MCAT – BIO: Print and Highlight in PDF

most bio molecules:
-lipids
-proteins
-carbohydrates
-nucleotide derivatives

70 to 80 % water is cell

water, small polar molecule, can H-bond
allows it to maintain liquid at room
cohesive forces squeeze
hydrophobic away from H20
hydrophilic dissolve easily
-negative charged ends attract the posi H's of H20.

Most macromolecules can be hydrolyzed, and formed via dehydration.

lipid – low sol in H20, high sol in nonpolar
make good barriers
1) Fatty acids
2) triaglycerols
3 phsopho lipids
4) glycolipids
5)steroids
6) terpenes

Fatty acids are building blocks for most lipids

Saturated FA's → only single C-bonds
Unsaturated → one or more double C-C bonds

most fats reach cell as FA, not triaglycerols

tria's are 3 carbon backbone – stores energy
--also thermal insulation, etc.

glycolipids have 3-C backbone with sugar attached. membranes of myelenated cells in nervous system

steroids – 4 rings. include hormones, vit D, and cholesterol (membrane)

Eicosanoids – local hormones – bp, body T, smooth muscle. Aspirin commonly use inhibitor of prostaglandins.

lipids insol, so transported in Hb via lipoproteins. classified by density, VLDL, LDL, HDL. (lipid::protein ratio).

Proteins: chain of aa's linked by peptide bonds
aka polypeptides

in humans, 20 alpha amino acids
amine attached to alpha carbonyl

10 are essential.
aa's differ in their R group.
digested proteins reach our cells as single aa's

Nonpolar:
Gly, *Ala*, Val, Leu, Iso, Phe, Tryp, Met, Pro
Polar
Ser, Thr, Cys, Tyr, *Asp*, *Glu*
Acidic
Aspr Acid, *Glu* acid
Basic:
Lysine, *Arginine*, Hist

(italics for mnemonic)

Proline induces turns.
2 types of proteins – globular and structural.
glob: enzymes, hormones, memb pumps
struct: cell / matrix structure. collagen.

glycolproteins – cell matrix
cytochromes – prothetic heme group. Hb

Carbohydrates
C and H20. C(H20). Glucose – 6 C's. all sugars broken down to glucose.
-2 anomers, alpha (trans) and beta (cis)
Animals eat Alpha. Bacteria break Beta

absence of insulin, neural and hepatic cells use facilitated txport for glucose.

cellulose has beta linkages

if you see N on the mcat, think protein

Nucleotides: 3 components
-5-C / pentose sugar
-Nitrogenous base
-phosphate group

bases in nucleotides – AGCT and U
polymers: DNA, RNA, Nucl-acids
joined by phosphodiester
nucleotides written 5' to 3'
DNA written so top strand is 5'→3'
bottom is 3'→5'
RNA is 1-stranded. U replaces T.
important nucleotide: ATP. energy. cyclic amp
is a messenger.

Enzymes
globular proteins
catalysts
lower activation E
not consumed, altered
do not alter Keq
lock-and-key theory / enzyme specificity.
specific shape.

second theory: induced fit. Shape of both enzyme and substrate altered during binding.

enzymes → saturation kinetics.
as [substrate] goes up, so does rxn rate, but curve slows as gets closer to Vmax.
Km good indicator of affinity for its substrate

temp and pH.
in human body, temp of 37C
pepsin in stomach likes ph< 2. Trypson, in small intestine likes ph between 6 and 7.

most enzymes require non-protein component called cofactor. → optimal activity.
Cofactors:
Minerals,
Coenzymes (many are vit's of their derivatives)
-cosubstrates
-prosthetic groups.
→ bind to specific enzyme, txfer chemical group to another substrate. cosubstrate then reverted back.

ATP is cosubstrate type of coenzyme

Enzyme inhib:
-irreversible → covalently bonded (penicillin)
-competitive → raise apparent Km but not Vmax
-noncompetitive → some other spot, change conformation. lower Vmax do not change Km

Regulation:

-zymogen/proenzyme – not yet activated. need another enzyme or change of pH. eg, pepsinogen.

-phosphorylation

-control proteins, eg, G proteins

-Allosteric interactions: negative or positive feedback mechanism.
negative: product downstream comes back to inhibit
positive: product activates first enzyme.
occurs much less often.
other proteins have these characteristics

negative allosteric inhibitors do not resemble substrates, they cause conformational change. can alter Km without affecting Vmax.
positive cooperativity. low [substrate], small increasees in [substrate] increase enzyme efficiency and rxn rate. positive are the first changes. it's why there is an 02 dissociation curve with Hb. (sigmoidal shape). both positive and negative cooperativity.

Enzyme Classification:
memorize "-ase" sometimes complex chemical has "ase" and you will know it is an enzyme, it contains nitrogen, and it is subject to denaturation.

lyase – catalyzes addition of one substrate to a double bond of a second substrate.

ligase also governs an addition rxn, but requires energy from ATP.

kinase – enzyme which phosphorylates something, phosphatase DEphosphorylates.
eg, hexokinase phosphorylates glucose as soon as it enters cell to prepare for glycolysis.

Metabolism: all the cellular chemical rxns
3 stages
1) macromolecules broken down into constituent parts (little E released)
2) constituent parts oxidized to acetyl CoA, pyruvate, or other metabolites forming ATP and reduced coenzymes (NADH and FADH2) which does not directly utilize oxygen
3) if O2 is avail, metabolites go into TCA and oxidative phosphorylation to form large amounts of energy (more NADH, FADH2, or ATP); otherwise, coenzyme NAD+ and other byproducts either recycled or expelled as waste. 2nd and 3rd stages, the energy acquiring stages, called respiration. aerobic and anaerobic versions.

anaerobic: 02 not required.
glycolysis first step.
glucose → pyruvate (3C's).
+ 2ATP, PO3, H20, 2NADH
happens in cytosol (fluid portion) of cells

glucose facilitated diffusion into cell.

resulting 3-C molecules each transfer one of their PO3 groups to an ADP to form one ATP each in substrate level phosphorylation.

Fermentation: anaerobic respiration.
glycolysis → reduction of pyr to ethanol or lactic acid. humans do the latter. no 02 avail or unable to assimilate E from NADH.
fermentation recycles NADH back to NAD+

Aerobic Respiration – requires O2. products of glycolysis will move into mitochondrial matrix. inner mitochondrial memberate less permeable. Once inside matrix, pyr converted to acetyl CoA producing NADH and CO2

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Krebs Cycle
Acetyl CoA – coenzyme which transfers 2 carbons to the 4 carbon oxaloacetic acid to begin krebs cycle (aka TCA). Each turn produces 1ATP, 3NADH, and 1 FADH2.
ATP production is substrate-level phosphorylation. during cycle, 2 CO2 given off. oxaloacetic acid is reproduced, cycle again.

Proteins → aa's → Pyruvic Acid + NH3 (waste) → Acetyl CoA → TCA/Kreb's

Fatty acids + energy → Acyl CoA + NAD+ + FAD → Acetyl CoA → enter TCA/Kreb's

Polysaccharides→ simple sugars → PGAL → Pyr acid → Acetyl CoA → TCA/Kreb's

aa's are deaminated in the liver. chemically converted to pyr acid or acetyl CoA.

Electron Transport Chain (ETC)
series of proteins, including cytochromes with heme, in the inner mitochondrial membrane. electrons passed down series and accepted by oxygen to form water. protons are pumped into intermembrane space for each NADH. → proton gradient → proton motive force → propels protons through ATP synthase to make ATP. Oxidative phosphorylation. 2-3 atps manufactured for each NADH. FADH2 similar fashion. only 2 ATPs, however.

intermembrane pH lower than matrix.
Glucose + 02 → CO2 + H20 (combustion rxn)
final electron acceptor is 02, that's why it's aerobic

Aerobic Respiration: 36 net ATP, including glycolysis. 1 NADH brings 2-3 ATPs, and 1 FADH2 brings about 2 ATPs. One glucose produces 2 turns.

Genes

gene – series of n-tides. codes for single polypeptide, or mRNA, rRNA, or tRNA. Eukary's have more than 1 copy of some genes. Prokary's only have 1 copy of each.

one gene; one polypeptide. exception: post transcriptional processing RNA.

Genome: entire DNA sequence of organism.

only ~ 1% of genome codes for protein
human DNA differs only at about 0.08%.
Small variation → big difference.

Central Dogma: DNA transcribed to RNA, translated to aa's for protein
DNA → RNA → Protein.
(same for all organisms)

4 bases of DNA:
-Adenine (purine) – two ring
-Guanine (purine) – two ring
-Cytosine (pyrimidine) – one ring
-Thymine (pyrimidine) – one ring

each n-tide bound to next by phosphodiester bond b/w 3rd carbon of one deoxyribose and the phosphate backbone of a single strand of DNA with 5'→ 3' directionality.

In DNA, two strands run antiparallel bound together by H-bond. Double stranded. h-bonding → base pairing.
complementary strands → double helix

each groove spirals once around double helix for every 10 base pairs.
diameter of double helix is 2 nanometers

remember: Ntide made of pentose sugar, P03 group, nitrogenous base.

pairings: AT, GC
2 H bonds in A-T, 3H bonds in C-G
"A2T, C3G"

DNA replication: semi-conservative
new dbl strand created → has one new one old.

Replication proceeds in both direction from origin – each direction produces a leading and lagging strand.

Prokaryotic replisome
DNA polymerase builds the new strand.
Requires RNA primer to get started.
reads parental in 3→5 direction
complementary strang 5→3
convention: DNA nucleotides 5to3 as well
5→3. 5 is upstream, 3 downstream.
"reading DNA like paddling upstream"

5 steps of replication:
1) helicase unzips double helix
2) RNA polymerase builds a primer
3) DNA polymerase assembles leading and lagging strands
4) Primers are removed
5) Okazaki fragments joined

process of replication: semidiscontinuous

telomeres: ends of eukaryotic chromosomal DNA. protect from chromosomal erosion

RNA
carbon 2 not deoxygenated
single stranded
uracil instead of thyamine
can move through the nuclear pores

3 types

-mRNA: delivers DNA code for aa's to cytosol for protein manufacturing

-tRNA: collects aa's in cytosol, transfers to ribosomes

-rRNA: combines w/ proteins to form ribosomes → protein synthesis.

DNA is produced by replication
only in nuc and mito matrix
RNA by transcription
also in cytosol

transcription: starts w/ initiation. promoter. RNA polymerase. promoter is upstream from gene.

replication: transcription bubble, elongation mode. strand transcribed: template or antisense. other strand is coding. RNA poly, like DNA poly, reads in the 3→5 direction, building new RNA to be made 5→3
no proofreading mechanism. slower. rate of error is higher. not hereditary errors. end is called termination. Coding strand resembles RNA transcript.

replication doesn't distinguish genes. transcription decides this. most regulation of gene expression during transcription by activators and repressors. bind to DNA promoter, and either activate or repress RNA poly. can be allos regulated by small molecules such as cAMP. respond to enviro changes.
eukaryotes: one gene per transcript
prokary: polycistronic

operator + promoter + genes = operon

eg, lac operon. codes for enzymes to allow E coli to import and metabolize lactose when low glucose. low glucose, high cAMP, activates CAP, activates promoter. operator downstream, too. Allows for repression via binding to a protein, allolactose (inducer).

initial mRNA sequence called primary transcript. processed by addition of n-tides, deletion of n-tides, modification of n-bases. 5' end capped with GTP. 3' end poly A tail to protect from exonucleases

primary txscript cleaved into introns, exons
snRNPs (snurps) recognize, form spliceosome, cut off introns. only 30,000 genes, but 120,000 proteins possible bc of splicing.
introns::exons = 24::1

denatured DNA – heat → separated strands.
more C3G pairs, higher Tm
DNA-RNA hybridization
restriction enzymes cut DNA at certain sequences, usually palindromic. leave DNA with sticky end so they can reconnect.
recombinant DNA.

DNA library – use a vector in a bacterium, then reproduce bacterium. active gene, turn blue with x-gal. some bacteria wont take up, so introduce lac-z with your inserted vector. introduce X-gal and the right ones will turn blue

one way to find gene in library – hybridization
radioactive labeled comp sequence of desired DNA fragment (probe). cDNA product – mRNA produced by the DNA. lacks introns (good).

better cloning: polymerase chain rxn (PCR). fast way to clone dna. heating and annealing. primers hybridize. polymerase replicates.

southern blotting: ID target fragments of known DNA in large pop of DNA. DNA cleaved into restriction fragments. separated by size in gel elctrophoresis. large moves slower than small. gel denatures DNA fragments. probe hybridizes w/ and marks target fragment.

Northern blot uses same techniques to ID specific sequences of RNA

Western blot: detects a protein with antibodies

RFLP: ID's individuals instead of specific genes. we are polymorphic for our restriction sites. can only negate people, cannot identify

Genetic code: mRNA nucleotides.
code is degenerative. more than one set of 3 nucleotides can code for a single amino acid. but 1 and only 1 aa, so unambiguous.
start codon is AUG
stop codons UAA, UAG, and UGA.
64 possible combinations of the bases

20 possible amino acids.
if protein contains 100 aa's, then 20<100 possible sequences.

RNA n-tides written 5'→3'

Translation: mRNA directed protein synthesis. mRNA the template. tRNA carries n-tides complementary for codon, called anticodon. rRNA with protein make up ribosome, which is the site of translation.

small subunit, large subunit. ribosomes require nucleolus for their origin.
tRNA posessing 5'-CAU-3' anticodon sequesters methionin and enters at P site. Large subunit joins (initiation). next tRNA enters A site. translocation. tRNA shifts, moves to E site.
initiation, elongation, and termination.

txlation begins on free floating ribosome. signal peptide can transport polypeptide to lumen. SRP can carry entire ribosome towards ER

Mutations
any alteration that is not recombination
gene mutation – sequence of n-tides in a single gene
chromosomal mutation – structure is changed

somatic vs. germ cell mutations
latter more serious

point mutation – single n-tide changed
base pair mutation – AT to GC, vice versa
missense – bp mutation in aa sequence of gene
may or may not be serious
eg, sickle cell anemia
insertion or deletion → **frameshift** mutation
multiples other than 3.
sometimes nonframeshift and still functional
usually frameshift is non-functional
nonsense – stop codon created by mutation

chromosomal mutations—
deletions—portion of chromosome breaks off
duplication – breaks off and incorporates into hmologous chromosome

Down syndrome result of aneuploidy where 3 copies of chromosome 21

translocation – segment of DNA from 1 chromo inserted into another
inversion – orientation reversed
transposons can excise themselves and insert themselves elsewhere

forward mutation – changing organism away from original state
backward – back to original state
original state called wild type

Cancer
proto-oncogenes – stimulate normal growth in cells. can be converted to oncogenese – genes that cause cancer, by UV radiation, chemicals, or simple random mutations. Mutagens that cause these called carcinogens

DNA is 5 ft for each cell. wrapped tightly around globular proteins, histones. 8 histones wrapped in DNA – nucleosome. wraps into coils, supercoils, entire complex called chromatin.

somatic cell: 46 double stranded DNA molecules. chromosome. 46 chromosomes before replication, 46 after replication. duplicates referred to as sister chromatids. Diploid means cell as 23 homologous pairs. sex cells haploid.

stages of cell's life
1) G1 – first growth
2) S – Synthesis
3) G2 – second growth phase
4) M – mitosis / meiosis
5) C – cytokinesis

1-3 called interphase.
in G1 – regions of heterochromatin have been unwound into euchromatin, RNA synth and protein synth very active. G1 checkpoint → S stage, if ratio of cytoplasm to DNA is high enough.
Gzero is nongrowing state. neurons, liver cells.
G2 checkpoint – Mitosis promoting factor (MPF)

Mitosis, nuclear division w/o genetic change
4 stages –remember PMAT: **prophase** (condensation of chromatin into chromosomes, centrioles move to opposite sides of cell. spindle apparatus forms of aster, centromeres at center. spindle micotubules connect two centrioles.) **metaphase** (chromosomes align along equator), **anaphase** (sister chromatids split at attaching centromeres, move towards opposite ends of cell. cytokenesis, separation

of cytoplasm due to microfilaments.), and **telophase** (nuclear membrane reforms followed by reformation of nucleolus. Chromosomes decondense and cannot be seen under microscope. Continuued cytokinesis).

Interphase is both before and after PMAT. Interphase = normal cell, nothing happening.

Meiosis – double nuclear division which produces four haploid gametes. aka germ cells. only spermatogonium and oogonium undergo it in humans.

after replication of S phase, cell is primary germ cell. in females, replication takes place before birth. life cycle arrested at primary oocyte stage until puberty. before ovulation, primary oocyte undergoes meitotic division to become secondary oocyte. 2ndary released upon ovulation, penetration of secondary by sperm stimulates anaphase II of second meitotic division of oocyte.

Two rounds of division for 4 daughters
meiosis I and II
similar to mitosis except:
prophase I, homologous cr-somes align along side, matching their genes exactly. May exchange exchange sequences of n-tides in crossing over. recombination happens here for euk's. Side by side homologues exhibit a total of four chromatids. called tetrads. chiasma, center of the x shape.

under microscope, metaphase in mitosis appears like metaphase II in meisosis, but not number I.

mitosis = meiosis except
-2 rounds
-daughters haploid
-genetic recomb occurs

Spermatogenesis
spermatogonium → primary spermatocyte → secondary spermatocytes → spermatids → spermatozoa

Oogenesis
oogonium → primary oocyte + first polar bodies → second oocyte + 2nd polar bodies → zygote

nondisjunction – centromere doesn't split during anaphase I or II. 1 cell has 2 extra chromatids. the other lacks a chromosome.

Microbiology

Viruses, tiny infectious agents. consists of protein coat (capsid), 1-400 genes (DNA or RNA) inside. mature virus outside host cell – viron.
not living bc need host cell to txfer genetic material. Do not metabolize nutrients. use host's ATP.
infection begins when virus absorbs chemical receptor of host, usually glycoprotein on membrane.

in bacteriophage, virus infects bacteria. nuc acid is injected through tail after it has made a hole in wall with enzymes. virus engulfed by endocytosis.

→ lytic or lysogenic infection.
lytic: virus takes over machinery and begins reproducing new viruses. cell lyses bc of the produced viruses. aka "Virulent Virus."

In **lysogenic** infection, viral DNA incorporated into the host genome. if RNA virus, has enzyme reverse transcriptase, DNA made from RNA and then incorporated into cell genome. "Temperate virus." Cell may show no symptoms. virus is dormant or latent.

common cold – unenveloped. plus strand RNA. plus = proteins can be directly translated from the RNA. enveloped version include retroviruses such as HIV. Retrovirus = reverse transcriptase = making DNA from RNA. → DNA incorporated into host cell.

minus strand rna include measles, rabies, and flu. must be transcribed to plus version first.

body defends against viruses w/ antibodies. antibodies bind to infected cell, and with cytotoxic T cells, kill the infected cell.

vaccine either injection of antibodies or injection of nonpathogenic virus w/ same capsid or envelope. viruses may attack several species at once.

Virus structure:
-capsid
-nucleic acid
-lipid-rich protein envelop for some

for most bacteriophages:
-tail
-base plate
-tail fibers

lysogenic, longer word, longer cycle

Prokaryotes – no memb bound nucleus.
either bacteria or archea. arch more similar to euk's

carbon source. all microorganisms tend to fix CO2, reducing it and using it to create organic molecules via Calvin cycle

however this is energy expensive. Autotrophs can use Co2 as sole source of carbon. Heterotrophs use organic molecules.

classification system of prokaryotes:
1) energy source – photo if light, chemo if from chemicals
2) carbon source- auto (CO2) and hetero (organic molecules)

some bacteria can fix nitrogen. N2 converted to ammonia. nitrification breaks down ammonia into nitrates, useful to plants.

prokary's don't have nucleus. euk's do. instead, prok's have single ciruclar double stranded molecule of DNA. Under microscope can be seen as a nucleoid. name often reveals shape, e.g., spiroplasma, staphylococcous, or pneumococcous.
cocci – round, and bacilli are rod shaped. helical called spirilla or spirochetes.

Bacteria have no complex membrane bound organelles. They have organelles, ribosomes, nucleoid, mesosomes, but not complex ones.

Phospholipid: phosphorylated alchohol head (phosphate), glycerol backbone + 2 fatty acid tails.
-polar heads
-nonpolar tails
aka amphipathic

embedded in plasma membrane are proteins. can act as transporters, receptors, attachment sites, and enzymes. amphipathic proteins that transverse the entire membrane are called integral or intrinsic. Peripheral or extrinsic are just on the surface.

the membrane is fluid, parts can move laterally but not separate. fluid mosaic model.
cholestorol moderates fluidity in eukaryotic membmrane. Prokary membrane only differs slightly from euk membrane

Diffusion. Moving down gradient if no electrical charge. chemical concentration gradient. if electric charge, also electrical gradient. the two can be added to form an "electrochemical gradient".

membrane must be permeable to allow diffusion
usually semipermeable membrane.

two things affect permeability – size and polarity. larger, less permeable
the greater the polarity of a mol, less permeable a membrane is. very large lipids (nonpolar) can therefore move easily.

eg, water is larger than sodium, but water is polar whereas sodium is a complete charge, so easier to pass through. → most membranes highly permeable to water.

water moving is considered passive diffusion. for larger, necessary compounds, proteins are needed. transport or carrier proteins

facilitated – occur down electrochemical gradient of all species. all human cells do this for glucose supply. selectively permeable, bc molecules of similar size and charge.

if against e-chemical gradient, active transport. requires expenditure of energy.

Bacterial Envelope. surrounds protoplast (plasma membrane). basic function: to prevent cell burst / lysis. most bacteria are hypertonic to enviroment (their soln has more solute when compared to outside).

bc of concentration gradient, water would like to move inside cell, but this would call cell burst.

as water goes in, hydrostatic pressure builds. eventually equals osmotic pressure and filling stops.

cell wall made of peptidoglycan. made of disaccharide chains w/ aa's
more elastic than cellulose, plant cell walls

can ID bacteria by their cell wall. via gram staining. if **gram positive** – thick cell wall, more peptidoglycan, shows up as purple.
gram negative – appears pink. outside these walls is a phospho bilayer, unlike gram neg. less peptidoglycan.

Flagella. Long hollow rigid cylinders. do NOT equal euk flagella, which are made of microtubules.

Bacterial reproduction. they don't do mit or mei. do not reproduce sexually. 3 alternative forms of genetic recombination: conjugation, transformation, and transduction. also can do binary fission (split).

binary fission
-circular dna replicated
-2 dna poly's begin at same point of circle (origin of replication)
-cell divides, leaving 1 chromosome in each daughter
-2 daughters are identical.

conjugation
requires one of the bact. have a plasmid w/ gene that codes for sex pilus. small circles of DNA that exist and replicate independently of bact. chromosomes. sex pilus – phalic, attaaches to the other bacterium. one strand is nicked. etc etc

2 important plasmids. F and R. F is called fertility factor. if it has F, called F+. if not, F-.

R plasmid denotes resistance to antibiotics.

Transformation – bacteria may incorporate DNA from external environment into genome. typical experiment: heat killed virulent bacteria mixed with harmless living. harmless living receive those genes and become virulent.

sometimes, capsid of bacteriophage w/ mistakenly encapsulate DNA fragment of host cell. when virons infect, they inject harmless bacterial DNA fragments. called transduction. virus that mediates this called vector. can be done in a lab.

Endospores – gram + bact. that can lie dormant for 100's of years. resistant to heat, uv, etc. can survive in boiling water.

Fungi. in divisions, not phyla. all are eukaryotic heterotrophs, obtain food by absorption. spend most of their time in the haploid state. can reproduce both sexually and asexually. most have cell walls called septa. most are saprophytic (rotten, decayeed). wall's made of chitin. more resistant to microbial attack.

In growth state, fungi consist of tangled mass called mycelium, of branched structures, hyphae.

haploid spores in hyphae give rise to new mycelia in asexual reproduction. yeasts, asexual occurs by budding / fission.

sexual repro occurs between hyphae from to mycelia of diff mating types + and – conjugation bridge.

asexual repro: when conditions are good
sexual: when it's tough. parent less adaptable

Defining feature of eukary's – nucleus. DNA cannot leave the nucleus, so transcription must take place in nucleus. RNA leaves nucleus thru nuclear pores.

nucleus wrapped in double phospholipid bilayer – nuclear envelope. large holes, pores. w/in nucleus is nucleolus where rRNA is transcribed and subunits are assembled.

cells can acquire stuff via endocytosis. diff types
-**phagocytosis**: memb protrudes outward. started by receptor binding.
-**pinocytosis** - extracelular fluid engulfed. nonselective
-**receptor mediated**. uptake of hormones and nutriants.

exocytosis is the reverse of endo.

ER separates cytosol from ER lumen / cisternal space. ER can be contiguous w/ cell membrane.

near nucleus, ER's cytosome side has a granular appearance (ribosomes). aka, rough ER.

Translation on RER propels proteins into ER lumen as they are created. They are tagged and sometimes glycosylated. Newly synthesized proteins moved through lumen towards golgi. Golgi organizes and concentrates proteins as shuttled by transport vesicles. end product: vesicle full of proteins. either can be expelled from the cell as secretory vesicles, released from golgi to mature into lysosomes, or transported to oother parts of cell such as mitochond.

Secretory vesicles: may contain enzymes, growth factors, or extracellular matrix components. release contents thru exocytosis.

Lysosomes contain acid hydrolases (function best in acidic environs). capable of breaking down any time of macromolecule w/in cell. interior pH of 5. fuse w/ endocytotic vesicles and digest contents. Problem: can release their contents into the own cell causing autolysis. happens during formation of tissue, however, to form fingers, etc.

SER lacks ribosomes. resembles tubes, not flattened sacs like RER.
-contains G6P, which can hydrolyze to glucose, glycolysis.
-triglycerides produced in SER and stored -adipocytes
-cholestorol formation, conversion to steroids

phospholipids in cell memb formed from SER. oxidizes foreign substances, drugs, toxins, etc. Key in liver.

Peroxisomes – vesicles in cytosol. grow by incorporating lipids. self replicate.

overview:
1) 2 basic "sides" of cell – cytosol and ER lumen. in order to get to cytosol, substance must cross membrane via passive or facilitated diffusion, or active transport. can reach er lumen via endocytosis w/o ever transporting across a membrane.
2) RER has Ribosomes attached to cytotic side. synthesizes virtually all proteins not used in cytosol. proteins synth on RER pushed into ER lumen and sent to Golgi
3) Golgi modifies and packages proteins for use in other parts of cell and outside
4) lysosomes come frome golgi, have hydrolytic enzymes to digest endocytosed substances
5) SER is site of lipid synthesis, eg steroids. SER also detox's, eg drugs.

Cellular filaments:
cytoskeleton determines skeleton and motility of a cell

2 major types of filaments:

-**microtubules**: larger than filaments. involved in flagella and cillia construction, and spindle apparatus. in humans, cilia only found in fallopian tubes and resp tract. rigid hollow tubes made of protein tubulin. spiral appearance from alpha and beta parts. mitotic spindle is made of microtubules

-**microfilaments**: smaller. squeeze membrane together in phagocytosis and cytokinesis. also force in the microvilli and muscle.

flagella and cilia specialized structures from microtubules. axoneme contains nine pairs of tubules arrangment 9+2. cross bridges from protein called dynein.

Eukaryotic flagella made from 9+2 microtubule configuration; prokaryotic is just thin strand of protein called flagellin. euk flagella do whip-like action, whereas prok just rotate.

microfilaments smaller than microtubules. actin is major component of microfilaments. contractile force in muscle, also cytoplasmic streaming, etc.

Cellular junctions

3 types of junctions that connect animal cells
-**tight** water tight seal, blocks water, ions, etc.bladder, intestines, kidney. also blocks apical and basolateral movement of proteins in membrane. fluid barrier around cells

-**desmosomes –** spot welds holding cells together. attach directly at cytoskeleton. found in places of stress: skin, intestinal epithelium.

-**gap –** tunnels b/w cells, allow exchange of small molecules. important in cardiac muscle to allow spread of AP's from cell to cell.

Mitochondria

mitochondria – powerhouses of euk cell. kreb cycle happens here.
endosymbiont theory: mito may have evolved from symbiotic rel'ship b/w ancient prok's and euk's. mito like prok's: have own DNA that replicates independently. Always inherited by momma.

Sturcutre:
-outer membrane
inter membrane space
-inner membrane (holds ETC chain)
(2 phospholipid bilayers, the space in between)
-cristae (invagination of inner membrane)
-matrix

Extracellular Matrix
tissue – group of cells of similar function
-some tissue have fibroblasts that secrete fibrous proteins elastin and collagen
---form molecular network that holds tissue in place (extracellular matrix)
can be liquid (blood) or solid (bone)

basal lamina – thin sheet of matrix material. separates epithelial from support tissue. also found around nerves, muscle, and fat. acts as semipermeable barrier.

Organization

cells of same tissue tend to have same embryology.
4 types of tissue in animals:
1) **epithelial** – separates free body surfaces from surroundings.
-simple: 1 layer, eg heart
-stratified: 2+ layers
2) **muscle**
3) **connective:** extensive matrix. eg, blood, bone, lymph, cartilage, etc.
4) **nervous**

the 4 types combined can form an organ, diff organs combine into a "system."
key to MCAT Bio is knowing that body is entire organism with systems that work in conjunction w/ eachother

Intercellular Communication

occurs via 3 types of mol's
1) neurotransmitters (nervous system)
2) local mediators (paracrine system)
-released into interstitial fluid
-act on neighboring cells mm away
-eg, prostaglandins, → smooth muscle contraction, inflammation
aspirin inhibits this.
3) hormones (endocrine system)

they differ mainly by distance traveled.
NT's travel over short intercellular gaps or synapses
local mediators function in immediate area around cell
hormones travel through the organism via the bloodstream

NT tends to be rapid, direct, and specific
hormonal tends to be slower, spread throughout the body, and affect many cells and tissues in many ways.

