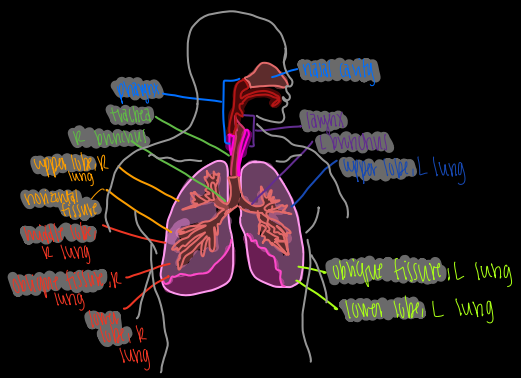
RESPIRATORY SYSTEM:

☆ LUNGS = thoracic cavity ☆

↳ ANATOMY:



☆ pharynx = behind nasal cavity ∴ back of mouth
↳ AIR ∴ FOOD

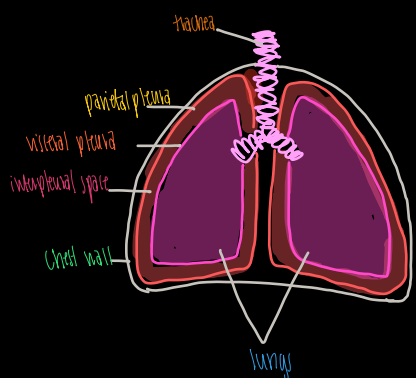
☆ larynx = below pharynx
↳ ONLY AIR → glottis ⇒ opening of larynx is covered w/ epiglottis during swallowing
vocal cords = maneuvered w/ skeletal muscle ∴ cartilage

☆ trachea = made of cartilage
☆ bronchi ∴ trachea = contain ciliated epithelial cells to catch material that has made it past nose ∴ mouth

AIR PATHWAY:
↳ entry through nares
↓
pharynx ∴ larynx
↓
trachea
↓
bronchi

↳ In the LUNGS ⇒ bronchi divide into bronchioles then into alveoli
☆ alveoli = site of gas exchange ☆
↳ contain surfactant: ↓ surface tension ∴ prevents alveoli from collapsing

↳ PLEURAE = surround each lung
↳ forms closed sac against which the lung expands
↓ VISCERAL: adjacent to lung
↓ PARIETAL: outer part



BREATHING:

↳ INHALATION: ☆ ACTIVE process ☆
↓
uses: diaphragm ∴ external intercostal muscles
↓
As diaphragm flattens ∴ chest wall expands outward intrathoracic volume ↑↑

☆ ↑↑ intrapleural volume = ↓↓ intrapleural pressure ☆
↳ gas in lungs now has ↑ pressure in intrapleural space ∴ lungs EXPAND ∴ lung pressure ↓↓

☆ diaphragm = divides thoracic cavity from abdominal cavity
↳ SOMATIC CONTROL

☆ intrapleural space = contains thin fluid layer
↳ helps lubricate 2 pleural surfaces

Air is sucked in from OUTSIDE world
= negative-pressure breathing

↳ driving force is LOWER pressure in intrapleural place than LUNGS

↳ EXHALATION: ✯ doesn't have to be active process ✯

↳ diaphragm ∴ external intercostals RELAX
∴ chest cavity ↓ in VOLUME

↳ pressure in intrapleural space is now ↑↑ than LUNGS
= air is PUSHED out

w/ ACTIVE tasks ⇒ we can SPEED UP this process

↳ using internal intercostal muscles ∴ abdominal muscles

= OPPOSE external intercostals ∴ pull ribcage DOWN

LUNG CAPACITIES ∴ VOLUMES:

✯ total lung capacity (TLC): max volume of air in lungs when one INHALES completely
~6-7 liters

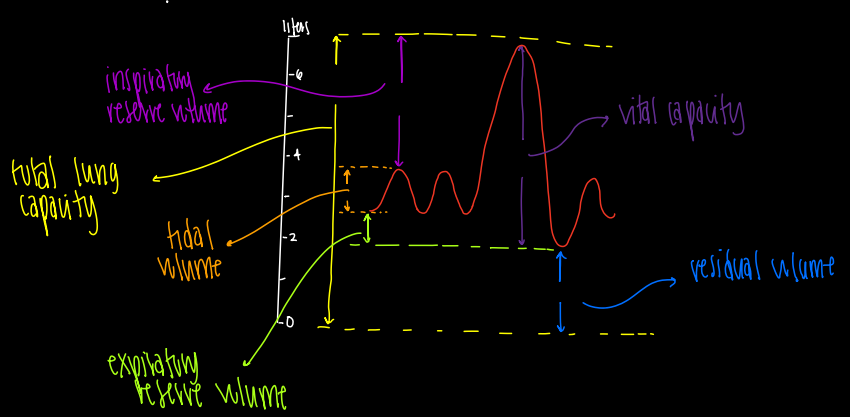
✯ residual volume (RV): minimum volume of air in lungs when one EXHALES completely

✯ Vital capacity (VC): difference between min ∴ max volume of air in lungs
(TLC(-RV)

✯ Tidal Volume (TV): volume of air inhaled/exhale in normal breath

✯ Expiratory Reserve Volume (ERV): volume of additional air that can be forcibly EXHALED after normal exhalation

✯ Inspiratory Reserve Volume (IRV): volume of additional air that can be forcibly INHALED after normal inhalation



REGULATING BREATHING: → requires input from nervous control center

☆regulating ventilation → by neurons in medulla oblungata called ventilation center
↳ fires rhythmically to cause contraction of resp. muscles

☆contain CHEMORECEPTORS = sensitive to [CO_2]
↳ when CO_2 partial pressure ↑ → hypercarbia / hypercapnia
↳ resp. rate ↑ so more CO_2 is EXHALED
∴ CO_2 in blood ↓↓

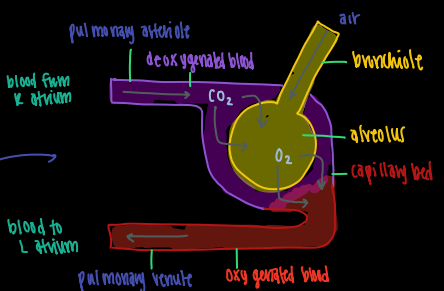
Respiratory System Functions:

Gas Exchange: ☆primary function of lungs☆

↓

☆CAPILLARIES → bring deoxygenated blood from pulmonary arteries

oxygenated blood returns to L atrium via pulmonary veins



☆ Thermoregulation: regulation of body temp

· heat = transfer of thermal energy → regulated w/ vasoconstriction / vasodilation

→ w/ capillary EXPANSION = more blood can pass ∴ larger amount of thermal energy can be dissipated

→ w/ capillary CONTRACTION = less blood can pass which CONSERVES thermal energy

☆IMMUNE FUNCTION: because of interactions w/ outside world... pathogens like bacteria, viruses ∴ fungi can cause infections or gain access to body w/ alveolar membranes

Lines of Defense:
1) Vibrissae (hair in nose): help trap particulate matter
2) Lysozyme: also in tears ∴ saliva; can attack peptidoglycan of G+ bacteria
3) Mucus: trap particulate matter ∴ larger invaders
4) Cilia: propel mucus cup resp. tract to oral cavity to be expelled / swallowed
↳ = called mucociliary escalator

↳ Lungs (esp. ALVEOLI): have immune cells like MACROPHAGES
↳ engulf/digest pathogens ∴ signal to rest of I.S. that there is invader

Mucosal surfaces ⇒ IgA
↳ help protect against pathogens ∴ contact mucous membranes

MAST CELLS
↳ have preformed IgE on surface when right substances attach to IgE ⟶ cells will release inflammatory chemicals to promote immune response

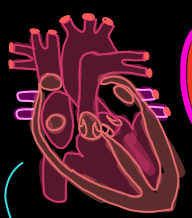
Controlling pH:

Bicarb Buffer system = to regulate pH balance

$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

☆ Body maintains pH → 7.35-7.45
↳ If pH is LOWER = $[H^+]$ is ↑ ... body will ↑ resp rate
↳ shifts buffer system = produces ↑↑ CO_2
☆ w/ ↑↑ resp. rate → more CO_2 is blown off
↳ shifts equation to L = due to removal of CO_2

☆ Kidney also plays a role in modulating secretion/reabsorption of acids/bases in NEPHRON ☆
↳ if blood is too basic = body will try to ↑ acidity
☆ w/ slowed resp rate ⟶ more CO_2 is retained which shifts buffer to R w/ produces more H^+ ions ∴ bicarb ions = ↓ pH



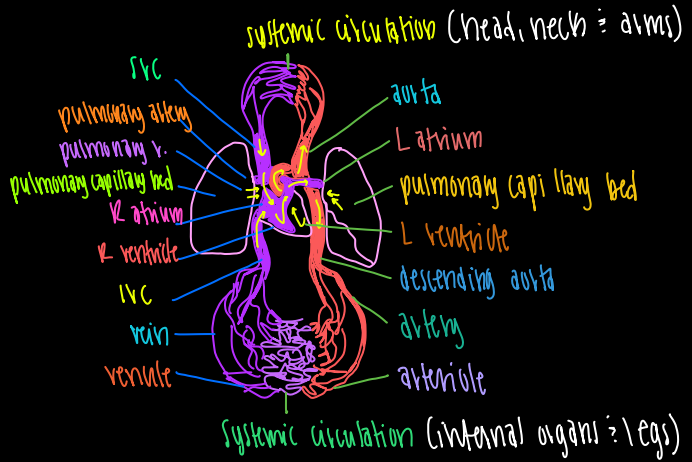
CARDIOVASCULAR SYSTEM:

☆ consists of 4 chambered heart, blood vessels, & blood

heart = pump which circulates blood through vasculature
↳ arteries, capillaries, & veins

HEART = 4 chambered structure of cardiac muscle
↳ made of 2 pumps:
↳ R side = accepts deoxygenated blood from body ∴ moves to lungs w/ pulmonary arteries = pulmonary circulation

↳ L side = receives oxygenated blood from lungs w/ pulmonary veins ∴ forces out to body w/ aorta = system circulation



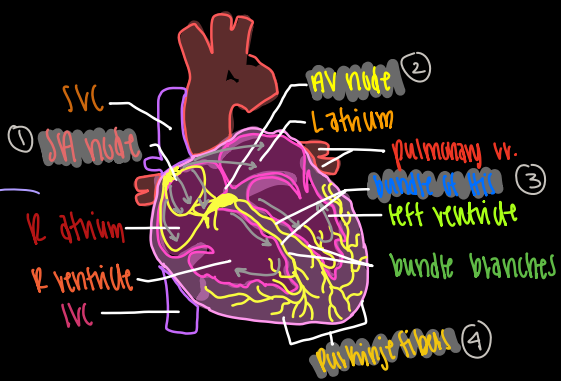
☆ Each side of heart has atrium + ventricle
↳ ATRIA ⇒ blood received from vena cava (deoxy. entering R heart) or pulmonary veins (oxy. entering L heart)
↳ contracts to push blood into ventricles
once ventricles fill → contract to send blood to lungs + systemic circulation

☆ atria seperated from ventricles by AV nodes
☆ ventricles seperated from vasculature by semilunar valves

↳ valve between R atrium + R ventricle = tricuspid (3 leaflets)
valve between L atrium + L ventricle = bicuspid (2 leaflets)

valve between R ventricle + pulm. circulation = pulmonary valve
valve between L ventricle + aorta = aortic valve
} ☆ both have 3 leaflets ☆

Mnemonic = LAB RAT
↳ Left Atrium = BICUSPID
Right Atrium = TRICUSPID



☆ ELECTRICAL conduction ⟹ SA node → AV node → Bundle of His → Purkinje fibers
☆ 60-100 signals per min

→ As depolarization spreads from SA node ⇒ 2 atria contract simultaneously
Most ventricle filling = PASSIVE but atrial systole (contraction) causes ↑↑ atrial pressure to force more blood into ventricles = ATRIAL KUCK

→ As signal reaches AV node ⇒ signal is delayed to allow ventricles to fill completely before they contract

→ signal travels down Bundle of His ⇒ embedded in interventricular septum
→ to Purkinje fibers ⇒ distribute signal through ventricular muscle

☆☆ Muscle cells are connected w/ intercalated discs
↳ contain gap junctions that directly connect cytoplasms of adjacent cells

