keratin and muscle proteins.

The more common **globular proteins** are compact, spherical tertiary or quaternary structure. Their shape (active sites) plays a vital role in their function. They play a variety of roles including:

- Cell membrane transport
- Immunity (antibodies are globular)
- Blood-borne carriers
- Cell identification/recognition
- Catalysis (enzymes)
- Hormone

When proteins lose their shape they lose their functionality and don't work anymore. This is called denaturation. What happens is the active site of enzymes changes shape and the enzyme no longer fits. The hydrogen bonds and ionic bonds that maintain the protein structure are affected by temperature and pH. If the body goes outside of these ranges, denaturation can occur. Sometimes it is reversible, and sometimes not (think egg whites).

NUCLEIC ACIDS are made up of nucleotides. The five common nucleotides are Adenine, Guanine, Cytosine, Thymine and Uracil. They are made up of a 5-carbon sugar (pentose...either ribose or deoxyribose) with a phosphate group added to the 5th carbon and a nitrogen containing base (A, G, C, T or U).

The **polymerization of nucleic acids** involves the sugar of one nucleotide binding covalently to the phosphate of the next nucleotide. This creates a long backbone of alternating sugars and phosphates, with the bases projecting outward.

There are three types of nucleic acids. DNA, RNA and ATP

DNA is deoxyribonucleic acid. It is the genetic material of the body. It is composed of A, C, G and T. The pentose involved in DNA is deoxyribose. Its structure is two antiparallel, complementary strands in a double helix.

RNA is ribonucleic acid. This is the “working copy” of DNA. It is composed of A, C, G and U. The pentose involved is ribose. There are three unique single-stranded conformations of RNA—mRNA, tRNA and rRNA.

ATP is adenosine triphosphate, the energy “currency” of the body. It is a derivative of RNA adenine nucleotide. It is three bound phosphate groups. The covalent phosphate bonds have high energy!!! ATP serves as the storage and transport of energy that is derived from nutrient oxidation. Energy is released when the phosphate bonds are broken...it yields ADP, inorganic phosphate and **USABLE ENERGY!!!**

Cell Organelles

Chapter 3

Cell Theory

- The cell is the smallest unit of life
- All living things are composed of cells
- Cells arise only from pre-existing cells

Components of cells

Cells are composed of the cell membrane, cytoplasm and the nucleus. Within the cytoplasm are the cytosol and the organelles (membraneous and non-membranous).

The Cytosol

The cytosol is the broth of the soup. The CYTOSOL is a viscous, semitransparent fluid that contains proteins, salts, sugars and nutrient monomers. The main salts in the cell are potassium and electrolytes.

Also in the cytosol are INCLUSIONS, which are non-encapsulated collections of material...kind of like an amphitheater...not an enclosure, but there's a general area. Inclusions include glycogen granules (liver and muscle cells), lipid droplets (adipose cells), and melanin (skin cells...protects nucleus from UV).

The Organelles

The organelles are “little organs” that are suspended in the cytosol. There are two types of organelles...membraneous organelles and non-membraneous organelles.

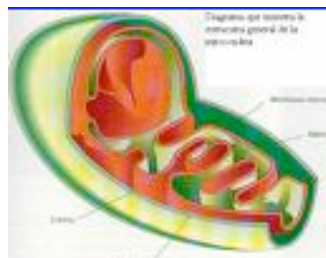
MEMBRANEOUS ORGANELLES are internal bodies surrounded by membrane. They maintain internal environments separate from cytosol.

NON-MEMBRANEOUS ORGANELLES are internal structures composed of protein or nucleic acid.

Mitochondria (Membraneous)

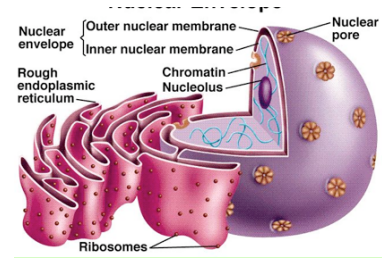
The Mitochondria are considered the “powerhouse” of the cell. This is where ATP production occurs in the cell (via cellular respiration). Mitochondria are capsule shaped, with a smooth outer layer and convoluted inner membrane that provides a lot of inner surface area. Mitochondria are unique in that they contain their own DNA! The quantity of mitochondria in a cell indicate its level of activity.

Mitochondria = plural
Mitochondrion = singular



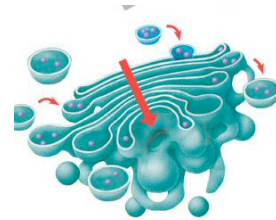
Endoplasmic Reticulum (Membraneous)

The ER is a network of flattened, fluid-filled sacs that is continuous with the membrane around the nucleus (it's part of the endomembrane system). There are two types of ER...the **ROUGH ENDOPLASMIC RETICULUM (RER)**, which has ribosomes imbedded into the membrane. This is the site of protein synthesis in the cell (just the basic protein product...not the end product). The **SMOOTH ENDOPLASMIC RETICULUM (SER)** is involved in lipid metabolism and the detoxification of drugs and carcinogens.



Golgi Apparatus (Membraneous)

Material from the ER goes to the **GOLGI APPARATUS** for modification, packaging and distribution. The Golgi apparatus is the “Pack-N-Ship” of the cell. It is a series of stacked, flattened and slightly concave discs



Vesicles (Membraneous)

Vesicles are “bubbles” of membrane containing some material. They are produced by the Golgi apparatus. There are three types of vesicles

1. Secretory vesicles
2. Lysosomes
3. Peroxisomes

SECRETORY VESICLES contain material to be released from the cell, such as hormones, enzymes and mucus. The membrane of the vesicles fuses with the cell membrane and replenishes it. **LYSOSOMES** contain digestive enzymes for degrading biological molecules. **PEROXISOMES** detoxify substances and neutralizes free radicals. Vesicles are the only organelles that go in and out of the cell.

Endomembrane System (Membraneous)

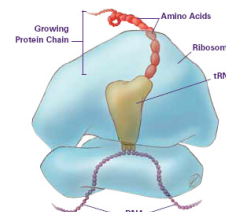
The endomembrane system is a continual flow of membrane through the cell. It does not include the mitochondria.

Material flows through...

- Nuclear envelope
- Endoplasmic reticulum
- Golgi apparatus
- Vesicles
- Plasma membrane

Ribosomes (Non-membraneous)

Ribosomes are the protein factories of the cell. They are made of ribosomal RNA (rRNA) and associated proteins in two unequal subunits that are only together when they are making protein.



