Must Know Topics from AP Biology Outline

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The following annotated outline is meant to serve as a guide to the specific content that most often appears on the AP Biology Exam (from within the very broad course description provided by the College Board). I created the outline by surveying past exams and by using my own experiences teaching AP Biology for 32 years. While other concepts may appear on any particular exam, my experience is that if students know all of the material below they will be successful on their exam.

I. Molecules and Cells

A. Chemistry of Life:

Water: it is polar! hydrogen bonds give it all of those great properties that you need to know; be sure you can you list those properties and explain them in terms of the structure of water molecules; i.e. they are polar and form H bonds, etc. also know how H+ bonds are formed; Dehydration synthesis: water is always formed when bonding monomers together into polymers; Hydrolysis: breakdown by adding water.

Basic chemistry terms, etc. to know: Exergonic, endergonic, Carbon atoms have 4 unpaired electrons (make 4 covalent bonds), O atoms have high electronegativity (so if you see an Oxygen atom bonded to something else, that bond is polar!)

Macromolecules: 1. **Carbohydrates**: made of CH_2O; water soluble; functions: energy storage (starch, glycogen, glucose); structural – cellulose! Know that glucose and all other monosaccharides always have a molecular formula = $C_6H_{12}O_6$ Sucrose and all disaccharides are always $C_{12}H_{22}O_{11}$ (Why isn't it simply 2 times glucose? Dehydration synthesis!)

2. **Lipids**: C, H >> O; not water soluble because they have **many** C-H bonds and C-C bonds both of which are nonpolar; important to know that the small portion of the molecule with the O atoms is polar, such as the carboxyl groups on the end of the fatty acid chains with the result that most lipids have both hydrophobic and hydrophilic regions; functions: energy storage; membrane structure (phospholipids form barrier portion of membrane; hydrophobic and hydrophilic regions are especially important here –be able to explain why); others to know: neutral fats (triglycerides) and steroids (recognize their structure of 4 rings).

3. **Proteins**: (**always emphasized on the test!**) contain C, H, O, N (sometimes S); monomers are amino acids;

levels of protein structure: **primary**= order of amino acids; **secondary** = basic repeating shape such as alpha helix and pleated sheet; held in these shapes by hydrogen bonds between "backbone" of the polypeptide; **tertiary** = overall shape with various folds of the secondary structure; held in this shape by – hydrogen bonds between polar amino acids AND hydrophobic interactions due to some amino acids being nonpolar AND van der Waals interactions between nonpolar amino acids AND disulfide bridges between amino acids with Sulfur groups; **quaternary** = two or more polypeptides held together into one protein; example: hemoglobin has four chains of amino acids.

Denaturing =? (changing the "natural" shape of a protein with heat, pH, etc. resulting in a loss of function; especially important when discussing enzymes)

Important proteins/functions to know: enzymes, such as catalase and amylase; hormones; antibodies; keratin and collagen (both part of skin); actin and myosin (in muscle); tubulin (cytoskeleton); hemoglobin (carries O_2 in blood; needs Iron to work; know about sickle-cell hemoglobin…)

Enzymes are proteins (always on the test!!) know enzyme labs (e.g. AP Lab 2 – catalase from liver or potatoes with H_2O_2 as the substrate; involves titrations to measure amount of H_2O_2 left which shows the amount broken down over time; controls? Constants? Dependent and independent variables? Why is the catalase usually kept cold? (to avoid denaturing it during the experiment) Your class might have also done a lab with floating discs of paper – the paper discs are soaked in catalase then dropped in different concentrations of H_2O_2 while one times how long it takes the disc to float back up on the bubbles produced)
Enzymes are catalysts; terms to know: substrate, active site, free energy changes (delta G), exergonic and endergonic reactions, inhibition (competitive and noncompetitive); environmental factors that affect the rate of activity? (temp, pH, enzyme concentration, substrate concentration) and How each causes that effect.

B. Cells

Prokaryotic vs. eukaryotic: **prokaryotic** – no internal membranes therefore no membrane-bound organelles (they only have ribosomes) and no nucleus; their chromosomes are circular and do not have histone proteins; bacteria and archeae are the only examples.
Eukaryotic – have organelles; DNA in linear chromosomes within a nucleus;
Key organelles to know functions of: **mitochondria, chloroplasts** (only organelles that can do chemiosmosis – meaning they make ATP!) of course, you also need to know these two for questions on cell respiration and photosynthesis; Remember endosymbiosis and the origin of these two organelles;
Ribosomes – make proteins by putting together amino acids based on instructions in genes; composed of protein + rRNA with rRNA being the functional part of the organelle.
Rough Endoplasmic Reticulum – network that carries products of ribosomes to vesicles for transport to the…
Golgi apparatus that packages and processes the proteins either for transport out of cell (secretions) or to remain in the cell (like hormones) or to form other organelles like the…
Lysosomes that contain digestive enzymes for breaking stuff down. This system of organelles working together is called the **endomembrane system**.
Smooth ER – makes lipids, steroids, more membranes
Peroxisomes – detoxify some poisons by adding H atoms to O forming H2O2 (hydrogen peroxide – hence the name) ; then they remove that H2O2 with catalase (remember lab 2?)
Vacuoles – especially central vacuoles in plant cells;
Cytoskeleton – microtubules (made out of the perfectly named protein: tubulin), microfilaments providing support; giving cells their shapes (structure and function!);