↳ SA node = 60-100 signals per min. = normal human HR: 60-100 beats per min

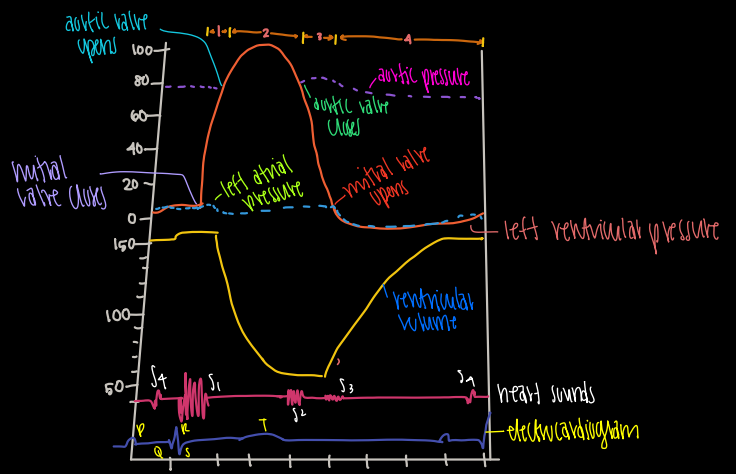
☆ circulatory system = AUTONOMIC control

- sympathetic:
  - speeds up HR ∴ ↑ cardiac muscle contractility
- parasympathetic:
  - provided by vagus nerve = slows down

CONTRACTION:

☆ SYSTOLE ⇒ ventricular contraction ∴ closure of AV valves occurs ∴ blood is pumped OUT of ventricles

☆ DIASTOLE ⇒ heart is relaxed, semilunar valves are closed ∴ blood from atria fills ventricles



☆ cardiac output = HR x SV
↳ TOTAL blood volume pumped by ventricle per min

☆ HR = beats per min
☆ SV = volume of blood pumped per beat

THE Vasculature:

→ MAJOR arteries: coronary, common carotid, subclavian ∴ renal arteries → divide bloodflow from aorta toward different peripheral tissues

☆ Arteries = largest is AORTA

↳ Arteries → Arterioles → capillaries → (join to form) venules → (join to form) veins

☆ ALL blood vessels have: endothelial cells ☆

ARTERIES → move blood away from heart → lungs ∴ other parts of body
↳ highly muscular + elastic
most = oxygenated EXCEPT... pulmonary ∴ umbilical ⇒ deoxygenated

CAPILLARIES → single endothelial cell layer ∴ small so RBC must pass in single file line
↳ easy diffusion of gases, nutrients ∴ wastes

VEINS → thin-walled that transport blood to heart
↳ EXCEPT for pulmonary/umbilical veins ALL other veins carry deoxygenated blood
☆ venule = smallest venous structures that connect capillaries to larger veins of body

↳ veins → smaller amounts of smooth muscle = less recoil than arteries
↳ able to stretch to accomodate larger quantities of blood

☆larger veins have VALVES to push blood forwar & prevent backflow
↳ failure of valves = varicose veins (distended where blood has pooled)

CIRCULATION:

↳ ☆ blood returns to heart from SVC & IVC → SVC = returns blood from body ABOVE heart
IVC = returns blood from body BELOW heart

☆ deoxygenated blood enters R atrium → tricuspid → R ventricle
On contraction... blood in R ventricle → pulmonary valve → pulmonary arteries

☆ full pathway of BLOOD: ☆

R atrium → (tricuspid valve) → R ventricle → (pulmonary valve) → pulmonary artery → lungs → pulmonary veins → L atrium
→ (mitral valve) → L ventricle → (aortic valve) → aorta → arteries → arterioles → capillaries → venules → veins
→ vena cava → R atrium

☆ In MOST cases = blood only passes 1 capillary bed before returning to ♥
↳ but... 3 portal systems where blood passes 2 capillary beds in series before returning to ♡

☆ HEPATIC: blood leaving capillary bed in walls of gut pass through hepatic portal vein before reaching capillary beds of liver

☆ HYPOPHYSEAL: blood leaving capillary beds of hypothalamus travel to bed in anterior pituitary for paracrine secretion of releasing hormones

☆ RENAL: blood leaving glomerulus travels through efferent arteriole before surrounding the nephron in capillary network called vasa recta

COMPOSITION:
By volume:
- 55% = liquid &
- 45% = cells

Liquid = PLASMA → mixture of nutrients, salts, respiratory gases, hormones & blood proteins

→ plasma can be further refined by removing clotting factors into serum

Cells = 3 major categories → erythrocytes, leukocytes, platelets } ALL formed from HSC that originate from bone marrow

Erythrocytes: RBC

= specialized cell for O_2 transport → O_2 can't just dissolve in cytoplasm ⇒ each RBC has HEMOGLOBIN to bind 4 molecules of O_2

Modifications = Biconcave ⇒ indented on both sides
↳ assists RBC in capillary travel ∴ ↑ surface area ∴ ↑ gas exchange

When mature = no nuclei, mitochondria ∴ other organelles
↳ to make room for Hb
☆ no nucleus = no division → RBC live 120 days before cells in liver/spleen phagocytize the old RBC ∴ recycle for parts

(RBC) = quantity of each cell type in blood

☆ Hb = amount of hemoglobin in blood → normal = 13.5-17.5 (males) ∴ 12-16 (females)
☆ Hematocrit = measures how much of sample is RBC (%)
→ normal = 41-53% (males) ∴ 36-46% (females)

Leukocytes: WBC

= < 1% of total blood volume → 4500-11,000 WBC per microliter of blood

☆ CRUCIAL for I.S. = defense against pathogens, foreign cells, cancer ∴ other materials not "self"

5 types of WBC in 2 categories:

☆ GRANULOCYTES: neutrophils, eosinophils ∴ basophils
contain granules involved in inflammatory reactions, allergies, pus formation ∴ destruction of bacteria/parasites } functions

☆ AGRANULOCYTES: lymphocytes ∴ monocytes
phagocytize foreign matter when leaving bloodstream = MΦ
different names in diff. locations

SPECIFIC I.R.
↳ some are 1° responders ∴ others are memory banks

LYMPHOCYTE MATURATION:
☆ for 3 locations.
mature in: Bone Marrow = B cell (↳ Ab generation)
Thymus = T cell
↳ kill virally infected cells

