BIO 2310 - HUMAN ANATOMY & PHYSIOLOGY I

LABORATORY OBJECTIVES

REQUIRED: Human Anatomy and Physiology Laboratory Manual, Current Edition, Elaine N. Marieb, R.N., Ph. D.

BIO 2310 Dissecting Kit. Available in bookstore; includes a scalpel with replaceable blades, a blunt probe, and small scissors.

Not required, but strongly recommended, are disposable gloves (bookstore, Payless drugs, med. supply stores), and a lab coat or an old shirt to protect your clothing. Respirators with filters and eye goggles are available upon request.

HISTOLOGY

Exercise 3: Review the use and care of the microscope.

Exercise 6: a) Observe the following tissue types: Simple squamous epithelium, Simple cuboidal epithelium, Simple columnar epithelium, Pseudostratified columnar epithelium, Stratified squamous epithelium, Transitional epithelium, Areolar (loose) connective tissue, Adipose tissue, Dense (fibrous) regular connective tissue, Hyaline cartilage, Bone, Skeletal muscle, Cardiac muscle, Smooth muscle, Nervous tissue.

b) Note: Martini has some excellent histology pictures in chapter 5 as well as the color plates in your lab manual.

SKELETAL SYSTEM (ANATOMY)

Recommended time schedule:
Week 2 - Through the skull,
Week 3 - through the upper extremity,
Week 4 - finish and review.

Exercise 9: Read in preparation of skeletal anatomy.

Exercise 10: AXIAL SKELETON - You are responsible for the following:

CRANIAL BONES:
FRONTAL (1), Supraorbital foramen, Glabella,
PARIETAL (2), Sagittal suture, Coronal suture,

TEMPORAL (2), Squamous suture, External auditory meatus, Styloid process, Zygomatic process, Mastoid process, Mandibular fossa, Jugular foramen, Carotid canal, Stylomastoid foramen, Internal acoustic meatus, **OCCIPITAL** (1),

Lamboidal suture, Foramen magnum, Occipital condyles , Hypoglossal canal, External occipital crest and protuberance, **SPHENOID** (1), Greater wings, Superior orbital fissures, Sella turcica, Lesser wings, Optic foramina, Foramen rotundum, Foramen ovale, foramen lacerum, **ETHMOID** (1), Crista galli, Cribriform plates with olfactory foramina, Superior and medial conchae (turbinates), perpendicular plate.

FACIAL BONES:
MANDIBLE (1), Body, Rami (sing. ramus), Mandibular condyle, Coronoid process, Angle, Mental foramina, Mandibular foramen, Alveoli, Mandibular symphysis, **MAXILLA** (2), Alveoli, Palatine processes, Infraorbital foramen, **PALATINE** (2), **ZYGOMATIC** (2), **LACRIMAL** (2), Lacrimal fossa, **NASAL** (2), **VOMER** (1), **INFERIOR CONCHAE** (2).

HYOID BONE.

Frontal sinus, Ethmoid sinuses, Sphenoid sinus, Maxillary sinus.

TYPICAL VERTEBRA, Body, Vertebral arch, Vertebral foramen, Transverse processes, Spinous process, Superior and inferior articular processes, Intervertebral foramina, Intervertebral discs, **CERVICAL VERTEBRAE** (7), atlas, axis, odontoid process (dens), **THORACIC VERTEBRAE** (12), **LUMBAR VERTEBRAE** (5), **SACRUM** (5 fused sacral vertebrae), **COCCYX** (3-5 fused).

STERNUM, Manubrium, Body, Xiphoid process, Jugular notch, Sternal angle, **RIBS**, Head, Tubercle, Costal cartilage.

Exercise 11: APPENDICULAR SKELETON:

PECTORAL GIRDLE: **CLAVICLE**, **SCAPULA**, Acromion process, coracoid process , glenoid fossa [cavity], Supraspinous fossa, Infraspinous fossa , Subscapular fossa.

PECTORAL APPENDAGE: **HUMERUS**, Head, Shaft, Greater and lesser tubercles, Intertubercular (bicipital) groove, Deltoid tuberosity, Trochlea, Capitulum, Medial and lateral epicondyles, Coronoid fossa, Olecranon fossa, **RADIUS**, Head, Radial tuberosity, Styloid process, **ULNA**, Coronoid process, Olecranon process, Semilunar notch, Styloid process, **CARPAL BONES** (8), **METACARPALS** (I -V), **PHALANGES** (Proximal, Middle, Distal).
PELVIC GIRDLE: **OS COXA** (Coxal bone), **ILIUM**, Sacroiliac joint, Iliac crest, Anterior superior spine, Posterior superior spine, Anterior inferior spine, Iliac fossa, **ISCHIUM**, Ischial tuberosity, Lesser and greater sciatic notches, **PUBIS**, Obturator foramen, Pubic symphysis, Rami, Acetabulum.

PELVIC APPENDAGE: **FEMUR**, Head, Greater and lesser trochanters, Lateral and medial condyles, Lateral and medial epicondyles, Gluteal tuberosity, Linea aspera, **PATELLA**, **TIBIA**, Medial and lateral condyles, Tibial tuberosity, Medial malleolus, **FIBULA**, Lateral malleolus, **TARSAL BONES** (7), Calcaneus, Talus, **METATARSAL** (I-V), **PHALANGES** (Proximal, Middle, Distal).

Exercise 12: Observe fontanels on the fetal skeleton.

EXAM

MUSCULAR SYSTEM (ANATOMY)

Week 6 - Through infraspinatus,
Week 7 - through quadriceps,
Week 8 - finish and review.

Exercise 14: Read section on naming skeletal muscles. Observe a slide of skeletal muscle tissue.

Exercise 15: There are enough cats so that every two people may have one cat. More than two people per cat makes work difficult. The cats may not leave the laboratory room! Dissect as described in your manual, but only dissect one side of the cat, **its left**. (This way you will still have half of a cat left for later labs.)

You are responsible for the following:
Cutaneous maximus, Platysma, Mylohyoid, Digastric, Masseter, Pectoralis major, Pectoralis minor, Pectoantebrachialis, Rectus abdominis , Linea alba, External oblique, Internal oblique, Transversus abdominis.

Trapezius group, Levator scapulae vertralis, Deltoid group, Latissimus dorsi, Serratus ventralis (anterior), Subscapularis, Splenius, Rhomboid group, Supraspinatus, Infraspinatus.

Triceps brachii (lateral, medial, long head), Brachialis, Brachioradialis, Extensor carpi radialis group, Extensor digitorum communis, Extensor digitorum lateralis, Extensor carpi ulnaris, Biceps brachii, Epitrochlearis, Pronator teres, Flexor carpi radialis, Palmaris longus, Flexor carpi ulnaris.

Fascia lata, Sartorius, Tensor fasciae latae, Gluteus medius, Gluteus maximus, Caudofemoralis, Biceps femoris, Semitendinosus, Semimembranosus, Gastrocnemius, Soleus, Peroneus muscles, Extensor digitorum longus, Tibialis anterior, Quadriceps - Vastus medialis, Rectus femoris, Vastus lateralis, Vastus intermedius, Gracilis, Adductor femoris, Adductor longus, Plantaris, Flexor digitorum longus, Flexor hallucis longus, External intercostals, Internal intercostals.

NEUROMUSCULAR PHYSIOLOGY

To be announced.

EXAM

ANATOMY OF THE BRAIN AND CRANIAL NERVES

Exercise 17: Observe a microscope slide of a typical neuron.

Exercise 19: Dissect the sheep brain as described. You are responsible for the following structures:

Meninges: Dura mater, arachnoid, pia mater

Dorsal Structures: Longitudinal fissure, convolutions, cerebrum, cerebral hemispheres, cerebellum, corpora quadrigemina (superior and inferior colliculi).

Ventral Structures: Olfactory bulbs, optic nerves, optic chiasma, optic tracts, hypothalamus (infundibulum, rnammillary body), cerebral peduncles, oculomotor nerve, trochlear nerve, pons, medulla oblongata, trigeminal nerve, abducens nerve, facial nerve, vestibulocochlear nerve, accessory nerve, and hypoglossal nerve. (Note, cranial nerves IX and X are often difficult to find or missing on some of the brains.)

Internal Structures: Corpus callosum, lateral ventricle, fornix, third ventricle, thalamus, hypothalamus, pineal body, midbrain, cerebral aqueduct, fourth ventricle, cerebral peduncles, pons, medulla, and cerebellum.

PERIPHERAL NERVES AND REFLEXES

Exercise 21: Dissect your cat as described in the exercise. Know all of the nerves mentioned of the brachial and lumbosacral plexuses.

Exercise 22: Complete all exercises, but omit the "Corneal Reflex", "Salivary Reflex", and "Other Autonomic Reflexes". However, you should read these omitted exercises.

SENSORY PHYSIOLOGY

Exercise 23: Complete the exercises on Two-Point Discrimination, Tactile Localization, and Adaptation of Touch Receptors. Read through omitted exercises.

Exercise 24: Complete the visual experiments.

Exercise 25: Complete all of the hearing laboratory tests [excluding audiometry).

Exercise 26: Complete the following experiments: Stimulation of Taste Buds, Plotting Taste Bud Distribution, Effect of Olfactory Stimulation on Taste, and Olfactory Adaptation.

EXAM

MUSCLE CONTRACTION EXPERIMENT: USING COMPUTERIZED HARDWARE

Using Intelitool Physiogrip™, we will study Threshold Stimulus, Spatial Summation, Wave or Temporal Summation and Tetany, and Single Muscle Twitch.

GETTING STARTED

1. With the Macintosh, McADDAM Physiogrip transducer, and stimulator connected, you may power up the Macintosh, McADDAM and stimulator. The power indicator on the upper right hand corner of MCADDAM will light when the unit is turned on.

2. Launch the Physiogrip program. Push the "acquire" button.

3. Calibrate the transducer by selecting "calibrate". Follow the dialogue until calibration is complete.

LOCATE YOUR MOTOR POINT and DETERMINE THRESHOLD STIMULUS

1. The electrical pathway for the stimulus required for the various experiments should only be from the inside of the right arm to the back of the right hand. Never touch wires in such a way as to allow the circuit to be completed in any other way. IN PARTICULAR - **NOT THROUGH THE CHEST.** Do not do these experiments if you have a history of heart trouble. The risks are very low, but don't ignore them.

2. Human muscle can be directly stimulated through the skin using a strong stimulus. When stimulating skeletal muscles in this way, certain sensitive spots can be located that elicit a much greater response. These spots are called motor points. Motor points usually are directly over the location where the nerve supplying the muscle being stimulated enters the muscle. In this lab, we will be stimulating the flexor digitorum superficialis. First try an electrical stimulus at motor point A on the diagram which is the median nerve. This will cause the third finger to flex. If unsuccessful, try motor point B on the ulnar nerve which causes flexion of the fourth finger. Attach electrode on the back of the right hand using a generous amount of gel as shown in the diagram. Once the motor point is located, you may want to mark the spot on the skin.

3. An electrical stimulus that barely induces a muscle twitch is called a threshold stimulus.

4. Set the stimulator at 20 volts, 1 stimulus per second, 10 milliseconds duration.

5. With the subject completely relaxed, apply the probe to the skin of the right arm in the area of the motor point. Use considerable pressure for good contact. If no tingling is felt, increase the voltage until a sensation is detectable.

6. Move the probe around the area until the finger flexes. It may be necessary to increase the voltage to 70-80 volts before the muscle reacts.

7. Start a new data file (select "New" from file menu). Set the controls on the control bar so that "Autostop" is on, "Samples per Second" is 50, "Seconds per Data Set" is 100, "Metronome" is off. Turn the stimulator bar off.

8. Place the finger that flexes on the trigger of the Physiogrip. Reduce the voltage to a point where there is no response on the screen (about 10 volts).

9. Gradually increase the voltage to a level where you see a slight response. Record this voltage as the threshold limit.

SPATIAL SUMMATION

1. With your finger still on the trigger, demonstrate spatial summation. Increase the voltage by 10 volts above the threshold stimulus and administer a single stimulus. Note the increased contraction as more motor units respond.

2. Repeating stimulating the motor point by successively increasing the voltage by small increments until all motor units are recruited (Maximal contraction). Note the stair stepping in the strength of responses (Treppe). Do not increase the voltage once maximum recruitment has occurred. DO NOT EXCEED 100 VOLTS.

3. Return the Main Menu (ESC key) and review and analyze. Measure the heights of the contraction caused by the threshold stimulus and maximal contraction.

WAVE {TEMPORAL) SUMMATION AND TETANY

1. Wave summation occurs when the frequency of stimulation is increased to the extent that the motor units do not have time to relax. Tetany occurs when the contractions fuse to produce a steady state of contraction.

2. Start a new data file (select "New" from file menu). Set controls so that "Autostop" i s on, "Samples per Second" i s 50, "Seconds per Data Set " is 100, Metronome is off. Turn the stimulator bar On.

3. Set stimulus duration at 10 ms, frequency at 1 per second, and sufficient voltage to produce a response that is 25% of the screen. Choose continuous or multiple mode.

4. Gradually increase the frequency (events/sec) of the stimulus up to a tetanic contraction. This should be accomplished within 2 screens. Sustain tetanic contraction for 1-2 seconds.

5. Go back to main menu and analyze. Determine and record the frequency of stimulation as the point where a tetanic contraction was reached.

SINGLE MUSCLE TWITCH

1. In this demonstration of a single muscle twitch, you will evaluate the durations of each phase of the phenomenon. Start a new data file (select "New" from the file menu). Set the controls so that "Autostop" is off, "Samples per Second" 100, "Seconds per Data Set" 50, "Metronome" off, turn the stimulator bar off.

2. Set the stimulator to the maximal stimulus previously determined, frequency 1/second, duration 10 msec, and continuous mode.

3. Place the finger on the trigger and the probe on the motor point. Increase the voltage until the response is about 75% of the screen.

4. Click the mouse to stop data acquisition. Be careful not to loose the motor point. Change controls to "Autostop" on, "Samples per Second" 500, "Seconds per Data Set " 20, "Metronome" off, and the stimulator bar should be on.

5. Your finger should still be twitching. Have your partner click the Start button. When you have collected 200 seconds of data, data acquisition will stop.

6. Under "Analyze" menu, select "Disp & Vel." Determine the millisecond durations of the latent period, contraction period, relaxation period, and entire twitch.

SUMMATION

Summation: the combining of two or more local potentials on a nerve cell that is great enough to cause an action potential on that nerve.

Temporal Summation

The arrival of a second stimulus at a synapse before the effects of the first stimulus have disappeared, bringing the nerve to depolarization threshold.

Lab example: frequency was slowly increased while voltage intensity remained constant.

*If we continue to increase the frequency while leaving intensity unchanged, the muscle will exhibit peak tension and eventually reach complete tetany.

Spatial Summation

The simultaneous arrival of two or more stimuli at different synapses may be powerful enough to bring the nerve to depolarization threshold.

Lab example: voltage intensity was increased, while frequency remained constant.
(If the frequency is set relatively slow we would see treppe, as the example on the left shows)

Note: Treppe is hard to demonstrate in lab. The frequency must be set perfectly. So, in lab we compensate for this by increasing the intensity over a period of time.

Single Muscle Twitch

A) Latency Phase: the period of time from when the motor end plate is depolarized until actual cross-bridging of the actin and myosin occur.
B) Contraction Phase: from the start of cross-bridging until cross-bridging has reached its peak.
C) Relaxation Phase: actin and myosin cross-bridges begin to detach until they are all detached.

COURSE NOTES

Anatomical Terminology

Anatomy: the study of internal and external structures of the human body

Gross anatomy: macroscopic structures
Microscopic anatomy: visible with magnification

Cytology:

Histology:

Physiology:

7 levels of Organization smallest to largest

1) Atom:

2) molecule:

3) cellular: molecules interact to form

4) tissue: groups of cells combined together to

5) organ: various tissue types come together to form an organ

6) organ system: eg; cardiovascular system; all organs combining for a common function

7) organism: all systems combining for a common function of maintaining life ex. human being

Homeostasis steady state;

for survival every living organism must maintain homeostasis or a balance to prevent disruptive changes to our internal environment

Two systems in the body help maintain homeostasis: information goes to control center which decides what to do with the information

1)

2)

Two types of homeostasis

1) **negative feedback loops**

a way that we have to bring us back to homeostasis,

Example:

2) positive feedback loops
not as common in the body;

it controls processes that once started must be completed quickly, doesn't really lend towards homeostasis; childbirth. have a little hormone, a little contraction, then more and more until baby is out. (*positive feedback stops when the stimulus is removed*)

Anatomical References

Anatomical Position: allows for a common ground of visualization; person standing up, facing us, palms facing forward. (*for cat dissection; anatomical for cat is on all fours*);
still his/ her right and left

supine; person in anatomical position lying on table and on back. palms upward
prone; anatomical person lying on table on belly. palms downward

Directional terms

lateral; away from midline, away from the long axis of the body

medial; towards midline, closer to the long axis of body

proximal; closer to point of origin (*is term usually for arms and legs; where is attaches to torso*)(*ex. elbow is proximal to wrist*)

distal; further away from point of origin (*ex. ankle is distal to knee*)

anterior; front side (*same as ventral in humans*)

ventral; belly side (*same as anterior in humans*)

posterior/ dorsal; back side,

superior; structure that is above (*interchangeable with **cephalic** in human*)

cranial; skull structure (*interchangeable with skull in human)*

inferior; below, toward the feet

caudal; towards the tail

superficial/ external; more external structure, towards the outside of the body

deep/ internal; more internal structure, toward the inside the body, deep: lying below another structure

palmer; palm side of hand (*also anterior or ventral side of your hands*)

plantar; sole side of foot (*top of foot is dorsal side*)

ipsilateral; means on same side of body (*rt arm, rt leg)*

contralateral; means on opposite sides of body *(rt arm, lt leg*)

bilateral; means on both sides of body

Planes and Sections

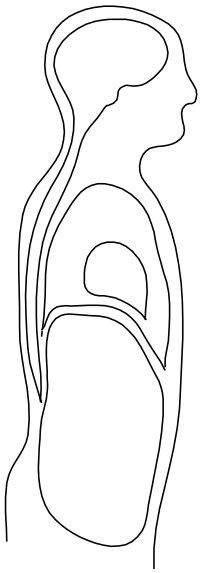
Planes parallel to the long axis of the body

1) sagittal plane (*section*); cut into lt and rt portions
-midsagittal plane (*section*); equal portions lt and rt
-parasagittal plane; off center

2) frontal plane (*coronal section*); cutting into anterior and posterior portions

transverse plane; (*aka cross section, horizontal);* cutting into superior/ inferior portions

Body cavities



Dorsal; (*posterior*)
Cranial:
Spinal:(*vertebral cavity*)

Ventral; (*anterior*); filled with all of your viscera (**guts**)

1) thoracic: chest cavity (*neck to diaphragm*)
pleural:

mediastinum: houses

Pericardial cavity houses the

2) abdominopelvic; inferior to the diaphragm

abdominal; digestive viscera, superior

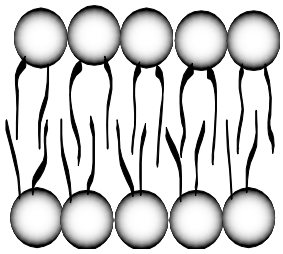
pelvic; inferior, the dividing line between the abdominal cavity and the pelvic cavity is an imaginary line between the sacral promontory and the pubic symphysis, the only reason you know you are in pelvic cavity is you are surrounded by the pelvic bones.; end of intestines, reproductive organs, bladder

The Cell Membrane

Also known as plasma membrane and plasmalemma, it forms the outer layer of the cell and separates the contents that are found inside the cell from is outside the cell, Structure of cell membrane; phospholipid bilayer; phospholipids are fats, also some proteins

Components of the cell membrane

1) Phospholipids
2) proteins
3) glycolipids
4) cholesterol



phospholipid bilayer: cell membrane is a phospholipid bilayer due to the fact that the cell membrane is made up of predominantly phospholipids aligned into two layers

Characteristics of the phospholipid bilayer

This phospholipid arrangement serves as an effective semipermeable membrane.

Proteins: make up

peripheral proteins attached to inner or outer part of cell membrane.

integral proteins embedded within the cell membrane,

Other proteins are involved in performing various functions within the cell including

1) cell to cell recognition
2) they also service receptor sites for binding hormones
3) they serve as enzymes
4) carrier proteins

Glycolipids: on surface of cell membrane are glycolipids

Cholesterol:

Functions of Cell Membrane

-physical isolation from outside environment
-regulation of exchange of materials with environment
-senses or recognizes changes to outside environment
-provides structure/ support for cell and cell's neighbor

Cell Membrane permeability

-impermeable (means it lets nothing pass through); cell membrane is not impermeable

-freely permeable (means it lets anything pass through); cell membrane is not freely permeable

-selectively permeable
membrane allows passage of some materials while restricting others, most membranes are selectively permeable *cell membrane is selectively permeable*

<u>Movement across membrane</u>

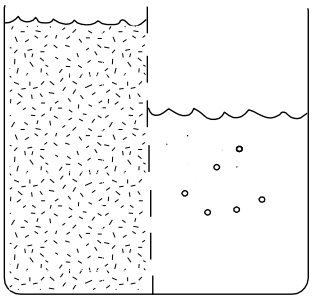
Molecules can move across the cell membrane in various ways

Diffusion-

A concentration gradient is the

Osmosis
Osmosis is

Let's explain how this works in physiologic system, for the sake of understanding, our definitions maybe slightly different than chemistry's definitions for these terms

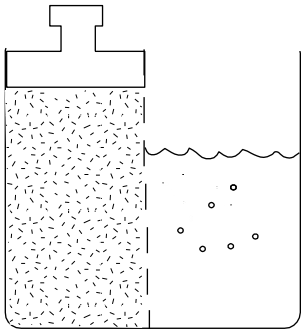


solute

solution

In osmosis water will flow across a membrane toward the solution containing the highest concentration of solute. Simply put,

osmotic pressure is defined as the amount of pressure needed on the

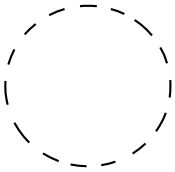


tonicity is the term given to describe the various effects osmotic solutions have on living cells

isotonic- isotonic solution has = concentration inside and outside the cell,

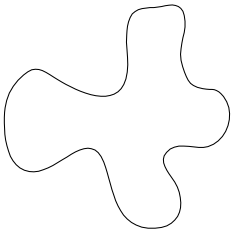
hypotonic-a hypotonic solution has less solute outside the cell inside.