Cell membranes are really important! (In fact all membranes are really important, such as the ones around and within organelles. Be sure to know the structural makeup and functions of all membranes.) Know their structure in detail: phospholipid bilayers with proteins embedded in them. Membrane Proteins do things like active transport, facilitated diffusion, cell receptors for chemical messages, serve as enzymes (like in mitochondrial membranes), etc.
Peripheral vs. integral proteins; Membranes are selectively permeable = ?
Intercellular junctions: be able to recognize the names (desmosomes, gap junctions, tight junctions in animals and plasmodesmata in plants) general function is to just hold the cells together to form tissues.

Membrane transport: passive vs. active transport; know the differences between diffusion (follows concentration gradients and does not use ATP), facilitated diffusion (faster than diffusion, but does not require cell energy either; examples are glucose absorption and osmosis), and active transport (uses ATP! Moves against the concentration gradient); role of aquaporins (water transport); know hypertonic, hypotonic and isotonic. AP Lab 1!
Endocytosis (e.g. phagocytosis) and exocytosis
Cell signaling: signal transduction = cell receives a chemical signal then amplifies that signal within the cell by producing more molecules (second messengers) that carry out the response. Receptor proteins in the membrane receive the signal by having the signal molecule (also a protein) bind to them which changes the shape of the membrane protein. That new shape then activates proteins within the cell (second messengers). Cyclic AMP is the most common second messenger. **NOTE:** exception for steroid hormones – since the hormone is a lipid, it passes through the cell membrane and binds to a receptor molecule within the cell instead of one in the membrane. This new complex (steroid plus receptor) then travels to the nucleus to regulate gene activity.

Cell Cycle: G_1, S, G_2, Mitosis (mitosis makes exact copies of the nucleus – genetic continuity) be familiar with the phases: PMAT and basic events; compare and contrast those events in mitosis and meiosis; cytokinesis (sometimes); control of the cycle involves changing levels of **cyclins** – be able to describe that process of control. Cancer = ?
Apoptosis = programmed cell death; when would you want this to happen? (tadpole tails, webbing between your fingers; removing damaged, old cells)
Haploid vs diploid; AP Lab 3A

C. **Cellular Energetics** (fancy term for cell respiration and photosynthesis!)

Coupled reactions: ATP couples exergonic reactions to endergonic reactions …
Cell respiration: do not try to memorize all of the steps, but you do need to know basic phases and where exactly each happens within the cell AND within the mitochondria (know the structure of a mitochondrion – two membranes, matrix, etc.)
glycolysis (breaking glucose into pyruvate; forms a few ATP and NADH; is anaerobic – does not use O_2; this phase is shared by ALL life on Earth)
Krebs cycle (uses O_2; forms a few ATP directly; forms lots of NADH and $FADH_2$)
Electron transport and chemiosmosis/oxidative phosphorylation (uses O_2; makes most of the ATP that is formed aerobically);
Know about AP Lab 5!
Fermentation – lactic acid and alcohol; **why?** (recycles NADH back to NAD+ to allow glycolysis to continue even though the NADH can't get to the electron transport chain)

Photosynthesis: AP Lab 4A and 4B; Do not memorize every step but do know: **Light reactions** (use light energy to make ATP and NADPH; ATP is made via electron transport which produces a proton gradient using chlorophyll electrons that have been excited by light followed by chemiosmosis using the same type of ATP Synthase molecule found in mitochondria; chloroplasts split water to replace electrons lost from chlorophyll when it is excited by light and in the process form O_2 as a by-product) best wavelengths/colors are red and blue – why? Photosystem II vs Photosystem I?
Chloroplast structure – know thylakoids, thylakoid space, stroma; and the pigments present within thylakoid membranes;

Calvin cycle (also called C3 cycle; carbon fixation; and light-independent, but does **NOT** happen in the dark! Uses ATP and NADPH from light reactions to fix CO_2 into carbohydrate - glucose $C_6H_{12}O_6$ so if it is dark, there are no ATPs or NADPHs and the cycle stops.)
Know effects of light intensity and light wavelengths (colors) on rates of photosynthesis;
Know **leaf anatomy** as it relates to photosynthesis: most photosynthesis is in palisade mesophyll (in C_3 plants); role of stomata;

Photorespiration – BAD! No ATP formed, happens in hot dry conditions; know why (role of rubisco here?)
Adaptations to reduce it? C_4 vs. CAM plants

