8.1 - Human Body Systems and Homeostasis

Human Body Systems

- Circulatory and lymphatic transport materials
- Blood: transports nutrients and O_2, remove waste
- Lymphatic: vessels absorb fat, collect excess tissue fluid → returned to blood/circulatory
- Digestive, respiratory, excretory: add/remove substances from blood
    - excretory/urinary: removes waste, regulates fluid level + chemical content of blood
- Integumentary (skin, nails, hair, etc):
    - Communicate with brain and spinal cord (thru nerve fibres)
- Muscular and skeletal:
    - Enable movement
- Nervous system:
    - Allows body to respond to (in/ex)ternal stimuli
- Endocrine:
    - Hormonal glands secrete chemicals → messengers between cells
    - Endocrine + nervous work together to regulate functions of other systems

Homeostasis

- 37°C internal temp
- blood glucose level of 100mg/mL
- Blood pH neat 7.4
- Internal remains stable despite external
- HOMEOSTASIS: tendency of body to maintain constant internal environment
    - Humans can only survive within narrow range of conditions
- Example:
    - Blood glucose rises, endocrine brings back down
    - Skip meal, endocrine and nervous will keep glucose levels up (in normal range)

Feedback Systems

- FEEDBACK SYSTEM: cycle of events where a variable (ex. body temp) is monitored, assessed, and adjusted
    - SENSOR: monitors and detects changes → sends signals to control centre
    - CONTROL CENTRE:
        - sets range that variable should be in/maintained

        - Receives info from sensor
        - Sends signals to effectors when needed
    - EFFECTOR: responds to control centre (signals) → change to variable

Negative Feedback Systems

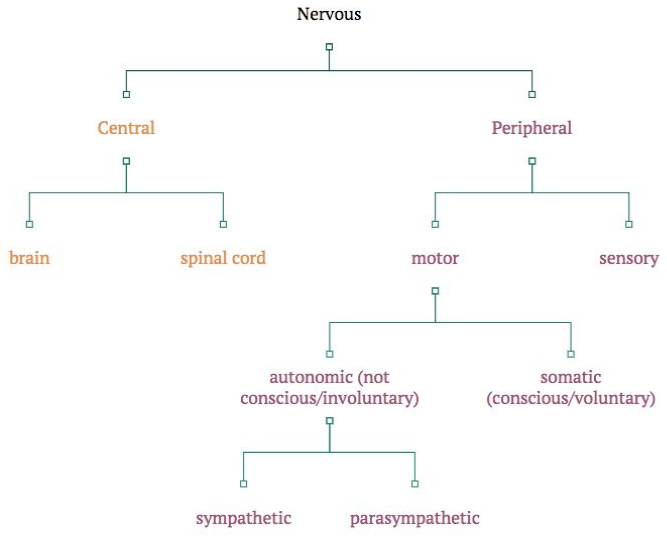
- NEGATIVE FEEDBACK SYSTEM: reverses change / variable is brought back
    - Sensor detects change → signals control centre → activates effector → change is reverserved = balanced state
- Example
    - Exercise raises blood temp (muscles produce heat)
    - Signals sent to control centre → forwards to effectors (blood vessels and sweat glands)
        - Blood vessels dilate = more heat loss
        - Sweat glands release sweat = release heat

Positive Feedback Systems

- POSITIVE FEEDBACK SYSTEM: response that increases or strengthens change in variable
    - Ex. injury → affected tissues release chemicals → activate platelets → start clotting
- Less common than negative feedback

8.2 - Nervous System

- Example:
    - temp falls below −50°C
    - Nervous system constricts blood flow (thus conserving body heat)
        - Constant constriction of blood vessels can lead to frostbite
- Nerve impulse can travel alone 10^{15} possible routes



An Overview of the Nervous System

- Distinction based on location of nervous tissue
    - Together, control sensory input, integration, and motor output
        - Sensory: temp, light, sound, pH, [CO_2]
        - Integration: signals brought together to create sensations/thoughts/memory
        - Motor: nervous system responds: muscles contract, etc
            - EFFECTORS: cause an effect in response to signals from NS (muscles, glands)
- CENTRAL NERVOUS SYSTEM:
    - Brain and spinal cord
    - Integrates and processes info sent by nerves
- PERIPHERAL NERVOUS SYSTEM:
    - Includes nerves that:
        - Carry sensory messages to central NS
        - Send info from CNS to muscles + glands
    - SOMATIC SYSTEM:
        - Sensory receptors in head and extremities
        - Voluntary control
            - Take info from CNS, send instructions to skeletal muscles
    - AUTONOMIC SYSTEM:
        - Controls gland secretions and function of smooth and cardiac muscles
        - Involuntary (heatbeat, peristalsis)
        - Sympathetic and parasympathetic work oppositely to each other in order to regulate involuntary processes

