AP Biology Summer 2018

Welcome to AP Biology.

I am so happy you have chosen to pursue this challenging yet rewarding course in Biology. The AP Biology course has been organized into four Big Ideas which have been woven into each unit of study. Throughout each unit we will need to pull our resources from each Big Idea to be able to analyze the course material. As you read through the following course material please take time to refresh yourself with the vocabulary and concepts contained herein. You have many resources at your disposal this summer including myself. I would suggest Bozeman Biology and Kahn Academy for video related support and the following websites for content specific support.

http://biologyjunction.com/welcome_to_ap_biology.htm
http://www.hhmi.org/biointeractive/activities/index.html
http://www.sophia.org/biology-topic
https://apstudent.collegeboard.org/apcourse/ap-biology

You may also be able to find a copy to Campbell biology online at

http://www.gavirtuallearning.org/Resources/ScienceResources/ScienceShared/SharedAPBiology17.aspx

Feel free to join Google classroom using the code: **jf5fy1q**

https://classroom.google.com/

Please take time to enjoy your summer. The four assignments should not consume all of your time and should be no more than one page in length. Feel free to email or text me with any questions.

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Big Idea 1: The process of evolution drives the diversity and unity of life.

Evolution is a change in the genetic makeup of a population over time, with natural selection its major driving mechanism. Darwin's theory, which is supported by evidence from many scientific disciplines, states that inheritable variations occur in individuals in a population. Due to competition for limited resources, individuals with more favorable variations or phenotypes are more likely to survive and produce more offspring, thus passing traits to future generations.

In addition to the process of natural selection, naturally occurring catastrophic and human induced events as well as random environmental changes can result in alteration in the gene pools of populations. Small populations are especially sensitive to these forces. A diverse gene pool is vital for the survival of species because environmental conditions change. Mutations in DNA and recombination during meiosis are sources of variation. Human-directed processes also result in new genes and combinations of alleles that confer new phenotypes. Mathematical approaches are used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population.

Scientific evidence supports the idea that both speciation and extinction have occurred throughout Earth's history and that life continues to evolve within a changing environment, thus explaining the diversity of life. New species arise when two populations diverge from a common ancestor and become reproductively isolated. Shared conserved core processes and genomic analysis support the idea that all organisms — Archaea, Bacteria, and Eukarya, both extant and extinct — are linked by lines of descent from common ancestry. Elements that are conserved across all three domains are DNA and RNA as carriers of genetic information, a universal genetic code and many metabolic pathways. Phylogenetic trees graphically model evolutionary history and "descent with modification." However, some organisms and viruses are able to transfer genetic information horizontally.

The process of evolution explains the diversity and unity of life, but an explanation about the *origin* of life is less clear. Experimental models support the idea that chemical and physical processes on primitive Earth could have produced complex molecules and very simple cells. Under laboratory conditions, complex polymers and self-replicating molecules can assemble spontaneously; thus, the first genetic material may not have been DNA, but short sequences of self-replicating RNA that may have served as templates for polypeptide synthesis. Protobiontic formation was most likely followed by the evolution of several primitive groups of bacteria that used various means of obtaining energy. Mutually beneficial associations among ancient bacteria are thought to have given rise to eukaryotic cells.

A Change in the genetic makeup of a population over time is evolution.
Natural selection is the major driving mechanism of evolution; the essential features of the mechanism contribute to the change in the genetic makeup of a population over time. Darwin's theory of natural selection states that inheritable variations occur in individuals in a population. Due to competition for resources that are often limited, individuals with more favorable variations or phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations. Fitness, the number of surviving offspring left to produce the next generation, is a measure of evolutionary success. Individuals do not evolve, but rather, populations evolve.

The environment is always changing, there is no “perfect” genome, and a diverse gene pool is important for the long-term survival of a species. Genetic variations within a population contribute to the diversity of the gene pool. Changes in genetic information may be silent (with no observable phenotypic effects) or result in a new phenotype, which can be positive, negative or neutral to the organism. The interaction of the environment and the phenotype determines the fitness of the phenotype; thus, the environment does not direct the changes in DNA, but acts upon phenotypes that occur through random changes in DNA. These changes can involve alterations in DNA sequences, changes in gene combinations and/or the formation of new gene combinations.

