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| **AP Biology** | **Curriculum Map**  **Molecular Genetics**  http://www.jeffersontownship.org/Portals/0/Images/Logos/hornet.jpg | | | | | |
| Textbook Resources:  **Chapters 16, 17, 18, 19, 20** | | Month(s):  **March** | | Time Frame:  **12 days (9/3block)** | | Assessment:  **Reading Quizzes**  **Unit Test** |
| **Learning Targets** | | | | **Support Text** | | **Bozeman Podcasts** |
| **EK 1.D.2: Scientific evidence from many different disciplines supports models of the origin of life.** | | | | | | |
| 1. Molecular and genetic evidence from extant and extinct organisms indicates that all organisms on Earth share a common ancestral origin of life. 2. Scientific evidence includes molecular building blocks that are common to all life forms. 3. Scientific evidence includes a common genetic code. | | | | **DNA Structure & Function**  Chapter 1.1 (p.8-10)  **Nucleic Acids**  Chapter 5.5 (p.86-89) | | [What is DNA?](http://www.bozemanscience.com/what-is-dna)  [DNA & RNA Part 1](http://www.bozemanscience.com/027-part-1-dna-rna)  [Nucleic Acids](http://www.bozemanscience.com/nucleic-acids) |
| **EK 1.B.1: Organisms share many conserved core processes and features that evolved and are widely distributed among organisms today.** | | | | | | |
| 1. Structural and functional evidence supports the relatedness of all domains.    1. DNA and RNA are carriers of genetic information through transcription, translation and replication    2. Major features of the genetic code are shared by all modern living systems | | | | **Genes Specify Proteins**  Chapter 17.1 (p.325-331)  **Genes are Universal**  Chapter 17.6 (p.346-347) | | [DNA & RNA Part 1](http://www.bozemanscience.com/027-part-1-dna-rna)  [DNA & RNA Part 2](http://www.bozemanscience.com/027-part-2-dna-rna) |
| 1. Structural evidence supports the relatedness of all eukaryotes.  * Linear chromosomes | | | | **Chromosomes**  Chapter 16.3 (p.320-321) | |
| **EK 3.A.1: DNA, and in some cases RNA, is the primary source of heritable information.** | | | | | | |
| 1. Genetic information is transmitted from one generation to the next through DNA or RNA. 2. Genetic information is stored in and passed to subsequent generations through DNA molecules and, in some cases, RNA molecules. 3. Non-eukaryotic organisms have circular chromosomes, while eukaryotic organisms have multiple linear chromosomes, although in biology there are exceptions to this rule. 4. Prokaryotes, viruses and eukaryotes can contain plasmids, which are small extra-chromosomal, double-stranded circular DNA molecules. 5. The proof that DNA is the carrier of genetic information involved a number of important historical experiments.    1. Contributions of Watson, Crick, Wilkins, and Franklin on the structure of DNA    2. Avery-MacLeod-McCarty experiments    3. Hershey-Chase experiment 6. DNA replication ensures continuity of hereditary information.    1. Replication is a semiconservative process; that is, one strand serves as the template for a new, complimentary strand.    2. Replication requires DNA polymerase plus many other essential cellular enzymes, occurs bidirectionally, and differs in the production of the leading and lagging strands. 7. Genetic information in retroviruses is a special case and has an alternate flow of information: from RNA to DNA, made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA. This DNA integrates into the host genome and becomes transcribed and translated for the assembly of new viral progeny. | | | | **DNA: the Genetic Material**  Chapter 16.1 (p.305-310)  **DNA Replication**  Chapter 16.2 (p.311-319)  **Retroviruses**  Chapter 19.2 (p.388-390) | | [DNA & RNA Part 1](http://www.bozemanscience.com/027-part-1-dna-rna)  [Nucleic Acids](http://www.bozemanscience.com/nucleic-acids)  [DNA & RNA Part 2](http://www.bozemanscience.com/027-part-2-dna-rna)  [DNA Replication](http://www.bozemanscience.com/dna-replication)  [Meselson-Stahl Experiment](http://www.bozemanscience.com/meselson-stahl-experiment)  [Viral Replication](http://www.bozemanscience.com/035-viral-replication) |
