I. Scientific Thinking

A. Accept the fact that there are scientific truths.

B. Use deductive and inductive reasoning when forming conclusions.
   1. Deductive reasoning
   2. Inductive reasoning

C. Do not trust your senses.

D. Use the Scientific Investigation Method
   1. Steps of the Scientific Method
      a. Define the problem
      b. Research the problem/observe and record data
      c. Make a hypothesis
      d. Test the hypothesis using a controlled experiment
      e. Record data
      f. Determine the validity of the hypothesis
      g. Retest at least three times
      h. Formulate theory if proven
2. Variables – Key to experimental design (Bombat activity)

   a. Dependent variable

   b. Independent variable

   c. Control

   d. Constants

II. Core Themes in Biology:

   A. Evolution accounts for life’s unity and diversity

   B. Organisms have levels of Organization

      1. Molecule

      2. Cell

      3. Tissue

      4. Organ system

      5. Organism

      6. Population

      7. Community

      8. Ecosystem
C. The Concept of Emergent Properties

Emergent properties are due to the arrangement and interactions of parts as complexity increases. Novel properties emerge that are not present at the level just below.

D. Properties of Life such as energy needed to perform work

E. All Characteristics of life depend on the DNA structure which is heritable information

F. There is a clear connection between form and function

An animal’s size and shape, features often called “body plans” or “designs,” are fundamental aspects of form and function that significantly affect the way an animal interacts with its environment. Tunas, sharks, penguins, dolphins, seals, and whales are all fast swimmers. All have the same basic form shape, tapered at both ends.

G. Regulation (regulatory mechanisms of the body) keeps the body in homeostasis

1. Negative feedback reduces the output of the system. A decrease in function in response to a stimulus. Example from the internet -

2. Positive feedback is the output quantity or signal adds to the input quantity or signal to get a response that is needed. Example from the internet -

H. Living organisms and their environment are interconnected.

Organisms respond to their environment by sweating or shivering.

Other examples -
I. Scientific Inquiry (scientific method see above)

J. Science, technology, and society

1. Bioinformatics

   a. BLAST: basic alignment search tool (see online)

   b. Other databases

      Human gene disorders

      http://www.ornl.gov/sci/techresources/Human_Genome/posters/chromosome/hfe.shtml

2. Research teams
I. Chemistry:

A. Properties of Elements

1. Element

2. Atoms

3. Molecule

4. Atomic Weight

5. Atomic Number

6. Isotope

7. Ions

B. Molecular Bonds and Forces

Chemical Bonds

1. Covalent bonds

2. Polar covalent bonds
3. Non-polar covalent bond

4. Ionic bond

Weak Bonds

5. Hydrogen bond

6. Van der Waals interactions

C. Properties of Water p. 48

1. Moderate Temperature

a. Celsius scale

D. Properties of acids and bases

E. Organic Molecules (organic chemistry-Yuck!!!)

1. Organic molecules contain carbon which is the backbone of biological molecules. Carbon is used in storage compounds and cell formation in all organisms.

2. All molecules that contain both carbon and hydrogen are hydrocarbons. Fats have hydrocarbon tails. The tails can be broken down to provide energy.

3. Functional groups are the parts of molecules involved in chemical reactions. See pages 64 & 65

F. Macromolecules are built from the movement of carbon from the environment to living organisms.

1. Macromolecules are giant molecules; the subcomponents of biological molecules and their sequence determine the properties of that molecule
   a. Most macromolecules are polymers built from monomers
   b. Dehydration or Condensation reaction
8: Hydrolysis

2. Examples of Macromolecules

   a. Carbohydrates are the fuel and building material of the body known as sugars
      1. Monosaccharide
      2. Disaccharide
      3. Polysaccharide

   b. Fats are not polymers but are large molecules formed by dehydration
      1. Glycerol
      2. Phospholipids
      3. Steroids

   c. Proteins have many structures resulting in a wide range of functions. The building blocks of proteins are amino acids. Polypeptides are the chains of amino acids held together by peptide bonds.