Nervous system

rapid and direct communication b/w specific parts of body
→ muscular contractions or glandular secretions
includes: brain, spinal cord, nerves, neural support cells, organs such as eye and ear.
main unit is neuron
-electrical signal from one cell via electrochemical means. so specialized it cannot divide. depends entirely on glucose. depends on aerobic respiration: low stores of glycogen and oxygen, so relies heavily on blood. usually soma (body) and 1 axon w/ many branches, as well as many dendrites.

dendrites receive signal to be transmitted electrical stimulus goes to axon hillock, if great enough, hillock generates AP towards synapse, which passes signal to cell.

Basic anatomy of neuron:
dendrites, nucleus, axon hillock, mitochondrion in soma. nodes of ranvier, myelin sheath, axon terminal.

Neurons do NOT depend on insulin to obtain glucose. Get it right from the blood.

Action Potential

AP is disturbance in e-field across membrane
resting potential – established by an equilibrium b/w passive diffusion across the membrane and Na+/K+ pump. it moves 2 + charged K+ ions into cell while 3+ Na+ ions out of cell. force pushing Na back into clel becomes greater. at equilibrium, inside memb has _ potential difference (voltage) compared to outside. called resting potential.

voltage gated sodium channels – allow Na+ to flow thru membrane shortly. the membrane reverses polarity. Depolarization. Neuronal membrane also contains voltage gated potassium channels. cause repolarization. hyperpolarization. passive diffusion returns membrane to resting postential. throughout, sodium-potassium pump keeps working.

AP Overview
1) Membrane at rest. Na/K channels closed
2) Na channels open, cell depolarizes
3) K channels open as Na channels begin to close
4) Na channels closed. Open K channels repolarize membrane
5) K channels close and membrane equilibrates to resting potential

AP is all or nothing. Membrane completely deporalirzes or no AP is generated. must pass a threshold stimulus. Once there is AP, absolute refractory period until another AP can happen.

Aps, besides in neurons, also in skeletal and cardiac muscle.

Neural impulses transmitted intercellularly via a synapse. Usually chemical, not electrical. aka motor end plate if neuron-muscle connex

unidirectional. small vesicles filled with NT reside just inside presynaptic membrane. membrane near end contains large number of Ca2+ voltage gated channels. When AP arrives, these are activated to allow calcium flow into cell. causes NT vesicles to be released through exocytotic process into synaptic cleft. diffuses across cleft with random or "Brownian" motion. Post synaptic

membrane contains NT receptor proteins. When attached, post syn membrane becomes more permeable to ions. ions move through now permeable proteins called ionophores, completing transfer of neural impulse.

NT attaches to receptor only for milisecond. then released back into syn cleft. if remains, can stimulate post syn memb over and over. to deal with this, cell can use enzyme to destroy NT. it can also be absorbed by cell…

Usually 1 NT per 1 synapse. Can either inhibit or excite. Some have diff effects depending on area;
-Acetyl Choline (ACh)
on heart: inhibitory effect
on visceral smooth muscle (intestines): excitatory

Receptors
-ion channels themselves, or,
-2nd messenger system

For prolonged change, eg, memory, 2nd messenger preferred.

G proteins initiatie 2nd messenger systems
-attached to receptor inside post syn memb.
-when receptor stimulated by NT, part of the G protein called alpha subunit breaks free
Alpha subunit may
1) activate separate specific ion channels
2) activate a 2nd messenger, eg, cAMP or GMP
3) activate intracellular enzymes
4) activate gene transcription.

overall: chemical synapse most important. slowest step in txfer of nervous signal, can only occur in 1 direction. 2nd messenger also important to recognize.

Support Cells

nervous tissue contains glia cells/neuroglia. usually ratio of 10::1 glia to neurons neuroglia, unlike neurons, CAN divide, and usually do during traumatic brain injury to fill any space created in CNS.

6 types of glia
-**microglia** – phagocytize microbes and debris in CNS
-**ependymal** – epithelial that line the cerebral fluid containing parts of CNS
-**satellite**- support ganglia in PNS
-**astrocytes** – star shaped neuroglia in CNS, give physical support to neurons, help maintain mileu
-**oligodendrocytes –** wrap around axons in CNS, creating electrical insulation.
-neurolemmocytes or **Schwann**. – in PNS, increases rate at which axon can txmit signals

only vertebrates have mylenated axons

to naked eye:
White matter – mylenated axons
Grey matter – neuronal cell bodies.

nodes of ranvier – tiny gaps b/w myelin, allows for saltatory conduction
Structure of Nervous System
Neurons are of 3 functions
1) **Sensory (afferent)**- rec'v signals from receptor cell from environment. txfers signal to other neurons. 99% is discarded by brain. Located located dorsally (toward back) from spinal cord.
2) **Interneurons –** txfers signals from neuron to neuron. 90% of neurons in body
3) **Motor (efferent) neurons –** carry signals to muscle or gland called "effector". Located ventrally (toward front) from spinal cord

Think of CNS as brain + spinal cord, PNS as everything else.

CNS integrates nervous signals b/w sensory and motor neurons. connected to peripheral parts of body via PNS. PNS handles sensory and motor functions of nervous system.

Simple reflex arc
receptor→dorsal root ganglion→sensory neuron→ interneuron→Motor neuron→ effector

PNS divides to

-**Somatic nervous system** – to respond to ext. environement. motor neurons only innervate skeletal muscle. cell bodies of these in ventral horns of spinal cord. use ACh for NT. considered "voluntary." sensory bodies located in dorsal root.
-**Autonomic nervous system** (ANS) – sensory receives singals from viscera, organs inside ventral body cavity. function is involuntary. NT used by all preganglionic neurons and by the post ones in the parasympathic is ACh. The post ganglionic in the symp system use either epinephrine (adrenaline) or norepinephrine (noradrenaline).
divides into 2 antagonistic systems:
-**sympathetic (fight or flight):**
activates heart, major skeletal muscles, dilates pupils for night hunting, redirects blood, etc. eg, heart, it increases beat rate, stroke volume, constricts vessels around digestive and excretory systems to increase flow around skeletal muscle.
signals originate in spinal cord. if in CNS, called nucleus, if outside CNS, called ganglion
-**parasympathetic (rest and digest)**
deactivates all of the above and activates intestines and excretory system.
eg, slows heart rate, increases digestive and excretory activity.

receptors for epi and norepi called **adrenergic**
receptors for ACh called **cholinergic**
2 types
-**nicotinic**: generally found in postsyn cells of synapse between ANS pregang and post gang neurons, and on skeletal membranes at neuromuscular junction.
-**muscarinic**: found on effectors of PNS.

Overview: ANS is involuntary. innervates cardiac and smooth muscle, some glands. somatic nervous system innervates skeletal muscle. Autonomic pathways controlled by hypothalamus.

Generally, when you hear
acetylcholine → somatic and parasympathetic nervous systems
(nor)epinephrine→ sympathetic nervous system

Central Nervous System
spinal cord, lowerbrain, all of higher brain acts mainly as conduit for nerves to reach brain
does limited integrating functions
-walking reflexes, leg stiffening, etc.

lower brain: medulla (pons, mesencephalon), hypothalamus, thalamus, cerebellum. Integrates subconcious activities such as resp system, arterial pressure, salivation, emotions, and rxn to pain, pleasure.

higher (cortical) brain: incapable to function w/o lower brain. acts to store memories, process thoughts. consists of cerebrum/cortex.

Sensory Receptors

overall: sensory receptors transduce physical stimulus to neural signals

5 types of sensory receptors
-mechanoreceptors (touch)
-thermoreceptors (change in T)
-nocireceptors (pain)
-e-magnetic (light)
-chemoreceptors (taste, smell)

on MCAT, prob just deal with eye and ear.

Eye
might show up as physics passage. understand lens of eye is converging, flatting the eye by relaxing ciliary muscles makes the lens less powerful, thus moving focal point away from lens.

let's follow path of light through eye.
light reflects off object in external environ, strikes first on cornea (nonvascular, made of collagen). refractive index of abt 1.4, bending of light occurs at interface of air and cornea, not lens.
→ goes to anterior cavity/aq. humor. (leaks out to canal of Schlemm. if blocked, glaucomma, blindness.)

from ant. cavity, light enters lens. ciliary muscle attached to it. circles lens. when it contracts, opening of circle decreases, allowing lens to be more like sphere, bringing focal point closer to lens. when relaxes, lens flattens, increasing focal distance.

eye acts as converging lens. object is outside focal distance, image on retina is real and inverted

Retina covers inside of back/distal part of eye contains rods and cones. tips of these contain pigments, chem change when e-trons struck by photon.
rods – rhodopsin pigment. made from protein retinal. derived from vit A. photon isomerizes retinal, causing membrane of cell to be less permeable to Na+, causes hyperpolarization. transduced into neural action potential, signal sent to your noggin. sense wv 390nm to 700. cannot distinguish colors.
cones – distinguish 3 types of colors.

fovea- small point on retina containing most cones. vwhere vision is most acute.

iris: colored portion of eye, creates opening called **pupil**. made of circular+radial muscles

in dark, symp ns contracts, dillating, allow more light in.
in light, parasymp contracts muscles, constricting pupil, ,screening out light.

The Ear

can show up on physics passage, concerning waves or mechanics. Know cochlea detects sound, while semicircular canals detect orientation/movement of head.

3 basic parts
1) **outer ear:** cartilage, helps direct sound into external canal. carries wave to tympanic membrane / ear drum / begin of middle ear
2) **middle ear:** malleus, incus, and stapes (bones). act as lever system, translate wave to oval window. increase in force. increase in pressure since oval window is smaller than ear drum. (physics, mech advantage).
3) **inner ear:** wave moves thru cochlea to center of spiral, spirals back out to round window. as wave moves thru cochlea, the alternating increase/decrease of P moves vestibular membrane in and out. movement detected by hair cells of organ of corti, transduced into neural signals towards brain. also here are semicircular canals, responsible for balance (contain fluid and hair cells). responds to gravity. senses motion.

Nose and Mouth

senses called olfactory and gustatory.
4 tastes
1)bitter
2) sour
3) salty
4) sweet
all tastes are combo's of the above.

Endocrine System

Hormone Chemistry
vs. NT's, which are "local hormones." General hormones are released by endocrine system, released into body fluids, blood, etc. affect many cell types in tissue, many types of tissues.

Exocrine – release enzymes to external enviro thru ducts. include sweat, oil, mucous, and digestive
Endocrine – release hormones directly into blood fluids.

Pancreas does both: releases digestive enzymes thru panc duct (exo), and releases insulin/glucagon directly into blood (endo)

endocrine tends to be slower, less direct, and longer lasting than nervous system. may take seconds to days to have an effect. Hormones need a receptor, either on membrane or inside cell.

each receptor specific to its hormone. one method of hormone regulation: reduction or increase of receptors, or modulating hormone concentration.

Endocrine system alters metabolic activities, regulates growth and development, guides reproduction. works in conjunction w/ nervous system. Many endocrine glands stimulated by neurons to secrete hormones

3 basic types of hormones
1) **peptide –** all made in RER, cleaved in ER lume, transported to golgi, packaged by golgi, exocytosed whenever the cell is stimulated by another hormone or nervous signal. Water soluble, move freely thru blood. But have trouble diffusing thru membrane of effector (aka target cell). Instead, must attach to receptor.

peptide must know's:
a)anterior pituitary: FSH, LH, ACTH, hGH, TSH, Prolactin
b) posterior pituitary: ADH, oxytocin
c) parathyroid: PTH
d) pancreatic: glucagon, insulin

Receptor – may act as ion channel, may (de)activate other intrinsic proteins. May activate intracellular **2nd messenger** such as cAMP, cGMP, or calmodulin. Creates cascade of of rxns that amplify hormone.

2) **steroid –** come from adrenal cortex, gonads, and placenta. lipids, can diffuse thru memb and act in nucleus. don't mix with blood, so need transport molecule. acts at the txscription level. increasing membrane or cellular proteins

steroid must know's:
a) glucocorticoids and mineral corticoids of adrenal cortex: cotisol and aldosterone
b) gonadal: estrogen, progesterone, testosterone.

3) **tyrosine derivatives –** thyroid hormones and catecholamines. Some can diffuse, some can't. thyroids diffuse, but catecholamines can't, so they use 2nd msnger.

tyrosine must know's:
thyroid hormones T3 and T4 (insoluble)
catecholamines formed in adrenal medulla → epinephrine and norepinephrine. (water soluble)

Negative Feedback
glands tend to over-secrete, usually aspect of effector will inhibit this. (negative feedback).

gland lags behind effector: high insulin does not create low blood glucose. high insulin responds to high blood glucose, and low blood glucose causes high glucagon to respond. so if patient has high levels of blood glucose, you would expect the hormone to be most present the one that is responding to the condition, not creating it. so: insulin.

eg, ADH holds water in body, decreasing urine output. increases blood pressure. so person w/ high blood Hg has low ADH.

eg2, aldosterone increases blood Hg. if low blood Hg in pt, high aldosterone.

Specific Hormones and their Functions
must know major hormones and glands and target tissues. group them together in the gland that secretes them.

Anterior Pituitary
aka adenohypophysis. located in brain beneath **hypothalamus –** controls release of ant. pituitory hormones with releasing and inhibitory hormones of its own. nervous signals control release of these.

6 major ant pit hormones (all peptide)

1) Human growth Hormone (hGH)
stimulates growth in nearly all cells. increases episodes of mitosis, cell size, rate of protein synthesis, mobilizing fat stores. increases aa txport across cell membrane → increases translation, transcription, decreasing breakdown of proteins and aa's.

2) Adrenocorticotropic hormone (ACTH)

stimulateds adrenal cortex to release glucocorticoids via 2nd msnger using cAMP. stimulated by stress. gluco's are stress hormones.

3) Thyroid-stimulating hormone (TSH)

aka thyrotropin. stimulates thyroid to release T3 and T4 via 2nd messenger cAMP. increases thyroid cell size, number, and rate of secretion of T3&4. their concentrations have neg feedback effect on TSH release, both at ant. pituitary and hypothalamus.

4) FSH and 5) LH

6) Prolactin
promotes lacation. inhibited by progesterone and estrogen if baby not yet born. hypothalamus, oddly, inhibits release of prolactin. suckling stimulates hypo to stimulate ant. pituitary to release, inhibits menstrual cycle. also: prolactin produces milk; oxytocin ejects milk.

Posterior Pituitary

aka neurohypophysis. hromones oxytocin and ADH synthesized in hyopthalamus, but txported down axons to posterior pituitary where released into blood. (small peptides).

Oxytocin: small peptide that increases uterine contractions during birth; causes milk ejection

Antidiuretic Hormone / Vasopressin (ADH):
small peptide, causes collecting ducts of kidney to become permeable to water, ↑ H20 reputake, ↑blood Hg. coffee and beer block ADH.

Adrenal Cortex
adrenal glands—on top of the kidneys. contain:
adrenal medulle and **adrenal cotex**: outside portion. secretes only steroid hormones. secretes 2 types of steroids, **mineral corticoids** (affect electrolyte balance in blood) and **glucocorticoids** (↑ [blood glucose], ↑ fat, protein metab). major one is cortisol.

Aldosterone, steroid, mineral corticoid. acts in distal conv. tubule and coll. duct to ↑Na+ and Cl- reabsorption, ↑K+,H+ secretion. ↑bloodHg.

Cortisol: steroid, glucocorticoid. ↑blood glucose by stimulating gluconeogenesis in liver. degrades adipose to fatty acids for energy. a "stress hormone". diminishes immune response.

Catecholamines:
tyr derivatives synth in adrenal medulla; epi and norepi (aka adrenaline and noradrenaline). Similar to sympathetic nervous response, but longer. both are vasoconstrictors of most tissues but they are vasodilators of skeletal muscle. consistent with fight or flight response (give the most blood to the parts of body that will carry you away). "stress hormones"

Thyroid Hormones
Triiodothyronine (T3) and thyroxine (T4) and calcitonin.
T3 and T4: very similar in effect. secretion regulated by TSH. both lipid soluble tyr derivitives, diffusable,a ct in nucleus of cell of their effector. ↑basal (resting) metabolic rate.

Calcitonin – large peptide. ↓blood Ca2+ via ↓osteoclast activity & number.

Pancreas (Islets of Langerhans)
acts as both endo and exocrine gland. 2 important endocrine are insulin and glucagon. also releases somatostatin, which inhibits both ins and gluc.
Insulin: peptide, released by B-cells of panc. α with energy abundance / high [nutrients] in blood. released when blood levels of carbs or proteins high. affects carb, fat, and protein metab. insulin α carbs uptaken as glycogen in liver and muscles, fat as adipose, aa's in cells and made into proteins. → lowers blood glucose. it uses a 2nd messenger, so it binds to receptor. does not affect neurons in brain. all others become highly permeable to glucose upon insulin binding. also,k intracellular metab enzymes activated, and even translation, transcription rates affected.

Glucagon: peptide hormone, released by α-cells of panc. nearly opposite to insulin. stimulates glycogenolysis (glyc breakdown). Acts via 2nd messenger cAMP. in higher []'s, breaks down adipose, increasing fa level in Hb. ↑blood glucose levels.

Parathyroid
4 small parathyroid glands attached to back of thyroid. they release:
parathyroid hromone (PTH) – peptide, ↑Ca2+ in blood. ↑osteocyte absorption of Ca and PO3- from bone and ↑osteoclasts. ↑renal Ca reabsorption, renal PO3 excretion. ↑Ca and PO3 uptake by gut, → renal production of DOHCC (vit D derivative). regulated by plasma ion conc, and glands grow & shrink accordingly.

Reproductive hormones FSH, LH, HCG, and inhibin are peptides. All others are steroids.

Male Reproductive System
male gonads = testes. production of sperm in seminiferous tubules. Spermatogonia located in tubules arise from epithelial to become → spermatocytes → spermatids → spermatozoa.

FSH causes sertoli cells to surround, nurture pre-sperm. lydig cells release testosterone when stimulated by LH. Test is the primary androgen (male sex hormone), stimulates germ cells → sperm. also resp for 2ndary sex characteristics, pubic hair, enlargement of larynx, growth of penis and vesicles.

when spermatid becomes spermatozoon, forms head, midpiece, and tail. head composed of nuclear material and acrosome for penetrating egg. carried to epididymus to mature. propelled thru vas deferens during ejaculation into urethra and out of penis. Semen is mixture of spermatozoa and fluid that leaves penis.

Female Reproductive System
oogenesis-begins in ovaries. all eggs are arrested as primary oocytes at birth. at puberty, FSH stimulates growth. form zona pellucida around egg. primary follicle. theca cells differentiate and form secondary follicle. LH stimulates androgen secretion, conversion to estradiol (type of estrogen). FSH stimulates its release into blood. estradiol is steroid hormone preparing uterine wall for pregnancy. inhibits LH secretion by ant pituitary. just before ovulation (bursting of folicle), estradiol levels rise rapidly, ↑LH secretion. (luteal surge). positive feedback loop. egg swept into fallopian (uterine) tupe or oviduct. remaining portion left behind to become corpus luteum. secretes estradiol and progesterone thruout pregnancy, or if no pregnancy, for about 2 weeks until corpus luteum degrades into corpus albicans.

Menstrual cycle repeats itself every 28 days after puberty until pregnancy. with each cycle, 3 phases
1) **follicular** – development of foillicle, ends at ovulation
2) **luteal**- begins w/ ovulation, ends w/ degeneration of corpus luteum into corpus albicans

3) **flow** – shedding of uterine lining for ~ 5days

in menstrual cycle, all of FSH, LH, and Estrogen peak right before ovulation. Estrogen and progesterone have peaks during secretory phase.

Fertilization and Embryology

once in fallopian, egg swept towards uterus by cilia. fertilization normally takes place in fallopian tube.

sperm entry into egg causes cortical reaction, preventing other sperms from fertilizing. NOW **oocyte** goes thru second meitotic division to become **ovum**, releases 2nd polar body. fertilization occurs when nuclei of ovum and sperm fuse to form **zygote**.

cleavage beings while zygote still in fallopian → many cycles of mitosis. when 8 or more cells, called **morula**. cells here are **totipotent**, or can express any gene.

Form hollow ball called **blastocyst**. lodges in uterus in process called implantation about 7 days after ovulation. egg begins secreting peptide hormone **human chorionic gonadotropin (HCG).** prevents degeneration of corpus luteum, maintains its secretion of estrogen and progesterone. HCG in blood and urine of mother a sign of pregnancy.

placenta is formed from tissue of egg and mother, takes over job of hormone secretion. starts secreting its own estro and progest.

After 8 cells, embryo starts to **differentiate**. committed developmental path – **determination**.

gastrulation forms **gastrula** in 2nd week. **primitive streak** formed in mammals, analagous to **blastopore** in aquatic vertebrates. cells destined to become mesoderm migrate to primitive streak. 3 germ layers formed:

1) **ectoderm** – outer coverings, skin, nails, tooth enamel, cells of nervous system and sense organs.

2) **mesoderm –** the stuff that lies between inner and outer coverings of body: muscle, bone, all the rest.

3) **endoderm –** lining of digestive tract, most of the liver and pancreas.

in 3rd week, gastrula → neurula (neurulation). notochord induces overlying ectoderm to thicken and form into neural plate. Eventually degenerates, while a neural tube forms from neural plate to become spinal cord, brain, and most of nervous system. (Induction is when one cell type affects direction of differentiation of another cell type).

Part of normal cell development is **apoptosis**, programmed cell death.
essential for development of nervous system, operation of immune system, and destruction of tissue b/w fingers and toes to create normal hands and feet. failure to do this → cancer
This is regulated by protein activity instead of transcription/translation level. Mitochondria plays important role. Proteins for apop are present but inactive in healthy cell.

Overview of Hormones

Anterior Pituitary
hGH – Growth of nearly all cells
ACTH – stimulates adr. cortex
FSH – grwoth of follicles (F); sperm prod (M)
LH – causes ovulation; stims estro, testost secretion
TSH – stims release of T3 and T4 in thyroid
Prolactin – promotes milk production

Posterior Pituitary
Oxytocin – milk ejection, uterine contraction
ADH – water absorption by kidney; ↑ Hb Hg

Adrenal Cortex
Aldosterone- ↓Na excretion; ↑K excretion; ↑ Blood Hg.
Cortisol - ↑ blood levels of carbs, proteins, fats

Adrenal Medulla
Epinephrine – stimulates sympathetic actions
Norepinephrine- stimulates sympathetic actions

Thyroid
T3, T4 - ↑basal metabolic rate
Calcitonin - ↓blood calcium

Parathyroid
PH – ↑ blood calcium

Pancreas
Insulin – Promotes entry of glucose into cells, ↓glucose blood level
Glucagon – Increases gluconeogenesis, ↑blood glucose levels

Ovaries
Estrogens – growth of F sex organs, LH surge
Progesterone – prepares, maintains uterus for pregnancy

Testes
Testosterone- 2ndary sex characteristics, closing of epiphyseal plates

Placenta
HCG – stimulates corpus luteum to grow, release estro and progest
Estrogens – " " to a lesser extent
Progesterone – " " to a lesser extent

Digestive and Excretory Systems

Digestion: breakdown of ingested foods bfore absorbed into body. major rxn for macromolecules is hyrdrolysis.

anatomy of digestive tract:
mouth → esophogous → stomach → small intenstine (duodenum, ileum, jejunum) → large intestine (ascending colon, transverse colon, descending colon, sigmoid colon) → rectum → anus.

Digestion begins in mouth w/ **α-amylase**. Starch is major carb in human diet. breaks down long straight cahins into polysaccharides. Chewing increases surface area of food, enables more enzymes to act on it at once. Form a bolus of food. Pushed into esophogous by swallowing and then down esophogous via peristalsis. performed by smooth muscle. no digestion in esophagus.

Stomach
All digestion, no absorption.
bolus enters stomach at cardiac sphincter.
stomach: flexible pouch that stores and mixes food, reducing it to semifluid mass called **chyme.** Has **exocrine glands** with gastric pits. another function of stomach: begin protein digestion with pepsin. low pH assists process by denaturation. full stomach has pH of 2. Helps kill ingested bacteria. 4 types of cells:

1) **mucous cells –** secrete mucous to line stomach wall and necks of exocrine glands. food can slide along wall without damage, protects epithelial lining from acidic environment. also secrete a little pepsinogen.

2) **chief (peptic) cells –** found deep in exocrine glands. secrete **pepsinogen**, the zymogen precursor to **pepsin**. activated to pepsin by low pH. Once activated, begins protein digestion.

3) **parietal (oxyntic) cells –** secrete hydrochloric acid (HCl) which diffuses to lumen. needs lots of energy to do this. CO2 involved, making carbonic acid inside cell. H+ ion expelled to lumen, while bicarbonate ion expelled to interstitial fluid side. net result lower pH of stomach and raised pH of blood. also secrete intrinsic factor, helps ileum absorb B12.

4) **G cells** - secrete gastrin to interstitium. large peptide hormone, absorbed into blood and stimulates parietal cells to secrete HCl.

major hormones that affect secretion of stomach juices:
-acetylcholine: ↑ all types of secretion
-gastrin: ↑ HCl mostly
-histamine: ↑ HCl mostly

Small Intestine

90% of digestion and absorption. 3 parts largest to smallest: **duodenum**, **jejunum**, **ileum**. Most digestion in duodenum, most absorption in the other two. small intestine wall contains **villi** – finger like projections. on apical surface of the cells of each villus cell (enterocytes) are much smaller finger length projections, **microvilli**. fuzzy covering, aka **brush border**. Contains membrane bound digestive enzymes for carbs, as well as dextrinase maltase sucrase and lactase; peptidates for proteins, nucleosidases for n-tides. Some epithelial are **goblet cells**, secrete mucus to lubricate intestine. Lots of cell death and growth here.

villus: capillary network and lymph vessel called **lacteal**. Nutrients absorbed pass thru cappilary and then lacteal.

intestinal exocrine glands deep in villi. secrete pH 7.6 juice and lysozyme (regulates bacteria).

Pancreas
chyme squeezed out of stomach thru **pyloric sphincter** into duodenum.
pancreas has sent bicarbonate, so pH is ~6. Panc also acts as exocrine gland, releasing enzymes from acinar cells thru panc. duct into duodenum.

Major panc. enzymes:

-trypsin: proteins → small polypeptides
-chymotrypsin: " "
-pancreatic amylase: hyrdolyzes polysacch's to disacch's and tri's. much more powerful than salivary.
-lipase- degrades fat, spef. triglycerides. fat is insoluble in aq. soln. reduced surface area unless bile breaks it up. bile produced in liver, stored in gall bladder. released thru cystic duct, empties into common bile duct shared w/ liver. → pancreatic duct → duodenum. **Bile** emulsifies fat, contains bilirubin, changing it

physically but not chemically. increases surface area, allowing lipase to break down into fatty acids and monoglycerides.
-ribonuclease -
-deoxyribonuclease

chyme is moved thru intestines by peristalsis. segmentation is mixing of chyme w/ digestive juices.

The Large Intestine
If get a large intest question, think water reabsorption. profuse water loss in diarrhea results from problem in the LI. know mutualistic symbiosis b/w humans and bacteria there. bacteria get leftovers, we get vitamins
4 parts:
1) ascending colon
2) transverse colon
3) descending colon
4) sigmoid colon

major functions: water abs and electrolyte abs if this fails → diarrhea. LI also has E.Coli. they produce vitamins K, B12, thiamin, riboflavin. healthy feces has 75% water. rest is dead bacteria, fat, inorganic matter, etc.

Gastrointestinal Hormones
don't need to know them but may appear. just understand idea of digestion. body eats to gain energy in form of food. digestive system breaks down food so it can be absorbed into body. one prob is that food may move to fast and come out undigested. stomach stores food, releases small amnt at time to be digested / absorbed by intestine. that way body can take in large amnt at a single time and take a long time to digest. GI hormones just help to regulate this process.

secretin – responds to HCl in duodenum.
cholecystokinin – responds to food in duodenum
gastric inhibitory peptide – responds to fat / protein in duodenum.

Absorption and Storage overview
convert ingested food into basic nutrients that small intestine is able to absorb. once absorbed into enterocytes, nutrients processed and carried to indiv. cells for use. Quick and dirty overview of the 3 main nutrients, carbs, proteins, fats…

Carbohydrates – 80% glucose. absorbed via 2ndary actie transport down conc. gradient of sodium. all absorbed into bloodtream and carried by portal vein to liver. liver's job is to maintain constant blood glucose level. liver converts the carbs to glucose and then glycogen, breaks down when needed. when glycogen stores are full, glucose is converted to fat for long-term storage. For big picture, think about glycolysis and kreb's cycle.

Proteins – virtually all dietary protein is broken down completely into aa's before being absorbed into blood. When you hear proteins, think "nitrogen." Uses cotransport mechanism.
ammonia is by-product of gluconeogenesis from proteins. nearly all NH3 converted to urea by liver and then excreted in urine by kidney.

Fats: fat is insoluble in water, so needs carrier, such as albumin (a lipoprotein). hear "fat" think "long-term energy storage, lots of calories (energy) with little weight.
most dietary fat consists of triglycerides. shuttled via bile micles to brush border of sm. intestine.
energy rate (cal per gram)
Fat > carbs > protein
but takes diff amnt of energy to break down globules called **chylomicrons** move into **lacteals** of the **lymph**. emptied into large veins at throactic duct. from adipose, most fa's transported as free fa, which combines immediately in blood w/ albumin.

The Liver
positioned to receive blood from capillary beds of intestines, stomach, spleen, and pancreas via **hepatic portal vein**. leads eventually to vena cava.