II. Heredity and Evolution

A. **Heredity**

Meiosis: function is to reduce chromosome number from 2N to 1N; includes 2 divisions; important events include – synapsis forms tetrads; crossing over occurs between homologous chromosomes; homologous chromosomes separate in meiosis I; female gametogenesis involves meiosis with unequal cytokinesis and the production of one gamete versus males with equal cytokinesis and four gametes; AP Lab 3B
"mistakes" to know – nondisjunction, inversion, translocation, deletion
Eukaryotic chromosomes: linear (unlike prokaryotic which are circular); have histones; know the general structure of chromosomes (kinetochores, telomeres, histones, packaging, etc.)
Inheritance patterns: Mendelian Genetics – be able to calculate probabilities of certain offspring and parents (Punnett squares, etc.); autosomal vs. sex chromosomes; be able to work genetics problems involving dominant-recessive, incomplete dominance, sex-linked traits and multiple alleles (for multiple alleles - especially ABO blood type problems); Also be able to analyze pedigrees for genetic traits; terms: testcross, karyotype, pleiotropy, epistasis, polygenic inheritance, Barr Body, linked genes;
Diseases to know: Down syndrome, sickle-cell anemia, cystic fibrosis, hemophilia, color-blindness, Huntington's disease

B. **Molecular Genetics**

RNA and DNA structure and function – evidence that genes are made of DNA and not protein; Anti-parallel, double-helix structure of DNA with hydrogen bonds between complementary bases (A-T and C-G) and covalent bonds connecting phosphates and sugars between nucleotides in backbone of "ladder." Must know the basic steps of DNA replication, Transcription and Translation. This includes knowing the enzymes and structures involved: For **Replication** - helicase, primase, DNA polymerases, and DNA ligase; For **Transcription** – RNA polymerase; Also need to know details of **RNA processing** – introns are removed and exons are used (expressed), spliceosomes use snRNA (ribozymes); GTP cap and AAAAA tail both protect RNA from hydrolysis (being broken down) by enzymes in nucleus.
For **Translation** – Ribosomes with rRNA and A, P and E sites; triplet codons of mRNA; role of tRNA in bringing amino acids to ribosome.
Gene Regulation – *lac* and *trp* operons as examples of prokaryotic gene regulation; in eukaryotes: packing and unpacking sections of chromosomes can turn genes off or on by making them either unavailable or available for transcription; DNA Methylation inactivates DNA segments; Enhancers make certain sections of DNA more available to RNA polymerase which increases its activity level.

Mutation: point mutations are changes in single nucleotides, such as: additions and deletions cause frame-shift mutations; substitutions are also point mutations, but do not cause frame-shifts; missense mutations produce a different protein; nonsense mutations result in an early stop codon and therefore no protein;

Viral Structure and replication – almost always ask something about HIV (know that it attacks helper T-cells; is a retrovirus that uses reverse transcriptase to transcribe DNA from it's RNA; and it causes AIDS – Acquired Immune Deficiency Syndrome!)
Know basic replication strategies of various types of DNA and RNA viruses.

Nucleic Acid Technology and Applications – **Gel electrophoresis**: used to separate DNA fragments based on size, uses polarity of DNA (negative) and electricity to move fragments through gels with pore sizes that sort the fragments; Restriction enzymes (from bacteria) used to cut DNA at specific sites, produces sticky ends for recombinant DNA production; This is how **DNA cloning** is done (cut plasmid with restriction enzyme, cut DNA to be cloned with the same enzyme to create matching sticky ends, combine in a test tube with DNA ligase, now you have a plasmid with the DNA to be cloned in it. Now do **transformation** to add this plasmid to bacterial cells and allow them to divide. As they divide, they will copy all of their DNA including the plasmid, which means the bacteria will copy/clone the DNA you inserted!
DNA fingerprinting: can be used for identity testing, or disease detection, etc.; can be done with **PCR** (know how the process works; note that it does NOT require cutting DNA with restriction enzymes); Key steps of PCR: add primers for selected region to the DNA sample along with DNA Polymerase and an abundance of nucleotides (A, T, C, G), then heat sample to separate DNA strands, then cool to allow primers to stick to the DNA single strands, then heat slightly to allow polymerase to extend the primers. Repeat the three temperatures in this order 30 times. The DNA polymerase must be able to withstand high temperatures without denaturing, so we use *Taq polymerase* (from heat-loving bacteria). The typical temps are 94, 58, and 72 degrees C.

DNA Fingerprinting can also be done with **RFLP analysis** (does require restriction enzymes that produce different size fragments from different DNA sources)

Be able to look at a gel and determine things like which suspect matches an evidence sample and which parents match which baby, etc.
AP Lab 6A and B!

C. Evolutionary Biology

Early Evolution of Life: origin of life – 4 basic steps: 1. abiotic origin of organic molecules (monomers), 2. joining of monomers to form polymers, 3. formation of membranes to enclose the organic molecules and create an internal environment different from surroundings, 4. origin of heredity (probably RNA first, with RNA serving as both genetic material and a catalytic function for copying itself; later DNA arose via slight modifications of RNA; today's system is DNA → RNA → Protein); In the big picture, some of the important early events occurred in the following order: organic compounds formed, then anaerobic prokaryotes arose, then photosynthesis evolved in bacteria (cyanobacteria) later, then some of those bacteria became chloroplasts in eukaryotes (know about endosymbiosis as the mechanism for the formation of chloroplasts and mitochondria), then plants would have evolved much later than this – got it?