Cells of the Nervous System

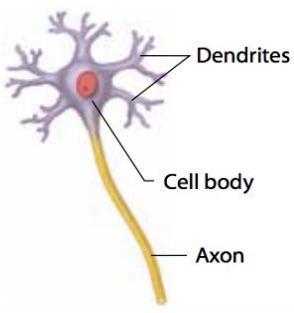
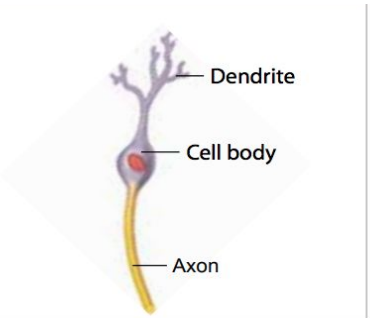
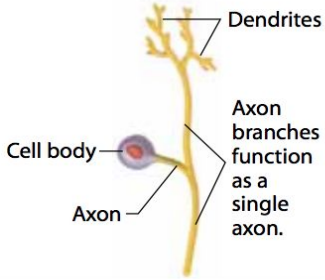
- 2 types:
    - NEURONS:
        - Basic structural and functional units
            - Nucleus, cell body, dendrites, cell body
        - Specialized to:
            - respond to physical and chemical stimuli
            - Conduct electrochemical signals
            - Release chemicals that regulate processes
        - Bundles → NERVES: message pathway. Surrounded by protective connective tissue
    - GLIAL CELLS:
        - Support neurons
            - Nourish, remove waste, defend against infection
        - Provides framework for all tissue in the nervous system

The Structure of a Neuron

- Neurons have cell membrane, cytoplasm, mitochondria, nucleus
- DENDRITES:
    - Short, branching terminals
    - Receive impulses from neurons or sensory receptors
    - Relay impulse to cell body
- CELL BODY:
    - Contains nucleus
    - Processes input from dendrites
        - If large enough, cell body relays to axon (impulse will be initiated)
- AXON:
    - Conducts impulses away from cell body
    - Terminal end branches into fibres
    - Releases chemical signals into space between it and receptors/dendrites of neighboring neurons/glands/muscles
    - Sometimes enclosed in MYELIN SHEATH:
        - Fatty, insulated layer
            - Gives glistening white appearance
        - Protects neurons and speeds up rate of transmission (nerve impulses)
            - Impulses jump from one node to the next
        - Made of schwann cells → type of glial cell
        - NODES OF RANVIER: areas b/w myelin sheath

Classifying Neurons

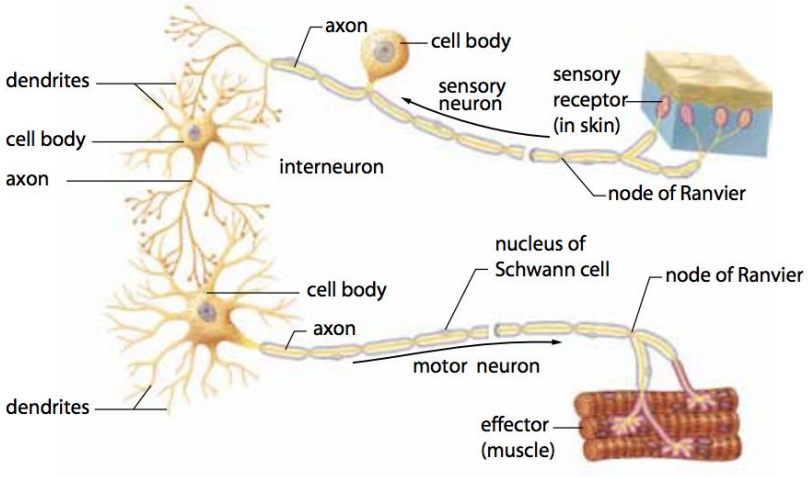
- Based on structure and function
    - Structure: number of processes extending from cell body

Multipolar	Bipolar	Unipolar
		
- Several dendrites - One axon - In brain & spinal cord	- One main dendrite - One axon - Inner ear, retina, olfactory area of brain	- Single process extending from cell body - Dendrite + axon fused - Peripheral nervous system

- Function:
    - Sensory, interneuron, and motor form basic impulse-transmission pathway
    - Depends on 3 overlapping functions:
        - Sensory input:
            - sensory receptors receive stimuli → form nerve impulse
            - Sensory neurons transmit the impulse from receptor → CNS
        - Integration:
            - Interneurons process and integrate sensory info coming in → relay motor info going out
        - Motor output:
            - Motor neurons transmit info from CNS → effectors
                - Muscles, glands, organs (that respond to motor neuron impulses)

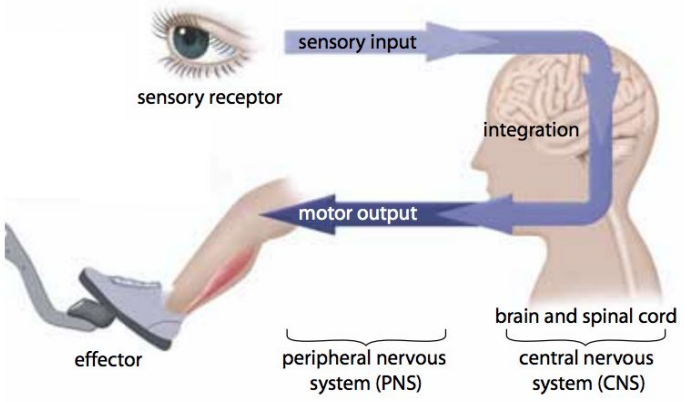
↙Sensory ↘

Integration →



↑ ↑
Motor

Sensory neurons



Inter-neurons

Motor neurons + effectors

The Reflex Arc

- REFLEXES: involuntary responses to certain stimuli
- REFLEX ARCS: simple connection of neurons → reflex action (response to stimulus)
    - Usually only involve 3 neurons (sensory, inter, motor)
    - Before brain centres involved with voluntary stuff have time to process