Although natural selection is usually the major mechanism for evolution, genetic variation in populations can occur through other processes, including mutation, genetic drift, sexual selection and artificial selection. Inbreeding, small population size, nonrandom mating, the absence of migration, and a net lack of mutations can lead to loss of genetic diversity. Human-directed processes such as genetic engineering can also result in new genes and combinations of alleles that confer new phenotypes.

Biological evolution driven by natural selection is supported by evidence from many scientific disciplines, including geology and physical science. In addition, biochemical, morphological, and genetic information from existing and extinct organisms support the concept of natural selection. Phylogenetic trees serve as dynamic models that show common ancestry, while geographical distribution and the fossil record link past and present organisms.

Assignment 1:

- Individuals with more favorable phenotypes are more likely to survive and produce more offspring, thus passing traits to subsequent generations.

- Genetic variation and mutation play roles in natural selection. A diverse gene pool is important for the survival of a species in a changing environment.

- Environments can be more or less stable or fluctuating, and this affects evolutionary rate and direction; different genetic variations can be selected in each generation.

Select two examples from below and briefly discuss how they relate to the ideas listed above about evolution of life on Earth.

Examples:

- o Flowering time in relation to global climate change
- o Peppered moth
- o Sickle cell anemia
- o DDT resistance in insects
- o Artificial selection

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

Living systems require free energy and matter to maintain order, grow and reproduce. Organisms employ various strategies to capture, use and store free energy and other vital resources. Energy deficiencies are not only detrimental to individual organisms; they also can cause disruptions at the population and ecosystem levels.

Autotrophic cells capture free energy through photosynthesis and chemosynthesis. Photosynthesis traps free energy present in sunlight that, in turn, is used to produce carbohydrates from carbon dioxide. Chemosynthesis captures energy present in inorganic chemicals. Cellular respiration and fermentation harvest free energy from sugars to produce free energy carriers, including ATP. The free energy available in sugars drives metabolic pathways in cells. Photosynthesis and respiration are interdependent processes.

Cells and organisms must exchange matter with the environment. For example, water and nutrients are used in the synthesis of new molecules; carbon moves from the environment to organisms where it is incorporated into carbohydrates, proteins, nucleic acids or fats; and oxygen is necessary for more efficient free energy use in cellular respiration. Differences in surface-to-volume ratios affect the capacity of a biological system to obtain resources and eliminate wastes. Programmed cell death (apoptosis) plays a role in normal development and differentiation (e.g. morphogenesis).

Membranes allow cells to create and maintain internal environments that differ from external environments. The structure of cell membranes results in selective permeability; the movement of molecules across them via osmosis, diffusion and active transport maintains dynamic homeostasis. In eukaryotes, internal membranes partition the cell into specialized regions that allow cell processes to operate with optimal efficiency. Each compartment or membrane-bound organelle enables localization of chemical reactions.

Organisms also have feedback mechanisms that maintain dynamic homeostasis by allowing them to respond to changes in their internal and external environments. Negative feedback loops maintain optimal internal environments, and positive feedback mechanisms amplify responses. Changes in a biological system's environment, particularly the availability of resources, influence responses and activities, and organisms use various means to obtain nutrients and get rid of wastes. Homeostatic mechanisms across phyla reflect both continuity due to common ancestry and change due to evolution and natural selection; in plants and animals, defense mechanisms against disruptions of dynamic homeostasis have evolved. Additionally, the timing and coordination of developmental, physiological and behavioral events are regulated, increasing fitness of individuals and long-term survival of populations.

Growth, reproduction and maintenance of the organization of living systems require free energy and matter.