What is evolution? Must know descent with modification (common ancestry) and natural selection; Darwin's work!

Evidence for Evolution: fossil record; biogeography; homologies (comparative anatomy; comparative biochemistry; molecular biology – DNA, protein sequences, etc.) be able to compare DNA or protein sequences and draw a cladogram, etc.
Hardy-Weinberg equilibrium - you **must know all five conditions** for maintaining equilibrium (i.e. gene and genotype frequencies staying the same from generation to generation) AND the consequences of not meeting each of those conditions (mechanisms of evolution – see below) AND be able to work Hardy-Weinberg genetics problems ($p^2 + 2pq + q^2 = 1$; and $p + q = 1$)
AP Lab 8!

Know what a biological species is. And how species are kept separate:
5 Prezygotic isolating mechanisms AND
3 Postzygotic mechanisms
Mechanisms of Evolution: not meeting any of the five conditions; know specific examples like genetic drift (founder effect and bottleneck effect); sexual selection; gene flow; natural selection is the only one that is adaptive (shifts the population towards better fitness in that environment). Evolutionary fitness is measured by reproductive success (producing fertile offspring).
Allopatric speciation: **key here is geographic isolation** of one part of the population from the parent population or original location. Example is adaptive radiation, like the fruit flies in Hawaii and finches and tortoises, etc. in Galapagos. Coevolution = ?
Sympatric speciation: speciation in the same geographic location. Example is polyplopidy in plants.
Punctuated equilibrium: describes species staying the same for long periods of time with occasional periods of geologically rapid change. So the species tend to stay the same (*equilibrium*) unless something happens that affects the population enough to lead to speciation (that "something" therefore *punctuates* the equilibrium with change). Idea was proposed by Stephen Jay Gould and Niles Elldredge.

III. Organisms and Populations
A. Diversity of Organisms
Evolutionary Patterns: This refers to what I call the "Big Events" in the history of life, such as the development of key traits in cladograms of animal evolution, or plant evolution or the overall evolution of kingdoms of life. They especially like to ask about adaptations for living on land instead of in water – for both plants and animals.
Key traits to be able to place on those 'trees":
For Animals: *symmetry* – none for Porifera (sponges), radial for cnidaria (jellyfish) and bilateral for all other branches/clades; *number of cell layers in embryo (also called **germ layers**)*: no true tissues in sponges, 2 layers/diploblastic (ectoderm and endoderm) in jellyfish and comb jellies, 3 layers/triploblastic (ecto, endo and mesoderm) in all others; *Body cavities (none, or pseudocoelom or true coelom)*: only applies to triploblastic animals, so this is a way to further divide the animals within the triploblastic, bilateral clade. Acoelomates are flatworms, like planaria. Pseudocoleomates are roundworms (Nematodes) and Rotifers. Coelmates are the rest (Annelids, Molluscs, Arthropods, Echinoderms and Chordates); ***Protostomes vs.Deuterostomes (this is a very important distinction – it refers to how the embryo develops):*** Protostomes are Annelids, Molluscs, Arthropods; Deuterostomes are Echinoderms and Chordates (which means we are more closely related to starfish than any other invertebrates). You should also know what gastrulation is in deuterostomes (the point where the blastopore pushes into the embryo at the blastula stage to form an embryo with multiple cell layers – like pushing your finger into a balloon full of air; be able to describe this step and to recognize it in diagrams)

For Plants: major groups/clades of plants are Mosses, Ferns, Conifers, Gingkos, Cycads and Angiosperms (flowering plants); Traits to use in classifying these groups: *no vascular tissue* (only in mosses) vs. *vascular tissue* (all of the others); Ferns have vascular tissue but no pollen and no seeds – since no pollen, they have swimming sperm use spores for dispersal. Note: mosses and ferns both have swimming sperm, so they need water for fertilization. *Use Pollen so no need for water in reproduction*: conifers, gingkos, cycads, and angiosperms; *Flowers and fruit (also means only this group has ovaries)* Angiosperms! Note that the conifers, gingkos and cycads do not have ovaries so they are called "naked seeds" (gymnosperms); *Also need to know that only angiosperms use double fertilization.)*

