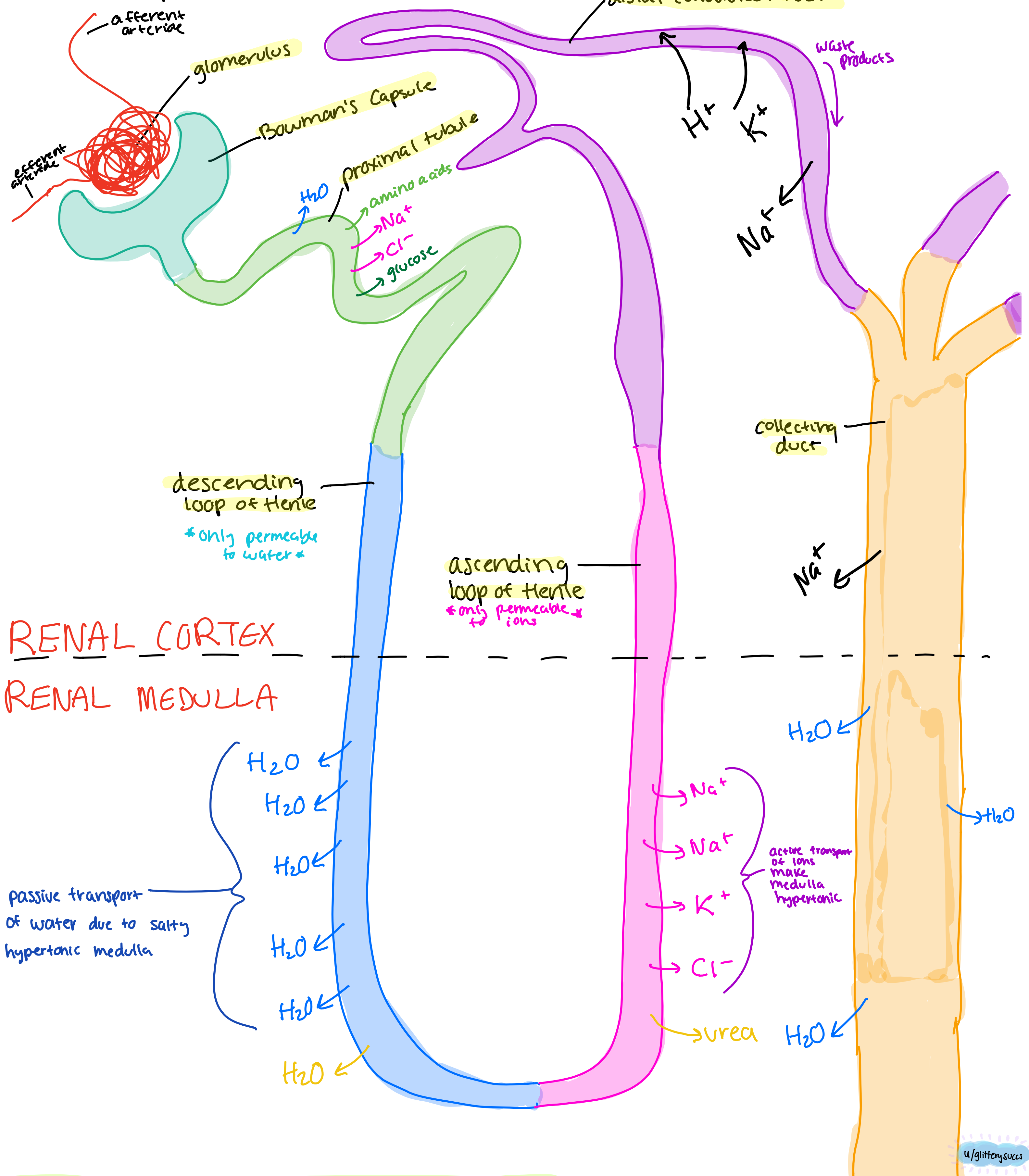
- glomerular filtration – process that kidneys use to filter excess fluid and waste products out of the blood
- tubular reabsorption – process that moves solutes and water out of filtrate and back into your bloodstream
- countercurrent multiplication – kidneys use energy to generate an osmotic gradient that enables the reabsorption of water from tubular fluid to produce concentrated urine



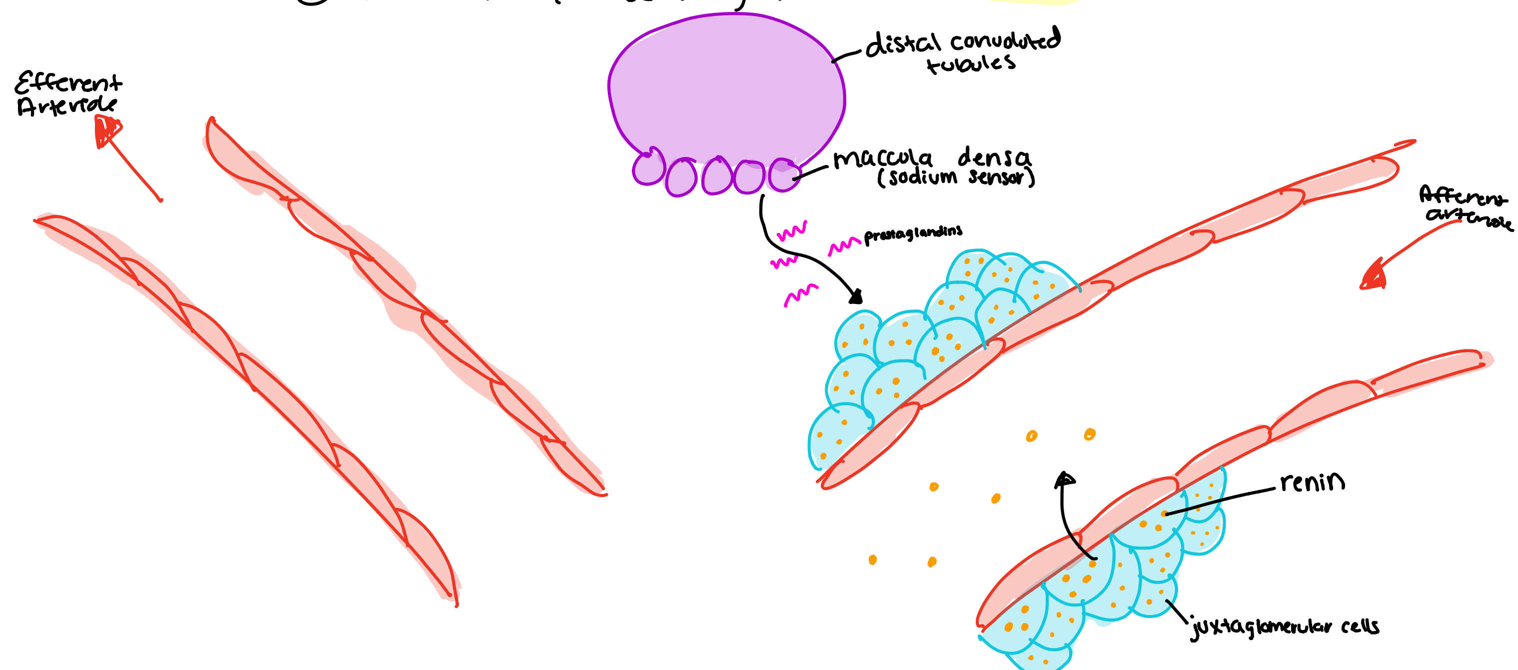
Diameter Of Arterioles & Filtration Rates