Thrombocytes: Platelets

☆ cell FRAGMENTS released from cells in bone marrow called megakaryocytes

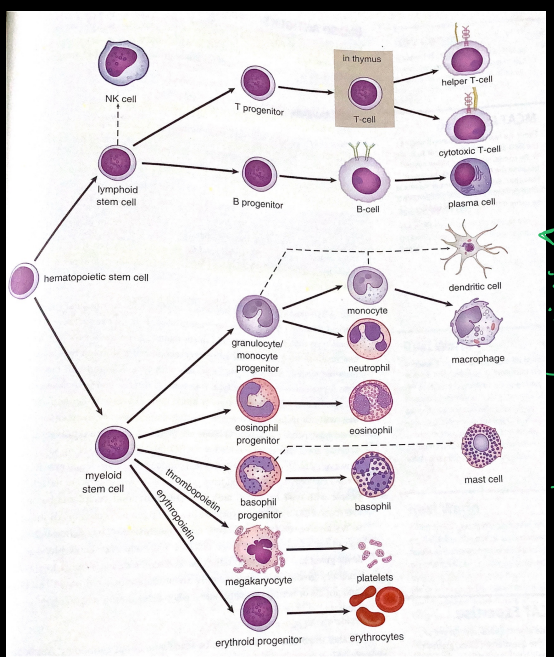
FUNCTION = assist w/ blood clotting

Hematopoiesis: production of blood cells + platelets

triggered by: hormones, GF + cytokines ☆ most important = erythropoietin

erythropoietin → secreted by kidney + stimulates RBC development

thrombopoietin → secreted by liver + kidneys + stimulates platelet development



hematopoiesis

BLOOD ANTIGENS:

☆ Antigens = any specific target that I.S. can react

ABO Antigens = A + B = CO-dominant (i.e. will be AB w/ 1 A allele + 1 B allele)

UNIVERSAL RECIPIENT = AB

O = neither Ag variant ∴ will not cause I.R. = UNIVERSAL DONORS ... but can only receive blood from another O ☆

ABO Blood Types

Blood type	Genotype	Ag produced	Ab produced	Can donate to...	Can receive from...
A	I^AI^A, I^Ai	A	anti-B	A + AB	A + O
B	I^BI^B, I^Bi	B	anti-A	B + AB	B + O
AB	I^AI^B	A + B	—	AB only	A, B, AB + O ☆universal recipient☆
O	ii	—	anti-A + anti-B	A, B, AB + O ☆universal donor☆	O only

✡ Rh Factor:

= surface protein on RBC

Rh+ / Rh- } presence/absence of allele D

✡ Rh+ = Autosomal DOMINANT = only 1 positive allele is enough for protein expression

✡ important in PREGNANCY:

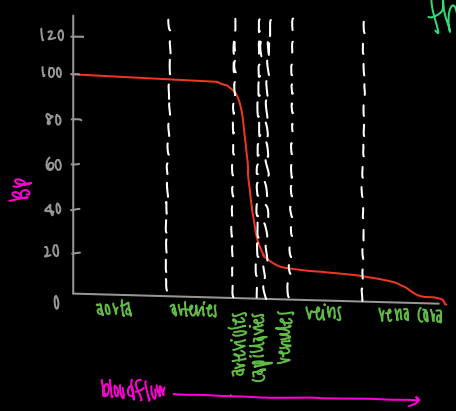
If woman is Rh- & fetus is Rh+ → sensitization to Rh factor ⇒ I.S. will make Ab against it
↳ not problem w/ 1st child BUT... w/ subsequent pregnancy w/ Rh+ fetus
can be issues bc maternal anti-Rh Ab can cross placenta & attacks fetal blood cells = hemolysis
↳ called erythroblastosis fetalis = can be fatal

Physiology of CV System:

✡ transports gases, nutrients & waste products via RBC & plasma
✡ important for immunity that help fight infections
✡ capillaries dilate/constrict to maintain proper body temp
✡ mediates formation of blood clots to repair damaged vessels

IMPORTANT for: maintaining BP → hypertension = ↑ BP
↳ can cause damage to blood vessels & organs
gas/solute exchange
coagulation
thermoregulation

BP = force per unit area exerted on wall of blood vessels (measured w/ sphygmomanometer)
↳ systolic = ventricle contraction
diastolic = ventricle relaxation



ΔP = CO x TPR
↳ ΔP = pressure differential across the circulation
CO = cardiac output
TPR = total peripheral (vascular) resistance

✡ LONGER BV = more resistance ✡
✡ LARGER cross-sectional area = less resistance ✡

w/ ↑↑ BP = specialized atrial cells secrete ANP (atrial natriuretic peptide)
↓
aids in loss of salt within nephron acting as natural diuretic

GAS ⇌ SOLUTE EXCHANGE:

★ O_2 = primarily carried by Hb
Hb has 4 subunits w/ prosthetic heme group that binds to O_2
↳ binding occurs at Fe²⁺ (ferrous) central iron = Redox reaction w/ binding / releasing of O_2

· oxygen saturation = % of Hb molecules carrying O_2

↳ IN LUNGS → O_2 diffuses into alveolar capillaries
- with binding → affinity for O_2 shifts ⇒ subsequent binding is EASIER
- when all O_2 subunits are bound to O_2 → removing $1O_2$ makes others EASIER to remove

termed: cooperative binding = sigmoidal shaped curve

★ CO_2 = removal of CO_2 (primary waste product of cell resp)
↳ due to ↓ solubility ⇒ only small % of total CO_2 being transported to lungs will be dissolved in plasma

↳ MOST CO_2 exists in blood as bicarb ion (HCO_3^-)
: when CO_2 enters RBC → encounters carbonic anhydrase → catalyzes combo reactions between CO_2 ⇌ H_2O to form carbonic acid (H_2CO_3)

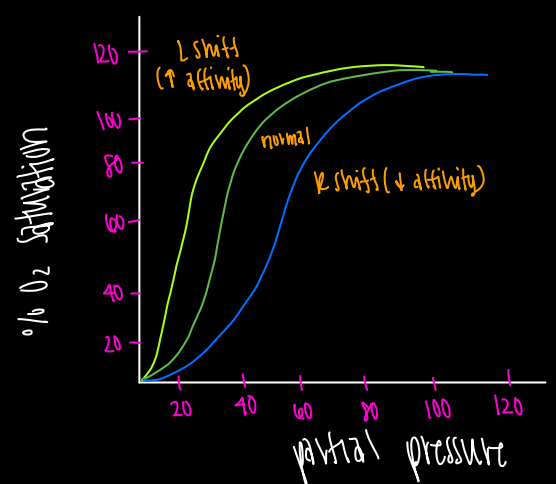
$$CO_2(g) + H_2O(l) \rightleftharpoons H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

breathing out CO_2

★ important for ridding body of CO_2
AND ↑ CO_2 shifts curve ⇒ ↓ pH ⇒ ↓ Hb affinity for O_2
↳ ↓ affinity = Bohr effect

