AP Biology
Annotated Course Outline/Syllabus
Grosse Pointe South High School
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Course Descripton: The curriculum of AP Biololgy parallels that of a freshman level college biology course. The content revolves around four central concepts that the College Board calls Big Ideas. Each Big Idea contains Enduring Understandings (EU) that help to clarify the content to be covered. The four Big Ideas and their Enduring Unstandings are listed below:

Big Idea1 - The process of evolution drives the diversity and unity of life.

~ How life changes over time

EU 1A: Change in the genetic makeup of a population over time is evolution.
EU 1B: Organisms are linded by lines of descent from common ancestry.
EU 1C: Life continues to evolve within a changing environment.
EU 1D: The origin of living systems is explained by natural processes.

Big Idea 2 - Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis.

~ **The structure and maintenance of life**

EU 2A: Growth, reproduction and maintenance of the organization of living systems require free energy and matter.
EU 2B: Growth, reproduction and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environment.
EU 2C: Organisms use feedback mechanisms to regulate growth and reproduction, and to maintain dynamic homeostatsis.
EU 2D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.
EU 2E: Many biological processes involved in growth, reproduction and dynamic homeostasis include temporal regulation and coordination.

Big Idea 3 - Living systems store, retrieve, transmit, and respond to information essential to life processes.

~ **The passing on of life and its abilities**

EU 3A: Heritable information provides for continuity of life.
EU 3B: Expression of genetic information involves cellular and molecular mechanisms.
EU 3C: The processing of genetic information is imperfect and is a source of genetic variation.
EU 3D: Cells communicate by generation, transmitting and receiving chemical signals.
EU 3E: Transmission of information results in changes within and between biological systems.

Big Idea 4 - Biological systems interact, and these systems and their interactions possess complex properties.

~ **Interactions within and between living things as well as their environment**

EU 4A: Interactions within biological systems lead to complex properties.
EU 4B: Competition and cooperation are important aspects of biological systems.
EU 4C: Naturally occurring diversity among and between components within biological systems affects interactions with the environment.

The approach to learning in this class concentrates on topics, concepts, and themes rather than memorization of facts. Lab work, much of which has been developed by the AP Biology Development Committee, is a significant form of assessment. There is a major shift in the AP Biology curriculum to make the laboratory work more inquiry based and student developed. An emphasis on applied mathematics within the laboratory setting is also included.

***Course Objective*:** To facilliate an understanding of the living world and begin to delve into its complexity and connectivity. In association with this goal will come an increase in knowledge of laboratory skills and scientific writing. As in any AP course, the objective is to show this understanding within the assessments of the course and on the AP test by achieving a 4 or 5.

Course Outline:

Introductory Unit: The nature and function of science within the context of Biology. (1 Week)

Objective: To illustrate and reinforce the process of scientific investigations and the mathematics involved.

Students will be required to generate a simple investigation that will include:

- Abstract
- Statement of the problem to investigate
- Development of background knowledge necessary to investigate
- Formulation of a hypothesis
- How quantitative data is generated and presented
- Statistical analysis performed on data to show validity

- Graphical displays of data to show trends
- Conclusions based on data analysis
- Discussion

Articles from Medical Journals will be used as examples of how laboratory investigations are developed, analyzed, and written for publication. The format of all formal lab write-ups in class will mimic the above.

Topic I: The structure and maintenance of life (***Big Idea 2***) ***[****COMPLETED 1ST QUARTER****]***

A. Chemistry of Life (EU 2A)

1. Why life revolves around water (quick review)
   - properties of polarity, specific heat, cohesion, adhesion, neutral *p*H, density
   - role as a solvent, evaporative coolant; capillary action, overturn in a lake, diffusion
2. Organic molecules in organisms
   - carbon can bond with many other atoms in an infinite variety of arrangements
   - macromolecules include polysaccharides, nucleic acids, proteins, and lipids
   - macromolecules are formed by dehydration synthesis and broken up by hydrolysis
3. Free energy changes
   - Energy can neither be created nor destroyed, but can be converted (first law of thermodynamics)
   - Life converts energy from the universe in an ordered state (from second law of thermodynamics)
   - catabolism releases energy; anabolism requires energy
4. Enzymes
   - enzymes are proteins that have active sites and regulatory (activation or inhibition) sites
   - enzyme shape is critical to its action, and can be altered by temperature, *p*H, or other molecules which alter active sites
   - enzymes can be deactivated by feedback inhibition (sufficient product) or activated by high precursor concentration