	diameter	filtration
afferent	$\uparrow$	$\uparrow$
	$\downarrow$	$\downarrow$
efferent	$\uparrow$	$\downarrow$
	$\downarrow$	$\uparrow$

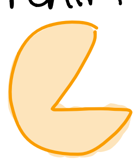
ADH works on the collecting duct to make it more porous to allow even more reabsorption of water

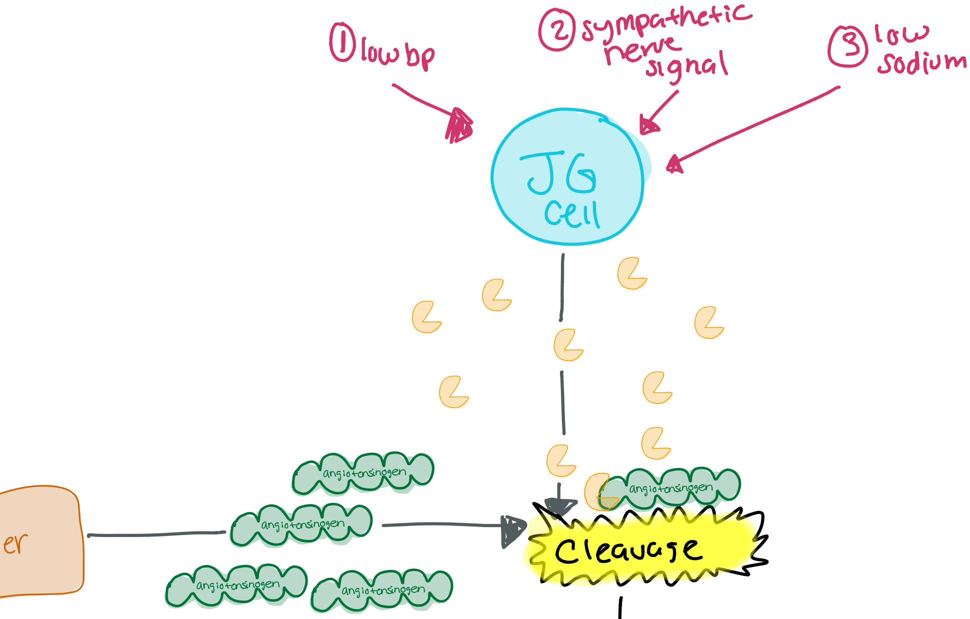
Renal Regulation of Blood Pressure

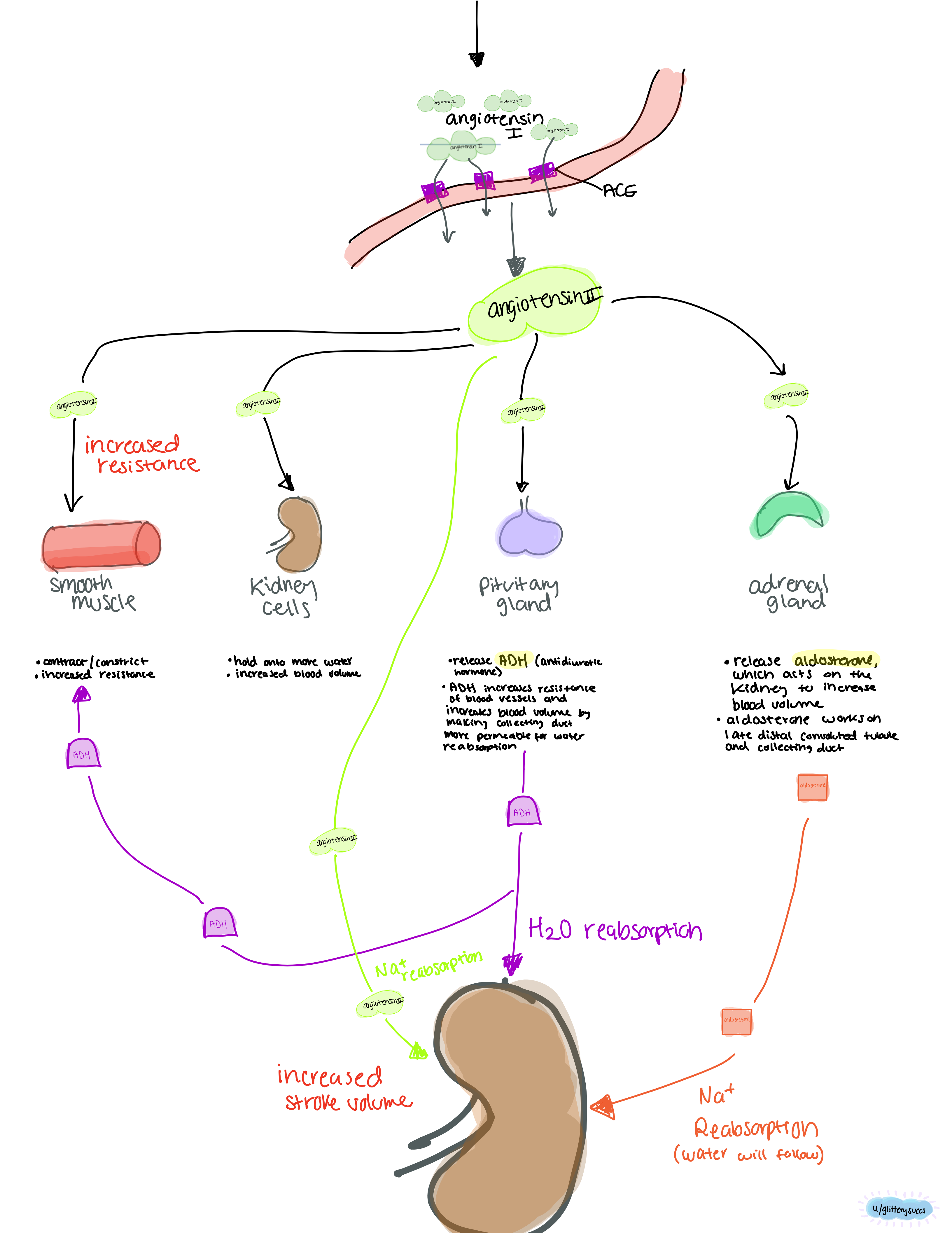
- Renin-Angrotensin-Aldosterone-System (RAAS)
- juxtaglomerular cells in the distal convoluted tubule are a type of smooth muscle cell; release renin
- renin – helps raise blood pressure when triggered by:
  1. low blood pressure (mechanically "feel" low bp)
  2. sympathetic nerve cell firing
  3. low salt (sensed by maccula densa in distal tubule



