CHAPTER 1 MOLECULAR BIOLOGY; CELLULAR RESPIRATION

1.2 Water

Hydrolysis: Addition of H_2O to a bond to break it apart. Most macromolecules use this process to dissemble.

Dehydration: Removal of H_2O to a bond to form it. Most macromolecules use this process to assemble.

1.3 Lipids

Any biological molecules that is hydrophobic.

E.G.:

- Fatty acids: building blocks for most complex lipids. $CH_3(CH_2)_nCOOH$
- Triglycerides: 3 fatty acid + glycerol. Energy storage.
- Phospholipids: Triglyceride with one fatty acid replaced by phosphate group. Cell membrane
- Glycolipids: Same as phospholipids except phosphate group replaced by one or more carbohydrate. Found in membranes of myelinated cells of the nervous system
- Steroids: 4 ringed structure. Hormones, vitamin D, cholesterol
- Terpenes: Vitamin A for vision.

Transported via lipoproteins. E.G. Chylomicrons, VLDL, LDL, HDL.

1.4 Proteins

Chains of AA linked by peptide bonds. AKA polypeptides

10 Essential AA – body cannot synthesize them

20 Total AA

4 types:

- Non-polar: Glycine, Alanine, Valine, Leucine, Isoleucine, Phenylalanine, Tryptophan, Methionine, Proline
- Polar: Serine, Threonine, Cystein, Tyrosine, Asparagine, Gluamine
- Acidic: Glutamic Acid, Aspartic Acid
- Basic: Histidine, Arginine, Lysine

Structure:

- Primary: AA acid sequence
- Secondary: Alpha helix or Beta pleated sheets. Reinforced by H-bond
- Tertiary: 3D shape. Disulfide bonds (btwn cysteine residues), ionic btwn acidic and basic side chains, H-bond, hydrophobic/hydrophilic interaction with H_2O
- Quaternary: Multiple subunits.

Denaturing agents:

- Urea – disrupts H-bond
- Salt or change in PH – electrostatic bonds
- Mercaptoethanol – disulfide bonds
- Organic solvents – hydrophobic forces
- Heat – all forces

Basic structure of one AA: $NH_2\text{-}CH\text{-}R\ \text{–}COOH$

How to tell L vs D AA: Use CORN rule. Put H in back, look at direction of COOH, then, R, then, NH_2 group. L-left D-clockwise

1.5 Carbohydrates

Empirical formula: $C(H_2O)$

Glucose: 80% of carbs absorbed by body is glucose

- Anomers: Alpha: OH on C1 is on opposite side of methoxy group of C6. Beta: opposite of alpha

Humans absorb alpha bonded glycogen.

Glycogen: polymerized polysaccharide used by humans

Storage: stored in liver as glycogen. Reforms sugar from glycogen and vice versa.

Starch: composed of amylose and amylopectin.
Cellulose: beta linked. Animals cannot digest it.

1.6 Nucleotides

3 components: 5 carbon sugar, Nitrogenous base, phosphate group

Base attach to C1, phosphate attach to C5, C3 used to attach to another sugar

DNA is missing OH on C2

1.7 Minerals

1.8 Enzymes

Lowers activation energy, do not alter equilibrium

Cofactor: used by many enzymes for optimal activity

Two types: Coenzymes: vitamins, ATP, etc. Minerals: Ca++, Na+

1.9 Enzyme inhibition

Irreversible: tend to be highly toxic, cannot be unbound.

Competitive: competes with substrate. Vmax unaffected, Km decreased

Non-competitive: do not compete with substrate. Vmax lowered, Km unaffected

1.10 Enzyme Regulation

4 types:

Proteolytic cleavage: Zymogen transformed into active enzyme

Reversible covalent modification: E.G. phosphorylation

Control proteins: protein subunits that associate with enzyme to activate or inhibit activity. E.G. G-protein

Allosteric interaction: binding of activator or inhibitor

Feedback: Negative – shut down upstream activity to inhibit further production of product. Positive: opposite.

1.11 Enzyme Classification

1. Oxidoreductase
2. Transferase
3. hydrolase
4. Lysase
5. Isomerase
6. Ligase

Note: Compounds that have –ase ending most likely enzyme. They are prone to denaturing.

Kinase: phosphorylates something

Phosphatase: de-phosphorylates something

1.12 Cellular Metabolism

Metabolism: Are all cellular chemical reactions

1.13 Glycolysis

Type of anaerobic respiration. Oxygen is not required

1st stage of respiration. Glucose turns into 2 pyruvate, 2 ATP, 2 NADH. Occurs in the cytosol.

1.14 Fermentation

Anerobic respiration.

Turns Pyruvate into ethanol or lactic acid.

Turns NADH back to NAD+

Expends 2 ATP, forms 4 ATP. Net: gains 2 ATP per glucose molecule

1.15 Aerobic Respiration

Requires oxygen
Occurs in the mitochondria
Pyruvate facilitate diffused into mito.
Convert Pyruvate into acetyl CoA. Forms CO_2 and NADH

1.16 Krebs Cycle

Acetyl CoA is a coenzyme that transfers two carbons from pyruvate to oxaloacetic acid to start the cycle

Uses substrate-level phosphorylation to produce ATP

1.17 Electron transport chain

Series of proteins in the inner membrane of mito.
NADH oxidized in the first protein
Electrons passed down chain of proteins
Protons are pumped into the intermembrane space (low pH)
High concentration protons propels through ATP synthase to synthesize ATP
Oxidative phosphorylation: synthesis of ATP by using proton-motive force.

CHAPTER 2 GENES

2.1 The Gene

Central Dogma: DNA -> RNA -> protein

2.2 DNA

Polymer of nucleotides
C&T – Pyrimidine
A&G – Purines
C&G – Three H-bonds
A&T – Two H-bonds
5’ to 3’ directionality

2.3 Replication

Semiconservative replication
Bidirectional
Reads 3’ to 5’, but synthesizes the complimentary strand 5’ to 3’
Steps:

1. Helicase unzips the double helix;
2. RNA Polymerase builds a primer;
3. DNA Polymerase assembles the leading and lagging strands;
4. the primers are removed;
5. Okazaki fragments are joined.