Ribosomes are located in the cytosol (free floating) where they create intracellular proteins, and in the RER where they create membrane-bound or exported proteins.

Cytoskeleton (Non-membraneous)

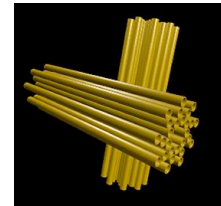
There are three types of cytoskeleton organelles. The first are the MICROTUBULES. These are the largest of the three and they are composed of tubulin. The microtubules radiate from the centrosome and function in internal cell movement.

MICROFILAMENTS are the smallest of the three. They are composed of actin (a globular protein) and function in cell motility.

INTERMEDIATE FILAMENTS are intertwined filamentous proteins whose composition varies among cell types. The static strands provide strength and support.

Centrioles (Non-membraneous)

Centrioles are paired barrel-shaped organelles that reside in the centrosome (the main microtubule organizing center). Their structure is a circular array of nine microtubule triplets. The centrioles aid in cell division and form the base of cilia and flagella.



Cilia (Non-membraneous)

Cilia are numerous projections of the cell membrane. They contain a core of microtubules arranged in nine doublets around a central pair. They create a wavelike fluid motion over the cell surface. The action moves stuff (like mucus) across the cell surface.

Flagellum (Non-membraneous)

Flagella are structurally similar to cilia, but they are significantly longer and exist singly (only one per cell). Their movement propels the cell through medium...sperm cells are the only flagellated cells.

Cell Membrane Chapter 3 cont'd

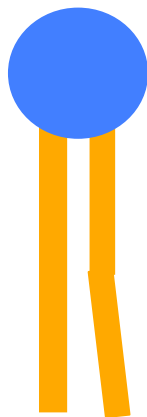
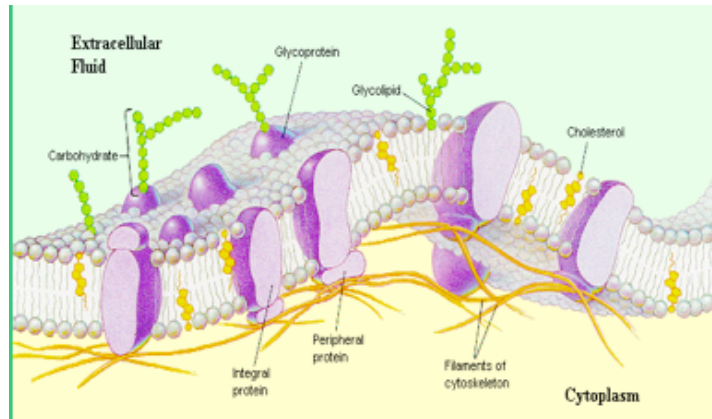
Fluid Mosaic Model

The Fluid Mosaic Model describes the structure of the cell membrane. It is made up of three components:

- 1) phospholipid bilayer
- 2) cholesterol
- 3) proteins

The Plasma Membrane

The basic material of the plasma membrane is the **PHOSPHOLIPID BILAYER**. It is composed of two layers of phospholipids that line up tail to tail.



Phosphate group is hydrophilic and polar. Faces water on inside and outside of cell

The tails are hydrophobic. They are slightly kinked and **UNSATURATED**, so the membrane is fluid. The tails are on the inside of the membrane and never come into contact with water.

The bilayer spontaneously forms in aqueous solutions. The ends close together to make a bubble!

CHOLESTEROL is another material of the membrane. It makes up about 20% of the membrane lipids. Cholesterol is a flat molecule that wedges between the tails of the fatty acids. This keeps the tails from packing too closely so it works to ensure the fluidity of the plasma membrane.

PROTEINS perform the most membrane functions, and there are a lot of proteins involved (which is the “mosaic” part of the Fluid Mosaic Model). **INTEGRAL PROTEINS** are imbedded in the bilayer. Most span the entire width of the membrane, and others protrude from one side only. The ones that span the entire width act as transport proteins, regulating the passage of materials into and out of the cell.

CHANNEL PROTEINS create a passive “pore”, contributing to the “leakiness” of the cell.

With CARRIER PROTEINS, a substance binds to the protein and it actively moves the substance across the membrane.

PERIPHERAL PROTEINS are attached to integral proteins or lipids, on one side of the membrane only (one or the other). The functions include acting as enzymes, receptors (when on outer surface) and mechanical support (when on inner surface).

The Glycocalyx

The glycocalyx is a carbohydrate rich layer surrounding the cell surface. It is made up of GLYCOPROTEINS and GLYCOLIPIDS. A glycoprotein is a protein with a small polysaccharide, and a glycolipid is a phospholipid attached to a carbohydrate. The function of the glycocalyx is to aid in cell-to-cell recognition. Cells have different patterns of sugars that make them recognizable.

Microvilli

Microvilli are tiny projections of membrane. They have a cytoskeleton core made of actin and microfilaments and a smaller than cilia. They don't actually move the way cilia do...their purpose is to increase the surface area of the cell membrane. It is most important in absorbant cells, such as the intestine.

Membrane Junctions

There are three types of membrane junctions.

1. Tight Junctions are a series of integral proteins interlocking with adjacent cells. This type of junction restricts movement between cells, and serves to keep things in and out. (EX: epithelial cells)
2. Desmosomes are rivet-like integral proteins between adjacent cells. They are STRONGER than tight junctions. Intermediate filaments join desmosomes across cells to provide strength, structure and resistance to pulls and stress. Desmosomes are found in tissues that stretch such as the heart and bladder. Desmosomes keep the integrity of the tissue.
3. Gap Junctions are transmembrane proteins that connect adjacent cells. This creates a cytoplasmic connection between cells, like a hallway between houses. This allows cells to communicate with neighbors and is especially important in electrically excitable cells, such as the heart muscle. Gap Junctions allow synchronicity of functioning.

Membrane Transport

The cell membrane regulates the flow of material between the internal cytosol and the external interstitial fluid.

Cell membranes are selectively permeable...it allows some things through, but not others.