Where does the water go?
What happens to the cell?

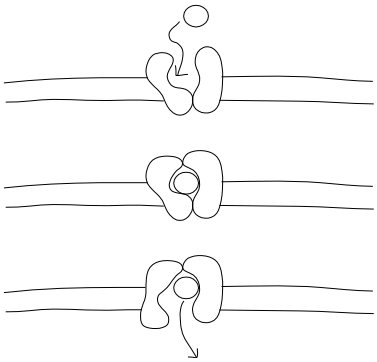


hypertonic- a hypertonic solution means that there's more solute outside to cell than inside.

Where does the water go?
What happens to the cell?



facilitated diffusion- molecules or passively transported across the cell membrane by carrier proteins
(aka passive transport)



Utilized for compounds like glucose for amino acids that are insoluble in lipids and/or are too large to fit through the membrane channels

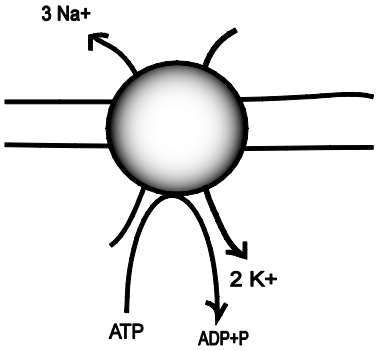
Filtration the movement of water and small solute molecules across a semi permeable membrane due to

movement by:

1) *hydrostatic pressure*- this simply means water pressure, this is the pressure created in the vessels from the pumping of the heart.

2) gravity-gravity forces H2O and small molecules through a semi permeable membrane

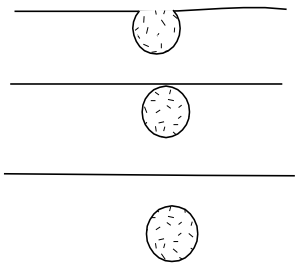
Active transport Energy from _____is used to transport molecules across the membrane independent of the concentration gradient.



Sodium potassium ATPase pump
For every ATP converted to ADP

Vesicular transport the transport of relatively large amounts of material into or out of the cell via small sacks known as vesicles.

Types of vesicular transport



Endocytosis-vesicle actively moved into cell (into the cell)

pinocytosis (means; cell drinking) vesicles of extracellular fluid are pinched off and brought into the cell containing H2O, lipids, sugars, amino acids, etc.

receptor mediated: requires specific receptors on cell membrane to fuse with a target molecule which allows the entire vesicle to be brought into the cell.

phagocytosis; (means; cell eating); white blood cells do this for a living. they eat other things. active process

Exocytosis- vesicle actively moves out of the cell.

B) **Cytoplasm**

THE CELLULAR MATERIAL OUTSIDE THE NUCLEUS BUT INSIDE THE PLASMA MEMBRANE; IS BOUT HALF CYTOSOL AND HALF ORGANELLES.

1) The Cytosol

CONSISTS OF A FLUID PORTION, A CYTOSKELETON, AND CYTOPLASMIC INCLUSIONS. FLUID PORTION IS A SOLUTION WITH DISSOLVED IONS AND MOLECULES AND A COLLOID WITH SUSPENDED MOLECULES (ESPECIALLY PROTEINS). MANY OF THESE PROTEINS ARE ENZYMES THAT CATALYZE THE BREAKDOWN OF MOLECULES FOR ENERGY OR THE SYNTHESIS OF SUGARS, FATTY ACIDS, NUCLEOTIDES, AMINO ACIDS AND OTHER

MOLECULES.

2) Organelles; *SMALL SPECIALIZED STRUCTURES WITHIN THE CELL. MOST HAVE MEMBRANES SIMILAR TO THE PLASMA MEMBRANE.*

a) cytoskeleton; *SUPPORTS THE CELL AND HOLDS THE NUCLEUS AND ORGANELLES IN PLACE. ALSO RESPONSIBLE FOR CELL MOVEMENTS. CONSISTS OF THREE GROUPS OF PROTEINS (MICROTUBULES, ACTIN FILAMENTS, AND INTERMEDIATE FILAMENTS)*

microfilaments; *SMALL FIBRILS THAT FORM BUNDLES, SHEETS, OR NETWORKS IN THE CYTOPLASM OF THE CELL. SPIDERWEB LIKE APPEARANCE. SUPPORT THE PLASMA MEMBRANE AND DEFINE THE SHAPE OF THE CELL.*

1) **actin;**

2) myosin

intermediate filaments; *PROTEIN FIBERS. PROVIDE MECHANICAL STRENGTH.*

thick filaments

microtubules; *HOLLOW TUBULES COMPOSED PRIMARILY OF PROTEIN UNITS CALLED TUBULIN. PROVIDE SUPPORT AND STRUCTURE TO THE CYTOPLASM, INVOLVED IN CELL DIVISION, TRANSPORT OF INTRACELLULAR MATERIALS, AND FORM ESSENTIAL COMPONENTS OF CERTAIN CELL ORGANELLES (CENTRIOLES, SPINDLE FIBERS, CILIA, AND FLAGELLA)*

Microvilli; *CYLINDRICALLY SHAPED EXTENSIONS OF THE PLASMA MEMBRANE. FUNCTION TO INCREASE THE CELL SURFACE AREA. DO NOT MOVE AND ARE SUPPORTED BY ACTIN FIBERS AND NOT MICROTUBULES.. HIGHLY MODIFIED TO FUNCTION AS SENSORY RECEPTORS.*

Centrioles; *FOUND IN THE CENTROSOME. EACH CENTRIOLE IS SMALL AND CYLINDRICAL, TWO CENTRIOLES ARE NORMALLY ORIENTED PERPENDICULAR TO EACH OTHER WITHIN THE CENTROSOME. THE WALL OF THE CENTRIOLE HAS 9 EVENLY SPACED, LONGITUDINALLY ORIENTED PARALLEL UNITS. EACH UNIT CONSISTS OF 3 MICROTUBULES JOINED TOGETHER.*

cilia; *APPENDAGES THAT PROTRUDE FROM THE SURFACE OF CELLS AND ARE CAPABLE OF MOVEMENT.*

flagella; *HAVE STRUCTURE SIMILAR TO CILIA BUT ARE LONGER AND USUALLY ONLY ONE EXISTS PER CELL.*

Ribosomes; *SITES OF PROTEIN SYNTHESIS. COMPOSED OF A LARGE SUBUNIT AND A SMALLER ONE.*

fixed; *FOUND IN THE E.R. AND CAN PRODUCE PROTEINS THAT ARE SECRETED FROM THE CELL.*

free; *PRIMARILY SYNTHESIZE PROTEINS USED INSIDE THE CELL.*

Mitochondria; *PROVIDE ENERGY FOR THE CELL. OUTER MEMBRANE HAS A SMOOTH CONTOUR, BUT THE INNER MEMBRANE HAS NUMEROUS INFOLDINGS CALLED CRISTAE. CELLS WITH GREATER ENERGY REQUIREMENTS HAVE MORE MITOCHONDRIA.*

Cristae; *ELECTRON TRANSPORT CHAIN EMBEDDED IN THE CRISTAE.*

Matrix; *SUBSTANCE LOCATED IN THE SPACE FORMED BY THE INNER MEMBRANE. KREB CYCLE TAKES PLACE HERE.*

Nucleus; *LARGE MEMBRANE BOUNDED ORGANELLE. CONTAINS MOST OF THE GENETIC INFORMATION OF THE CELL. USUALLY LOCATED NEAR THE CENTER OF THE CELL.*

nuclear envelope; *COMPOSED OF TWO MEMBRANES SEPERATED BY A SPACE. AT MANY POINTS ON THE SURFACE, THE INNER AND OUTER MEMBRANES FUSE TO FORM PORELIKE STRUCTURES; NUCLEAR PORES. MOLECULES MOVE BTWN THE NUCLEUS AND CYTOPLASM THROUGH THESE PORES.*

nucleoplasm; *SURROUNDED BY A NUCLEAR ENVELOPE.*

chromosomes; *CONDENSED CHROMATIN DURING CELL DIVISION*

histones; *PROTEINS THAT PLAY A ROLE IN THE REGULATION OF DNA FUNCTION*

nucleosome;

chromatin; *DNA AND PROTEIN STRANDS*

nucleoli;
Endoplasmic Reticulum; *CONSISTS OF BROAD, FLATTENED, INTERCONNECTING SACS AND TUBULES. INTERIOR SPACES ARE CALLED CISTERNAE AND ARE ISOLATED FROM THE REST OF THE CYTOPLASM.*

Rough ER; *ENDOPLASMIC RETICULUM WITH ATTATCHED RIBOSOMES. (PROTEIN SYNTHESIS)*

Smooth ER; *ENDOPLASMIC RETICULUM WITHOUT ATTACHED RIBOSOMES.*

functions; *MANUFACTURES LIPIDS, CARBOHYDRATES, CHOLESTEROL, AND STEROID HORMONES; ALSO PARTICIPATES IN DETOXIFICATION; SKELETAL MUSCLE SMOOTH ER STORES CALCIUM IONS THAT FUNCTION IN MUSCLE CONTRACTION.*

Golgi Apparatus; *FLATTENED MEMBRANOUS SACS, CONTAINING CISTERNAE, STACKED UPON EACH OTHER*

functions; *MODIFIES, PACKAGES, AND DISTRUBUTES PROTEINS AND LIPIDS MANUFACTURED BY THE SMOOTH AND ROUGH ER.*

transfer vesicles; *FORMS FROM THE MEMBRANE OF THE E.R. THE VESICLE MOVES TO THE GOLGI APPARATUS, FUSES WITH ITS MEMBRANE AND RELEASES PROTEINS INTO ITS CISTERNAE.*

secretory vesicles; *PINCH OFF FROM THE GOLGI APPARATUS AND MOVE TO THE SURFACE OF THE CELL. THEIR MEMBRANES FUSE WITH THE PLASMA MEMBRANE AND THE CONTENTS OF THE VESICLE ARE RELEASED TO THE EXTERIOR BY EXOCYTOSIS.*

Lysosomes; *MEMBRANE BOUND VESICLES THAT PINCH OFF FROM THE GOLGI APPARATUS. FUNCTION AS INTRACELLULAR DIGESTIVE SYSTEMS.*

Peroxisomes; *MEMBRANE BOUNDED VESICLES THAT ARE SMALLER THAN LYSOSOMES.CONTAIN ENZYMES THAT BREAK DOWN FATTY ACIDS AND AMINO ACIDS. CELLS WHICH ARE ACTIVE IN DETOXIFICATION HAVE MANY PEROXISOMES.*

Cell Attatchment

Gap Junctions

Tight Junctions

Intermediate Junctions

Desmosomes

Cell Life Cycle

Interphase; *THE PHASE BETWEEN CELL DIVISIONS. 90% OF THE TYPICAL CELL'S LIFE IS SPENT HERE. MAJOR GROWTH PHASE.*

G0 phase; *'RESTING' CELLS REMAIN HERE UNLESS STIMULATED TO DIVIDE*

G1 phase; *THE FIRST GAP PHASE.ROUTINE METABOLISM*

S phase; SYNTHESIS PHASE; DNA REPLICATION

DNA polymerase; *ADDS NEW NUCLEOTIDES AT THE 3' END OF THE GROWING STRANDS.*

ligases; *SPLICES SHORT SEGMENTS OF DNA*.

G2 phase; *SECOND GAP PHASE. ROUTINE METABOLISM*

Gm phase; MITOSIS.

Mitosis; *THE DIVISION OF THE NUCEUS INTO TWO NUCLEI, EACH OF WHICH HAS THE SAME AMOUNT AND TYE OF DNA AS THE ORIGINAL NUCLEUS. SOMATIC CELLS UNDERGO MITOSIS (GERM LINE CELLS UNDERGO MEIOSIS)*

Prophase; *CHROMATIN STRANDS CONDENSE. DNA REPLICATES*

Metaphase; *CHROMOSOMES ALIGN ALONG THE METAPHASE PLATE*

Anaphase; *CENTROMERES SEPERATE AND ARE PULLED BY SPINDLE FIBERS TO THE POLES OF THE CELL*

Telophase; *THE MIGRATION OF CHROMOSOMES IS COMPLETE. NUCLEAR ENVELOPE DEVELOPS AND NUCLEOLI REAPPEAR. CHROMOSOMES UNRAVEL AND CLEAVAGE FURROWS.*

Cytokinesis; *THE DIVISION OF THE CYTOPLASM TO PRODUCE TWO NEW CELLS. FIRST SIGN IS A CLEAVAGE FURROW. COMPLETE WHEN THE MEMBRANES OF THE TWO HALVES SEPERATE AT THE CLEAVAGE FURROW TO FORM TWO SEPERATE CELLS.*

Control Mechanisms at the Cellular Level

High Energy Compounds

Phosphorylation

ATP

ADP

GTP

UTP

Phosphagens

Creatine Phosphate

Pathways of Energy Production

Glycolosis; *CONVERSION OF GLUCOSE TO PYRUVIC ACID. TAKES PLACE IN THE CYTOPLASM*

Glucose-6-Phosphate + 2NAD + 2 ATP---------->

2 Pyruvate + 4 ATP + 2 NADH2
(inside cytosol)

Translation; *THE CHANGING OF SOMETHING FROM ONE FORM TO ANOTHER.*

(coenzyme A)
pyruvic acid----------> Acetyl CoA
(inside mitochondria)

The Citric Acid Cycle (Kreb Cycle)
(inside mitochondria)

Acetyl CoA enters Kreb Cycle to produce

1) 2 ATP

2) 3 reduced NADH2 and 1 reduced FADH2 which enter the electron transport chain

***oxidation- the loss of an electron**

***reduction- acceptance of electrons or H atoms**

<u>The Electron Transport System (inside mitochondria)</u>

The electrons from NAD and FAD enter the Electron Transport System and cascade down through a series of metalloproteins called cytochromes (a protein and a pigment molecule that contains either copper or iron). At the end of this cascade, oxygen atoms accept the electrons to create O- which has a strong affinity for H+ ion which accepts another H+ to become water

ATP is produced indirectly from the elecrochemical gradient that develops across the mitochondrial membrane. 32 ATP are produced via the Electron Transport System.

Total ATP produced for each glucose molecule = 36 ATP

<u>Summary</u>

Glycolosis

4 ATP produced by phosphorylation

-2 ATP used to initiate glycolosis

2 ATP net gain to cell

Kreb Cycle and ETS

4 ATP from NADH2 produced in glycolosis

24 ATP from NADH2 from TCA cycle

4 ATP from FADH2 generated in TCA cycle

2 ATP via GTP produced by substrate level phosphorylation

_____

36 ATP produced from aerobic metabolism of one glucose molecule

The Genetic Code

DNA; *ULTIMATELY DETERMINES THE STRUCTURE OF PROTEINS AND THEREBY CONTROLS THE STRUCTURAL AND FUNCTIONAL CHARACTERISTICS OF THE CELL.*

gene; *ALL OF THE TRIPLET CODES REQUIRED FOR THE SYNTHESIS OF A SPECIFIC PROTEIN.*

triplet code; *EVERY THREE NUCLEOTIDES CODE FOR AN AMINO ACID AND IS A BUILDING BLOCK OF PROTEIN.*

Transcription; *SYNTHESIS OF mRNA ON THE BASIS OF THE SEQUENCE OF NUCLEOTIDES IN DNA.*

mRNA; *MESSENGER RNA; TRAVELS FROM THE NUCLEUS TO RIBOSOMES IN THE CYTOPLASM WHERE THE INFORMATION IN THE COPY IS USED TO CONSTRUCT A PROTEIN*

RNA polymerase;

Translation; *THE CHANGING OF SOMETHING FROM ONE FORM TO ANOTHER.*

codon; *THE GENETIC CODE IS CARRIED IN GROUPS OF THREE NUCLEOTIDES CALLED CODONS.*

1) Initiation

light ribosome subunit

Heavy ribosome subunit

ribosomal RNA

transfer RNA

anticodon; ***CONSISTS OF THREE NUCLEOTIDES. STOPS TRANSLATION***

2) Elongation

3) Termination

Polyribosomes; *AFTER THE INITIAL PART OF mRNA IS USED BY A RIBOSOME, ANOTHER RIBOSOME CAN ATTACH TO THE mRNA AND BEGIN TO MAKE A PROTEIN. THE RESULTING CLUSTER IS CALLED A POLYRIBOSOME.*

Control of Genetic Activity

1) Control by negative feedback

2) Control by repressors

3) control by inducers

The Four Major Tissue Types

A) Epithelial; tissue that covers the_____. when you look at a slide, it may not have just one tissue on it. key is to know where to look to find the tissue. Epithelial tissue comes _____(digestive tract, lining of lungs, skin.) A layer of tissue that helps to form a barrier.

function;

1. lines an exposed surface

2. *SECRETING, TRANSPORTING, AND ABSORBING SELECTED MOLECULES*

B) Connective Tissue; *CONSISTS OF CELLS SEPERATED FROM EACH OTHER BY ABUNDANT EXTRACELLULAR MATRIX*

ex. cartilage, ligament, bones, blood, adipose, tendons, joint capsules

function

1.

2. involved in storing energy and transporting nutrients

3. provides structural support for the body

C) Muscle Tissue; *CONTRACTS OR SHORTENS WITH FORCE AND IS THEREFORE RESPONSIBLE FOR MOVEMENT*

three main muscle types.

1) Skeletal muscle. skeletal muscle is

2) **Cardiac muscle.** it is

3) **Smooth muscle**. it is

D) Neural Tissue; *CHARACTERIZED BY ABILITY TO CONDUCT ELECTRICAL SIGNALS CALLED ACTION POTENTIALS.*

nervous tissue will only fire on certain cell types. A nerve can fire on another nerve, it can fire on a muscle tissue, and on a gland.

1. carries information

2. conducts an electrical impulse

I. The Integumentary System
one of largest organs in the body and is certainly vital to survival. also known as the skin.

Functions of the Skin

1.

2.

3.

4.

5.

6.

The 3 Main Components of the Skin

A) Epidermis; outer layer of the skin. deep to epidermis is the dermis.

1. Stratum Corneum; *MOST SUPERFICIAL STRATUM OF EPIDERMIS.*

*made up of 15-30 layers of flat keratinized cells. Keratinization occurs to the cells exposed to the surface, keratinization is the production of keratin. This protein serves to increase the durability of the cells. They become tough, durable and water-resistant. Function: protective barrier of dead durables cells that slough off after 2 to 3 weeks.

*

2. Stratum Lucidum; usually only seen in the thick skin of the body.
*

*translucent layer filled with eleidin, a protein derived from keratohyalin, both are important in forming keratin

3. Stratum Granulosum *third layer in.

4. Straum Spinosum

*also contain Langerhan's cells

5. Stratum Germinativum made up of

stem cells -undergoing constant division, attached to the basement membrane of the epidermis the stem cells continually divide and migrate upward toward the surface

merkel cell –found in areas where there is no surface hair,

melanocytes – melanocytes produce

epidermal ridges-ridges that extend into the dermis, increasing the area of contact between the two regions

B) Dermis ; located below the epidermis. Two layers

1. Papillary Layer; *more superficial. consist of loose connective tissue.
*named after the

2. Reticular Layer; *deep to papillary layer.
*meshwork of dense, irregular connective tissue (made of collagen fibers)
*this is region that houses

C) Accessory Structures

1. Hair

about 5 million hairs on the human body

functions-

a)

b)

c)

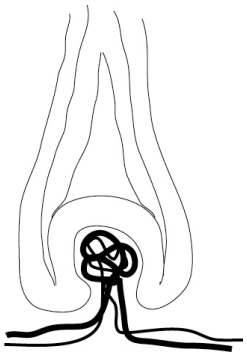
d)

<u>Anatomy of the Hair Follicle</u>

HAIR IS DIVIDED INTO SHAFT AND ROOT. SHAFT PROTRUDES ABOVE THE SURFACE OF THE SKIN, ROOT IS BELOW THE SURFACE. BASE OF ROOT IS EXPANDED TO FORM THE HAIR BULB.

MOST OF ROOT AND SHAFT COMPOSED OF COLUMNS OF DEAD KERATONIZED EPITHELIAL CELLS ARRANGED IN THREE CONCENTRIC LAYERS; MEDULLA, CORTEX,

CUTICLE.



MEDULLA; CENTRAL AXIS OF HAIR. CONSISTS OF 2-3 LAYERS OF CELLS CONTAINING SOFT KERATIN.(just above the matrix)
CORTEX; FORMS BULK OF HAIR AND CONSISTS OF CELLS CONTAINING HARD KERATIN
CUTICLE; SINGLE LAYER OF CELLS THAT FORMS THE HAIR SURFACE. CONTAINS HARD KERATIN, AND EDGES OF CUTICLE CELLS OVERLAP LIKE SHINGLES ON A ROOF.
(this is the hair shaft itself)
HAIR FOLLICLE CONSISTS OF A DERMAL ROOT SHEATH AND AN EPITHELIAL ROOT SHEATH.
HAIR BULB IS AN EXPANDED KNOB AT THE BASE OF THE HAIR ROOT. INSIDE THE BULB IS THE MATRIX, WHICH PRODUCES THE HAIR AND THE INTERNAL EPITHELIAL ROOT SHEATH.

Papilla-region in the center of hair bulb containing capillaries and nerves.