B. Cells (EU 2B)

1. Prokaryotic and eukaryotic cells
   - prokaryotic cells lack membrane-bound organelles, except primitive ribosomes
   - eukaryotic cells are believed to be collections of prokaryots (cell symbiosis)
2. Membranes
   - phospholipid bilayer with polar (hydrophilic) heads on the outside and hydrophobic (nonpolar) tails facing inward
   - proteins embedded in the membrane which act to allow passage of special ions/molecules
   - glycoprotein receptors on the outside for endocytosis, hormone messages, antibody recognition
   - small, nonpolar molecules and water freely pass through the membrane
   - water potential is the measure of water's tendency to enter or leave a cell by osmosis
   - Na^+ pumps establish gradients for cotransport and countertransport through proteins
3. Subcellular organization and endomembrane system
   - organelle functions include protein synthesis and packaging (nucleus, RER, ribosomes, Golgi, lysosomes, vesicles); energy production (chloroplasts and mitochondria); homeostasis (plasma membrane, vacuoles, lysosomes); and heredity (nucleus, chromosomes, microtubules)
   - plant cells (chloroplasts, cell walls) differ from animal cells (centrioles, microfilaments, basal bodies)
4. Cell cycle and its regulation
   - genetic continuity is assured since each daughter cell is identical to the parent cell
   - steps provide for the replication and equal distribution of the chromosomes and the division of cytoplasm and organelles
   - cells have theoretical size limit; small cells have a much more efficient surface area-to-volume ratio
   - regulation is by genes which produce proteins to act as "on" or "off" switches

C. Cellular Energetics (EU 2A and EU 2C)

1. Coupled reactions
   - ATP is formed during respiration and the light reactions of photosynthesis (catabolic), and is used in the Calvin cycle and cellular work (anabolic)
   - chemiosmosis uses the energy from an electron and H^+ gradient to produce ATP
2. Fermentation and cellular respiration
   - food molecules are broken down to release energy to form ATP
   - O_2 provides the final acceptor of H^+ (from food) to fuel oxidative phosphorylation in mitochondria
   - ATP may still be generated in the absence of O_2 by fermentation (substrate level phosphorylation)
   - Feedback is used at all stages of cellular repiration to regulate levels of breakdown
3. Photosynthesis
   - light energy becomes chemical energy when excited chlorophyll splits water to establish the gradient needed for the formation of ATP
   - plants synthesize PGAL, which can be used to produce other molecules at the base of the energy pyramid in an ecosystem
   - energy that was once in light is now in food, which can be respired to produce ATP

- photorespiration occurs when O_2 occupies the active site of rubisco, wasting potential food energy
- C_4 plants counter the effects of photorespiration by separating light reactions and Calvin cycle into mesophyll and bundle sheath cells

D. Environmental changes challenge dynamic homeostasis (EU 2C, EU 2D, and EU 2E)

1. Supplies of matter and energy vary and cause organisms to react
   - Altering of biological cycles and availability of food effects populations and causes adaptation
   - Models can be used and analyzed that predict the impact of alterations of matter and energy
2. The adaptations of specific organisms to varying environments reflect common ancestry
   - Survival in an environment with its given resources required evolutionary adaptations
   - Examples include water regulation in arid areas, fermentation when lacking oxygen, C_4 metabolism, needles as leaves, nocturnal animals, and nastic/taxis behaviors.
3. Nervous and endocrine systems react to environmental changes to maintain homeostasis
   - Nervous systems take in sensory input and react accordingly for survival
   - Endocrine hormonal responses control water levels, mineral levels, sugar levels, and reproductive timing all in response to environmental conditions
4. Plants and animals have defenses against infectious agents
   - Immune systems response to invaders and react accordingly
   - Plants produce physical and chemical defenses to ward off macroscopic and microscopic invaders