There are two methods for crossing the membrane:

1. Passive processes
 - a. Diffusion
 - i. Simple Diffusion
 - ii. Facilitated Diffusion
 - b. Osmosis
 - c. Filtration
2. Active processes
 - a. Primary Active Transport
 - b. Secondary Active Transport
 - c. Vesicular Transport
 - i. Exocytosis
 - ii. Endocytosis

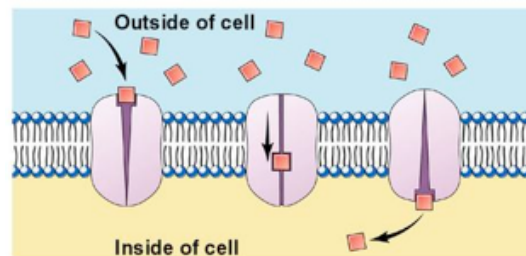
Passive Processes

DIFFUSION involves the molecules of a solute distributing evenly throughout the solution...the way a sugar cube will dissolve in tea. The solutes move due to KINETIC ENERGY of the molecules...and they move DOWN THE CONCENTRATION GRADIENT. This movement occurs until equilibrium is reached and the gradient no longer exists. The speed with which this occurs depends on:

- The steepness of the gradient (steeper = faster)
- The size of the molecules (smaller = faster)
- The temperature (hotter = faster)

There are two types of diffusion...simple diffusion and facilitated diffusion. In SIMPLE DIFFUSION, the solute moves directly across the phospholipids membrane. The solute must be non-polar and lipid-soluble. This includes oxygen, CO₂, fat-soluble vitamins and alcohol.

In FACILITATED DIFFUSION, the solute moves through a carrier or channel protein. This process is for polar and or larger molecules (glucose, amino acids, ions). There is a maximum amount that can get across at any given time b/c there are only so many proteins available.



OSMOSIS involves the solution (generally H₂O) moving DOWN its own concentration gradient. This process comes into play when the membrane itself is impermeable to the solute. Because the solute molecule is too big to cross the membrane, the water itself moves across.

TONICITY refers to the ability of a solution to change the H₂O volume of a cell through osmosis.

ISOTONIC SOLUTIONS = the same concentration of solutes.
No net movement

HYPERTONIC SOLUTION = has a higher concentration than the other solution.
Will draw water TOWARD IT TO DILUTE ITSELF
The compartment will EXPAND

HYPOTONIC SOLUTION = has a lower concentration than the other solution
Water will be DRAWN FROM IT
The compartment will SHRINK

In FILTRATION, the driving force is hydrostatic pressure gradient. The membrane selectively depends on the solute size. This occurs in capillaries and kidney tubules.

Active Processes

ACTIVE TRANSPORT is similar to facilitated diffusion in that it requires a carrier integral protein. The difference is that it moves the solute UP THE CONCENTRATION GRADIENT by way of a “pump.” Active transport uses ATP for energy. There are two types: primary active transport and secondary active transport.

PRIMARY ACTIVE TRNSPT = involves the direct usage of ATP to move solute
= solute binds to protein and waits for ATP to hydrolyze
= the energy release transforms the shape of the protein

SECONDARY ACT TNSPT = does not use ATP directly
= the ACTIVE transport of one solute CREATES A GRADIENT that may be used to move a second solute

If it moves in the same direction it's SYMPORT
If moving in both directions, it's ANTI-PORT

VESICULAR TRANSPORT involves the moving of large particles across the membrane (bacteria and macromolecules such as proteins). This is used for the bulk intake of fluid. There are two types of vesicular transport...exocytosis and endocytosis. EXOCYTOSIS is the outward movement of particles. Vesicles are formed internally by the Golgi apparatus. Exocytosis is used for secretions such as mucus, signal molecules (hormones and neurotransmitters), and cellular waste....and for adding fresh membrane

molecules to replenish the cellular membrane. ENDOCYTOSIS is the inward movement of particles...vesicle forms at the cell surface.

STEPS OF EXOCYTOSIS:

1. Vesicle migrates to the cell surface
2. It fuses with the membrane
3. Contents are expelled into extracellular space

STEPS OF ENDOCYTOSIS:

1. Cell creates cytoplasmic extensions
2. They envelop extracellular particles/fluid
3. Vesicle is moved internally

Phagocytosis (cell “eating”) is common among macrophages...and pinocytosis (cell “drinking”) is when the cell takes in fluid droplets containing solutes. Pinocytosis is common among absorptive cells. In RECEPTOR MEDIATED ENDOCYTOSIS, specific membrane-bound proteins bind substances like a lock & key. It allows for selective endocytosis...the cell gets exactly what it wants. This happens with things like enzymes, LDLs, iron and some hormones.

NO NET SOLUTE MOVEMENT IS WHEN THE MEMBRANE IS IMPERMEABLE OR WHEN EQUILIBRIUM IS REACHED.

THE CELL NUCLEUS

The structure of the nucleus:

- Contains information for cell functions
- Most cells are uninucleate
- Some are multinucleate (these were formed by the fusion of multiple cells. EX: skeletal muscle and osteoclasts.
- Some cells are anucleate such as red blood cells (they eject the nucleus!) and platelets (fragments of cells)

The NUCLEAR ENVELOPE (AKA nuclear membrane)

- Has a double phospholipids bilayer...the outer layer is continuous with the ER
- Is punctuated by nuclear pores where the two bilayers meet
- The pores allow large molecules to get out of the nucleus (mRNA and rRNA)

Inside the envelope is the NUCLEOPLASM

- Similar to cytosol (the broth of the nucleus)
- Differences are that it has different components and more nucleotides
- Contains CHROMATIN (collective term for ALL the DNA)
- Also present with the DNA are histones and nucleosomes
- The DNA supercoils/condense into distinct CHROMOSOMES (the compact structure)

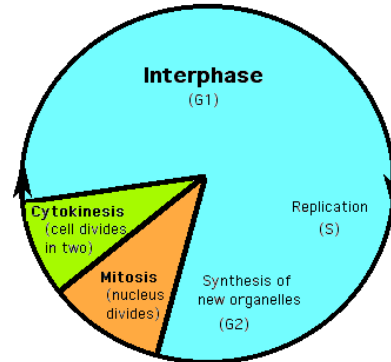
Within the nucleus is the NUCLEOLUS

- Dense area of chromatin
- This is where ribosomes are synthesized (RNA, hormones & enzymes)
- Active cells have MANY nucleoli

THE CELL LIFE CYCLE

There are two major phases of the cell life cycle:

1. Interphase: non-dividing growth phase. The cell is performing its function
2. Cell division phase: distribution of chromatin & cytoplasm into 2 daughter cells



INTERPHASE has three stages: G1, S and G2.

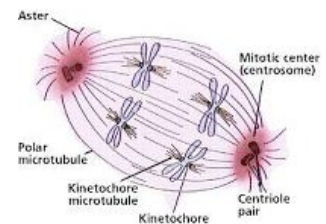
- G1: The cell grows some
Performs its functions
Most variable in length among different cells
- S: DNA replication
One copy of DNA for each daughter cell
The first step in preparation for cell division
- G2: Cell manufactures organelles
Slight growth in size

CELL DIVISION has two stages: Mitosis and Cytokinesis

MITOSIS has four stages: Prophase, metaphase, anaphase, telophase.