Neuron Repair

- NEURILEMMA: thin membrane surrounded axon
    - Promotes regeneration of damaged axons
    - Not in all nerve cells
- White matter:
    - Nerve cells in brain
    - Contain myelinated fibres + neurilemma
- Grey matter:
    - Nerve cells in brain and spinal cord
    - No myelin sheath or neurilemma
    - This is why spinal and brain injuries are often permanent

Fixing CNS Damage

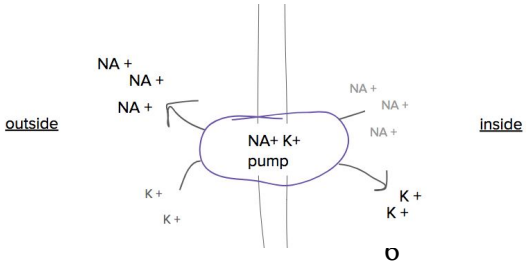
- Reattach 2 torn nerves (low success)
- Take graphs from the PNS

The Electrical Nature of Nerves (Electrochemical Impulse)

- Nerve impulses are similar to electric
    - Slightly slower, but stay the same strength throughout
    - Electrochemical msgs made by ion movement across nerve cell membrane
    - Nerve cell membrane is permeable to ions
    - Ions move across membrane to create electrical chemical potential
- Example:
    - Tiny electroe in squid's large nerve cell
    - Nerve was excited → fast change in electric potential
        - - 70 mV → + 40 mV
        - ACTION POTENTIAL (travels across neuron/ dendrite → axon)

Resting Membrane Potential

- In resting neuron, the neuron is more positive outside than inside (polarized)
    - Sodium potassium pump uses ATP to put 3 NA+ out and 2 K+ in
    - Negative ions don't diffuse out (large, can't get through membrane)
- MEMBRANE POTENTIAL: separation of electrical charge across a membrane
- RESTING POTENTIAL: charge difference b/w outside and inside of neuron
    - Again, polarized at rest



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Action Potential

- Dendrites receive impulse → change in membrane permeability
    - Depolarization: Na+ diffuse into neuron thru sodium channels
        - Moves as a wave thru neuron

cHaRgE

- Electrochemical event is cause of imbalance of positive ions across membrane
- High concentration of K+ ions in cell tende to diffuse out
    - As this happens, Na+ diffuses in
- Resting membrane is approx. 50x more permeable to K+ than Na+
    - More K+ diffuse out than Na+ in, making outside more positive

eXciTemEnt

- When cell is excited, membrane becomes more permeable to Na+ than K+
    - Opposite of resting
    - Na+ gates open, K+ gates close
    - Rapid flow of Na+ into cell (depolarization/making inside more positive and outside less)
    - Once inside becomes positive, sodium gates close
- Sodium-potassium pump restores resting membrane (3 Na+ out, 2 K+ in)
    - REPOLARIZATION requires ATP
        - Happens once action potential has peaked (refractory period starts)
- Refractory period:
    - neurons can't transmit impulses (1-10 ms)
        - Gotta wait til resting is restored.
    - The spike in voltage caused K+ pumps to open → K+ move out
        - So many move out that charge goes below resting. Neuron can't react to stimuli during undershoot

Movement

- Impulse moves along axon b/c positive ions that rushed into cell during depolarization are attracted to negative ions in adjacent regions
- Current moves in one direction cause one side is in refractory period
    - *Impulse moves from dendrite → axon*

Threshold Levels

- THRESHOLD LEVEL: min. level of stimulus needed to produce response
    - All or nothing
- More intense stimulus means greater frequency of impulses
    - not increased response. Intensity and speed of transmissions stay they same. Fire at max. or not at all

Synaptic Transmission

- SYNAPSES: small spaces b/w neurons or b/w neurons and effector (ex. muscle)
- Impulses move along axons and release neurotransmitters from the end plate
    - NEUROTRANSMITTERS: small vesicles containing chemicals. Found in end plate

Neurotransmitters

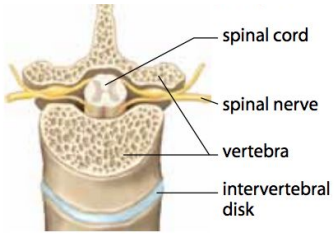
- Chemicals produced in neuron, released when neuron's stimulated, creates an effect on other neurons
- 2 types: small molecule, neuropeptides
- SYNAPTIC CLEFT: space b/w neurons (presynaptic/where impulse is coming from, postsynaptic/where the signal's going)
- Neurotransmitters are released → diffuse through synaptic cleft → received → cause dendrites to depolarize
- Slows down transmission, so more synapses = slower speed
- Example:
    - Acetylcholine is an excitatory neurotransmitter
        - Opens sodium channels on postsynaptic neuron
    - Once postsynaptic neuron has reached action potential, cholinesterase breaks down acetylcholine (sodium channels will close)
- Inhibitory neurotransmitters open potassium channels
    - Potassium diffuses out cause its highly concentrated inside
    - Causes hyperpolarization and inside becomes negative
    - Prevents the activation of postsynaptic neuron