Survey of the Diversity of Life: Know the **three Domains (Archaea, Bacteria and Eukarya**) the kingdoms under those domains: Archaea and bacteria are sometimes used as kingdom names, too. Eukarya contains: Protists, Fungi, Plants and Animals.
Basic traits to know for these groups: Archaea and Bacteria are **prokaryotic**, while Eukarya are all **eukaryotic** – imagine that!
Only certain prokaryotes can live completely anaerobic existences; so all eukaryotes are aerobic and so are many prokaryotes.
Protists: aerobic, single-celled or simple multi-celled; very diverse; **not monophyletic** so this is not really a true kingdom and many biologists no longer use this term as a kingdom, instead dividing it into many separate kingdoms; wide range of nutrition (some are autotrophic, some heterotrophic and some are both – mixotrophic!)
Fungi: aerobic; cell walls of chitin; heterotrophs that feed by absorption; many are important decomposers, others are parasites like athlete's foot, others are mutualistic symbionts. Mycorrhizae are fungi that live on or in plant roots; they give the plant inorganic, mineral nutrients and get organic nutrients in return. Mycorrhizae were probably important to the very first land plants in helping them colonize the land.
Plants: multicellular, cell walls of cellulose, autotrophic with the ability to split water during photosynthesis (i.e. they release O_2). Lots of more specific plant info below under part III. B.
Animals: multicellular, heterotrophic with feeding by ingestion, no cell walls at all in animals.
Phylogenetic Classification and Evolutionary Relationships – covered above

B. **Structure and Function of Plants and Animals –**

This section deals with all of the various systems in plants and systems in animals (things like digestion, circulation, etc.). I will simply list each system along with the major concepts to know for each. Use your notes and book to review these in enough detail to know them for the test.

Let's start with **PLANT SYSTEMS!**

Alternation of Generations – found in all plants (and in algae!) **Gametophyte generation is haploid** and produces gametes by mitosis, then the gametes fuse (fertilization) to form a diploid zygote that starts the **diploid Sporophyte** generation (this is the "baby plant" inside a seed), then the sporophyte matures and produces **haploid spores (called megaspores and microspores in angiosperms)** by meiosis, the spores grow into the next gametophyte generation and the cycle continues. In mosses, the gametophyte generation is dominant, but the sporophyte is dominant in all other plants.

Tissues/Growth- only plants have *meristematic tissue* which is tissue that remains embryonic throughout lifetime (i.e. can always divide); other tissue types to know: ground tissue vs. vascular tissue vs dermal tissue; xylem with lignin = wood;

Types of growth in plants: **Primary growth** = growth in length, as in the stem growing longer/taller and the roots growing deeper into the ground; this primary growth is accomplished by the *apical meristem* at the tips of stems and roots (plants grow from the tips!); know the zones of growth in roots;
Secondary Growth – growth in diameter as in a trunk getting thicker; this secondary growth is done by the *lateral meristem*. Lateral meristem is also called *vascular cambium* in stems and the *pericycle* in roots. (So, vascular cambium produces secondary tissue in a stem and lateral roots grow from the pericycle in roots – those are the sorts of questions they often ask.) One more type of lateral meristem is the *cork cambium* that forms bark in woody trees.
Be able to recognize/label these tissues in cross sections of stems and roots. For instance, in a stem if we start on the inside, the inner most tissue is primary xylem, then secondary xylem, then vascular cambium, then secondary phloem, then primary phloem, then the cortex, then cork cambium, then bark or cork. If asked to start on the outside, obviously this list would be in reverse. (after doing this in class, the order is easier to remember; picture the vascular cambium laying down these tissues with xylem being placed to the inside of the cambium and phloem being placed to the outside; this means that the oldest xylem (primary xylem) is in the middle of the stem, but the oldest phloem (primary phloem) is on the outer edge of the stem with only cortex and bark outside of it. AP Lab 9B on plant tissues!

Transport: the evolution of vascular tissue was a major innovation in the history of plants as it allowed them to live on land and to grow taller than mosses.
You must know the function of both xylem and phloem:
Xylem: dead cells that form hollow tubes; carry water from roots to leaves; transpiration is the mechanism that moves water through the stem and out of the leaf; know the conditions that affect the rate of transpiration (AP Lab 9A!). Tracheids and vessel elements
Phloem: living cells that transport food from leaves to roots in a process called translocation; sieve-tube members;
Know the importance of: Casparian Strip; heartwood vs sapwood; root hairs
Must know the transpiration-cohesion-tension mechanism; guard cells and stomata?

Reproduction: The emphasis is always on flowering plants, but they might throw in a question or two about reproduction in other plants like gymnosperms, ferns or mosses.
Swimming sperm cells (and therefore the need for water) are used in mosses and ferns.
Pollen (and therefore no need for water) is used in gymnosperms and angiosperms (flowers).
Pollen was a major development because it freed the plants from a dependence on water for reproduction and allowed more success at fertilization.
Know about seed formation – a seed is an embryo plant with a food source inside a coat and these are only found in gymnosperms and angiosperms.
Fertilization: Pollen grain is put on the stigma; then a pollen tube grows to the ovule inside the ovary, then a sperm cell from the pollen grain fertilizes the egg.
Angiosperm details to know: *double fertilization!!* Same as above, but two sperm cells leave the pollen grain and enter the ovule. One sperm cell fertilizes the egg to create a diploid zygote and another sperm cell fertilizes two polar nuclei to form the triploid endosperm (food source). This is only in angiosperms. *Pollination*: mechanisms to transfer pollen from one plant to another? (wind, insects, birds, other animals – even people) and adaptations to help this happen, such as hooks on pollen grains, scented flowers to attract pollinators, etc. Most plants do NOT self-pollinate. Why not? What is the advantage of cross-pollination? Mechanisms to prevent self-fertilization?