Telomerase: repeated 6 nucleotide units that protects chromosomes from being eroded through multiple replication.

2.4 RNA VS DNA:

U instead of T
C2 has OH instead of H only
Single stranded
Can move through nuclear pores

3 Types:

mRNA: delivers DNA code to be translated
rRNA: combines with proteins to form ribosomes
tRNA: transfers AA to ribosome for translation

2.5 Transcription

Requires a promoter: short piece of DNA tells RNA pol where to begin transcription
The template strand or (-) antisense strand is transcribed
The coding strand or (+) sense strand protects its partner from degradation
Moves in 3' to 5' direction, but synthesizes 5' to 3'
Terminates at the termination sequence
Most regulation occurs at transcription. Activators or repressors bind close to promoter for regulation.
Prokaryotic gene: The genetic unit including the operator, promoter, and genes is called the operon.

2.6 Post-transcriptional Processing

Initial mRNA sequence: primary transcript
5' cap added
3' poly A tail added
Introns excised out

2.7 DNA Technology

Restriction Enzyme: cuts nucleotide at a specific palindromic sequence
cDNA Library: complimentary library made from reverse transcribed mRNA
PCR: denature, anneal, amplify cycles
Southern blot: DNA restricted, resolve using electrophoresis, probe using radioactive DNA or RNA compliment, visualize
Northern blot: RNA
Western blot: Protein via primary and secondary antibodies
RFLP: analyze individuals by different restriction site digestion

2.8 The Genetic Code

AUG: start codon. Methionine
UAA, UAG, UGA: stop codon

2.9 Translation

Ribosome is the machinery used to translate mRNA to protein
Ribosome requires nucleolus to be manufactured
3 sites: E (exit), P (peptidyl) , and A (amino); physically located the same sequence
Translation steps:
Initiation: Methionine settles at the P site. Both subunits join together.
Elongation: Next AA with its corresponding tRNA settles in the A site. Peptide bond forms. mRNA shifts 3 peptide down.
Termination: Stop codon reaches A site. Peptide is freed from tRNA and ribosome.
Post translational processing may occur. Sugars, lipids or phosphate groups may be added
Protein destination:
Rough ER: 20 AA signal peptide sequence near the front of the polypeptide routes the ribosome onto the rough ER. Proteins made at the rough ER is to be excreted or membrane bound.
Cytosol free floating ribosome synthesizes proteins to be used in the cell.

2.10 Mutations

Gene mutation: alteration in the DNA sequence in a single gene
Chromosomal mutation: structure of chromosome is changed
Point mutation: change in a single base pair
Base-pair mutation: one base-pair is replaced by another
Missense mutation: base-pair mutation that occurs in the amino acid coding sequence of a gene. May or may not alter AA sequence of a protein
Insertion or deletion: may result in frame shift mutation if deletion or insertion of peptides other than 3n.
Nonsense mutation: stop codon created from a mutation. Protein is truncated.
Translocation: one chromosome inserted into another

Inversion: orientation of a section of DNA is reversed on a chromosome

Transposition: a segement of DNA called transposable element may move from one location to another on a chromosome

Forward/backward mutate: mutation that leads away/towards the wild type

2.11 Cancer

Unrestrained and uncontrolled growth of cells.

Proto-oncogenes: genes that stimulate normal growth in human cells

Oncogenes: converted from proto-oncogenes that causes cancer.

2.12 Chromosomes

Histones: proteins that wraps DNA around itself to compact its size

Nucleosome: 8 histones

In nucleus, we have 46 double stranded DNA molecules or 23 homologues

2.13 Cell Life Cycle

G1, S, G2, M

Interphase: G2, S, G2

G1: cell has just split. Growth in size and synthesize organelles and proteins

G0: nongrowing phase distinct from interphase. Enteres from the end of G1 phase

S: synthesize of DNA.

G2: cell prepares to divide.

2.14 Mitosis

Prophase: condensation of chromatin into chromosomes

Centrioles move to opposite of cell

Nucleolus then nucleus disappear

Spindle apparatus forms consisting of aster, centromeres, and spindle microtubules. (kinetichore is locatged at the contromere of the joined chromatids)

Metaphase: chromosomes line up

Anaphase: sister chromatids split at centromeres and move apart.

Cytokinesis (separation of cellular cytoplasm due to controction of microfilaments about he cnetger of the cell) may commense towards the end of the phase

Telophase: nuclear membrane reform, then nucleolus. Cytokinesis continue.

2.15 Meiosis

Only spermatogonium and oogonium undergo meiosis

Prophase I: homologous chromosomes line up along side each other. Cross over occur. The X shape formed is called a tetrad

Crossing over forms an “x” shape calleld chiasma

Metaphase I: homologues remain attached and move to metaphase plate

Anaphase I: Separate homologues from their partners. 2n -> n

Telophase I: nuclear membrane reform and cytokinesis occur. New cells are haploid with 23 replicated chromosomes called secondary permatocytes or oocytes. In female, one of the oocytes is called polar body with much smaller cytoplasm.

Prophase, metaphase, anaphase II: appears much like normal mitosis, except results in 4 haploid cells with 23 chromosomes.

CHAPTER 3 MICROBIOLOGY

3.1 Viruses

Size comparable to large protein

Composition:

Capsid: protein coat surrounding genetic material

Genetic material: either single or double stranded DNA or RNA, but not both (can be sense or anti-sense)

Envelope: outer protective covering borrowed from host cell or manufactured. Present in most animal, some plant, and few bacterial viruses.

Bacteriophages: tail, base plate, tail fibers

Not considered living because virus requires host cell for ATP and machinery to replicate. Can be crystallized and retain virulence.

Infection steps:

Virus binds to specific chemical receptor (often a glycoprotein). Virus cannot infect if receptor is not present.

Nucleic acid penetrates the cell.

For bacteriophages: Chemicals digest cell wall and nucleic acid injected through the tail of the virus

For eukaryotic viruses: Most enter cell via endocytosis.

Latent period: period between infection and first fully formed virus appear.

Two pathways:

Lytic: virus begins to replicate. Virus called virulent virus.

Lysogenic: DNA incorporated into host genome. Becomes virulent when host cell is under stress.