   Proteins have an amino (NH$_2$) end and a carboxyl (COOH) end, and consist of a linear sequence of amino acids connected by formation of peptide bonds by dehydration synthesis.
Protein shapes and folding:

1. Four levels of Protein structure

2. Denaturation and Renaturation of Proteins (Enzymes)

   ![Image of enzyme and substrate process]

   d. Nucleic Acids are DNA and RNA; nucleotides are monomers of DNA and RNA.
e. History of life that includes theories of how macromolecules joined to support the origin of life. Was RNA the 1st genetic material?

1. Primitive Earth provided inorganic molecules from which organic molecules could have been synthesized due to the presence of free energy and the absence of oxygen. These molecules served as monomers for the formation of more complex molecules including amino acid and nucleotides. Organic soup model (Primordial Soup) states that these complex reaction sets could have occurred in a solution or as a series of reactions.

2. The RNA world hypothesis describes an early Earth with self-replicating and catalytic RNA but no DNA or proteins. This has spurred scientists to try to determine if RNA molecules could have spontaneously formed that were capable of catalyzing their own replication. Early bacteria (prokaryote) would have followed. Mutually beneficial associations among bacteria would have given rise to eukaryotic cells.

3. A number of hypotheses of modes of formation have been put forward. Early cell membranes could have formed spontaneously from proteinoids, which are protein-like molecules produced when amino acid solutions are heated while in the correct concentration in aqueous solution.

4. The Earth formed approximately 4.6 billion years ago (bya). The Earth was too hostile for life until 3.5 bya which is supported by fossil evidence.

5. As new technological advances are developed, the Origin of the Earth hypothesizes have been reevaluated and revised.

http://ngm.nationalgeographic.com/2006/12/early-earth/appenzeller-text/1

Summary of National Geographic article:
I. Cell Theory and Components (P.94)

A. Comparison between Prokaryote and Eukaryote

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Eukaryote</th>
<th>Prokaryote</th>
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<tbody>
<tr>
<td>1. DNA</td>
<td></td>
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<tr>
<td>2. Nuclear Membrane</td>
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<tr>
<td>3. Membrane bound Organelles</td>
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<tr>
<td>4. ATP production</td>
<td></td>
<td></td>
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<tr>
<td>5. Reproduction</td>
<td></td>
<td></td>
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<tr>
<td>6. Cell Wall</td>
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<tr>
<td>7. Cytoskeleton</td>
<td></td>
<td></td>
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<tr>
<td>8. Flagella</td>
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</tbody>
</table>


1. Cell Wall (Google what organisms have a cell wall and what are they made of)
   Protective boundary around the cell
   a. 
   b. 
c.

2. Centrioles

3. Chloroplasts capture energy from the sun in plants and convert it into sugars; double membrane that compartmentalizes processes.

4. Cilia and Flagella are for movement using a 9 + 2 pattern (p.115)

5. Endoplasmic Reticulum is a double membrane organelle that compartmentalizes processes and aids in transport throughout the cell
   a. Rough ER contains ribosomes aids in protein synthesis
   b. Smooth ER doesn’t contain ribosomes aids in lipid synthesis

6. Golgi Body is a double membrane organelle that compartmentalizes processes and packages up materials for transport and production of lysosomes; it consist of a series of flattened sacs

7. Lysosome contain enzymes to digest food particles and worn out cell parts; aids in programmed cell death (apoptosis)

8. Peroxisome breaks down hydrogen peroxide

9. Cytoskeleton a network of structural proteins that strengthens the cell, maintains shape, facilitates movement, and organelle transport. This structural evidence supports the relatedness of all eukaryotes. Three types: (P.113)
   a. Microfilaments are the thinnest fibers
   b. Microtubules are the thickest fibers
   c. Intermediate filaments are the in-between fibers

10. Mitochondria breaks down glucose (sugar) and releases energy and has a double membrane; this supports the idea that all eukaryotes are related and descend from a common ancestor
The inner membrane is highly convoluted, forming folds called cristae which contain enzymes important to ATP production and functions to increase the surface area for ATP production.