Matrix-epithelial cells around the papilla under constant division produce cells that are pushed up and out that make up the hair

2. Glands of the Skin

a) Sebaceous;*oil glands at the base of the hair follicle.
*produces

This is a holocrine secretion –

Sebaceous follicle -freestanding, not associated with the hair follicle

b) Sweat

1. true sweat glands, most widely distributed throughout body. 99% water,

Function

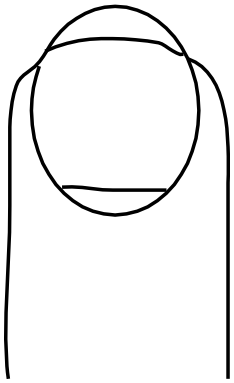
1)
2) excrete water and electrolytes
3) protect from the environment by diluting chemicals and decreasing bacterial growth

Merocrine glands-

2. Sudoriferous Gland
*located in the

Apocrine Gland-

3. Nails protect the dorsal surface of the fingers and toes, composed of dead tightly-pack keratinized cells



Free edge

Hyponychium- underneath

Eponychium- on top, stratum corneum fold over nail root

Nailbed

Lunula- region underneath the nailbed where the vessels are obscured

Nail route- Close to the periosteum, where the nail growth occurs

Lateral groove

II. THE SKELETAL SYSTEM

when we talk about skeletal system, we talk about bones, ligaments and cartilage because they all develop in the same way.

functions

1. support-

2. Storage of

3. blood cell production-red, white and other blood elements produced in the red marrow

4. protection-encases and protects

5. leverage-provides

A) Cartilage and Ligaments

Composed of: like other connective tissues, made of three main things.

1. Specialized Cells: *CARTILAGE CONSISTS OF SPECIALIZED CELLS THAT PRODUCE A MATRIX SURROUNDING THE CELLS.* (small fraction of the weight of structures) 2%

2. Extracellular Protein Fibers- three types

a) collagen-most common, flexible,

b) elastic fibers-branch, after being stretched

c) reticular fibers- branch and interwoven,

3. Ground Substance; fills in the spaces btwn the cells and the fibers. Made of glycoproteins (more protein than sugar) and proteoglycans (more sugar than protein)

Matrix:

Cartilage matrix contains specific proteoglycans called

Chondrocytes: chondro means cartilage. cyte means cell.

Lacunae: space w/in the matrix that

In general cartilage is avascular-no blood supply, nutrients must diffuse through matrix

***Perichondrium:** fibrous membrane that surrounds the cartilage.

<u>Three Types of Cartilage</u>

1. **Hyaline:** most common type of cartilage. Made of collagen fiber, make up 40% of its weight,
   Functions
   1) stiff, yet slightly flexible

2)

Location

1) joint surfaces
2) Tracheal rings
3) Rib and sternal junction

2. **Elastic:** as name implies, contains elastic fibers.
   Function
   1)

   Location
   1)

   2)

   3)

3. **Fibrocartilage:** very little ground substance

   Function: extremely, durable and shock absorbent

   Location:

B.) Bone: very similar to cartilage in make-up

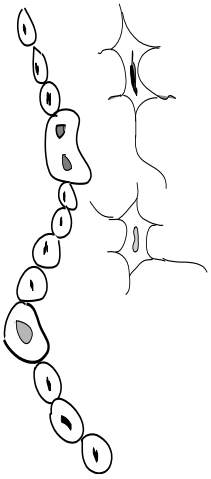
1. Matrix: ground substance plus fibers.

a) **Ground Substances**: calcium phosphate accounts for approximately two thirds of the weight of bone

   calcium phosphate interacts with calcium hydroxide to form hydroxyapatite which gives rigidity to boney matrix.

b) **Fibers:** collagen fibers make up about 1/3 of the weight of the bone. It is soft tissue. What do they add to characteristics of bone?

2. Specialized Cells; make up about 2% of the weight of bone



a) *OSTEOBLASTS* immature bone cell.

b) *OSTEOCYTE* mature bone cell. Lies inside the lacuna of bony matrix
functions: 1)
2)

c) *OSTEOCLAST:* giant, multinuecleated, immunocompetent cell. derived from immune system.

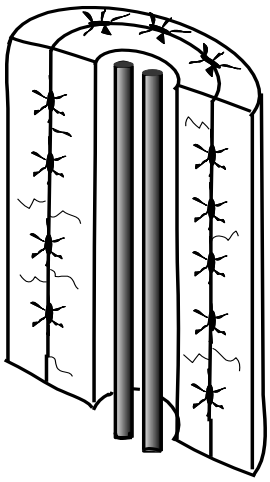
d) *OSTEOPROGENITOR CELL:* divide to produce daughter cells that

Wolf's law-

Two Types of Bone

A) Compact Bone: very dense, as name implies. This is bone we think of when we think of the long bones; the majority of bones.

Osteon- *HAVERSIAN SYSTEM.* Cylindrical shaped structure. aka haversian system. has a central canal known as haversian canal. Contains arterial and a venule. This is where osteon gets blood supply. also have concentric rings called concentric lamellae (rings that radiate outwards from central canal. sandwiched in between lamellae are osteocytes. Next are little channels called canaliculi (means little canal);



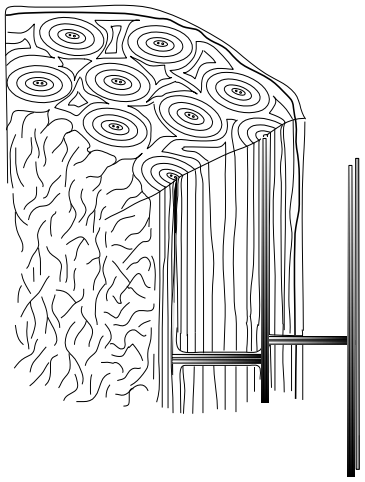
Haversian or central canal-contains vessels to supply the osteon

Lamella-concentric rings surrounding the central canal

Lacuna-houses the osteocyte

Endosteum -lines central canal, involved in repair

Canaliculi -passageways that connect lacuna with each other in the central canal for nutrients transport-diffusion



Interstitial Lamellae –

Canal of Volkmann- also known as the perforating canal,

Perisosteum; outer layer of bone, divided into two layers. peri means surrounding.

Outer layer- is fibrous CT layer (lots of collagen fibers),

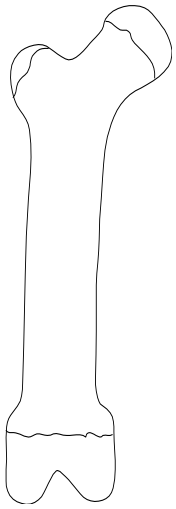
Inner layer- is cellular layer.

B) Spongy Bone: also known as cancellous bone or trabecular bone, forms a network of struts and plates within the central region of the bone. Found within the marrow cavities. no osteons located here. Instead, there is a series of interstitial lamellae that are aka trabeculae.

functions

1. reduces the weight of the skeleton
2. protects the stored fat in the yellow marrow for energy reserves
3. protects the blood cell formation in red marrow

Typical Long Bone Structure: *DIAPHYSIS, EPIPHYSIS, AND EPIPHYSEAL PLATE.*



DIAPHYSIS-SHAFT

EPIPHYSIS –HEAD

EPIPHYSEAL PLATE *REGION OF PRIMARY BONE GROWTH,*

METATHESIS-*FLARED REGION NEAR THE ENDS*

MEDULLARY CAVITY *FILLED WITH MARROW*

RED MARROW; SITE OF BLOOD CELL FORMATION, TRABECULA FOUND HERE

YELLOW MARROW; MOSTLY ADIPOSE TISSUE, VERY LITTLE TRABECULA FOUND HERE

Two Types of Bone Ossification

A) Enchondral Ossification: conversion of *CARTILAGE TO BONE;* begins with cartilage formation as an embryo. This is the way that long bones develop.

Four Steps Involved

Step 1: Chondrocyes w/in medullary cavity begin to enlarge and their lacunae enlarge with them reducing the matrix to small struts (trabeculae) that begin to calcify.

Step 2: Blood vessels encircle the diaphysis. and cartilage cells of diaphysis are converted to osteoblasts which then cause calcification of diaphysis. Blood vessels grow toward the cartilage. Calcified diaphysis (outside in)

Step 3: Blood vessels then pierce diaphysis growing into medulla allowing fibroblasts to migrate into medulla where they are converted to osteoblasts. (inside out)

Step 4: capillaries and osteoblasts move to the perimeter to replace cartilage tissue.

Primary growth centers in the center of the bone
Secondary growth centers around the periphery of the bone

B) Intramembranous Ossification; *CONNECTIVE TISSUE TO BONE;* allows us to form dermal bones, because this takes place in deep layers of the dermis, forming bones that are typically flatter than the long bones

Three Steps Involved

Step 1: osteoblasts cluster in deep layers of the dermis and secrete a matrix which mineralizes through the crystalization of calcium salts. Process begins ossification center, which traps osteoblasts converting them to osteocytes. (flat bones)

Step 2: bone grows outward from the center

Step 3: initially on this bone resembles spongy bone due to all of the spicules, but over time the spaces are filled in to produce compact

Appositional bone growth- this type of bone growth describes an increase in diameter over time as the bone envelops blood vessels lying along the outside of the periosteum to be brought in as blood vessels with in the haversian canal.

The Six Main Classifications of Bones

1. Long Bones: have a diphysis and epiphyses, typically enchondral ossification. i.e. femur, humerus

2. Short Bones: box-like. i.e. wrist and ankle

3. Flat Bones; thin, dermal bones. i.e. ribs, sternum, flat bones of the skull

4. Irregular Bones; complex shape with many ossifications centers. i.e. vertebrae

5. Sesamoid Bones; small, round, develop inside tendons, increase leverage. i.e. patella

6. Sutural Bones; AKA "wormian bones"; small flat bones found between sutures of the skull.

Bone surfaces markings

Due to Wolf's law- bones model to the stresses put upon them, forming projections and depressions etc.

Process-the projection or bump, general term

Ramus-an extension of bone making an angle to the rest of the structure

Trochanter-a large projection were a ligament or a tendon attaches

Tuberosity-a smaller rough projection where a ligament or tendon attaches

Tubercle-even smaller rounded projection where a ligament or tendon attaches

Crest-a prominent ridge where a ligament or tendon attaches

Line-a low ridge where a ligament or tendon attaches

Head-an expanded articular end of an epiphysis separated from shaft by metaphysis, it articulates with another bone

Condyle-a smooth rounded articular process

Trochlea-a smooth grooved articular process shaped like a pulley

Facet-a small flat articular surface

Spine-a pointed process

Fossa-a shallow depression

Sulcus-a narrow groove

Foramen-an opening or passageway for nerves or blood vessels

Fissure-an elongated or deep cleft or groove

Meatus-a canal leading through substance of bone

Sinus or antrum-a chamber in bone normally filled with air

Canal-in brain, a passageway that does not pass directly through the cranial vault like a foramen

Main Divisions of the Skeleton

I**. Axial Skeleton (80 bones);**

longitudinal axis of the body

1. skull - 22 bones
2. ossicles - 6 bones (hearing/ 3 each side)
3. hyoid - 1 bone
4. vertebral - 26 bones
5. thoracic - ribs 24 bones
6. sternum - 1 bone (really three; manubrium, body and xiphoid process)

II. Appendicular Skeleton (126 bones)

Axial Skeleton Covered First

A) Skull (two main divisions: Cranial bones and facial bones)

1. Cranium ; protect and house the brain

The 8 Cranial Bones

Paired	**Unpaired**
2 - temporal	1- frontal
2- parietal	1- occipital
	1- sphenoid
	1- ethmoid

Sutures; wiggly lines that join the flat bones of the skull together (joints), immovable

The Four Main Sutures of the Skull

1. Lambdoidal; joins the two parietal bones with the occipital bone

2. Sagittal; joins the two parietal bones together, runs in a sagittal plane

3. Coronal; joins the two parietal bones together with the frontal bone. runs in a coronal or frontal plane

4. Squamous; joins the squamous portion of the temporal bone with the parietal bone

Lambda-the point where the sagittal suture meet the lambdoidal suture
Bregma- the point where the sagittal suture meets the coronal suture

Principle Structures and Contents of Cranial Bones

1) Occipital Bone- houses occipital portion of the brain

a) occipital crest; attachment for ligamentum nuchae (ligament that runs along the back of the neck.

b) External Occipital Protuberance; also an attachment for the ligamentum nuchae

c) Superior and Inferior Nuchal Lines; attachment site for muscles and ligaments of the neck

d) Foramen Magnum; large opening for spinal cord exiting the skull

e) Hypoglossal Canal; hypoglossal nerve passes through here (nerve for the tongue)

2) Parietal Bones

a) Superior and Inferior temporal Lines; attachment site for temporalis muscle (exterior skull)

b) Groove for the Middle Meningeal Artery; groove on the inside of the skull for the artery that passes through foramen spinosum

3) Frontal Bone-

a) Supraorbital Margins; superior portion of the orbit

c) Supraorbital foramen; houses the opthamalic portion of the trigeminal nerve

c) Lacrimal fossa; located at the lateral root of the orbit, contains lacrimal gland (lab manual is wrong. book is right.)

d) Frontal Sinuses; behind glabella

4) Temporal Bones

2 Parts- **A) squamous- flat part, l**ateral
B) Petrous- pyramid shaped (houses the middle and inner ear)

a) Mastoid process; attachment site for muscles that move the head, mastoid sinus-lighten this skull

b) Styloid process; attachment site for ligaments and muscles that support the hyoid bone and swallowing muscles

c) Stylomastoid foramen; passage for facial nerve (trigeminal nerve V2)

d) Jugular foramen; passage for internal jugular vein, CN IX, X, XI

e) Carotid Canal; passage for internal carotid artery- enters skull through foramen Lacerum

f) Foramen lacerum; in the living body fibrocartilage tent covers the external opening of foramen lacerum. In the dead body, this covering degenerated and exposes this foramen

g) Mandibular Fossa; located just posterior to zygomatic arch. Houses the mandibular condyle.

h) Auditory Ossicles; bones of the middle ear located within the petrous (pyramid shaped) portion of the temporal bone

i) External Auditory Meatus; outer passageway for vibratory sound conduction to tympanic membrane

j) Internal Auditory Meatus; passageway for nerves from inner ear to brain

k) Zygomatic process; forms the posterior portion of the zygomatic arch

5) Sphenoid Bone

a) sella turcica; (turkish saddle)- a boney enclosure that houses the pituitary gland

Parts of the Sella turcica

1) hypophyseal fossa; is the depression in the center of the saddle that holds the pituitary gland (aka hypophysis)

2) Anterior and Posterior Clinoid Process; back and front part of the sella turcica

b) Optic groove; depression running between the two optic foramen

c) Optic foramen; passageway for the optic nerve

d) Superior Orbital foramen; passageway for several cranial nerves, CN III, IV, V, VI

e) Foramen Rotundum; passageway for a branch of the 5th cranial nerve. This nerve exits through infraorbital foramen

f) Foramen Ovale; passageway for a branch of the 5th cranial nerve

g) Foramen spinosum; passageway for middle meningeal artery

h) greater wing; lower/ larger wing

i) lesser wing; upper/ smaller wing

*medial and lateral ptyergoid plates are attachment sites for jaw muscles

6) Ethmoid Bone

a) Crista Galli; attachment site for meningeal coverings of the brain

b) Cribriform Plate; sieve-like structure with many holes through which olfactory nerve rootlets pass (smell)

c) Perpendicular Plate; forms superior part of nasal septum

d) Lateral Masses; attach laterally to cribriform plate and are filled with sinuses

e) Superior and middle concha; thin scrolls of bone that arise off of the lateral masses and project into the nasal cavities and create air turbulence as air passes around them during breathing

Purpose; filtration and warming of air

Principle Structures and Contents of Facial Bones

1) Maxillary Bone; largest facial bone; forms upper jaw

a) Orbital Rim; lower portion of the orbit

b) Infraorbital Foramen; branch of the 5th cranial nerve passes through here from foramen rotundum

c) Inferior Orbital Fissure; passageway for nerves

d) Alveolar Processes: house the teeth

e) Maxillary Sinuses; largest sinus in the skull- above the teeth

f) Palatine Processes; form anterior part of the roof of the mouth

2) Mandible; lower part of jaw, hinged and moveable

a) body; horizontal portion

b) Ramus; vertical portion

c) Angle; where body meets ramus

d) Condylar Process: articulates with the mandibular fossa of temporal bone. makes up the TMJ

e) Coronoid Process; (coronoid means knife-like); process anterior to condyle- attachment site for muscle that closes the jaw

f) Alveolar Processes; attachment sites and pockets for the teeth to set in

g) Mandibular Foramen; entrance for inferior alveolar nerve

h) Mandibular Canal; passageway for inferior alveolar nerve and vessels going to teeth

i) Mental foramen; inferior alveolar nerve exits through this foramen, providing sensation to the chin

Miscellaneous Information Regarding the Skull

1) Nasal Complex; just know the two main components of the nasal septum.
1) the upper part- the perpendicular plate of the ethmoid bone
2) the lower part - vomer bone

a) Nasal septum - parts
1) vomer-inferior and posterior
2) ethmoid-superior and anterior
3) maxilla makes up floor of the nasal cavity
4) nasal-makes up the bridge of the nose

b) nasal Concha; scroll-like bones located in the lateral walls of the nasal cavities

Function-cause air turbulence during breathing to filter dust particles

1) superior; ethmoid

2) middle; ethmoid

3) inferior; inferior nasal concha bone (seperate bone)

c) paranasal sinuses- lighten skull, humidify warm air, produce mucus to filter dust particles

1) frontal; located within the frontal bone behind glabella

2) ethmoid; in ethmoid bone, directly behind nasal bone

3) sphenoid; in sphenoid bone below sella turcica

4) maxillary; largest, below orbits

2) Zygomatic Arch - made up of zygoma (cheekbone); 2 parts

1) Temporal Process of the Zygomatic Bone

2) Zygomatic Process of the Temporal Bone

3) Bones of the Orbit

a) superior- frontal bone

b) lateral; zygomatic bone

c) posterior; sphenoid bone

d) medial; anterior to posterior

1) maxillary

2) lacrimal

3) ethmoid

4) sphenoid

e) inferior

1) maxillary

2) zygomatic

4) Fontanels- large areas of fibrous connective tissue that connects the flat bones of the skull together during fetal and neo natal development

functions;

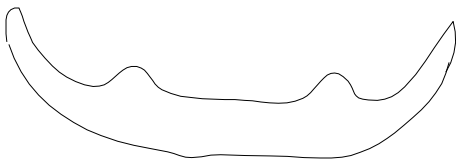
1) to provide flexibility during delivery

2) allows room for brain growth

Hyoid Bone ; only bone in the body that does not articulate with any other bone

-below mandible

- muscles and ligaments that attach to it are involved in swallowing, the tongue and the voicebox



Body

Greater cornu

Lesser cornu

2nd Part of the Axial Skeleton

Vertebral Column

5 Main Regions

1) cervical; neck (7 vertebra)

2) thoracic; chest (12 vertebra)

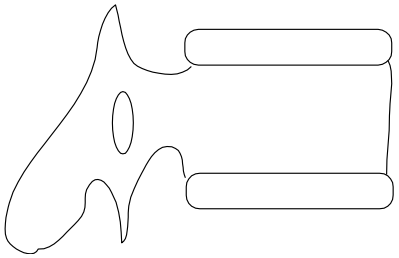
3) lumbar; low back (5 vertebra)

4) sacrum; pelvis (5 fused vertebra)

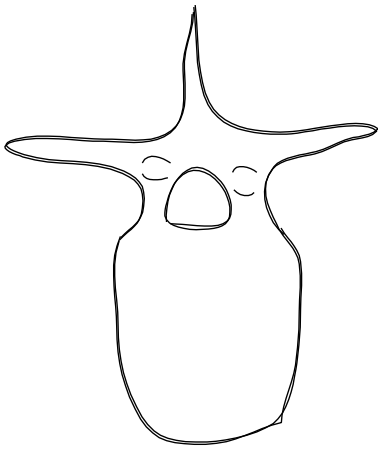
5) coccyx; tail bone (3-5 fused or unfused vertebra)

Vertebral Bone Structure

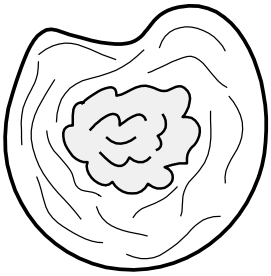
Superior articular facet/process
Spinous process
Lamina
Transverse process
Inferior articular facet/process
Body
Pedicle
Superior and inferior vertebral notches
Intervertebral disk



Transverse process
Spinous process
Vertebral arch
Pedicle
Body
Superior articular process
lamina



Intervertebral disc; flexibility and shock absorption



annulus fibrosis; outer fibrous ring

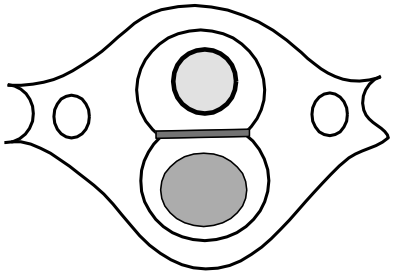
nucleus pulposis; jelly-like center (water and fat), shock absorber

Distinguishing features of each region

A) Cervical

1) transverse cervical foramen; vertebral artery

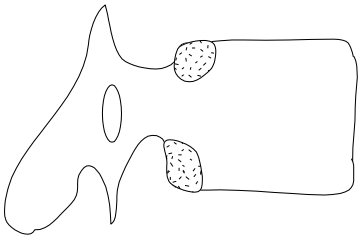
2) increased flexibility; due to first two cervical vertebra



a) atlas; C1 (upper)- has no vertebral body. serves for flexion and extension

b) axis; C2 - odontoid process (dens) fills the space where the body of C1 should be. Serves for axial rotation between C1 and C2.