MNEMONIC: causes of R shift to Hb curve ⇒ Exercise is right thing to do
↳ 3 things: ↑ $P_a CO_2$
↑ $[H^+]$ ⇒ ↓ pH
↑ temp

LEFT SHIFT ⇒ ↓ $P_a CO_2$
↓ $[H^+]$ ⇒ ↑ pH
↓ temp ⇒
↓ 2,3-BPG



✡ Nutrients, Waste ∴ Hormones = Carbs ∴ A.A. are absorbed in small capillaries ∴ enter circulation by hepatic portal system

Fats are absorbed into lacteals in small intestine ∴ bypass hepatic portal circulation to enter by thoracic duct

Wastes (like CO_2, ammonia ∴ urea) enter bloodstream by travelling down concentration gradients from tissues ⟶ capillaries

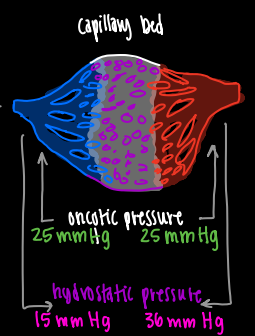
Hormones enter circulation in/near organ where hormone is produced (usually exocytosis which secretes hormones into bloodstream)

FLUID BALANCE:

2 pressure gradients in bloodstream are essential to maintain balance between blood ∴ interstitium

1) HYDROSTATIC = force per unit area that blood exerts against vessel walls
✡ generated by contraction of ♡ ∴ elasticity of arteries ✡
↳ measured UPSTREAM in large arteries as BP

2) OSMOTIC = "sucking" pressure generated by solutes as they attempt to draw water into bloodstream
✡ because MOST osmotic pressure is attributable to plasma proteins ⟶ oncotic pressure



hydrostatic pressure (pushes fluid out) is LOWER than oncotic pressure (drawing fluid in)
= NET INFLUX of water back into circulation

hydrostatic pressure (pushes fluid out) is HIGHER than oncotic (draws fluid in)
= NET EFFLUX of water from circulation

balance of opposing pressures = STARLING forces ⟶ ESSENTIAL for maintaining proper fluid volumes inside/outside vasculature

✡ IMBALANCE = too much/little fluid in tissues
↳ EXCESS fluid in interstitium = EDEMA

✡ Most lymph fluid is returned to CVS through thoracic duct
↳ blocking lymph nodes due to infection ⟶ EDEMA ✡

COAGULATION:

★ CLOT = both coagulation factors + platelets
↳ FUNCTION: prevent or minimize blood loss

★ ENDPOINT = activation of prothrombin → thrombin
↳ by thrombinplastin

thrombin → converts fibrinogen → fibrin

★ fibrin = forms small fibers that aggregate + cross-links into net-like structure
↳ captures RBC + other platelets to form stable clot over damaged area

→ when B.V. endothelium is damaged
↳ underlying C.T. is exposed (contains collagen + tissue factor)
As platelets contact collagen they sense INJURY
↳ release contents + clump together
coagulation factors sense T.F. + initiate activation cascade

THROMBUS FORMATION: also called blood clotting

★ occurs when blood vessels are injured
↳ platelets attach to exposed matrix when endothelial cells lining blood vessels are disrupted
Attachment activates $\alpha_{2b}\beta_3$ integrin + causes them to adhere to circulating proteins (like fibrinogen that forms bridges to other platelets)

cells + proteins form network of cells + fibers dense enough to plug injury area + prevent blood loss until wound is repaired

★ blood clot will have to be broken down
↳ done w/ plasmin → from plasminogen

REPRODUCTIVE SYSTEM:

Cell Cycle + Mitosis

autosomal = DIPLOID (2n)
germ cells = HAPLOID (n)

★ cell cycle = where a cell grows + synthesizes DNA + divides

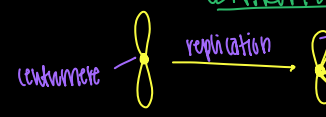
↳ cell cycle for ACTIVELY dividing cells ⇒ G_1, S, G_2 + M
G_1, S + G_2 = Interphase
↳ longest part of cell cycle

G_0 = cells that do not divide

Interphase (G_1, S + G_2):
↳ G_1 = cell create organelles for energy + protein production (mitochondria, ribosomes + ER) + ↑↑ SIZE
↳ to pass into S phase ⇒ restriction point

↳ S = cell replicates genetic material so each daughter cells with IDENTICAL copies

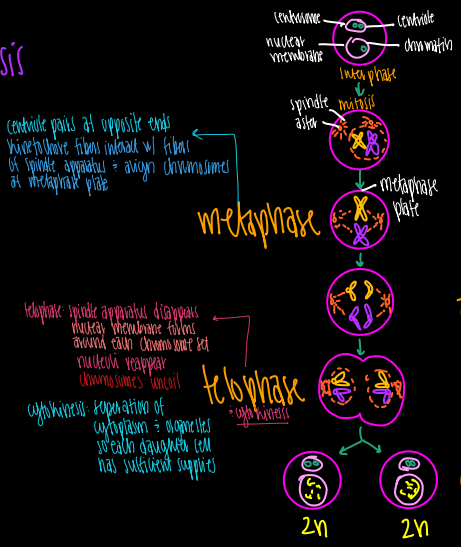
After replication, each chromosome has 2 identical chromatids bound together at CENTROMERE



↳ G_2 = cell passes another checkpoint
→ DNA is duplicated ∴ cell checks that there are enough organelles ∴ cytoplasm to divide

∴ makes sure DNA replication occured properly so no errors are passed to daughter cells

↳ MITOSIS = 4 stages + cytokinesis
↳ Prophase
Metaphase
Anaphase
Telophase



prophase → condensing of chromatin → chromosomes
centriole pairs seperate ∴ move to opposite poles
↳ once further away form spindle fibers
nuclear membrane dissolves to allow spindle fibers to contact chromosomes
kinetochores appear at centromere

centriole pairs at opposite ends
kinetochore fibers interact w/ fibers of spindle apparatus ∴ align chromosomes at metaphase plate