Living systems require energy to maintain order, grow and reproduce. In accordance with the laws of thermodynamics, to offset entropy, energy input must exceed energy lost from and used by an organism to maintain order. Organisms use various energy-related strategies to survive; strategies include different metabolic rates, physiological changes, and variations in reproductive and offspring-raising strategies. Not only can energy deficiencies be detrimental to individual organisms, but changes in free energy availability also can affect population size and cause disruptions at the ecosystem level. Several means to capture, use and store free energy have evolved in organisms. Cells can capture free energy through photosynthesis and chemosynthesis. Autotrophs capture free energy from the environment, including energy present in sunlight and chemical sources, whereas heterotrophs harvest free energy from carbon compounds produced by other organisms. Through a series of coordinated reaction pathways, photosynthesis traps free energy in sunlight that, in turn, is used to produce carbohydrates from carbon dioxide and water. Cellular respiration and fermentation use free energy available from sugars and from interconnected, multistep pathways (i.e., glycolysis, the Krebs cycle and the electron transport chain) to phosphorylate ADP, producing the most common energy carrier, ATP. The free energy available in sugars can be used to drive metabolic pathways vital to cell processes. The processes of photosynthesis and cellular respiration are interdependent in their reactants and products.

Organisms must exchange matter with the environment to grow, reproduce and maintain organization. The cellular surface-to-volume ratio affects a biological system's ability to obtain resources and eliminate waste products. Water and nutrients are essential for building new molecules.

Carbon dioxide moves from the environment to photosynthetic organisms where it is metabolized and incorporated into carbohydrates, proteins, nucleic acids or lipids. Nitrogen is essential for building nucleic acids and proteins; phosphorus is incorporated into nucleic acids, phospholipids, ATP and ADP. In aerobic organisms, oxygen serves as an electron acceptor in energy transformations.

Assignment 2:

1. *Diagram the basic molecular structure of Carbohydrates (CHO), Lipids (CHO), Proteins (CHON) and Nucleic Acids (CHONP).*

2. *Briefly describe the following Energy-related pathways.*

    - Krebs cycle
    - Glycolysis
    - Calvin cycle
    - Fermentation

3. *Organisms use various strategies to regulate body temperature and metabolism. Provide a description and example of endothermy and ectothermy.*

4. *Autotrophs capture free energy from physical sources in the environment. Explain photosynthesis.*

5. *Heterotrophs capture free energy present in carbon compounds produced by other organisms. Explain cellular respiration.*

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

Genetic information provides for continuity of life and, in most cases, this information is passed from parent to offspring via DNA. The double stranded structure of DNA provides a simple and elegant solution for the transmission of heritable information to the next generation; by using each strand as a template, existing information can be preserved and duplicated with high fidelity within the replication process. However, the process of replication is imperfect, and errors occur through chemical instability and environmental impacts. Random changes in DNA nucleotide sequences lead to heritable mutations if they are not repaired. To protect against changes in the original sequence, cells have multiple mechanisms to correct errors. Despite the action of repair enzymes, some mutations are not corrected and are passed to subsequent generations. Changes in a nucleotide sequence, if present in a protein-coding region, can change the amino acid sequence of the polypeptide. In other cases, mutations can alter levels of gene expression or simply be silent. In order for information in DNA to direct cellular processes, information must be transcribed (DNA→RNA) and, in many cases, translated (RNA→protein). The products of transcription and translation play an important role in determining metabolism, i.e., cellular activities and phenotypes. Biotechnology makes it possible to directly engineer heritable changes in cells to yield novel protein products.

In eukaryotic organisms, heritable information is packaged into chromosomes that are passed to daughter cells. Alternating with interphase in the cell cycle, mitosis followed by cytokinesis provides a mechanism in which each daughter cell receives an identical and a complete complement of chromosomes. Mitosis ensures fidelity in the transmission of heritable information, and production of identical progeny allows organisms to grow, replace cells, and reproduce asexually.

Sexual reproduction, however, involves the recombination of heritable information from both parents through fusion of gametes during fertilization. Meiosis followed by fertilization provides a spectrum of possible phenotypes in offspring and on which natural selection operates.

Mendel was able to describe a model of inheritance of traits, and his work represents an application of mathematical reasoning to a biological problem. However, most traits result from interactions of many genes and do not follow Mendelian patterns of inheritance. Understanding the genetic basis of specific phenotypes and their transmission in humans can raise social and ethical issues.

The expression of genetic material controls cell products, and these products determine the metabolism and nature of the cell. Gene expression is regulated by both environmental signals and developmental cascades or stages. Cell signaling mechanisms can also modulate and control gene expression. Thus, structure and function in biology involve two interacting aspects: the presence of necessary genetic information and the correct and timely expression of this information.