Temperate virus: virus in the lysogenic cycle.

Provirus: Virus in the lysogenic cycle if the host is bacterium

Types:

Plus-strand RNA: Protein can be directly produced from RNA

Retrovirus: virus with RNA and reverse transcriptase to produce DNA from RNA

Minus-strand RNA: compliment of mRNA. Must be transcribed into plus-RNA before being translated.

Other: double stranded RNA, single and double stranded DNA

3.2 Defense Against Viral Infection

Antibodies bind to virus and cytotoxic T cells destroy the tagged virus.

Antibodies recognize the spike proteins present in the outer membrane that gives viruses their ability to recognize new host cells

Carrier population: one or more animals that acts as a carrier to a virus. Virus coexist in them while infecting other animals.

Broad classification according to energy and carbon source:

Energy source:

Phototrophs: Uses light for energy

Chemotrophs: uses chemicals

Carbon source:

Autotrophs: uses CO_2

Heterotrophs: uses pre-formed organic material

Electrons or hydrogen source:

Lithotrophs: inorganic matter

Organotrophs: organic matter

3.3 Prokaryotes

No membrane bound nucleus

Split into two domains:

Archaea: typically found in extreme environments such as salty lakes and boiling hot springs. Have more similarities with eukaryotes than bacteria. Cell walls are not made from peptidoglycan.

Bacteria:

3.4 Structure of Prokaryotes

Usually single double stranded circular DNA. Associated with histones in Archaea and similar protein in Bacteria.

No nucleus. Instead, DNA, RNA, and protein form nucleoid. Not bound by membrane.

No complex, membrane bound organells. But they do have organells such as ribosomes, mesosomes, etc, but not membrane bound and complex.

Bacterial shape: bacterial naming usually contain shape information. E.G. staphylococcus, spiroplasma.

- Cocci: round
- Bacilli: rod shaped
- Spirilla: spiral, ridgid
- Spirochetes: spiral, non-ridgid

3.5 Membranes

Plasma membrane: Cytosol of bacteria is surrounded by a phospholipid bi-layer called plasma membrane.

Proteins found on plasma membrane:

- Integral (intrinsic) proteins: Proteins that traverse the plasma membrane
- Extrinsic (peripheral) proteins: Proteins that is found on the surface of the plasma membrane. Do not easily flip orientation on the plasma membrane.

Fluid mosaic model: everything on the plasma membrane, including the membrane itself, is fluid-like. Everything moves laterally in a random fashion. Cholesterol moderates fluidity.

3.6 Membrane Transport

Passive diffusion: No energy is used. Molecules diffuse down concentration gradient. Depends upon lipid solubility

Facilitated diffusion: Transport protein assist in the diffusion of molecules down the concentration gradient. E.G. glucose into cell

Active transport: Energy used to transport molecules against electro-chemical gradient

3.7 Bacterial Envelope

Envelope surrounding bacterial plasma membrane.

Function: Prevent hypertonic bacteria plasma from bursting.

Composition: Peptidoglycan. More flexible than cellulose. Porous.

Gram staining:

- Gram positive: thick bacterial envelope. Purple.
- Gram negative: think bacterial envelope. Pink. Outside of envelope, another phospholipids bilayer exist. This membrane posses polysaccharides to resist antibiotics.

Flagella:

- Long, rotates for movement, made from flagellin.

3.8 Bacterial Reproduction

Major reproduction method: Binary fission. 1 cell -> 2 identical cells

Genetic recombination methods:

- Conjugation: One bacteria contain a plasmid called sex pilus. Sex pilus is a hollow tube that connects two bacterium for exchanging DNA material. Once two bacterium connects, they exchange plasmid DNA.
  - Important plasmids:
    - F plasmid: fertility plasmid
    - R plasmid: Resistance plasmid. Plasmid that codes for antibiotic resistance.
- Transformation: bacteria incorporates DNA from external environment.
- Transduction: virus assisted DNA transfer into bacterium

3.9 Endospores

Bacteria in a highly resistant dormant stage that can survive for hundreds of years.

3.10 Fungi

Eukaryotic heterotrophs

Absorb nutrient by secreting digestive enzymes and absorb digested nutrient from the external environment.

Life cycle mostly in haploid form

Most fungi are saprophytic

Septa: fungi cell wall made of chitin (same stuff as exoskeletons)

Reproduce sexually and asexually

Multicellular except for yeast

3.11 Fungal Reproduction and Life Cycle

Asexual: spores carried by air, water, or host, or budding in yeast

Sexual: Hyphae from two mycelia of different mating types (+ and –) touch, forming a conjugation bridge. Two gametes form at the bridge and they fuse into a diploid zygote. The zygote differentiate into haploid spore forming cell.

CHAPTER 4 THE EUKARYOTIC CELL; THE NERVOUS SYSTEM

4.1 The nucleus

Contains all genetic material (except a small amount from mito)

Double phospholipids bilayer (nuclear envelope)

Nuclear pores enable RNA to escape

Nucleolus reside within nucleus to transcribe rRNA and assemble ribosome

4.2 The membrane

Phagocytosis: (greek: to eat)

engulfing large particles

few specialized cells

Pinocytosis: (greek: to drink)

small invagination, random, non selective, performed by most cells

Exocitosis: opposite of endocytosis

ER: Maze of cell walls,

contiguous in many places with cell membrane and space between double bilayer of nucleus

Smooth ER:

tubular in shape.

Produce proteins destined for cytosol, glucose from glycogen, triglycerides, cholesterol, conversion of cholesterol to various steroids, neutralizing toxic chemicals, and oxidize forein substances.

Rough ER:

Shape like flattened sacks.

Synthesize virtually all proteins not used in cytosol.

Golgi apparatus:

Series of flattened membrane bound sacks.

Proteins with correct signal sequence move from rough ER to Golgi, shuttled across using transport vesicles, organize, concentrate, modify proteins.

End product is a vesicle full of proteins

End product: secretory vesicles, lysosome

Secretory vesicles: growth factors, enzymes, cell wall components destined for exocitosis

Lysosomes:

acid hydrolases in low PH environment capable of digesting all major cell components.

Fuse with endocytotic vesicles to digest content.

Undigested content ejected from cell using exocytosis.