- Early Prophase:
- ASTERS EXTEND from centrioles (asters are projections of microtubules)
 - Asters form a MITOTIC SPINDLE
 - As MICROTUBULES extend toward each other they push each other toward poles
 - CHROMOSOMES condense
 - Sister chromatids (the two DNA strands) remain attached at the centromere
 - NUCLEOLI disappear

- Late Prophase:
- NUCLEAR ENVELOPE breaks down
 - KINETOCHORE microtubules form
 - The spindle fibers from the CENTRIOLES attach to the chromatid



-POLAR MICROTUBULES cross-link...they lengthen and push the centrioles apart

Metaphase: -CHROMOSOMES align on METAPHASE PLATE by the push-pull of the microtubules
-Equal pull on the kinetochore microtubules aligns pairs of sister chromatids

Anaphase: -SISTER CHROMATIDS separate
-Centromere splits and kinetochore microtubules continue to shorten while polar microtubules continue to lengthen and push
-The cell ELONGATES

Telophase: -The nuclear envelope reforms
-Chromosomes decondense
-Nucleoli reappear
-Mitotic spindle breaks down

CYTOKINESIS is the second stage of cell division. It involves the division of the cytoplasm. In cytokinesis:

- Contractile proteins form a ring around the equator
- This creates a CLEAVAGE FURROW which is caused by the shortening microfilaments
- They continue to shorten until they pinch the cell in half
- This process overlaps mitosis...it begins in late anaphase and ends after telophase

Protein Synthesis

Protein synthesis is the decoding of DNA to produce proteins...DNA is used almost exclusively to produce protein!

A GENE is a DNA segment that provides instructions for the synthesis of one polypeptide chain.

There are three steps to PROTEIN SYNTHESIS:

1. Transcription (making a copy of the DNA strand)
2. Editing (the copy is long...have to edit and delete portions)
3. Translation (have to translate into the correct language)

STEP 1: TRANSCRIPTION is the process of making a copy of the DNA strand...it involves RNA polymerase.

- RNA polymerase binds to and unwinds segments of the DNA strand (helicase is not needed)
- RNA polymerase only replicates one strand of the DNA

- As it moves along, it inserts and polymerases complementary RNA bases (Adenine binds with uracil, instead of thymine)
- This short segment is called mRNA...it is a complementary copy of the segment of DNA

STEP 2: EDITING

Pre-mRNA contains segments of “nonsense”...these are INTRONS. Spliceosomes excise introns and put the “good” pieces together. The rejoined segments are EXONS.

STEP 3: TRANSLATION

Nucleic acids are the language of DNA/RNA. This language must be translated into the “amino acid language” of proteins. Nucleic acids are composed of combinations of 4 letters (ACGU). Proteins contain 20 “letters”, which are the 20 common amino acids. Nucleic acids are used in groups of three to code for amino acids...this is called a CODON. There are 64 possible codons (4^3).

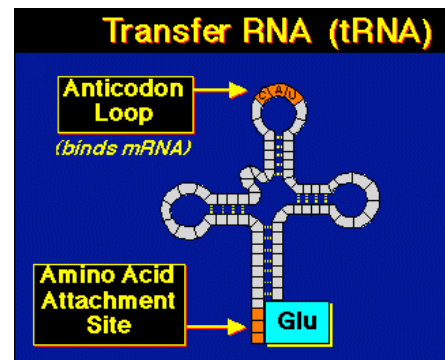
It is important to note that there is redundancy in the code...several codons will code for the same amino acid. This helps to reduce errors. For example, GUU, GUC, GUA and GUG all code for valine.

There are a few “special codes”... AUG is the universal start signal, and the stop signals are UAA, UAG and UGA.

The process of translation

First, mRNA leaves the nucleus via the nuclear pores and then binds to the large ribosomal subunit at a unique leader sequence of bases. The tRNA is a clover-leaf shaped molecule with a stem region that binds to a specific AA. The anticodon is the codon that is complementary to the code (AGC—UCG).

Protein synthesis is initiated when an mRNA, a ribosome, and the first tRNA molecule (carrying its Methionine amino acid) come together.



Messenger RNA (**mRNA**) provides the template of instructions from the cellular DNA for building a specific protein. Transfer RNA (**tRNA**) brings the protein building blocks, amino acids, to the ribosome. tRNA binds to the large ribosomal subunit.

Once the Ribosome is complete (both subunits together), it starts scanning the mRNA for the START CODON (AUG=methionine). Next, the tRNA binds the correct amino acid in place. The ribosome enzyme forms a peptide bond between the first two amino acids and the protein has begun!!

The ribosome then shifts down along the mRNA, bringing the next codon into the ACTIVE SITE. The first tRNA leaves and the process repeats. It stops when it comes

across a STOP codon on mRNA (UAA, UAG or UGA). The ribosome then disassembles and our protein is complete ☺ It then goes to the ER then the Golgi body for export, or it hangs out in the cytoplasm to do something for that particular cell.

DNA Replication

There are three stages to DNA replication

1. Uncoiling
2. Polymerization
3. Ligation

In UNCOILING the DNA uncoils from the nucleosomes with the aid of DNA helicase which unzips the strands by breaking the hydrogen bonds that hold them together. As helicase moves along the strand it forms a replication bubble, and the strands meet at a replication fork.

In POLYMERIZATION a group of enzymes converge on a single DNA strand, forming a replisome. One of these enzymes is primase. Primase creates an RNA primer, which is temporary. Next, DNA polymerase III (the molecule which does the actual polymerization) starts pulling in nucleotides and binding them to complementary nucleotides, moving in a 5 to 3 direction only. (A with T, G with C).

In LIGATION, there is a leading strand and a lagging strand. The leading strand is created by polymerase moving in the *same direction as the helicase*. It is formed continuously. The lagging strand is created by polymerase moving in the *opposite direction as the helicase*. It is formed in segments which are spliced together by DNA ligase.

Tissues Chapter 4

A TISSUE is a group of cells and cell products that are specialized to perform a common or related function. Tissues are not all made of the same cell type, but there is usually one main type and all of them are similar. The cells are differentiated... meaning they take on a specific role.

CELL DIFFERENTIATION is the process by which cells become progressively more specialized. It is a normal process through which cells mature.