Functions:

Blood storage: liver can expand to act as Hb reservoir for body
Blood filtration: kupfer cells phagocytize bacteria picked up from intestines
Carbohydrate metabolism: liver maintains normal blood glucose levels thru gluconeogenesis, glycogenesis, and storage of glycogen.
Fat metabolism: liver synthesizes bile from cholesterol and converts carbs, proteins into fat. oxidizes fa's for E, forms most lipoproteins.
Protein metabolism: liver deaminates aa's, forms urea from NH3 in the Hb, synthesizes plasma proteins such as fibrinogen, prothrombin (important clotting factors) albumin (major osmoregulatory protein in Hb), and most globulins (group of proteins and antibodies), and synthesizes nonessential aa's.
Detoxification: detoxified chemicals excreted by liver as part of bile or polarized so may be excreted by kidney.
Erythrocyte destruction: Kupfer cells also destroy irregular erythrocytes. Mostly done by spleen.
Vitamin storage: liver stores vitamins A, D, and B12. also stores iron combining with protein apoferritin to form ferritin.

when liver metabolizes fat for E, produces ketone bodies. → **ketosis / acidosis.**
when liver metabolizes fat or protein for energy, bloody acidity increases ↓pH.

The Kidney
3 functions:
1) excrete waste: urea, uric acid, NH3, PO3.
2) maintain homeostasis of body fluid V, solute composition.
3) control plasma pH.

2 kidneys. each is made up of **outer cortex** and **inner medulla**. Urine created by kidney and emptied into the **renal pelvis**. emptied by **ureter**, which caries urine to **bladder**, drained by **urethra**.

nephron: functional unit of kidney. blood flows first into capillary bed of nephron called **glomerulus**. **Bowman's capsule** and glomerulus make up the **renal corpuscle**. Hydrostatic pressure forces some plasma through **fenestrations** of golmerular endothelium and into Bowman's capsule. fenestrations screen out blood cells and large proteins from entering the capsule. fluid entering is called **filtrate**. moves to **proximal tubule**. where **reabsorption** takes place. 2ndary active transport proteins on apical membranes of prox tubule cells, reabsorb nearly all glucose, most proteins, and other solutes. transport proteins become saturated until reach **transport maxiumum**. any more solute washed into urine. some solutes reabsorbed by passive or facilitated diffusion. Water is rabsorbed into renal interstitium of prox tubules across relatively permeable tight junctions down the osmotic gradient.

drugs, bile, uric acid, antibiotic, toxins, other solutes **secreted** into filtrate by **proximal tubule**. H ions secreted thru antiport system w/ Na. → net result: reduce amnt of filtrate in nephron w/o changing osmolarity.

from prox tubule, filtrate flows into **loop of Henle**. loop dips into medulla. function is to increase solute concentration and thus osmotic pressure of medulla. water passively diffuses out of loop of Henle and into medulla. descending loop has low permeability to salt, so filtrate osmolarity goes up. as filtrate rises out of medulla, salt diffuses out of ascending loop, passively at first, then actively. ascending loop is nearly impermeable to water. 2nd capillary bed called vasa recta surround loop and helps to maintain [ ] in medulla.

Distal tubule: reabsorbs Na+ and Ca2+ while secreting K+, H+, and HCO3-. Aldosterone acts on distal to increase sodium and potassium memb transport proteins. Net effect: lower filtrate osmolarity. **collecting tubule**: at end of the distal, ADH acts on it to increase permeability to H20. → more concentrated filtrate. empties into **collecting duct**. cd carries filtrate into highly osmotic medulla. impermeable to water, but sensitive to ADH. if ADH, permeable to water, urine is more concentrated. → renal calyx → renal pelvis.

Juxtaglomerular Apparatus
-monitors filtrate pressure in distal tubule.
-**granular cells** secrete **renin**.
→ initiates regulatory cascade of angiotensins I, II, and III. → adr. cortex secretes aldosterone. → distal tubule forms proteins to absorb sodium and secrete potassium.

ADH = "Always Digging Holes" in the collecting duct.

Overview: know function of each section of the nephron: filtration occurs in renal corpuscle; reabsorption and secretion mostly in proximal tubule; loop of Henle concentrates solute in medulla, distal tubule empties into the collecting duct; collecting duct concentrates urine. Amnt of filtrate is related to hydrostatic pressure of glomerulus. Descending loop of henle is permeable to water, and ascending loop is impermeable to water and actively transports sodium into Kidney.

big picture: function of kidney is homeostasis.

Cardiovascular Anatomy
consists of heart, blood, and blood vessels. for MCAT, must be able to trace

circulatory path of blood:

left ventricle, pumped through aorta. from aorta, branch with many smaller arteries, which branch into still smaller arterioles, which branch into still smaller capillaries. collected into venules, which themselves collect into larger veins, which collect again into superior and inferior vena cava. the vena cava empty into the right atrium of the heart. systemic circulation – 1st half.

from right atrium, blood squeezed into right ventricle, r ventr pumps blood through pulmonary arteries to arterioles to capillaries of lungs. from lung capillaries, blood collects in venules, then veins, finally in pulmonary veins leading to heart. pulmonary veins empty into left atrium, which fills left ventricle. 2nd half of circulation is called pulmonary circulation. Closed circulatory system for humans.

concentrate on function: left v contracts w/ the most force to propel the blood through systemic circulation

Heart is large muscle. Not attached to bone. **Systole** occurs during contraction; **diastole** during relaxation of entire heart, and then contraction of atria.

Blood is propelled by hydrostatic pressure created by contraction of heart. Rate of contractions controlled by ANS. Not initiated by ANS, though. Contracts automatically by specialized cells called **sinoatrial node (SA node)** located in R atrium. spreads contractions to surrounding muscles via electrical syapses via **gap junctions**. SA pace is faster than normal heartbeats but parasymp **vagus** innervates SA node, slowing contractions. AP generated by SA nodes spreads around both atria causing them to contract and spread to **AV note**. AV is slower to contract. from AV node, moves to **bundle of His** (on wall separating ventricles). spread to **Purkinje fibers**. AP is spread through muscle.

must know the vagus nerve. parasympathetic, innverates heart and digestive system. slows rate of heart contractions and increaes digestive activity of enzymes. Know role and location of purkinje fibers.

Arteries: elastic. stretch as fill w/ blood. when ventricles fully contract, stretched arteries recoil. smooth muscle; innervated by sympathetic nervous system.

Epinephrine: powerful vasoconstrictor causing narrowing of arteries.
Medium-sized arteries constrict under sympathetic stimulation; large ones less affected.

Arterioles: very small. Wrapped by smooth muscle. constrict/dilate to regulate blood pressure, also rerouting.

Arteries – blood away from heart. Not always oxygenated. Pulmonary arteries contain the most deoxygenated blood in the body.
Veins – blood to heart.

Capillaries – microscopic blood vessels. only 1 cell thick. this is where nutrient and gas exchange happens. 4 methods of crossing:
1) Pinocytosis
2) diffusion or transport through cap memb's
3) movement thru cell fenestrations
4) movement thru space b/w cells

found close to all cells of body.
as blood flows:
-hydrostatic P > osmotic P at artery end
→ net fluid out of capillary, into interstitium
-osmotic P > hydrostatic P towards venule end

Venules and veins – similar in structure to arterioles and veins.

larger lumen than arteries, containing far greater V of blood.

blood velocity α 1/cross-sectional area

blood moves slowest through capillaries
Bernouli's equation states that
Pressure α 1/cross-sectional area
this is not the case for blood, because not an ideal flow.

Pressure: Hb Hg ↑ near the heart and ↓ at capillaries.

Velocity: single artery bigger than capillary, but far more capillaries than arteries. Blood follows continuity equation Q = Av, so velocity is greatest in arteries' cross sectional area is smallest.

Respiratory System
provides path for gas e/x b/w external enviro and blood. Air enters through nose, moves through pharynx, larynx, trachea, bronchi, bronchioles, and into alveoli where O2 is e/x for CO2 w/ the Hb.

Inspiration occurs when medulla oblongata sends singal to diaphragm to contract.
-diaphragm is skeletal muscle and innervated by phrenic nerve. if relaxed, dome-shaped. flattens upon contraction. chest expands.

nasal cavity: space inside nose.
filters, moistens, and warms incoming air.
coarse hair, mucus secreted by goblet cells.
Cilia move mucus and dust.

pharynx (throat)- passageway for food + air

larynx (voice box) – behind epiglottis which prevents food from entering trachea during swallowing. contains vocal chords.

trachea (windpipe)- lies in front of esophogous. composed of ringed cartilage. contains mucous and cilia, usher dust towards pharynx. trachea splits into L and R **bronchi**. each bronchi branches into tiny **bronchioles**, terminating into grape-like clusters **alveoli**. There, O2 diffuses into capillary where picked up by red Hb cells. they release CO2, which diffuses into alveolus and expelled upon **exhallation**.

Since microtubules found in cilia, and ciliated cells in respiratory tract (and fallopian tubes and ependymal cells of spinal cord), a problem in microtubule production might result in breathing problems (or fertility or circulation of cerebrospinal fluid).

Chemistry of Gas Exchange
air inhaled: 79% N2, 21% O2.
air exhaled: 79% N2, 16%O2, 5% CO2.
inside lungs, partial pressure of O2: 110mmHg.
CO2: 40 mmHg
→ O2 moves into capilaries, CO2 leaves to alveoli.

98% of O2 in blood binds rapidly and reversibly with protein **hemoglobin** inside the erythrocytes forming oxyhemoglobin. Composed of 4 polypeptide subunits, each with single **heme cofactor**. (has iron atom center). Each of 4 Fe atoms can bind with one O2 molecule. Binding / Unbinding accelerates the same thing for nearby ones. → "cooperativity"

As O2 pressure ↑,
O2 saturation of Hb ↑ sigmoidally
Oxyhemoglobin (HbO2) dissociation curve:
-shows % Hb bound to O2 at varies pp's of O2. arteries of normal person breathing air, O2 saturation is 97%. straight portion show small fluctuations have little effect.

↑P(Co2) α ↑ [H+] α ↑Temp

O2 saturation of Hb also dependent on CO2 pressure, pH, and T. **O2 dissociation curve shifted to right by increase in CO2 pressure, hydrogen ion concentration, or temperature.**
→ lowering of Hb's affinity to O2. If CO poisoning, pure O2 can be administered to replace.

O2 P usually 40mmHg in body tissues
CO2 carries by blood in 3 forms
-physical soln
-bicarbonate ion → 80% of the time
-carbamino cpds

bicarb ion formation governed by carbonic anhydrase in reversible rxn:
CO2 + H20 → HCO3- + H+

When CO2 absorbed into lungs, bicarb diffuses into cell. To balance, chlorine is expelled.

↑CO2 pressure α ↑ Hb content of CO2.
when Hb saturated with O2 α ↓CO2 affinity

Rate of breathing affected by central chemoreceptors in medulla. also peripheral ones in cartoid arteries and aorta. Increase breathing when CO2 concentration gets too high.

Nitrogen's effect on body: extremely stable bc of triple bond. diffuses into blood, but doesn't interact. Divers: more pressure, more N2 diffused. bubbles→ the bends

Lymphatic System

-collects excess interstitial fluid, returns it to blood
-takes up proteins and large particles that capillaries cannot take up
-monitors for infection.
-reroutes low soluble fat digestates around small capillaries of intestine into large veins of neck.
-Drains almost all tissues except CNS.
-open system

Fluid is propelled in 2 ways
1) smooth muscle contracts when stretched
2) may be squeezed by adjacent skeletal muscles

empties into large veins @ thoracic duct and R lymphatic duct. All throughout, many lymph nodes containing large quantities of lymphocytes.

Blood

Blood is **connectivie tissue**: contains cells + matrix. regulates extracellular movement of body by transporting nutrients, waste products, hormones, even heat. also involved in immune

blood in centrifuge separates into **3 parts**:

Plasma (matrix: water, ions, urea, ammonia, proteins, etc.). Contains proteins **albumin** (txports fatty acids, steroids), **immunoglobulins** (antibodies), and **clotting factors** (eg, fibrinogen).

Buffy Coat (white blood cells). Aka **Leukocytes**. no Hb. protection from invaders. neutrophils, eosinophils, and basophils are **granular leukocytes**. live shorter bc are nonspecific infection fighters. **Agranular** include mono, lympho, and megakaryocytes. Live longer bc respond specifically to infectious agents. need to hang around for when they return. monocytes become macrophages.

Red blood cells (35-50%). Aka **Erythrocytes**. bags of hemoglobin. No organelles, no nucleus. no mitosis or meiosis. disk shaped. main fx to deliver O2 and remove CO2.

All blood cells differentiated from stem cells, in bone marrow.

Platelets: small portions of memb-bound cytoplasm. agranular. adheres to, activates other platelites when encounters injured endothelium.
→ coagulation. 3 steps
1) **a dozen factors** form coagulation complex called protrombin activator
2) **protrombin** activator catabolizes conversion of prothrombin into thrombin
3) **thrombin**: enzyme that governs polymerization of protein fibrinogen to fibrin threads that attach to platelits. Bloot clot formation (coagulation) appears in seconds in small injuries.

Immune System
innate immunity – generalized protection against most intruding organisms, toxins. Includes skin barrier, stomach acid, phagocytotic cells, and chemicals in blood.

acquired immunity- attacking specific organisms or toxins after recognition.

Inflammation: caused by histamine, prostaglandins, lymphokines. dilation of blood vessels, ↑ capillaries, tissue swelling, migration of granulocytes, macrophages to inflamed area.

when neutrophils and macrophages engulf dead tissue/bacteria, they die and become pus. Eosinophils mostly against parasitic infections Basophils release chemicals for inflamm rxn

2 types of acquired immunity:
-humoral/B-cell immunity promoted by B lymphocytes. differentiate, mature in bone marrow, liver. capable of making single antibody, displays it on membrane. will recognize antigen. macrophages present antigenic determinants of engulfed microbes on their surfaces. if B lymph recognizes, then helper T cell, differentiates into plasma cells and memory B cells. → synthesize free antibodies, releasing into blood. antibody attached to mast cell, releasing histamine, etc. cause antigenic perforation. antibodies may cause antigenic substance to agglutinate. may mark for destruction by macrophages or natural killer cells. primary response. Memory b cells proliferate and remain in body. 2ndary response. much shorter.

effective response against bacteria fungi, parasites, viruses, blood toxins.

-cell-mediated/T-cell immunity

Cell-mediated immunity involves **T-lymphocytes**. effective against infected cells. mature in thymus. antibody like protein at surface. unlike B cells, never make free antibodies. tested against self-antigens. if responds to self-antigen, it is destroyed. if passes test, allowed to circulate in blood & lymph. Differentiate into:

-helper T cells: assist in activating B lymphocytes. the ones attacked by HIV
-memory T cells: similar to memory B cells.
-supressor T cells: negative feedback.
-killer / cytotoxic T cells: bind to antigen-carrying cell; release perforin, punctures and kills antigen-carying cell. can kill many cells. implicated in cancer fighting and transplanted tissue.

Overview of Infection
first: Inflammation. macrophages, neutrophils engulf bacteria. Interstitial fluid flushed to lymphatic system where lymphocytes wait in their nodes. Macro's process and present antigens to B lymphocytes. W/ Helper T cells, B lymphocytes differentiate into memory and plasma cells. Prepare for future attack. plasma cells produce antibodies.

Know a single antibody is specific for a single antigen, and a single B lymphocyte produces only 1 antibody type.

Blood Types

defined by the A and B surface antigens. if type A, then you don't make A antibodies, of course. Type O has neither A nor B antigens, but makes both A and B antibodies. Blood donor may only donate to an individual that does not make antibodies to donors blood. O may donate to anyone; individual with AB may receive from anyone.

Genes that produce A and B antigens are codominant. Type O is 2 recessive alleles. A or B may be hetero or homozygous.

Rh factors: surface proteins on red blood cells. Rh-negative or Rh positive. usually mild w/ transfusions. Important during pregnancy of an Rh-negative mother with Rh-positive fetus. 1st pregnancy, mother not exposed to fetal blood until birth. but by 2nd birth, has developed imune response. Can attack baby if not caught early.

Muscle, Bone, and Skin

Muscle
3 types of muscle tissue:
1) skeletal
2) cardiac
3) smooth

muscle contraction has 4 possible functions:
1) body movement
2) stabilization of body position
3) movement of substances thru body
4) generating heat for homeostatis

Skeletal Muscle
voluntary muscle tissue; can be consciously controlled. connects one bone to another. attaches to the **tendon** attached to the bone. usually stretches across a joint.

Muscles work in groups,

antagonistic:

- the **agonist contracts**
- the **antagonist stretches**
example: upper arm muscle – biceps and triceps.

OR

synergistic:

-movement / posture.

ligaments connect bone to bone.

shivering - involuntary skeletal movement controlled by hypothalamus to generate heat.

Physiology of Skeletal Muscle Contraction
sarcomere: smallest functional unit. composed of many strands of 2-protein filaments, **thick and thin**. surrounded by endoplasmic reticulum of muscle cell called **sarcoplasmic reticulum.** – its lumen is filled with Ca2+ ions. lots of mitochondria, nuclei. skeletal muscle is **multinucleate.** sarcolemma wraps several myofibrils together to form a muscle cell or muscle fiber. many fibers bound into fasiculus, fasiculae into single muscle.

Know that during contraction, H zone and I band get smaller, while A band does not change size.

thick filament of sarcomere made up of **myosin.** globular heads protrude along both ends of thick filament. thin filament is mostly globular protein **actin**. attached are troponin and tropomyosin.
Myosin and actin work together sliding alongside to make contractile force of muscle.

Each **myosin head** crawls in **5 stage cycle.**
1) tropomyosin covers active site on actin; prevents myosin head from binding. myosin head remains "cocked" in high-energy position with phosphate and ADP attached.
2) Presence of Ca2+ ions: troponin pulls tropomyosin back, exposing active site, allows myosin head to bind to actin.
3) Myosin head expels phosphate and ADP and bends into low-E position, dragging actin with it. called "power stroke" bc of shortening of sarcomere and muscle contraction.
4) ATP attaches to myosin head, releasing it from active site, which is covered immediately by tropomyosin.
5) ATP → PO3 + ADP → causes myosin head to cock into high-E position.

Cycle repeats many times to form a contraction. Ca2+ is important.

muscle contraction begins with AP. neuron attaches to muscle cell: **neuromuscular synapse.** AP of neuron releases ACh into cleft. activates ion channeles in sarcolemma of muscle cell creating AP. AP moves deep into muscle cell via small tunnels in membrane called **T-tubules.** allows for uniform contraction by allowing to AP to spread more rapidly. AP spreads to sarc retic, allows in Ca2+ ions. begin 5 stage cycle. at the end of the cycle, Ca2+ is "reuptaken" by sarc retic.

A Motor Unit
fibers thruout muscle innervated by single neuron.
neuron + fibers = **motor unit**
smaller mu's react quicker than large ones. smooth motion works via this process.
fingers: small mu's, intricate movement
back: large mu, large force

Skeletal Muscle Type
3 types:
1) **slow oxidative** (type I) fibers. "slow twitch". Red. large amounts of **myoglobin**, (O2 storing protein similar to Hb, but can only store one molecule of O2.) lots of mitochondria. slow at splitting ATP. slow to fatigue, but slow to contract.
2) **fast oxidative** (type IIA) fibers. "fast twitch." also red. split ATP at high rate. contract rapidly, not as resistant to fatigue as slow.
3) **fast glycolytic** (type IIB) fibers. "fast twitch B." low myoglobin. appear white. contract rapidly, lots of glycogen.

Most muscles in body mixture of these 3. Depends where… Posture muscles mostly type I. type IIA in legs. type IIB in upper arms.

Adult human skeletal muscle: so specialized they don't do mitosis. Instead, they change due to force. including: diameter of muscle fiber ↑, number of sarcomeres and mitochond ↑, sarcormeres' length ↑. Changes referred to as hypertrophy.

Cardiac Muscle
heart: mostly cardiac muscle. striated, composed of sarcomeres. Each cell only 1 nucleus. separated from others by intercalated disc (contain gap junctions, allowing AP to spread via synapse). mitochondria of cardiac cell much larger and more numerous than skeletal. also, not connected to bone. forms a net, contracts upon itself like squeezing fist.
-involuntary
-grows via hypertrophy
-AP has plateau after depolarization
→ caused by Ca2+ entry from voltage gated channels.

Smooth Muscle
mostly involuntary. innervated by ANS. like cardiac, only 1 nucleus. thick and thin filaments, but not organized into sarcomeres. contain intermediate filaments, connected to dense bodies. when contract, cause intermediate filaments to pull dense bodies together. smooth muscle cell shrinks length-wise.

2 types of smooth muscle:
1) **single-unit**: visceral. most common smooth muscle. connected by gap junctions, spreading of AP. cells can contract as single unit. found in small arteries and veins, stomach, intestines, uterus, urinary bladder. many cells innervated by 1 neuron.
2) **multi-unit**: each multiunit muscle fiber attached directly to a neuron. 1 cell, 1 neuron. group of fibers can contract independently. large arteries, bronchioles, iris, etc.

Also contract/relax in presence of hormones, changes in in pH, O2, CO2 levels, T, ion conc's.

Bone
living tissue
supports soft tissue, proects internal organs assists in movement of body, minteral storage, blood cell production. energy storage, too: adipose in bone marrow.

4 types of cells surrounded by matrix:
1) **Osteogenic/Osteoprogenitor** cells: differentiate to osteoblasts
2) **Osteoblasts**: secrete bone-forming collagen. –incapable of mitosis. differentiate into osteocytes as they release matrix around themselves.
3) **Osteocytes**: also incapable of mitosis. E/x nutrients and waste w/ blood
4) **Osteoclasts**: reabsorb bone matrix, releasing
minterals back to blood. Develop from WBC called monocytes.

Spongy bone – contains red bone marrow, site of RBC development (homopoiesis).

Compact bone – surrounds medullary cavity, holds yellow bone marrow. contains adipose. highly organized.

Compact bone remodeling process: osteoclasts burrow tunnels, called **Haversian** canals. Osteoblasts then lay down new matrix fofrming concentric rings, **lamellae**. Osteocytes exchange nutrients via canaliculi. H canals contain blood and lymph vessels, connected by crossings called **Volkmann's canals**. Entire system of lamellae and H canal called "osteon."

Bone Function in Mineral Homeostasis
Ca salts mostly insoluble. usually bound to proteins in blood. Free Ca2+ in blood is important concentration.

too much: membranes hypo-excitable → lethargy, fatigue, memory loss
too little: cramps and convulsions.

Most calcium stored in bone matrix ashydroxyapatite.

Bone Types and Structure
4 types: long (finger, arm), short (ankle or wrist), flat (skull, ribs, made of spongy bone), or irregular.

Bone is not just for support, protection, and movement. Also stores calcium and phosphate, maintains their concentrations in blood. Stores energy in adipose. Also, site of blood cell formation.

Cartilage
flexible, resilient, connective tissue. mostly collagen. great tensile strength. no blood vessels or nerves except in outside membrane called perichondrium.
3 types: 1) hyaline 2) fibrocartilage 3) elastic
hylaine most common. reduces friction and absorbs shock in joints.

Joints
3 types
1) **Fibrous** – b/w 2 bones closely/tightly together. little or no movement. eg skull bones or teeth w/ mandible
2) **Cartilaginous**: - also restricted movement. b/w 2 bones connected by cartilage, ribs/sternum, eg.
3) **Synovial**: not bound directly by innervating cartilage. separated by capsule filled w/ synovial fluid. allows lubrication and nutrients to cartilage. also has phagocytic cells that remove microbes from wear/tear. allow for lots of **movement**.

Skin
considered organ. group of tissues working together.

FUNCTIONS:
1) **Thermoregulation**: blood conducts heat to skin. hairs excreted and can trap heat. skin has warmth and cold receptors.
2) **Protection**: physical barrier against bacteria, dehydration chemicals, UV rays
3) **Environmental Sensory Input**: skin gathers info from environment. sense T, P, pain and touch.
4) **Excretion**: water and salts excreted.
5) **Immunity**: specialized cells of epidermis are components of immune system. besides being a barrier.
6) **Blood reservoir**: vessels in dermis hold 10% of our blood.
7) **Vitamin D synthesis**: UV rays activate molecule in skin that is precursor to vit D. modified by enzymes in liver and kidneys to become the vitamin.

2 PARTS

1) **epidermis**: avascular epithelial. made up of keratinocytes for waterproofing. melanocytes for melanin (pigment). Langerhans for interaction with helper T cells of immune system. Merkel cells attach to sensory neurons for sensation of touch.
5 strata
deepest layer is Merkel cells and stem cells. continually divide to produce keratinocytes and others. Keratinocytes rise to the top layer. as they rise, accumulate keratin and die, losing cytoplasm and nucleus, etc. at top layer, slough off and die. 2-4 week process. pressure or friction stimulates thickening called callus.

2) **dermis**:
fat beneath skin important insulator for body. connective tissue from mesoderm. embedded by Hb vessels, nerves, glands, hair folicles. collagen and elastic fibers → strength.

Meissner's corpuscle – touch
sebaceous gland – oil
Pacinian corbuscle – vibration

Populations

Mendelian Concepts
Mendel, monk, crossed purple flowered plants w/ white flowered. first filial, F1, produced purple flowers. → purple dominant, white recessive. 2nd generation had mendelian ratio of 3:1 dominant to recessive.

test cross – Mendel crossed unknown purple F1 w/ homozygous recessive (white) parent. White offspring of this proved F1 was heterozygous

phenotype – expression of trait
genotype – genetic makeup

complete dominance: two homologous chromosomes. corresponding genes @ same locus on respective chromosomes. (homozygous dominant) When there is no blending of dominant and recessive.

partial / incomplete dominance – blend of dominant and recessive.

codominant – both traits exhibited.

Each gene contributes to an allele to genotype. 1 dominant + 1 recessive = heterozygous = "hybrid"

(1st) Law of Segregation – alleles segregate independently when forming gametes. 50% chance of possess any allele.

Inbreeding: what mendel did. does not change %'s of alleles but causes homozygotes ↑

Outbreeding is mating of nonrelatives → heterozygotes ↑

Punnett square – predicts genotypic ratios.
dihybrid cross
Ww+Gg x Ww+Gg → 9 y, r
3 y, w
"dihybrid cross" 3 g, r
1 g, w

9:3:3:1 = phenotypic ratio of dihybrid cross

(2nd) Law of Independent Assortment – genes on diff chromosomes assort independently. closer genes are on a chromosome, more likely they will stay together.

male vs. female chromosomes
23rd pair establishes sex of individual.
aka "sex chromosome"

The pair of sex chromosomes appear as an X and a Y. If found on either, gene considered sex-linked. woman is carrier if she has one recessive sex-linked gene.

Barr body – condensed X chromosome in somatic cells.

Hemophilia – sex-linked disease. sex-linked = X-linked = males have 1 in 2 chance of disease.

Evolution

gene pool – total of all alleles in population
Evolution – change in gene pool (not just phenotype)

Ordering system for organisms:
Kingdom > Phylum > Class > Order > Family > Genus > Species

Ontogeny recapitulates phylogeny = course of development from embryo to organism reflects humans' evolutionary history. e.g., human fetus has pharyngeal pouches → gilled ancestor.

3 new superkingdoms called "domains"
1) Bacteria 2) Archaea 3) Eukarya

Species – usually all organisms that can produce fertile offspring with each other.

speciation – geographic isolation, habitat isolation, seasonal isolation, mechanical isolation, gametic isolation, developmental isolation, hybrid sterility, selective hybrid elimination, and behavioral isolation.

niche – way species exploits their environment

survival of the fittest – one species will exploit environs more efficiently – leading to extinction of other with same niche.

2 operating reproductive strategies
r-selection: large numbers of offspring with no parental care
K-selection: slow maturing offspring, strong parental care → sigmoidal growth curve leveling off at carrying capacity.

Adaptive radiation – several species arise from single ancestral species.

evolutionary bottleneck: shift in allelic frequencies of survivors of a crisis.

Divergent evolution – 2 or more species evolving from same group from common ancestor.

Convergent evolution – 2 species independently evolving similar structures → homoplastic structures. eg, wings of bats and birds. no common ancestor, but common structure.

Some phenotypes vary gradually w/in species, such as height. Those that are distinct (yellow or white petals) is called polymorphism.

Symbiosis – rel'ship b/w two species. if beneficial for both → **mutualism**.

beneficial for only one but neutral for other → **commensalism**.

Benneficial for one, detrimental for other → **parasitism**.

Hardy-Weinberg Equilibrium

There should be no change in gene pool of sexually reproducing population posessing 5 following conditions:

1) large population
2) mutational equilibrium
3) immigration or emigration does not change gene pool
4) random mating
5) no selection for fittest organism.

No population has all 5 characteristics. Small populations subject to genetic drift → one allele permanently lost due to death of all the carriers.

Binomial theorem:

$p^2 + 2pq + q^2$

predicts genotypic frequency w/ only 2 alleles in population

so if A is dominant and a is recessive, and they are only alleles for specific gene.

if 80% of genes are A, 20% a.
Same percentages for gametes.
Probability that two A's come together is
0.8 squared = 0.64 64%
Two s's come together
0.2 squared = 0.04 = 4%
All remaining = heterozygotes
32%

only 2 alleles, so p + q =1.

Origin of Life

universe is 12-15 B yrs old
early earth probably had atmosphere mainly from N2 and H2 gas, very little O2.

Urey-Miller experiments of early earth: autosynthesis of molecules such as urea, amino acids, and adenine from just H2S, NH3, and CH4 methane.

first cells thought to have been coacervates, or lipid protein layer bubbles. spontaneously form from fat.

earliest organisms 3.6 Billion years old.