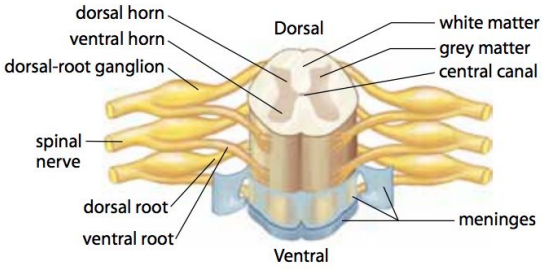
8.2 - Central Nervous System

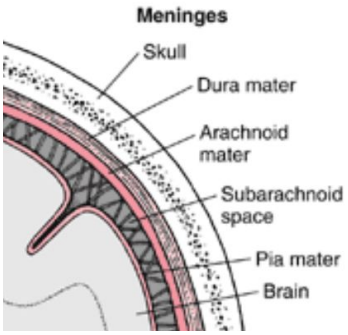
- Brain and spinal cord
- Receives info from sensory/afferent neurons, evaluates it, initiates response through efferent neurons
- White matter:
    - Inner region of some places in brain, outer area of spinal cord
    - Made of myelinated neurons
- Grey matter:
    - Outside areas of brain, core of spinal cord
    - Unmyelinated

Spinal Cord

- SPINAL CORD: column of nerve tissue ending out of skull (from brain) and down the canal in backbone
- Link b/w the brain and PNS
- In spinal cord, afferent/sensory nerves carry msgs from body → brain to interpret
- Efferent nerves relay msg from brain → effectors
- Contains primary reflex centre
- Grey matter is surrounded by white
- sensory/afferent nerves enter spinal cord through dorsal root
- Efferent nerves leave through ventral root
    - Carries info from spinal cord to peripheral muscles, organs, glands







- Spinal cord tissue is protected
    - Cerebrospinal fluid, meninges, spinal column
    - MENINGES: 3 layers of tough, elastic tissue in skull and spinal column
        - Directly encloses brain and spinal cord
        - Dura mater: tough outer membrane attached to skull
        - Arachnoid: web-like middle layer. Reabsorbs cerebrospinal fluid
        - Pia mater: inner layer containing blood vessels. Closely covers brain and spinal cord

Blood-Brain Barrier

- BLOOD-BRAIN BARRIER: protective barrier of glial cells and blood vessels
    - Separates blood from CNS
- Prevents substances in blood from entering cerebrospinal fluid
    - Protects brain (blocks toxins, etc.)
- Supplies brain with nutrients and O_2
- Caffeine, nicotine, alcohol, anesthetics cross barrier

Cerebrospinal Fluid (CSF)

- Dense, clear liquid
- Derived from blood plasma
- Found in: ventricles of brain, central canal (spinal cord), around meninges
    - Between 2 meninges layers – arachnoid and pia mater (shock absorber)

- Transports hormones, white blood cells, and nutrients across b-b barrier

The Brain

Hindbrain

- Coordination + homeostasis
- Cerebellum
    - Unconscious coordination (movements + reflex)
    - Fine, voluntary motor skills (bike, write)
    - Damage → lose coordination of motor movements
- Medulla oblongata
    - Base of brainstem, connecting brain to spinal cord
    - Coordinates reflexes and automatic functions (that maintain homeostasis)
        - Heart rate, constriction/dilation of blood vessels, breathing, swallow, cough, sneeze
- Pons (bridge)
    - Above and in front of medulla oblongata
    - Bridge b/w neurons in left and right halves of cerebrum, cerebellum, and rest of brain

Midbrain

- Process sensory input
- Above pons in brainstem
- Processes info from sensory neurons (eyes, ears, nose)
    - Relays visual and auditory info b/w hindbrain and forebrain
- Important in eye movement and skeletal muscle control

Forebrain

- Thought, learning, emotion
- Thalamus
    - Connects parts of brain
        - Mainly fore and hindbrain, areas of sensory (minus smell) and cerebellum
- Hypothalamus
    - Regulates internal environment
        - Temp, blood pressure, heart rate, thirst, hunger, sleep, water balance
    - Regulates emotions
    - Link b/w nervous and endocrine
    - Coordinates hormone production
    - Damage → violent behaviour
- Cerebrum
    - higher thought process, learning, memory, consciousness, speech
    - Interprets sensory info, coordinates voluntary motor responses
    - Outer surface (cerebral cortex)

        - Thin outer covering (grey matter)
        - thinking and feeling: language, memory, personality, vision, conscious thought, other stuff
    - Inner surface
        - White matter
    - Linked by corpus callosum (white matter)
    - Right side of brain controls left, left controls right
    - Right side: intuitive thinking, visual-spatial, creativity, art
    - Left side: logical thinking, language, math