There are over 200 unique tissues in the body, and **FOUR PRIMARY TISSUE TYPES**:

1. Epithelium
2. Connective Tissue
3. Nervous Tissue
4. Muscle Tissue

most
varied

Epithelial Tissue Types

Epithelial tissues are **COVERINGS**. They cover surfaces exposed to external environments (skin and mucous tracts – digestive, respiratory, urinary and reproductive)

Epithelial tissues are the **LININGS OF INTERNAL** surfaces. They line the ventral body cavity, pleural cavity, blood vessels, eyeball, inner ear and brain vesicles.

Epithelial tissues are **GLANDS**!

Epithelial Tissue Has 6 Major Functions

1. Protection (mechanical abrasion, chemicals, UV, dessication)
2. Absorption (lungs, digestive tract)
3. Filtration (kidneys)
4. Secretion (salivary enzymes, mucus, pancreas)
5. Excretion (sweat)
6. Sensory Reception

Characteristics of Epithelial Cells

- Highly cellular--cells live side by side with little extracellular material. Think of a housing project in the city.
- They have polarity--Epithelial cells have differences in their polarity between one side and the other. One side faces the outside world/internal environment and is the **APICAL SURFACE**. The side facing the underlying surface is the **BASAL SURFACE**. The sides facing adjacent cells are the **LATERAL SURFACES**.
- They have many **SPECIALIZED CELL JUNCTIONS**—lots of tight junctions and desmosomes.

- They have a BASEMENT MEMBRANE composed of two layers called LAMINA. The BASAL LAMINA is next to the epithelia and is secreted by epithelial cells. The RETICULAR LAMINA is secreted by the underlying connective tissue.
- They are INNERVATED (they have nerves!)
- They are AVASCULAR (they do not have blood vessels!)...except for endocrine glands, which are richly vascular.
- They are highly REGENERATIVE

Classification of Epithelial Tissue

Epithelial tissues are classified by the number of cell layer and the shape of the cell.

1. Number of cell layers
 - a. ONE cell layer = simple epithelia. Very delicate-used for absorption & secretion.
 - b. TWO or more cell layers = stratified epithelia. It is thicker/more protective.
2. Shape of the cell
 - a. Squamous are flat cells with a fried egg shape. It has a flat cytoplasm with bulging nuclear region.
 - b. Cuboidal are about as tall as they are wide.
 - c. Columnar are tall & thin

Specific Types of Epithelium

A. Simple epithelia

- a. SIMPLE SQUAMOUS EPITHELIA line protected areas of the body such as the ventral body cavity. SSE secretes a water serous fluid that allows frictionless movement between organs such as the heart and lungs. They also allow for diffusion and filtration, such as in the kidneys.
- b. SIMPLE CUBOIDAL EPITHELIA line most ducts and are used for secretion and absorption.
- c. SIMPLE COLUMNAR EPITHELIA line ducts and mucous tracts. They are used for secretion and absorption. This type is heartier than cuboidal. Some are ciliated to move mucus over the surface.
- d. PSEUDOSTRATIFIED COLUMNAR EPITHELIA line part of the respiratory tract and male reproductive tract. It appears to have multiple layers because the nuclei are at different heights above the basal membrane. All cells, however, do rest on the basal membrane. This type of cell secretes and absorbs, and the ciliated variety secrete and propel mucus.

LOCATIONS
SIMPLE SQUAMOUS
heart lining
blood vessels
renal glomeruli

LOCATIONS
SIMPLE CUBOIDAL
kidney tubules
glands

LOCATIONS
SIMPLE COLUMNAR
digestive tract

LOCATIONS
PSEUDOSTRATIFIED
COLUMNAR
respiratory tract
male reproductive tract

B. Stratified Epithelia

- a. **STRATIFIED SQUAMOUS EPITHELIUM** covers external surfaces (the skin). It is made up of multiple layers which protect against mechanical abrasion. The basal cells are mitotically active...this means maturing cells are pushed toward the surface and they flatten out.
- b. **STRATIFIED CUBOIDAL EPITHELIUM** consists of two layers of cells. This type is very rare and is usually transitional...existing between two epithelia. It lines some ducts of major glands such as sweat glands and mammary glands.
- c. **STRATIFIED COLUMNAR EPITHELIUM** consists of two layers of columnar cells, with the deeper layer having a cuboidal shape. The mature surface layer is columnar. This is a very rare tissue!
- d. **TRANSITIONAL EPITHELIUM** consists of multiple layers of cuboidal to columnar cells, with no distinct layering. It is found on surface areas that need to stretch. At its relaxed state, the cells are cuboidal. As the tissue stretches, they flatten out into squamous cells.

LOCATIONS
STRATIFIED SQUAMOUS
skin
oral lining
vaginal lining

LOCATIONS
STRATIFIED CUBOIDAL
sweat glands
mammary glands

LOCATIONS
STRATIFIED COLUMNAR
glandular ducts
part of pharynx
part of urethra

LOCATIONS
TRANSITIONAL
most of urinary tract

Glands

All glands are outgrowths of epithelium. A gland is one or more cells specialized to **SECRETE** a particular product (the secretion).

Glands are classified by the type of secretion (where it's released to), their cellularity (how many cells compose the gland), their structure (branching of the duct and shape of the secretory unit) and their mode of secretion (how product released from cell).

A. Type of secretion

- a. **EXOCRINE** gland has a product secreted from the **APICAL** surface onto an **EXTERNAL** surface or into an **INTERNAL** cavity.
- b. **ENDOCRINE** gland secretes **HORMONE** into extracellular space surrounding the gland. Endocrine glands are highly vascular!

B. Cellularity

- a. **UNICELLULAR** are individual cells scattered among other epithelial cells. These are **GOBLET CELLS**. Goblet cells secrete mucus onto the surface.
- b. All others are **MULTICELLULAR**

C. Structure of the Gland

- a. Ducts can be SIMPLE—one single duct
- b. Ducts can be COMPOUND—a branched duct
- c. The secretory unit can be one of three varieties
 - i. Tubular – long, tubelike pouches
 - ii. Alveolar/Acinar – rounded, sac-like region
 - iii. Tubuloalveolar – both types are present



D. Mode of secretion.

- a. MEROCRINE Method (most common). The cell secretes by exocytosis...example is the pancreas, sweat glands and salivary glands
- b. HOLOCRINE Method. The whole cell fills with vesicles containing the material. Once full, it ruptures and releases its product...example is sebaceous glands
- c. APOCRINE Method. Apical portion of the cell fills with vesicles. The apical portion pinches off and ruptures. This occurs in animals, and it's not clear if it occurs in humans.

Connective Tissue

Connective Tissues (CT) are located everywhere in the body. CT is the MOST ABUNDANT and widespread tissue.