2.3 B yrs ago → cyanobacteria. first able to use sunlight and water to reduce CO2 (fixate it). First photosynthetic bacteria. → atmosphere fills with O2. Eukaryotes come in at about 1.5 B yrs ago. millions of yrs later → multicellular organisms.

Chordata: phylum that contains humans. means "bilateral symetry" Deuterosomes – anus develops from or near blastopore. vs. proteosomes, where mouth develops from or near the blasteopore. Chordates have coelom (body cavity w/in mesoderm). Posess notochord during development (embryonic axial support), pharyngeal slits, dorsal, hollow nerve cord, and tail.

Vertebrata – subphylum. have notochord replaced by segmented cartilage or bone structure. brain enclosed in skull. Mammals arose from reptiles about 220 million years ago.

MCAT Chemistry

Atoms, Molecules, and Quantum Mechanics

atom: **nucleus** surrounded by e-trons
radius of ~ 10(-4) A. Protons and neutrons.

Neutrons = Protons = ~1 amu each
mass of e-tron about 1/1800th of neutron/proton
e-tron and protons – equal magnitude, opposite charges

1e = 1.6x10e-19 coulombs of charge.

atoms are electrically neutral (vs. ions).
most of the atom is empty space b/w nuc and e

Element – over 100. cannot be decomposed into simpler substances via chemical means.

$^{A}_{Z}X$ → where Z is atomic number, A is mass number

element always has the same atomic number.
protons = constant. isotopes → neutrons vary

isotope – 2 or more of same element w/ different numbers of neutrons. aka "nuclide".

amu = "dalton" = 1 proton = 1 neutron
mass number, Z, is not exact. amu weight is a weighted average of its isotopes.
mole – number of elemental atoms in A grams of element X. Avogadro's number = 6.02e23
moles = grams / molecular weight

Periodic Table
lists elements in order of atomic number
periods = rows
groups = columns

nonmetals on right, metals on left, metalloids diagonal from IIIA to Rn. AT.
Metals – large atoms. Tend to lose e's to form +ions or form + oxidation states (eg, in cpd). fluid nature of valence e's. They are lustrous, ductile, malleable, thermally and electrically conductive.
-They easily form ionic oxides such as BaO
Nonmetals – lower Tm than metals. Form negative ions. Molecular (organic) substances usually made only from nonmetals. Form covalent oxides such as SiO_2 or CO2

Know: alkali metals (IA), alkaline earth metals (IIA), halogens (VIIA), and noble gases (VIIIA).

Elements in same column → similar properties. eg, # of bonds formed, similar charges.
Characteristics w/in Groups
Hydrogen stands out from its family.

1A alkali metals – low densities and Tm's. usually form 1+ cations. highly reactive w/ nonmetals to form ionic cpds. also react with Hydrogen to form hydrides.
2A alkaline earth metals – harder, denser, higher Tm's. form 2+ cations. less reactive than alkali metals.
4A can form covalent bonds w/ nonmetals. All but carbon can form 2 additional bonds w/ lewis bases. only C can form strong dbl / triple
bonds
5A – can form 3 covalent bonds all except N can form five bonds by using d orbitals. 6th covalent if with Lewis base. N can make strong double and triple bonds.
6A – O2 is 2nd most e-negative element. usually exists as O2 and O3. reacts w/ metals to form oxides. Na2S is very commonly found in nature. can form up to 6 bonds.
7A – halogens. stable. highly reactive. Like to gain electrons. Flourine always has oxidation state of -1. others can make more than one bond, sometimes up to 7.
8A – noble gases. unreactive. inert.

Assume HONClBrF is diatomic, especially if MCAT mentions "nonreactive."

small atoms – good p orb overlap → strong pi bonds possible
large atoms – weak p orb overlap → unable to form strong pi bonds. Have d orbitals allowing for more than 4 bonds.

Ions
fewer or greater electrons than protons.
metals → cations; nonmetals → anions.

Common transition metal ions: Cr^{3+} Mn^{2+} $Fe^{2/3+}$ Co^{2+} Ni^{2+} $Cu^{1/2+}$ Zn^{2+} Ag^{+} Cd^{2+} Sn^{2+} $Hg^{(2)2+}$ Hg^{2+} $Au^{1,3+}$ Pt^{2+} Pb^{2+} Bi^{3+}

cations are smaller than anions bc of radius.

Coulomb's law: $F=kq_1q_2/r^2$
describes electrostatic forces holding e to nucleus.

in atoms with more than 1 e-tron, there is e-shielding. 2nd e-tron doesn't feel entire charge. 2nd e'tron's feel of charge called
effective nuclear charge (Zeff) -
Zeff = Z minus avg # etrons b/w nucleus and e'tron in question.

Periodic Trends
Zeff increases left to right. → each electron is pulled in more strongly toward nucleus → smaller atomic radius.
Atomic radius increases from top to bottom.
ionization energy – E required to remove electron. increases from left to right, and from bottom to top. explained by Zeff.
Electronegativity – tendency of atom to attract electron in bond that it shares w/ another atom. Pauling scale goes from 0.79 at bottom-left of chart to top-right, Florine. undefined for noble gases.
Electron affinity – willingness of atom to accept additional electrons. increasees left to right and bottom to top. most exothermic top right.
metallic character increases from right to left, top to bottom.

easy way to remember 5 periodic trends:
if begins with an E, then it increases going to the right and up. If it doesn't begin with E, then it increases oppositely so. ionization energy is known as energy of ionization. Zeff is not considered for this mnemonic. Also, these are just trends, and are violated frequently. Try to group Hydrogen as above Carbon.

top-right trend *– E of ionization, e-affinity, electronegativity.*

bottom-left trend *– Atomic radius, metallic character.*

SI Units, Prefixes – Important for all MCAT Sections
7 base units in SI system:
Mass – kg
Length – m
Time – s
E current- A (ampere)
Temp – K
Luminocity – cd (candela)
Amnt of substance – mol
Force – 1 newton: 1N = 1kg m / s^2

common prefixes:
Mega (M) – 10^6
Kilo (k) – 10^3
Deci – 10^{-1}
Centi- 10^{-2}
Milli (m)- 10^{-3}
Micro (u) - 10^{-6}
Nano (n) - 10^{-9}
Pico (p) - 10^{-12}

Bonds
covalent (shared electrons)
negative e's pulled toward both positvely charge nuclei by electrostatic forces. "tug of war" repulsive and attractive forces balance out until bond length is met (equilibrium, lowest energy).

E required to break bonds, no energy is released. compound is 2 or more elements. ratio is empirical formula.

bond energy – E required to break bond.

% mass of element in molecule = weight of element / weight of molecule

empirical formula from % mass = take 100g sample. put weight of element over its molar mass → # of moles. do the same for the other element. Compare their relative ratios → empirical formula.

Nomenclature

Ionic cpds – named after cation and anion. roman numeral I or II refers to +1 or +2. also, cup**ric** = higher charge, cup**rous** = lower charge. cation name in front of anion name.

Monatomic/simple anions = "ide"
polyatomic anions w/ multiple oxygens: **ite** (fewer) or **ate** (more), depending on # of oxygens. hypo and per are least and most oxygens, respectively.

Acids: named by their anions.

molecular cpds w/ only 2 elements: name begins w/ element towards bottom left.

Chemical Rxns, Eqns
physical rxns are melting, evaporation, dissolution, rotation of light. molecular structure maintained.

chemical rxn – molecular structure changed. eg, combustion, redox. common combustion: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_20$

*MCAT will give balanced eqn unless otherwise stated

runs to completion – runs to right until supply of at least 1 of reactants is depleted. rxns often don't get here bc get to equilibrium first.

limiting reagent – that which would be completely used up if rxn were run to completion

Chemical Yield = Actual / Theoretical x100 → Percent Yield.

Fundamental Rxn Types
Combination: A + B → C
Decomposition: C → A + B
Single Displacement/Replacement:
A +BC → B +AC
Double Dis/Replacement / Metathesis:
AB + CD → AD + CB

Rxn Symbols
Δ means change in. or heat is added if above a rxn arrow.
double arrow means equilibrium can be reached
∩ means there are resonance structures.
[ ] indicates concentration
° indicates standard state conditions

Bonding in Solids
solids can be crystalline or amorphous.
ionic crystals – oppositely charged ions held together by electrostatic forces.
Molecular crystals – composed of individual molecules held together by intermolecular bonds. eg, ice.

Quantum Mechanics
elementary particles can only gain or lose energy in discrete units. eg, walking up stairs.
-Quantum numbers
a set of 4 numbers as ID for an e- in given atom. no 2 e's have same 4.
1st is principal quantum number: n.
designates shell level. the larger, the greater size / E of orbital. outermost shell designated by rows.
Valence e's – contribute most to element's chemical properties. located in outermost shell. typically only s and p shells.
2nd is azimuthal quantum number: ℓ.
designates subshell. these are orbital shapes: s (l =0), p (l=1), d (l=2), and f (l=3).

$\ell = n-1$
s subshells look like sphers
p subshells look like peanuts
3rd: magnetic quantum number: m_l designates precise orbital of subshell. each subshell has possible m_l values from $-\ell$ to $+\ell$. so for first shell n=1, $\ell = 0$, only possible m_l is 0.
For n = 3, 5 possible orbitals with m_l equaling -2, -1, 0, +1, +2.
4th number is e- spin number: m_s can be +½
or + ½. Pauli exclusion principle – no 2 e's can have same 4 coordinates.

Heisenberg Uncertainty Principle
dual nature of matter – wave and particle inherent uncertainty in product of a particle's position and its momentum. on the order of Planck's constant (6.63e-34 J-s).

Energy Level of Electrons
Aufbau principle – each new proton added for new element, new e-tron added, as well. Nature prefers lower E state. more stability. electrons thus look for orbital with lowest e state whenever they add to atom. lowest subshell.

Electron configuration – lowest to highest energy subshells

1s
2s2p
3s3p3d
4s4p4d4f
5s5p5d5f

if we follow arrows, they show us order of increasing energy for subshells. not necessarily in numerical order: eg, 4s subshell lower energy level than 3d.
1s→2s, 2p → 3s, 3p → 4s → 3d → 4p → 5s…
Think of "d" as dilatory in the order.

*total number of e's in your configuration should equal that for atom / ion.

Like charges repel. if placed close to each other, ↑ PE. explains why only 2 electrons can fit into one orbital.

explains **Hund's rule**: e's will not fill any orbital in same subshell until all orbitals in subshell contain @ least 1 electron. unpaired electrons will have parallel spins. (bus to camden)
This is moderated by having to climb an extra energy step.

2p___
2s____
1s__

Before 2p will start filling, 1s and 2s must be paired.

Planck's quantum theory: electromagnetic E is quantized in discrete units.
$\Delta E = hf$
(where h =Planck's constant = 6.6e-34 J-s).

Einstein: if we think of light as particle (ie, photons), we can use same equation.

deBroglie: wave nature of electrons follow equation
$\lambda = h / mv$

when electron falls from higher E rung to lower E rung, energy given off in form of photon.
photon must have frequency which corresponds to energy change **$\Delta E = hf$**
The reverse is true: photon collides w/ electron, it can only bump electron to another rung.

photoelectric effect- one-to-one photon to electron collision. proved light is made of particles (einstein). KE ectrons increases only when intensity is increased by frequency of photons. minimum E required to eject an electron called work function, Φ, of metal.
KE of ejected electron given by E of photon minus work function
$KE = hf - \Phi$

Gases Kinetics and Chemical Equilibrium

gas – loose collection of weakly attracted atoms moving randomly.
STP - 0°C and 1atm
speed – 481 m/s at STP
mean free path – distance traveled by gas between collisions ~ 1600Angstroms

unlike liquids, all gases are miscible w/ each other, regardless of polarity. with time and low temp, heavier gases settle below lighter ones
Ideal gas obeys ideal gas law:
PV = nRT
where P is in atm, V in litres, T in Kelvin, and R is **universal gas constant** (0.082 L-atm / mol K)
ideal gas:
1) zero volume; 2) no forces other than repellant 3) completely elastic 4) avg KE α T

@ STP 1 mole of any gas occupies 22.4 L

partial pressure = total pressure of mixture times mole fraction of gas→
$P_a = X_a P_{total}$
where Xa = moles a / total moles of gas

Dalton's Law – total gas pressure is sum of partial pressures of each gas.
$P_{total} = P_1 + P_2 + P_3 \ldots$.
KEavg = 3/2 RT
valid for both gases and liquids

in sample of gas, KE of molecules will vary from molecule to molecule, but there will be average of the KE of the molecules that is proportional to the T and independent of the type of gas.

Graham's law; $v_1/v_2 = \sqrt{m_2} / \sqrt{m_1}$

Effusion: spreading of gas from high P to low P through a "pinhole."
effusion $rate_1$ / effusion $rate_2 = \sqrt{m_2} / \sqrt{m_1}$
Diffusion – spreading of one gas into another gas or into empty space. approximated by Graham's law.

Real Gases
deviate from ideal behavior when molecules are close together. volume of molecules become significant compared to volume around molecules. High pressure / tiny container, low temp.
Basically, real gases take into account their own volume, so
Vreal > Videal.
2nd, real gases exhibit forces on each other. so
P real **< P** ideal

Chemical Kinetics
study of rxn mechanisms, rates.
typically deals w/ reaction as it moves towards equilibrium (eg, how fast it's achieved).

collision model – reactants must collide.
activation E – threshold
Arrhenius eqn: $k = zpe^{-Ea/RT}$
where z = collision frequency.

rate of rxn increases with T.

Equations for Rxn Rates
rates given in molarity per second (mol/L-s)

$aA + bB \rightarrow cC + dD$

$$rate = \frac{-1}{a}\frac{\Delta[A]}{t} = \frac{-1}{b}\frac{\Delta[B]}{t} = \frac{1}{c}\frac{\Delta[C]}{t} = \frac{1}{d}\frac{\Delta[D]}{t}$$

Intermediates – products of one step, reactants in another. Often at very low concentration.

rate law for fwd rxn
$rate_{forward} = k_f[A]^{\alpha}[B]^{\beta}$
where alpha and beta are the order of each respective reactant, the sum of them are the overall order.

Determining the Rate Law by Experiment
relatively simple.
consider
2A + B + C → 2D
compare a pair of trials at a time
if concentration doubles and rate doubles, then superscript is 1. if rate quadruples with doubled concentration, exponent of 2. if rate does not change with doubling of a concentration, that exponent is zero.

add the exponents → eg, third order.

Reversible Rxns

slow step = rate determining step. steps prior to it can still contribute to rate law.
use equilibrium concentration of any intermediates.

Catalysis
catalyst – substance that increases rate of rxn w/o being consumed or permanently altered lower the Ea. creates new rxn pathway which includes an intermediate
-heterogeneous – in diff phase than reactants and products
-homogeneous – same phase

first order uncatalyzed rxn example:
$rate = k_0[A]$

new one would be (if cat by acid):
$rate = k_0[A] + K_{H+}[H+][A]$

catalyst changes Ea, but not delta G.

Effects of Solvent on Rate
liquids have 100x more collisions than gas.
most with solvent → no rxn.
solvation affects k. they can electrically insulate reactants, reducing forces b/w them.

Equilibrium
chemical equilibrium = fwd rxn rate equals reverse. no change in [pdts] or [rcts]

consider A→B
forward rate law is rate = kf[A]
reverse is rate =kr[B].
they are directly proportional to each other.
@ equilibrium [B] > [A], kf > kr

rate definition
$$\textbf{rate} = \frac{-1}{a}\frac{\Delta[A]}{t}$$
rate at equilibrium is zero. does not mean rxn rate is zero.

$$K = \frac{[C]^c[D]^d}{[A]^a[B]^b} = \frac{\text{Products}^{\text{coefficients}}}{\text{Reactants}^{\text{coefficients}}}$$

equilibrium constant depends only on T
don't confuse with equilibrium itself.
K has no units. proportion → activity.
good for all equations, including non-elementary

*Do not include solids or pure liquids (eg water)

Partial Pressure Equilibrium Constant

rxns for more than 1 pathway. any 2 or more single rxns or series resulting in same products from same reactants must have same Keq.

Kp is partial pressure Keq, n sum of coefficients of products minus sum of coeff of reactants.

Reaction Quotient

For reactions not at equilibrium…
$$Q = \frac{\text{Products}^{\text{coefficients}}}{\text{Reactants}^{\text{coefficients}}}$$

use to predict direction of rxn.
we always move toward equilibrium. Q→K
if Q = K → **equilibrium**; if Q>K, products>reactants than *when at equilibrium*; rxn rate reverse > fwd **left shift**

if Q < K → products < reactants than *when at equilibrium* . rxn rate fwd > reverse. **right shift**.

Le Chatelier's Principle
when a system at equilibrium is stressed, system will shift to reduce stress.
3 stressors
1) addition or removal of pdt or rct
2) changing P of system
3) heating or cooling system

consider the following:
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g) + Heat$

if we add N2 gas to rigid container, rxn moves right. H2 partial pressure also reduced bc it's forward rxn. NH3 and heat created.

if we raise T, rxn pushed to left. NH3 decreased.

if size of container reduced in constant temp, or when solution is concentrated/diluted, rxn moves to side of least gas moles.

Does not always predict correct shift. exceptions include salts, solvation rxns, and nonreactive gas. Helium does not affect equilibrium at all.

Thermodynamics

study of energy and macroscopic properties.
divide universe into system and surroundings.

System	ΔE?	ΔM?
Open	Yes	Yes
Closed	Yes	No
Isolated	No	No

State functions- physical condition of system. pathway independent.
extensive- change w/ amount in system. eg, volume, number of moles.
intensive- independent of system's size. Pressure and temperature, eg.

Heat
aka, "q." movement of E via Always from hot to cold (down the gradient).

1) **conduction** - mollecular collisions. requires physical contact. substances conduct at different conductivity, *k*.

2) **convection** – heat txfer via fluid movements, such as air currents.

3) **radiation**. via e-magnetic waves. all objects at T > 0K radiate some heat, some e-magnetic waves. only type that txfers through vacuum.

Work
any energy transfer that isn't heat.
PV work – a system at rest with no gravitational PE or KE, but pressure and volume change create work.
w = PΔV (constant pressure)

0th Law – temperature exists

3rd law – perfect crystal at 0 K is assigned entropy value of zero. all other substances and all T's have positive entropy value.

First Law of Thermodynamics
E of system and surroundings always conserved.
ΔE = q + w
(where work on system considered positive)

Heat Engines
gas pushes against piston, now held by outside force we can control. heat gas, it expands while at constant T. Total E of gas does not change as it expands. energy of heat we've added changes completely into PV work done by force against piston. heat of liquid gets disipated into a cold reservoir nearby. compressed to original state, back to where we started.

2nd law of Thermodynamics – Heat cannot be changed completely into work in a cyclical process.

reverse of heat engine = refridgerator.

Thermodynamic State Functions: Internal Energy (U); Temperature (T); Pressure (P); Volume (V); Enthalpy (H); Entropy (S); Gibbs Energy (G).

Internal Energy
molecular energy such as vibrational, rotational, translational, etc.
ΔU = q + w

Temperature
how fast molecules are moving / vibrating.
→ hot T bc of more molecular movement.
Described by zeroth law.

avg KE of single molecule in a fluid:
KEavg = 3/2 kT
Kelvin = Celsius + 273
virtually all phys properties change w/ T

Pressure
P of ideal gas is random translational KE per volume.
PV = nRT

Enthalpy
extra capacity to do PV work. cannot be intuited, just memorize equation:

ΔH = ΔU + PΔV

Standard State (not same as STP). = reference form for a substance at any chosen temperature T and P of 750 torr.

Standard Enthalpy of Formation – **ΔH°f** Δ in E enthalpy for rxn that creates 1 mole of cpd from raw elements. the naught symbol indicates standard state conditions. consider water:

H2(g) + fiO2(g) → H20(l)
ΔH°f = -285.8kj/mol

For rxns involving no change in P, ΔH°f = q

Hess's Law: When you add rxns, you add their enthalpies.

ΔH°f reaction = ΔH°f products - ΔH°f rcts

endothermic = positive enthalpy
exothermic = negative enthalpy

top of the hill in a rxn graph = transition state

catalyst lowers Ea of fwd and rev. rxns affects the rate, NOT the equilibrium, and NOT the enthalpy.

Entropy
nature's tendency towards disorder (S)
more likely α more entropy

2nd law of thermodynamics – entropy of an isolated system never decreases.

ΔS(sys) + ΔS (surr) = ΔS (univ) > 0

fwd entropy = (-) reverse entropy

"reversible" = Ea lower than fwd Ea.
irreversible = "" Opposite

Entropy, not energy, dictates direction of rxn. it increases

3rd Law of Thermodynamics – zero entropy for any pure substance @ absolute zero and in internal equilibrium.

entropy units are J/K.

Gibbs Free Energy

equilibrium achieved by maximizing entropy of universe.

ΔG = ΔH – TΔS

a negative ΔG usually implies spontanaeity
it is a state function. non-PV work. eg, contracting muscles, transmitting nerves, batteries.
deals with change of enthalpy / entropy of a system.

If + enthalpy, -entropy → nonspontaneous
If – enthalpy, +entropy → spontaneous

higher T favors direction favored by entropy

Solutions

solution: homogenous mixture of 2+ cpds in single phase, eg, solid, liquid, gas.
solvent: compound which there is more of.
solute: cpd of which there is less.

Colloids
like soln, but only solute particles are larger.
eg, hemoglobin. usually can't pass semipermeable membrane.

More Solutions
dissolved – when solute is mixed w/ solvent
like dissolves like – nonpolar solvents dissolve nonpolar solutes, etc.
London dispersion forces – hold together nonpolar molecules. weak interactions.
Ionic cpds – dissolved by polar solvents. break into cations and anions surrounded by respectively charged ends of polar solvent. called **solvation**. Water does this really well. H+ sides of H20 would surround Cl- ion, whereas O- side would surround Na+ ion. water-solvated = **hydration.** said to be in aqueous phase.
water is poor conductor of electricity unless it contains **electrolytes**, cpds that form ions in aq soln.

Be aware of some common ions:
nitrite NO_2^-, **Nitrate** NO_3^-, **sulfite** SO_3^{2-}, **sulfate** SO_4^{2-}, **hypochlorite** ClO^-, **cholrate** ClO_3^-, **perchlorate** ClO_4^-, **carbonate** CO_3^{2-}, **bicarbonate** HCO_3^-, **phsphate** PO_4^{3-}

Units of Concentration
Molarity (M) = moles solute / volume solution
Molality (*m*) = moles solute / kg solvent
Mole fraction (*X*) = mols solute / all mols
mass % = mass solute / total mass soln x 100
ppm = mass solute / total mass soln x 10^6
"parts per million"

Soln concentrations always given in terms of the form of the solute before dissolution
eg, 1 mol NaCL + 1 L H20 = approximately 1 molar solution NOT 2 molar, even though NaCl goes to 2 ions.

Normality measures number of protons per acid. H_2SO_4 would be 2 normal, whereas HCl would be 1 normal.

Solution Formation
Physical rxn:
3 steps: 1) breaking of solute molecules, 2) breaking of solvent molecules, 3) forming intermolecular bonds b/w solvent and solute.

E required to break bond.
heat of soln given by
ΔHsol =ΔH1 + ΔH2 + ΔH3
first 2 steps endothermic, last is exothermic

breaking a bond always requires energy input. solution with –ΔH will give off heat when it forms. Solution that gives off heat when forming creates stronger bonds w/in solution.

positive heat of solution → weaker intermolecular bonds than before

forming of solutions α entropy↑
(solutions usually more disordered than its separated pure substances)

Vapor Pressure
Equilibrium b/w liquid and gas phases of cpd when it moves quickly… VP necessary to bring liquid and gas phases to equilibrium is vapor pressure of the cpd.
Clausius-Clapeyron as it relates to VP:
$\ln(Pv) = \frac{-\Delta Hvap}{R}\frac{(1)}{(T)} + C$
vaporization is ENDOthermic
so → ↑VP α ↑T

when VP = local atmosph pressure → boil

melting is T at which vpliquid = vpsolid

nonvolatile solute – solute w/ no vapor pressure.

Raoult's Law (nonvolatile) – if 97% of the soln is solvent, then the vapor pressure will be 97% of the vapor pressure of the pure solvent.

$P_v = X_a P_a$

Raoult's Law (volatile) – if 97% of soln is solven, vapor pressure will be 97% of the vapor pressure of the pure solven PLUS 3% of the vp of the pure solute.
$P_v = X_a P_a + X_b P_b$
Negative heats of soln form stronger bonds and lower vp; Positive heats of soln form weaker bonds and raise vp.

Solubility
solute's tendency to dissolve in solvent.
on MCAT: usually salt in water.
reverse rxn: **precipitation**.
when rate of dissolution = precipitation → saturated.

Equilibrium of solvation rxn:
own eq constant, solubility product Ksp.
set equal to products over reactants raised to their coefficients in balanced equation. leave out pure solids, liquids.

eg, $Ba(OH)_2(s) \leftrightarrows Ba^{2+}(aq) + 2OH^-(aq)$
$K_{sp} = [Ba^{2+}][OH^-]^2$
"solubility product" changes only with tempereature
→ constant found in a book.

Solubility is the max number of moles of solute that can dissolve in soln.
depends on T and ions

spectator ion – ion w/ no effect on eq
common ion – if added to a saturated soln, will shift Keq increasing precipitate.
unsaturated – not in equilibrium

Solubility Guidelines
cpds with H20 solubilities of less than .01 mol/L → insoluble

Solubility Factors
solubility affected by P and T.
P on gas α ↑solubility

Vpa α *Xa*
Henry's law demonstrates that solubility of gas is proportional to VP. think of opening a can of soda – gas is released bc of ↓ solubility
α ↓ pressure (α ↑ Temp)

↑T α Salt solubility ↑

Heat Capacity, Phase Change, and Colligative Properties

homogeneous system – constant properties
various phases – aqueous, pure liquid, vapor, crystalline solid, amorphous solid.

Heat Capacity
measure of E change needed to alter T of substance.
defined as: $C = \frac{q}{\Delta T}$ given in cal /g - C
H20 = 1cal/g-C
→ **$q = mc\Delta T$**
either at constant V or P

Calorimeter
coffee cup calorimeter – constant P.
measures E change at atmospheric P. can measure heat of rxn
bomb calorimeter - measures E change at constant volume. measure heat of water.

Phase Changes
graph with various slopes…

plateaus for heat of fusion, and later, heat of vaporization.
the slopes - mcΔT
phase changes: melting/freezing; vaporization/condensation; sublimation/deposition.
each phase of water has its own specific heat (different slopes of the lines)

Evaporation – partial p above liquid < vp liquid. atmospheric P > vp.
Entropy – positive for melting and vaporizing, positive for freezing and condensing.

Phase Change Diagram
indicates phases of substance at different P and T. Temp on x axis, Pressure (atm) on y axis.
graph forms a **Y shape** with
left: solid; **top/middle**: liquid; **right**: gas
1atm line runs just above the **triple point** changing from H20 to CO2, we see the \ in the letter **Y** move towards middle; 1atm line is now intersecting solid and gas, only.

line separating solid and liquid has negative slope in H20, but positive slope in CO2. Most phase diagrams resemble CO2 in this respect. negative slope in water explains why ice floats; water is denser than ice. why? its crystal structure takes up more volume because of the lattices.

Colligative Properties
properties that depend on "how many" and not "what type."
→ vapor pressure, boiling point, freezing point, osmotic pressure.
boiling point elevation eqn:
$\Delta T = constant \times m \times i$
m = molality
i = **van't Hoff factor**, # of particles a single solut will dissociate into.
on MCAT, use the expected value of van't hoff unless they tell you an "observed" one that is less bc of ion pairing…

addition of nonvolatile solute → bp elevation
addition of nonvolatile solute → mp depression
same equation, different constant

osmotic pressure – tendency of a solvent to move into a solution. relative term when comparing solutions
divid pure liquid by membrane that is permeable to liquid but not solute.

$\Pi = iMRT$
where M is molarity if the soln

osmotic potential – partial measure of system's free energy.
think of osmotic pressure as pressure pulling into a solution ↓ and hydrostatic pressure as pusshing out of a solution ↑

$\Pi(b) = pgh(b) - pgh(a)$ physics

Acids and Bases
3 definitions you must know:

Arrhenius– anything that produces H+ ions (acid) or OH- ions (base) in solution.
Bronsted-Lowry – anything that donates a proton (acid), anything that accepts a proton (base).
Lewis – most general. anything that accepts a pair of electrons (acid), anything that donates a pair of electrons (base).

Any aqueous soln contains both H+, OH-
think of acid as H+, base as OH-.
acidic soln: greater [H+] than [OH-]
basic soln: the reverse
neutral soln: equal concentrations

pH = -log[H+]

log(AxB) = log(A) + log (B)

each one unit of pH represents a 10-fold difference in H+ concentration

$HA + H_2O \leftrightarrows A^- + H_3O^+$
acid base conj. base conj. acid

the stronger the acid, the weaker the conj. base
the stronger the base, the weaker the conj. acid

Kw = KaKb

Many rxns in living cells involve proton transfer. the rate of such rxns depend on the pH.

amphoteric – substances act as either base or acid, depending on environment. eg, water. can act as base (accepting proton), or acid (donating proton).

Strong Acids: HI, HBr, HCl, HNO_3, $HClO_4$, $HClO_3$, H_2SO_4
Strong Bases: NaOH, KOH, NH_2^-, H., $Ca(OH)_2$, Na_2O, CaO.

polyprotics on the MCAT – pay attention to first one, unless Ka values differ by less than 10^3

"strong acid" or "strong base" = completely dissociates in water.