May autolysis and kill cell under certain conditions.

Tay-Sachs disease – autosomal recessive for missing protein in lysosome, accumulation of lipids in brain.

Peroxisomes:

self-replicate. Produce and break down of hydrogen peroxide.
Inactivate toxic chemicals such as alcohol.
Play role of synthesis and breakdown of lipids.
Metabolism of nitrogenous bases and carbohydrates.

4.3 Cellular Filaments

Cytoskeleton:

responsible for structure and mobility of cell.
Anchor some proteins and cell components.
Move cell components and cell itself. Two major types:
Microfilaments:

Actin polymerized
contractile force in microvilli and muscles
responsible for squeezing membrane together in phagocytosis and cytokinesis.

Microtubule:

Larger than microfilaments.
Hollow tubes made from alpha and beta tubulin.
Mitotic spindle, Flagilla, cilia.
- end attach to microtubule organizing centers (centrosome) + grows outwards

4.4 Cellular Junctions

Tight Junctions:

Watertight seal blocks water, ions, and other molecules from moving past cell. Complete fluid barrier
Epithelial tissue such as bladder, intestine, skin

Desmosomes:

Spot welds btwn cells
Found in tissues that experience stress such as skin and intestinal epithelium

Gap junctions:

Small tunnels connecting cells. Allow small molecules and ions to flow between cells. Action potential propogation.

Plasmodesma:

Narrow channels between plant cells. Contains narrow tube of ER surrounded by cytoplasm.

4.5 Mitochondria

Endosymbiont theory: symbiotic relationship between ancient eukaryot and prokaryot.
Own circular DNA
Independent replication, from mother's side only
Own mitochondria
Structure:

Double phospholipids layers.
Inner layer forms invaginations called cristae
Intermembrane space: space between outer and inner membrane where electron transport chain takes place

4.6 The Extracellular matrix

Definition: elastin and collagen excreted by fibroblasts that forms a molecular network that holds tissue cells in place.
Different tissue forms drastically different matrix. E.G. liquid in blood or solid in bone
Function:

May provide support

May help determine cell shape and mobility
May affect cell growth

4.7 Organization in Multicellular Eukaryotes

4 Types of tissues:

Epithelial: Separates free body surfaces from their surroundings. E.G. endothelium linings
Connective Tissue: Extensive matrix. E.G. Bone, blood, lymph, cartilage, tendon, ligaments
Muscle:
Nervous:

4.8 Intercellular Communication

3 types:

Neurotransmitters: nervous system
Local mediators: paracrine system
Hormones: endocrine system

Differences between neurotransmitters and hormones: Neurotransmitters are fast, direct, specific. Hormones are slow, affect many cells in different ways, affects globally.

4.9 Paracrine system

Local mediators released in interstitial fluid
Acts on neighboring cells a few mm away

4.10 Nervous system

Transmission path: Dendrites -> axon hillock -> axon -> axon terminal

4.11 Action potential

Resting potential:

Negative inside due to Na/K pump.
Pumps out 3 Na and 2 K per cycle.
Always on and in equilibrium of Na/K diffusion

1st: Na voltage gated channels open, Na flows in, polarizing the cell. Potential spikes to positive

2nd: Na channels close, K channels open, K flows out, hyperpolarizating the cell. Potential spikes to more negative than resting because K channels are slow

All or nothing
Must match threshold potential in order to start potential propogation

4.12 The synapse

Slowest part of neural cellular communication
Two Types: electrical and chemical synapse
Electrical: uncommon. Bidirectional. Fast. E.G. Cardiac muscles, visceral smooth muscle, and very few neuron in brain
Chemical: unidirectional

Ca++ channels open upon action potential reaching synapse.
Ca++ flows into cell
Neurotransmitter vesicles release content into synaptic cleft
Neurotransmitter diffuse across cleft and attach to receptor proteins
Ions flow into post synaptic neuron, transferring the action potential

Receptor proteins:

Ion channels: action potential directly transferred.
G-protein coupled: neurotransmitter binds, alpha subunit detaches from cytosol side and perform one of the following:

1. activate separate specific ion chaIu1els;
2. activate a second messenger (i.e. cyclic AMP or cyclic GMP);
3. activate intracellular enzymes;

4. activate gene transcription.

4.13 Support Cells

6 types: microglia; ependymal cells; satellite cells; astrocytes; oligodendrocytes; and neurolemmocytes or Schwann cells

Schwann cells: cells that wrap around axon to form myelin in the PNS.

Oligodendrocytes: cells that wrap around axon to form myelin in the CNS.

4.14 Structure of Nervous System

Three functions:

1. Sensory (afferent) neurons: (mnemonic: Arrive) Located dorsally (towards the back)
2. Interneurons: Transfer signal from neuron to neuron. 90% of all neurons
3. Motor (efferent) neurons: (mnemonic: Exit) Located ventrally (towards the front)

CNS: Interneurons. Integrate signals between the sensory and motor neurons. Brain and spinal cord

PNS: everything not in CNS. Divided into:

Somatic nervous system:

Voluntary.
Primarily respond to external environment.
Contains sensory and motor neurons.
Motor neurons enervate only skeletal muscles.
Cell bodies of somatic motor neurons located in ventral horn of spinal cord.
Uses acetylcholine and synapse directly on effectors.
Sensory neuron cell bodies are located in dorsal root ganglion

Autonomic nervous system:

Sensory neurons receive signals from viscera (organs inside ventral body cavity).
Motor neurons effects smooth muscle, cardiac muscle, and glands.
Involuntary.
Divided into two systems: Most organs are innervated by both.