renin







angiotensin I
ACE
angiotensin II
increased resistance
smooth muscle
Kidney cells
Pituitary gland
adrenal gland
• contract / constrict
• increased resistance
• hold onto more water
• increased blood volume
• release ADH (antidiuretic hormone)
• ADH increases resistance of blood vessels and increases blood volume by making collecting duct more permeable for water reabsorption
• release aldosterone, which acts on the kidney to increase blood volume
• aldosterone works on late distal convoluted tubule and collecting duct
ADH
aldosterone
H2O reabsorption
Na+ reabsorption
increased stroke volume
Na+ Reabsorption (water will follow)
u/glitterysuccs

Aldosterone

- affects principle cells in the collecting duct
  1. makes Na^+/K^+ ATP synthase work harder to pump K^+ out of blood and into principle cells
  2. puts K^+ channels on apical side of principle cells to release K^+ into collecting duct
  3. puts Na^+ channels in apical side of principle cells to let Na^+ flow in from collecting duct to be moved back into the blood via Na/K^+ ATP synthase

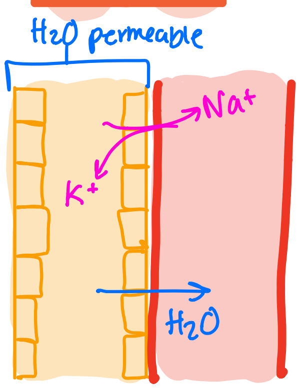
ALSO: removes acid from blood

* helps power H^+ transporter to actively transport H^+ out of the α-intercalated cell and into urine using ATP
* Na^+/H^+ antiporter uses concentration gradient of Na^+ into the cell to drive H^+ out; revved up by aldosterone.

Antidiuretic Hormone (Pituitary)

- nerve cells innervating the posterior pituitary release ADH when triggered
- Triggers include:
  1. blood too hypertonic (salty)
  2. low blood volume (less stretch in vena cava)
  3. decrease in bp (baroreceptors in carotid & atria)
  4. Angiotensin II (as part of RAAS)
- ADH interacts with collecting duct cells to make aquaporin vesicles fuse with the apical membrane to allow water to flow and to be reabsorbed from the filtrate

Aldosterone

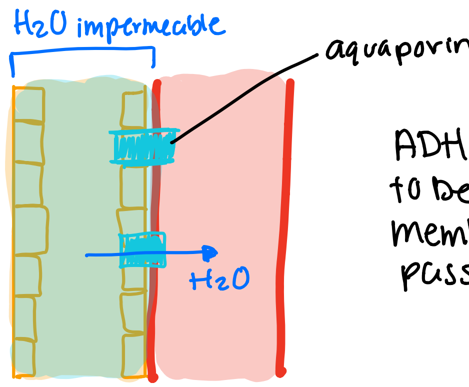


Aldosterone pulls in more water by increasing tonicity (Na^+ reabsorption)

Volume

Osmolarity (osmoles/volume)

ADH



ADH induces aquaporins to be placed in the membranes to allow passage of water

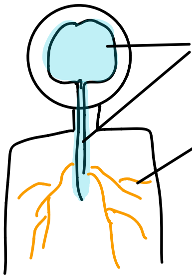
Volume

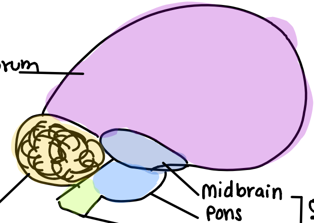
Osmolarity (osmoles/volume)

Volume ↑ $\frac{\text{Osmoles} \uparrow}{\text{Volume} \uparrow}$ ∴ osmolarity does not change	Volume ↑ $\frac{\text{osmoles}}{\text{volume} \uparrow}$ ∴ ADH affects osmolarity by decreasing it

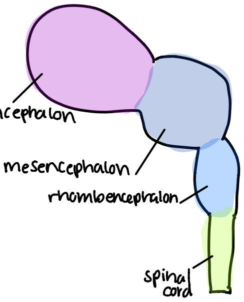
Practice: which hormone should you use if:

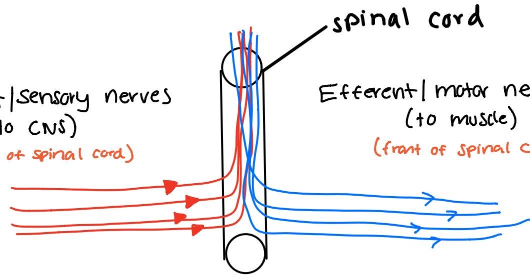
	Aldosterone	ADH
a) increase volume, maintain osmolarity	aldosterone ↑	~~ADH~~
b) increase volume, regardless of osmolarity	aldosterone ↑	ADH ↑
c) decrease osmolarity, regardless of volume	~~aldosterone~~	ADH ↑
d) decrease osmolarity, maintain volume	aldosterone ↓	ADH ↑





Embryonic Brain Development

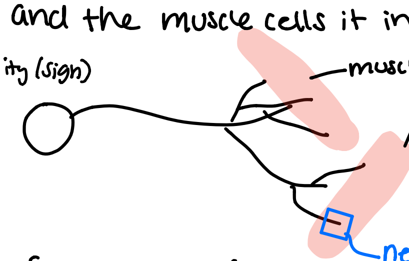




Motor unit: lower motor neurons (efferent) and the muscle cells it innervates

lower motor neuron abnormality (sign)

- muscular atrophy
- fasciculations (twitches)
- hypotonia
- hyporeflexia



Functions of the Nervous System

BASIC
- motor (skeletal muscle)
- sensory (the senses)
- automatic functions (reflexes, sweating, breathing)

HIGHER
- cognition
- emotions
- conciousness

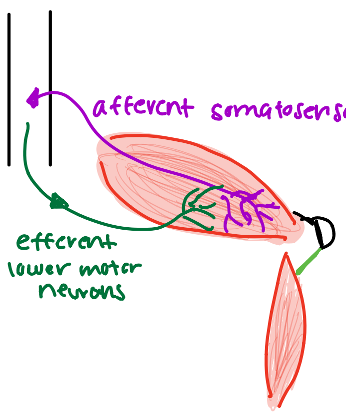
Peripheral Somatosensation

large diameter axons, highly myelinated — **FAST**
- position
- vibration
- touch

} mechanoreceptors

small diameter axons, less myelination — **SLOW**
- pain } nociceptors
- temperature } thermoreceptors

Muscle Stretch Reflex



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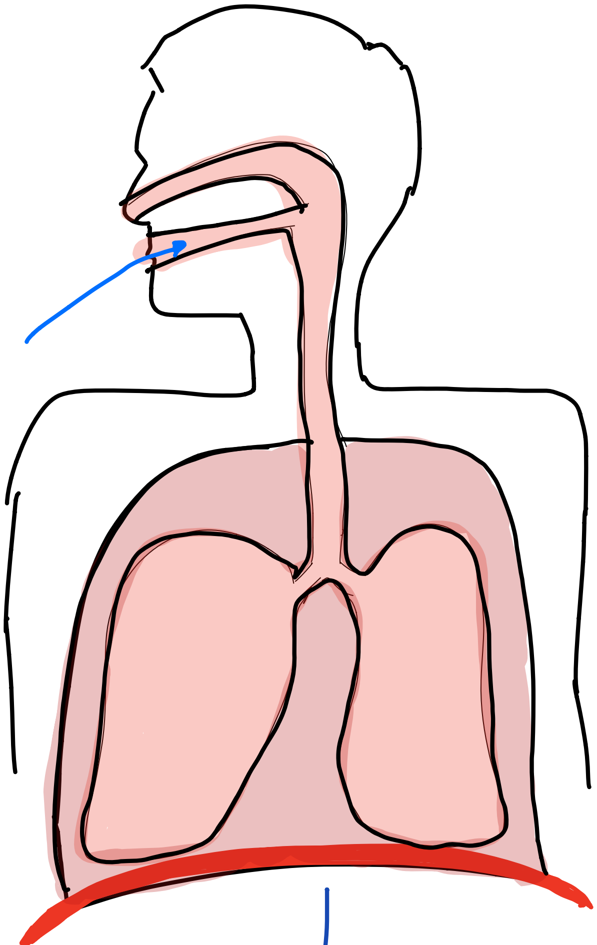
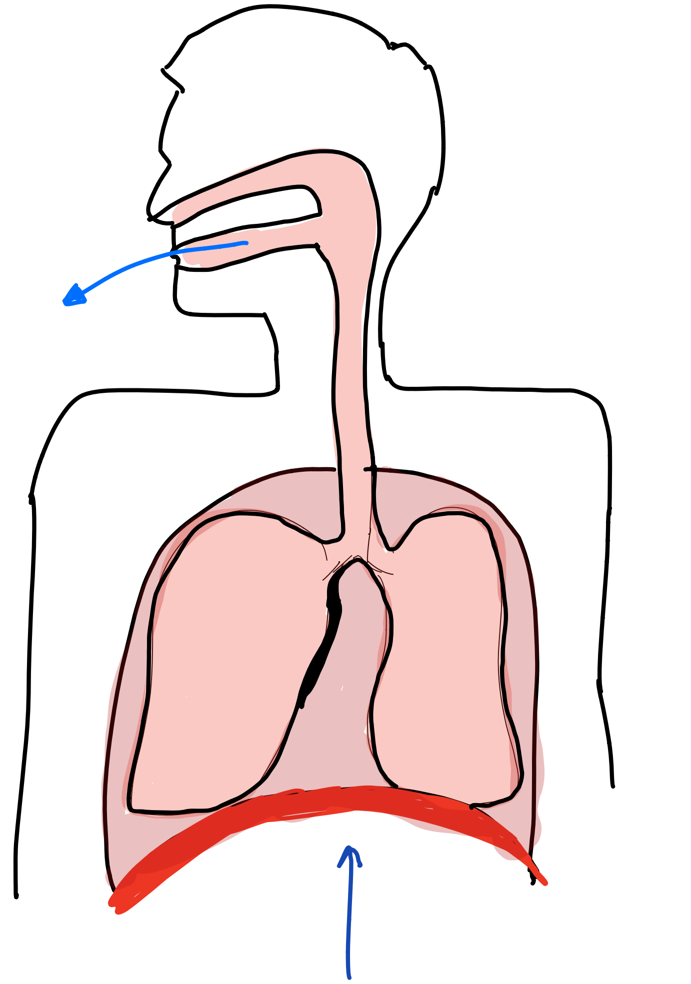


diaphragm contracts
interpleural volume increases
pressure drops
air is inspired



diaphragm relaxes
interpleural volume decreases
pressure increases
air is exhaled