Characteristics of CT

- Low cellularity
- Lots of space between cells (think Little House on the Prairie)
- Abundant non-living EXTRACELLULAR MATERIAL
- Very diverse types of CT that all derive from a common origin (the stem cell that differentiates...the MESENCHYME)
- High variable vascularity (some have none, some have a lot)
- No polarity of cells (b/c they're not on the surface they have no defining orientation)

CT is made up of CELLS and MATRIX, which is the extracellular/non-living material. The matrix consists of fibers suspended in ground substance.

Types of Cells

BLAST CELLS are the:

- Fibroblasts (makes fibers)
- Chondroblasts (makes cartilage)
- Osteoblasts (makes bone)
- Hemopoietic cells (makes blood)

WHITE BLOOD CELLS (WBC) include:

- Macrophages (eaters)
- Mast cells (signaling cell, produces histamine)
- Plasma cells (a lymphocyte)
- Eosinophils (release histamine)
- Neutrophils (gobble up cells)

ADIPOCYTES are the fat cells. They are not in bone or cartilage

MESENCHYMAL CELLS are the stem cells of all connective tissue. Mesenchymal tissue is the precursor to all adult connective tissue. It is found in embryos and umbilical cord (Wharton's Jelly)

The Matrix

The Matrix consists of fibers suspended in ground substance. The fibers are long strands of protein molecules.

There are three major types of FIBERS in CT.

1. COLLAGEN (most prominent)
 - a. Dense bundles of collagen protein (think of a thick rope)
 - b. High tensile strength

2. **RETICULAR fibers**
 - a. Made of same protein as collagen
 - b. Thin collagen fibers arranged in networks
 - c. This creates a 3D framework in solid organs (liver, spleen, lymph nodes)
3. **ELASTIC fibers**
 - a. Composed of the protein elastin
 - b. Allows CT to recoil to original size
 - c. Abundant in tissues that undergo stretching (heart, skin)

The **GROUND SUBSTANCE** is composed of:

- Interstitial fluid (similar to blood serum)
- Cell adhesion proteins (intercellular glue that attaches the cell to matrix components)
- Proteoglycans (large protein-polysaccharide aggregates that trap water and alter the **viscosity** of the matrix).

More proteoglycans
=
Higher viscosity of
ground substance

Types of Connective Tissue

1. **CT Proper** supports and wraps. The two types of CT PROPER are LOOSE CT and DENSE CT.
2. **Supportive CT** is more dense and strong. CARTILAGE and BONE fall into this category
3. **Fluid CT** makes up blood, which is mainly the fluid connective tissue. Lymph can also be considered fluid connective tissue.

Blast Cell of CTP
FIBROBLAST

Blast Cell of SCT
CHONDROBLAST
OSTEOBLAST

Blast Cell of FCT
HEMOPOIETIC CELL

Connective Tissue Proper (Loose CT and Dense CT)

AREOLAR CONNECTIVE TISSUE (a LOOSE CT) is the most generalized of all the CTs. It is found throughout the body and is sort of cobweb-ish in appearance. It underlies most epithelia and has a lot of ground substance (space between cells). Other characteristics and functions include:

- fills space
- binds tissues and organs together
- holds fluids, immune cells and adipose

AREOLAR LOCATIONS
under most epithelia
throughout the body

ADIPOSE (a LOOSE CT) is similar to areolar connective tissue (how?). It is made up of abundant adipocytes that pack the tissue, with little extracellular space. The cells contain lipid droplets that take up most of the cell, with the nuclei pushed off to the side.

ADIPOSE LOCATIONS
subcutaneous tissue
around heart and kidneys
behind eyeballs

Adipose connective tissue is richly vascularized, which makes the energy in the fat available via the blood.

RETICULAR TISSUE (a LOOSE CT) is also similar to areolar. It contains ONLY reticular fibers...no collagen at all. It forms the STROMA of solid organs (the liver, spleen). Stroma refers to the internal framework of the organ.

RETICULAR LOCATIONS
liver
spleen
lymph nodes
bone marrow

DENSE REGULAR TISSUE (a DENSE CT) is made up of densely packed collagen fibers. The fibers align in the same direction, which resists linear stress. DRT has high tensile strength! It is an elastic CT, because it contains more elastin, which is stretchy. Characteristics of the tissue include nuclei that are dense, dark and flattened. It is pretty avascular.

DENSE REG LOCATIONS
tendons (ropes)
ligaments
aponeuroses (sheets)

DENSE IRREGULAR TISSUE (a DENSE CT) is made up of thicker bundles of collagen. The bundles are arranged in multiple directions, so this CT is found in areas where tension is applied in multiple directions. It is vascular.

DENSE IR LOCATIONS
joint capsules
organ coverings
deep dermis

Supportive Connective Tissue (Cartilage and Bone)

CARTILAGE is avascular, which is why it doesn't heal well. It is also not innervated. Cartilage has no blood and no nerves! There are THREE TYPES OF CARTILAGE:

1. Hyaline
2. Elastic
3. Fibrocartilage

HYALINE CARTILAGE is the most common type in the body. It is firm, but slightly pliable, so it can be broken. Under the microscope, hyaline looks like big bubble-like cells that tend to cluster together.

HYALINE LOCATIONS
ends of long bones
nasal bridge
sternal ends of ribs

ELASTIC CARTILAGE is similar to hyaline, but has abundant elastic fibers. So, under the microscope EC is going to look a lot like hyaline, but with the presence of dark granular fibers. It has great resiliency!

ELASTIC LOCATIONS
ear pinna
epiglottis

FIBROCARILAGE is the toughest type of cartilage. It is structurally in between hyaline (with its rows of chondrocytes) and dense regular CT (with its dense collagen fibers). It has high tensile strength and compressability. Fibrocartilage often has a bluish stain, and to me looks a lot like dense regular CT...one notable difference is that the nuclei in fibrocartilage aren't squished like they are in DRCT.

FIBROCARILAGE
LOCATIONS
intervebral discs
pubic symphysis
knee minisci

BONE, the other type of supportive connective tissue) has a matrix embedded with mineral salts. It has more collagen than cartilage. Its dense, hard material is designed to resist compression. Bone is innervated and highly vascular.

Fluid Connective Tissue

BLOOD is the main fluid connective tissue, though some argue that lymph is also a FCT.

There are three types of blood cells:

1. erythrocytes (red blood cells)
2. leukocytes (white blood cells)
3. platelets

The MATRIX OF BLOOD is the PLASMA. Within the plasma are dissolved fibers used in clotting, and ground substance (serum). Ground substance is an aqueous solution with many dissolved substances.