Sympathetic: “fight or flight”

Cell bodies located in spinal cord
Sympathetic post ganglion bodies are located in paravertebral ganglion
Preganglion uses Acetylcholine
Postganglion uses epinepherin or norepinepherine (aka adrenalin or noradrenalin)

Parasympathetic: “rest or digest”

Cell bodies located in both spinal cord and brain
Parasympathetic post ganglion bodies are located near their effectors
Preganglion AND postganglion uses Acetylcholine

4.15 The Central Nervous System

Hindbrain:

Pons - relay between cerebrum and cerebellum
Cerebellum – coordination, timing, balance
Medulla – breathing, heart rate, GI activity

Midbrain:

Joins forebrain with spinal cord
Motivation, motor control, visual/auditory impulses

Forebrain:

Cerebrum (cerebral cortex) – thought, conciousness, memory
Olfactory bulb
Hypothalamus – water balance, blood pressure, and temp regulation
Thalamus - relay for cerebral cortex / spinal cord

4.16 Sensory Receptors: not important to learn for DAT

4.17 The Eye

Light path: cornea -> lense -> retina

Lense: attached by ciliary muscles. Contraction\relaxation cause the lense to thicken\flatten which cause the focal point to shorten\lengthen. Age cause elasticity to decrease, causing difficulty to focus on nearby objects

Retina: Rods = light/dark. Cones = 3 types, red, blue, green.

Iris: Increase/decrease pupil size by sympathetic/parasympathetic nervous system.

4.18 The Ear

Outer ear: auditory canal, timpanic membrane

Middle ear: stapes, malleus, incus

Inner ear: coclea, semicircular canals

4.19 The nose and mouth

4 taste sensations: bitter, sour, salty, sweet

CHAPTER 5 THE ENDOCRINE SYSTEM

5.1 Hormone Chemistry

Exocrine glands: glands that release hormones through ducts

Endocrine glands: glands that release hormones directly to the blood stream

Role of hormones: alter metabolic activities, regulate growth, guide reproduction

Peptide hormones:

- Derived from peptides.
- Rough ER
- Water soluble
- Membrane bound receptor
- May activate ion channels or activate intracellular second messenger system such as cAMP, cGMP, calmodulin
- Anterior pituitary: ACTH, LH, FSH, prolactin, TSH, hGH
- Posterior pituitary: oxytocin, ADH
- Parathyroid: PTH
- Pancrease: glucagons, insulin

Steroid hormones:

- Smooth ER
- Lipid soluble
- Pass through membrane, bind to cytosol receptor, and act on transcription
- Ovaries: estrogen, progesterone
- Testies: testosterone
- Adrenal cortex: cortisol, aldosterone

Tyrosine derivatives:

- Lipid or water soluble
- Thyroid: T3 (triiodothyroxine), T4 (thyroxine). Lipid soluble
- Adrenal medulla (catecolamines): epinephrine, norepinepherine. Water soluble

5.2 Negative feedback

Control point of the feedback is the conduct of the effector.

In other words, glad lags behind the effector.

In yet other words, hormone responds to the condition.

E.G. High glucose levels cause high insulin levels.

5.4 Anterior Pituitary: Peptide hormones

hGH: (somatotropin) human growth hormone stimulates growth in almost all cells of body

ACTH: adrenocorticotropic hormone stimulates adrenal cortex to release glucocorticoids (e.g. cortisol)

TSH: thyroid stimulating hormone stimulates thyroid to increase in size and release T3 & T4. T3&T4 negative feedback on TSH

FSH & LH: see reproduction

Prolactin: increase milk production.

5.5 Posterior Pituitary: peptide hormones. Produced in hypothalamus and released here.

Oxytocin: Milk let-down

ADH: (mnemonic: always digging holes in collecting duct). Increase water reabsorbtion, blood pressure, urine concentration

5.6 Adrenal Cortex: Steroid hormone

Aldosterone: (mineral corticoid) increase ion reabsorption in distal tubule. Na+, Cl- reabsorption, K+ & H+ secretion.

Eventually leads to increase water retention and higher blood pressure due to net ion increase in blood.

Cortisol: (glucocorticoid, stress hormone) Increase blood glucose concentration. Stimulate gluconeogenesis – creation of glucose from lactic acid, amino acid, or glycerol. Degrade adipose tissue to fatty acids.

5.6.b Adrenal Medulla: Catecholamines (tyrosine derivative)

Epinephrine & norepinephrine: Long lasting vasoconstrictors of skin and organs. Vasodialators of muscles. Stress hormones.

5.7 Thyroid

T3 & T4: 3 vs 4 iodine. Lipid soluble tyrosine derivative. Increase basal metabolic rate.

Calcitonin: peptide hormone. Decrease blood calcium level.

5.8 Pancrease: peptide hormone

Insulin: Produced by beta islet cells. Decrease blood glucose level by increasing cell glucose permeability and increase cell metabolism.

Glucagon: Produced by alpha islet cells. Stimulate glycogenolysis (glycogen -> glucose) and gluconeogenesis in the liver. Net effect is to raise blood glucose level.

5.9 Parathyroid

PTH: Increase blood calcium. Increase osteoclast activity, renal Ca++ reabsorption.

5.10 Reproduction

5.11 Male Reproduction

Sperm production:

Occurs in the seminiferous tubules in the testes

Epithelia tissue differentiate into Spermatogonia cells -> spermatocytes -> spermatids -> spermatozoa

FSH stimulates sertoli cells which surround and nurture spermatocytes

Leydig cells release testosterone when stimulated with LH

Testosterone stimulate maturation into sperm

Androgen: hormone that stimulate masculine characteristics. Testosterone is the primary one

Sperm composition:

3 areas:

Head: Nucleus and Acrosome (tip of the sperm. Contains hyaluronidase, an enzme to dissolve cell membrane.)

Midpiece: mitochondria dense region that provides energy

Tail:

Semen composition:

Spermatozoa, fluids from seminal vesicles, prostate, bulbourethral glands (aka cowper's gland)

Capacitation: process in which spermatozoa becomes activated for fertilization in the vagina

5.12 Female Reproductive System

All eggs arrested at primary oocyte at birth

Ovulation stages

Follicular:

FSH rise

Several follicles are stimulated, but one ultimately matures

Maturing follicle secretes estradiol (a type of estrogen), which stimulate buildup of endometrium

Ovulation:

Immediately before ovulation, estradiol peaks, causes luteal surge (rapid rise in LH)

Follicle walls weaken, releases secondary oocyte

Luteal:

FSH and LH cause follicle to transform into corpus luteum

Corpus luteum secretes estrogen and progesterone (which maintains endometrium wall)

If implantation occurs, hCG is released, maintaining the corpus luteum

If not, corpus luteum degrades, causing menstruation

5.13 Fertilization and Embryology

Takes place in the fallopian tube

Enzyme in acrosome dissolve cell membrane

Cell membrane of sperm and oocyte fuse

Oocyte undergo cortical reaction to prevent additional sperm entering

Oocyte undergo second meitotic stage and release second polar body

Fertilization occurs when genetic materials fuse, forming zygote

When repeated cleavage forms 8 or more cells, it is now called morula

blastocyst forms and implants in the uterus at day 5-7.