3 factors contributing to acid strength
1) strength of H- bond. 2) polarity of bond.
3) stability of conj base.

oxyacids: more oxygens ↑ α ↑ acid strength

Hydrides – cpd with 2 elements, one of which is hydrogen. basic ones are group 5, acids are group 6.

autoionization of water:
$H_2O + H_2O \rightarrow H_3O^+ + OH^-$

Kw = [H+][OH-]
(h30+ is equivalent to saying "h plus")

$K_w = 10^{-14}$

so if solution is pH 2, ion concentrations will be $[H+] = 10^{-2}$ mol/L ; $[OH-] = 10^{-12}$ mol/L

larger the Ka and the smaller the pKa, the stronger the acid. eg, Ka > 1; pKa < 0.
same is true for Kb and pKb of a base

acid dissociation constant Ka:
$K_a = \frac{[H+][A-]}{[HA]}$
equilibrium constant for that acid's conj. base w/ water:
$K_b = \frac{[OH-][HA]}{[A-]}$
(if you multiply Ka x Kb equations, you'll come out with Kw).
pKa + pKb = 14

Finding pH with strong acid:
eg, 0.01 M HCl will have 0.01 mol/L of H ions
→ $0.01 = 10^{-2}$; -log ans = 2. pH =2
Finding pH of strong base:
0.01 M NaOH soln. 0.01 mol/L of OH- ions
pOH will equal 2, so pH equals 12.
double check that your pH makes sense. if base, pH always >7.

Finding pH with weak acids:
given 0.01 M HCN
1) set up Ka equation:
$K_a = \frac{[H+][CN]}{[HCN]} = 6.2 \times 10^{-10}$
2) assume x mol of HCN has dissociated. so x mol of H plus x mol of CN. plug it into your equation above:
$K_a = \frac{[x][x]}{[0.01]} = 6.2 \times 10^{-10}$
3) solve for x. double check your pH is reasonable.

4) for a base, the process is the same, except what pops out is pOH. make sure you subtract from 14 to get pH.

Salts
ionic cpds that dissociate in water.
Na+ and Cl- are conjugates of NaOH and HCl so it produces a neutral solution.
Remember that all cations, except metals (such as Ca2+, Sr2+, Ba2+), act as weak lewis acids in aq solns.

Titrations
drop-by-drop mixing of an acid and base. performed to find the concentration of some unknown by comparing it with known concentration of titrant.

titration curve of strong acid titrated with strong base (base added to acid) is sigmoidal, with mid point **usually** equaling pH of 7. but not with diprotic acids…

if starting with base in a titration, sigmoid starts at a high y intercept
if starting with acid in titration, sigmoid starts at low y intercept.

Titration of weak acid w/ strong base
y intercept is slightly higher than rock bottom
there are 2 plateaus, not 1
half equivalence point: where pH = pKa; at middle of 1st plateua, **equivalence point** is on the second slope in the middle.
end point range is a little bit above and below equivalence point.
buffer zone: the plateau where the ½ equivalence point lies. you can add the largest amount of base or acid with the least amount of pH change.

Henderson-Hasselbach equation:
$pH = pKa + \log \frac{[A-]}{[HA]}$
basically says, "@ half equiv point, pH = pKa of the acid."
half equivalence = where [acid] = [base]

on MCAT realize that adding small amount of water to ideally dilute, buffered solution will have no effect on the pH.

To Find equiv point, we use an **indicator**. usually weak acid whose conj. base is a diff color. "**endpoint**" – where indicator changes color, i.e., changes into conj base.

Polyprotic Titrations
assume 1st proton completely dissocaiates.
two ½ equiv points, two equiv points. pKa1 and pKa2

Electrochemistry
redox rxn: e's txferred from one atom to another. OIL RIG.
eg, $2H_2 + O_2 \rightarrow 2H_2O$
when H+ is oxidized, oxi state has increased from 0 to +1.
when O is reduced, oxi state reduced from 0 to -2.
oxidation state: possible charge value for an atom w/in a molecule. sum of each atom's oxi states must add up to net charge on molecule.

Oxi States worth Memorizing
Elements:

elemental atoms	0
Flourine	-1
Hydrogen	+1
bonded to metal	-1
Oxygen	-2

Compounds:

Group 1 elements	+1
Group 2	+2
Group 5	-3
Group 6	-2
Group 7	-1

(first table has priority over 2nd)

reducing agent / reductant: cpd whose element gives e-trons to atom

oxidizing agent / oxidant: compound containing the atom that is being reduced.

Potentials
electric potential E associated w/ any rxn.
when you reverse the rxn, it's E's sign switches

positive E voltage → spontaneous rxn
negative E voltage → endergonic

Nickel, Iron, Zinc, and water do not spontaneously oxidize, or give up their electrons.

half reaction potential is NOT multiplied when rxn is multiplied, but half reactions are ADDITIVE.

Galvanic/Voltaic Cell
turns chemical energy into electrical energy.
salt bridge – electrolyte conduction solution
TEIET – Terminals, electrodes, ionic conductor, electrodes, terminal. **emf** is the voltage b/w T and T.

electrodes
anode – negative sign. oxidation happens here.
cathode – positive sign. reduction happens here.
"RED CAT" mneumonic

both usually a strip of metal in solution.
one side may be called a "half cell."

cell potential E / electromotive force (emf):
potential difference between terminals when not connected. connection → reduces voltage due to internal resistance in the cell.

electrons flow alphabetically
from **a**node to **c**athode.

bc electrons are negatively charged, like repels like.
cell potential for galvanic cell always +

Free Energy and Chemical Energy
$\Delta G = -nFE_{max}$
determines a spontaneous rxn
F is faraday's constant (~100,000 C / mol)
w=qV

$\Delta G° = -RTln(Keq)$
where K equals eq constant
Q is where rxn does not yet equal equilibrium

if K = 1 then $\Delta G° = 0$
if K > 1 then $\Delta G° < 0$
if K < 1 then $\Delta G° > 0$

that is to say, if rxn has Keq that's greater than 1, it will be spontaneous at STP.

Nernst equation:
$E = E° - \frac{0.06}{n} \log (Q)$

Concentration Cell
a cell that is taking place in two jars. never at standard conditions.
never @ standard conditions, so use nernst.

galvanic cells have + cell potential
electrolytic cells have (-) cell potential

Red Cat, An Ox

Physics

Key to solving probs: well drawn diagram.
write a know/want table.

vectors and scalars
vector has magnitude and direction
scalar has magnitude only

to add vectors, place head of first vector to tail of second vector, draw arrow from tail of first to head of second.

multiplying
vectors can be multiplied/divided by scalars
eg, mass (scalar) times accel (vector)
→ force (a vector)
any vector can be broken up into component vectors, whose sum is the original.
lengths of components – through pythagorean and
O=HsinΦ
A=HcosΦ
these values w/ be provided
common MCAT triangles: 3/4/5; and 5/12/13
speed = distance/t ; velocity = displacement/t

$a = \Delta v / t$

velocity and accel not always in same direction

Uniformly Accelerated Motion
constant a.

$x = x_0 + v_0t + 1/2\ at^2$
$v = v_o + at$
$v^2 = v_o^2 + 2ax$
$v_{avg} = \frac{(v + v_o)}{2}$

Displacement versus Time Graph
displacement versus time.
upward slope: + velocity
downward: - velocity
plateau: 0 accel
curve: +/- accel
slope = velocity

Velocity versus Time Graph
slope = acceleration

Projectile Motion
separate the projectile path into perpendicular components.
peak height of projectile given by:
$v_o sin\Phi = \sqrt{(2gh)}$ when v. is zero.
acceleration on the ball is constant (-9.8m/s)
in the absence of air resistance, mass does not affect projectile motion.

Air resisance
surface area α air resistance
irregular, rough objects α " "
higher velocity α " "
Mass α 1/air resistance, bc less affected by it.
(think of an anvil versus hollow rubber ball)

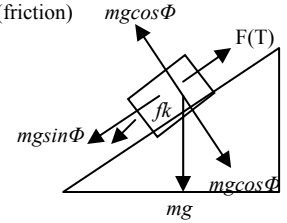
Force

inertia – tendency to remain in present state
Mass- quantitative measure of inertia (kg)
Weight – gravitational force on an earth (N)
on earth this is "mg"

Center of Mass – single point at which all mass is concentrated. any force here in any direction, same magnitude of acceleration… sometimes CoM is not "in" the object (a ring)
center of gravity – single point where force of gravity can be applied to entire mass.

For MCAT assume CoM = CoG

forces on MCAT:
1) **gravitational force** (mg);
2) **electromagnetic force** (charged object or magnet)
3) **contact force** – perpendicular to surface (aka normal force) and/or parallel to surface (friction)

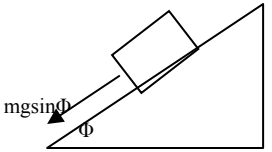


Newton's 1st Law: law of inertia.
Newton's 2nd Law: F = ma
Newton's 3rd Law: every force has opposite force

Newton's Law of Universal Gravitation:
$F = \frac{Gm_1m_2}{r^2}$
G = 6.67 e-11 m^3/kg-s

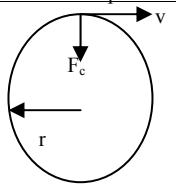
F of A on B equals F of B on A
why earth doesn't move when we jump on it?
too massive
$\frac{F}{\text{huuuuuuuge mass}}$ = tiny a

inclined plane
without friction, only forces are Fn and gravity



Shortcut to inclined planes:
Normal force = mgcosΦ
one portion counters some gravity
the rest is accel.
gravitational = mgsinΦ

Circular Motion / Centripetal Force
$a_c = v^2/r$
$F_c = \frac{mv^2}{r}$



Friction
1) Normal force always perpendicular to contact surface
2) F_r always parallel to contact surface

static friction – force oppositng motion when contiguous surfaces are not moving rel. to each other.
Kinetic friction – force resisting motion once the two surfaces start sliding.

for any two surfaces, there are 2 coefficients of friction: u_s and u_k.

$f_s \leq u_sF_n$
$f_k = u_kF_n$

with tension problems, a box being held by a string, if no movement, F(T) = mg

Hooke's Law
force due to stretched or compressed object
F = -kΔx

Equilibrium, Torque, and Energy

equilibrium: no translational / angular acceleration
static equilib: all velocities = 0
dynamic equilib: nonzero but constant v

$F_{upward} = F_{downward}$
$F_{rightward} = F_{leftward}$

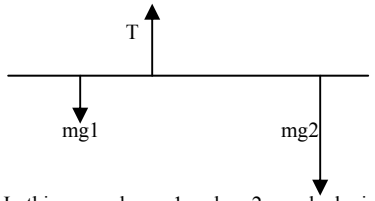
Only system not in equilib MCAT tests is one that experiences translational acceleration.
to solve these probs:
1) write equations as though it were in equilibrium
2) before solving, add "ma" to side w/ less force

ΣF = ma

Torque
twisting force. clockwise or counter clockwise.
product of Force and position vector "r"
τ = F x l (assuming perpendicular force)

r = point of rotation.

Solving torque probs:
$\mathbf{F_{upward} = F_{downward}}$
$\mathbf{F_{rightward} = F_{leftward}}$
$\boldsymbol{\tau_{clockwise} = \tau_{counterclockwise}}$



In this example, mg1 and mg2 are clockwise and equal in sum to force of tension T.
Forces upwards = Forces downwards
also, the torques are equal
so Tx = mgd + mgL

Energy
units of joule (J). for macroscopic systems
units of electron-volt (eV) for microscopic.
one joule = 1 kg-m^2/s^2

KE = ½ mv²

Potential Energy (U)
U_g = mgh

Elastic Potential Energy
U_e= ½ k Δx²

Systems
Law of Conservation of energy: constant E
$E_{before} = E_{after}$

Work
Work – transfer of energy via force, measured in Joules.

W = FdcosΦ for all forces except friction

W = ΔK + ΔU

assuming no dissipation in form of heat

Conservative / Nonconservative Forces
Law of Cons. of Mechanical E
|ΔK| = |ΔU|

Nonconservative forces – those that change mechanical E when they do work. KE
frictional force and the pushing and pulling of animals.
for this: W = ΔK + ΔU

Work and Friction
ΔK + ΔU = fdcosΦ
if internal energy change is avail use formula
W = ΔK + ΔU + ΔE_i

Power
rate of energy transfer. unit is watt (W).
equivalent to J/s. don't confuse with W work.

$$P = \frac{\Delta E}{t}$$

if you know force and time:

$$P = \frac{W}{t} \rightarrow$$

P = FvcosΦ

Momentum, Machines, Radioactive Decay

Momentum:
p = mv
given in kg-m / s

momentum is always conserved.
momentum is a vector.

Collisions
Elastic – mechanical E conserved. no E dissipated to heat, sound, etc. eg, atomic collisions.

$U_i + K_i = U_f + K_f$

Inelastic – colliding objects lose some mech E to internal energy.
Completely inelastic – when colliding objects stick together upon collision.
can use conserv. of momentum for inelastic:
$p_i = p_f$

can be further broken down into
$p(x)_i = p(x)_f$
$p(y)_i = p(y)_f$

might have to use cos/sin to break into vectors

momentum is conserved before and after collision…

Reverse Collisions
opposite of completely elastic: one object spontaneously combusts into 2.

Impulse (J) is equal to change in momentum

J = Δp
J = F_{avg}Δt
Δmv = F_{avg}Δt

Machines
if you see on MCAT, ideal machines reduce force but don't change work.

ramp: inclined plane. pushing an object up ramp, you are pushing mgsinΦ.
W = mgh
W=Fd
work is held constant, so
F α 1/d

lever – based on torque. like ramp, allows us to increase the distance over which force acts.

pulleys are actually modified levers. multiple tension strings add up to counter act mg.

Radioactive Decay

Particle	Symbol
alpha	$\alpha\ {}^4_2$
beta	$^-\beta$ or $^0_{-1}e$
positron	$^+\beta$ or $^0_{+1}e$
gamma	γ

Half-Life Problems
4 variables: initial amnt of substance, final amount of substance, number of half lives, and the half life. MCAT will give you 3 of these.

electron capture :
$201/80Hg + {}^0_{-1}e \rightarrow 201/79\ Au$

Mass Defect
$E = mc^2$
where $c = 3x10^8$ m/s

Fission and Fusion
Fusion – combining of 2 nuclei to form heavier nucleus.
Fission- splitting of single nucleus to 2 lighter.

Fluids
fluid – liquid or gas. conforms to shape of container. battleship floats bc ocean conforms to surface so that always normal force.
density – "heaviness of fluid" units kg/m^3
ρ= m/V
compression of a gas makes it more dense. assume not possible for solids, liquids.

Specific Gravity-
SG = $\rho_{substance}$ / ρ_{water}

know H20 density on MCAT:
ρ_{water} = 1000 kg/m^3 = 1 g/cm^3

fluid pressure – result of molecular collisions.
P = F/A in units Pascal (Pa)

sucking water out a straw, how's it work? atm pressure above water in straw lower than atm pressure above water in cup.
Fluids at rest – only perpendicular forces on it.
P = ρgy

if an open container exposed to air:
$P = \rho gy + P_{atmosphere}$

Patmosphere = 101kPa

gauge pressure – measure of pressure compared to local atmospheric P
absolute P = pgauge + patm

hydraulic lift – works via Pascal's principle.
$F_1d_1 = F_2d_2$ or $F_1A_1 = F_2A_2$

$F_{buoyant} = mg_{water} = \rho_{fluid}Vg$

fraction submerged = $\frac{\rho_{floating\ object}}{\rho_{fluid}}$

an object floating displaces its weight in fluid, a submerged object displaces its volume in fluid.

Fb doesn't change w/ depth.

V = AΔh
Fb = pg AΔh
Fb = pgΔh
A
ΔP = pgΔh

random translational motion – contributes to fluid P at rest
uniform translational motion – shared equally by all the molecules at a location of fluid.

Ideal fluid – 1) no viscosity; 2) incompressible; 3) steady/laminar flow; 4) not rotating.
→ most likely to show up on MCAT

assume non-changing volume…
water through a pipe has **volume = $\pi r^2 xd$**

continuity equation:
Q = Av
where Q = flow rate

I = pQ = pAv
where I equals mass flow rate.

flow rates are constant in an ideal fluid.

Bernouli's Equation (memorize):
$P + pgh + 1/2\ pv^2 = K$
where K is fluid-specific constant.
where h is distance above some arbitrary point sum of the three terms is constant throughout the fluid.
v = √(2gh)
velocity of fluid as it leaves a spicket.
Non-Ideal Fluid- drag and viscocity act to impede flow. the narrower the pipe, the greater the drag. (greater velocity, too).
slower than ideal fluid, but similar principles.

ΔP = QR

Surface Tension
although denser than H20, a needle can float on water. due to intensity of intermolecular forces per unit length.

capillary action – fluid may be pulled up a thin tube. intermolecular/cohesive forces and adhesive forces (sticking to each other and sticking to the tube.

Solids
Stress = F/A in units N/m^2
Strain = Δdimension / original dimension
strain responds to stress.

Modulus of elasticity = stress/strain

3 moduli to know for MCAT:
1) Young's modulus (E) [tensile]
2) shear modulus (G) [shear]
3) bulk modulus (B) [compression/expansion]

$E = (F/A)/(\Delta/h_o)$
$G = (F/A)/(\Delta/x_o)$
$B = \Delta P/(\Delta V/V_o)$

Waves
wave – txfer of momentum and E from one point to another. for MCAT, assume ideal.

wavelength λ – measured crest-to-crest
frequency (f) – number of wavelengths / time
units of herts (Hz) or cycles/s aka s^{-1}
v = λf

period (T) - reciprocal of frequency;
T = 1/f
amplitude (A) – maximum displacement from zero.

velocity is dictated by the wave's medium.
elasticity; inertia.
for a gas, velocity increases with temperature.
sound waves move more quickly thru hot gas...

intensity (I) = ½ pw^2A^2v

$$I = \frac{P}{4\pi r^2}$$

Intensity levels and dB. if intensity ↑ by a factor of 10, the decibels increase by the "addition" of 10 decibels.
eg, from 30 W/m^2 to 3000 W/m^2 = adding 20 decibels.
β = 10log (I / Io)
where Io is threshold intensity (lowest we can hear)

ΔI	ΔB
x10	+10
x100	+20
x1,000	+30
x10,000	+40

wave phase – horizontal shift of wave on a graph. "out of phase" vs "in phase."

Two or more waves can occupy same space. superposition → interference

Constructive – sum of displacements = larger displacement
Destructive – sum of displacements = smaller displacement

Beats – case of superpositioning waves.
$\mathbf{f_{beat} = |f_1 - f_2|}$

piano tuner. he listens until beat frequency is zero.
beat frequency = alternating increase and decrease in noise intensity. hearing the pitch. frequency creating this is the average of the frequencies from piano and tuning fork.

high pitch α high frequency α high note

when wavelength crosses to a different medium, wavelength changes, frequency remains the same.

standing wave – string is still at the nodes while waves move up and down at antinodes.

harmonic series – list of all wavelengths from longest to shortest.
longest = **first harmonic** (λ1) or fundamental wavelength. fewest number of nodes (2).
second harmonic (λ2) requires extra node.

harmonic series totally closed or open:
$\mathbf{L = \frac{n\,\lambda_n}{2}}$ (n=1,2,3…)
where L = distance b/w 2 ends of string and n = number of the harmonic.

when one end is tied down harmonic series is:
$\mathbf{L = \frac{n\,\lambda_n}{4}}$ (n=1,3,5…)

standing waves cause string to resonate @ natural, resonant frequency.

v=f λ

Simple Harmonic Motion – perfect sin wave. sinusoidal function in time.

$a(t) = -w^2x(t)$

acceleration α -displacement α √f

Hooke's law: $\mathbf{F = -mw^2x}$
elastic potential energy: $PE = ½\,kx^2$
$F = -k\Delta x$

periodic motion for mass on a spring
$\mathbf{T = 2\pi\sqrt{(m/k)}}$

pendulum – exchanges energy b/w PE and KE.
$\mathbf{T = 2\pi\sqrt{(L/g)}}$

on MCAT may come in the form of:
orbit of planet as viewed from side, tetherball around pole, electrons oscillating back and forth in AC current.

Hooke's law → acceleration of any system in SHM α displacement α √f

if hanging on a string and swinging:
$\mathbf{F_T = mg\cos\Phi + m(v^2/r)}$

wackem	wiggle
$\mathbf{w = \sqrt{(k/m)}}$	$\mathbf{w = \sqrt{(g/L)}}$
box on a string	pendulum

so we see that period of a swinging string is independent of the mass on the end of it.

Doppler Effect
waves are unaffected by speed of their source. if source moves relative to receiver, each wae w/ travel diff distance, so frequency of receiver/observer will seem different.

$\mathbf{\frac{\Delta f}{f_s} = \frac{v}{c}}$ **and** $\mathbf{\frac{\Delta\lambda_s}{\lambda_s} = \frac{v}{c}}$

c is not necessarily speed of light, can be speed of sound, radio, etc.

understand this qualitatively. when relative velocity brings the observer and source closer, observed frequency ↑ and observed λ ↓

higher frequency α higher pitch

blue shift = wavelength appears shorter (source and obs closer than b4)
red shift → oppositte

when objects are moving in same velocity, frequency change is zero.

Electricity and Magnetism

because of history of science, current runs in opposite direction of the electrons.

Charge (q) given in units coulombs (C)

Universal Law of Conservation of Charge- universe has no net charge.

charg eis quantized. smallest unit is one electron unit ($e = 1.6\times10^{-19}$C). photon or electron.

opposite charges attract, like charges repel.

Coulomb's law:
$\mathbf{F = \frac{kq_1q_2}{r^2}}$
where k is coulomb constant of 9×10^9 and r is distance b/w centers of charge.

mass/gravity very similar to charge

field can be represented by lines of force—points in direction of the field. (positive to negative for e-fields). positive test charge.

Electric field – electrostatic force / unit charge E. vector pointing in direction of field. units N/C or V/m.
$\mathbf{E = \frac{kq_1}{r^2}}$
in units N/C
F=Eq
W=U=qEd
V=Ed volts in units J/C

voltage due to point charge
V = (kq)/r

Movement of Charge
conductors – metals, allow e's to flow freely
resistors – bad conductors, hold e's tightly in place. eg, diamond, glass.

can charge a conductor by induction.

current – moving charge. in units amps (A) or C/s
moves in the direction of (+) charge

think of electrical movement like fluid.

Circuits
circuit – cyclical pathway for current
all substances resist flow of charge
measured quantitatively with **resistivity (ρ)**

measure of this is called **Resistance (R)** in **ohms (Ω)**

R = (ρL) / A
if a wire is doubled in length or its cross sectional area is halved, R↑ by factor of 2. (analogous to fluids)

resistance x current → voltage:
V=iR (Ohm's law)

Kirchoff's first rule: amount of current flowing in = amount of current flowing out.
node – any intersection of wires.

Kirchoff's second rule: voltage around any path in a circuit must sum to zero.

battery adds energy to circuit → increases voltage from one point to another. rated with **electromotive force (EMF)**, aka **voltage.** assume no internal resistance on MCAT.

capacitor – temporarily stores energy in a circuit. **parallel plate capacitor** – separated by small distance. creates E field that is constant everywhere b/w the plates. E field given by
$\mathbf{E = \frac{1}{K}\frac{Q}{A\varepsilon_0}}$
Q = charge on either plate: Eo is constant.

capacitance – ability to store charge per unit voltage.

$\mathbf{C = \frac{Q}{V}}$

the farther apart the plates, the greater the voltage, the lower the capacitance.
C α A / d

Q = CV
$\mathbf{U = ½\,QV = ½\,CV^2 = ½\,Q^2 / C}$

dielectric constant, K – substance between plates of capacitor. must be insulator, to allow buildup of charge.

capacitor sign – both plates same size
battery sign – diff sizes

$\mathbf{R_{eff} = R_1 + R_2 + \ldots}$ **(resistors in series)**

$\mathbf{\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots}$ **(resistors in parallel)**

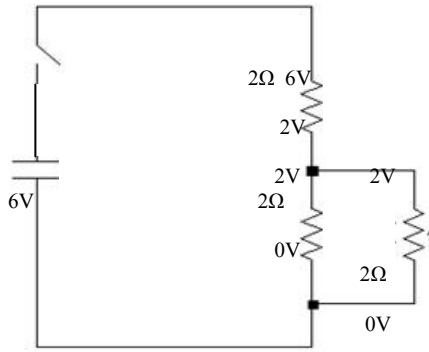
$\mathbf{\frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots}$ **(capacitors in series)**

$\mathbf{C_{eff} = C_1 + C_2 \ldots}$ **(Capacitors in parallel)**

mneumonic: "C, it's inverted in the series"

Power
power – interchangable with mechanical power

$\mathbf{P = iV = i^2R = V^2/R}$



AC Current
direct current (DC) – net movement of etrons in one direction around circuit.
alternating current (AC) – oscillating e-trons back and forth in SHM. in home outlets in US. described as sine wave.

$\mathbf{V_{max} = \sqrt{2}V_{rms}}$
$\mathbf{i_{max} = \sqrt{2}i_{rms}}$

rms = square root of the average of the squares

rms voltage in US is usually 120 Volts, 170 max.

Magnetism
measured in tesla, T. north and south poles.

a changing electric field creates a magnetic field. a stationary charge does not create a magnetic field.

$\mathbf{B = \frac{u_o\,iLsin\Phi}{4\pi r^2}}$

for a long wire:

$\mathbf{B = \frac{u_o i}{2\pi r}}$

right hand rule. thumb in direction of current (i) and grab wire, direction in which our fingers wrap is the direction of magnetic field (B).

F = qvBsinΦ

force is directed perpendicularly to both velocity and magnetic field.

2nd right hand rule: point thumb in direction of moving positive charge (v), point fingers in direction of magnetic field (B) palm will point diagonally in direction of F.

$qvB = (mv^2) / r$

$F = ilB\sin\Phi$

A changing magnetic field → electric field.

changing magnetic flux → emf E

$$E = \frac{-\Delta\Phi}{\Delta t}$$

Faraday's Law

Overall picture:
1) magnetic field is generated by moving charge and;
2) moving charge experiences force when moving through electric field.

→ F = qvB

Light and optics

electromagnetic wave – traveling oscillation of electric and magnetic fields. transverse wave.

sppeed (c) at which wave propagates thru free space is constant, equal to ratio of magnitudes of electric field and magnetic field:

Light – tiny sliver of em spectrum. visible light in wavelengths 390 to 700 nm

$1nm = 1x10^{-9} m$

shorter wavelength α violet light → UV
longer wavelength α red light → infrared

each wavelength has corresponding frequency

speed of light in vacuum is constant.

from c = fλ →

$c = f\lambda$

light slower when propagating thru medium. index of refraction..

$n = c / v$

when light crosses into new medium, f remains same, but λ changes**.**

indeces on MCAT:
water- 1.3
glass- 1.5

plane-polarized light – filtered light w/ all E fields oriented in same direction.

light's dual nature – propegates like a wave, but has E transformative properties like a particle.

angle of incidence measured from an imaginary perpendicular line to the surface. Φ of incedence is between line normal and ray of light. Φ reflection is between normal line and deflected light. Φ refracted is the ray of light in new medium.

angle of reflection (same medium):
$\Phi incidence = \Phi reflection$

angle of refraction (new medium):
$n_1\sin\Phi_1 = n_2\sin\Phi_2$

$E photon = hf$

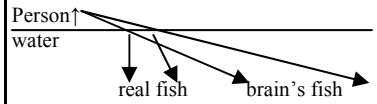
higher frequencies, such as violet and blue light, have more E than lower f's.

when light moves to higher n, Φ can be so great as to cause total internal reflection. → all photons reflected @ angle of reflection, no refraction. "critical" angle.

Diffraction – another type of wave-bending phenomenon. light thru small slit. size of opening ~ wavelength or smaller. constructive vs destructive interference. smaller the opening α larger the opening α greater bending of wave

Images
mirrors reflect light; lenses refract light.

our mind doesn't account for light bending in other mediums:



An image may or may not exist:
virtual image – does not exist outside of mind of observer; no light rays emanate from virtual image. no image would appear on paper. our reflection in a mirror. brain's fish above.

real image – exists separately from obs. rays of light actually intersect and then emanate from point of intersection. if sheet were there, image would appear on it.

Mirrors and Lenses
mirrors – convex and concave
lenses - converging, diverging.

concave looks like a cave, reverting back to cavement would be a divergement.

always assume light originates from object.

thicker center converges

assume spherical mirrors for MCAT.

light from horizontal rays reflected by concave mirrors to focus on a single point, **focal point**.

focal point α radius of curvature.
$f_{mirror} = ½ r$

focal point is also affected by refractive indices of lens and medium of lens. also affected of radii of curvature of both sides.

power of a lens. in units of diopters (m^{-1}):
$P_{lens} = 1/f$

Ray diagrams are not useful for MCAT.

overview of ray diagrams:

convex mirror (object same side): image behind, upright, smaller, not real.
concave mirror: object same side, image behind is upright, larger, not real.

Diverging lens: object far side, image farside is upright, smaller, and virtual..

Converging lens: object far side, image farside, larger, upright, and virtual.

lateral magnification m – ratio of size of image to size of object. h1 vs. h0

$$m = \frac{-d_i}{d_o} = \frac{h_i}{h_o}$$

angular magnification:

$$m\Phi = \frac{\Phi_i}{\Phi_{np}}$$

Φ obj. to eye, front of lens
Φ obj. to eye, at near point

for any mirror or lens, distance of imge related to focal length and distance of object:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

hardest part is determining when value is + or -

In any double system, use first image as the object of the 2nd.

for a convex mirror or diverging lens, f is always negative.

for a concave mirror and converging lens, f is always positive.

$$P = \frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$$

$$M = \frac{-d_i}{d_o} = \frac{h_i}{h_o}$$

$f_{mirrors} = ½ r$

Two lens systems
on MCAT would be microscope or teloscope:

$M = m_1m_2$

$P_{eff} = P_1 + P_2$

Notes from 6.24.08

all nitrates & sodium salts are water soluble

single bond length > double > triple

given: Pb(OH)2 ← → Pb2+ and 2OH-
if pH raised, rxn would shift left

P = IV

"proton" = H+ = ion

Photon E → ejected electron E
ionization energy reached. all extra energy is for the electron to have after ejection.
eg, if 12 eV required to eject, and photon is 15eV, e- has 3eV of KE.