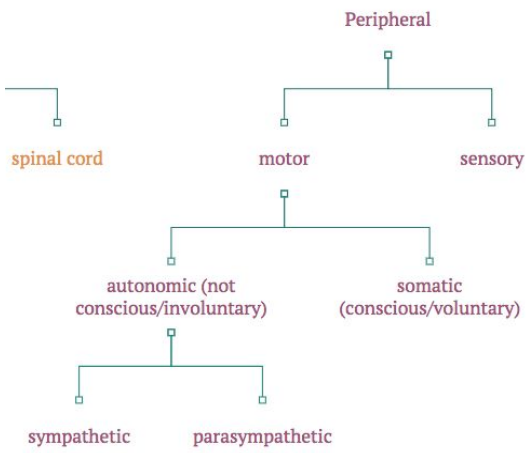
Cerebral Cortex

- Frontal lobe
    - Reasoning, critical thinking, memory, personality
    - Primary motor area (coordinates responses)
    - Nerves from either side cross over in brainstem (controls opposite side)
- Parietal lobe
    - Primary somatosensory and taste area
    - High concentration of sensory receptors in face, hands, genitals
    - Processes info about body's position
- Temporal lobe
    - Primary auditory area
    - Process visual info
    - Understanding speech
    - Accessing verbal and visual memories
- Occipital lobe
    - Primary visual
    - Analyzes visual info
    - Object recognition

8.2 - Central Nervous System

The Autonomic System

- Controls:
    - involuntary gland secretions
    - Smooth and cardiac muscles
- Adjusts body without thinking
- Controlled by hypothalamus and medulla oblongata



Sympathetic Nervous System

- Activated in stressful situations
    - Fight-or-flight
- Sympathetic neurons and adrenal glands release epinephrine and norepinephrine
    - Excitatory neurotransmitters
    - Activate stress response (increased heart rate and blood pressure, decreased digestion)

Parasympathetic Nervous System

- Activated when body is calm
- Conserves energy
    - Rest-and-digest
- Neurotransmitter acetylcholine
    - Reduces heart rate and blood pressure, increased digestion
- Both branches work in opposition to balance reactions and maintain homeostasis

10.1 - Excretory System

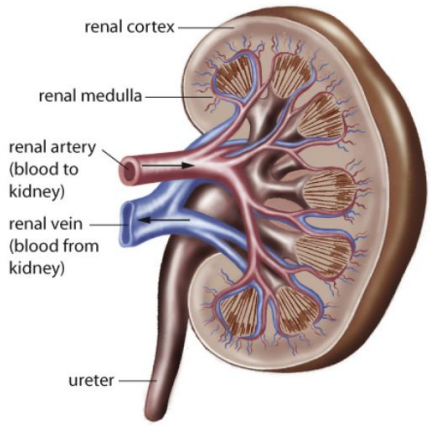
- Waste must be removed from body to maintain life processes
    - Liver transforms toxins and products of protein metabolism
    - Kidneys remove waste, baland blood pH and maintain water balance
- Excretion in unicellular organisms
    - Water moves directly out of cell
- Excretion in multicellular organisms
    - EXCRETION: separate waste from body fluids and eliminate from body
- 4 main functions:
    - Excretion of metabolic wastes
        - Nitrogenous ammonia, urea, uric acid
    - Maintain water-salt balance. Regulates blood pressure (K^+, Ca^{2+})
    - Maintain acid-base balance. Regulates blood pH (around 7.4) and urine pH (around 6. Excretes H^+ to absorb HCO_3^-)
- Excess protein is converted into carbs
    - DEAMINATION: breaking of amino acids and removal of amino group
        - Occurs in liver
        - Ammonia is byproduct
            - Combines with CO_2, making urea
        - Uric acid is formed during breakdown
        - Ammonia, urea, and uric acid are removed by kidneys
- Generally, liver removes/breaks down waste in blood. Then kidneys filter blood and sends waste to bladder

Releasing Hormones (kidneys)

- Erythropoietin
    - Released when O_2 is needed
    - Stimulates production of RBC in bone marrow
- Calcitriol
    - Released when calcium levels in blood are low
    - Promotes Ca^+ absorption from digestive tract

Kidneys

- 2 major blood vessels
    - Renal artery: delivers blood to kidney
    - Renal vein: drains blood from kidney
- 3 regions
    - Renal cortex/outer layer
        - Bowman's capsule (efferent/blood out + afferent/blood in arterioles)
    - Renal medulla/inner layer (cone shaped tissue)
        - Loop of Henle descends into this
    - Renal pelvis/central space (continuous with ureter)



10.2 - Urine Formation in the Nephron

- Nephron expels unneeded or harmful substances, and reabsorbs useful substances
- 120 mL of fluid is filtered by kidney each min. 1 mL of urine is formed, 119 is reabsorbed
- Urine's formed by:
    - Filtration of blood
    - Reabsorption into blood
    - Secretion from blood

Filtration

- Glomerulus and bowman's capsule are involved
- 4x pressure in glomerulus than capillary bed
- Blood from afferent arteriole → glomerulus (high pressure filter)
- Solutes (water, NaCl, H^+) pass into bowman's capsule
    - Large molecules don't (protein, blood cells, platelets)

Reabsorption

- Involves active and passive transport (selective reabsorption)
- Carriers:
    - move Na^+ across membranes, and negative ions follow
    - Glucose + amino acids, move nephron → blood
- Reabsorption continues til threshold is reached
- Excess salt stays in nephron and excreted w/ urine
- Active transport: solutes move out of nephron and create osmotic gradient (draw water from nephron)
    - Proteins remain in blood and draws water in from interstitial fluid
        - This makes solute more concentrated, so urea and uric acid move out into blood too (but ultimately less than original)