| 1. DNA and RNA molecules have structural similarities and differences that define function.    1. Both have three components — sugar, phosphate and a nitrogenous base — which form nucleotide units that are connected by covalent bonds to form a linear molecule with 3' and 5' ends, with the nitrogenous bases perpendicular to the sugar-phosphate backbone.   2. The basic structural differences include:   1. DNA contains deoxyribose (RNA contains ribose). 2. RNA contains uracil in lieu of thymine in DNA. 3. DNA is usually double stranded, RNA is usually single stranded. 4. The two DNA strands in double-stranded DNA are antiparallel in directionality. 5. Both DNA and RNA exhibit specific nucleotide base pairing that is conserved through evolution: adenine pairs with thymine or uracil (A-T or A-U) and cytosine pairs with guanine (C-G). 6. Purines (G and A) have a double ring structure 7. Pyrimidines (C, T, and U) have a single ring structure 8. The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function. 9. mRNA carries information from the DNA to the ribosome. 10. tRNA molecules bind to specific amino acids and allow information in the mRNA to be translated to a linear peptide sequence. 11. rRNA molecules are functional building blocks of ribosomes. 12. The role of RNAi includes regulation of gene expression at the level of mRNA transcription. | | | | **Nucleic Acids**  Chapter 5.5 (p.86-89)  **Genes Specify Proteins**  Chapter 17.1 (p.325-331) | | [Nucleic Acids](http://www.bozemanscience.com/nucleic-acids)  [DNA & RNA Part 2](http://www.bozemanscience.com/027-part-2-dna-rna)  [Transcription & Translation](http://www.bozemanscience.com/transcription-translation) |
| 1. Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein. 2. The enzyme RNA-polymerase reads the DNA molecule in the 3' to 5' direction and synthesizes complementary mRNA molecules that determine the order of amino acids in the polypeptide. 3. In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications.    * + Addition of a poly-A tail      + Addition of a GTP cap      + Excision of introns 4. Translation of the mRNA occurs in the cytoplasm on the ribosome. 5. In prokaryotic organisms, transcription is coupled to translation of the message. Translation involves energy and many steps, including initiation, elongation and termination. 6. The mRNA interacts with rRNA of the ribosome to initiate translation at the “start” codon. 7. The sequence of nucleotides on the mRNA is read in triplets called codons. 8. Each codon encodes a specific amino acid, which can be deduced by using a genetic code chart. Many amino acids have more than one codon. 9. tRNA brings the correct amino acid to the correct place on the mRNA. 10. The amino acid is transferred to the growing peptide chain. 11. The process continues along the mRNA until a “stop” codon is reached. 12. The process terminates by release of the newly synthesized polypeptide. | | | | **Transcription**  Chapter 17.2 (p.331-334)  **RNA Modification**  Chapter 17.3 (p.334-336)  **Alternative Splicing**  Chapter 18.2 (p.362)  **Translation**  Chapter 17.4 (p.337-334) | |
| 1. Phenotypes are determined through protein activities.    * + Transport by proteins (cystic fibrosis)      + Synthesis (sickle-cell disease)      + Degradation (Huntington’s disease) | | | | **Genetic Disorders**  Chapter 14.4 (p.276-279) | | [Genotypes & Phenotypes](http://www.bozemanscience.com/033-genotypes-and-phenotypes) |
| 1. Genetic engineering techniques can manipulate the heritable information of DNA and, in special cases, RNA.    * + Electrophoresis      + Plasmid-based transformation (recombination)      + Restriction enzyme analysis of DNA      + Polymerase Chain Reaction (PCR) | | | | **DNA Cloning, Restriction Enzymes & Recombination**  Chapter 20.1 (p.396-400)  **Bacterial Recombination**  Chapter 27.2 (p.561-564)  **PCR**  Chapter 20.1 (p.403-404)  **Electrophoresis**  Chapter 20.2 (p.405-407) | | [Mechanisms Increasing Genetic Variation](http://www.bozemanscience.com/034-mechanisms-that-increase-genetic-variation)  [Molecular Biology LAB](http://www.bozemanscience.com/ap-bio-lab-6-molecular-biology)  [DNA Fingerprinting](http://www.bozemanscience.com/dna-fingerprinting/?rq=dna%20fingerprinti) |