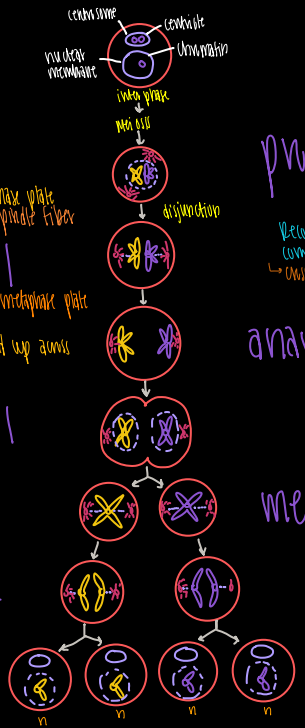
anaphase → centromeres split so each chromatid has own distinct centromere
sister chromatids are pulled toward opposite ends of cell by kinetochore shortening

telophase: spindle apparatus disappears
nuclear membrane forms around each chromosome set
nucleoli reappear
chromosomes uncoil
cytokinesis: separation of cytoplasm ∴ organelles in each daughter cell has sufficient supplies

MEIOSIS: ★occurs in gametocytes ∴ results in 4 nonidentical gametes★

↓
Meiosis 1:
results in homologous chromosome separation w/ HAPLOID daughter cells
= reductional division

↓
Meiosis 2:
results in separation of sister chromatids
= equational division



prophase I → chromatin condenses into chromosomes
spindle apparatus forms ∴ nucleoli, nuclear membrane disappear
★homologous chromosomes come together ∴ tetrad = synapsis★
each pair has 4 chromatids = tetrad
↳ held together by synaptonemal complex
chromatids may break at contact point (chiasma)
∴ exchange DNA = crossing over (only between homologous chromosomes)
Recombination can explain unlinked genes which ↑ variety of genetic combinations
↳ crossing over explains Mendel's 2nd law (independent assortment)

homologous pairs align at metaphase plate
each pair attaches to seperate spindle fiber by kinetochore

metaphase I
★each chromosome is linked up to metaphase plate by 2 spindle fibers = MITOSIS
★homologous chromosomes are linked up across each other = held by 1 spindle fiber

anaphase I → homologous pairs seperate ∴ pull to opposite poles = disjunction = accounts for Mendel's 1st law (segregation)
during disjunction each chromosome from paternal origin seperates from homolog and either can end up in daughter cells
separation of 2 homologous chromosomes = segregation

telophase I
nuclear membrane forms around each new nucleus
each chromosome is still 2 sister chromatids joined at centromere
cells are HAPLOID
cell divides into 2 daughter cells by cytokinesis

metaphase 2 → chromosomes line up on metaphase plate

(centromeres) divide ∴ seperate chromosomes into sister chromatids
these chromatids are pulled to opposite poles by spindle fibers

telophase 2 → nuclear membrane forms around each new nucleus
after... cytokinesis ∴ 2 daughter cells are formed

Continuing Cell Cycle: controlled by CHECKPOINTS between G_1 ∴ S AND G_2 ∴ M

↳ G_1/S = cell determines if DNA is good enough for synthesis
★if damage = cell cycle ARRESTS until DNA is repaired★
↳ (p53)

↳ G_2/M = cell is concerned w/ ensuring cell is adequate SIZE
∴ organelles are replicated properly

☆Molecules responsible for CELL CYCLE =
↳ cyclins + cyclin-dependent kinases [CDKs]

• CDKs require signal cyclins
↳ during cell cycle = concentrations of cyclins ↑ + ↓ during specific stages
↳ cyclins bind CDKs to create activated CDK-cyclin complex
these then phosphorylate transcrip. factors → promote transcription of genes required for next stage of cell cycle

CANCER: cell cycle is essential to ensure cells damaged or inadequately sized do not divide

↳ If the cell cycle becomes deranged + damaged cells undergo mitosis = CANCER

common mutation = p53 → produced from TP53

☆ mutations accumulate + cause cancerous cells to divide continuously ☆
↳ cancer cells undergo rapid cell division that create TUMOURS

REPRODUCTIVE SYSTEM:

Biological sex is determined by 23rd chromosomes
↳ XX = female
XY = male

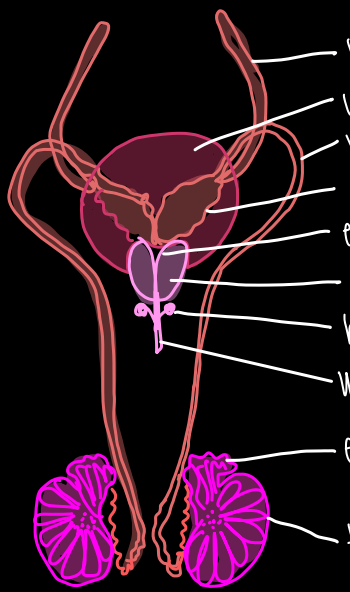
☆ Ovum = only carries X
☆ Sperm = either X or Y

☆ X chromosome = carries most genetic info
+ mutations can lead to sex-linked (X-linked) disorders
↳ males = HEMIZYGOUS → only 1 X copy

↓
Most X-linked disorders = RECESSIVE so females express the disorder far less frequently than males
↳ carrier = female carrying diseased allele but don't exhibit disease

☆ Y chromosome = carries less genetic info
↳ one important gene = (SRY) (sex-determining region Y)
↳ codes for transcription factor that initiates testis differentiation
+ formation of male gonads

MALE reproductive anatomy:



- ureter
- urinary bladder
- vas deferens
- seminal vesicle → fructose to nourish sperm
- ejaculatory duct
- prostate gland → mild alkalinity to sperm to survive acidic femal reprn. tract
- bulbourethral gland → clear viscous fluid to clear remnants ∴ lubricates
- urethra → carries sperm through penis as exits body
- epididymis → sperm flagella gain motility ∴ are stored until ejaculation
  during ejaculation sperm travel through vas deferens to ejaculatory duct
  2 ejaculatory ducts fuse to form URETHRA
- testis → 2 functional components:
  - seminiferous tubules (produce sperm ∴ nourished by sertoli cells)
  - interstitial cells of Leydig (secrete testosterone ∴ other male hormones)