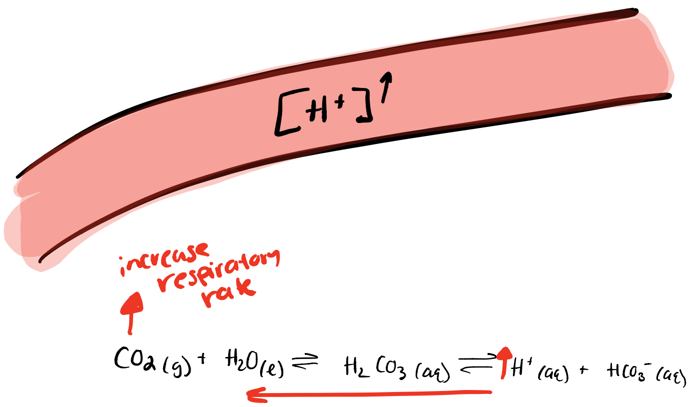
commonly tested lung volumes:

- Total Lung Capacity — max volume in lungs when one inhales completely
- Residual Volume — minimum volume of air in lungs after fully exhaling
- vital capacity — difference between maximum and minimum lung capacity (TLC−RV)
- tidal volume — the volume of air inhaled or exhaled in a single normal breath
- expiratory/inspiratory reserve volume — the volume of additional air that can be exhaled/inhaled after normal inhalation

Receptors of CO_2 partial pressure in the ventilation center of brainstem increase respiratory rate when pCO_2 is elevated.

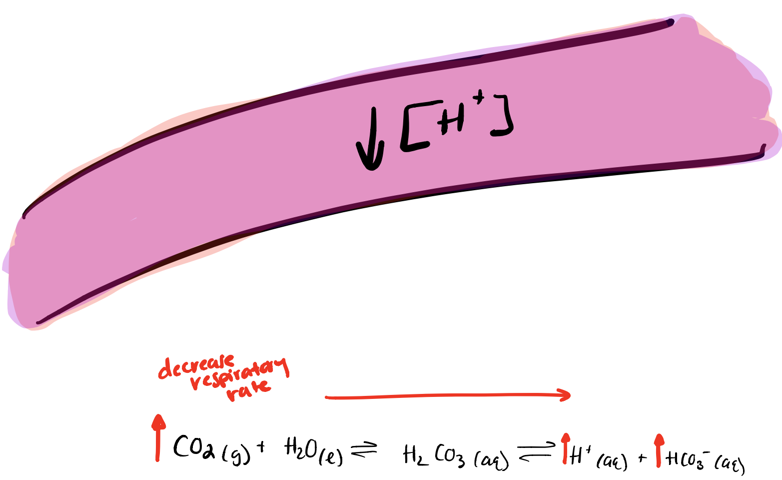
Control of pH

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$



When pH drops (Acidemia)

1. increase respiratory rate
2. more CO_2 is pushed out, shifting equation to left
3. shifting equation to the left means more H^+ are going to be bound to shift and equilibrate the lost CO_2, stabilizing $[H^+]$



When pH increases (Alkalemia)

1. decrease respiratory rate
2. retain more $[CO_2]$, shifting the equation to the right
3. shift to the right causes the dissociation of H^+, increasing the acidity back to normal

H^+ is a strong acid

HCO_3^- is a weak base

Classification of Hormones

- **peptide** – small or large; act as primary messengers; do not require carriers, short acting; do not cross cell membrane
- **steroid** – cross cell membranes; effects are slower but longer lived; must be carried by proteins such as albumin
- **amino-acid derivative** – epinephrine, norepinephrine (catecholamines → bind to GPCRs); T3, T4 (→ bind intracellularly); derived from amino acids w/ modifications.

• tropic hormones need an intermediary to act

Endocrine Organs

Hypothalamus

• secretes compounds into the hypophyseal portal system to communicate with the anterior pituitary

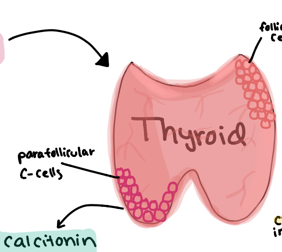
Secreted by the Hypothalamus		Secreted by the Pituitary in Response	
Gonadotropin-releasing hormone GnRH	→	↑ follicle stimulating hormone (FSH) ↑ lutenizing hormone (LH)	anterior pituitary
Growth-hormone releasing hormone GRHR	→	↑ growth hormone (GH)	anterior pituitary
Thyroid-releasing hormone TRH	→	↑ thyroid stimulating hormone (TSH)	anterior pituitary
Corticotropin-releasing factor CRF	→	↑ adenocorticotropic hormone (ACTH)	anterior pituitary
prolactin-inhibiting factor PIF	→	↓ prolactin	anterior pituitary
through nerve impulses	→	↑ oxytocin ↑ vasopressin, ADH	posterior pituitary

Thyroid Gland

major functions

① setting basal metabolic rate
② calcium homeostasis

TRH → TSH →



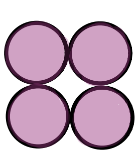
calcitonin

- acts to decrease blood Ca^{2+} levels by:
  ① increasing Ca^{2+} kidney excretion
  ② decreasing Ca^{2+} absorption from gut
  ③ increasing Ca^{2+} storage in bone
- stimulated by high blood calcium