| 1. Genetic engineering can produce important products and technologies for humans    * + Genetically modified organisms (GMO’s)      + Transgenic animals      + Cloning      + Pharmaceuticals: human insulin | | | | **GMO’s**  Chapter 20.4 (p.422-423)  **Transgenic Animals**  Chapter 20.4 (p.419-420)  **Cloning**  Chapter 20.3 (p.412-416) | |
| **EK 3.C.3: Viral replication results in genetic variation, and viral infection can introduce genetic variation into the hosts.** | | | | | | |
| 1. Viral replication differs from other reproductive strategies and generates genetic variation via various mechanisms. 2. Viruses have highly efficient replicative capabilities that allow for rapid evolution and acquisition of new phenotypes. 3. Viruses replicate via a component assembly model allowing one virus to produce many progeny simultaneously via the lytic cycle. 4. Virus replication allows for mutations to occur through usual host pathways. 5. RNA viruses lack replication error-checking mechanisms, and thus have higher rates of mutation. 6. Related viruses can combine/recombine information if they infect the same host cell. 7. HIV is a well-studied system where the rapid evolution of a virus within the host contributes to the pathogenicity of viral infection. | | | | **Replicative Cycles of Viruses**  Chapter 19.2 (p.384-390) | | [Viruses](http://www.bozemanscience.com/viruses)  [Viral Replication](http://www.bozemanscience.com/035-viral-replication) |
| 1. The reproductive cycles of viruses facilitate transfer of genetic information. 2. Viruses transmit DNA or RNA when they infect a host cell.    * + Transduction in bacteria      + Transposons present in incoming DNA 3. Some viruses are able to integrate into the host DNA and establish a latent (lysogenic) infection. These latent viral genomes can result in new properties for the host such as increased pathogenicity in bacteria. | | | |
| **EK 3.B.1: Gene regulation results in differential gene expression, leading to cell specialization.** | | | | | | |
| 1. DNA regulatory sequences, regulatory genes, and small regulatory RNAs are involved in gene expression. 2. Regulatory sequences are stretches of DNA that interact with regulatory proteins to control transcription.    * + - Promoters        - Terminators        - Enhancers 3. A regulatory gene is a sequence of DNA encoding a regulatory protein or RNA. | | | | **Prokaryotic Gene Regulation**  Chapter 18.1 (p.351-355) | | [The Operon](http://www.bozemanscience.com/the-operon)  [Gene Regulation](http://www.bozemanscience.com/031-gene-regulation) |
| 1. Both positive and negative control mechanisms regulate gene expression in bacteria and viruses. 2. The expression of specific genes can be turned on by the presence of an inducer. 3. The expression of specific genes can be inhibited by the presence of a repressor. 4. Inducers and repressors are small molecules that interact with regulatory proteins and/or regulatory sequences. 5. Regulatory proteins inhibit gene expression by binding to DNA and blocking transcription (negative control). 6. Regulatory proteins stimulate gene expression by binding to DNA and stimulating transcription (positive control) or binding to repressors to inactivate repressor function. 7. Certain genes are continuously expressed; that is, they are always turned “on,” e.g., the ribosomal genes. | | | |
| 1. In eukaryotes, gene expression is complex and control involves regulatory genes, regulatory elements and transcription factors that act in concert. 2. Transcription factors bind to specific DNA sequences and/or other regulatory proteins. 3. Some of these transcription factors are activators (increase expression), while others are repressors (decrease expression). 4. The combination of transcription factors binding to the regulatory proteins at any one time determines how much, if any, of the gene product will be produced. | | | | **Eukaryotic Gene Regulation**  Chapter 18.2 (p.356-366) | |