Upon implantation hCG is secreted by the egg

Gastrulation occurs and forms gastrula in second week. Forms the following:

Ectoderm: skin, nail, tooth enamel, nervous system, sense organs

Mesoderm: digestive tract, liver, pancrease

Endoderm: muscle, bone

Nurulation occurs and forms nurula in third week.

Notochord (from mesoderm) cause ectoderm to form neural plate -> neural tube -> nervous system

A placenta is formed and takes over hormone secretion of estrogen and progesterone by the end of first trimester

Apoptosis: death of cells. E.G. btwn toes and fingers. Absense of apoptosis occurs in cancer.

CHAPTER 6 DIGESTION

6.1 Anatomy

Mouth, esophagus, stomach, small intestine (duodenum, ileum jejunum), large intestine (ascending, transverse, descending, sigmoid), rectum, and anus.

6.2 Mouth and Esophagus

Digestion begins in mouth with alpha amylase digesting starch into polysaccarides.

Chewing increase surface area of food

Swallowing along with peristaltic action move food into stomach.

6.3 Stomach

Begin protein digestion via pepsin
Stores food for gradual digestion
Low PH kills bacteria and denature protein for digestion
4 cell types:
Mucus cells: produce mucus
Chief (peptic) cells: Pepsinogen
G-Cells: produce gastrin which stimulate parietal cells to produce HCl
Parietal cells: Produce HCl into stomach and bicarbonate into blood.

6.4 Small intestine

90% absorption takes place
Duodenum: most digestion takes place
Ilium & Jejunum: most absorption takes place
Walls of small intestine:
Villi: finger-like projections that increase surface area.
Microvilli: smaller finger-like projections on villi. Fuzzy under light microscope called brush border. Contain digestive enzymes.
Goblet cells: produce mucus for protection
Nutrient pass into capillary network and lacteal (lymph vessels) inside villi.

6.5 The Pancrease

Bicarbonate ion: Produced by pancrease to increase PH of chyme to 6.
Digestive enzymes: trypson, chymotrypson, pancreatic amylase, lipase, ribonuclease, deoxyribonuclease
Trypson & chymotrypson: degrade proteins into small polypeptides. Brush border reduce polypeptide into mono, di & tri peptides
Pancreatic amylase: hydrolyze polysaccharides into di and trisaccarides. Brush border hydrolyze polysaccarides into monosaccarides
Lipase: Degrades triglycerides into monoglycerides and fatty acids. Crossed brush border.
Bile: Produced by liver and stored in gall bladder. Emulsifies fat. Do NOT digest fat.

6.6 The Large Intestine

Major functions: water resorption & electrolyte absorption.
Symbiotic relationship with bacteria E.G. E-coli produce vitamin.

6.7 GI hormones

Cholecytoskinin: Increase bile release & slows down digestion due to large amount of fat present.

6.9 Carbohydrate Absorption and storage

95% monosaccaride in blood is glucose
Glucose absorbed by secondary active transport down Na gradient.
All carbohydrates absorbed and carried by portal vein to the liver.
Liver converts galactose and fructose into glucose then into glycogen for storage
When glycogen storage is full, liver convert glucose into fat, a long term storage.

6.10 Proteins Absorption and storage

Polypeptide -> mono, di, & tri peptides during digestion
Converted into monpeptide inside enterocyte and absorbed into the blood stream directly
All cells absorb amino acids especially liver.
When AA storage reach their peak, AA can be converted into fat or burned for energy.

Urea: Ammonia is produced as a by-product of gluconeogenesis from amino acids which is converted into Urea by liver.

6.11 Fats Absorption and storage

Most energy dense nutrient

Triglycerides digested into monoglycerides and fatty acids. Shuttled via bile micelles into enterocyte.

Smooth ER converts back into triglycerides

Golgi package triglycerides along with other proteins into globules called chylomicrons

Exocytosis occurs and transport them into lacteals which empties into the large veins at the neck.

Majority absorbed by liver, and some by adiposites.

6.12 Liver

Hepatic portal vein receives blood directly from intestines, spleen, stomach, and pancrease and processed.

Hepatic artery supplies second blood supply

Hepatic vein collects all processed blood and pass into vena cava

Functions:

- Blood storage
- Blood filtration: Phagocytize bacteria
- Carbohydrate metabolism: gluconeogenesis (synthesize glucose and glycogen from non glucose source)
- Fat metabolism: Bile production. Convert carb and protein into fat. Oxidize fatty acid for energy
- Protein metabolism: Convert AA into fat, produces ammonia->urea. Synthesize plasma proteins.
- Detoxification:
- Erythrocyte destruction: Minor role compared to spleen
- Vitamin storage:

When metabolizing fat or protein for energy, keytone bodies increase, decreasing blood PH.

6.13 Kidney

Functions:

- Excrete waste such as urea, ammonia, uric acid, phosphate
- Maintain homeostasis of body fluid volume and solute composistion
- Help control PH

Functional unit: nephron

Nephron path: Renal corpuscle, proximal tubule, descending loop of henle, ascending loop of henle, distal tubule, collecting duct, collecting tubule.

Renal corpuscle:

- composed of capillary bed (glomerulus) and bowman's capsule (surrounding capsule).
- Hydrostatic pressure forces small ions, water, molecules, proteins from glomerulus into bowman's capsule

Proximal tubule:

- Majority of resorption takes place. Active resorption of proteins and glucose.
- Drugs and other toxins secreted into tubule.
- Change solute composition but does not change osmolarity

Loop of Henle

- Descending: Permeable to water. Water flows out, concentrating urine
- Ascending: Permeable to ions. Ions actively flow out, diluting urine

Distal tubule:

- Reabsorbs Na & Ca. Secrete K, H, HCO_3
- Aldosterone increase Na & K transport proteins. Net effect is to decrease filtrate osmolarity.