B) Thoracic



1) articular facets on transverse process, costal facets

2) demifacets; on superior and inferior part of posterior portion of body for articulation with rib

3) decreased motion; due to attachment to ribs

C) Lumbar

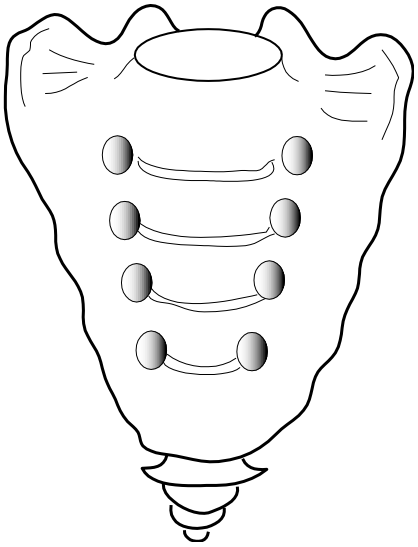
1) moderate flexibility

2) large bodies; bearing of body weight

D) Sacrum; 5 fused vertebra that articulate with hip bones (pelvis and os coxa)

1) 5 fused vertebrae

Anterior view



Articular process

base

Ala

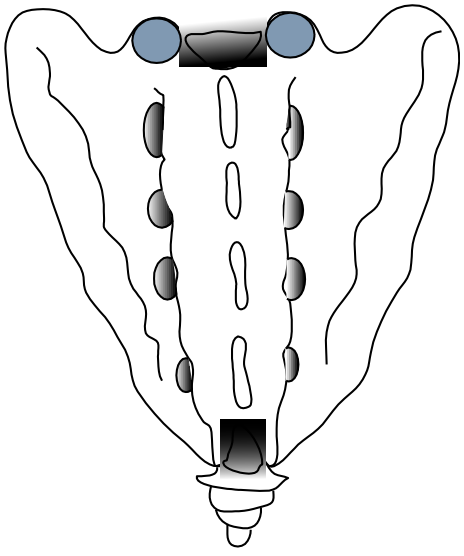
Auricle

Sacral foramina

Cornu

Body

Apex



Sacral canal

Articular facets

Sacral foramina

Median sacral crest

Lateral sacral crest

Coccygeal Cornu

Sacral hiatus

3rd Part of the Axial Skeleton

Thoracic Cage - 2 parts

A) Sternum-

1) manubrium; superior

2) body; middle

3) xiphoid process; inferior

B) Ribs; 12 pairs total

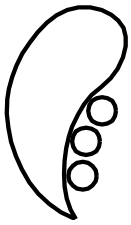
1) true ribs (vertebrosternal); 1st 7 pair. connect vertebra in back to sternum in front via costal cartilages (costal cartilage allows for more flexibility)

2) false ribs:

a) vertebrochondral; 8-10, costal cartilages. 8, 9, 10 fuse together and merge with 7th costal cartilage

b) floating; 11 and 12 ribs do not connect with sternum

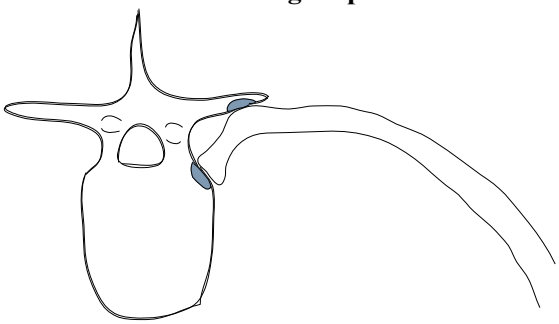
Rib Anatomy



Costal groove

Vein
Artery
Nerve

Rib movement- during respiration termed the bucket handle effect



Articular facets

tubercle
Angle

Neck

Head

body

Osseous Anatomy of the Upper Extremity

I) Pectoral Girdle (3 Bones)

A) Scapula (shoulder Blade)

1) body; forms a broad triangle with a:

a) superior border

b) medial border (vertebral border)

c) lateral border (axillary border)

2) Angles

a) superior

b) inferior

c) lateral (socket joint- glenoid fossa), glenoid labrum

3) anterior surface; faces ribs

a) subscapular fossa; muscle attachment (subscapularis)

4) posterior surface

a) spine

b) supraspinous fossa; separated by the spine

c) infraspinous fossa; separated by the spine

d) acromion; blunt process at the end of spine

e) glenoid fossa; large lateral shallow cup. Articulates with humeral head

f) glenoid labrum; cartilage lip that serves to deepen the glenoid fossa

g) coracoid process; arising off the superior border - medial to glenoid fossa

h) suprascapular notch; notch on the superior border, medial to the coracoid process

B) Clavicle

1) medial/ sternal end- only boney articulation of the pectoral girdle that articulates with the axial skeleton

2) lateral/ acromial end- articulates with the acromion (acromioclavicular joint). an A.C. tear is known as a shoulder separation

C) Humerus (Brachium)

***proximal articulation;** glenoid fossa of scapula

***distal articulation;** radius of ulna

<u>Boney Landmarks</u>

1) head; ;large, round process that articulates with the glenoid fossa
glenohumeral joint; (G.H. joint) a tear here is a shoulder dislocation

2) greater tubercle; lateral to head on proximal epiphysis. site for rotator cuff muscle attachment

3) lesser tubercle; anteromedial surface of proximal epiphysis. site for rotator cuff muscle attachment

4) intertubercular groove; (bicipital groove)- groove btwn greater and lesser tubercles that houses the long head of the biceps tendon

5) anatomical neck; region btwn the head and the tubercles

6) surgical neck; metaphysical region distal to the tubercles

7) shaft; long round diaphysis (shut your mouth)

8) deltoid tuberosity; process on lateral, central region of shaft attachment site for deltoid muscle

9) radial groove; distal to deltoid tuberosity on posterior aspect of the humerus. Houses the radial nerve

10) medial and lateral epicondyles- expansions of the distal metaphysis, proximal to the distal articulations; on lateral and medial sides of distal humerus

11) condyles

a) trochlea (pulley); medial anterior boney prominence, pulley shaped, articulates with ulna

b) capitulum (head); spherical "head" shaped. articulates with radius distally

12) coronoid fossa- depression for the coronoid process of ulna; proximal or superior to trochlea

13) radial fossa- depression for the radial head; proximal to capitulum. Allows room for radial head during forearm flexion

14) olecranon fossa- depression for the olecranon process; on posterior side, just proximal to condyles. room for olecranon (elbow) during extension of forearm

II. Radius and Ulna

1. bones that makeup the forearm (antebrachium)
2. proximally they articulate with the humerus
3. distally they articulate with the wrist or carpal bones

A) Ulna - medial

Boney Landmarks

1. olecranon process; elbow projection

2. trochlear notch; (semilunar notch) anterior articulating surface of olecranon that articulates with humeral trochlea

3. coronoid process; projection at the anterior surface of the trochlea, fits into coronoid fossa of the humerus

4. radial notch; small articulating surface lateral to trochlear notch. articulates with the radial head

5. interosseous membrane; fibrous membrane attaching the radial and ulnar shafts together

6. styloid process; small process on medial side of distal ulna

B) Radius - lateral, rotates about its long axis

Boney Landmarks

1. Head- articulates with the capitulum; proximal, cylindrical - shaped prominence

2. Neck; narrow portion distal to head

3. radial tuberosity; process distal to neck. attachment site for some forearm flexors

4. styloid process; distal process on lateral side

III. Carpals (wrist bones) 8

Distal Row- lateral to medial

1. Trapezium

2. trapezoid

3. capitate

4. hamate

Proximal row- lateral to medial

1. scaphoid

2. lunate (lunar shaped)

3. triangular (triquetral)

4. pisiform; pea shaped; sits on the triquetrum

IV. Metacarpals

labeled 1-5 lateral to medial

1. base (proximal)
2. shaft
3. head (distal)

V. Phalanges (digits)

1. Thumb (pollex) digit #1
*metacarpophalangeal joint - saddle joint

2. 2-5 phalanges

-base, shaft, head

a) proximal- attaches to metacarpal bones

b) middle

c) distal- has finger nail

Carpometacarpal joint - btwn carpals and metacarpals

Metacarpophalangeal joint - btwn metacarpals and phalanges

Proximal and Distal Interphalangeal joint- btwn phalanges

Lower Extremity

I. Pelvic Girdle

-articulates with the sacrum posteriorly and the pubic symphysis anteriorly
- made of three fused bones (os coxa)

A) Ilium- largest, most superior

Boney Landmarks

1. Anterior Superior Iliac Spine (ASIS)

2. Anterior Inferior Iliac Spine (AIIS)

3. Iliac Crest

4. Posterior Superior Iliac Spine (PSIS)

5. Posterior Inferior Iliac Spine (PIIS)

6. Iliac Fossa; medial, shallow fossa

7. Sacroiliac joint; auricular surface

8. Greater Sciatic Notch; above ischial spine

B) Ischium- posterior, inferior

Boney Landmarks

1. Ischial Tuberosity; most inferior process of os coxa, hamstring attachment site

2. Ischial spine; separates the greater and lesser sciatic notches

greater sciatic notch; above
lesser sciatic notch; below

3. Ischial ramus; posterior portion of obturator foramen; anteriorly projecting arm that fuses with inferior pubic ramus

C) Pubis- anterior

Boney Landmarks

1. Pubic Symphysis; fibrocartilage junction between the right and left pubic bones

2. superior ramus; travels laterally and superiorly to fuse with ilium

3. inferior ramus; travels laterally and inferiorly to fuse with ischial ramus

*The ilium, ischium, and pubic bones join together at the hip to form the acetabulum or the hip socket. This structure articulates with the femoral head.
*The acetabular labrum is a fibrocartilage rim or "lip" that serves to deepen the acetabulum

II. Leg

A) Femur

Boney Landmarks

1. Head; articulates with the acetabulum

2. fovea capitus; depression in the top of the head
*ligamentous attachment and arterial supply for femoral head. Dislocation can rupture this artery

3.anatomical neck; separates the head from the trochanters

4. greater trochanter; prominence on the proximal lateral superior femur, attachment for lateral hip stabilizers

5. lesser trochanter; prominence inferior and medial to greater trochanter, attachment for hip flexors

6. intertrochanteric line; line btwn trochanters on the anterior femoral surface for ligament and joint capsule attachment

7. gluteal tuberosity; posterior prominence distal to the trochanters that merge with the linea aspera

8. linea aspera; crest running along the entire posterior shaft of the femur, attachment site for adductor and quadriceps muscles

proximal- merges with the gluteal tuberosity

distal- merges with medial and lateral supercondylar ridge

9. medial condyle- large smooth process on distal medial portion of the femur

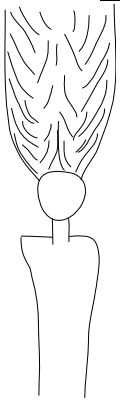
10. lateral condyle; large smooth process on the distal lateral portion of femur

11. intercondylar fossa; deep groove btwn the condyles (anterior and posterior cruciate ligament lie in this groove)

12. medial and lateral epicondyles; processes that sit laterally on top of each condyle

13. patellar surface; anterior distal smooth surface- articulates with the patella

Patella



*largest sesamoid bone in the body. lies in the quadriceps tendon

1) base- superior

2) apex- inferior

*popliteal fossa; posterior region of the knee

III. Foreleg- two bones

A) Tibia; medial bone, weight bearing 5/6th of the weight

Boney Landmarks

1. medial and lateral condyles; large flat prominences on proximal tibia with articular surfaces that articulate with femoral condyles

2. intercondylar eminence; small ridges that separate the two articular surfaces of the condyles

3. tibial tuberosity; a process distal to the condyles in anterior surface, attachment site for patellar tendon

4. interosseous crest; attachment for interosseous membrane on lateral shaft

5. medial malleolus; "mallet or hammer" the distal medial prominence

B) Fibula; non-weight bearing (1/6th the weight) lateral bone

Boney Landmarks

1. fibular head; most proximal prominence, does not articulate with femur

2. interosseous crest; attachment site for interosseous membrane on medial site

3. lateral malleolus; most inferior prominence of fibula (more distal that medial malleolus)

IV. Ankle (tarsus) 7 bones, analogous to carpal bones of the wrist

A) Talus; most superior bone, articulates with tibia and fibula proximally.

B) Calcaneous; most posterior, forms base for talus bone, aka heel bone, attachment for Achilles tendon ("tendon calcaneus")

C) Navicular; anterior to talus on medial side of foot (keystone-medial longitudinal arch)

D) Cuboid; anterior to calcaneus, lateral to navicular

E) Cunieforms (3) medial, intermediate, lateral; lie anterior to the navicular and articulate the first three metatarsals distally.

V. Metatarsals (5); analogous to the metacarpals of the hand. each has a proximal base, shaft and distal head

VI. Phalanges (5); as in the upper digits there are:

1) proximal
2) middle
3) distal

Hallux; big toe (digit #1) only has a proximal and distal phalanyx

1) proximal; phalanyx
2) distal ; phalanyx

Articulations where joints come together

A) Synarthrosis; immoveable joint

1) fibrous joint:

a) sutural joint: ex. joints of the skull. (fibrous connection with interdigitations). immoveable.

b) gomphosis: teeth,

2) Cartilage:

3) Boney Fusion:

B) Amphiarthrosis amphi- means slightly; slightly moveable joint

1) Fibrous:

2) Cartilage:

C) Diarthrosis freely moveable joint. also commonly called synovial joint, AKA. Synovial joint- synovial membrane lines the inside of joint secreting a viscous fluid to lubricate the joint to reduce friction. The fluid is contained within the joint capsule to prevent leaving dissipation

(arthritis: joints surrounded by ligaments as well/ made up of collagen fibers; true strength to joint is due to muscles that cross that joint. all ligaments really do is ensure that biomechanics are as they should be. if you were to injure joint, say on one side, then ligament on one side is more lax than on other side. this alters normal biomechanics and creates uneven wear. what does body do in this case? body can't tighten the ligament, so it begins to lay down extra bone to increase surfaces btwn the two bones-more stable base- that increased surface area look like little boney spur. this wears down some of the cartilage.)

Anatomy of a synovial joint

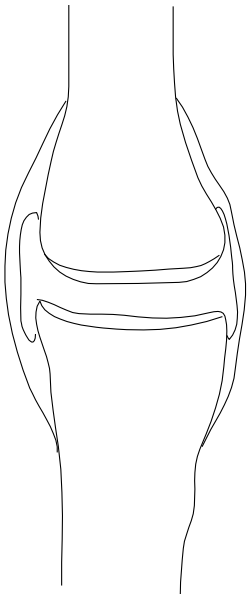
Joint cavity

Hyaline cartilage- hard and smooth

Joint capsule- continuous with periosteum
Reinforced by ligaments

periosteum

synovial membrane- produces synovial fluid



MUSCLE TISSUE
one of four primary tissue types. Muscle tissues do one thing and one thing only-

Various Functions of Muscle Tissue

1.

2.

3.

4.

5.

6.

Three Types of Muscle Tissue

A) Skeletal muscle tissue: voluntary and striated. relatively fast contracting, move the body and its parts through space. Multi-nucleated

B) Cardiac muscles: heart, involuntary and striated; push blood through the body. also have intercalated discs (gap junction; little ports or holes from one cell membrane to another cell membrane),

C) Smooth Muscle: involuntary and not striated. Still have actin and myosin, but have no striations. Relatively slow contracting. Involved in moving materials through the body

Components of Skeletal Muscle Tissue

Outermost to innermost

1. superficial fascia: loose connective tissue just below the skin that attaches the skin to the deeper tissues

2. epimysium: outer dense regular connective tissue surrounds the muscle belly.

3. perimysium: is a combination of collagen and elastic fibers surrounding muscle bundles

4. endomysium: collagen fiber layer that

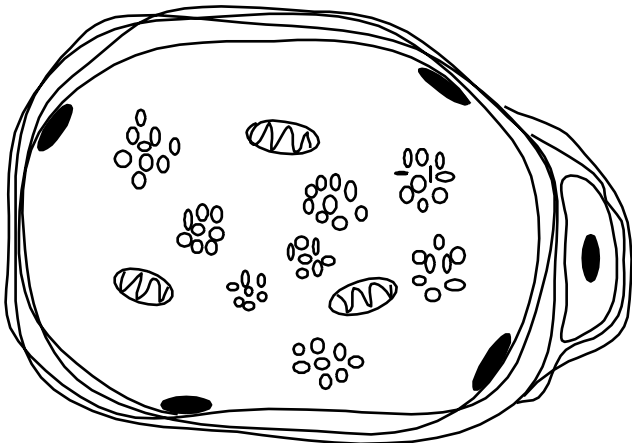
5. muscle fiber/cell:

6. myofibril

Skeletal Muscle Microstructure:

during embryonic development muscle cells called myoblasts fuse together to form one large multi nucleated cell called a skeletal muscle fiber

Anatomy of a Skeletal Muscle Fiber



Sarcolemma-cell membrane of the muscle fiber surrounding cytoplasm or sarcoplasm

Sarcoplasm-cytoplasm of muscle

Endomysium

Satellite cell-involved in muscle repair and regeneration

Mitochondria-cellular energy

Nuclei

Myofibril-attaches to the sarcolemma at each end and in their contraction shortens the entire cell

Sarcomere; functional unit of the

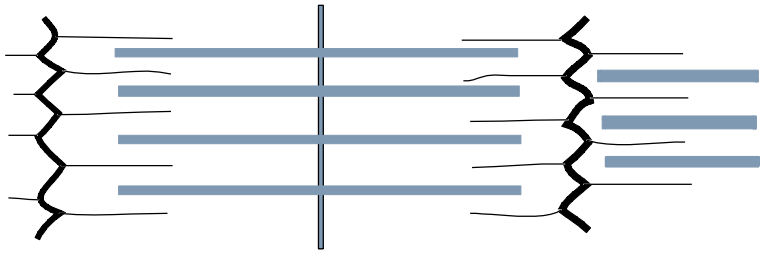
Microfilament/ myofilaments
Aligned in such a way to give striations to skeletal muscle

Two Types

1. Actin

2. Myosin

Anatomy of a Microfibril



M Line- vertical protein filaments attaching myosin filaments together, backbone of myosin. attaches to myosin filaments,

Z Line- vertical protein filaments attaching actin filaments together, sarcomere goes from z line to z line. attaches to the actin filaments. backbone of the actin

A Band- the region containing all of the myosin filaments

H Band- the band containing only myosin filaments

I Band- the band containing only actin filaments

Zone of Overlap- where the actin and myosin overlap

Sarcoplastic Reticulum and It's Components

A) Sarcoplasmic Reticulum (sarco means muscle);

B) Transverse Tubule: *'t tubule';* tube that connects the sarcolemma (cell membrane) indirectly with the sarcoplasmic reticulum

C) Terminal Cisternae: enlarged ends of sarcoplasmic reticulum at the zone of overlap.

D) Triad:

Muscle Cell Contraction

A) The Protein Filaments: contractile filaments inside the muscle (myosin and actin can bind with each other under the right circumstances)

1) Myosin: the thick filament. ATP binds to myosin head. myosin head splits ATP into ADP and P which cocks the head into open (ready) position, many myosin molecules form one thick myosin filament.

Tail hinge head

2) Actin: the thin filament. Consists of two twisted protein strands with active sites located on these strands that allow it to bind with the myosin head.

F actin-filamentous actin

G actin-globular actin

B) Associated Molecules

Two molecules involved in the covering and uncovering of the active sites on actin

1. Tropomyosin: filamentous (long) strand of protein that covers the active site on the actin when muscle is at rest. Prevents cross bridge binding of actin/myosin

2. Troponin: globular protein that attaches to tropomyosin. When calcium binds to the troponin, the troponin will rotate tropomyosin off the active sites on the actin. Exposing the active sites on actin for muscle contraction.

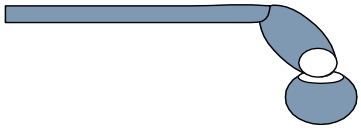
Sliding Filament Theory
states that actin and myosin slide over each other during muscle contraction. The most common explanation for muscle contraction

The Contraction Cycle (5 Steps)

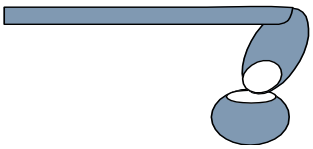
Step 1: calcium ions bind to the troponin, rotating tropomyosin off the active site on the actin. Exposing the active sites on actin.

The myosin head is cocked in the open, ready position from the splitting of ATP

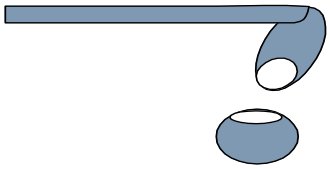
Step 2: crossbridging occurs between the active site on the actin and the myosin head



Step 3: myosin head pivots or ratchets toward the center of the sarcomere, pulling the z lines closer together causing contraction (ADP and P are released at this point)

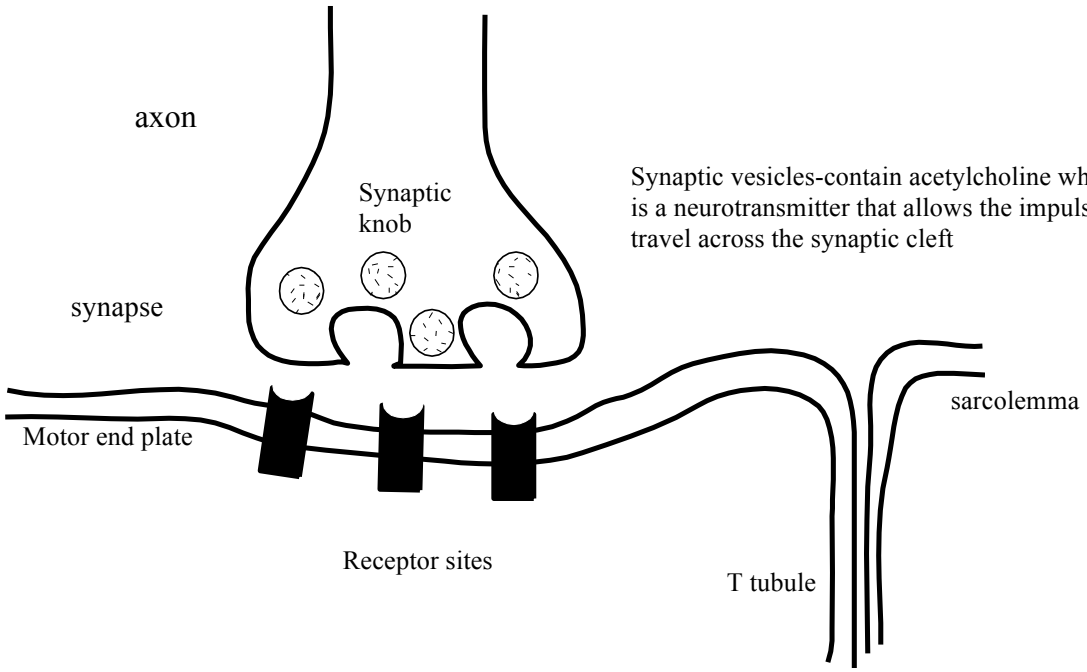


Step 4: crossbridging detachment- the bond remains intact until the myosin head binds with another ATP molecule. (rigor mortis; there is no more ATP production, so the muscle will remain contracted until the enzymes break it down)



Step 5: myosin activation; the free myosin head splits the ATP into ADP and P which re-cocks the head again for the next cycle. The cycle stops when calcium levels return to low levels

The Neuromuscular Junction



Acetylcholinesterase-breaks down acetylcholine quickly so contraction is brief

Nerve Impulse Perpetuation (6 Steps): causing muscle contraction

1. the nerve impulse travels down the axon causing an influx of calcium into the synaptic know which causes synaptic vesicles to fuse with nerve cell membrane.