T3 & T4

- increased concentrations of T3 and T4 increase cellular respiration
- negatively feedback to turn off TRH and TSH hormones
- deficiency is termed **hypothyroidism** – characterized by lethargy, weight gain, slowed respiratory & heart rate, and cold intolerance
  - **cretinism** in children
- excess is termed **hyperthyroidism** – heightened activity level, increased body temp, increased respiratory and heart rate, heat intolerance and weight loss

Parathyroid Gland



- produces **parathyroid hormone** (PTH)
  - ① increases bone resorption to free up Ca^{2+}
  - ② increases gut absorption of Ca^{2+}
  - ③ decreases kidney excretion of Ca^{2+}
  - activates vitamin D, which is required for the absorption of calcium in the gut

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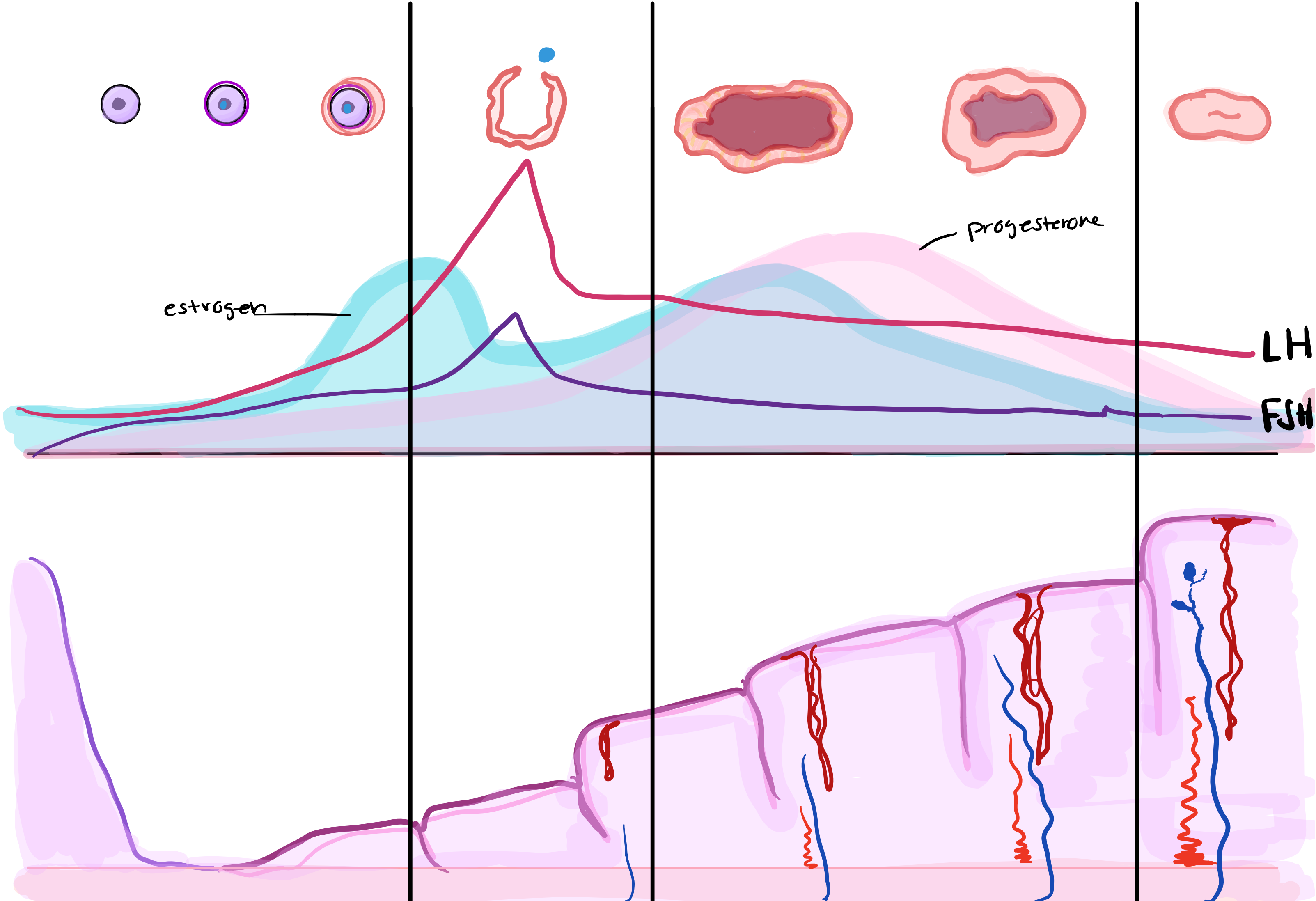
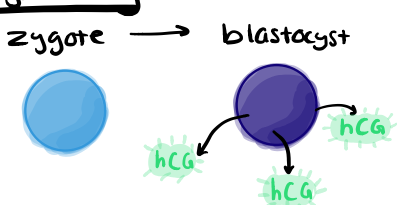


Follicular Phase	Ovulation	Luteal Phase	Menustration
① begins with menstrual flow ② GnRH levels increase in response to drop in estrogen & progesterone ③ GnRH stimulates LH and FSH production ④ Follicles begin to develop & produce estrogen ⑤ estrogen negatively feedbacks & causes GnRH, LH, and FSH to level off and stimulates endometrial growth	① increased levels of estrogen cause for a positive feedback ② GnRH, LH, and FSH levels spike ③ surge in LH triggers ovulation	① LH causes ruptured follicle to form the corpus luteum, which secrets progesterone ② Progesterone maintains endometrial lining ③ High progesterone negatively feedbacks and shuts off GnRH, LH, and FSH to prevent multiple ovulations.	① corpus luteum loses stimulation from LH ② progesterone levels decline ③ uterine lining sloughs off ④ Loss of high levels of progesterone & estrogen remove block on GnRH; GnRH stimulation restarts the cycle