Tubular Reabsorption (Loop of Henle)

- Descending: water moves into capillary through osmosis and solute diffuse into nephron
- Ascending: thin segment. Nephron is impermeable to water and solute diffuse out and into the capillary
- Ascending: thick segment. Na^+ is transported to capillaries through active, making filtrate less concentrated
    - By now, 2/3 of Na^+ and water in filtrate has been absorbed into capillaries

Secretion

- Occurs in proximal and distal tube
- Waste from blood moves into nephron
    - Nitrogen containing
    - Excess H^+ and K^+ are actively moved from blood to distal tubule to maintain blood pH
    - Other unnecessary substances (antibiotics and other meds) are moved into distal tube as well
    - Water movement is controlled by hormones
- Distal tubule is lined with mitochondria loaded cells
    - Mitochondria is needed cause the tubular secretion is done by active transport
        - K+ and H+ moved from blood to distal tubule (pH of blood)
    - Any substances (meds) body doesnt need are moved out of blood into distal tubule
        - Controlled by hormones
- Filtrate that ends up in collecting duct has lots of water
    - Surrounded by salty environment, so water is passively reabsorbed out of the filtrate into the blood
    - Controlled by hormones
    - Filtrate is 4x more concentrated, leaving 1% of original filtrate (urine)

Summary

Glomerulus/Bowman's capsule:

- Fluid from blood → Bowman's/nephron
- 4x normal blood pressure to force blood plasma thru glomerulus walls into Bowman
    - Water, NaCl, glucose, amino acid, H+

Proximal tubule:

- Essential solutes and water is reabsorbed into bloodstream
    - Passive: water and K+
    - Active: NaCl (Na+ and Cl- follow), bicarbonate, glucose, amino acids
    - Movement of solute creates osmotic gradient (less solute, more water)

Descending Loop of Henle:

- Water moves out with concentration gradient
    - Salt is concentrated at the bottom of the loop

Ascending loop:

- Thin portion is permeable for salt (leaves w/ concentration gradient)
- Thick portion: salt continues to leave through active transport

Distal Tube:

- Stuff move out of nephron → blood (bicarbonate for pH adjustment)
    - Water moves out too cause gradient
- Drugs and poisons removed from blood

Collecting duct:

- Urine releases toxins
- Maintain body's electrolyte and acid-base balance

Kidney stone: hard mass made of crystals that separate from urine. Don't normally from cause there's inhibitors in urine. Commonly contains calcium + oxalate/phosphate

10.3 - Functions and Disorders of Excretory System

Urinary Tract Infections

- More common in females cause urethra is closer to anus
- Symptoms:
    - painful burning during urination

    - Frequent need to pee
    - Bloody or brown urine
- Infections more serious when it reaches kidneys cause it can cause kidney failure
- Prevention: hygiene and hydration

Kidney Stones

- Crystal formations (common in kidneys)
- Result of excess calcium in pee
- Causes of calcium: urinary tract infections, chronic dehydration, low activity
- Some pass through urinary tract, others need meds to break down calcium crystals. Large stones need surgical removal

Renal Insufficiency

- Kidneys can't maintain homeostasis b/c of nephron damage
- Causes:
    - Kidney infection
    - High blood pressure (main)
    - Polycystic kidney disease (genetic)
    - Trauma to surrounding area
    - Poison from heavy metals (mercury, lead)
    - Atherosclerosis (reduced blood flow to kidney)
    - Tubule blockage
- Homeostasis can't be maintained if more than 75% of nephrons are destroyed
    - Kidney transplant

Dialysis

- DIALYSIS: dissolved substances diffuse thru semipermeable membrane
    - From high to low concentration
    - Used to remove waste and excess fluid from blood in kidney failure
- HEMODIALYSIS: kidney dialysis that uses artificial membrane in external device
    - Connected to artery and vein (arm) to filter blood/remove waste + fluid
- PERITONEAL DIALYSIS: kidney dialysis using lining of intestines as dialysis membrane

Kidney Transplants

- Transplant is needed if kidney is under 10% functional
- Success rate is 95-98%

Urinalysis (evaluate kidney function)

- Urine composition reflects the water and solutes kidneys must remove or keep to maintain homeostasis
    - Urinalysis checks for health and kidney function

- Urine should not contain:
    - Acetone and ketones
    - albumin/protein
    - Bilirubin
    - Glucose
- Can have:
    - Calcium (less than 150 mg/day)
    - Urea (25-30g/day)
    - Uric acid (0.5-1g/day)

Blood Test

- Lots of urea nitrogen in blood → kidneys not functioning properly (usually taken out)
- Lots of creatinine (waste from muscles) → kidneys not filtering blood properly

9.1 - Glands and Hormones of the Endocrine System

- Homeostasis depends on nervous and endocrine together (feedback loops)
    - hypothalamus: structure in nervous system that secretes hormones
    - Epinephrine is neurotransmitter and hormone
    - Suckling baby → sensory msg (thru neurons) → signals hypothalamus to ask posterior pituitary to release oxytocin → milk secretion