Other Tissues (Membranes, Nervous Tissue & Muscle Tissue)

MEMBRANES are specialized multicellular sheets that are combinations of epithelium and connective tissue...so a combination of two types of tissue. There are three true membranes:

CUTANEOUS MEMBRANE

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
the skin	stratified squamous (keratinized)	areolar CT (superficial) Dense irregular CT (deep)	dry on surface

MUCOUS MEMBRANE

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
lining of tracts open to the exterior digestive respiratory urinary reproductive	stratified squamous (non-keratinized) OR Simple columnar	areolar CT (lamina propria)	Moist some secrete mucus

SEROUS MEMBRANE			
LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
Internal cavities that DO NOT open to outside world pleural cavity peritoneal cavity (examples)	simple squamous	areolar CT (superficial)	Secrete watery lubricating fluid called serous fluid (no friction btwn organs)

SYNOVIAL MEMBRANE (an additional one)

LOCATION	EPITHELIAL COMPONENT	CONNECTIVE TISSUE COMPONENT	CHARACTERISTICS
lining of joint cavities	Not a true epithelium. Rather, it's an incomplete layer of fibroblasts and macrophages	areolar CT	moist secrete watery synovial fluid

NERVOUS TISSUE is made up of two types of cells:

1. Neuron (can be really big). Neurons generate and transmit electrical signals. Most neurons have numerous cellular extensions (axons, etc...)
2. Glial cells (AKA “neuroglia” or “glia”). These are non-conducting support cells that insulate and protect neurons.

MUSCLE TISSUE is highly cellular and highly vascularized. The cells contain dense bundles of contractile proteins. There are three types of muscle tissue:

1. SKELETAL MUSCLE is characterized by long cells that are cylindrical (tapered at the ends). These long cells are multinucleate and the tissue itself is striated. Skeletal muscle is VOLUNTARY MUSCLE, in that it responds to nervous stimulation and we choose to move it.
2. CARDIAC MUSCLE is characterized by short cells that branch. They are uninucleate and the tissue is also striated. The hallmark feature of cardiac cells are

the intercolated discs...areas where two cells are joined. Cardiac muscle is INVOLUNTARY.

3. SMOOTH MUSCLE is characterized by spindle shaped cells that are uninucleate. Under the microscope it can look like dense regular connective tissue, so take note of the nuclei appearing more oval in smooth muscle, and not as squashed as in dense regular. Unlike skeletal muscle and cardiac muscle, smooth muscle is NOT STRIATED. Smooth muscle is also INVOLUNTARY (digestive system).

Tissue Repair

There are three stages of tissue repair, and they overlap a bit.

Stage 1: Inflammation

Stage 2: Organization

Stage 3: Regeneration ---or--- Fibrosis

INFLAMMATION occurs when tissue damage causes a release of chemicals which signal the immune cells to come to the rescue. The chemicals increase the diameter and permeability of the capillaries so stuff can leak out and enter the damaged tissue. The things that leak out of the capillaries into the tissue are white blood cells, plasma and clotting proteins. These guys attack pathogens and seal off the area. Dead pathogens and cells are also cleared by the macrophages.

ORGANIZATION involves granulation tissue replacing damaged tissue. It is made up of new capillaries and fibroblasts. Fibroblasts secrete growth factors and lay down collagen which bridges gaps in damaged tissue, eventually pulling wound edges together.

REGENERATION is the re-growth of the original tissue. Epithelia grow in over the fibrous connective tissue scar tissue. Regeneration occurs in smaller wounds and in tissue that is highly regenerative.

----or---

FIBROSIS occurs in bigger wounds or in tissue that is not regenerative, such as cardiac muscle tissue. In fibrosis, the destroyed tissue is replaced by fibrous connective tissue scar tissue.

HIGHLY REGENERATIVE Epithelium Bones Areolar CT Dense Irregular CT Hemopoetic Tissue
MODERATELY REGENERATIVE Smooth Muscle Dense Regular CT (tendons, ligaments)
WEAKLY REGENERATIVE Skeletal Muscle Cartilage
DO NOT REGENERATE Cardiac Muscle Nervous Tissue

Chapter 5 Integumentary System

Functions of the Integumentary System (I.S.)

Petite	Protection
Rhinos	Regulation of Body Temperature
Can't	Cutaneous Sensation
Mimic	Metabolic Function
Big	Blood Reservoir
Elephants	Excretion

Protection

The I.S. provides the body with a **CHEMICAL BARRIER** via secretions that lower pH which retards bacterial growth. The skin also secretes *human defensin*, a natural antibiotic. The I.S. also acts as a **PHYSICAL BARRIER**. The keratinized surface is tough and water resistant. Plus, it's dead...so it's hard to harm something that isn't living. The I.S. also acts as a **BIOLOGICAL BARRIER**. Langerhans cells & macrophages reside in the skin.

Regulation of Body Temperature

When it is hot out, the body utilizes **VASODILATION** to bring blood closer to the surface to help dispel the heat. When it is cold, the body utilizes **VASOCONSTRICTION** to pull the blood away from the surface. Also, **SWEAT GLANDS** carry heat away from the body via evaporation.

Cutaneous Sensation

The I.S. has receptors for temperature, light touch, pressure and pain.

Metabolic Function

The I.S. activates Vitamin D and supplements chemical conversions relating to the liver.

Blood Reservoir

About 5% of the body's blood volume is held in the skin. When the body undergoes severe blood loss, this reservoir is diverted from the skin to the internal organs where it is needed most.

Excretion

The I.S. excretes small quantities of nitrogenous wastes, as well as a few other wastes.

Anatomy of the Skin

The skin is cutaneous membrane. All membranes are made up of two types of tissues...an epithelial component and a connective tissue component. The epithelial layer is the epidermis. The connective tissue layer is the dermis.

Characteristics of the Epidermis

The epidermis is the epithelial component of the cutaneous membrane (skin). It is characterized by:

- Stratified squamous cells
- Keratinized cells (a feature unique to skin cells)
- Avascular (remember... minor paper cuts do not bleed!)

Cells of the epidermis are:

- **Keratinized stratified squamous** (the predominant cell). These cells produce fibrous protein called keratin. They are shed every 25-45 days.
- **Melanocytes**. They are located in the deepest layer and are highly branched cells whose extensions inject melanin into keratinocytes. The pigment melanin is produced in melanosomes. Melanin absorbs UV radiation.
- **Langerhans cells**. (aka epidermal dendritic cells). These cells are part of the immune system. They don't attack, but rather act as scouts and alert the immune system that help is needed. They arise in bone marrow and migrate to the skin. They have many cellular extensions that help them to detect invading cells.
- **Merkel cells**. These are located in the deepest layer of the epidermis because they remain in contact with a free nerve ending. They act as light touch receptors.