  ↓ located in scrotum (external pouch below penis)

★PATHWAY of sperm: SELF (IN) UP

↳ Seminiferous Tubules
Epididymis
Vas deferens
Ejaculatory Duct
Urethra
Penis

↳ As sperm passes through reproductive tract = mix w/ SEMINAL FLUID → combined effort by seminal vesicles, prostate ∴ bulbourethral

★COMPONENTS =

↳ fructose to nourish sperm = seminal vesicles
fluid alkalinity so sperm can survive acidity of female rep. tract = seminal vesicles ∴ prostate gland
clear viscous fluid to clean urine ∴ other remnants ∴ also lubricates urethra during arousal = bulbourethral glands

★ SEMEN = sperm + seminal fluid ★

SPERMATOGENESIS:

formation of haploid sperm through meiosis
∴ occurs in seminiferous tubules

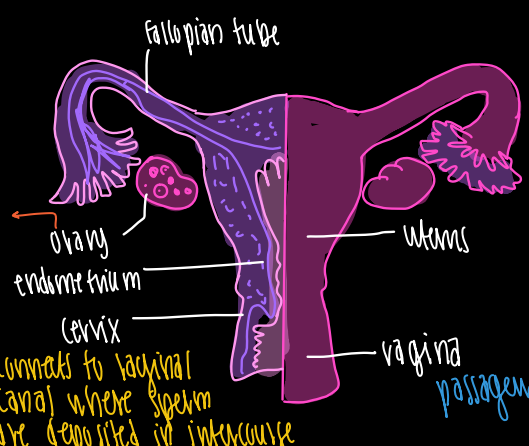
DIPLOID stem cells = spermatogonia
↳ once replicated, they develop to 1° spermatocytes
1st meiotic division = 2° spermatocytes that undergo meiosis 2 → haploid spermatids

spermatids mature to becum spermatogonia

SPERM = composed of head → contain genetic material
midpiece → generates ATP from fructose
☆ filled w/ mitochondria that generate energy for sperm to reach ova ☆
∴ flagellum → motility

↳ sperm head ⇒ covered by ACROSOME
↳ derived from Golgi ∴ is needed to penetrate ovum

FEMALE reproductive anatomy:



produces estrogen/progesterone
consists of follicles that nourish ∴ protect immature ova

☆ between puberty ∴ menopause 1 egg is ovulated each month into peritoneal sac
☆ drawn into fallopian ducts w/ cilia to propel egg forward
☆ fallopian tubes connect to uterus (the site of fetal development)

cervix connects to vaginal canal where sperm are deposited in intercourse

passageway where childbirth occurs

oogenesis: production of female gametes

☆ no unending supply of stem cells → all oogonia a woman will ever have are formed in fetal development

↳ By birth = all oogonia have undergone DNA replication ∴ are called 1° oocytes
↳ arrested in prophase

☆ When a woman reaches MENARCHE ⇒ 1 1° oocyte per month will complete meiosis I
= 2° oocyte ∴ a polar body

↳ OOCYTES: surrounded by 2 layers: zona pellucida = surrounds oocyte ∴ is mixture of glycoproteins to protect oocyte ∴ contain compounds necessary for sperm cell binding

corona radiata = outside zona pellucida and is layer of cells that adhere to oocyte during ovulation

SEXUAL DEVELOPMENT:

before puberty, hypothalamus restricts GnRH. But when puberty starts the hypothalamus release GnRH that trigger anterior pituitary to synthesize FSH ∴ LH that trigger other hormones to develop ∴ maintain rep. sys

MALE:
during fetal period (9 weeks after fertilization until birth) presence of Y chromosome leads to androgen production
↳ testosterone = produced by testes
⚠ ↑ in puberty ∴ sperm production starts ⚠
↳ FSH stimulates sertoli = sperm maturation
LH causes interstitial cells = produce testosterone

⚠ testosterone develops/maintains male repro. system ∴ causes development of secondary sex characteristics
= face ∴ arm pit hair
deepening voice
changes to growth patterns

FEMALE:
ovaries are also under control of FSH ∴ LH
↳ secrete estrogen ∴ progesterone

⚠ Estrogens secreted in response to FSH
establish ∴ maintain development of female repro. system

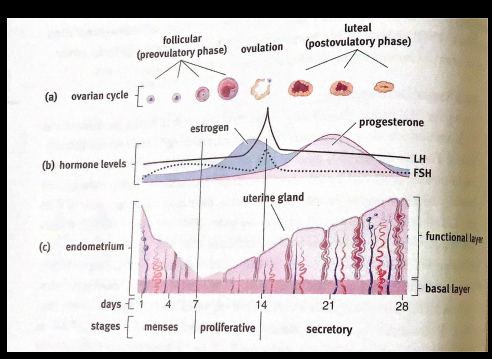
⚠ AND cause secondary characteristics
= breast growth
widening of hips
changes in fat distribution
↳ for embryo → estrogen causes uterus endometrium thickening each month to prepare for implantation

⚠ Progesterone secreted by corpus luteum in response to LH
development ∴ maintenance of endometrium but not initial endometrium thickening

↳ by end of 1st trimester = progesterone is supplied by placenta so corpus luteum atrophies

MENSTRUAL CYCLE:

= 4 events
↳ 1) follicular phase
2) ovulation
3) luteal phase ∴
4) menstruation



→ estrogen ∴ progesterone levels rise ∴ fall in cyclic pattern

☆FOLLICULAR:

begins when menstrual flow starts
↳ sheds uterine lining of previous cycle

☆GnRH secretion ↑ in response to ↓ estrogen ∴ progesterone☆
↳ ∴ ↑ GnRH = ↑ FSH ∴ LH that work together to develop ovarian follicles
the follicles produce estrogen ⟶ negative feedback ∴ causes estrogen
progesterone ∴
GnRH to LEVEL OFF

☆OVULATION:

estrogen can have positive / negative feedback
↳ late follicular = developing follicles have ↑ ∴ ↑ concentrations of estrogen
eventually estrogen reaches threshold that results in positive feedback
∴ GnRH
FSH ∴ LH levels spike