Hormones (chemical signals): Know the functions of the hormones; especially *Auxin, cytokinin, gibberellin, abscisic acid* and *ethylene* (the only gaseous hormone). Typical questions on hormones ask something like: "Which hormone is most important in causing phototropism?" (auxin) "The major role of ethylene is to: " (promote fruit ripening); or "The major role of gibberellins in seed germination is to:" (cause the synthesis of amylase - to breakdown starch in the seed and give sugar to the growing embryo); "Which plant hormone is an inhibitor?" (abscisic acid / ABA); "Which of the following is a gaseous compound?" (ethylene)
Tropisms – phototropism and gravitropism; what are they and why do they happen?

ANIMAL SYSTEMS TO KNOW!
Be able to relate adaptations in each system to the organisms' diet, environment, etc.

Digestive system: emphasis on vertebrates; functions of regions of digestive tract – note that many of these are the same in invertebrates like worms (mouth, esophagus, stomach, or crop, small intestine, large intestine); enzymes/chemicals involved in digestion plus the regions where produced and their functions: **amylase** in mouth - Starch is substrate; **pepsin** in stomach – protein is substrate (pepsin is the only enzyme typically studied that works in an acidic environment!); **bile** not an enzyme but it comes from liver and it physically breaks down/emulsifies fat; **lipase** from pancreas - fats/lipid is substrate; H2CO3 (sodium bicarbonate) from pancreas neutralizes acid ; **proteases** from pancreas – protein substrates; intestinal lining also produces enzymes to complete the break down of all food groups;
roles of: peristalsis, insulin, glucagon, leptin;

Homeostasis/ excretory system: Know about **negative feedback** and its role in regulating temperature, water and wastes in the blood; nephron anatomy and functions are important, especially its role in water balance; know how the loop of Henle and the collecting duct reabsorb water, Also remember the hormone that affects the permeability of the collecting duct is ADH/ anti-diuretic hormone – when would it be released from the hypothalamus? (whenever you are low on water as when walking around in the desert! So if you are low on water, you release more ADH, which means you pee less and save water for your blood – remember all of that?)

Respiratory system: be able to compare and contrast the basic mechanisms across animal groups and environments – such as: fish use gills with counter-current exchange to increase diffusion of oxygen from water into bloodstream; amphibians use skin breathing (so they must stay moist at all times) and a simple, smooth lung; reptiles use scaly skin to retain water and stay moist inside which means they **can't** breathe through skin, but they do use complex lungs; birds use lungs with elaborate air sacs; mammals like us use complex lungs; also know what factors influence your breathing rate (high CO_2 and/or low pH both = faster breathing rate, as well as the reverse) – both are monitored by the medulla oblongata in the brain (pons also involved in regulating rate in heavy breathing).

Circulatory System: types of hearts in vertebrate classes: fish have 2 chambers – one atrium and one ventricle, amphibians have 3 – two atria and one ventricle which allows blood to return to the heart after picking up oxygen so that it can get a pressure boost before going to the body tissues, but some mixing of oxygenated and deoxygenated blood in the single ventricle; most reptiles have 3 chambers but the ventricle has a partial septum to reduce mixing of blood; birds, crocodiles and mammals have four chambered hearts with 2 atria and 2 ventricles to provide 2 separate circuits of blood flow (one for getting oxygen and one for delivering it to the tissues);

Know about the changes in pressure and velocity that happen as blood moves through your body from the heart to arteries to capillaries to veins and back to the heart (highest pressure in arteries; lowest **pressure** in veins; lowest **velocity** in capillaries because they have such a large surface area); know pathway of blood through your heart starting in the right atrium until it leaves the left ventricle in the Aorta. Cardiac cycle: systole and diastole; AP Lab 10!
Know roles of molecules in blood – especially hemoglobin! Carries oxygen; uses Iron as a cofactor; can also carry CO_2 remember that this acts to buffer blood against carbonic acid from CO_2 mutation in the gene for hemoglobin leads to sickle-cell anemia (why does it stay around? Protects against malaria…);
Know mechanisms of transporting: O_2 – hemoglobin (98%) and dissolved in plasma;
CO_2 – Bicarbonate ions, bound to hemoglobin, dissolved in plasma
Functions of each blood cell type: Red Blood cells contain hemoglobin to carry oxygen and carbon dioxide; role of erythropoietin, especially in moving from lower to higher altitudes, etc.