Genetic information is a repository of instructions necessary for the survival, growth and reproduction of the organism. Changes in information can often be observed in the organism due to changes in phenotypes. At the molecular level, these changes may result from mutations in the genetic material whereupon effects can often be seen when the information is processed to yield a polypeptide; the changes may be positive, negative or neutral to the organism. At the cellular level, errors in the transfer of genetic information through mitosis and meiosis can result in adverse changes to cellular composition. Additionally, environmental factors can influence gene expression.

Genetic variation is almost always advantageous for the long-term survival and evolution of a species. In sexually reproducing organisms, meiosis produces haploid gametes (1N), and random fertilization produces diploid zygotes (2N). In asexually reproducing organisms, variation can be introduced through mistakes (mutations) in DNA replication or repair and through recombination; additionally, bacteria can transmit and/or exchange genetic information horizontally (between individuals in the same generation). Viruses have a unique mechanism of replication that is dependent on the host metabolic machinery. Viruses can introduce variation in the host genetic material through lysogenesis or latent infection.

To function in a biological system, cells communicate with other cells and respond to the external environment. Cell signaling pathways are determined by interacting signal and receptor molecules, and signaling cascades direct complex behaviors that affect physiological responses in the organism by altering gene expression or protein activity. Non-heritable information transmission influences behavior within and between cells, organisms and populations; these behaviors are directed by underlying genetic information, and responses to information are vital to natural selection and evolution. Animals have evolved sensory organs that detect and process external information. Nervous systems interface with these sensory and internal body systems, coordinating response and behavior; and this coordination occurs through the transmission and processing of signal information. Behavior in the individual serves to increase its fitness in the population while contributing to the overall survival of the population.

Assignment 3:

1. *Diagram the process of protein synthesis*

2. *Briefly explain mitosis, meiosis and fertilization.*

   **Memorization of the names of the phases of mitosis is beyond the scope of the course and the AP Exam. There will be many of these exclusion statements throughout the year. They are important because they give us clues as to the limits to which College Board will test our knowledge. That said, we will often tread these waters to help us better grasp the critical concepts. Do not be timid what charting new territory.*

3. *Endocrine signals are produced by endocrine cells that release signaling molecules, which are specific and can travel long distances through the blood to reach all parts of the body. Briefly describe the negative feedback mechanism in the regulation of blood glucose levels.*

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

All biological systems are composed of parts that interact with each other. These interactions result in characteristics not found in the individual parts alone. In other words, "the whole is greater than the sum of its parts." All biological systems from the molecular level to the ecosystem level exhibit properties of biocomplexity and diversity. Together, these two properties provide robustness to biological systems, enabling greater resiliency and flexibility to tolerate and respond to changes in the environment. Biological systems with greater complexity and diversity often exhibit an increased capacity to respond to changes in the environment.

At the molecular level, the subcomponents of a biological polymer determine the properties of that polymer. At the cellular level, organelles interact with each other as part of a coordinated system that keeps the cell alive, growing and reproducing. The repertory of subcellular organelles and biochemical pathways reflects cell structure and differentiation. Additionally, interactions between external stimuli and gene expression result in specialization and divergence of cells, organs and tissues. Interactions and coordination between organs and organ systems determine essential biological activities for the organism as a whole. External and internal environmental factors can trigger responses in individual organs that, in turn, affect the entire organism. At the population level, as environmental conditions change, community structure changes both physically and biologically. The study of ecosystems seeks to understand the manner in which species are distributed in nature and how they are influenced by their abiotic and biotic interactions, e.g., species interactions. Interactions between living organisms and their environments result in the movement of matter and energy.

Interactions, including competition and cooperation, play important roles in the activities of biological systems. Interactions between molecules affect their structure and function. Competition between cells may occur under conditions of resource limitation. Cooperation between cells can improve efficiency and convert sharing of resources into a net gain in fitness for the organism. Coordination of organs and organ systems provides an organism with the ability to use matter and energy effectively.

Variations in components within biological systems provide a greater flexibility to respond to changes in its environment. Variation in molecular units provides cells with a wider range of potential functions. A population is often measured in terms of genomic diversity and its ability to respond to change. Species with genetic variation and the resultant phenotypes can respond and adapt to changing environmental conditions.