11. Nucleus has a double membrane
   Controls cell activities and contains the hereditary material of the cell
   a. Nucleolus
   b. ER carries material through the cell and aids in making proteins

12. Ribosomes synthesize proteins.

13. Vacuoles

14. Vesicles are transport containers attached to the Golgi complex.

C. Mitochondria and Chloroplasts change energy from one form to another.

1. These organelles are semiautonomous organelles that grow and reproduce within the cell.
2. They both contain a small amount of DNA and were thought to have evolved independently. They were eventually integrated into a eukaryotic cell (endosymbiotic theory).
3. In animals, mitochondrial DNA is transmitted by the egg so that they are maternally inherited. These organelles are an exception to simple Mendelian rules.

The Seven Daughters of Eve (2001, ISBN 0-393-02018-5) is a book by Bryan Sykes that presents the theory of human mitochondrial genetics to a general audience. Sykes explains the principles of genetics and human evolution, the particularities of mitochondrial DNA, and analyses of ancient DNA to genetically link modern humans to prehistoric ancestors.
D. Cell Connections: (P.120&121)

1. Plants: Plasmodesmata between plant cells allow material to be transported from cell to cell.

2. Animals: Tight Junctions

3. Animals: Desmosomes

4. Animals: Gap Junctions is used for communications between cells.
   a. Cells communicate with each other through direct contact with other cells or from a distance via chemical signaling.
   b. Immune cells interact by cell-cell contact, antigen-presenting cells (APCs), helper T-cells and killer T-cells. Google images of killer cells.
   c. Cells communicate over short distances by using local regulators that target cells in the vicinity of the emitting cell. What is a neurotransmitter?
   d. Signals released by one cell type can travel long distances to target cells of another cell type. Endocrine cells release signaling molecules that travel through the blood to all parts of the body. How does insulin work?
II. Cell Membranes separate the internal environment of the cell from the external environment.

A. Membrane Structure based on the Fluid Mosaic Model

1. Selective permeability is a direct consequence of membrane structure, as described by the fluid mosaic model.


3. Phospholipids give the membrane both hydrophilic and hydrophobic properties. Draw the phospholipid man!!

   a. The hydrophilic phosphate portion

   b. The hydrophobic fatty acid portion

4. Small, uncharged polar molecules and small nonpolar molecules, such as N₂, freely pass across the membrane. Hydrophilic substances such as large polar molecules and ions move across the membrane through embedded channel and transport proteins. Water moves across membranes and through channel proteins called ______________.

5. The plasma membrane, cytoplasm and the organelles contribute to the overall specialization and functioning of the cell.

B. Transport

1. Passive transport does not require the input of __________; the movement of molecules is from high concentration to low concentration.

   a. Passive transport plays a primary role in the import of resources and the export of wastes.

   b. Membrane proteins play a role in facilitated diffusion (transport with a helper) of charged and polar molecules through a membrane. Example molecule:
c. External environment can be hypotonic, hypertonic or isotonic to internal environment of cells.

1. Hypotonic solution: “hypo” means

2. Hypertonic solution: “hyper” means

3. Isotonic solution: “iso” means
2. Active Transport is a process where free energy (ATP) is used by proteins embedded in the membrane to “move” molecules and/or ions across the membrane and to maintain concentration gradient.

a. Membrane proteins are necessary for active transport.

b. Exocytosis is the process of secretion of large molecules out of the cell.

c. Endocytosis is the process of the cell taking in molecules by forming new vesicles that come from the plasma membrane.

III. Cellular processes and Enzymes

A. Chemical Reactions (P. 145)

1. Metabolism as a whole manages the energy resources of the cell. (P.142)

a. Catabolic pathways

b. Anabolic pathways

2. Life requires a highly ordered system and is maintained by constant free energy input into the system. Increased disorder or entropy is offset by biological processes that maintain or increase order.

3. Order is maintained by putting together cellular processes that increase entropy with those that decrease entropy. Entropy is the inability to convert free energy into usable work.

4. Energy input must exceed free energy lost to entropy to maintain order and to power cellular processes.

5. Energetically favorable exergonic reactions such as ATP -> ADP, have a negative change in free energy can be used to maintain or increase order in a system by being put together with reactions that have a positive free energy change. Enthalpy -

a. Exergonic reactions (P.146)

b. Endergonic reactions (P.146)
B. Enzymes speed up metabolic reactions by lowering energy barriers.