Pregnancy

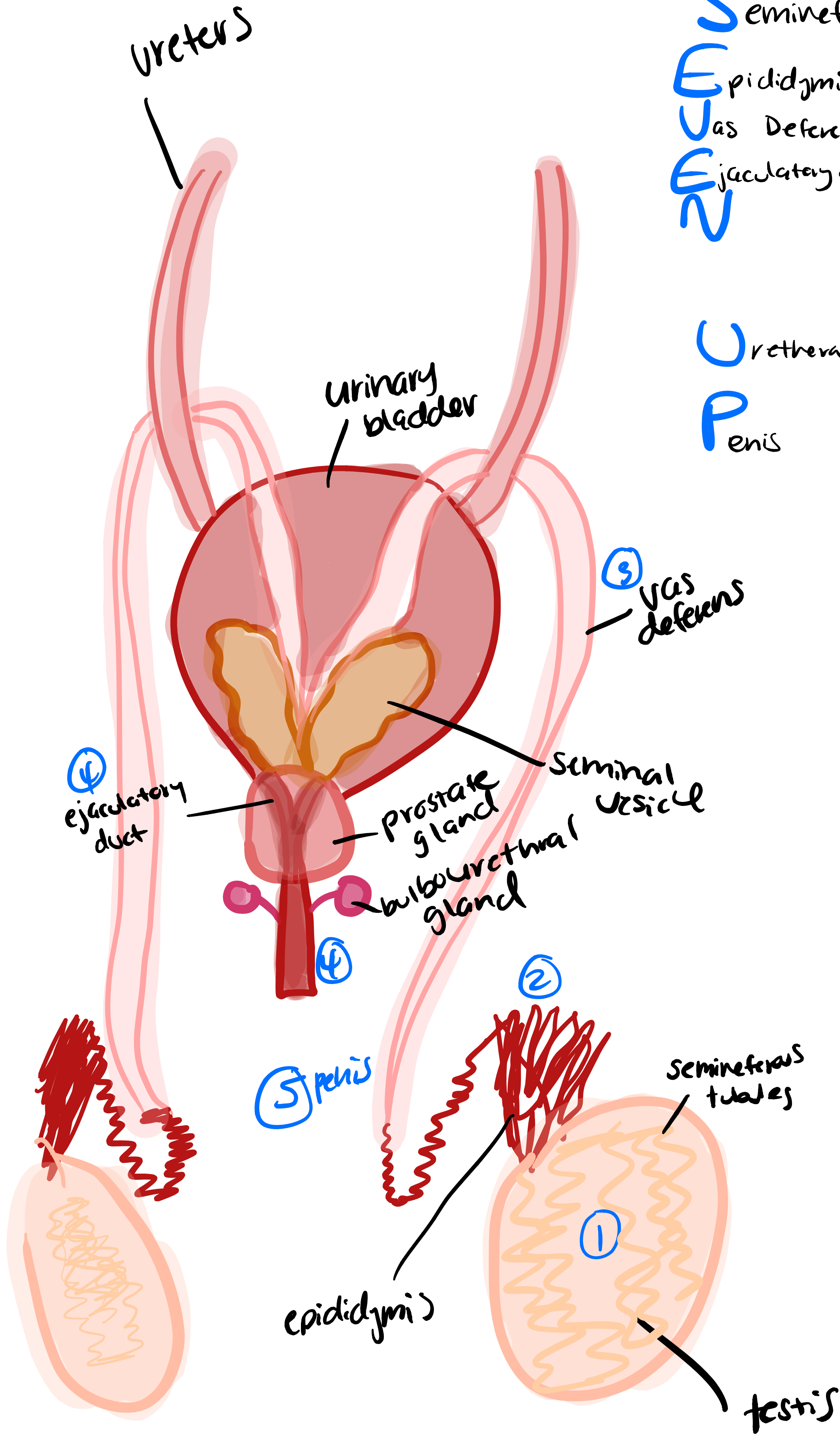


↳ human chorionic gonadotropin is an analog of LH; maintains corpus luteum to continue producing progesterone in the first trimester of pregnancy

Menopause

ovarian atrophy due to the reduced sensitivity of the ovaries to FSH and LH

the negative feedback on LH and FSH is removed, causing them to be in high concentrations in the blood



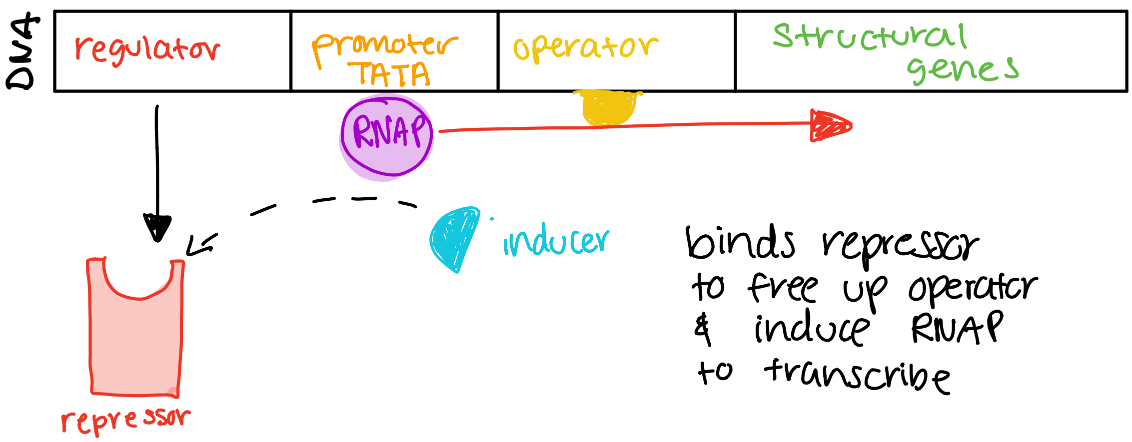
Semineferous Tubules
Epididymis
Vas Deferens
Ejaculatory duct
N