2. vesicles dump neurotransmitters into the synaptic cleft

3. NT binds to receptor sites on sarcolemma (post-synaptic membrane)

4. NT binds to receptor sites opening ions channels in receptor protein allowing sodium into the muscle changing membrane polarity causing depolarization of the sarcolemma. In essence, this changes the membrane's polarity or membrane's electrical potential, which creates an action potential which is an electrical wave traveling over the entire sarcolemma, like a wave from the pebble dropped into a pool.

5. this wave of depolarization travels over the surface of the sarcolemma and down into the t tubules

6. this causes the release of calcium from the terminal cisternae which causes the actin active sites to be exposed

Muscle Fatigue: a muscle is fatigued when it can no longer contract despite continued neural stimulation

A) **Aerobic Depletion**: during aerobic activity muscle fatigue is due to depletion of

B) **Anaerobic Depletion**: during intense, short bursts of exercise

So ATP is produced without oxygen in glycolysis. Pyruvate, not glucose, is the energy source here. So muscle is less efficient. A byproduct of this process is lactic acid, which causes muscle soreness.

C) **Anaerobic Threshold**: boundary between aerobic energy usage (glucose and oxygen) and anaerobic energy usage (pyruvate).

***Muscle restoration period**: can take up to one week. The focus is on the removal of lactic acid. The liver converts it back to glucose, which is then stored as glycogen in muscle.

Muscle Mechanics

Muscle Contraction (3 Phases)

1. **Latency Phase**; 2 milliseconds between beginning of nerve stimulation and start of muscle contraction.

2. **Contraction Phase**; 20 msec-

3. **Relaxation Phase**; 20 msec-

Motor Unit: one nerve fiber and all the fibers it innervates.

eye-
calf-

All or None Principle of muscle contraction
When the motor neuron fires, all of the muscle fibers in the motor unit fire as well, not just some of them

Graded Contractions: muscle responses are actually graded contractions of the motor units. The total force exerted by a muscle, as a whole, depends on

Fast and forceful contractions-
Slow and weak contractions-

Definitions of Various Types of Muscle Contractions

1. Multiple Motor Unit Summation: aka recruitment. It is a smooth and steady increase in muscle tension from increasing the number of active motor units

2. Wave Summation: It is a second more powerful muscle stimulus arriving before the relaxation phase of the previous contraction has completely set in. The tension will eventually rise to a peak.

3. Incomplete Tetanus: a series of muscle contractions producing a peak tension during rapid cycles of contraction and relaxation

4. Complete Tetanus: a series of muscle contractions where the rate of stimulation is such that the relaxation phase has been eliminated.

5. Treppe: a series of muscle contractions where the muscle is stimulated a second time immediately after the relaxation phase has ended. The following contraction will have a slightly higher tension

Muscle Tone: the resting tension within a muscle.

Isotonic Contractions- tension in the muscle increases enough to overcome the resistance (weight), allowing the muscle to shorten

Isometric Contractions-tension in muscle rises, but muscle length remains the same.

<u>The Three Types of Skeletal Muscle Fibers</u>

A) Fast: "white fibers"
majority of the muscle fibers (skeletal)
contract in less than
large diameter

B) Slow: "red fibers"
One half the diameter of fast fibers

C) Intermediate;

- have properties of both fast and slow
-look like fast fibers, but resist fatigue better

The Relationship Between Bones and Skeletal Muscle for Producing Movement

Muscle Fiber Contraction; all muscle fibers have an optimum length for producing maximum contraction

1) stretch too far-

3) near or at full contraction- near or at full overlap,

Maximal Tension (these same concepts above apply to the entire muscle)- all muscles have a small range of motion where maximal tension is reached

Ex. Elbow

A) Full Extension

1.

2.

B) Flexion (90%) optimum angle

1.

2.

C) Full Flexion

1.

2.

Muscle Power Arcs (the range of motion or degrees where the muscle exerts most of its force); muscles overcome the narrow ranges of motion where the muscle is most efficient by evolving different muscle shapes within one large muscle.

Muscle Shapes (5 General Types)

1. parallel: straight,

2. convergent: fan-shaped,

3. unipennate: feather,

4. bipennate: two feathers,

5. circular:

<u>The Three Classes of Biomechanical Levers</u>

A) First Class: the fulcrum lies between the effort and resistance,

B) Second Class: the resistance lies between the fulcrum and effort,

C) Third Class: the effort lies between the fulcrum and resistance,

The Three Parts of a Muscle

A) origin- beginning of muscle base, typically the most proximal portion, the immovable end of the attachment. Closest to the axial skeleton.

B) belly- the body or bulk of the muscle fibers

C) insertion- the attachment site of a muscle that is typically at the distal end. Also the movable end of the attachment site, away from the axial skeleton.

Muscle Actions

A) agonist 'prime mover'- a muscle whose contraction is chiefly responsible for a particular movement. (biceps-forearm flexion)

B) synergist- assists the prime mover. Stabilizes during motion.

C) antagonist- also prime movers, but their action opposes the agonist being considered. (forearm flexion-triceps)

Clues to Understanding Muscle Names

Rectus- straight
Medius- medial
Obliqus- fibers run at an oblique angle
Transversus- fibers run transverse
Superficialis- more superficial
Profundus- more deep
Superioris- closer toward head
Minimus- smaller
Maximus, Majorus- larger
Internus-inside
Brevis- short

Dynamic Motion

Flexion- reduces the angle between articular elements

Extension- increases the angle between articular elements

Hyperextension- extension which continues past the anatomical position

Abduction- refers to moving the distal end of an extremity or body part away from the body or midline in a coronal plane

Adduction- refers to moving the distal end of an extremity or body part toward the body or midline in a coronal plane

Rotation- movement of a body part about its long axis

Supination- refers to the forearm, internal rotation of the palm, or rotation of the forearm about it's long axis to the posterior palm position

Circumduction- active or passive circular movement of the limbs or eyes

Elevation- general term, to raise up a body part superiorly

Depression- general term, to lower a body part inferiorly

Protraction- moving a body part forward in a horizontal plane

Retraction- moving a body part backward in the horizontal plane

Inversion- refers to the ankle, turning the sole of the foot inward in a coronal plane

Eversion- refers to the ankle, turning the sole of the foot outward in a coronal plane

Plantar Flexion- refers to the foot and ankle, flexing the foot in a plantar direction

Dorsiflexion- refers to the foot and ankle, flexing the foot superiorly toward the head-not called extension

HUMAN MUSCLES

*If a muscle has an asterisk next to it, you must know all three components of the muscle, including its origin, insertion and action. If there is no asterisk next to the muscle, then you must know the action and the muscle's general location in the body.

Muscles of Facial Expression

1. **Orbicularis oris**
   Sphincter around mouth
   A= closes and protrudes lips

2. **Orbicularis oculi**
   Sphincter around eye
   A= closes eyelid

3. **Zygomaticus**
   O= zygomatic bone
   I= angle of the mouth
   A= raise angle of the mouth- smile

4. **Risorius**
   O= fascia of masseter muscle
   I= angle of the mouth
   A= draws angle of mouth laterally as in tenseness

5. **Buccinator**
   O= alveoli of mandible and maxilla
   I= Orbicularis oris
   A= compress cheek; blowing

6. **Platysma**
   O= fascia over deltoid and pectoralis major muscles
   I= mandible, skin of chin and cheek
   A= depress mandible; draws lips downward as in pouting; tightens and wrinkles skin of neck (monster and or turtle face)

7. **Frontalis**
   O= Galea aponeurotica
   I= skin and muscles of forehead
   A= raises eyebrows, wrinkles forehead, draws scalp forward

8. **Occipitalis**
   O= occipital bone
   I= galea aponeurotica
   A= draws scalp backward

Muscles of Mastication

***1. Masseter**
   O= zygomatic arch
   I= ramus of mandible
   A= elevates mandible

2. Temporalis
   O= temporal line
   I= coronoid process of mandible
   A= elevates and retracts mandible

3. Digastric (floor of oral cavity)
   O= hyoid bone
   I= inner surface of lower border of mandible (chin); mastoid process of temporal bone
   A= elevates hyoid and larynx, depresses mandible

Muscles that Move the Head

***1. Sternocleidomastoid**
   O= sternum and clavicle
   I= mastoid process of the temporal bone
   A= if both sides contract, it flexes the neck; if one side contracts, it rotates the head toward the opposite side

2. Splenius Capitus
   O= ligamentum nuchae and spines of C7-T4 vertebrae
   I= occipital bone and mastoid process of temporal bone
   A= both sides extend head; one side rotates head to the same side as the contracting muscle

Muscles that Move the Shoulder

1.Serratus anterior
O= first 9 ribs
I= vertebral border of scapula, ventral side
A= abducts scapula

2.Pectoralis minor
O= ribs 3-5
I= coracoid process of scapula
A= depresses scapula; protracts scapula

3.Rhomboideus (major and minor)
O= Spines of C7-T5 vertebrae
I= vertebral border of scapula
A= adducts scapula

***4. Trapezius**
O= occipital bone, ligamentum nuchae, spines of C7-T12
I= clavicle, acromion, scapula
A= Elevates (upper portion) or depresses (lower portion) scapula; adducts scapula, extends head

Muscles that Move the Arm

***1. Pectoralis major**
O= clavicle, sternum, costal cartilages of ribs 2-6
I= lateral lip of the bicipital groove
A= flexes, adducts and medially rotates the arm

***2. Latissimus dorsi**
O= spinous processes of T7 through all lumbar through sacrum, posterior iliac crest, lumbodorsal fascia
I= medial lip of the bicipital groove
A= extends, adducts and medially rotates arm

***3. Deltoid**
O= clavicle, acromion and spine of scapula
I= deltoid tuberosity of humerus
A= abducts arm, forward flexion, extension of shoulder

***4. Supraspinatus**
O= supraspinous fossa
I= greater tubercle of humerus
A= abducts arm

***5. Infraspinatus**
O= infraspinous fossa
I= greater tubercle of humerus
A= rotates arm laterally

***6. Subscapularis**

O= subscapular fossa
I= lesser tubercle of humerus
A= rotates arm medially

***7. Teres major** (lat's little helper)

O= inferior angle of scapula
I= intertubercular groove of humerus (medial lip of bicipital groove)
A= medially rotates and adducts the arm

***8. Teres minor**

O= lateral (axillary) border of scapula
I= greater tubercle of humerus
A= rotates arm laterally

Muscles that Move the Forearm

***1. Biceps Brachii**

O= above the glenoid fossa (long head) ; coracoid process of scapula (short head)
I= radial tuberosity
A= flexes forearm (elbow) and supinates forearm

2.Brachialis

O= anterior surface of humerus
I= coronoid process of ulna
A= flexes forearm

***3. Triceps Brachii**

O= below glenoid fossa (long head), lateral and posterior shaft of humerus proximally (lateral head), posterior surface of humerus distally (medial head)
I= olecranon process of ulna
A= extends forearm (elbow), some shoulder extension as well

4.Supinator

O= lateral epicondyle of humerus
I= lateral surface of proximal radius
A= supinates forearm

5.Pronator teres

O= medial epicondyle of humerus; coronoid process of ulna
I= middle of the lateral surface of radius
A= pronates forearm

6.Pronator quadratus

O= distal ulna (anterior)
I= distal radius (anterior)
A= pronates forearm

Muscles that Move the Wrist and Fingers

***1. Flexor carpi radialis**
O= medial epicondyle of humerus
I= ventral surface of metacarpals II, III
A= flexes and abducts palm

2.Flexor carpi ulnaris
O= medial epicondyle of humerus; upper dorsal border of ulna
I= base of metacarpal III-V
A= flexes and adducts palm

3.Palmaris longus
O= medial epicondyle of humerus
I= palmar aponeurosis
A= flexes palm

4.Flexor digitorum superficialis
O= medial epicondyle of humerus, coronoid process of ulna, anterior surface of radius
I= ventral surface of middle phalanges 2-5
A= flexes phalanges

5.Flexor digitorum profundus
O=Anterior medial surface of ulna
I= ventral surface of distal phalanges 2-5
A= flexes phalanges

6.Extensor carpi radialis (longus)
O= lateral epicondyle of humerus
I= dorsal surface of metacarpal II
A= extends and abducts palm

7.Extensor carpi ulnaris
O= lateral epicondyle of humerus
I= metacarpal V
A= extends and adducts palm

***8. Extensor digitorum**
O= lateral epicondyle of humerus
I= dorsal surface of phalanges
A= extends phalanges and palm

Muscles that Move the Thigh

***1. Gluteus maximus**
O= iliac crest, sacrum, coccyx
I= gluteal tuberosity of femur
A= extends thigh (hip joint) and laterally rotates thigh

2.Gluteus medius

O= ilium
I= greater trochanter of femur
A= abducts and medially rotates thigh

3.Gluteus minimus

O=ilium
I= greater trochanter of femur
A= abducts and medially rotates thigh

4.Tensor fascia latae

O= iliac crest (anterior part)
I= lateral fascia of tibia
A= tenses lateral fascia, flexes thigh (hip) and abducts thigh

***5. Adductor longus**

O= pubis
I= linea aspera of femur
A= adducts thigh

6.Adductor magnus

O= pubis and ischium
I= linea aspera of femur
A= adducts thigh

7.Adductor brevis

O= pubis
I= linea aspera of femur
A= adducts thigh

<u>Muscles that Act on the leg</u>

***1. Quadriceps femoris**

***Rectus femoris**

O= anterior inferior iliac spine
I= tibial tuberosity via patellar ligament
A= extends leg (knee), flexes thigh (hip)

***Vastus lateralis**

O= greater trochanter and lateral to linea aspera of femur
I= tibial tuberosity via patellar ligament
A= extends leg, knee extension

***Vastus medialis**

O= medial to linea aspera of femur
I= tibial tuberosity via patellar ligament
A= extends leg

Vastus intermedialus
O= anterior surface of femur
I= tibial tuberosity via patellar ligament
A= extends leg

***2. Hamstrings**

***Biceps femoris**
O= ischial tuberosity and linea aspera
I= lateral condyle of tibia and head of fibula
A= flexes leg and extends thigh

***Semitendinosus** (more superficial)
O= ischial tuberosity
I= medial surface of proximal tibia
A= flexes leg and extends thigh

***Semimembranous** (more deep)
O= ischial tuberosity
I= medial condyle of tibia
A= flexes leg and extends thigh

3.Gracilis
O= pubis
I= medial surface of tibia below condyle
A= flexes leg and adducts thigh

4.Sartorius (longest muscle in the human body)
O= anterior superior iliac spine
I= medial surface of proximal tibia
A= flex thigh and leg, rotate thigh laterally
(Tailor's muscle)

Muscles that Move the Foot and Toes

1.Tibialis anterior
O= lateral condyle and body of tibia
I= metatarsal I
A= dorsiflex foot

2.Extensor digitorum longus
O= lateral condyle of tibia, anterior surface of fibula
I= dorsal surfaces of phalanges 2-5
A= extends toes, dorsiflexes foot

3.Peroneus longus
O= lateral condyle of tibia, head of fibula
I= ventral surface of metatarsal I
A= plantar flexes and everts foot

***4. Gastrocnemius** (2 heads)
O= above lateral and medial condyles of femur
I= calcaneus by way of Achilles tendon
A= plantar flexes foot and flexes leg at knee

***5. Soleus**
O= posteromedial tibia; head of fibula
I= calcaneus by way of Achilles tendon
A= plantar flexes foot

6.Flexor digitorum longus
O= posterior surface of tibia
I= distal phalanges 2-5
A= flexes toes and plantar flexes foot

Muscles of the Abdominal Wall

***1. External abdominal oblique**
O= lower 8 ribs
I= linea alba and iliac crest
A= compresses abdomen; flexes or bends spine; depresses ribs

2.Internal abdominal oblique
O= iliac crest
I= linea alba and lower ribs
A= compresses abdomen, flexes or bends spine; depresses ribs

3.Transversus abdominis
O= iliac crest, lumbar fascia and costal cartilage of lower ribs
I= linea alba and pubis
A= compresses abdomen

***4. Rectus abdominus**
O= xiphoid process and costal cartilages of ribs 5-7
I= symphysis pubis
A= compresses abdomen, flexes vertebral column, and depresses ribs

Muscles Used in Breathing

1.Diaphram
O= Xiphoid process, costal cartilage of ribs 4-10 and lumbar vertebrae
I= central tendon of diaphragm
A= increases size of thoracic cavity for breathing

***2. External intercostals**
O= one rib
I= next rib
A= breathing (elevates ribs)

***3. Internal intercostals**

O= one rib
I= next rib
A= breathing (depresses ribs)

Muscles that Move the Vertebral Column

1.Erector spinae

Iliocostalis (most lateral)
O= iliac crest and ribs
I= ribs
A= extends the vertebral column

Longissimus (intermediate)
O= transverse process of lumbar, thoracic and lower cervical vertebrae
I= transverse processes of the vertebrae above the vertebra of origin, plus the mastoid process of the temporal bone
A= extends vertebral column

Spinalis (medial)
O= spinous process of lumbar and lower thoracic vertebrae
I= spinous process of upper thoracic vertebrae
A= extends the vertebral column

The Nervous System

Two systems of the body regulate and coordinate the activities of the body's organ systems.

1) the endocrine system (involved in hormone release); ductless system that releases hormones directly into the bloodstream. exocrine system; releases digestive enzymes via ducts to different areas of the body>
-relative to the other systems

2) the nervous system

Maintaining Homeostasis (both systems are involved in maintaining homeostasis)

A) involved in sensing changes in our internal and external environment (ex. Of hand on stove is sensing external environment. Example of internal environment; heart rate, blood pressure.)

B) also then involved in interpreting those changes

C) then involved in initiating action to help maintain homeostasis

The Two Main Parts of the Nervous System

A) CNS- central nervous system
1.
2.

B) PNS- peripheral nervous system (any nervous tissue outside of the CNS/ nerves that we have running through the body)

1. **afferent nervous system**-

2. efferent nervous system-.
Efferent carries information from the CNS outwards. Causes something to happen. Impulses from the CNS will travel to one of three structures to initiate some type of response.

a. **somatic nervous system**: soma means body. Impulses from the CNS travel to the skeletal muscles to initiate contraction.

b. **autonomic nervous system**: here we have impulses traveling from the CNS to

Nerve Cell: (Also known as a neuron)

Dendrite

Cell body

Axon

synaptic knob

Axon hillock

A) cell body: contains the nucleus and is responsible for the majority of the metabolic processes for that cell

B) dendrites: receive information from other neurons and conducted it to the body (you can see that dendrites increase surface area of the cell, so they do make it easier to receive information).

C) axon: a long thin projection that transmits an electrical impulse away from the body to another nerve, a gland, or a muscle

*electrical impulse travels from the dendrites through the cell body to the axon.

Neuronal Classification According to Structure

1. **anaxonic nerve cell**: nerve cell in which you cannot tell the axon from the dendrites. Relatively small neuron.

2. unipolar nerve cell: dendrite and the axon are continuous with the cell body lying off to one side.

2. **bipolar nerve cell**: soma lies between the axon and the dendrite.

3. **multi-polar neuron**: has several dendrites and one long axon.

Locations of Nerve Cell Bodies: these groups perform the same general functions. (majority of the nerve cell bodies are located in the CNS/ however there are certain areas where nerve cells will be located outside the CNS)

A) Nuclei group of nerve cell bodies located within the spinal cord.

B) Ganglia group of nerve cell bodies located

C) Centers group of nerve cell bodies located within the brain.

Myelination axons of the CNS and the PNS are insulated from each other as they travel in bundles by cells that surround each axon.

*When you look at a cross section of brain tissue (CNS), the areas that are myelinated are white in color. Myelin is a lipid.

Two Cell Types

1. Schwann cell is a myelinated cell of the PNS.

2. Oligodendrocyte-myelinated cell of the CNS

Function- both of these cells send out wide, flat projections that wrap around the axons of nerve cells. Bottom line is to protect one nerve cell from another nerve cell.

a) prevent short circuiting between nerves (MS is a demyelinating disease)
b) serves to increase the speed of impulse down the axon

Anatomy of a Myelinated Cell

Axolemma  neurilemma

Node of Ranvier- cells nearly butt up against each other

Gray and White Matter

two colors of tissue located in the CNS and PNS

A) CNS

1. gray matter; the gray matter represents areas where there are cell bodies (CNS). These areas are gray in color because the cell bodies are not covered with myelination. Gray matter is on the outside of the brain. In spinal cord, gray matter is on inside (in brain nerve cells are on outside to allow lots of space for connection to other nerve cells. In the spinal cord, it is less important that cell bodies are located on the outside.) gray matter represents the superficial layer in the brain whereas in the spinal cord it is the deep portion.

2. white matter; represents areas of myelination. So, in the brain, white matter is deep to gray matter whereas in the spinal cord it lies superficial to the gray matter.

B) PNS

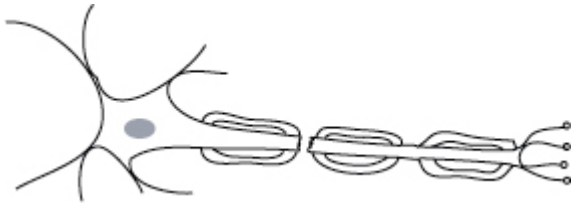
1. Gray matter; areas where ganglia are located outside the CNS.