Topic II: The passing on of life and its abilities (**Big Idea 3**) *[COMPLETED 2ND QUARTER]*

A. Heredity

1. Meiosis and gametogenesis (EU 3A)
   - meiosis halves chromosome number so that fertilization maintains it
   - meiosis produces gametes in animals, and spores which develop into the gametophyte generation in plants
   - variety is assured by genetic contribution from each parent and through crossing over
   - meiosis includes one replication stage and two divisions, thus producing four haploid cells
   - meiosis is initiated by hormone messages in plants and animals
2. Eukarytoic chromosomes (EU 3A)
   - genomes of most plants and animals are diploid, with chromosomes combined with histone proteins
   - histones are believed to serve in compacting the DNA, regulating its expression, and protecting it from mutagens
   - chromosomes contain much nonsense information (introns)
3. Inheritance patterns (EU 3A)
   - Mendel's laws included dominance, segregation, probability, incomplete dominance, and independent assortment
   - ther types (*X*-linked, *Y*-linked, multiple alleles, mutliple loci, sex influenced, jumping genes, nondisjunction, linked)

B. Molecular genetics

1. RNA and DNA structure and function (EU 3B)
   - double stranded DNA, semi-conservative replication
   - single stranded mRNA (codons) complements single stranded portion of tRNA (anticodon)
   - codons include start and stop codes, as well as generic third base codes to protect against point mutations
   - tRNA complements both mRNA and a specific amino acid
   - ribosomes assemble during protein synthesis, allow complementing of mRNA and tRNA and dehydration synthesis of amino acids into protein
2. Gene regulation (EU 3B)
   - operons are gene units involved in regulation of transcription
   - inducible and repressible models function in a fashion similar to feedback inhibition and precursor activation of enzymes
   - the *lac* operon is a model repressed by high concentrations of the products of lactose hydrolysis in *E. coli*
3. Mutation (EU 3C)
   - mutagens can alter gene structure by inserting, deleting, inverting, or causing incorrect base pairing
   - changes range from harmless to fatal; some are beneficial
4. Viral structure and replication (EU 3C)
   - lytic viruses (e.g., bacteriophages) enter host cell, replicate their DNA, synthesize protein coats, repeat with new host
   - lysogenic viruses (e.g., retroviruses, HIV) contain RNA; use reverse transcriptase to incorporate their genes into host DNA; can transduce host into pathogen
5. Nucleic acid technology and applications
   - current technologies include gel electrophoresis, gene splicing, PCR, RFLP, gene cloning, transfection, and gene sequencing
   - technology can be used to make large quantities of proteins and to improve the productivity of foods
   - technology can be used to determine identity, paternity, guilt or innocence, and susceptibility to genetic disease
   - many new ethical issues have been raised

6. Cellular Communication and its connection to genetic control mechanisms (EU 3D)
    - Chemical signaling beween cells
    - Signal transduction pathways (cAMP)
    - Hormones and their activities
    - Conversion of totipotent stem cells ~ Disease research

D. Heredity passes on abilities (EU 3E)
1. Nervous systems respond to information
    - Neurons, synapses, and chemical signaling allow organisms to function
    - Inherited central nervous system capabilities allow for varying levels of cognition
2. Behaviors are inherited
    - Behaviors are eiter innate or learned. Both are determined by heredity: directly or indirectly.
    - Innate behaviors are "hard-wired" and are used for survival
    - Learned behaviors reflect ability to analyze and react to environments.

Topic III: How life changes (**Big Idea 1**) *[COMPLETED 3RD QUARTER]*

A. Origin and Evolution of life (EU 1A)
    - Evolution is the change in the genetic makeup of a population over time and is driven by natural selection.