KE electron α Voltage

Xray emmission α Intensity

W = Fd

↑ KE α ↑ evaporation

$d = ½ at^2$

Translational equilibrium = all F's cancel = acceleration is zero

α particle decay = Helium ejection

$$\frac{d_{object}}{d_{image}} = \frac{h_{object}}{h_{image}}$$

Cu(s) + H2SO4 → SO2 + Cu+
sulfur's oxi state went from +6 → +4

Power = work / time

Short period α short wavelength

Harmonic: $\frac{1^{st}}{\lambda_1} < \frac{2^{nd}}{\lambda_2} < \frac{3^{rd}}{\lambda_3}$

$P_1 < P_2 < P_3$

$f_1 > f_2 > f_3$

guitar harmonics always sound high
high pitch α high frequency

P α wavelength α harmonic number α 1/f

harmonic – multiple of the original frequency.
4th harmonic is 16x natural frequency
as determined by **2^n**

$\lambda f = v = 3x10^8 m/s$ = speed of light

voltage sources in parallel produce same output voltage as single source; but if in series, their voltages would be additive.

freezing pt depression is colligative:
totally dependent on # of solute particles in water

↑ **molarity of solute α ↓ Tm**

½ equiv point (first flat part) – [Acid] and [Conj. base] are equal.

"reducing agent" → causes reduction. eg, Fe.

BS

all somatic cells in body have same DNA / Chromosomes regardless of stage of life

cholesterol – precursor to steroid horomones
→ estrogen

vasoconstriction of intestinal villi lacteals
→ ↓ fat absorption

crossing Tt x Tt
one would expect Mendelian ratio of 3::1 of tall to short plants

metabolism of aa's from proteins → see Nitrogen urine concentration ↑ α starvation

starvation: carbs, lipids used up, start breaking down body proteins

C=O bond makes molecule more polar
↑ polarity α BP ↑

chips, air bubbles break surface tension of liquid, preventing superheating during a vacuum filtration

Heat distillation flask @ slower rate → better fractionation

Stereogenic carbon = chirality center
diff makeup → diff enantiomers
chiral if 4 diff constituents
→ dbl bonded carbons are not able to be chiral.

Boiling point: when vapor pressure of liquid = surface pressure

↓ BP α surface of liquid ↓

methyl ketone formation → (+) iodoform test

acetone on the NMR – 6H's the same → singlet.

If rare gene, assume only 1 parent has it, and that it's recessive.
if P phosphorylates R then
P splits /uses ATP → ADP, and R becomes phosphorylated: R-(p)
now activated.
to de-phosphorylate is to quickly deactivate

distal tubule – reabsorbs glucose.

↓ Hb Hg α ↓ GFR rate α ↑ reabsorption

albumin ↑ α hypertonic Hb ↑
→ flow of H20 from tissue to bloodstream

Protein such as pepsin operates well at pH of 2 or 1.5, but if as low as pH 1, will be denatured and no longer operate.

PTH ↓ α ↑ Ca^{2+}

Calciton(in) – brings Ca^{2+} in-to bone
Parathy(rid) – Ca^{2+} gotten rid from bone.

edema caused by ↓ albumin, ↑ body tissue swelling.

Kappacofigus
KPCOFiGuS
----------→ relatedness

(Br2 + CCl4) → turns colorless if dbl bond formed. "dehydration"

A → B
removing pdt A as it is formed will cause a leftward shift

Imprinting – perception of object enhanced during critical development period.

Cyclohexane has lowest heat of combustion among cyclo-anes bc highly stable chair configuration.

Steric hindrance → bad nucleophile

Practice test notes

review circuits, plain mirrors, soln chemistry, e structure, sound, atomic, nuclear structure, skip VR nat sciences and double check them, immune / circulatory systems, digestive enzymes.

tend to have 10 min at end of each section. mark liberally.
PS
Φ of tilt most important in incline probs

van der walls, aka London dispersion
α polarizability
α boiling point
α number of electrons

32g O2 = 1 mol O2

Doppler effect. As signal approaches, frequency gets higher.

$$\frac{\Delta f}{f} = -\frac{v}{c}$$

where c is speed of the medium
Csound < Cradio

"apparent loss of mass" = mass of fluid displaced

"common ion effect" – saturated soln, eg NaCl
if you add any other soln that has Na+ or Cl-, you're gonna get precipitate

Resonant wavelength of pipe or tube
open pipe has resonant wavelength = 2xl

mechanical waves such as water/sound
→ only Energy is propegated
electrons have dual energy/matter phenomenon

w/ fixed potential difference (voltage) between cathode and anode, electric field α 1/L

E = (V – IR) / L

electron @ cathode has V = to voltage in eV

incedent photons only affect # of electrons emitted, not their energies.

electron accelerates from anode to cathode.

$P = I^2R$
(amps)x(ohms) → Watts

electron ejections ↑ α current flow (I) ↑

photon frequency α speed of ejected e-

radiation emitted when e's ↓ orbital

currents in parallel resistors α 1/indiv resistors

BS
a-choline / morphine /heroin → constricts pupils. "pinpoint" pupils diagnostic of opiate intoxification.

nor/epinephrine → fight or flight / sympa response → dilated pupils

IR peak around 1700 → C=O double-bond.

fungal spores metabolically inactive, haploid.

aldosterone → Na+ reabsorption → H20 reabsorption

impurities in any substance α melting (aka freezing) point depression α decreased intermolecular interactions. why? interrupts intermolecular attraction.

↑ **intermolecular strength α ↑ boiling point**
eg, why when you add salt to a pot of water it boils at a hotter temperature. because salt is attracted to water.

amines soluble in dilute acid (eg, dilute HCl).
carboxylic acids soluble in dilute base.
ester →hydrolysis → ROH + ROOH

DNA replicates in S phase.

saponification: ester + (NaOH) → Salt + (acid) → ROOH

molecular weight of cpds of varying structures should give a hint about the identity.

lung inflation – possible because of negative pressure by suction.

antibiotic resistance can be innate bc of chance mutations, eg, E Coli not killed with a first round of antibiotics for infection.

E Coli live in colon, move b/w colon and appendix freely. outside of them are abdominal cavity.

Bacterial conjugation = recombination.
ffjf

Interneuron synapses → pain, efferent neurons to brain. Here are ealso the dorsal root ganglion attached to sensory neuron, feeds interneuron, interneuron tells the motor neuron and effector to pull finger away from stove.

Bacteria versus viruses: bacteria can reproduce via fission.

√recessive people in populaetion = # of recessive genes in all. the remainder are the # of dominant genes in all. **Hardy-weinberg says # of heterozygotes is equal to**
2 x (% of dominant genes alleles)
x (% of recessive alleles)
aka 2pq.

Blood pressure:
depends on 2 things:
1) Cardiac output = stroke volume x heart rate
2) resistance to blood flow

anti-inflammatory drugs on a pt w/ septic shock:
risk → decrease of endogenous antibacterial defense

Bonding

e's neg charged
enf b/w e's & (+) nucleus
⇒ bonds -

Lowest Energy
∝ low orbital
∝ new nucleus.

Bond - 2 e's have positioned b/w 2 nuclei to take advantage of both attractive forces

single bond - 1 σ
double bond - 1σ, 1π
triple bond - 1σ, 2π

→ rare except for C, N, O, S.
→ and P in ATP.

Pi bonds prevent rotation.

Hybridization

sp - Linear (180°)
sp^2 - Trig Planar (120°)
sp^3 - Tetrahedral (109.5°)
(dsp^3) - trig bipyramidal (90°)

Lone pairs, π bonds require more space -

Resonance - Diff e⁻ arrangements of same molecule

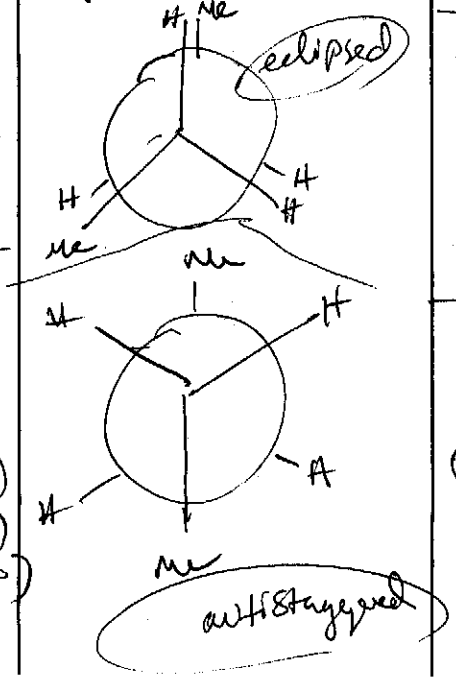
Tautomerism - addition/removal of Hydrogen

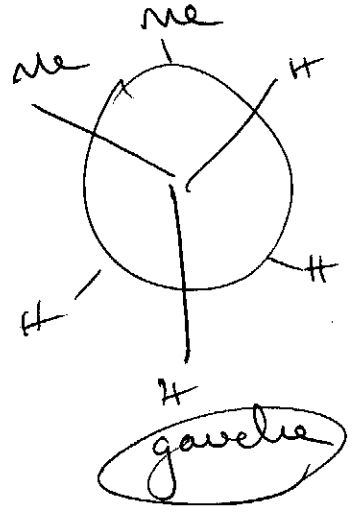
aromaticity
4n+2 π e⁻ rings

Dipole Moment

molecular & intramolecular.

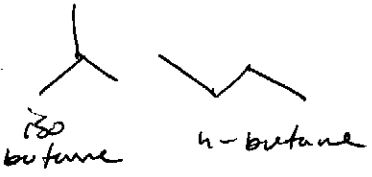
Dipole << Covalent





anti > gauche > eclipsed
low E → high E

Struct. isomers



Chirality - handedness
Carbon is chiral when bonded to 4 different substituents.

absolute config
R & S.
priority ∝ atom. weight
triple > double > single bond

2 chiral cpds rotate plane pol-light differently.
"racemic"
optically inactive"
→ no chiral center
(+)/(-)

Stereoisomers

enantiomers
opposite @ each chiral C.
diff pol-light
diff reactivities

diastereomers
cis/trans
cis has dipole moment
∝ ↑ T_{BP}
∝ ↓ T_m
strong intermolecular

if multi substituted use Z/E system.
• atom weight grps
•

max # of optically active isomers
$= 2^n$
n = chiral centers.

meso - split in ½.

epimer - 1 diff chiral center

anomer - ring closure @ epimer.
⇒ anomeric carbon.
Glucose forms anomers.

alkanes - saturated
1° 2° 3°

R groups ∝ MW ↑ ∝ T_{BP} ↑ T_m

Branching ↑ ∝ T_{BP} ↓ T_m

water-insoluble.
low density, floats on water
soluble in benzene, CCl_4 etc.

Ring strain - ∅ for cyclohexane.

½ chair > boat > chair

most substituents prefer equatorial.
if chair flips, equatorial becomes axial. vice versa.

Organic Chem

Just basics needed for the MCAT-

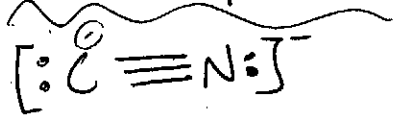
Lewis Dot Structure

↳ basic formulas.

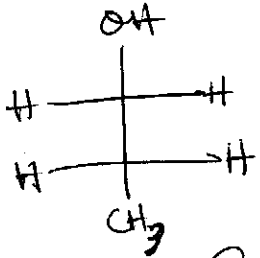
1) ~~total~~ valence e's

2) 1 pair of e's → 1 bond

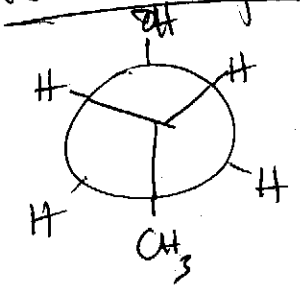
3) arrange rest to satisfy duet / octet rule



Fisher Projection



Newman Projection



Index of Hydrogen Deficiency

of pairs of H's required to be saturated.

$$\frac{(2n+2)-x}{2}$$

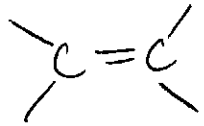
n = C ; x = H

Key to groups

Recognizing functional groups.

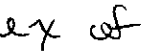
alkane

alkene

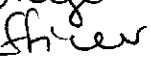


alkyne

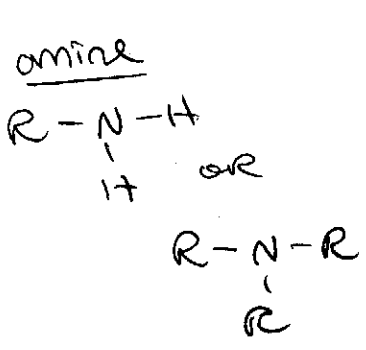
alcohol



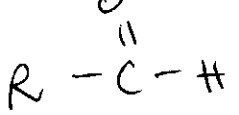
ether



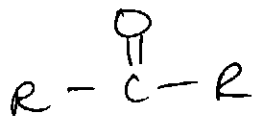
amine



aldehyde



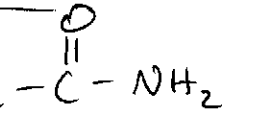
ketone



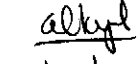
carboxylic acid

ester

amide

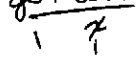


alkyl



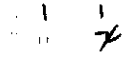
halogen

gem-dihalide

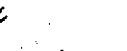


vic-dihalide

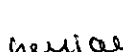
hydroxyl



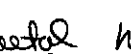
alkoxy



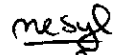
hemiacetal



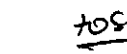
hemiketal



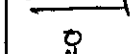
mesyl



tosyl



carbonyl

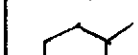


acetyl

acyl

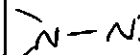
anhydride

aryl

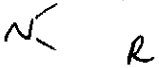


benzyl

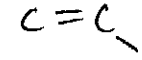
hydrazine



hydrazone

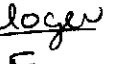


vinyl

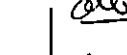


vinylic

allyl



nitrile



epoxide

enamine

oxime

imine

nitro

nitroso

n-propyl

isopropyl

n-butyl

isobutyl

sec-butyl

tert-butyl

IUPAC

first C is one w/ most substituents and longest chain.

Substituents ordered alphabetically.

Alkanes - don't react very well w/ enough E_a will combust.

$CH_4 + 2O_2 \xrightarrow{\Delta} CO_2 + 2H_2O + A$

used to compare isomers.

$\uparrow \Delta H_{combust}$ ∝ $\uparrow E_{levels}$ ∝ $\downarrow$ stable molecule

Alkanes rct w/ Halogens F, Cl, Br to form free radical

alkyl radicals

$3° > 2° > 1° > Me$

combustion ⅓ radical both exothermic

Fluorine prefers 1° pdt bc so reactive.

Alkenes - synthesized via Elim Rxn.

Dehydration of an R-OH.

Saytzeff's rule - Predominate pdt will be most substituted alkene

E1 - 2 steps (wk base)

E2 - 1 step. (strong base)

Sn1 - 2 steps

Sn2 - 1 step.

Syn addition

$C{=}C + H_2 \xrightarrow{Ni, Pd, Pt} Me-Me$

same for carbocation stability as Radical stability

Alkene Oxidation

$C{=}C \xrightarrow[2.\ Zn, H_2O]{1.\ O_3} C{=}O + O{=}C$

"ozonalysis"

Electrophilic addition.

⅓ Markovnikov's rule.

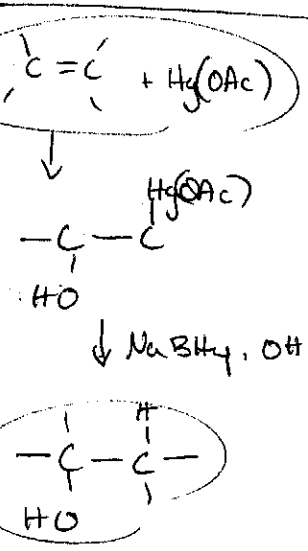
Markov: more stable carbocation: 3° > 2° > 1°

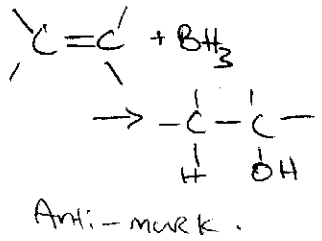
But if peroxides are present (ROOR) Br will add anti Markov.

Reactivity ∝ thermodynamically stable, ∝ low E_a carbocation

Alkene + H_2O ⇌ Alcohol

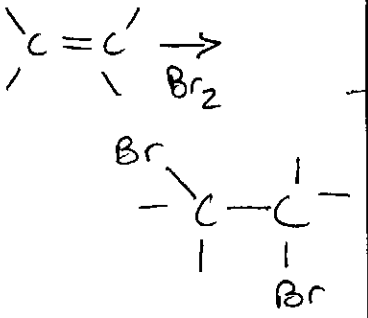
Organometallic cpds: metal likes to lose e's and take on a full or partial ⊕ charge.





Anti-mark.

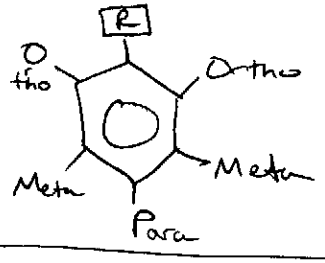
Halogenation of alkene.



Benzene.

undergoes substitution NOT addition.

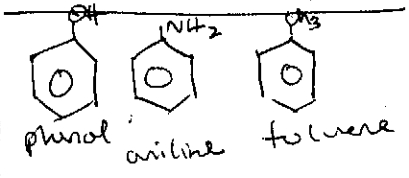
aromaticity rarely disturbed.



EWG in R position, directs meta. CN N^+ CF_3 C=O

EDG directs ortho/para (if it's got a lone pair) + Halogens.

O^-, OH, NR_2 OR, R



alkene dbl bond donates large electron cloud, stabilized by EDG's ⇒ more acidic.

Substitution: 1 functional group replaces another.

~~Sn2~~ Sn1 - slow ⅓, fast step

Slow is rate determining ∝ [substrate] (the attackee)

tertiary substrate preferred.

Sn2 - single step.

∝ [nucleophile] ∝ [substrate]

configuration (S/R) flips

prefers least steries.

(E2 will predominate w/ strong base but high steries)

Polar protic solvents stabilize nucleophile and any carbocations

stable nucleophile ∝ ↓Sn2 ∝ ↑Sn1

weak base & good LG
& EWG groups.

Sn2
- strong Nu
- sterics bad
- nonpolar solvent
- [substrate] + [nucleophile]
- inverts stereochem
- no rearrangement.
- E2 can accompany.

Sn1
- N/A
- sterics good
- polar solvent
- [substrate]
- racemic mix
- may rearrange
- E1 can accompany

↑ MW & BP ↑ & ↑ MP
& Hydrogen bonding.

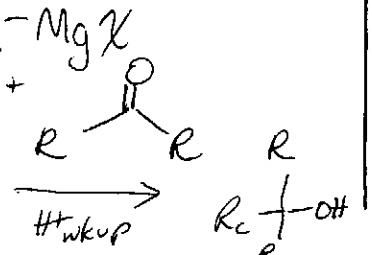
Water bonds = 104.9°.

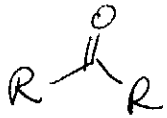
Alcohols behave as acids

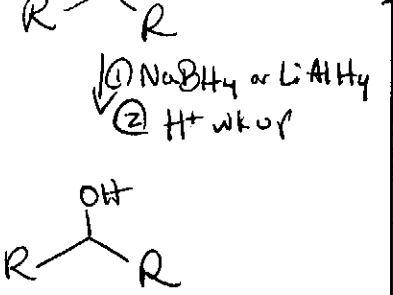
acidity & pKa.

EWG + ROH
& ↑ acidity.

Grignard synth of R–OH





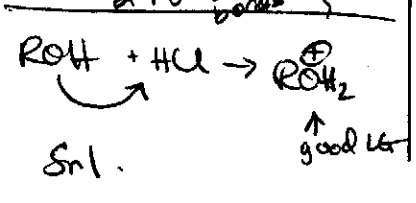


Hydrides prefer to ~~Rs~~ add to carbonyls w/ H vs. R, OR, or O⁻

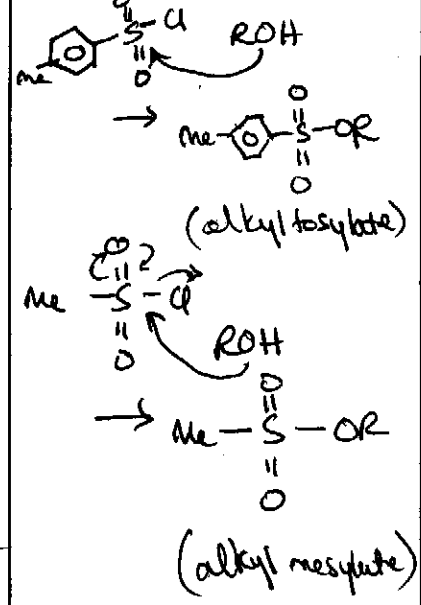
Alcohols like to be nucleophiles.

Oxidation – loss of H_2.
add of O_2 or π

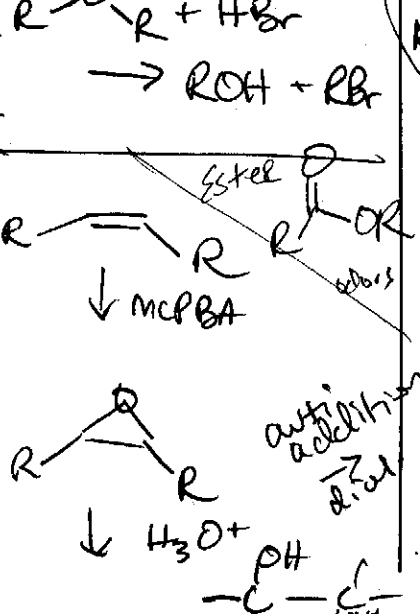
Ox agents	Red agents
$KCrO_4$	$LiAlH_4$
$KMnO_4$	$NaBH_4$
H_2CrO_4	H_2, pressure
O_2	& ↓ C=O bonds
Br_2	
& ↑ C=O bonds	

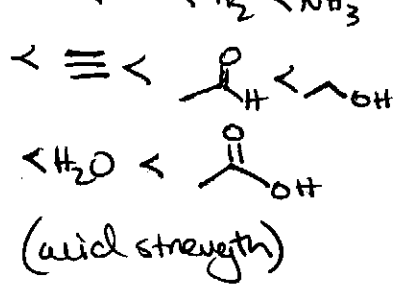


Tosylates / Mesylates



Ether – non reactive polar.
low BP, good solvents

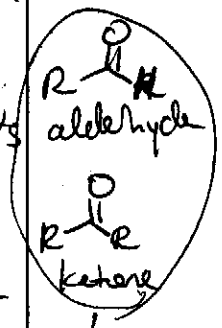


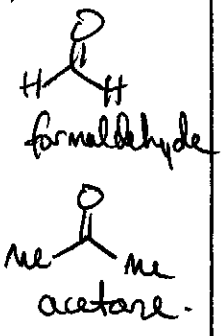


Carbonyl ⇒

δbl bonds shorter...
- ★ planar stereochem'istry
- ★ partial ⊕ charge on C.

Readily undergo attack by nucleophiles





& Polar & ↑ BP
cannot H bond, so lower BP than alcohols.

Water soluble.

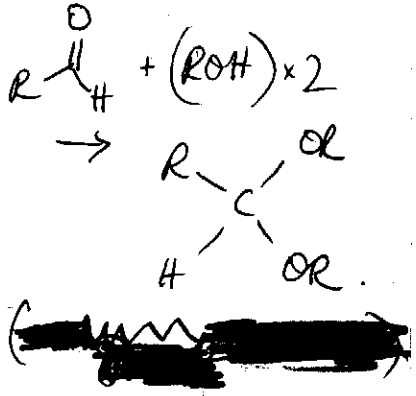
act as either:
① Nu addition substrate
② acid by donating H.

α carbon – one attached to carbonyl. its H is most acidic!

anion stabilized via resonance → enolate.

Keto-enol tautomerization, Proton shift.

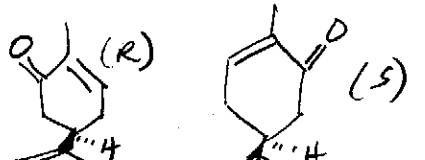
Aldehyde / ketone
+
Alcohols
↓
hemiacetal / ketal



[redacted]

can be used as blocking groups

carvone



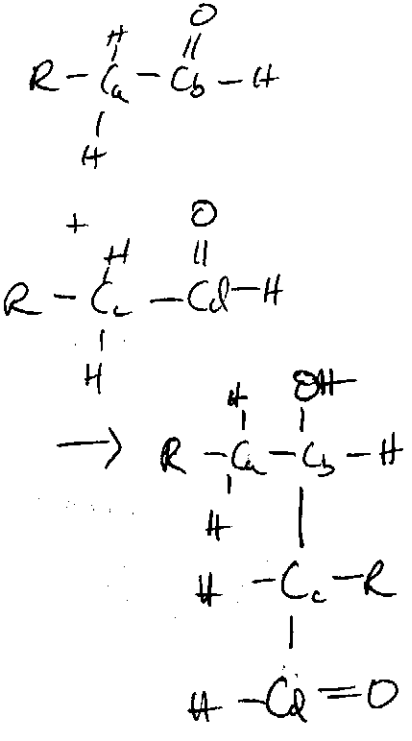
Aldol Condensation

α H activity ↑, susceptibility of  to nucleophile.

or ketone.

(acid catalyzed)

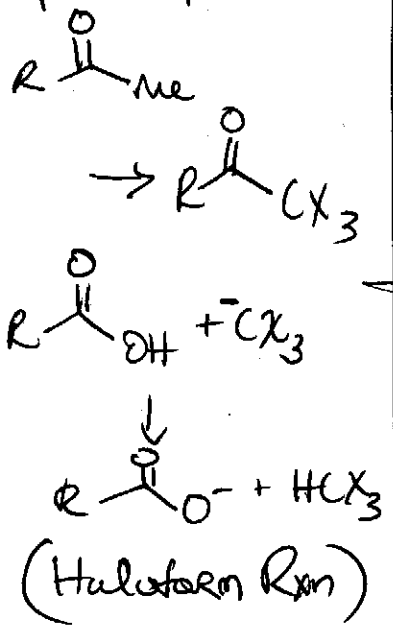
base



(aldol)

Halogens added to ketones @ α-carbon in presence of base or acid.

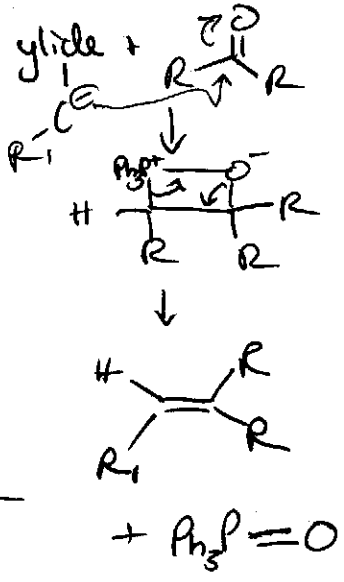
w/ methyl ketone.



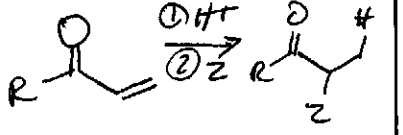
(Haloform Rxn)

Wittig Rxn.

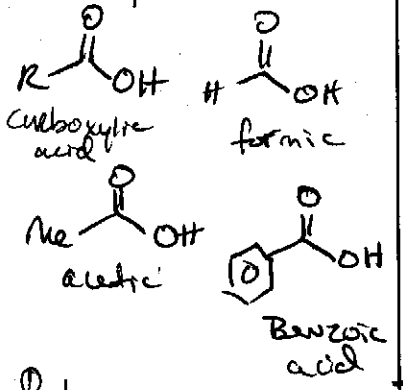
ketone ⟹ alkene



α-β Unsaturated Carbonyls



Carboxylic Acids.



Behaves as acid in S_N1 or S_N2

EWG's on α-C

α ↑ acidity

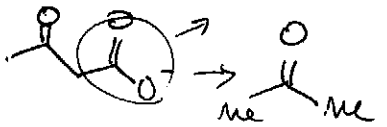
make strong H-bonds

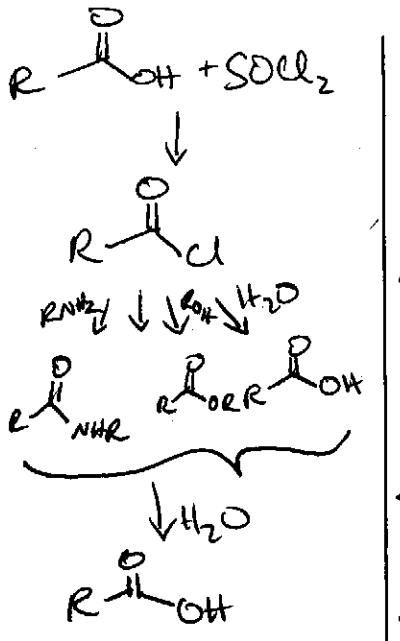
α ↑ BP

↓ MP bc no crystal lattice.