- HORMONES: chemical regulators produced in one area, and affects another
    - Over 200 in body

Endocrine Glands

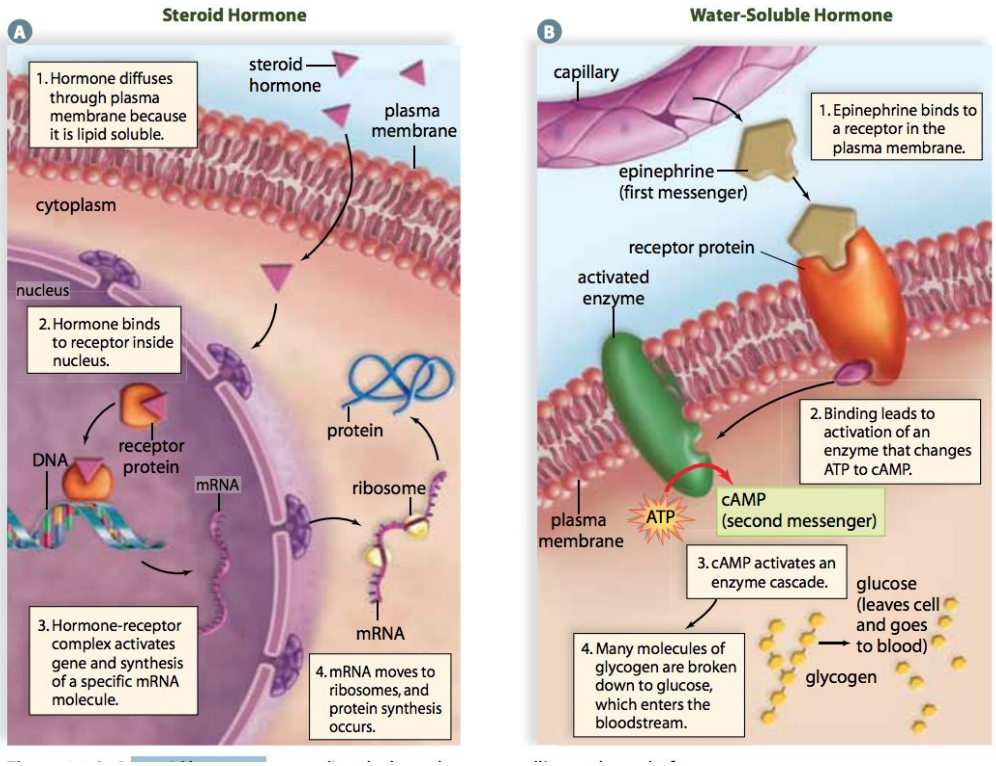
- ENDOCRINE GLANDS: secrete hormone straight into bloodstream
    - Endocrine hormones
        - Non-target: affect different cells in body (insulin, growth, epinephrine)
        - Target: affect specific cells/tissues (parathyroid, gastrin)
- Carried by circulatory through body
- function exclusively as endocrine glands:
    - Pituitary
    - Pineal
    - Thyroid
    - Parathyroid
    - Adrenal
- tissues/organs that secrete hormones but also do other stuff:
    - Hypothalamus
    - Thymus
    - pancreas

Chemical Control

- Endocrine is long term control, nervous is short term
- Hypothalamus regulates pituitary gland
    - posterior with nerves
    - Anterior with hormones
- Pituitary gets other glands to release hormones
- Hormones only affect cells that have the right receptor

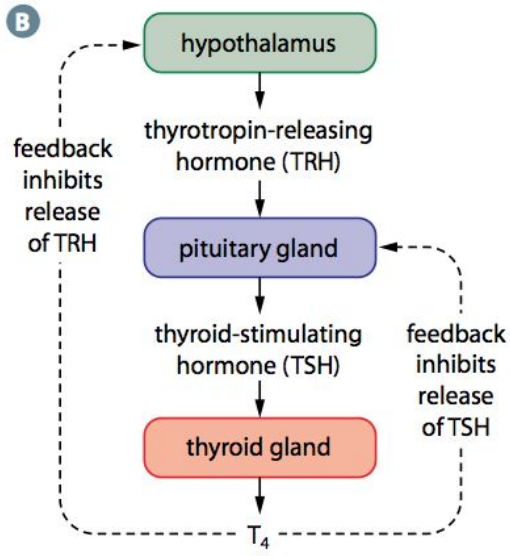
Types of Hormones

- STEROID HORMONES: cholesterol → fat soluble
    - Passes thru membrane of target cell and binds to receptor inside (in cytoplasm)
    - induce or suppress expression of genes
- PROTEIN HORMONES: made of amino acids → water soluble
    - Ex. epinephrine (adrenaline), human growth hormone (hGH somatotropin), insulin
    - Bind to receptors outside membrane
    - Starts signal transduction pathway
        - Usually hormone → receptor → activates G protein → binds to/activates enzyme (adenylyl cyclase) → catalyzes ATP → cyclic AMP → cascade activated