| 1. Gene regulation accounts for some of the phenotypic differences between organisms with similar genes. | | | |
| **EK 2.C.1: Organisms use feedback mechanisms to maintain their internal environments and respond to external environmental changes.** | | | | | | |
| 1. Negative feedback mechanisms maintain dynamic homeostasis for a particular condition (variable) by regulating physiological processes, returning the changing condition back to its target set point.    * + - Operons in gene regulation | | | | **Feedback Mechanisms**  Chapter 1.1 (p.10-11)  **Operons**  Chapter 18.1 (p.351-355)  Figure 18.2 (p.352) | | [The Operon](http://www.bozemanscience.com/the-operon)  [Gene Regulation](http://www.bozemanscience.com/031-gene-regulation) |
| **EK 2.E.1: Timing and coordination of specific events are necessary for the normal development of an organism, and these events are regulated by a variety of mechanisms.** | | | | | | |
| 1. Observable cell differentiation results from the expression of genes for tissue-specific proteins. | | | | **Cell Differentiation & Embryonic Development**  Chapter 18.4 (p.366-373)  **Cell Fate Specification**  Chapter 47.3 (p.1035-1042) | | [Cellular Specialization](http://www.bozemanscience.com/044-cellular-specialization)  [Development: Timing and Coordination](https://www.youtube.com/watch?v=pa9uPnIeVKU&feature=youtu.be) |
| 1. Induction of transcription factors during development results in sequential gene expression. 2. Homeotic genes are involved in developmental patterns and sequences. 3. Embryonic induction in development results in the correct timing of events. 4. Genetic mutations can result in abnormal development. 5. Genetic transplantation experiments support the link between gene expression and normal development. 6. Genetic regulation by microRNAs plays an important role in the development of organisms and the control of cellular functions. 7. Temperature and the availability of water determine seed germination in most plants. | | | |
| 1. Programmed cell death (apoptosis) plays a role in the normal development and differentiation.    * + - Morphogenesis of fingers and toes        - *C. elegens* development | | | | **Apoptosis**  Chapter 11.5 (p.223-225) | |
| **EK 3.B.2: A variety of intercellular and intracellular signal transmissions mediate gene expression.** | | | | | | |
| 1. Signal transmission within and between cells mediates gene expression.    * + - Expression of SRY gene triggers male sexual development in animals. | | | | **SRY Gene & Sex-Linkage**  Chapter 15.2 (p.289-290) | | [Signal Transmission & Gene Expression](http://www.bozemanscience.com/032-signal-transmission-and-gene-expression)  [Cellular Specialization](http://www.bozemanscience.com/044-cellular-specialization)  [Development: Timing and Coordination](https://www.youtube.com/watch?v=pa9uPnIeVKU&feature=youtu.be) |
| 1. Signal transmission within and between cells mediates cell function.    * + - HOX (homeobox) genes and their role in development | | | | **HOX Genes**  Chapter 21.6 (p.445-447) | |
| **EK 4.A.3: Interactions between external stimuli and regulated gene expression result in specialization of cells, tissues and organs.** | | | | | | |
| 1. Differentiation in development is due to external and internal cues that trigger gene regulation by proteins that bind to DNA. | | | | **Cell Differentiation & Embryonic Development**  Chapter 18.4 (p.366-373)  **Cell Fate Specification**  Chapter 47.3 (p.1035-1042) | | [Cellular Specialization](http://www.bozemanscience.com/044-cellular-specialization) |
| 1. Structural and functional divergence of cells in development is due to expression of genes specific to a particular tissue or organ type. | | | |
| 1. Environmental stimuli can affect gene expression in a mature cell. | | | | **Epigenetic Inheritance**  Chapter 18.2 (p.358) | | [Genotype Expression](http://www.bozemanscience.com/053-genotype-expression)  [Epigenetics](http://www.bozemanscience.com/epigenetics) |