Urethra
Penis

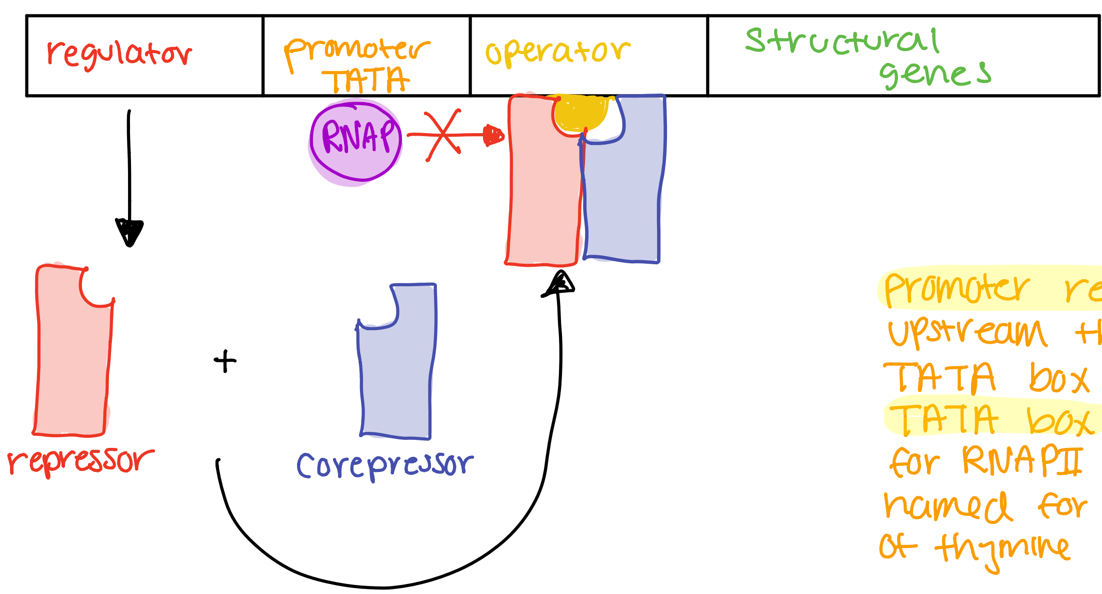
Operons – Jacobs-Monod model

Operon – cluster of genes in prokaryotes transcribed as a single mRNA

Inducible System



Repressible System



Promoter region – portion of DNA upstream the gene; contains TATA box (within 25bp of transcription start site)

TATA box – site of binding for RNAPII during transcription; named for high concentration of thymine and adenine bases

Operator site – component of operon in prokaryotes; binds repressors

Corepressor – binds with a repressor to bind the operator site to stop transcription of a gene

Enhancer – several response elements that allow for the control of one gene's expression by multiple signals (more than 25bp upstream)

Transcription factors – proteins that help RNAPII locate and bind the promoter region of DNA

Shine-Delgarno Sequence – site of initiation of translation in prokaryotes

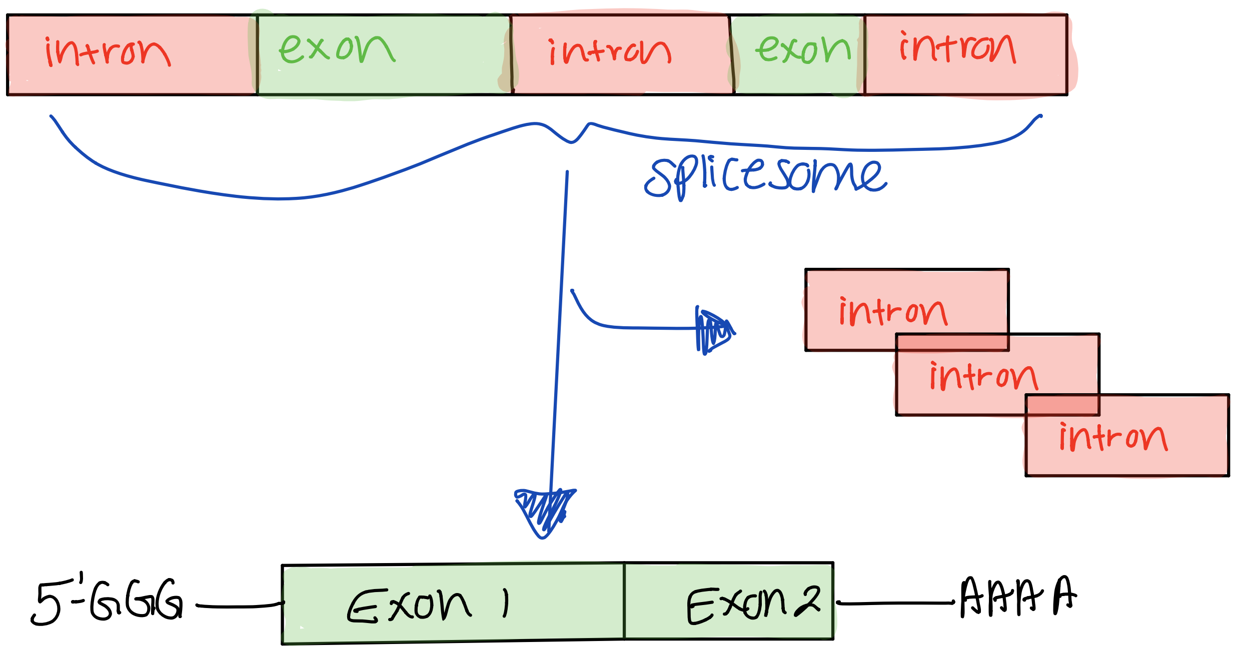
u/glitterysuccs

After Transcription to mRNA

- polycistronic — coding pattern of prokaryotes in which 1 mRNA may code for multiple proteins; needs alternative splicing
- monocistronic — coding pattern of eukaryotes in which 1 mRNA codes for only 1 protein

Hetergenous Nuclear RNA (hnRNA) — preprocessed mRNA; converted to mature mRNA by adding a 5' cap and poly-A tail & splicing out introns

- * Splicesome — apparatus used for splicing out introns and and bringing exons together during mRNA processing
- * Introns — portion of hnRNA removed by splicesome
- * exons — portion of hnRNA kept & glued together by splicesome
  - → lariat — lasso shaped structure formed during the removal of introns in mRNA processing



mature mRNA

Initiation — start of translation; small subunit of ribosome binds mRNA & first tRNA is met (AUG)

↓

Elongation — adding of amino acids to the growing chain

↓

Termination — requires a release factor, which is the protein that binds to the stop codon