↳ LH surge = OVULATION

☆LUTEAL:

after ovulation, LH causes ruptured follicle to form corpus luteum that secretes progesterone
↳ progesterone ↑ ∴ estrogen remains high
- ↑ progesterone causes negative feedback on GnRH, FSH, LH ∴ prevents ovulation of multiple eggs

☆MENSTRUATION:

if implantation doesn't occur, corpus luteum loses LH stimulation
progesterone levels ↓↓ ∴
uterine lining sloughs off

↳ REMOVAL of high levels of estrogen / progesterone removes GnRH block so next cycle can start

☆PREGNANCY:

if fertilization occurs, zygote will develop to blastocyst that will implant in uterine lining ∴ secrete hCG
hCG = LH ∴ very similar to each other
↳ hCG maintains corpus luteum ∴ is CRITICAL during 1st trimester bc
estrogen ∴ progesterone keep uterine lining in place

by 2nd trimester, hCG declines because PLACENTA is sufficient in size
to secrete progesterone / estrogen by itself

↳ ↑ estrogen / progesterone = negative feedback to prevent further GnRH secretion

☆MENOPAUSE:

w/ age ovaries become less sensitive to FSH ∴ LH = Ovarian atrophy
↳ as estrogen / progesterone ↓, endometrium atrophies ∴ menstruation stops

w/ negative feedback on FSH ∴ LH removed = blood levels of FSH ∴ LH rise ⇒ MENOPAUSE

↳ physical/physiological changes accompany menopause

↳ flushing
hot flashes
bloating

headaches ∴
irritability

= between ages 45-55

EMBRYOGENESIS ∴ DEVELOPMENT:

fertilization:

usually occurs in widest part of fallopian tube = AMPULLA
when sperm meets 2° oocyte in fallopian tube, it binds ∴ releases acrosomal enzymes which enable head of sperm to penetrate corona radiata ∴ zona pellucida

↳ Once first sperm contacts 2° oocyte cell membrane it forms acrosomal apparatus extends to ∴ penetrates cell membrane
after penetration ⇒ cortical reaction releases Ca^{2+} ions
↳ leads to depolarization of ovum membrane this prevents fertilization of ovum w/ multiple sperm ∴ ↑ $[Ca^{2+}]$
↑ metabolic rate of zygote

now the membrane is depolarized ∴ impenetrable ⇒ fertilization membrane

Twins:

2 mechanisms

DIZYGOTIC = fraternal; form from fertilization of 2 different eggs released during 1 ovulatory cycle
↳ each zygote will implant in uterine wall ∴ develop its own placenta chorion ∴ amnion

MONOZYGOTIC = identical; when single zygote splits into 2
↳ genetic info is IDENTICAL

☆w/ incomplete division = CONJOINED TWINS = 2 offspring are physically attached

classified by # of shared structures:
- monochorionic / monoamniotic ⇒ share amnion ∴ chorion
- monochorionic / diamniotic ⇒ twin have own amnion but share chorion
- dichorionic / diamniotic ⇒ each have own amnion ∴ chorion

Cleavage: rapid mitotic cell divisions

- 1st Cleavage = embryo
  - ↳ cells ↑ nuclear:cytoplasm ratio = surface area to volume ratio

↳ 2 types of CLEAVAGE:

- Indeterminate: results in cells that can still develop into complete organisms
- Determinate: results in cells with fates that are already determined

BLASTULATION: w/ several divisions → embryo becomes MORULA

☆ once morula forms ⇒ it undergoes BLASTULATION → to form BLASTULA (hollow ball of cells w/ fluid filled inner cavity = blastocoel)

↳ mammal blastula ⇒ BLASTOCYST w/ 2 cell groups

- trophoblast: surrounds blastocoel = gives rise to chorion = later: placenta
- inner cell mass: protrudes into blastocoel

↳ IMPLANTATION:

blastula moves through fallopian tubes to uterus = burrows into endometrium
trophoblast cells → specialized to create interface between maternal blood supply = embryo

☆ give rise to chorion = develops into placenta
↳ trophoblasts form chorionic villi = penetrate endometrium
As they develop into placenta → they support maternal-fetal gas exchange

↳ umbilical cord ⇒ connects embryo to placenta
↳ 2 arteries = 1 vein

☆ VEIN = freshly oxygenated blood w/ nutrients from placenta to embryo
☆ ARTERIES = carry deoxygenated = waste to placenta for exchange

Until placenta is functional... embryo is supported by yolk sac → site of early blood cell development

involved in EARLY fluid exchange between embryo = allantois
= yolk sac

ultimately umbilical cord forms from remnants of yolk sac = allantois

2 extra embryonic membranes

- surrounds allantois
- ↓ amnion: composed of thin tough membrane w/ amniotic fluid → serves as shock absorber during pregnancy

↳ CHORION = also forms outer amnion membrane which aids PROTECTION

↳ GASTRULATION: generation of 3 distinct cell layers

- merging of 2 membranes = GASTRULA
- membrane invagination into blastocyst = archenteron → later develops into gut
  ↳ opening of archenteron ⇒ blastophore

Primary Germ Layers:

☆ ECTODERM = outermost layer ∴ gives rise to: integument: epidermis
hair
nails ∴ epithelia of nose
mucosa ∴
lower anal canal

→ also: eye
nervous system ∴
inner ear

☆ MESODERM = middle layer ∴ develops into systems: musculoskeletal
circulatory ∴ most of
excretory system

→ also: gonads ∴ muscular/connective tissue layers of digestive ∴
respiratory systems

☆ ENDODERM = innermost layer ∴ forms epithelial linings of: digestive ∴ respiratory tracts
↳ pancreas
thyroid
bladder ∴
distal urinary tracts

DIFFERENTIATION:

☆ selective transcription ⇒ only genes needed for that particular cell type are transcribed ☆

often related to INDUCTION:
- ability of 1 group of cells to influence fate of other nearby cells

mediated by INDUCERS
diffuse from organizing cells → responsive cells

NEURULATION: development of nervous system

★ PROCESS: 1) Rod of mesodermal cells (notochord) forms along long axis of organism
↳ notochord induces group of ectodermal cells to slide inward to form NEURAL FOLDS
surrounds neural groove

2) Neural folds grow toward one another → fuse into NEURAL TUBE
↳ gives rise to CNS

3) At tip of each neural fold = neural crest cells
migrate outward to form PNS → specific types in other tissues

4) Ectodermal cells migrate over neural tube → cells to cover rudiment nearly N.S.