Immune system: know lines of defense – skin and mucous membranes first (nonspecific defense), then nonspecific white blood cells (phagocytosis of any type of bad guys), then specific defense (lymphocytes that are specific for each type of infection are used; these are B-cells and T-cells) know humoral immunity refers to the B-cells producing antibodies that flow through the body fluids (blood and lymph); cell-mediated refers to T-cells directly attacking infected cells and foreign tissue to destroy them;

Primary immune response = first encounter with an invader, like the first time you get the chicken pox; Secondary immune response = every time you encounter that specific invader after the first time – this uses **memory cells** that respond faster so you get rid of the invader without even getting any symptoms (that is why most people do not get the chicken pox twice);

Also need to know basic structure of antibody molecules: they look like the letter Y; are proteins with constant region that is the same in all antibodies of that type PLUS variable regions that are different and specific for each antigen ("invader" molecule).

Integumentary System (SKIN): Know major proteins in the skin – collagen provides strength and support for skin; elastin makes the skin able to stretch slightly without damage; keratin is part of the outermost layer (epidermis) and helps protect the skin by making it waterproof and providing a physical barrier to penetration by bacteria, etc., keratin is also the main component of structures that grow from the skin, such as hair, fingernails, hooves, etc.

Muscles: 3 types – skeletal, cardiac and smooth; know structure of skeletal muscle in detail, as well as the details of how it contracts (sliding-filament model); you do not need to know the names of any specific muscles.

Structure and function: One cell = a fiber; each fiber contains many smaller myofibrils, which are in turn composed of filaments made of **two proteins, called ACTIN and MYOSIN**. Actin and myosin form a repeating unit within the cell called a sarcomere ("muscle unit"). Myosin makes up the thicker filament. It has heads that are attracted to actin molecules. When the myosin heads are phosphorylated by ATP, they move into a high-energy configuration (meaning they are ready to "pull" the actin molecules), then they attach to actin, forming a cross-bridge, then the myosin heads return to their low-energy shape which causes them to pull the actin molecules across the myosin. Then the myosin grabs the actin in a new spot and repeats the whole process, with the result being that the filaments slide across each other and the muscle cell/fiber gets shorter – contracts!

Nervous System: know the structure of a typical vertebrate neuron/nerve cell– dendrites, cell body, axon, myelin sheath (Schwann cells) and synapse; also need to know how a neuron conducts an impulse – resting potential is converted to an action potential; an action potential IS an impulse. When a neuron is stimulated, an action potential results (Sodium/Na goes IN and Potassium/K goes OUT during an action potential).
The synapse is a gap between neurons. You need to know how the impulse is transmitted across the synapse – this is done with chemicals released from the end of the neuron. These chemicals are called neurotransmitters.

Central Nervous System is the brain and spinal cord: **BRAIN** – know the following parts of the brain and their functions:

Medulla oblongata – visceral reflexes (automatic/homeostasis reflexes), such as breathing rate, heart rate, swallowing, vomiting, and digestion.

Cerebellum – muscle coordination, such as balance, walking, running, athletic activities.

Thalamus – directs messages to the correct part of the cerebrum

Hypothalamus – regulates body temperature, hunger, thirst, fight-or-flight response (the hypothalamus is the connection between the nervous and endocrine systems).

Cerebrum – the most highly evolved part of your brain; controls movements and feeling of all body parts; also is the center for higher brain functions (thinking, personality); divided into two hemispheres (left and right) connected by the **corpus callosum** which allows the left and right sides of the cerebrum to "talk" to each other.

Endocrine system: the system that produces hormones; we covered the important hormones as we covered each individual system where they act.
Know the relationships between the hypothalamus, the pituitary and the other endocrine glands; be able to discuss negative feedback as the major mechanism the body uses to control hormone levels; the ovarian and menstrual cycles provide great examples of negative feedback and hormones (see below).

Also, know the general mechanism of hormone action: (signal transduction) the hormone matches a receptor in the cell membrane; once it binds to the receptor, another chemical is activated inside the cell, leading to a series of chemicals being activated until the final action is accomplished. The chemicals inside the cell are called "second messengers" and the most common one is cAMP (cyclic AMP).

Reproduction: **You must know the menstrual cycle in detail, including the ovarian cycle and the events in the hypothalamus, because they often use this as a way to ask about hormones and feedback mechanisms. The most important hormones in the menstrual and ovarian cycles are:**

GnRH: from hypothalamus, these start the ovarian cycle by stimulating the release of LH and FSH from the pituitary;

FSH (follicle-stimulating hormone): stimulates the development of follicles in the ovary (the ovarian cycle), leading to the production of estrogen by the developing follicle.

LH: stimulates ovulation

Estrogen and progesterone: stimulate growth of uterine lining (in preparation for arrival of fertilized egg (zygote); when levels of estrogen and progesterone drop, the lining of the uterus is released (menstruation occurs).

*Development (embryology)**:*** the most important events in the development of an embryo are – fertilization, cleavage (cell divisions) produce a solid ball of cells called a morula, then the morula expands into a hollow, fluid-filled ball of cells called a blastula, then the cells of the blastula are rearranged in a very important process called **gastrulation** (the blastopore pushes into the hollow ball – like your finger pressing into a balloon full of air). **Gastrulation creates multiple cell layers in the embryo** – also called "germ layers." Some animals have only two cell layers – ectoderm and endoderm (these animals are called diploblastic), but most animals have three cell layers ectoderm, endoderm and mesoderm (these animals are called triploblastic).