Interactions within biological systems lead to complex properties.

All biological systems, from cells to ecosystems, are composed of parts that interact with each other. When this happens, the resulting interactions enable characteristics not found in the individual parts alone. In other words, "the whole is greater than the sum of its parts," a phenomenon sometimes referred to as "emergent properties."

At the molecular level, the properties of a polymer are determined by its subcomponents and their interactions. For example, a DNA molecule is comprised of a series of nucleotides that can be linked together in various sequences; the resulting polymer carries hereditary material for the cell, including information that controls cellular activities. Other polymers important to life include carbohydrates, lipids and proteins. The interactions between the constituent parts of polymers, their order, their molecular orientation and their interactions with their environment define the structure and function of the polymer.

At the cellular level, organelles interact with each other and their environment as part of a coordinated system that allows cells to live, grow and reproduce. For example, chloroplasts produce trioses through the process of photosynthesis; however, once trioses are synthesized and exported from the chloroplast, they may be packaged by the Golgi body and distributed to the edge of the cell where they serve as a building block for cellulose fibers comprising the cell wall. Similarly, several organelles are involved in the manufacture and export of protein. The repertory of subcellular organelles determines cell structure and differentiation; for instance, the components of plant leaf cells are different from the components of plant root cells, and the components of human liver cells are different from those in the retina. Thus, myriad interactions of different parts at the subcellular level determine the functioning of the entire cell, which would not happen with the activities of individual organelles alone.

In development, interactions between regulated gene expression and external stimuli, such as temperature or nutrient levels or signal molecules, result in specialization of cells, organs and tissues. Differentiation of the germ layers during vertebrate gastrulation is an example of one such divergence. The progression of stem cells to terminal cells can also be explained by the interaction of stimuli and genes. Additionally, cells, organs and tissues may change due to changes in gene expression triggered by internal cues, including regulatory proteins and growth factors, which result in the structural and functional divergence of cells.

Organisms exhibit complex properties due to interactions of their constituent parts, and interactions and coordination between organs and organ systems provide essential biological activities for the organism as a whole. Examples include the vessels and hearts of animals and the roots and shoots of plants. Environmental factors such as temperature can trigger responses in individual organs that, in turn, affect the entire organism.

Interactions between populations within communities also lead to complex properties. As environmental conditions change in time and space, the structure of the community changes both physically and biologically, resulting in a mosaic in the landscape (variety or patterns) in a community. Communities are comprised of different populations of organisms that interact with each other in either negative or positive ways (e.g., competition, parasitism and mutualism); community ecology seeks to understand the manner in which groupings of species are distributed in nature, and how they are influenced by their abiotic environment and species interactions. The physical structure of a community is affected by abiotic factors, such as the depth and flow of water in a stream, and also by the spatial distribution of organisms, such as in the canopy of trees. The mix of species in terms of both the number of individuals and the diversity of species defines the structure of the community. Mathematical or computer models can be used to illustrate and investigate interactions of populations within a community and the effects of environmental impacts on a community. Community change resulting from disturbances sometimes follows a pattern (e.g., succession following a wildfire), and in other cases is random and unpredictable (e.g., founder effect).

At the ecosystem level, interactions among living organisms and with their environment result in the movement of matter and energy. Ecosystems include producers, consumers, decomposers and a pool of organic matter, plus the physiochemical environment that provides the living conditions for the biotic components. Matter, but not energy, can be recycled within an ecosystem via biogeochemical cycles. Energy flows through the system and can be converted from one type to another, e.g., energy available in sunlight is converted to chemical bond energy via photosynthesis. Understanding individual organisms in relation to the environment and the diverse interactions that populations have with one another (e.g., food chains and webs) informs the development of ecosystem models; models allow us to identify the impact of changes in biotic and abiotic factors. Human activities affect ecosystems on local, regional and global scales.

Assignment 4:

Choose a biological organization level (molecular, cellular, organismal, ecological) and create a visual representation of Big 4 emphasizing the interactions of biological systems at that level.

I hope you have enjoyed this assignment. The information gleaned from this work will prove invaluable as we navigate the challenges of AP biology together.

Have a great restful summer,

Mr. Woerner