1. Early evolution of life (EU 1D)
    - biological macromolecules are believed to have been formed from reactions in the earth's early atmosphere and seas
    - eukaryotic cells are believed to be collections of prokarytoic cells, since some organelles contain their own DNA and protein machinery
2. Evidence for evolution (EU 1A)
    - fossil record, recapitulation, embryological comparisons, homologies, vestigial structures, biogeographical distribution, chromosomal comparisons, gene sequencing, protein sequencing, geological record
3. Mechanisms of evolution (EU 1A)
    - selection, gene flow between populations, drift (small populations), mutation, nonrandom mating
    - change in gene pools requires allopatric (geographical) or sympatric isolation
    - sympatry can be behavioral, ecological (niche selection), seasonal (mating time), mechanical (can't mate)
    - selection leads to divergence of gene pools to the point that interbreeding is impossible (speciation)
    - divergence shows adaptive radiation of homologies; convergence shows similarity of analogies due to similarity in selective pressures
4. Evolutionary patterns (EU 1B)
    - animals have body plans featuring asymmetry, radial symmetry, and bilateral symmetry
    - accompanying symmetry is cephalization, the tube-in-a-tube body plan, the coelom, and segmentation
    - plants have body plans that improve competition for light, water, and minerals, and improve distribution of offspring
5. Brief survey of the diversity of life (review)
    - bacteria differ in morphology and nutrition: chemoautotrophs, chemoheterotrophs, photosynthetic, chemosynthetic
    - protozoa are unicellular and are classified by type of locomotion
    - algae are mostly unicellular and are classified by type of chlorophyll; chlorophyta are the forerunners of plants
    - molds develop from a spore into a mycelium that produces more spores
    - major animal phyla are Porifera, Cnidaria, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropodoa, Echinodermata, and Chordata
    - plant divisions are Bryophyta and Tracheophyta
6. Phylogenetic classification (EU 1B)
    - Monera are prokaryotic; Fungi are heterotrophic; Protista are a mixed collection of mostly unicellular, eukaryotic life
    - Bryophyta lack vascular tissue; Tracheophyta have xylem and phloem
7. Evolutionary relationships
    - animal phyla can be divided into coelomates and acoelomates, segmented or not, by type of symmetry, and whether protostome or deuterostome. These traits help to tie organisms together and show common ancestry
    - despite great anatomical differences, DNA comparisons show great similarity and common ancestry
    - all life is made of the same types of macromolecules, and all can obtain energy through anaerobic respiration

Topic IV: Interactions within and between living things as well as their environment (**Big Idea 4**) [Completed 4th Quarter]

A. Organisms possess complex biological systems that interact
1. Reproduction, growth, and development
    - the terrestrial strategy in animals includes the reptilian amniotic egg, the mammalian placenta, and hormone regulation
    - embryonic development is influenced by cell migration, maternal mRNA, genetic regulation, and induction
2. Structural, physiological, and behavioral adaptations (EU 4A and EU4B)
    - organ systems involve cells specialized in various ways from the "typical" cell
    - cells coordinate their activities through chemical messengers

- systems interact to maintain a tolerable internal environment (homeostasis)
- the movement of plants to land was accompanied by the evolution of support tissue, conductive tissue, a means of distributing and caring for offspring, and hormones to coordinate growth, development, and dormancy
- the move of animals to land was accompanied by methods to regulate temperature and water balance, skeletons for movement and support, and efficient means to allow for development of young
- innate and learned behavior patterns contribute to survival and mating success

3. Response to the environment (EU 4C)
   - many plant hormones respond to periods of light (photoperiodism); apical dominance is initiated
   - inhibitory hormones are involved in leaf abcission and dormancy
   - external stimuli can generate action potentials in neurons which lead to response
   - hormones work like neurotransmitters in that they alter activities of target cells