You should know the sorts of structures that develop from each cell layer, such as –
Ectoderm: epidermis (skin and its structures like hair), plus the nervous system;
Endoderm: digestive system and its glands, respiratory system;
Mesoderm: muscles, bones and blood, plus the excretory and reproductive systems.

Animal behavior: there is much to cover here, but it is rarely on the AP Bio test. When it is, these are the most commonly asked concepts:

Taxis vs kinesis (AP lab 11!)
ethology = study of behavior; learning vs. fixed action patterns (FAP)
FAPs = behaviors that are not learned; they are programmed in the genes and seem to be basically unchangeable within an animal; examples include male stickleback fish attacking other males with red stripes;
Imprinting = learning that occurs during a critical period and can't be unlearned; the classic example is baby birds imprinting on their mother – like the baby geese following mom around (did you see that movie where the birds followed the girl in the ultralight aircraft? If you are the first animal a baby bird sees after hatching, it will imprint on you and follow you around!)
Operant conditioning = trial and error learning; reward and punishment systems involved.

C. Ecology

Levels of ecology: a. Organismal ecology– individual organism's metabolism, etc.
b. **Population** ecology: involves interactions between members of a species in an area, as well as studying the growth of the population size (population = able to mate and reproduce);
c. **Community** ecology: interactions between different species in an area (all biotic factors in that area);
d. **Ecosystem**: community plus abiotic factors; energy flow and chemical cycling;

Population Ecology: Models used to predict changes in the size of a population –
Exponential model: the equation does not include any limits on the size of the population; equation is:

So far, history of human population has shown exponential growth, but can't continue forever.

Logistic model: includes the **carrying capacity (K)** in the formula; as the size of the population increases and gets closer to K, the rate of population growth decreases.
The equation is:

Know how demographics affect future growth of the population; especially age-structure tables that show the percentage of the population that is a particular age; be able to predict how the population size will change in the future based on these tables.
K-selected populations = have few babies at a time and those offspring are likely to survive so the population is limited by the carrying capacity of that environment. In plants, these species are found in climax communities.
r-selected populations = have many, many offspring and most die due to density-independent factors like freezes, etc. i.e. the babies are not likely to survive, so they have to make lots of babies to keep the population going; these populations do not usually reach K.

Community Ecology: predator-prey interactions; How do the numbers of predators and prey affect each other? For ex. If the number of predators in a community is low, what will happen to the number of prey?
Know the various types of community interactions and whether each is +/+, +/-, +/0
Interspecific competition; Predation; parasitism; mutualism; commensalism
Coevolution = reciprocal evolutionary adaptations of two interacting species
Trophic Structure (feeding relationships): know the levels (producer, primary consumer, secondary consumer, tertiary consumer, decomposer); limits to the number of levels (10% rule);
Competitive exclusion principle: no two species can occupy exactly the same niche;
Keystone species = occupy important niches that affect entire community. If the numbers of this population drop too low, entire community structure is drastically affected.
Biomes: know the basic terrestrial and freshwater biomes; i.e. names and basic characteristics

Ecological Succession: sequence of changes in a community either as it first colonizes newly available rock/land (primary succession); or as it recovers from a disaster such as a forest fire (secondary succession); the stable community that might result is called the climax community.

Ecosystem Ecology: deals with abiotic factors that affect communities - especially energy flow and chemical cycling; Food chains and food webs; trophic levels fall under ecosystems, too, as we consider the flow of energy through the levels and how energy loss at each level limits the number of levels;
Gross Primary productivity: the rate at which producers convert light energy into chemical energy (also the rate ay which inorganic carbon molecules are converted into organic carbon molecules). This is done using light energy and the process of photosynthesis. Gross primary productivity is therefore the overall rate of photosynthesis by all producers in an ecosystem. (The only exception is for the producers at the bottom of the ocean, or under the Earth's crust where there is no light.)
Net Primary Productivity: is equal to gross primary productivity minus the rate energy is used for cell respiration in the producers. Net P.P. tells us how much organic material is available to the consumers after the producers have used some of the material they produced to do their own cell respiration.
Remember lab 12 on productivity in water: Be able to describe how to measure both gross and net primary productivity in a body of water, such as a lake or pond.
Relate to eutrophication! Oligotrophic and eutrophic lakes, etc.
Be able to predict and explain the effects of different depths, different seasons, etc. on the rates of productivity.

There WILL be at least one free response question that is lab-based. Be thoroughly familiar with all 12 of the "AP Labs." Look over the objectives of each lab and think about possible essay questions that could cover those objectives. Then write out some sample answers. This is the only part of the test I can guarantee. 12 labs are not very many. KNOW all 12 and you will get a 10 on that one essay!! The average score on all four essays combined will be about 15 points and you can get 10 from this one essay. Be ready for it and you will be way ahead of almost everyone else in the country!