2. White matter; areas of myelination around the axons ….myelinated axons that bundle as a group and are known as nerves.

Nerve Regeneration: (aka Wallerian degeneration) What happens if a nerve is cut?
Sometimes, under the right circumstances, some nerves can regenerate.

<u>Two Main Steps to Nerve Regeneration</u>

A) first thing that happens after the nerve is cut. The distal axon is phagocytized by the white blood cells (macrophages) (distal schwann cells are not destroyed)
(Macrophages go in and remove all of the dead parts of the distal portion of the tunnel)



B) second: new schwann cells proliferate to bridge the gap towards the distal axon tunnel. This allows the proximal axon stump to travel down that tunnel as it regrows

-in order for this to work the cut ends must line up

*growth is very slow.

*in the CNS,

Neuroglial Cells: supporting cells for neurons

A) CNS

1. ependymal cell: cuboidal or columnar cells that line various portions of the brain and spinal cord. One of main functions is to produce CSF (cerebrospinal fluid); involved in helping to cushion and protect the brain.

2. astrocyte: serves as the framework for the CNS Also involved in repair and helping to maintain the blood-brain barrier.

3. oligodendrocyte: myelinated cell of CNS

4. microglial cell: microglia; derived from the immune system and phagocytizes cellular debris and pathogens.

B) PNS

1. schwann cell; myelinated cell of PNS

2. satellite cell surrounds the cell bodies within the ganglia. (ganglia are collection of nerve cell bodies)

***Interneurons;** nerve cell that connects other nerve cells together.

Nerve Physiology

1. **Cation:** positively charged ion. (ex. K)
2. **Anion:** negatively charged ion (ex. Cl)

*cations and anions are attracted to each other, like charges repel from each other.

Polarized Membrane

Positive charge outside, negative charge inside cell. Tremendous amount of energy to maintain this. Many of cells in body have to maintain cell membrane polarity.

How does this come about?

1. Na/K ATPase pump (sodium/postassium pump),
we know that it converts ATP into ADP + P. This is a pump that sends 3 Na out for every 2 K that go in…more positive going out than negative coming in.

2. Na/K ion leak channels; uses no ATP, requires no energy. K leaks back out of the cell 100 times faster than than sodium leaks into the cell. That

said, as much K as leaks out, there is still more K on the inside of the cell membrane than there is outside

3. negatively charged protein molecules a large number of negatively charged protein molecules are located on the inside of the cell membrane and are impermeable to the cell membrane.

Note* realize that all three of these things are involved in generating that polarized membrane

Transmembrane or Resting Potential: difference in charge between the inside and the outside of the cell membrane.

In a resting cell membrane, the resting potential is (let's say) -70 millivolts. This represents the electrical charge difference between the inside and the outside of cell membrane. The minus denotes the overall negative charge on the inside of the cell membrane.
Remember: the greater the number, the greater the voltage across the membrane. The minus sign only denotes the negative charge across the cell membrane. If we had a positive sign, then that means that there are now an overwhelming number of positive charges inside the cell at that given moment. (Usually in the form of potassium.)

*Any stimulus allowing ions to pass freely through the cell membrane to equal out the charges across that cell membrane are said to **depolarize the cell membrane**. This moves the transmembrane potential in the plus or positive direction, which also means there is less electrical potential across the cell membrane. Remember: zero means there is no electrical charge at that given moment across the cell membrane.

Two Types of Ion Channels

1.Chemically regulated ion channels (located on the dendrites and the soma of a neuron) in order for a nerve to conduct an electrical impulse, it must depolarize.* open and close when NT bind to them causing a local depolarization of the nerve cell membrane. (a lot like throwing a pebble in a pond) the wave spreads over the cell membrane in all directions, not just one direction

2. **Voltage regulated ion channels** (located on the axon) region where we transition from chemically regulated to voltage-regulated gates on the cell. So the gates on the soma are predominately chemically regulated gates and the gates on the axon are voltage-regulated gates. Local changes in voltage across the cell membrane will either open or close the channels. Opening the gates will cause a local depolarization the membrane.

Depolarization Threshold- a local stimulus strong enough to cause an opening of the voltage regulated ion gates. If we allow enough plus charges inside to reach depolarization threshold, we will open up voltage regulated ion gates.

Let's say that the voltage gates open at -65 millivolts. This would be considered the depolarization threshold. Anything less than -65 mV would not cause or allow the voltage gates to open. There are many other nerves firing on this nerve cell at any given time, but only a stimulus strong enough to allow us to reach -65 mV at the axon hillock, where we transition from mostly chemically regulated gates to voltage regulated gates will allow us to create a depolarization threshold strong enough to create the next phenomenon we'll talk about.

Action Potential; is the depolarization of the cell membrane which travels like a wave down the axon to the synaptic knobs. (domino effect)

Local or Graded Potentials

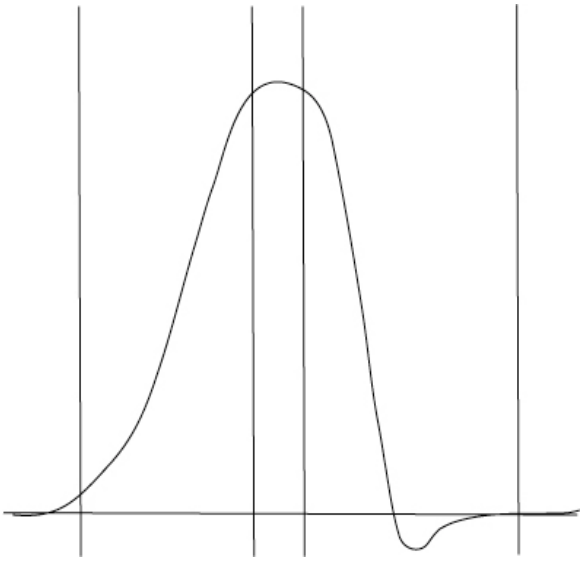
1. A depolarization stimulus confined to a small area of a membrane.

2. If powerful enough, they can cause an action potential. If not, it will only cause local depolarization without creating an action potential that travels down the axon.

3. Called local or graded potentials because multiple, mild stimuli can combine to create a stimulus strong enough to reach depolarization threshold at the axon hillock.

All or None Phenomenon; action potential is an all or none occurrence.
It either happens or it doesn't. If the stimulus is strong enough, then the axonal membrane depolarizes creating connection potential. A gun is a perfect analogy.

Anatomy of a Nerve Impulse On Axon



1. Local depolarization reaches DT
2. Voltage regulated Na channels open allowing Na to flood into the cell changing it's transmembrane potential to + 30 mV
3. Voltage regulated Na gates closes and then voltage regulated potassium gates open allowing potassium to rush out of the cell to allow repolarization of the cell.
4. Voltage regulated potassium channels begin to close SLOWLY allowing temporary hyperpolarization of the cell.
5. NA-K ATPase pump helps restore to resting membrane potential levels.

Continuous propagation of the action potential

Sodium ions travel along the inside of the cell membrane and depolarize adjacent segments of the axon causing opening of new voltage regulate sodium ion gates. This happens over and over again down the unmyelinated axonal membrane. However, the impulse speed here is

Determining the Speed of a Nerve Impulse (2 factors)

A) Myelin Sheath

1. myelin sheath increases the speed of the impulse significantly
Some books will say that the speed of the electrical impulse can reach speeds of up to 150 mph.

2. In myelinated fibers the depolarization can only occur at the Nodes of Ranvier. Na rushes in at the first node causing depolarization there. Some Na from the first node's depolarization ends up beneath the next node. This represents enough of a positive charge under the second node to cause it to depolarize causing the second node's voltage gates to open up. The Na rushing in at the second node allows Na to end up below the third node causing it to depolarize

and the process continues down the axon as the action potential. The action potential leapfrogs from node to node.

B) Axon Size; the larger the diameter of the axon, the faster the impulse travels. Due to less resistance within the cytoplasm of the axon. Less resistance means easier movement of ions within the cell. The more easily they move, the faster they move, which means faster impulse propagation. Less resistance in a larger wire and more room to move in a larger room.

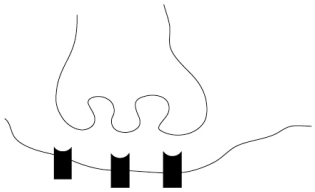
Nerve Impulse Direction: impulse travels forward along the axon because the previous segment is still in its refractory period. Which means that the voltage regulated Na gates are open or the transmembrane potential has not yet reached resting levels of -70 mv. The Na activation gates are still closed

Acetylcholine: one example of a NT (chemical messenger that bridges the synapse), it is a chemical messenger allows the electrical impulse to travel from the pre-synaptic membrane to the post-synaptic membrane.

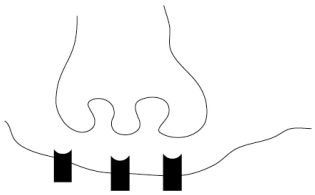
Acetylcholinesterase: an enzyme that breaks down acetylcholine in the synaptic cleft so depolarization is not a continuous event.

<u>Movement of the Action Potential Across the Synapse</u>

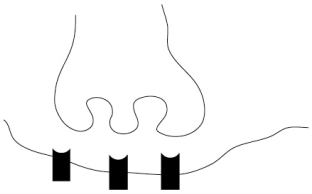
1. Arrival of action potential at synaptic knob. Opens voltage regulated Ca gates and Ca flows into the cytoplasm of the synaptic knob.



2. This triggers exocytosis of ACH into the synaptic cleft from the vesicles.



3. ACH binds to receptor sites on post-synaptic membrane



a) These receptor sites are chemically regulated ion channels that allow the influx of Na into the cell.

b) The influx of Na causes a graded potential (local depolarization). The more ACH that is released, the larger the local depolarization.

EPSP- Excitatory Post Synaptic Potential; graded **<u>depolarization</u>** of post synaptic membrane by the arrival of a NT. (ACH)

IPSP- Inhibitory Post Synaptic Potential; local **<u>hyperpolarization</u>** of post-synaptic membrane. Often from an opening of chemically-regulated K gates allowing even more plus charges outside the cell further driving the transmembrane potential in that region down, away from depolarization threshold. (GABA)

Catecholamines; also NT (ie. Epinephrine, norepinephrine, dopamine) work with a ***secondary*** messenger to depolarize membrane.

<u>Depolarization with a Secondary Messenger</u>

1. Action potential depolarizes synaptic knob.

2. Ca enters axoplasm triggering norepi. Release into synaptic cleft (1^{st} messenger)

3. Norepi. Binds to receptor site causing adenyl cyclase within the cytoplasm to catalyze the formation of cyclic AMP from ATP

4. Cyclic AMP (2^{nd} messenger) opens ion channels allowing NA to depolarize membrane

Summation
The integration of EPSP's and IPSP's to reach depolarization threshold. (A typical EPSP may produce local depolarization of .5mV when an action potential may require -15 to -20mV charge to reach depolarization threshold)

Two Ways for EPSP's to Reach Depolarization Threshold

A) **Temporal Summation** (same location, different time) a stimuli occurring in rapid succession at the same synaptic knob. Close enough together that none could generate a depolarization threshold on its' own. Each action potential causes the release of more ACH from the vesicles, which causes more Na influx= action potential on the presynaptic cell.

B) **Spatial Summation** (same time, different location) stimuli arriving at the same time at different locations in close proximity. Together they generate enough electrical potential to reach depolarization threshold.

Adaptation
A reduction in sensitivity in the presence of a constant stimulus. Our body just gets used to it and starts to ignore it. This is a good thing, otherwise many things could drive us crazy like wearing a suit that is extremely uncomfortable; Tonic receptors exhibit very little adaptation (DTRs)

Neural Interaction
patterns of neuronal interaction

A) **Convergence**: several neurons synapsing on same post synaptic neuron

B) **Divergence**: spread of one neuron's info to several neurons

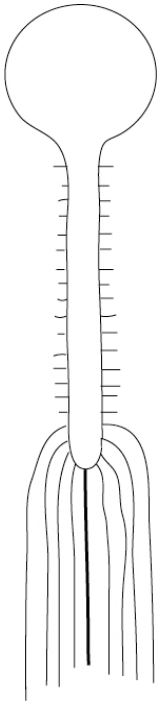
C) **Serial Processing**: neurons lined up in a sequential manner

Receptor; a specialized cell that monitors conditions or receives info from the body or external environment. Receives sensory information, sends it to the CNS. Monitors- nociception, pain, touch, body position, proprioception, etc…

Effector; a peripheral gland or muscle cell innervated by a motor nerve (efferent neuron)

SPINAL CORD AND NERVES

The Spinal Cord- an extension of the CNS that travels down through the spinal canal of the vertebra to approximately the L1 level.



Gross Anatomy of the Cord

Approximately 30 pairs of nerves

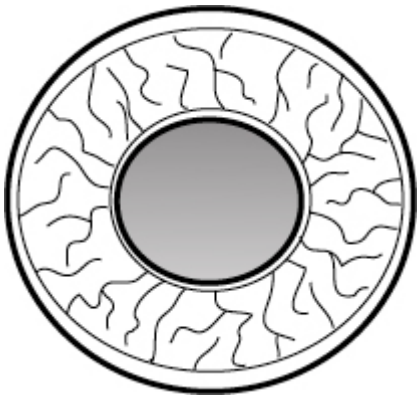
Conus meduallaris- tapered, conical end of the spinal cord, L1 vertebral level.

Filum Terminale- not a nerve, pia mater attaches cord to the sacral apex.

Cauda equina- horses tail, nerves that innervate the lower body

Protective Coverings of the Cord

Meninges- continuous coverings of the brain and spinal cord; provides protection



A) Dura Mater (tough mother); outer most covering. Tough, fibrous connective tissue

B) Arachnoid layer delicate middle layer, just below dura mater. Spider-like projections that anchor it down

C) Pia Mater (delicate mother); inner most layer. Adheres closely to the nervous tissue

Cross Sections of the Cord; consists of both gray and white matter

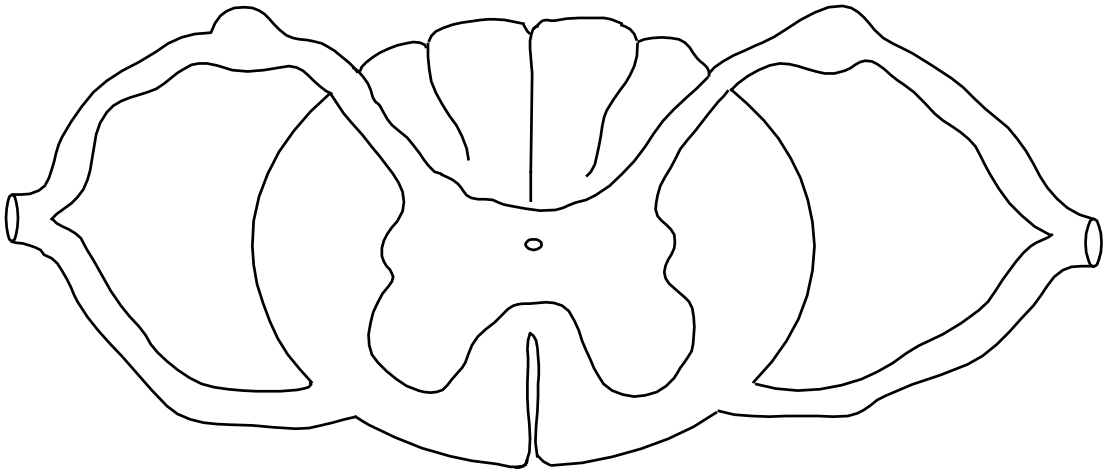
A) Gray Matter;
   a. Nerve cell bodies
   b. Unmyelinated axon and dendrites

B) White Matter; tracts or columns of myelinated axons that run superiorly and inferiorly within the cord

Anatomical Cross Section of the Cord

General Parts outside Cord

1. **Dorsal Root**: afferent-
2. **Ventral Root**: efferent-
3. **Spinal Nerve**: mixed-
4. **Dorsal Root Ganglion**: cell bodies of afferent sensory neurons



Gray Matter of the Cord

"H shaped"

5. **Dorsal Horn**: afferent cell bodies and synapses- somatic/ visceral sensation
6. **Lateral Horn**: autonomic nervous system cell bodies
7. **Anterior Horn**: cell bodies of motor neurons; information going out- somatic motor control
8. **Gray Commissure**: connects the right and left gray halves

White Matter of the Cord
-*Outside the gray mater*
A) Posterior column
B) Lateral column
C) Anterior column
D) White commissure; connects Rt and Lt white halves

Ascending Tracts: tracts within the white matter that carry

Descending Tracts: tracts in the white matter that carry

Reflexes
A rapid, automatic response to a stimulus. Response from sensory has an effect on a muscle or a gland

Three General Types

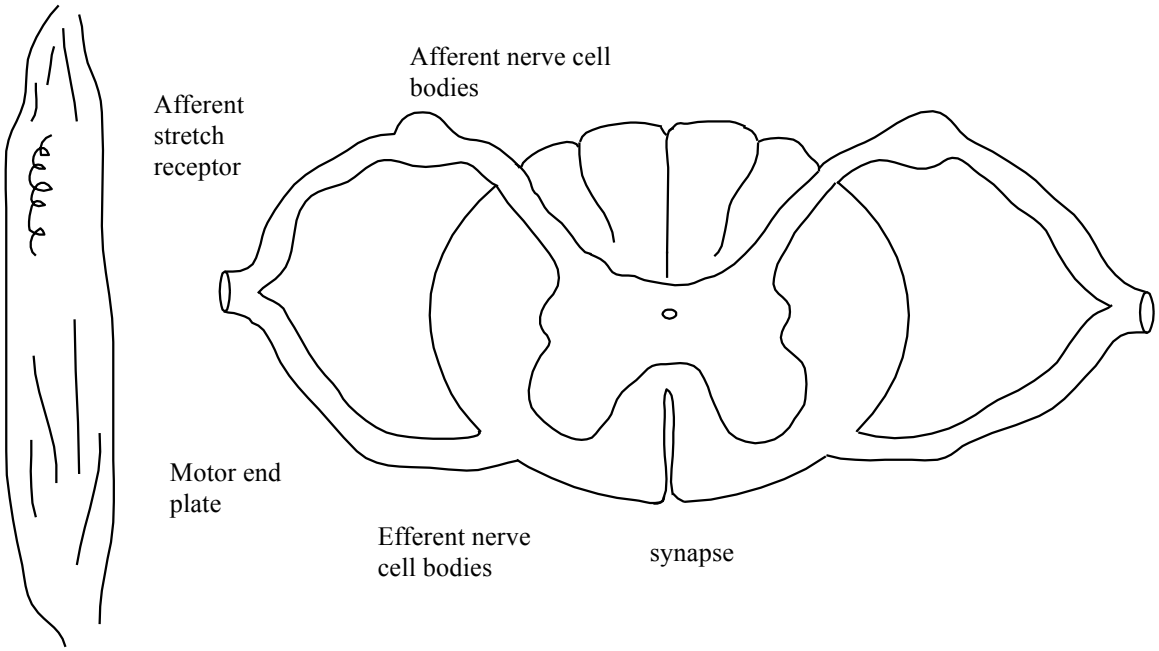
A) **Spinal reflex:**

B) **Somatic Reflex:**

C) **Visceral (Autonomic) Reflex**: causes either

1)
2)

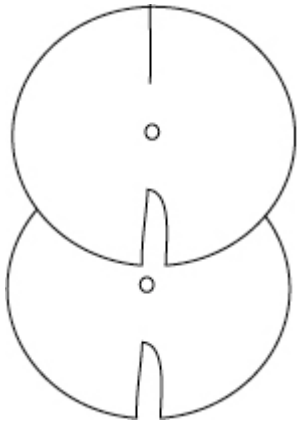
Anatomy of a Reflex Arc



*hitting patellar tendon will cause a lengthening of the tendon, which will cause the muscle spindles to fire. They will synapse on motor neurons. This will cause the muscle belly to contract.