Decarboxylation

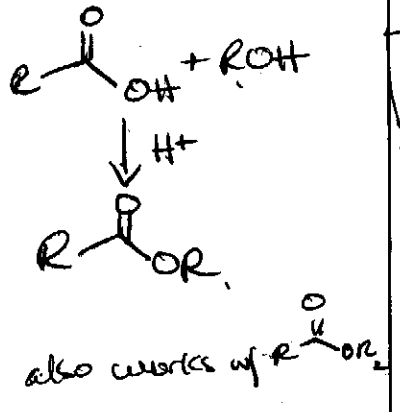
lose CO_2.



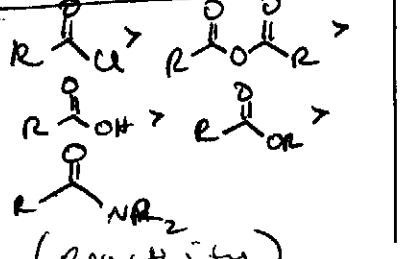


Acid chlorides ↑ reactivity ↓ nucleophiles

Esterification.



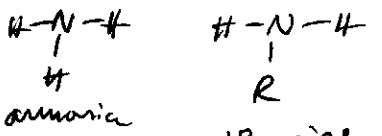
also works w/



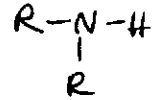
(Reactivity)

Amines

Derivatives of ammonia



ammonia — 1° amine



2° amine.

N can make 3-4 bonds

- may act as Lewis base
- may be nucleophile.
- can take 4th bond → ⊕ charge

act as weak bases.

EWG α ↓ basicity

EDG α ↑ basicity

2° > 1° > ammonia basicity w/ EDG groups

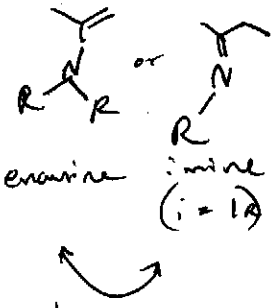
aromatic amines → weak bases.

amines ↑ ammonia H-bond

α ↑ BP α ↑ H_2O Solubility

Ketone Condensation

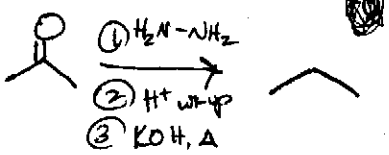
Amine + aldehyde/ketone ⇒ imine/enamine



tautomers.

Wolff-Kishner

reduce ketone or aldehyde by removing Oxygen & replacing w/ 2 H's.



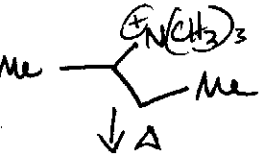
Alkylation & Hoffman Elim.

$NH_3 + RX \rightarrow RNH_2 + HX$

$NRH_2 + RX \rightarrow R_2NH + HX$

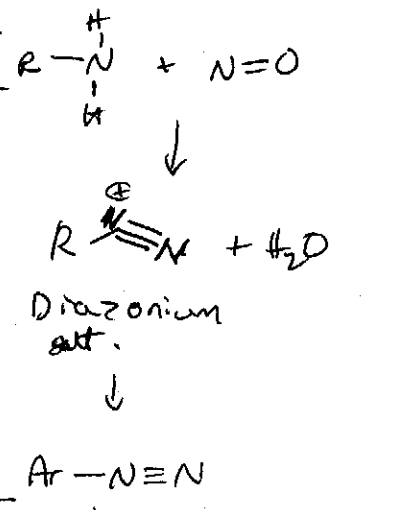
$NR_2H + RX \rightarrow R_3N + HX$

$NR_3 + RX \rightarrow R_4N^+ + X^-$



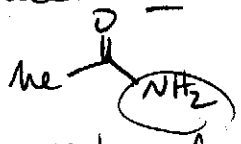
* least substituted (Hoffman) is major product

1° amine + Nitrosonium



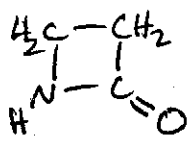
Amides

acetamide



weak acid or base. able to H-bond.

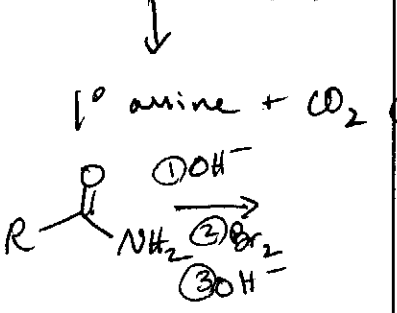
β lactams



electrophilic ↑

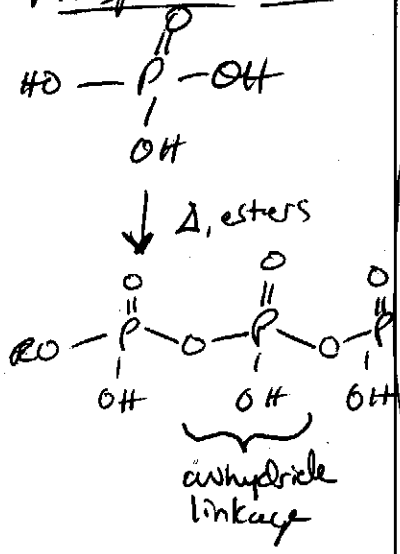
Hoffman Degradation

1° amide + chloric or bromic base



→ $R-NH_2 + CO_2 + OH^-$

Phosphoric Acid



in our cells @ pH 7, triphosphates are (−) charged, more stable. ATP is an important triphosphate.

Biochem & Lab Techniques

Fatty Acids — long C-chains w/ carboxylic acid end.

① hormones, intracellular messengers (eicosanoids, prostaglandins)

② components of phospho & glyco-lipid membranes

③ fuel for body.

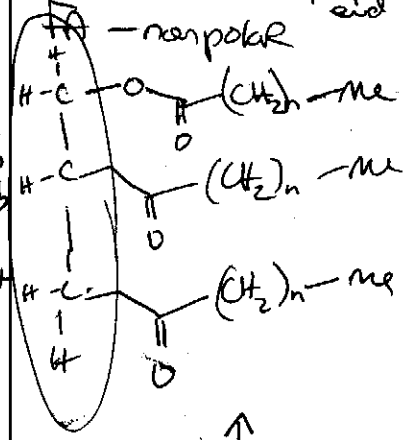
↳ stored as triacylgycerols

↓ hydrolysis

glycerol + FA. (lipolysis)

triacylgycerols can be cleaved by addition of NaOH ⇒ saponification

fatty acids are amphipathic (hydrophilic + hydrophobic end)



glycerol ↑ fatty acids (3) ↑

"triacylgycerols"

Separation by lipases & H_2O hydrolysis (saponification)

FA's enter Krebs cycle

2 carbons @ a time.

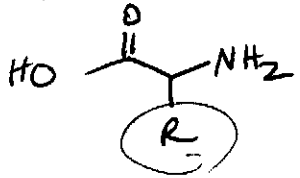
Stored in triacylgycerols in adipose cells

Lypolysis ↑ α ↑ (nor)epi
↑ glucagon
↑ ACTH

once in cell, FA linked to coenzyme A → oxidized to acetyl CoA

Amino Acids.

Building blocks of proteins.



functionality.

We use 2 amino acids

aa's in 4 groups

nonpolar — vipmaltpg

polar — stc tga

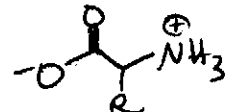
acidic — a & g acid

basic — hal.

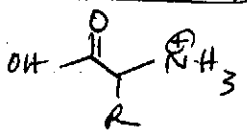
Hal is basic

[redacted]

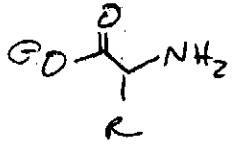
zwitterion



aa in low pH



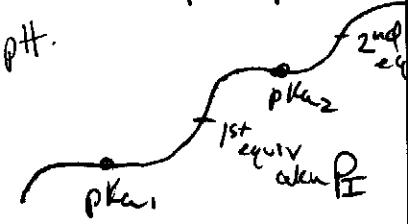
aa in high pH



titrate diprotic acid w/ strong base

pH ↑ → carboxylic acid loses proton.

½ equiv point → buffered pH = pKa



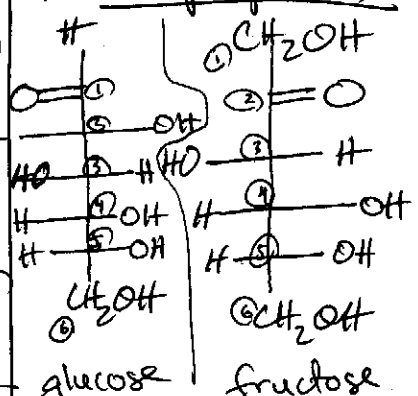
alanine w/ strong base

Carbohydrates.

$C_n(H_2O)_n$

usually fructose or glucose.

Fischer projections



chiral carbons named D or L

D = OH on #5 is right

L = OH on #5 is left

anomeric carbon = carbonyl

5 membered ring → furanose

6 membered → pyranose.

Saccharides

Sucrose - 1'1 link. glucose w/ fructose

maltose - α1-4 two glucose

Lactose - β-1,4 galactose & glucose

Cellulose - β-1,4 glucose

Amylose - α 1,4 glucose

Amylopectin - α1,4 glucose w/ α1,6

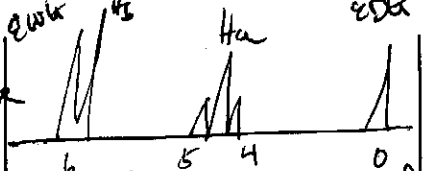
Glycogen - α1,4 glucose w/ α1,6

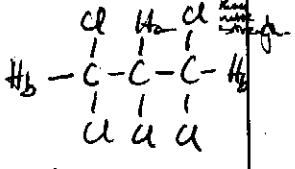
Broken via hydrolysis. enzyme. We need enzyme to break β.

Lab Techniques

- spectroscopy
  - NMR
  - IR
  - UV
- mass spec
- Separation
  - chromatography
  - distillation
  - crystallization
  - extraction.

NMR - studies H nucleus. use odd atomic number or mass





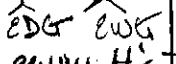
Splitting → neighboring hydrogen

area under peak ∝ # hydrogens

splits = n + 1

n = neighbors.

Aldehyde proton is @ 9.5.



chemically equiv H's have same peaks (attached to same Carbon)

IR spec.

infrared radiation.

OH - wide peak @ 3,000

C=O - sharp @ 1700

N-H - small @ 3300

C-H - sharp @ 3,000

C≡N - 2200

C=C - 1600.

fingerprint region: 600 - 1400

UV spec

200 - 400

30 - 40nm increase for each dbl bond conjugated and 5 for each alkyl grp

dienes @ 280.

Visible Spectrum

8 or more dbl bonds in conj

eg. β carotene. absorbs @ 497

⇒ complementary color of red-orange

Mass Spec

gives MW.

m/z = mass :: charge ratio.

Chromatography.

separation of mixture by passing it over matrix that absorb @ diff affinities.

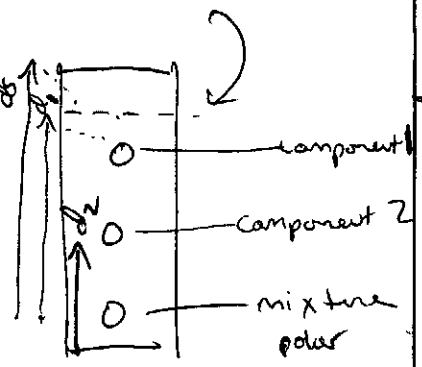
Solid to Liquid

column chromatography

Polar & slower

Paper Chromatography

Solvent line



$$R_f = \frac{d_1}{d_s}$$

Polar moves slowly (attracted to polar paper)

R_f = dist traveled by component / dist traveled by solvent

b/w 0 → 1

Thin Layer chromatography

Same thing but w/ coated glass.

Gas Chromatography

gas passed over coated column.

Distillation

separation based on vapor pressure via slow boiling.

The cpd w/ the lower BP (higher VP) will boil off and be captured. condensed in cool tube.

Raoult's law - impure mixture boils sooner than either of its pure components.

Fractional Distillation

Same thing but vapor is run thru glass beads to let cpd w/ higher BP to condense back into soln.

Crystallization:

Purity & ease of crystallization

icebergs made up of pure water.

exothermic for salts

hardly used in lab.

Extraction

based on solubility due to similar polarities (Like dissolves like)

Organic layer + aqueous layer. Don't mix.

3 steps

① strong acid polarizes organic layer. polar amines leave

② weak base. leave deprotonates strong acids polar carboxylic acids leave.

③ strong base. Reacts w/ weak remaining acids

[redacted]

Amines leave COOH leaves then Phenol leaves.

Saponification

hydrolysis of an ester under basic conditions → form R-OH & salt of the carboxylic acid

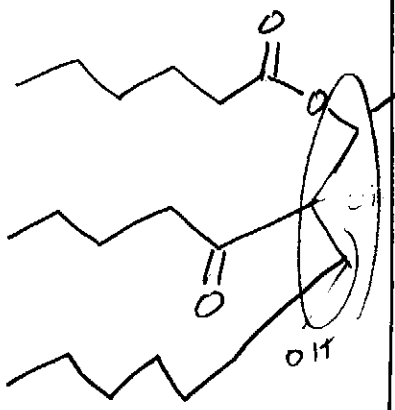
Triglyceride

molecule of fat or oil.

3 FA molecules on glyceral backbone.

(3) NaOH cleaves glyceral backbone to form glycerine.

(3) Na^+ joins Fatty acids to form 3 soap molecules.



3 FA

leaves as glyceral

Force (N)	$1\ kg \cdot \frac{m}{s^2}$
Energy (J)	$1\ N \cdot m$
Power (W)	$1\ J/s$
Charge (C)	$1\ A \cdot s$
Potential (V)	$1\ J/C$
Resistance (Ω)	$1\ V/A$
Capacitance (F)	$1\ \frac{C}{V}$
Magnetic Field (T)	$\frac{1\ N}{A \cdot m}$
Cycles (H_z)	s^{-1}
Wavelength (λ)	m or nm

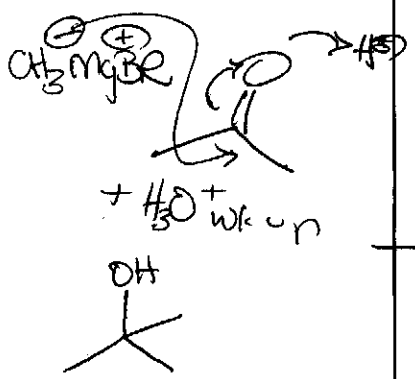
Be sure to write main idea @ beginning & end. as well as AA's struc.

Re-read your outline b4 going on to attempt questions.

Skip humanities pssgs until the end

Beware of "simple" answers.

Grignard reagent attacks carbonyls



Acetal - think "protecting a carbonyl"

D_2O acts like H_2O. used to see where stuff is added.

ACh ↑ ∠ Muscular contraction ↑ releases Ca^{2+} from sarcoplasmic reticulum.

Blocking ACh-ase increases ACh in synapse.

Poisons ∝ non-competitive inhibitors

only way to reverse is to increase metabolic/elimination rate.

if receptor mutation → membrane is affected.

sexual reproduction good for species ∠ ↑ genetic variation

S phase - doubling of DNA.

Organ undergo meiosis division.

Polyploidy - common in plants & bacteria.

↓ binary fission (amitotic)

↓

meiosis distribution of chromosomes

Heterozygote cross

Rr x Rr

3 : 1

dominant-to-recessive phenotype.

classic Jazz

Bye Bye Blackbird Coltrane & Davis. Charlie Parker.

Coltrane favorite Things Billie Holiday

Zwitterion → ∠ solubility & dipolar ↑

∠ | β prefixes describe stereochem of C-OR bond @ anomeric carbon

Differs @ C-1

AA composition difference

KPCOFGS

More Less

3 processes of bacteria genetic exchange

- Conjugation - sex pilus, plasmid genes, fertility & fuck
- Transformation - Gram(-) bacteria take up DNA from surroundings
- Transduction - genes transferred by virus.

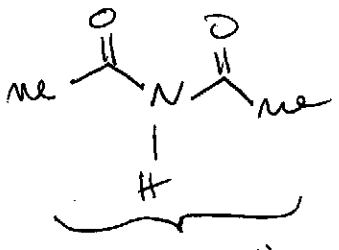
Translocation

cellular/organismal movement

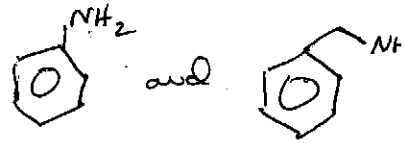
contraction of diaphragm. "works reflexively"

∠ negative intrapleural pressure

∠ inspiration.



"imine"



Both are $R-NH_2$

⇒ Both primary amines.

Pulmonary arterial Blood

less O_2, more CO_2, lower pH than aortic Blood.

veinous blood lower pH than arterial

LV wall thicker than RV wall and higher P when contracting.

25 mm Hg 120 mm Hg

RV → just to lungs
LV → entire rest of body

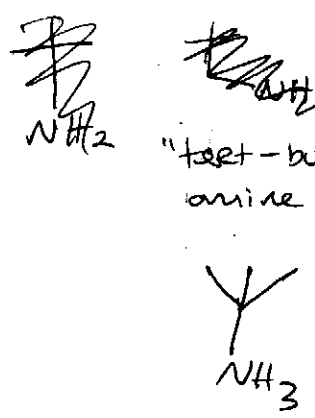
If blood flow to alveolus blocked
⇒ no flow of Hb rich blood cells to take away O_2 and no influx of CO_2 from blood
⇒ cavity will have ↑P_{O_2} and ↓P_{CO_2}

Hepato-pancreas ("liver")
Digestive system in arthropods.

Instead of kidney to remove waste, insects use tubules.

embryology — coelom development (cavity) pouch in the mesoderm

Gallbladder helps digest triglycerides (fats)



sweat glands — special channels thru skin

Virions are obligate parasites. much smaller than eukaryotes need tissue to be grown.

most viral proteins produced directly by txlation of viral nucleic acid.

translation: RNA → protein.
transcription: DNA → RNA

think alphabetical central Dogma

Peptide Bonds
N & C terminus joined.

If given formula draw the structure

Breathing rate (it)
10 breaths/min
tidal vol.
800 mL/breath
sys vol.
150 mL (dead space)
⇒ 6500 mL fresh air each minute

Unpaired electron = Radical
↓ reactivity.

Entropy is state fx.
$S_{Rxn} = S_{pdt} - S_{rctt}$
we do multiply coefficients.
(# gas moles matter!)
$O_3 \rightarrow O_2$ ↑ entropy

Oxidation States
F always -1
Grp 1 metal - always +1
Grp 2 metal - always +2
Element - always 0
H - almost always +1
O - almost always -2
Cl, Br, I - almost always -1.

$v = f\lambda$
wave every 3 s
wavelength is 1 m
$v = (3s^{-1})(1m)$
$v = \frac{1\,m}{3\,s} = .67\,m/s$

particle frequency
↑ radius of its circle

same heavy calculation/stoich probs to the end

↑ rcts ↗ ↑ yield.

adding more catalyst doesn't affect #g's of pdt.

if pKa of $H_2PO_4^-$ to HPO_4^{2-} is 6.7
and soln is buffered @ 8.7,
there is a difference
100::1 ratio of
$[HPO_4^{2-}] :: [H_2PO_4^-]$
base acid.
Makes sense — buffered @ basic pH

β decay — electron emission.
Z changes. nothing else.

$KE_{avg} = \frac{mv^2}{2}$

$\mathcal{E} = \frac{hc}{\lambda}$
if $\lambda = 450nm$
⇒ $\mathcal{E} = \frac{(6.6\times10^{-34}\,J\cdot s)(3\times10^{8}\,m/s)}{(450\times10^{-9}\,m)}$
$= 4.4\times10^{-19}\,J$

$Cl_2(g)$ more e-neg than I_2 (s)
Cu has +2 w/ Cl_2 than w/ I.

Practice Test Notes

↗ electronegativity

E emitted = photon.

Odd # atomic number
⇒ nonzero net spin.
be MRI.
eg. $^{19}_{9}F$, $^{1}_{0}H, C$

↑T ∝ ↑ KE rcts

~~Activation energy~~

K_{sp} of A_aB_b
$= [A]^a[B]^b$

$M(OH)_2 = [M][OH^-]^2$
if Solubility is $S \frac{mol}{L}$
$[M] = S\ mol$
$[OH^-] = 2S\ mol$
$K_{sp} = S(2S)^2 = 4S^3$

$W_{ice} = mg = \rho_{fluid} V_{submerged} g$

weight ↔ buoyant force ∝ g.

$W_{ice} = m = \rho_{fluid} V_{submerged}$.

fiber optics
Light over long distances w/ minimal loss of A
⇒ Reflection
"total internal reflection"

$F_B = \rho V g$

$PV = nRT$

@ bottom of pool, a weighted balloon has higher T, more ↑P ∝ T ↑

vertical forces in fluid... weight and F_B only.

$P_{water} \perp$ to all sides.

$V_{fluid} \propto \frac{1}{\text{cross-sectional area of pipe}}$.

$nRT = P_1V_1 = P_2V_2$

Insulator - valence e's tightly bound to atoms. cannot move easily b/w atoms.

R = resistivity $\times \frac{L}{A}$

7.15g $Na_2CO_3 \times 10H_2O$

$\frac{7.15\ g}{286.15\ mol} \times \frac{1}{40} = 0.025\ mol$.

$\times 2\ Na^+$ ions
⇒ 0.05 mol
actual ions =
$(0.05)(6.02 \times 10^{23}) = 3 \times 10^{22}$ ions.

Red litmus paper turns blue in base.

mol of $NiSO_4$ in 6.57 g of complex

$\frac{6.57}{262.84} = 0.025\ mol$

$HCl + CO_3^{2-} \rightarrow CO_2 \uparrow$

Nickel (II) soln has color b/c unfilled d-orbitals. absorb light to excite e's.

no rxn → sol in water.

K_{sp} for A_aB_b
$= [A]^a[B]^b$
if cpd exceeds this → precipitate

Metathesis
Mixing cations, anions.
ionic cpds switch their partners.

~~Solubility of ppt~~

precipitate = Rxn
no precip = no rxn

↓ K_{sp} ∝ ↓ [ ]'s of cation/anion in H_2O.
∝ ↑ precipitate

Fatty acid general formula
$R_n - CO_2H$

FA salt would be
$R_n - CO_2^- Na^+$

review saponification rxn

4 FA's from triglyceride
if one of C's was unsaturated
⇒ isomerization

3 equivs OH^- needed to saponify a triglyceral.
⇒ 3 FA groups.

$V = \mathcal{E} - iR$
battery

$n_1\Theta_1 = n_2\Theta_2$

Speed of sound constant in still air.

$f'_{obs} = \frac{v}{v \pm v_{source}} f$

independent of distance.

Δp = impulse
$(F\Delta t)$

correct VR. answers will use "hot words" from passage.

microtubules, cytoskeletal element → cell shape
leukocyte phagocytosis has high microtubule activity, no shape change to engulf

Write down narrowed down choices for "marked" ans's.
Review all answers

Bio. bone ‖ blood Ca^{2+}

low Ca^{2+} in blood
⇒ ↑ osteoclast
↑ PTH
parathyroid calcitonin ∝ ↑ Ca^{2+} in Hb
↑ Vit C ∝ ↓ Ca^{2+}
∝ ↓ PTH

high Ca^{2+} in Hb
⇒ calcitonin ↑

nonpolar – fat soluble

Removal of PTH
⇒ hypocalcemia in Hb
neuromuscular excitability ↑

CUT – pyrimidines.

KFCOFGS

KAPCOFGS.

King Phillip Came Over for Great Soppers

Kinetically controlled pdt
formed faster than thermo controlled pdt
$\Delta G = \Delta H - T\Delta S$

$Ea_{kpdt} < Ea_{\Delta pdt}$

Thermodynamically controlled pdt
↳ formed under equilib.
more stable.

Splitting of H's nearby

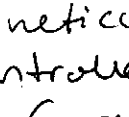
eg, 

H is singlet.

uric acid – bird poo

washing w/ H_2O
⇒ removes H_2O soluble impurities.

cyclohexane hybridization.



SP^2 hybridized (3 atoms)

Aldosterone released by adrenal glands
∝ ↑ Na^+ ∝ ↑ H_2O
∝ ↑ Hb Htg

↑ GFR → BP systemic
↑ urine.
if this fails
⇒ hypertension

BP ↓ GFR ↓
↑ angiotensin → ↑ aldosterone
↑ Na^+ ↑ H_2O ↑ BP

$P = CO \times VR$
BP = cardiac output × vascular resistance
if resistance increased by 50% and BP doubled
⇒

$\frac{2P}{\frac{3}{2}VR}$ = new CO would be $\frac{4}{3}$ of original.

$P = I^2R$

hypertension caused by vasoconstriction of smooth muscle blood vessels.

ER – antibody synthesis.

to remove triethylamine, wash with HCl.

cyclohexanes largest groups (eg, butyl) go equatorial.

glomerulus: filtration of uric acid.

triglyceride has 1 stereogenic C.

"Alkaline tale"
↳ Basic solution

H-bonding
if lone pair on every atom.
N, O, F

Glycine (aq) can exist as 3 types of ions:
low pH: $H_3\overset{\oplus}{N}-CH_2-COOH$
high pH: $H_2N-CH_2-COO^{\ominus}$
pH 7: $H_3\overset{\oplus}{N}-CH_2-COO^{\ominus}$

Atomic radius
↙ ↗
Ionization.

Sum of protons, neutrons & electrons in Strontium-90
90 total weight − 38 protons
= 52 neutrons
38 p + 38 e^- + 52 N
⇒ 128 total.

Ionic Bond
First 2 columns w/ last 3 columns
eg NaCl, CaI.

Radio signal ν
$c = 3\times10^8$ m/s.

satellite kept in orbit bc of centripetal force.

$F_G = \frac{G M_1 M_2}{r^2}$

if mass quadrupled and orbit radius 6x.

$F_G \propto \frac{4}{6^2} \propto \frac{1}{9}$

$P = IV$ = Watts.

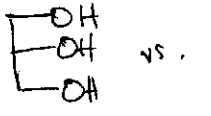
Beat frequency
↳ subtract 2 diff f's
⇒ H_2

EM waves travel slower thru atmosphere than vacuum bc of index of refraction.

Saponification
Cleaving triglyceride into its fatty acids
Requires base.

1 cal = $\frac{1\,C}{1000}$

metabolism ⇒ calories



Higher BP (>10°C)

↑ H-bonding ∝ ↑ T_{BP}

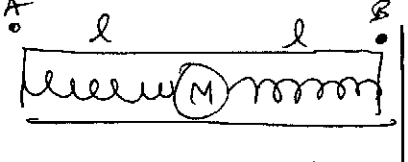
E_a ↗

For a redox rxn to occur, E° must be positive for both Galvanic & Voltaic

$f = \frac{1}{T}$

Roundtrip time for ball thrown upward

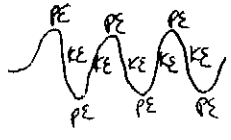
$t = \frac{2v}{g}$



Effective spring constant?
$F = -Kx$
when mass M is @ B, two springs are disturbed.
⇒ effective 2-spring constant.
⇒ 2K

Calculate T (s)
K (N/m); M (kg)
$F = ma$
K (kg/s²)
$s^2 = (kg)/(kg/s^2)$
$T^2 \propto \frac{M}{K}$

Oscillating systems usually have total E conserved



PE $\frac{Kx^2}{2}$

$E_{int} = 2\left(\frac{KA^2}{2}\right)$

$\Rightarrow K = E_{int}/A^2$

Specific heat in units J/(kg·K)

$\rho_{Gas\ X} < \rho_{Gas\ Y}$

Gas X will diffuse faster, bc it has lower molar mass than Y.

consider
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
if introduce a catalyst, the amt of NH_3 will remain the same
position in equilibrium solely determined by $(\Delta G^\circ_{Prdts} - \Delta G^\circ_{Rcts})$.
Catalyst speeds rxn by lowering E_A doesn't affect position
★ sped up ✓
★ amount − same ✗

Solid body in rotational equilibrium when external Σ sum to $\emptyset$.

Newton's Laws

① Law of Inertia
② $F = ma$
③ action ⅓ reaction

Low Pressure $\propto$ Sublimation/Deposition

Sunlight does not reflect significantly from gasses, more from solids.

Spectroscopy — used to identify composition of materials.

Positive ions $\propto$ E field

---

^6Li isotope. 6 = # protons + # neutrons

$qV = \frac{1}{2}mv^2$

if voltage is decreased, ion moves slower.

---

protons = elemental identity.

Which is more soluble in 1M HCl than 1M NaOH?

$\Rightarrow Pb(OH)_2$

$Pb^{2+} + 2OH^-$ + H^+ acid

$\Downarrow$

H_2O (soluble)

Rxn $\rightarrow$ right (LeChatelier)

Intensity less when wall b/w source ⅓ detector bc some sound is reflected.

Hooke's Law

$\frac{F}{A} = \frac{Y\Delta L}{L}$

if Length ⅓ radius doubled.

$\Rightarrow \frac{F}{2^2A} = \frac{Y\Delta L}{2L}$

ΔL decreased by factor of 2

~~Rxn~~

$Cu^{2+} + SO_4^{2-} + 2e^- \rightarrow CuSO_4$

if current is increased, Rxn will go to the right.

Electric power for tx over long distances "stepped up"

$\frac{\uparrow\uparrow V}{I} = R$

to cut down on resistance.

Asthma — difficulty exhaling

$\uparrow CO_2$ $\downarrow$ pH below 7.4 $\rightarrow$ acidosis.