Collecting duct:

- ADH increase water reabsorption, concentrating urine.

Juxtaglomuerular apparatus:

Sense filtrate pressure in distal tubule.

CHAPTER 7 CARDIOVASCULAR SYSTEM & RESPIRATORY SYSTEM

7.1 cardiovascular anatomy

Path: L Atrium, L ventricle, aorta, arteries, arterioles, capillaries, venuoles, veins, superior and inferior vena cava, R atrium, R ventricle, Pulmonary artery, Pulmonary vein

Heart electrical path:

SA node -> atriums -> AV node -> Bundle of his -> purkinje fibers -> ventricles

SA node: Autorythmic. located in R atrium. Vagus nerve innervates SA node, SLOWING it down

AV node: Located in the walls between the aortas. Slower, creates a timed delay.

Bundle of his: bundle of fibers located between the ventricles

Purkinje fibers: fibers branching out of the bundle of his. Propogates action potential more simultaneously to all cells of the ventricle, allows for more unified and stronger contraction.

Arteries: elastic. Wrapped in smooth muscle that is typically enervated by sympathetic nervous system. Large, so vasodialation do not affect much.

Arterioles: Very small, so vasodialation may be used to reroute blood.

Capillaries: microscopic. Single RBC pass through. One cell thick walls. Nutrient exchange occurs here only.

Arteriole side: hydrostatic pressure dominate, fluid flows out

Venule side: osmotic pressure dominate, fluid flows in

Net: 10% fluid loss into interstitium

7.2 Respiratory System

Path: Nose, Pharynx, Larynx, Trachea, Bronchi, Bronchiole, Alveoli

Larynx: voice box

Epiglottis: cartilaginous member that prevent food from entering the trachea when swallowing

Trachea: lies in front of the esophagus

7.3 Chemistry of Gas Exchange

98% O_2 binds to hemoglobin.

Hemoglobin is composed of 4 subunits with one heme cofactor and one iron in the middle. Exhibit cooperativity when binding AND releasing O_2.

Oxygen dissociation curve: %O_2 saturation vs O_2 tension (mm Hg). Inc [H+], temp, PCO_2 -> shift right (decrease O_2 affinity)

CO_2: By far carried in blood as bicarbonate. Other: physical solution, carbamino (combined with hemoglobin and other proteins)

Carbonic anhydrase: enzyme to convert CO_2 to bicarbonate ion

Breathing and PH in blood: Low PH cause increase breathing in order to expel bicarbonate which increase PH

7.4 Lymphatic System

Returns excess interstitial fluid to the blood for most all tissue, except for the nervous system

Monitor blood for infection

Open system

One way valves

7.5 The Blood

Type of tissue: Connective. Composed of cells and matrix (plasma)

Centrifuged blood separates into:

Plasma: water, albumin (transport fatty acids, regulate osmotic pressure), immunoglobulins, clotting factors,

Buffy coat: white blood cells (leukocytes).

Red blood cells (erythrocytes): transport O2 and CO2. Live 120 days.

Serum: plasma with fibrinogen removed

Platelets: membrane bound cytoplasm split from magakaryocytes. Stick to injured endothelium then swell and activate other platelets

Clotting: Platelets aggregate, making a loose plug. Prothrombin convert to thrombin. Thrombin convert fibrinogen to fibrin attaches to platelet to form tight plug.

7.6 Immune system

Two types:

Innate: skin, stomach acid, phagocytic cells, chemicals in blood

Acquired: Two types:

Humoral (B-cell immunity):

Macrophage present antigen to B lymphocytes.

If recognized, T-helper cell helps B lymphocytes to differentiate into memory (to retain memory) and plasma cells (to produce immunoglobulin).

Effective with bacterial, fungi, protozoans, virus, blood toxins.

Cell-mediated (T-cell immunity):

T-lymphocytes mature in thymus and have antibody-like protein on surface.

Produce no free antibodies.

Effective against infected cells

Steps of bacterial infection:

Inflammation

Macrophages then neutrophils engulf bacteria

Interstitial fluid flushed into lymph where macrophage present antigen to B lymphocytes.

T-helper cells assist activated B lymphocyte differentiate into plasma and memory cells

Plasma cell produce antibody

Single antibody is specific against single antigen

Single B lymphocyte produce single antibody type

7.7 Blood types

Easy

CHAPTER 8 MUSCLE, BONE, AND SKIN

8.1 Muscle

Types: skeletal, smooth, cardiac

8.2 Skeletal Muscle

Voluntary, connected by tendon to bone

Work in groups. Agonist contract while antagonist lengthen

Synergistic muscles assist by stabilizing the joint

Squeeze blood and lymph while contracting to aid in circulation

Shivering from muscles is used as one mechanism to warm the body

8.3 Physiology of Skeletal Muscle Contraction

What part of the sarcomere change length during contractions? H zone and I band

All or none contraction.

Composition:

Sarcomere: functional unit of skeletal muscles with many strands of myosin and actin

Myofibril: sarcomeres positioned end to end

Sarcoplastic reticulum: surrounds myofibril. Contains Ca++ ions

Sarcolemma: membrane that wraps several myofibrils together to form a muscle

Multinucleated

Contraction:

Ca++ released from SR.
Troponin pulls tropomyosin back, exposing binding site on actin
Myosin binds to actin
ADP release, myosin head moves, contracting muscle
ATP binds to myosin, releasing grip on actin
Troponin moves back to cover binding site
ATP -> ADP. Myosin head cocked and ready to go

Action potential that leads to contraction:

Acetylcholine released into the neuromuscular synapse
Ion channels open, propagating action potential along the transverse tubule that carries the action potential deep within the tissue and allows for even contraction
Action potential propagates into SR, releasing Ca++ ions

8.4 A Motor Unit

Unit of muscle fibers innervated by one nerve. Can be 2 to 2000 fibers in one motor unit.
Force of contraction for a muscle group depends on number and size of motor unit recruited