The 5 layers of epidermis!

Stratum basale

- Regenerates sloughed cells
- Location of skin stem cells
- 1-layer thick

Stratum spinosum (spiny layer)

- Contains Langerhans cells
- Keratinocytes contain melanosomes
- Melanin is here!

Stratum granulosum

- Keratin production begins
 - Stored in packets
 - Provides strength and water resistance
- Cells begin to flatten & die

Stratum lucidum

- Only present in thick skin*
- Thin, clear layer of flattened cells
- This is not what makes thick skin thick

Stratum corneum

- Thick layer of dead cells
- Cells are cornified...horn-y...hard and tough
- This layer is thicker in thick skin

5 layers of epidermis	
Boys	Basale
Suck	Spinosum
Girls	Granulosum
Love*	Lucidum*
Cats	Corneum

Layers of the dermis

Papillary layer

- Thin layer of areolar CT
- Dermal papillae are present. These are irregular pegs of CT that protrude up into the dermis like an egg-crate mattress
- This forms extensive ridges in thick skin (fingerprints!)

Reticular layer

- Thicker dense irregular CT
- Highly vascular & innervated
- Houses epidermal appendages (hair, nails, glands)

Skin Color

HEMOGLOBIN is a red pigmented molecule. It carries oxygen in the blood. Skin is semi-translucent, so red capillaries show through, giving a pinkish color to lighter-skinned people.

CAROTENOIDS are brownish-yellow/orange-ish pigment molecules. The breakdown products of some nutrients get deposited in skin (carrots!)

MELANIN is the major source of skin color. It is produced by melanocytes as a response to exposure of the skin to UV radiation. Melanin absorbs UV rays to protect the chromosome from mutation. There are three varieties of melanin:

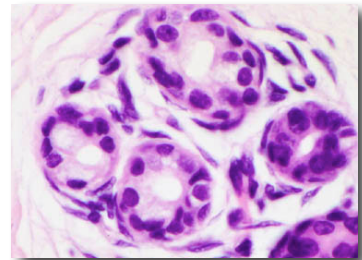
- 1) reddish brown (Native American)
- 2) yellow-ish brown (Asian)
- 3) blackish brown (African, Mediterranean)

RACIAL DIFFERENCES in skin color are not because of the number of melanocytes. The number of melanocytes among different races is roughly equal. The differences result in varying amounts of different hues of melanin. The darkness of one's skin has to do with the size and persistence of the melanosomes and where it is in the epidermis (how close to the superficial layer).

Epidermal Appendages (sweat glands, nails, hair)

SUDORIFEROUS GLANDS are the sweat glands. There are two types.

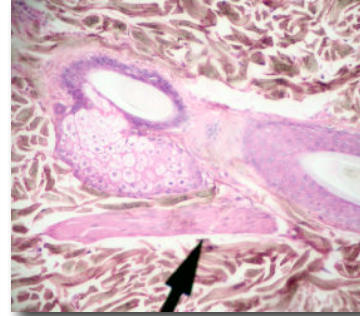
1. Eccrine sweat glands
 - a. These are everywhere!
 - b. They produce a watery sweat to help cool the body via evaporative cooling
 - c. SOME on while SOME off
 - d. Secretes by merocrine method



2. Apocrine sweat glands
 - a. Develop at puberty
 - b. Located in axilla, inguinal region, around nipples
 - c. Produce milky sweat that is high in lipids and proteins
 - d. Function is unclear, probably pheromonal
 - e. ALL on or ALL off
 - f. Secretes by merocrine method.

SEBACEOUS GLANDS

- secrete the oily sebum onto the surface of the skin and onto the hair shaft.
- Located only in thin skin
- Purpose is to lubricate skin & hair, prevent water loss and contains antibiotics



CERUMENOUS GLANDS

- Located in external ear canal
- Secretes cerumen (ear wax)
- Purpose is to capture particulate matter in the ear canal

MAMMARY GLAND

- Modified apocrine sweat gland
- Secretes milk

NAILS

- Protect the distal dorsal surface of digits
- Made up of modified epidermis, where the epithelial cells produce HARD KERATIN
- Grows from an area called the NAIL MATRIX
 - Heavily keratinized cells are pushed out over the nail bed
 - Seen on nail as white crescent called LUNULA
- Cuticle is also known as the EPONYCHIUM

HAIR

- Provides limited protection
- Covers all of the skin except for the palms, soles, lips, nipples and parts of the external genitalia
- It is a column of dead keratinized cells in concentric layers
- Produced of HARD KERATIN
- Grows in the HAIR FOLLICLE from the HAIR MATRIX
- HAIR MATRIX is a single layer of epidermal cells that overlies the HAIR PAPILLAE (a peg of dermal tissue at base of the follicle)
- Hair grows at a rate of about 0.33 mm per day.
- Rate varies by body region, gender and age

Hair growth cycle

Each follicle is active for weeks to years...the scalp is active for 6-10 years while the eyebrows are 3-4 months. This explains why your eyebrows never get as long as your hair. At the end of its active period, the hair follicle is inactive for a period of a few weeks or months. At this time the hair may fall out when the hair matrix cells die. As the matrix cells proliferate, new hair forms. As the new hair forms it will push old hair out of the follicle if any is present.

The ARRECTOR PILI MUSCLE pulls hair follicle upright in response to cold or fear. This is what gives us goosebumps!

Burns

Burns are caused by heat, electricity, chemicals and radiation (sunlight). The effects of burns on the microscopic level are denatured proteins and cell death. The effects on the clinical level are a loss of body fluids, metabolic imbalance and microbial infection.

RATING OF BURNS

- | | |
|------------------------|--|
| 1 st degree | -epidermis damaged
-regenerates in 2-3 days
-ex: sunburn |
| 2 nd degree | -epidermis & upper dermis damaged
-results in blistering
-heals in 2-3 weeks
-ex: scalding |
| 3 rd degree | -full thickness burn (epidermis & dermis)
-usually requires skin grafting, though technically CAN heal on its own. It would just take too long and the other factors are too dangerous. |

RULE OF NINES is used to estimate how much surface area has been lost so fluid replacement needs can be determined. The body is divided into 11 regions. Each region represents 9 percent, so take the number of regions and multiply by 9 to get the percentage.

1. Head & neck
2. Right arm
3. Left arm
4. Chest
5. Abdomen
6. Upper back
7. Lower Back & Buttocks
8. Right thigh
9. Left thigh
10. Right lower leg
11. Left lower leg