Regulation

- Receive signal from body's sensors → hypothalamus secretes (releasing) hormones into anterior pituitary→ anterior pituitary releases hormones into bloodstream → act on other endocrine gland → hormone released in blood → travels to target tissue
- Controlled by negative feedback:
    - Third hormone prevents release of the first 2
    - Ex. thyroid-stimulating hormone (TSH):
        - Low T_4 in blood → response in hypothalamus
        - Hypothalamus → TRH → pituitary → TSH → thyroid → T4
        - Increase in T4 inhibits first 2 hormones
- TROPIC HORMONES: targets endocrine glands and makes them release other hormones



9.2 - Hormonal Regulation of Growth, Development, and Metabolism

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Pituitary Gland

- Connected to hypothalamus
- Posterior (stores hormones) and anterior (produces hormones) lobe
    - Posterior stores and releases ADH and oxytocin made by hypothalamus
    - Anterior is connected to a portal system (blood vessels connect to hypothalamus, where secreted hormone stimulates or inhibits anterior hormone production)
- Controls endocrine glands using tropic hormones
- Regulates growth

Human Growth Hormone (hGH)

- Regulates growth, development, metabolism

- Affects loads of tissues
- Increases: protein synthesis, cell division + growth, breakdown and release of fats in adipose tissue

Thyroid Gland

- Secretes hormones that regulate metabolic rate
- Require iodine
    - Not enough: T_4 (3rd hormone) can't be made, no signal to stop TSH (2nd)
- Secretes T_4 (thyroxine), which increases metabolism rate of fat, protein, carb (energy)
    - Low production is hypothyroidism → cretinism
        - Symptoms: stocky + shorter, mental developmental delays, fatigue, weight gain
        - Treatment: hormone injections
    - Overproduction is hyperthyroidism
        - Symptoms: anxiety, insomnia, weight loss, grave's disease (immune system attacks thyroid)
        - Treatment: meds or removal or part of thyroid
- Secretion has negative feedback, controlled by TSH, second hormone
- GOITRE: thyroid gland constantly stimulated by TSH, but deficiency of iodine means thyroxine can't synthesize and create negative feedback → enlargement of thyroid gland

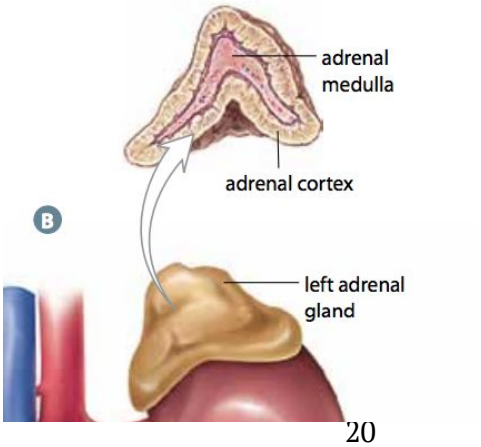
Calcium Homeostasis

- Needed for nerve conduction, muscle contraction, skeletal development, healthy teeth
- Ca level in blood regulated by negative feedback (calcitonin if too much, parathyroid hormone PTH if too little)
- Example:
    - Ca levels high in blood → thyroid gland makes calcitonin → bones take Ca
    - Ca level low → parathyroid gland releases PTH → bones break down and make Ca for blood → PTH also asks kidneys to reabsorb Ca from urine (activate vitamin D → absorption of Ca from digestive)

9.3 - Hormone Regulation of Stress Response and Blood Sugar

Adrenal Glands

- Above kidney
- Regulate carb and salt usage (prep body for emergency)
- 2 adrenal glands: adrenal medulla surrounded by adrenal cortex
- ADRENAL MEDULLA: produces epinephrine (adrenaline) and norepinephrine (noradrenaline)
    - Fight or flight (short-term response)



    - Neurons from sympathetic carry msg from hypothalamus → adrenal medulla
    - Response lasts 10x longer than nervous response
- ADRENAL CORTEX: produce glucocorticoids (increase blood sugar), mineralocorticoids (increase blood pressure) and sex hormones (androgens)
    - Long term response
    - Hypothalamus secretes hormone → stimulates anterior pituitary → secretes ACTH → adrenal cortex secretes cortisol
        - Too much cortisol → impair thinking, damage heart, early death
    - Damage → Addison's disease
        - Result: not enough glucocorticoid + mineralocorticoid
        - Low blood sugar, Na and K imbalance, weight loss

Pancreas

- ISLETS OF LANGERHANS: endocrine cells in pancreas
    - Alpha cells produce glucagon (raise blood glucose levels. Glycogen → glucose)
    - Beta cells produce insulin (blood glucose decrease cause cells more permeable)

Diabetes

- Death, blindness, kidney failure, nerve damage, limb amputation
- Not enough insulin (production or use)
- HYPERGLYCEMIA: blood glucose rise b/c no insulin
    - Kidneys can't reabsorb all the glucose so it ends up in urine
    - b/c of glucose in urine, water follows making them thirsty and pee a lot
- Type I:
    - Pancreas cant produce insulin cause beta cells (in islets of langerhans) degraded early on
    - Gotta take insulin to live
- Type II:
    - Decreased insulin production, ineffective use of what it does produce
    - Usually in adults
    - Control with diet, exercise, oral drugs (stimulate islets of langerhans)
- DIABETES MELLITUS: body doesn't produce enough insulin/doesn't respond properly to insulin. Sharp rise in blood-glucose after meals and stays at high level.