Two Types of Reflex Arcs

1. monosynaptic; only involved 2 neurons and one synapse

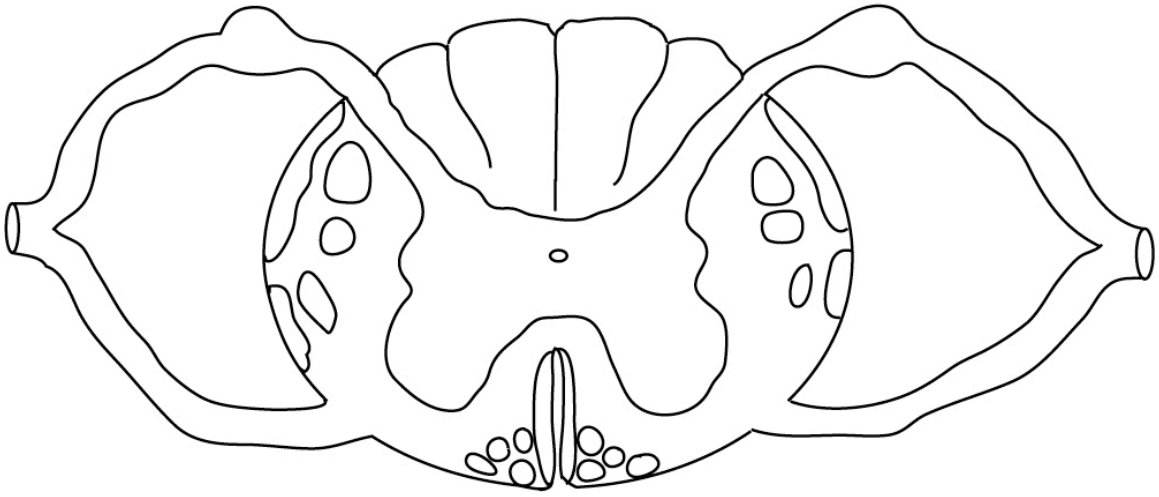


2. polysynaptic; a reflex involving more than one synapse and involves sensory motor and association neurons (much more common and relevant)

***Association Neurons**- aka interneurons.
Bridge the gap between sensory and motor neurons of the same or opposite sides of the cord

Ipsilateral Reflex ; a reflex whose arc stays on the same side of the cord (ex. Deep tendon reflex)

Contralateral Reflex (bilateral reflex)
a reflex whose arc travels to the opposite side of the cord (ex. Crossed-extensor reflex)



GENERAL CROSS-SECTIONAL REPRESENTATION

Sensory/Ascending Pathways

A) Posterior Column Pathways

1. **fasciculus gracilus-** lower body, proprioception, fine touch pressure, vibration
2. **fasciculus cuneatus**- upper body, proprioception, fine touch pressure, vibration

B) Spinocerebellar

3. **Posterior**- muscle fiber proprioception,
4. **Anterior**- whole limb proprioception

C) Spinothalmic

5. **Lateral**- pain and temperature
6. **Anterior**- crude touch, pressure

Motor/Descending Pathways

A) Pyramidal pathways

7. **Lateral Corticospinal Tract**- voluntary control of the skeletal muscles- crosses at the pyramidal decussation, 85% of fibers cross here

8. Anterior Corticospinal Tract- same as above, but represents the 15% of the fibers that don't cross
9. Corticobulbar Tract- voluntary control of the head and neck muscles that run with other corticospinal tracts

B) Extrapyramidal Pathways

10. Rubrospinal Tract- involuntary control of posture and muscle tone
11. Reticulospinal Tract- involuntary control of reflex and autonomic function
12. Vestibulospinal Tract- regulates body and muscle tone in response to head and neck movement
13. Tectospinal Tract- involuntary control of eyes, head, neck and arms in response to visual and auditory stimulus "Startle Reflex"

Nerve Plexus (4)

Definition- a network of nerve roots arising off of the spinal cord

A) Cervical Plexus – most superior, C1-C5, innervates neck and diaphragm

1. Ansa Cervicalis- C1-C4, throat muscles
2. C2-C3- sensory to the skin of the chest, shoulders, and neck muscles
3. C3-C5- Phrenic nerve- innervates diaphragm
4. C1-C5 – motor to the muscles of the neck

B) Brachial Plexus – C5-T1, innervates arm and shoulder girdle

1. Axillary nerve- C5, C6- skin and muscle of the shoulder
2. Radial nerve – C5-T1, skin and forearm extensors
3. Musculocutaneous nerve – C5-C7, skin and arm flexors
4. Median nerve – C8-T1- skin and muscles of medial forearm flexors

C) Lumbar Plexus – T12-L4

1. Femoral nerve- anterior and lateral thigh muscles (generally)

D) Sacral Plexus – L4-S4

1. Sciatic nerve- posterior thigh muscles (generally)
   *C and D collectively called the Lumbosacral plexus

THE BRAIN and ASSOCIATED STRUCTURES

A) Associated Structures- as in the spinal cord, the brain has the same coverings with a slight difference

Meningeal Coverings

1. Dura Mater- two layers

a. periosteal; outer layer- - adheres to the inside of the skull

b. meningeal; inner layer- adheres to the periosteal layer and innervates into the cerebral hemispheres

2. Arachnoid Mater

3. Pia Mater

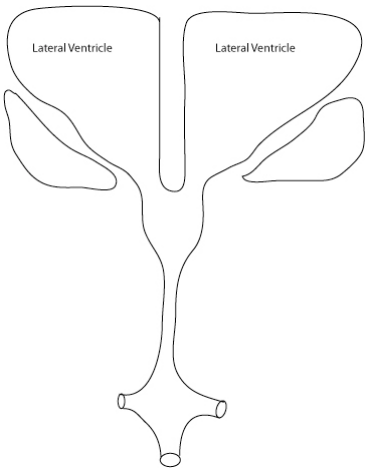
Dividers of the Brain; meninges also form dividers between the different parts of the brain

1. Falx cerebri- separates the left and right cerebral hemispheres. Lays vertically

2. Tentorium cerbelli (tent-covering the top of the cerebellum)- separates the cerebrum from the cerebellum.
Lays horizontally

3. Falx cerebelli- separates the left and right cerebellar halves. Lays vertically

Ventricles of the Brain- cavities within the brain that produce and transport CSF



Thalamus

Interventricular foramin

Third ventrical

Aqueduct of Sylvius

Fourth Ventrical

Cerebrospinal Fluid Formation- CSF is formed by a specialized capillary network called the choroids plexus located in the lateral, 3rd and 4th ventricles. This network acts as a filter, allowing only certain components of the blood to flow into the ventricles and become CSF.

CSF Functions
by a specialized network of capillaries called the choroid plexus located in each of the four ventricles

1.

2. provides support to brain tissue-

3. transports nutrients, chemicals, waste products

4. it is the main component that passes through the blood-brain barrier

Blood-Brain Barrier- a protective barrier that prevents certain components of the blood from entering the CSF, while allowing others to freely pass

a) freely pass-

b) slowly pass –

c) impermeable-

Capillaries of the Choroid Plexus- different from other capillaries

1. the walls are more densely packed
2. surrounded by many glial cells
3. basement membrane is continuous

*CSF is filtered into the ventricles because the blood pressure is greater than pressure in ventricles

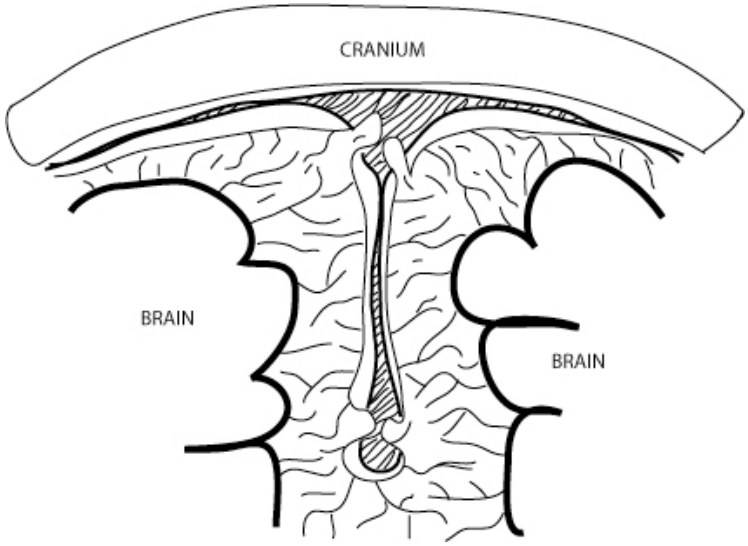
Cerebrospinal Fluid Flow

Lateral ventricles- intervertebral foramen – 3rd ventricle – Aqueduct of Sylvius

--4th ventricle--- central canal of the cord
- subarachnoid space of the cord
- subarachnoid space of the brain

Return of CSF to the Venous System

CSF returns to the venous blood via the Arachnoid Villi (a portion of the arachnoid layer that projects through the meningeal layer of the dura mater) and dumps into the dural sinuses, which is basically a venous drainage system located between the two dural layers that drains into the internal jugular veins and eventually into the heart.



The Four Main Parts of the Brain

1. **Brainstem**- involved in lower function tasks, i.e.- respiration, heart rate

3 Parts

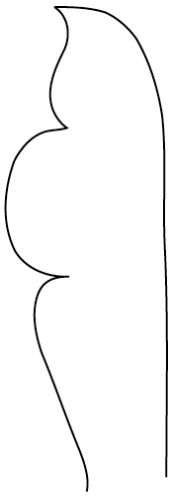
A) Midbrain (Mesencephalon) most superior, located just below third ventricle

Functions-

1) Processes sight and hearing information

2) produces involuntary skeletal motor response

3) maintains consciousness



B) Pons (means bridge)- below midbrain

Functions-

1) sensory relay to

2) controls

C) Medulla Oblongata- below pons

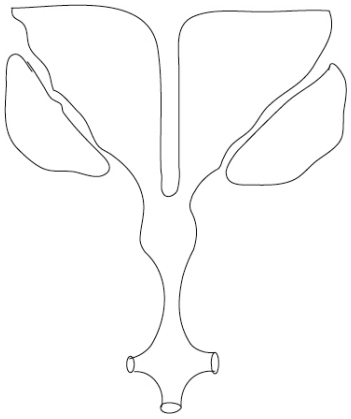
Functions-

1) sensory relay to thalamus

2) centers for visceral function

3) pyramidial decussation-

2. **Diencephalon** (means- two brains)



A) Thalamus – above midbrain and lateral and inferior to lateral ventricle

Function- relay and processing center for sensory information

B) Hypothalamus- below thalamus of either side of 3rd ventricle

Function- controls emotion, autonomic function and hormone production

C) Reticular Formation
aka. Reticular Activating System

Function- regulates HR, breathing rhythm, vessel diameter, controls coughing, sneezing, hiccups

3. Cerebellum

Location- its two halves occupy the inferior, posterior aspect of the cranium, below tentorium cerebelli, joined in the middle by

Functions- involved in subconscious movement of skeletal muscle

4. **Cerebrum** – largest portion of the human brain

Processes
1) conscious though
2) intellectual function
3) memory storage
4) involuntary regulation of skeletal motor patterns

Cerebral Cortex
- the outer surface of the cerebrum is composed of gray matter approximately 2-4mm thick. Contains millions of cells and consists of six indistinct layers of nerve cell bodies

Cerebral Surface – hill and valley appearance
1.) Gyri –

2.) Sulci –

3) Fissure – deep groove

White Matter- axons within the cerebrum connecting the cerebrum with different parts of the brain

Fiber Tracts within the White Matter (3 Types)

1.) **Association Fibers-** connect or transmit information between gyri in the

2.) **Commissural Fibers-** transmit information from one gyri to the corresponding gyri in the

3.) **Projection Fibers-** ascending or descending fibers going from the cerebrum to

Four Lobes of the Brain

1) Frontal-

2) Parietal-

3) Occipital-

4) Temporal-

Functional Areas of the Cerebral Cortex

*Broadmann's Areas- a surface map of the brain denoting the locations of the different functional areas of the cerebrum

<u>3 Main Divisions of the Cerebral Cortex Functional Areas</u>

A) Motor Areas (4)

1) Primary Motor Area-

Location- precentral gyrus of frontal lobe (BA 4)

2) Premotor Area- concerned with complex learned motor activity

Location- anterior to primary motor area (BA 6)

3) Frontal Eye Field Area-

Location-anterior to premotor area (BA 8)

4) Language Area (aka Broca's Area)-

Location- frontal lobe below BA 8, just above lateral sulcus (BA 44, 45)

B) Sensory Areas (9)

1) Primary Sensory Cortex- conscious perception of

Location- post central gyrus

2) Sensory Association Area- sensations are analyzed and sent to Gnostic area for interpretation

Location- posterior to primary sensory cortex

3) Primary Visual Area- sensory impulses from the eyes are interpreted into

Location- posterior tip of occipital lobe (BA 17)

4) Visual Association Area- evaluates and recognizes past and present visual experiences.

Location- anterior to primary visual areas (BA 18, 19)

5) Primary Auditory Area- interprets characteristics of sound

Location- superior part of temporal lobe (BA 41, 42)

5) Auditory Association Area- interprets whether sound is speech, music, noise, etc.

Location- inferior to primary auditory area in temporal lobe (BA 22)

7)Primary Gustatory Area- interprets

Location- at the base of the central sulcus

8) Primary Olfactory Area- interprets

Location- medial aspect of temporal lobe

*primary gustatory and primary olfactory work closely together

9) General Interpretive Area (aka Gnostic Area) intetrates sensory information so common thought can be formed, only on one side, usually the left.

Location- large part of parietal lobe behind post-central gyrus
(BA 5,7,39,40)

C) Association Areas- connect all motor and sensory areas to each other, and lies throughout cerebrum

Purpose- concerned with memory, emotion, reasoning, will, judgment, personality and intelligence

Other Parts of the Cerebrum

1) Basal Nuclei- lie within each hemisphere beneath the floor of the lateral ventricle

Basal Nuclei Divisions

1) Caudate Nucleus

2) Lentiform Nucleus
   a) Putamen
   b) Globus pallidus

3) Claustrum

4) Amygdaloid Body; also part of the Limbic system

Function of the Basal Nuclei-

1) involuntary adjustment and modification of voluntary motor commands

2) helps process visual information

2) Limbic System-

Function- processes memory, creation of emotions, drives, and associated behavior

Components of the Limbic System

1) Limbic Lobe
   a) cingulated gyrus
   b) parahippocampal gyrus
      *both are involved in memory storage

2) Hippocampus- storage of learned information

3) Amygdaloid Body- also part of the basal nuclei

4) Fornix-

5) Mamillary Body- processes olfaction and controls eating movement

6) Thalamus- rage, pain, sexual arousal, pleasure

7) Hypothalamus- alertness, lethargy

8) Reticular Formation- connects all of these together

Brain Lateralization (Split Brain Concept)

Rt. brain- analyzes touch, smell, taste, sight, feelings, non-verbal visual patterns (drawings)

Lt. brain- interprets speech, reading, writing, logical decisions, analytical, mathematical

The Cranial Nerves

I. Olfactory Nerve
Arises from cerebrum
Exits skull through olfactory foramina in cribriform plate of ethmoid
Function- sensory only. Sense of smell.

II. Optic Nerve
Arises from diencephalon
Exits skull through optic foramen of sphenoid
Function- sensory only. Vision

III. Oculomotor Nerve

Arises from brain stem
Exits skull through superior orbital fissure of sphenoid
Function- mixed nerve (both sensory and motor). Motor to extrinsic and intrinsic eye muscles. Sensory for muscle sense (proprioception) of same area

IV. Trochlear Nerve

Arises from brain stem
Exits skull through superior orbital fissure of sphenoid
Function; mixed nerve. Motor to extrinsic eye muscles. Sensory for muscle sense of same area

V. Trigeminal Nerve

Arises from brain stem
-*Opththalmic* branch exits skull through superior orbital fissure
-*Maxillary* branch exits skull through foramen rotundum of sphenoid
-*Mandibular* branch exits skull through foramen ovale of sphenoid
Function; mixed nerve. Motor to mastication muscles. Sensory to face, scalp, tear glands, mucous membranes of the nasal cavity and mouth

VI. Abducens Nerve

Arises from the brain stem
Exits the skull through the superior orbital fissure
Function; mixed nerve. Motor to extrinsic eye muscles. Sensory for muscle sense of same area

VII. Facial Nerve

Arises from brain stem
Exits skull through stylomastoid foramen of temporal bone
Function; mixed nerve. Motor to muscles of facial expression, salivation and lacrimation. Sensory for taste and muscle sense

VIII. Acoustic = Vestibulocochlear Nerve

Arises from the brain stem
Exits skull through internal auditory meatus of temporal bone
Function; sensory only. Vestibular branch is sensory for equilibrium, cochlear branch is sensory for hearing

IX. Glosopharyngeal Nerve

Arises from brain stem
Exits skull through jugular foramen of temporal bone
Function; mixed nerve. Motor to swallowing and salivation. Sensory for taste from posterior part of tongue and muscle sense

X. Vagus Nerve

Arises from brain stem
Exits skull through jugular foramen
Function; mixed nerve. Motor to pharynx, larynx, viscera of thorax and abdomen (parasympathetic nervous system) sensory for muscle sense to same areas and taste

XI. Accessory Nerve

Comprised of two nerves;

Cranial

arises form brain stem

Spinal

Arises from cervical spinal cord

Both

Exit skull through jugular foramen
Function: mixed nerve- motor muscles of pharynx and larynx and to head movement muscles (sternocleidomastoid and trapezius) sensory for muscle sense to the same area

XII. Hypoglossal Nerve

Arises from brain stem
Exits skull through hypoglossal canal of occipital bone
Function; mixed nerve. Motor to tongue, sensory for muscle sense of tongue

Somatic Motor Pathways

Upper Motor Neurons; cell body that lies in upper CNS processing centers. Involved in facilitating or inhibiting a lower motor neuron

Lower Motor Neuron; cell body that lies in motor nucleus of brain or spinal cord. Function is to innervate skeletal muscle

UMN injury: causes

LMN injury: causes

AUTONOMIC NERVOUS SYSTEM

Involved in regulating the activities of smooth muscle, cardiac muscle and glands.

Characteristic comparisons between SNS and ANS

Somatic Nervous System

1. conscious control of skeletal muscles

2. mixed nerves; motor and sensory. (sensory is proprioception)

Autonomic Nervous System

1. subconscious control of visceral activities (organs, glands, smooth and cardiac muscle)

2. predominantly motor. (When it fires, it will cause an action of some type (secretion of a gland or contraction of a muscle. Do not typically need proprioception for this)

3. predominantly controlled by the hypothalamus

The Two Divisions of the ANS

A) Sympathetic nervous system:

B) Parasympathetic nervous system:

Effects of the ANS

	Parasympathetic	**Sympathetic**
1. pupils	*-constriction*	*-dilation*
2. digestion/ glands	*-increase in secretion*	*-decrease in secretion*
3. smooth muscle	*-increase in activity*	*-decrease in activity*
4. digestion	*- increase in activity*	*-decrease in activity*
5. respiratory passages	*-constriction*	*-dilation*
6. heart	*-decrease in HR*	*-increase in HR*
7. skin vessels	*-no innervation*	*-constriction at skin vessel*
8. skeletal muscle vessels	*-no innervation*	*-dilation (more O2)*
9. adrenal glands	*-no NT*	*-release epinephrine and norepinephrine*

Autonomic Pathways

A) Sympathetic (T1-L2)

White rami communicans: from spinal nerve to sympathetic cell body
Gray rami communicans: from ganglia posteriorly

Autonomic Ganglia

1. Autonomic ganglia has a cell body and a synapse
2. Autonomic ganglia is a motor, not a sensory cell body

B) Parasympathetic: aka craniosacral division either S234 or brainstem

Can be a plexus or a ganglion

The Sympathetic Nerve Network

A) The Sympathetic Chain Ganglia: a series of ganglia lying in a vertical row on either side of the vertebral column. They receive preganglionic fibers from the sympathetic thoracolumbar division only.

Function:

1) to receive preganglionic fibers from the lateral horn/ sympathetic division (T1- L2)

2) fibers terminate in the skin to innervate (connect with nerves)
(If they synapse in the chain ganglia, those terminal fibers will innervate the skin; Sweat glands of the skin, the vessels of the skin (general vasoconstriction), and the erector pili muscles.)

B) The Collateral Ganglia: preganglionic fibers- "splanchnic nerves" that pass through the sympathetic ganglia to synapse in one of the three collateral ganglia. These collateral ganglia are located anterior to the vertebral column. (Named after the arteries that they are near or around)
Function: -innervate organs of the abdominopelvic cavity.

The Three Collateral Ganglia

1. celiac ganglion:most superior- innvervates

2. superior mesenteric ganglia: middle-

3. inferior mesenteric ganglia: lowest-

C) The Adrenal Medulla (located on top of the kidneys)
Preganglionic fibers pass through the sympathetic chain. They also pass through the collateral ganglia (the celiac ganglion) without synapsing, to eventually synapse in the adrenal medulla. Inside the medulla the preganglionic fibers synapse on specialized cells that release neurotransmitters (epinepherine and norepinephrine) that are then carried to the bloodstream.

The Parasympathetic Nerve Network; AKA the craniosacral division

A) The 4 Cranial Ganglia

1. sphenopalatine ganglion: (pterygopalatine ganglion); travels with cranial nerve VII to innervate the

2. ciliary ganglion: comes off the pons and lies along the cranial nerve III.

3. submandibular ganglion: goes to the submandibular gland and is associated with cranial nerve VII.

4. Otic ganglion: associated with cranial nerve IX, and innervated

B) The Intramural Ganglia; intramural means

1. Vagus Nerve; arises off brainstem and innervates chest and abdomen.

a) cardiac and pulmonary plexus: to heart and lungs

b) celiac plexus: innervates the

c) hypogastric plexus: innervates the

Plexus: nerve network of branching Parasympathetic fibers

2. Pelvic Nerves; arise off of cord levels

<u>Autonomic Neurotransmitters</u>

1. Cholinergic fibers- release ACH

a) ACH is released from all preganglionic ANS fibers
- including parasympathetic and sympathetic fibers

b) ACH is released from all postganglionic parasympathetic fibers
*effects are short-lived and local due to the presence of Acetylcholinesterase

ACH "Postsynaptic" Receptor sites- effects on target organ dependent on the receptors on that organ

a) Nicotinic- receptors for ACH on the postganglionic synapse (dendrites + cell body)
-causes firing of all para and sympathetic postganglionic fibers

b) Muscarinic- receptor sites on all parasympathetic target organs and some sympathetic target organs
- results are variable- causes exitation or inhibition, depending on the organ

2. Adrenergic Fibers- release epinephrine and norepinephrine

a) released from most postganglionic sympathetic fibers

b) affects are longer lasting and more widespread

"Postsynaptic Receptors"- Alpha and Beta receptors- have variable effects depending on the specific target organs involved

Control of ANS

-controlled through higher centers in the cerebral cortex and the hypothalamus

Interpretation of Sensory Information

Definitions:

1. Sensations: refer to the state of awareness of external or internal body conditions

2. Receptors: specialized nervous tissue that picks up a stimulus and converts it to a nerve impulse

3. Stimulus: is how a sensation is perceived (i.e. light, heat, pressure and pain)
*generator potential; a stimulus strong enough to cause depolarization

Characteristics of Sensation

1. Projection: process by which the brain perceives sensations as coming from their point of stimulation

2. Adaptation: (mentioned earlier) the perception that a sensation is decreasing even though the stimulus is still being applied

3. After images: when a sensation persists even after the stimulus has been removed. (ex. Look at a light and then close eyes)

4. Modality: refers to the different sensations perceived as pain, pressure, touch, proprioceptors

I. General Senses

A. Exteroceptors- provide information about external environment
*randomly distributed, located near body surface
*some areas more densely populated than others

examples:

Two Point discrimination: we use calipers here to measure the distance between the two closest points that each part of the body can detect.
The most sensitive
The least sensitive

First Class of Exteroceptors

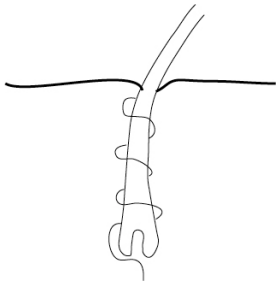
1. Fine Touch

a) Meissner's Corpusle- detects touch and vibration

-mass of dendrites covered by a connective tissue layer in dermal papilla, numerous in

b) Merkel's Disc- touch and pressure receptor

d) Root Hair Plexus- surrounds hair root, stimulated if hair shaft moves, adapts quickly.