Leukotrienes & Neutrophils & eisonophils respond to...

T lymph $\rightarrow$ cytokines $\rightarrow$ B lymph

Eisonophils $\rightarrow$ leukotrienes $\rightarrow$ leukocytes, Bronchial smooth muscle

mast cells $\rightarrow$ histamines $\rightarrow$ vasodilation $\rightarrow$ Microvascular endothelium

---

Bimolecular data table implies E2 or SN2.

(The "two" stands for bimolecular)

Saystseff's rule

Internal alkene is more stable.

$\Rightarrow$ formed from internal halide

Staph & Strept trigger toxic shock syndrome by stimulating exaggerated immune responses.

---

amino acids comprise 1° structure of peptide.

1×10^5 strain A req'd

5×10^4 strain B req'd

$\rightarrow .5 \times 10^5$ req'd

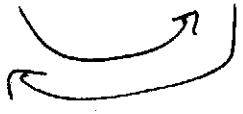
$\Rightarrow$ Strain A is ½ as potent as strain B.

Preventing bacterial synthesis:

- add stop codon in gene
- add repressor protein to bind w/ operon
- add complementary strand to bind to mRNA

[adding tRNA would not work]

NaIl + $Cd(NO_3)_2$



Displacement Rxn.

$CdCl_2$ precipitate

S tends to be −2

$Cu + HNO_3 \rightarrow NO_{(g)}$

Strip of Cu (neutral) placed in $Ag^{(+1)}NO_{3(aq)}^{(-1)}$

new metal forms on strip

Cu is oxidized and Ag^+ reduced.

$I_{2(s)} \rightarrow I_{2(g)}$

$\Delta S > 0$

Doppler shift. When source sound moves away from observer, appears

to have lower f; higher λ

Read carefully any probs that seem tricky.

eg, if you forgot EXCEPT or a negative sign, etc.

⊕ ← ⊖ accelerates.

fixed free

transition metals. 3d electrons are the ones that bond.

Oxygen
- ↑ H_2O solubility
- ↑ polarity.

PE → KE + thermal (friction)

- Momentum conserved
- Energy NOT conserved

$t = \sqrt{\left(\frac{2h}{g}\right)}$

time to fall.

$v = \sqrt{2gh}$

PE to KE

$mgh = \frac{mv^2}{2}$

if height is halved →

$\sqrt{\left(\frac{1}{2}\right)2gh} = v^2$

$\sqrt{gh} = v$

instead of $\sqrt{2gh}$ slower by factor of $\sqrt{2}$

Standing wave: equal amplitudes moving in opposite directions

A laser only has 1 mode of oscillation.

$\Rightarrow$ monochromatic and coherent

$v_{light} = c$

$F_B = \rho V g$

if object totally immersed in 2 fluids

↑ 12N and 5N↑

$\rho V g = F_{B1} = 5N$

$F_{B2} = 12N$

$\rho_1 = 0.7$

$\frac{12}{5} = \frac{\rho_2}{0.7}$

$(2.4)(0.7) = \rho_2$

$1.7 \approx \rho_2$

Assume a saturated soln of $Ca(OH)_2$. What happens when we lower pH.

K_{sp} is unchanged but add'l $Ca(OH)_2$ will dissolve.

→ NOT colligative but state property

→ lower pH

→ ↑ solubility

near sighted (myopic) individual

image of distant object is focused in front of retina requiring divergent lens correction.

Orgo Priority System.

Substituents in order of decreasing atomic #

N > C > H

---

stereoisomers = 2^n

where n = chiral centers

---

ester vs. ether

TLC:

OH → more polar → lower Rf than S.M.

---

tert alcohols react quickest w/ strong acids

best to form alkyl halides

---

cyclin protein ↑ during interphase, proteolysis in mitosis

Immune sys avoids attacking own cells

If ulcer penetrates colon, gastric juice → peritoneal cavity.

Antigens on the surface of cells/proteins

---

watch out for EXCEPT questions

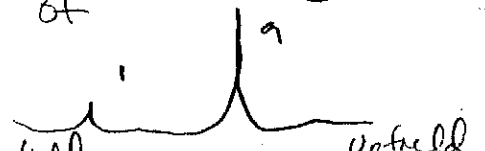
---

non-Mendelian inheritance:

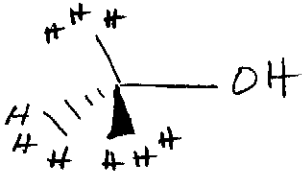
- incomplete penetrance
- limited expressivity
- polygenic disorder

↑ alkyl groups → stabilize carbocation thru hyperconjugation.

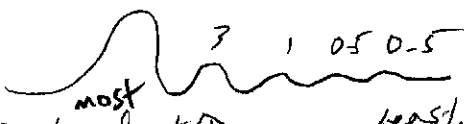
NMR splitting of



consistent w/



Gas Chromatography



$$\frac{3}{48 \cdot 1 + 2(0\text{-}5)} \Rightarrow \boxed{6\%}$$

---

quenching of carbocations → alcohols → peak @ 3500

SER resembles Golgi

Both are folded membrane organelles

Triglyceride can be hydrolized to form RCOOH + glycerol.

Lipases help hydrolyze fats & carboxylic acid esters (similar)

Diff substrates, similar linkages

Antibodies may be denatured in stomach

Leukocytes & Inflammation

Enzymatic activity in stomach → protein digestion.

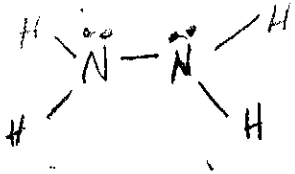
Direction of cell differentiation signal: from totipotent to → fated

---

Liver regenerates after via Mitosis

---

cholesterol → sex hormones



full octet

expanded octet

Basicity $\propto K_b$

$\Delta S \uparrow \propto$ # mols gas.

& structure
Phase, phase equilib.
atomic & nuclear structure.
Sound
motion.
Waves.
Fluids / Solids.

Ion more massive than electron

Elements in same group (aka column)
→ similar properties

low BP
weak intermolecular forces.
expect van Der Waals not H-bonds or covalent

fractional distillation
↳ desired cpd has lower BP than solid impurities.

$V_{real} > V_{ideal}$
b/c ideal neglects volume of indiv. gas mols

From air to glass
Light slows down
Sound speeds up
↳ $n_{glass} > n_{air}$
↳ more rigid bonds than air
$v_{sound\ solid} > v_{sound\ air}$

ear or train track.

molarity of pure cpd =

$$\left(\frac{\text{density}}{mL}\right)\left(1000\,mL\right)\left(\frac{\text{molar}}{\text{weight}}\right)$$

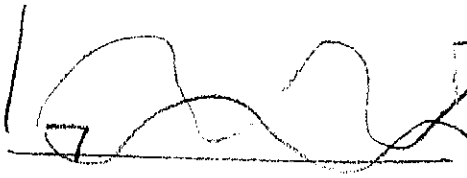
Light is 400 to 700 nm
395 is near UV side.
ultrafast → ↑ν ∝ ↓λ

$P = IV$

interference —
same frequency.

Electromagnetic waves are transverse —
sound pressure waves longitudinal.

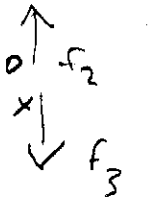
Light



BP ∝ intermol. force

$$v = \frac{\lambda}{T} = \left(\frac{m}{s}\right)$$

Doppler Effect
• source



f_2's wavelength decreased
f_3's $\frac{\lambda}{\lambda}$ increased

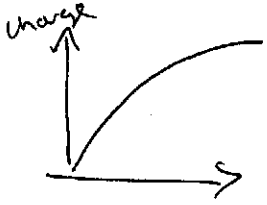
E of H atom as e jumps up a shell.
Energy of atom increased

1F = 1 mole e charge

Indicator changes color depends on its pKa or pK_b

25 errors → ∅.

Switched closed on circuit.



E force on particle independent of particle's speed.

Capacitance (C) ∝ $\frac{A}{d}$

$F = ma = Eq$

Capacitors in series: overall less than if parallel

electron b/w parallel plates accelerates towards the positive plate.

OH group: able to hydrogen Bond in water.

Entropy > ∅ if # moles gaseous prdt > # moles gaseous rcts.

Greater the vapor pressure, greater the rate of evaporation.

H-bonding & intermolecular strength ∝ T_{mt}

$P = \rho gh$. ∝ T_{bp} ↑

$pH = pK_a + \log \frac{[\text{conj base}]}{[\text{acid}]}$

$pK_a = -\log K_a$.

$NH_4NO_{3(s)} \xrightarrow{H_2O} NH_{4(aq)}^+ + NO_{3(aq)}^-$

Strong Base + Buffered solution ⇒ slight (<0.1pH) increase

Why is $NaNO_{2(aq)}$ basic? Arrhenius Base

NO_2^- rcts w/ water, effectively forms OH^- ions in soln

Gravity is often a "restoring" force.

$v = f\lambda$

Why do oscillations persist? Energy conservation.

v_{sound} ∝ metal ∝ T_f

Brønsted Pro Donor	then liquid then air

ROY G BIV

700 nm ⟷ 400

slow two nm.

Adiabatic — P ↑ rapid compression little heat loss. ∝ ↑T ⇒ other energy like PV work.

↑ ($\Delta U = nR\Delta T$) ↑

Octahedral — central metal plus 6 ligands eg AlF_6^{3-}

Lewis acid accept pair of e⁻s.

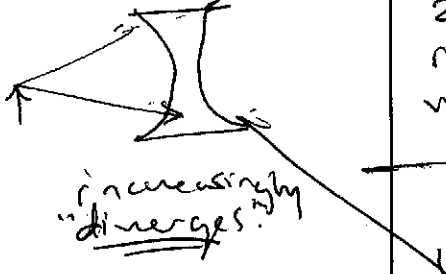
Reduction @ cathode in both galvanic AND electrolytic cells.

ANOX, RedCAT

If chromosome duplication 2× before tetrad ⇒ 4 hap. sperm

1 mol STP gas = 22.4 L

radius of curvature ∝ focal length.



increasingly "diverges"

same light absorbed by lens or mirror, becomes warm.

light travels slower w/ increasing n. Why? ⇒ light absorbed & re-emitted by atomic structure of optically dense medium.

$Sn2^*$ prefers no steric.

~~if magnitude~~ $E = \frac{kQ}{r^2}$

$E \propto Q$

$E \propto \frac{1}{r^2}$

relax at diaphragm
- rib cage elevates
- reduction of plural cavity P.
- contraction of ext intercostal rib
- diaphragm contract muscles

2N can't be resultant of vectors 7N & 11N

K_{sp} for $PbCl_2$ tells us how much Pb^{2+} w/ precip. when HCl added.

β decay — atomic # goes up by 1. mass ≈ same.

if oligonucleotides were degraded too rapidly ⇒ cell differentiation less coordinated

$Sn1$ likes steric. 3° most stable

negative feedback

hypo & Ant. Pituitary

gonads

Hypo Ant.Pit.

(GnRH) → LH FSH

inhibit

blood

gonads

estrogen

Negative Feedback

FSH ↓ ∝ progest ↓

estrogen ↓

GnRH ↑

Both bacteria & eukaryotes have plasma memb.

↳ no mitochond no) ER.

if X inhibits translation, acts on Ribosomes.

semilogarythmic graph is straight lined- (looks like $\frac{v}{t}$ graph.

Osmotic P diff b/w membs bc solvent can pass thro.

min +60 kcal

-80

capillaries

→ Passive H_2O diffusion.

Blood clot on venous side of capillary bed

⇒ net fluid flow in interstitial space

⇒ edema

Not in dialysate to maintain isotonicity w/ blood.

Free radical Bromination. Good candidate

CH_3.

3° free radical intermediate

Gas chromatography area ∝ % pdt.

1:2 ⇒ 33% A

67% B

HNMR of

Br (deshielded)

H

H_3C — C — C — CH_3

CH_3 CH_3

⇒ singlet, doublet, septet

Dihydroxyacetone

CH_2OH -alcohol

C=O -ketone

CH_2OH -carb.

enol of

COO⁻

C=O

CH_3

is:

O

C — O⁻

C — OH

CH_2

Delivery of antisense gene: infect embryo w/ modified virus to carry gene!

methyl H moves ⇒ ketone O atom

⇒ dbl bonded carbon.

alcohol grp → ketone (Redox)

2 ↑ H bonds to Oxygen

endothelial cells common to arteries, veins, capillaries.

not all arteries dilate/constrict veins have valves!

Metabolically active tissue, such as muscle...

∝ ↑ Mitochondria

∝ ↑ need for O_2

∝ ↑ capillaries

~~Nitrogen, base, sugar~~

~~Group~~

H-bonding ability

H covalently bonded to e-neg element eg (OH) or (NH

2 helix - 2nd arg strucd

Cell line viability / basal functions ⇒ control groups

Bone resorption = decrease in bone mass

antisense drugs prevent RNA translation

mRNA 5'-CGACUAC-3'

3'-GCUAUG-5'

will hybridize

review these probs

Stoichiometry

1/4 , 4/6 ✓

Solution chemistry

4/7 , 2/4 ✓

Atomic, nuc structure

~~1/2~~ 1/3 , ~~2/3~~

2/4

e-statics, e-magnetism

1/2 2/3

Fluids, solids

2/4 , 1/2

light, geo optics

1/2

Work & Energy

1/2

Trans motion

2/3

Bio molecules

2/4

Oxygen-containing gods

1/3

Enzymes

2/3 . 0/3

Eukary cells

4/6 , 2/3

Nervous, Endo

2/3 , 0/3

Phase equilibria ✓

2/5

Sound

1/2 , 1/3

Wave characteristics & Periodic motion

1/5. - 2/4

Hydrocarbons ~ separations

0/3 , 0/2

Circ. Lymph system

2/5. , 4/7

FA salts

Practically dissolve in both polar and non-polar

* CHO chain (nonpolar)

* charged CO_2^- head (polar)

Pancreas - produces proteolytic enzymes.

eg. trypsin, chymotrypsin, carboxypeptidase

hydrolyze

leaving group → pentanol

w/ $H_2{}^{18}O$

CH_3CO_2H will have radioactive Oxygen.

heart & blood - mesoderm.

↑T ∝ ↑sweat ∝ water loss

no interbreeding no fertile offspring → separate species.

Natural Selection

those who produce more offspring their trait ad "evolve by nat selection

w/in sarcomere, microfilament length stable. one end anchored by Z line; other by a protein.

Watson-Crick model

G - C G = C

A - T A = T

Stoichiometry.

1 mol = 6.02×10^{23} atoms

combination rxn

$S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$

neutralization rxn:

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

Solutions

K_{sp} = [products]$^{\text{coefficients}}$

↑ some constant.

the lower, the less likely to dissolve. ⇒ precipitate

leave out pure liquids & solids.

solubility pdt $\propto T$

solubility $\propto T$ and ions.

Normality

$\frac{\text{g of solute}}{L \text{ of soln}}$

Atomic, Nuc Structure.

mass # $^{A}_{Z}X$ element

atomic #

1 mol = 6.02×10^{23} atoms.

Isotope – Diff # of neutrons

Ion – Diff # e-trons

Photon Energy:

$$\mathcal{E} = \frac{hc}{\lambda} = hf$$

n. larger the n, higher e-level and radius of e-tron's orbit.

Z_{eff}

$\mathcal{E}$ of ion

$\mathcal{E}$ affinity

$\mathcal{E}$ neg

↗ Atomic radius, metallic character

Bottom left + top right ⇒ ionic cpd

Phase equilibria

FP depression

$\Delta T_f = K_f m$

Osmotic P

$= \Pi = MRT$

Diffusion – gas diffuses thru mixture

Effusion – to another compartment thru small opening.

$q = mc\Delta T$ Hfusion $q = mc\Delta T$ Hvaporization

$\mathcal{E}$ statics | Magnetism

$$F = \frac{kQ_1Q_2}{r^2}$$

$\mathcal{E}$ field

$$\mathcal{E} = \frac{F}{q} = \frac{kq}{r^2}$$

$U = qEd$

$\mathcal{E}$ potential

$$V = \frac{W}{q} = \frac{kQ}{r}$$

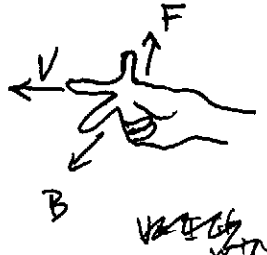
$V = \mathcal{E}d$

magnetic field

1 Tesla = $1 N/M \cdot C$

$F = qvB\sin\theta$

$F = iLB\sin\theta$



V is also function of i if current.

current carrying wire.

$R = \rho\frac{L}{A}$

Fluids | Solids.

$\rho = \frac{m}{V}$

$S.G. = \frac{\rho_{subst.}}{\rho_{water}}$

$\rho_{water} = 1 g/cm^3$

$P = \frac{F}{A} = \rho g y$

Hydraulic lift (Pascal's principle)

$F_1 d_1 = F_2 d_2$

$F_B = \rho_{fluid} V g.$

fraction submerged = $\frac{\rho_{floating\ object}}{\rho_{fluid}}$.

F_B is constant despite change in depth.

⇒ constant q

$W = \rho g V$

mass = ρV

F_B = weight of displaced fluid

if $F_B < W_{object}$

⇒ sink

if $F_B > W_{object}$

⇒ float.

Light, Geo Optics

mirror eqn:

$$d_i^{-1} + d_o^{-1} = \frac{1}{f} = \frac{2}{r}$$

Lens eqn:

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

Concave mirror

enlarged, virtual image if obj w/in focal dist.

Convex mirror

virtual erect image

Converging lens

obj. outside f → real, inverted img

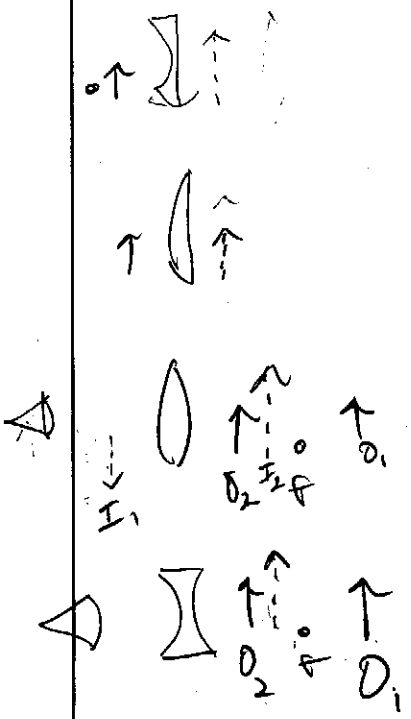
inside f → virtual, erect, enlarged img

Diverging lens

$$m = \frac{-d_i}{d_o}$$

$-m$ indicates inverted.

Waves



Copper in pennyhas ox state of 0

---

covalent bonds only

↑ energy density

OH

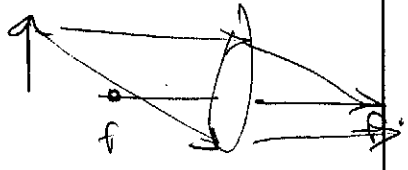
has both covalent & weak inter-molecular

K rcts most violently w/ cold water.

also most metallic ox

K, Mg, Fe, Zn.

(Periodic trend question)



opposite -

$W = Fd$.

$v_0 = \sqrt{2gh}$.

for projectile.

---

if earth's radius doubled and mass doubled

g would be $\frac{1}{2}$ as large bc denominator is squared

$$\frac{2m}{(2r)^2}$$

$\Rightarrow \frac{1}{2}$

That which is reduced is the oxidizing agent.

Losses oxidizing/oxidized

↓FP ∝ osmolarity.

.05M $CaCl_2$ > .20 NaCl

[redacted]

HOAc dissociation

$HOAc \rightleftharpoons H^+ + OAc^-$

Because

$[H_3O^+] = [OAc]$

$\Rightarrow K_a = \frac{[H_3O^+]^2}{[HOAc]}$

$\Rightarrow \frac{x^2}{\text{known } K}$

---

same atomic number (# protons) & same ~~properties~~.

Chemical behavior.

Electric field given in $\left(\frac{\text{volts}}{\text{meter}}\right)$

$\frac{5\,V}{0.03\,m}$ for separation of 3cm.

$\Rightarrow 166.7\,\frac{V}{m}$

$1\,V = 1\,\frac{J}{C}$

$166.7\,\frac{V}{m} = 166.7\,\frac{N}{C}$

destructive interference

@ $\frac{1}{2}$ wave difference or $180°$

$mass = \rho V$

---

oleic acid,

like other fatty acids, has polar head & nonpolar tail.

---

nonpolar solvents

- Benzene
- Diethyl ether
- Chloroform
- → all dissolve hydrocarbons

Particle accelerator

---

neutron - negligible ionization in chamber. uncharged.

single particle passing thru multiwire chamber can initiate 1+ signals. if ionization trail is equidistant from more than 1 anode wire.

Voltage in proportional chamber causes e⁻s cascade to signals produced @ anode w/ not be 2 weak to detect.

Curved trajectories > straight ones because radius of curvature can be used to ID particle

Spatial resolution of stacked multiwire chamber determined by spacing of anode wires

α particle would have largest anode signal $\downarrow$ c/ of its 2^+ charge

Standing person: $P_{blood\ leg} > P_{blood\ arm}$. Column of blood has hydrostatic pressure

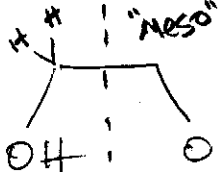
$P = \rho g h$.

$\alpha \uparrow$ gravity $\alpha \uparrow P$.

"ideal gas" => neglected individual molecular volume and intermolecular forces

@ peak height of propeller $a = -g$, $v = 0$

Chromosomal damage → mutation or cancer



will have just 2 distinct NMR signals $-CH_2$ and $-OH$.

heart - striated & skeletal. fibers.

hybridization - base pairing b/w DNA sequences.

voles = rodents aka mice

transcription → nucleus

O_2 has greatest electron affinity in the ETC

mitotic divisions of oogenia. → b/w fert & birth.

cell cycles

G G M S

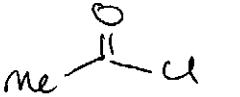
↓

nothing

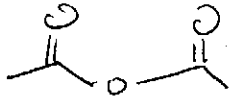
Both bact & euks use ATP synthase. ribosomes differ.

bact chromosome one circular (plasmids) whereas euk's are linear.

Grignard reagent needs ether.



most similar to



both can be acetylating agents

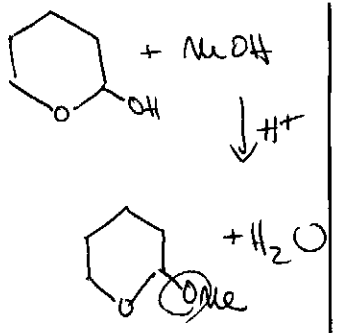
transmitter release α extracellular $[Ca^{2+}]$ imported into syn bouton

Power LG $\alpha \uparrow$ Hoffman. $I > Cl > F$

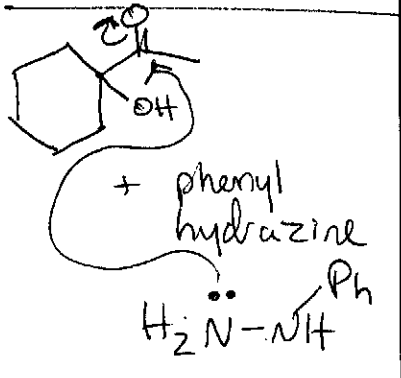
normal path of semen "Semen Up"

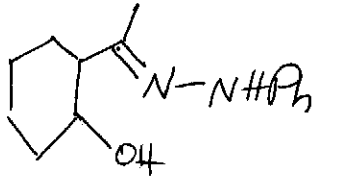
seminiferous tubules → epididymus → vas deferens → urethra → vagina → cervix → uterus → fallopian tubes

cell size limit: $S : A$ area. ↓ face



^{18}O-labeled methanol used. Would be on circled Oxygen





phenylhydrazone

first step of this rxn is addition

Alternative to sexual reproduction
↳ Parthenogenesis (1 individual)

Sympathetic
↑ division of ANS
↗ ↑ heart rate

↑ vagus nerve
↗ ↑ Parasympathetic
↗ ↑ ACh
↗ ↓ heart rate

Scar tissue
lacks exocrine glands
↗ overheating

O_2 in Hb
↗ breathing rate
↗ [Hb]
↗ alveoli surface area

NOT influenced by pulmonary artery BP.

↑ BP ↗ ↑ GFR
↗ ↑ urine

weight ↗ energy consumption

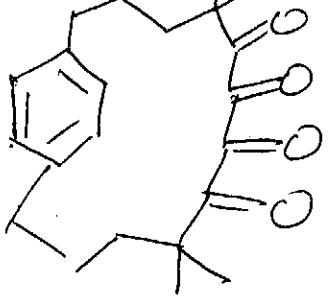
liver damage affects production of bile salts.

Digestive enzymes made in glandular cells in GI tract.

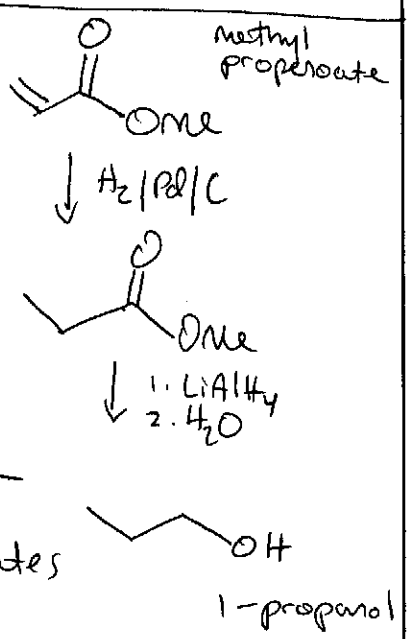
125 / 70 mm Hg.
(ventricles contracted; atria & ventricles relaxed.)

Role of pyridine
=> base. Deprotonates Sm to convert to nucleophile.

Acid chlorides more reactive than carboxylic acids.

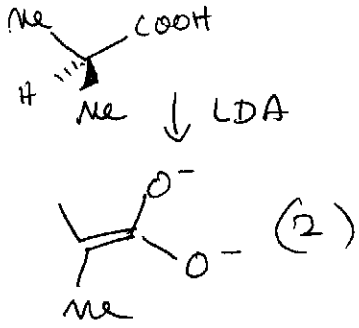


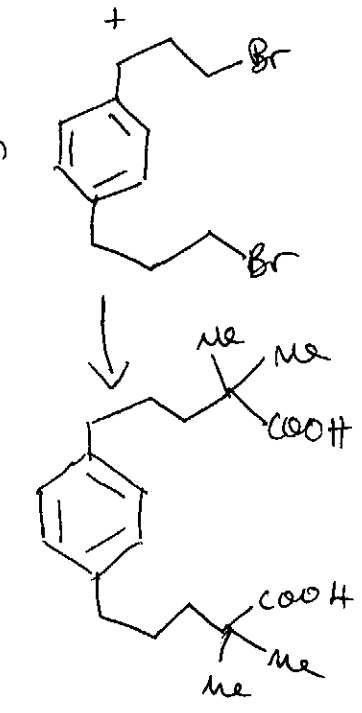
Why the bunny ears? (4 Me grps)
Prevents enolization since no α-Hydrogen



1-propanol

Macrophage – high rate of endocytosis. engulf extracellular material





ER – translation of antibody proteins & ribosomes.

Golgi – processing & export of proteins

Development:
Optic cup fails
↳ lens fails. (ectoderm)
⇒ ex. of cells inducing their neighbors to differentiate.

Expressing disease genes important in regulating normal physiology:
altered expression of disease genes leads to disease.

Distributed disorder such as neuro-fibromatosis:
all features arise from defects in gene expression.

---

change in type of transcript
&
change in type of protein synthesized.

---

mechanisms that regulate gene expression are complex and occur @ many levels w/in cell.

- regulating transcription of DNA
- post-transcriptional RNA modification in nucleus
- modifying stability of mRNA & protein in cytoplasm.

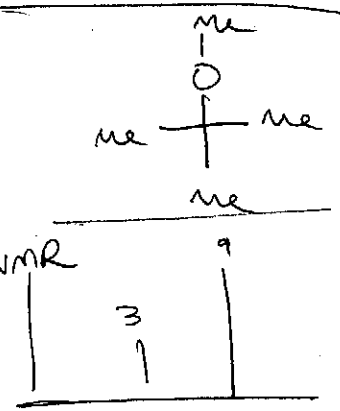
Expression & external cues & gene interaction

Differentiated cells express different proteins than do undifferentiated cells.
⇒ transcript changes as cell differentiates

Multiple proteins can be encoded by a single gene
⇒ evolutionary advantage

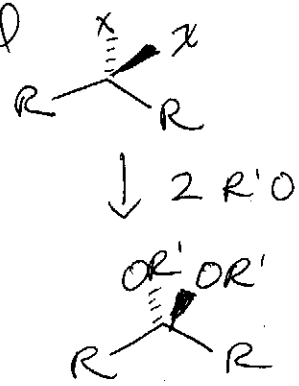
---

for ether synth, choose solvent that resembles nucleophile.



symmetrical
1pd → 2 signals

Geminal dihalide w/ 2 equivs alkoxide.
⇒ acetal



Sex-linked recessive

---

mostly sons affected.
skips generations

---

muscle cell in medium
Why is no lactate made?
⇒ no ATP present.
require investment of @ least 1.

Decolorization of Br_2 in CCl_4

---

presence of double bonds
-noic - 1 dbl
di/trienoic - 2/3

Anterior pituitary
ACTH → cortisone
TSH
LH

---

adrenal medulla

---

epinephrine

Human bone
- Ca^{2+}
- PO_4
- OH^-

} hydroxy-apatite

No Potassium