C. Ecology (EU 4B)

1. Population dynamics
   - populations tend to increase in a geometric progression until limited by food, water, disease, predators, etc.
2. Communities and ecosystems
   - energy flow in an ecosystem is described by a pyramid of trophic levels, with energy lost at each step
   - most elements cycle through nature in inorganic and organic forms, often involving bacteria
   - N_2 must be fixed by bacteria into an organic form, so that plants may convert this into amino acids
   - the number and size of trophic levels in an ecosystem depends upon the amount of energy introduced by producers
   - succession is a predictable series of events that produces a climax community with maximum productivity
   - the make-up of a community is determined mainly by temperature and precipitation
3. Global issues
   - humans alter biogeochemical cycles by adding chemicals to the environment through combustion and sewage run-off
   - the alleged greenhouse effect can be caused by an excess of CO_2 in the atmosphere, which traps heat underneath
4. Competition leads to competitive exclusion and symbiotic relationships

***AP Biology Labs*:** Eight of the following thirteen labs are required by the College Board (2 per Big Idea). Every effort will be made to do them all in this class. With the shift to inquiry based labs, time may be an issue and require some flexibility of students to do work outside of the normal school day.

Big Idea 1 Labs: (3rd quarter)
Investigation 1: Artificial Selection
Investigation 2: Mathematical Modeling: Hardy-Weinberg
Investigation 3: Comparing DNA Sequences to Understand Evolutionary Relationships with BLAST

Big Idea 2 Labs: (1st quarter)
Investigation 4: Diffusion and Osmosis
Investigation 5: Photosynthesis
Investigation 6: Cellular Respiration

Big Idea 3 Labs: (2nd quarter)
Investigation 7: Cell Division: Mitosis and Meiosis
Investigation 8: Biotechnology: Bacterial Transformation
Investigation 9: Biotechnology: Restriction Enzyme Analysis of DNA

Big Idea 4 Labs: (4th quarter)
Investigation 10: Energy Dynamics
Investigation 11: Transpiration
Investigation 12: Fruit Fly Behavior
Investigation 13: Enzyme Activity

Lab write-ups:

Each student will create their own laboratory notebook. This notebook will contain all the formal labwork of the year and will be collected and graded at the end of each quarter. Specific information as to the format of the notebook will be provided in class. The general layout of each lab write-up includes:

A. Abstact
B. Background Information
C. Hypothesis
D. Concise Procedure to test hypothesis
E. Data usually in table form
F. Statisitcal analysis of data with graphs and writen explanation.
G. Conclusion
H. Discussion

Less formal presentations of lab work will occur by each group in class. All lab work will constitute approximately 30% of class time and of the overall course grade.

Non-Lab Assessments:

All unit assessments will mimic the actual AP Test. They will consist of multiple-choice, objective sections, along with short answer and one major essay question. Each short answer and essay question will use a rubric that includes all information that will earn points within each essay. Unit assessments will constitute 50% of the overall quarter grade.

At the end of each quarter, a Quarter Test will be given that mimics the AP Biology test. These will be cumulative in that the test will include all material covered prior to the test, not just that quarter. It will count as 20% of the quarter grade.

Each Friday of the quarter, a lab group will present a societal issue found within the context of biology. This presentation will require an explanation of the issue, statistical analysis of the issue, and modeling to predict the future nature of this topic. These will be scored and be included in the Quarter Test grade.

Return of work policy:

All lab quizes and labs are returned to students, reviewed, and kept by the student. Approximately 2 or 3 formal labs will be done each quarter. The multiple choice portion of each unit test is returned to students and reviewed in class. This portion is not kept by students in order to insure the validity of a test compiled and reworked over the last seven years. The essay portion is returned, discused, and kept by the student. Essay rubrics are posted on the web for further review by the students.

Resources:

Each student will receive a textbook distributed by the bookstore at registration. The text is a comprehensive text used by many first year biology courses in universites. These textbooks come within online subscriptions and a CD version of the text. Many students enjoy the freedom to acess the information within carrying around such a large book.

Biology, 7th ed., Campbell and Reece. Pearson – Benjamin Cummings. 2006.