8.5 Skeletal Muscle Type

Myoglobin: stores O2 in muscles. Only 1 subunit instead of 4 like hemoglobin
Type I slow oxidative: Red from large amount of myoglobin, lots of mitochondria, slow to fatigue, low contractile force
Posterior muscles
Type IIa fast oxidative: Red, fast contraction, intermediate resistance to fatigue
Upper legs
Type IIa fast glycolytic: White (low myoglobin), fast contraction, quick to fatigue, large amount of glycogen
Upper arms
Note: most muscles are mixture of above 3 types

8.6 Cardiac Muscle

Striated: composed of sarcomeres
Mononucleated
Intercalated disks between muscle cells
Large amount of mitochondria
Slow voltage gated Ca++ channels create a positive potential plateau after depolarization to lengthen contraction

8.7 Smooth Muscle

Involuntary
Innervated by autonomic nervous system
Not organized into sarcomeres
Intermediate filaments connects on dense bodies forming a web on each cell that enables the cell to contract length wise

8.8 Bone

Function: Support, protection, mineral storage, blood cell production, energy storage
Cells that make up the bone:
Osteoblasts: secrete collagen and other compounds to make bone. Once trapped within bone, it becomes osteocytes
Osteocytes: exchange nutrients and waste material with blood
Osteoclasts: resorb bone matrix
Long bone composition:
Spongy bone at ends of the bone. Contains red bone marrow for RBC production
Hollow compact bone in the middle. Contains yellow bone marrow for fat storage

8.9 Bone Function in Mineral Homeostasis

Ca++ stored as hydroxyapatite

Hydroxyapatite crystals lie alongside collagen fibers to give bone high compression strength

Stores and releases Ca++ and HPO4 --

8.11 Cartilage

Flexible resilient connective tissure

Composed primarily of collagen

8.12 Joints

Fibrous joint: close and tightly held together with little or no movement. E.G skull

Cartilaginous joint: allows for little movement. E.G. Ribs, sternum

Synovial joint: joint with synovial fluid in between. Allows for wide range of movement

8.13 Skin

Functions of skin:

Thermoregulation: Heat dissipation

Protection: physical barrier to the outside world

Environmental sensory input: Pressure, pain, touch

Excretion: water and salt loss

Immunity: Specialized cell of epidermis are components of the immune system

Blood reservoir:

Vitamin D synthesis: Requires UV light to synthesize precursor.

Composition:

Epidermis: avascular (no blood vessels) tissue.

Keratinocytes: produce keratin for water proofing

Melanocytes: skin pigment

Langerhans cells: interact with helper T-cells

Merkel cells: one component of touch sensation

Dermis: derived From mesodermal cells

Embedded with blood vessels, nerves, glands, and hair follicles

CHAPTER 9 POPULATIONS

9.1 Mendelian Concepts

Fn designation: nth filial generation. E.G. F1 is the generation after the first crossing

Phenotype: expression of a trait

Genotype: genetic makeup in a particular locus. E.G. blood type 6 genotypes: AA, AO, BO, OO, BB AB

Complete dominance: dominant allele override recessive allele completely

Locus: a region on a chromosome that codes for a particular gene

Allele: alternative DNA sequence at a locus which may or may not result in different phenotypic trait. E.G. blood type has 3 alleles.

Mendel's 1st law: law of segregation: alleles segregate independently from each other when forming gametes

Mendel's 2nd law: law of independent assortment: genes on different chromosomes assort independently from each other

Dihibrid cross: crossing of two heterozygous genes for the phenotypic ratio of 9(both dominant):3(one recessive):3(other recessive):1(both recessive). If found, then the two genes obey Mendel's laws: 1 & 2.

How to perform two genotype cross: Write out 4x4 punnet square. For each side, write out possible gamete genotype (1 allele from each gene 4 possible combinations). Perform cross.

Karyotype: map of chromosomes. 46 total chromosomes or 23 homologous chromosomes

Sex-linked trait: Carried on the X chromosome; therefore, expressed in males whether or not it is dominant. Therefore, a carrier female crossed with normal male will produce 50% expressed males. On females, normal dominance occur because of two X chromosomes.

9.2 Evolution

Gene pool: total of all alleles in a population. E.G. 70% B & 30% b

King Philip came over for good soup

Species: subset of all organisms that can produce fertile offspring

Niche: the way in which a species exploit the environment

Survival of the fittest: the most successful will mate the most time, therefore, be more successful at propagating its genes

R-selection: many offspring, little or no care. Exponential growth. Do well in density independent factors. E.G. flood, temp fluctuation, etc.

K-selection: few offspring, high energy spent on offspring. Sigmoidal curve that peaks at carrying capacity. Do well in density dependent factors

Speciation: process which new specie is formed

Adaptive radiation: several species arise from single ancestral species

Divergent evolution: process in which a common structure diverges into different forms. E.G. leg of human and flippers of whales

Convergent evolution: different species evolve similar structures. E.G. wings of bat and bird

Polymorphism: Phenotypes in which distinct forms are present as opposed to continual change. E.G. white and red flower color vs height.

9.3 Symbiosis

Mutualism: Both organisms benefit.

Commensalism: One organism benefit while the other is neither harmed nor benefit.

Parasitism: One organism benefit while the other is harmed

9.4 Hardy-Weinberg Equilibrium

Hardy-Weinberg equilibrium: no change in alliel frequency if the following 5 conditions hold

1. large population
2. mutational equilibrium
3. immigration or emigration must not change gene pool
4. random mating
5. no selection of the fittest

Genetic drift: Occurs in small population where death of one subset of population having bias against one alliel causes disturbance of the gene pool. Random event.

Binomial theorem: $p^2 + 2pq + q^2 = 1$ & $p+q=1$ Frequencies of alliels sums to one.

9.5 Origin of Life

Urley-Miller experiment: autosynthesis of basic molecules from primordial soup of methane, ammonia, sulfur, etc..

First photosynthetic organism is probably photosynthetic bacteria. Ancestors of cyanobacteria.

9.6 Chordate Features

Chordata not equal to backbone

Bilateral symmetry

They are deuterostomes (anus develops from or near blastopore)

During development, they posses a notochord (embryonic axial support, derived from mesoderm not back bone), pharyngeal slits, a dorsal hollow nerve cord, and a tail

Most chordates are vertebrata (notochord replaced with bone structure with distinct brain structure enclosed in a skull)