2. Crude Touch

a) Pacinian Corpusle- oval receptor, perceives deep pressure and vibration in the deep dermis, resembles an

3. Thermoreceptors

-detect heat and cold. Free nerve ending, no known morphological difference between hot and cold receptors, travels down the same pathway as pain (Lateral Spinothalamic tract)

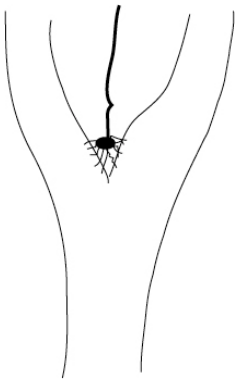
4. Pain Receptors (Nociceptors): lateral spinothalmic tract, internal or external

a) Myelinated Type A Fibers- 150-300 mph

b) Unmyelinated Type C Fibers

B) Enteroceptors- perceives sensations within the body

1. Chemoreceptors- determine pH levels, O2 and CO2 levels, hormone levels, taste, smell, etc. located throughout the body, but we also have specific chemoreceptors



a) Carotid Body- located at the branch of internal and external carotid aortic arch.

b) Aortic Body- located between major branches of aortic arch

2. Baroreceptors- monitor changes in internal pressure, in vessel walls, digestive track and respiratory tract, (i.e. carotid sinus/aortic sinus- monitor blood pressure)

3. Proprioceptors- monitor joint position, muscle, ligament and tendon tension. AKA The Kinesthetic Sense.

a) Joint Kinesthetic Receptors

-in joint capsule, inform on the

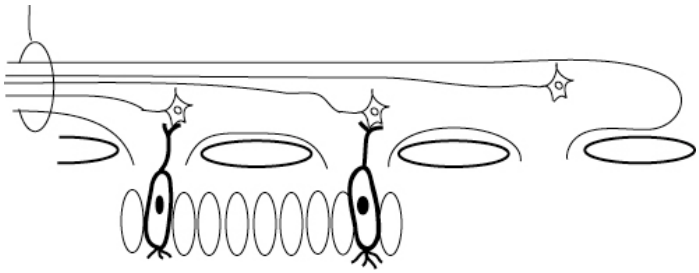
(anterior spinocerebellar)

b) Neuromuscular Spindles
-in skeletal muscle, inform on the
(posterior spinocerebellar)

c) Golgi Tendon Organs
-located at junction of muscle and tendon, inform on the

II. Special Senses- taste, smell, sight, hearing

A) Olfaction- sense of smell, fibers from the olfactory bulb pass through the cribriform plate of the ethmoid bone.



How is the sense of smell determined?
Axons pass through cribriform plate to synapse at cell bodies of olfactory bulb ending up at olfactory areas of the brain, medial anterior temporal lobe, each olfactory cell picks up only certain smells, so it will only fire if that smell is present.

B) Gustation- sense of taste

Where is sensation for taste picked up?- on taste buds (on the sides of papilla) located on the
1) tongue
2)
3)

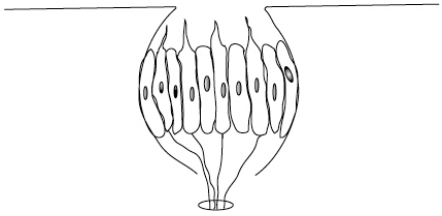
Papilla- epithelial projections on the surface of the tongue that

1. Circumvallate- largest type, circular shaped, form an inverted V shaped row at the back of the tongue.

2. Fungiform Papilla- mushroom shaped, knob like elevations, found on the tips and side.

3. Filiform Papilla- pointed, or

Taste Bud



Gustatory pathway 'taste bud'- (VII, IX, X)>>medulla>>thalamus>>post central gyrus of parietal lobe (BA 43)

III. Sight (Vision)

Associated Structures

A) Eyeball- 2.5 cm (1 in) in diameter, three layers of the eyeball

1) Fibrous Tunic- outer, 'fibrous coat'; 2 parts

a) sclera- posterior part

b) cornea- anterior part,

tissue that makes up the anterior portion of the eyeball, the cornea is covered by a continuous epithelial layer which is part of the conjunctival epithelium.

***Limbus**- junction between the cornea and the sclera

2) Vascular Tunic- middle layer, aka uvea

Three Parts

a) Choroid- posterior 2/3rd of the eye, deep to the sclera,

b) Ciliary Body- thick anterior part of choroid, contain ciliary muscles that attached to suspensory ligaments that hold the lens in place

Ciliary Muscles- alter lens shape for visual acuity

i) **contraction**- causes the lens to round outward for close vision.

ii) relaxation- causes the lens to flatten for distant vision

c) Iris- smooth muscle fibers responsible for constriction and dilation of pupil

pupil- inner opening of the iris

Iris muscle fibers- arranged in the shape of a doughnut

i) **circular**- contraction causes

ii) **radial**- contraction causes

3) Retina- inner coat of eye, contains the visual receptors for sight; covers only posterior part of eye

Two Layers

a) Nervous tissue layer- superficial to light

b) Pigmented layer- deep to the neural layer.

Structures Associated with the Retina

1) Optic Disc- 'blind spot'-

2) Macula Lutea- yellow spot in exact center of retina,

3) Central Fovea- depression in center of macula lutea.

The Chambers and Cavities of the Eye

1) Anterior Cavity- two parts

A) Anterior Chamber -

B) Posterior Chamber-

Flow of Aqueous Humor- anterior cavity contains this water like fluid called aqueous humor produced by ciliary body→ travels through posterior chamber→ through pupil → through anterior chamber → to canal of Schlemm → drained by canal of schlemm→ return to venous blood

Glaucoma-

2) Posterior Cavity- one part, aka Vitreous Body

-behind lens to retina, contains a gelatinous like mass call

Functions

a) stabilizes eyeball

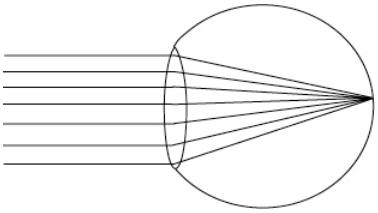
b) holds retina against tunica, (detached retina)

c) transparent

The Lens
A transparent, biconcave structure, located behind the iris, attached to the ciliary body by suspensory ligaments,

*cataracts:

Focal Point- light passing through the lens is bent or refracted to a specific point



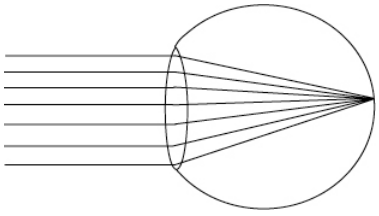
Focal Distance-

Accommodation- flattening or bulging of the lens to place focal point on the retina to allow the object to be focused

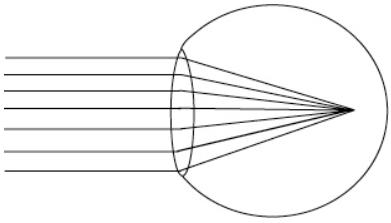
Visual Acuity- clarity of vision

20/20 –	normal
20/15 –	better than average. Able to see objects at 20 feet that normally would be seen at 15 feet.
20/30 –	worse than average. Able to see objects at 20 feet that normally would be seen at 30 feet
20/200 –	

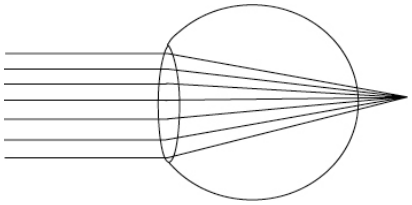
Emmetropia- normal vision, when ciliary muscles are relaxed the lens flattens, placing a distant image in focus on retina



Myopia- near-sighted, can see normal at close range, blurs at distances,



Hyperopia- far-sighted. Can see normal at distance, but not close up.



- *Presbyopia*-

Single Binocular Vision- humans, both eyes focus on one object, Object is refracted to identical spots on both retinas

Diplopia- double vision. The perception of 2 images of a single object

Strabismus- cross-eyed. Usually doesn't have double vision, because

Astigmatism- imperfections in the cornea disrupting clarity of vision

PHOTORECEPTORS

-visual receptor neurons in the retina, named after the shape of their discs

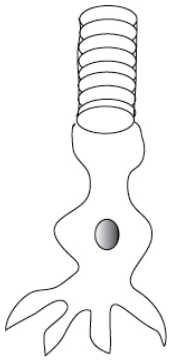
Two Types of Photoreceptors

A) Rods- highly sensitive to minimal light.

Disc -containing

Nucleus

synaptic ending



Rhodopsin

Photon of light

Opsin retinene (Visual Yellow) vitamin A required to make retinene

ATP

ADP

Rhodopsin

*Ghost Images- in bright light, rhodopsin is broken down faster than it can be remanufactured.

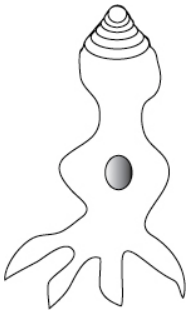
B) Cones- receptors for color and visual acuity (sharp vision)

Highest concentration in the

1) macula lutea

2) fovea centralis

Disc
nucleus
synaptic endings



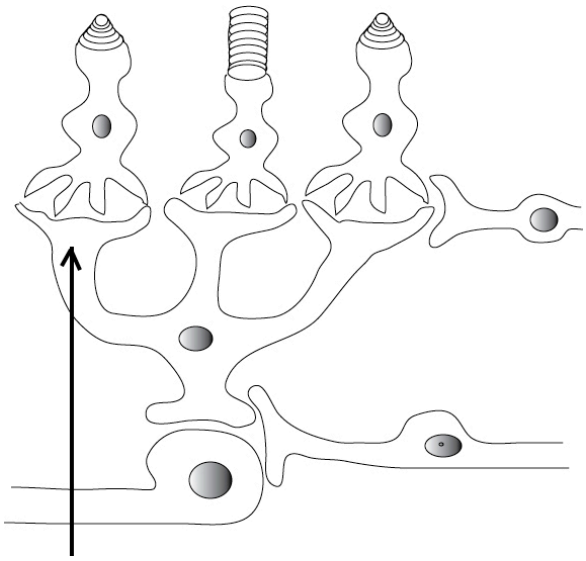
*cones contain three types of photopigments that require bright light for breakdown. (These are yet unidentified)

Normal Population Breakdown

-green cones
-blue cones
-red cones

*white light results in

Schematic of the Retina



Pigmented layer absorbs light

Photoreceptor

Horizontal cell

Bipolar cell-

Amacrine cell-

Ganglion cell

Dark adaptation: an increase in sensitivity to

Light adaptation: a decrease in sensitivity to

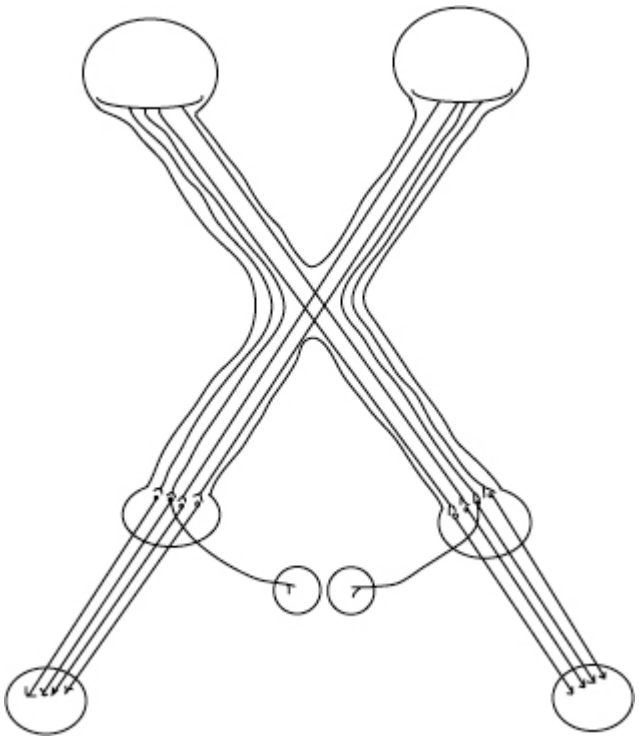
Direct Pupillary Reflex: light shining directly into one eye causes that pupil to constrict

Indirect (Consensual) Light Reflex: pupil of the opposite eye constricts when the light is shined into the other eye

Purpose of both reflexes;

1) decrease the light entering the eye
2) protects the retina from overexposure
3) increases depth of field
4) improves image sharpness

Visual Pathway of the Eye



Eye

Optic nerve

optic chiasm

Optic tract

lateral geniculate ganglion

Optic radiation

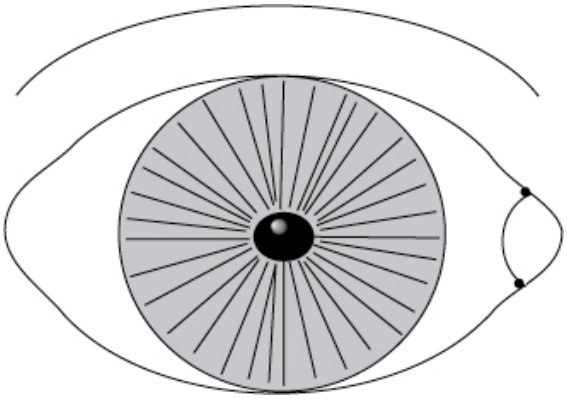
visual cortex

superior colliculi

External Structures of the Eye

Lateral canthus

palpebral fissures



Palpebra –eyelids

lacrimal puncta -drain tears into nasal cavity

medial canthus

lacrimal caruncle -produce secretions that lubricate the eye

Meibomian Glands- sebaceous glands located along the inner eyelid. Produce a

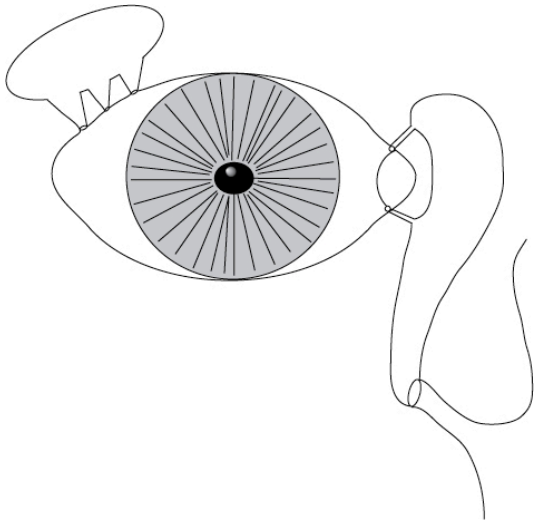
Chalazion-

Sty- painful swelling of the

Tarsal Plate- thick fold of connective tissue lining each eyelid to provide support

Lacrimal Flow

Lacrimal gland



Lacrimal puncta

lacrimal duct

lacrimal sac

nasolacrimal duct

Concha

inferior meatus

Conjunctiva- a protective specialized epithelial tissue that covers the eyelids and eyeball

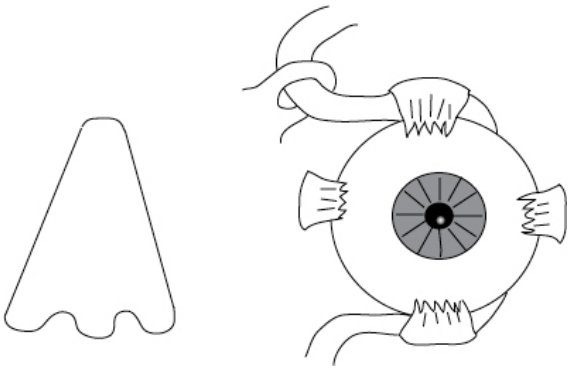
Two Parts

1) palpebral-covers

2) bulbar- covers

*fornix- fold between the palpebral and bulbar conjunctiva.

Eye Movement



Trochlea- pulley

superior oblique

superior rectus

lateral rectus

medial rectus

inferior oblique

inferior rectus

IV. HEARING

Anatomy of the External Ear

External auditory meatus

tragus

ceruminous glands –

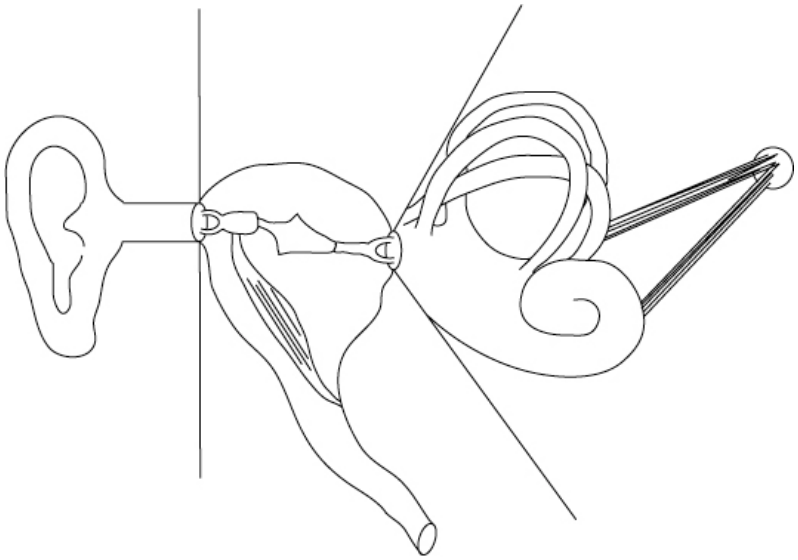
Pinna

Three Parts of the Ear

External **Middle** **Internal**

malleus incus stapes

vestibular apparatus



Vestibulocochlear nerve

vestibular portion

cochlear portion

Contents
vestibular apparatus –

cochlea

Contents
Pinna-
external auditory canal –

Contents
eustachian tube -

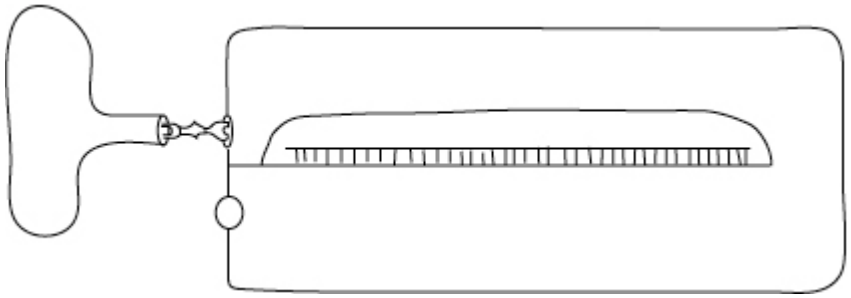
ossicles-
tensor tympani and stapedius -

Mechanism of Hearing

-housed in cochlea

Diagram of unwound cochlea

Ossicles oval window endolymph scala vestibuli



organ of corti
tectorial membrane
stereocilia
Basilar membrane
vestibular membrane

Round window Scala media scala tympani perilymph

Steps for Hearing

1) Sound waves come into the scala vestibule causes the vestibular membrane vibrate

2) causing endolymph to transmit sound waves to the tectorial membrane which vibrates causing the stereocilia to move

3) movement of the hair cells of stereocilia cause a nerve impulse the distance the sound wave travels down the membrane depends on the frequency of the soundwave

a) high frequency- perceived

b) low frequency- travels

***deafness-**

Neural deafness- caused by

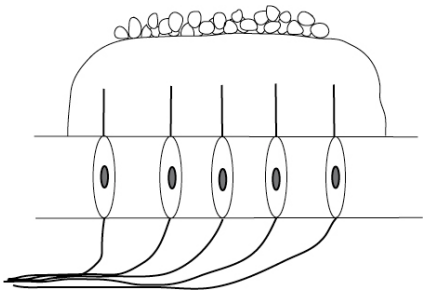
Conduction deafness- caused by

Equilibrium
Two types

A) Static Equilibrium- *(head relative to gravity)* housed inside the utricle and saccule

Macula- receptors inside the utricle and saccule that

Otoliths-



Gelatinous mass

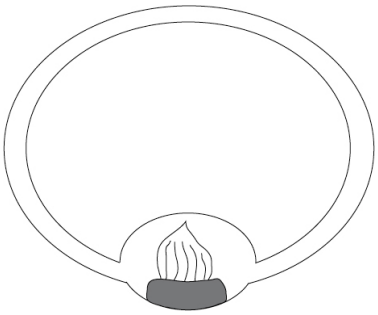
hair cells

Changes in the position relative to gravity cause a shift in the position of the gelatinous mass causing hair cells to fire

B) Dynamic Equilibrium- housed in the semicircular canals
-detects

Semicircular canals- 3 of them, all at right angles to each other to

Anatomy of the Semicircular Canals



Endolymph

semicircular canals -

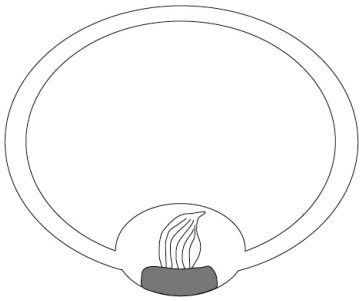
Cupula-

Crista-

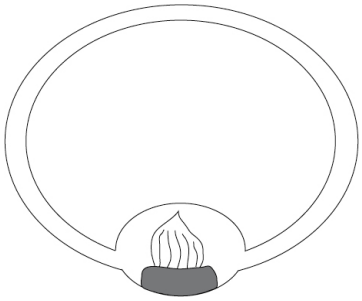
Ampulla -

Three steps involved in Dynamic Equilibrium

1) Initial rotation of the head
-when the head rotates, the cupula bends due to movement of endolymph against the cupula. This stimulates hair cells to fire.



2) Inertia is overcome- now the endolymph is moving at the same speed as the cupula and the cupula does not bend and the nerve does not fire.



3) Head stops rotating and the endolymph continues to rotate and the cupula is displaced in the opposite direction- nerve fires again.

-Individual feels as if he is rotating in the other direction which causes Nystagmus- movement of the eyes until the cupula is no longer bent (causes rapid lateral repetitive eye movement)