| **EK 4.C.2: Environmental factors influence the expression of the genotype in an organism.** | | | | | | |
| 1. Environmental factors influence many traits both directly and indirectly.  * Height and weight in humans * Flower color based on soil pH * Seasonal fur color in arctic animals * Sex determination in reptiles * Density of plant hairs as a function of herbivory * Presences of UV on melanin production | | |  | | [Genotype Expression](http://www.bozemanscience.com/053-genotype-expression) | |
| **EK 3.C.1: Changes in genotype can result in changes in phenotype.** | | | | | | |
| 1. Alterations in a DNA sequence can lead to changes in the type or amount of the protein produced and the consequent phenotype. 2. DNA mutations can be positive, negative or neutral based on the effect or the lack of effect they have on the resulting nucleic acid or protein and the phenotypes that are conferred by the protein. | | | | **Mutations**  Chapter 17.5 (p.344-347)  **Genetic Disorders**  Chapter 14.4 (p.276-279) | | [Mutations](http://www.bozemanscience.com/mutations)  [Examples of Natural Selection](http://www.bozemanscience.com/002-examples-of-natural-selection) |
| 1. Errors in DNA replication or DNA repair mechanisms, and external factors, including radiation and reactive chemicals, can cause random changes, e.g., mutations in the DNA. 2. Whether or not a mutation is detrimental, beneficial or neutral depends on the environmental context. Mutations are the primary source of genetic variation. | | | | **Sources of Genetic Variation**  Chapter 23.1 (p.471-472)  **Observations of Evolutionary Change**  Chapter 22.3 (p.460-462)  **Changes in Developmental Genes**  Chapter 25.5 (p.525-529) | |
| **EK 3.C.2: Biological systems have multiple processes that increase genetic variation.** | | | | | | |
| 1. The imperfect nature of DNA replication and repair increases variation. | | | | **Mutations**  Chapter 17.5 (p.344-347) | | [Mutations](http://www.bozemanscience.com/mutations) |
| 1. The horizontal acquisitions of genetic information primarily in prokaryotes via transformation (uptake of naked DNA), transduction (viral transmission of genetic information), conjugation (cell-to-cell transfer) and transposition (movement of DNA segments within and between DNA molecules) increase variation. | | | | **Evolution of Viruses**  Chapter 19.2 (p.390)  **Bacterial Recombination & Conjugation**  Chapter 27.2 (p.561-564) | | [Mechanisms Increasing Genetic Variation](http://www.bozemanscience.com/034-mechanisms-that-increase-genetic-variation) |

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| **Vocabulary** | | | | | |
| 5’ GTP cap | deletions | hydrogen bonds | nonsense mutation | regulatory gene | stop codon |
| A, P, E site | deoxyribose | inducer | nucleotides | replication fork | structural genes |
| adenine | DNA fingerprinting | insertion | Okazaki fragments | repressor | template strand |
| amino acid | DNA ligase | introns | operator | restriction enzyme | thymine |
| antiparallel | DNA polymerase | lac operon | origin of replication | retrovirus (HIV) | topoisomerase |
| bacteriophage (lambda phage) | DNA replication | lagging strand | peptide bond | reverse transcriptase | transcription |
| base pairing | double helix | leading strand | phosphate group | ribose | transcription factors |
| base substitution | exons | lysogenic cycle | phosphodiester bonds | RNA polymerase | transformation |
| chaperone proteins (chaperonins) | frameshift | lytic cycle | plasmid | RNA primase | translation |
| cloning vector | gel electrophoresis | missense mutation | poly(A) tail | RNA processing | translocation |
| codons | gene expression | mRNA | polymerase chain reaction (PCR) | rRNA | tRNA |
| complimentary | genetic engineering | mutation | polypeptide | silent mutation | trp operon |
| corepressor | guanine | nitrogenous base | promoter | spliceosome | uracil |
| cytosine | helicase | non-template strand | protein synthesis | sticky end |  |