1. Catalyst

2. Enzymes lower the activation energy needed to run the reaction.

3. Substrate
   
   a. Active Site

   b. Induced fit

   c. Cofactors are nonprotein helpers for catalytic activity and can be bound permanently to the enzyme.
d. Coenzymes are cofactors that are organic molecules. Most vitamins are coenzymes.

e. Inhibitors are chemicals that stop or inhibit the action of specific enzymes. They may reduce the productivity of enzymes by blocking substrates from entering the active site. They can be competitive inhibitors or noncompetitive inhibitors.

Video and information on Enzymes:

http://students.cis.uab.edu/clight/finalprojectwhatisanenzyme.html

What is the medical problem associated with lactose intolerance and how is it related to enzymes? Read the article below and answer the question.

http://science.howstuffworks.com/environmental/life/cellular-microscopic/cell2.htm
A. ATP structure and function

1. ATP is a high energy storing molecule.
2. Adenosine triphosphate transports chemical energy within cells for metabolism.
3. The molecule contains three phosphorous groups that are connected by oxygen molecules to each other, and there are also side oxygen molecules connected to the phosphorous atoms.

B. **Cellular Respiration** is the most prevalent and efficient catabolic pathway.

1. C.R. in eukaryotes involves a series of coordinated enzyme-catalyzed reactions that harvest free energy from simple carbohydrates.
2. C₆H₁₂O₆ + 6O₂ --> 6CO₂ + 6H₂O + energy: write out in words the equation for cellular respiration –
3. C.R. is a redox reaction (oxidation-reduction reaction) in which the transfer of electrons releases energy stored in organic molecules (glucose). Oxidation is the loss of electrons from one substance and reduction is the addition of electrons to another substance.
4. The three Stages of Cellular Respiration:
a. Glycolysis occurs in the ________________. Glucose is added and is rearranged releasing a minor amount of ATP from ADP. A byproduct called Pyruvate is formed.

1. Pyruvate is transported from the cytoplasm to the mitochondrion where further oxidation occurs. This is known as Pre-Krebs.

2. Glycolysis produces 4 ATP but only nets _________ ATP. Substrate level phosphorylation occurs. This is the production of ATP from the donation of a phosphate group to ADP. (P. 165)

b. Krebs cycle occurs in the ________________. Carbon dioxide is released from organic intermediates. ATP is synthesized from ADP which is substrate level phosphorylation.

1. Electrons are captured by coenzymes.

2. Electrons that are extracted in the Krebs cycle are carried by NADH and FADH$_2$ which are coenzymes.

c. Electron Transport Chain captures free energy from ______________ in a series of coupled reactions that establish an electrochemical gradient across membranes.

1. ETC occurs in the _______________________.

2. Electrons delivered by FADH and FADH$_2$ are passed to a series of electron acceptors as they move toward the final electron acceptor _______________. This will produce water.

3. The passage of electrons is accompanied by the formation of a proton gradient across the inner mitochondrial membrane.

4. The flow of protons back through membrane-bound ATP synthase (P.171) by chemiosmosis generates ATP from ADP and inorganic phosphate.

5. 34 to 36 ATP is produced in this final process which is oxidative phosphorylation. Total produced per glucose molecule is 36 to 38 ATP. (P.172)

C. Fermentation produces organic molecules, including alcohol and lactic acid; and it occurs in the absence of ______________.

1. Fermentation occurs outside the mitochondria in the ________________.
2. Fermentation (anaerobic respiration) produces less ATP - usually 2 per glucose molecule - than aerobic cellular respiration.

http://www.sumanasinc.com/webcontent/animations/content/cellularrespiration.html

D. **Photosynthesis** converts light energy to the chemical energy of food.

1. \(6\text{CO}_2 + 6 \text{H}_2\text{O} + \text{light energy} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 + 6\text{H}_2\text{O}\) – write the equation out in word form:

2. Photosynthetic organisms capture free energy present in sunlight. Photosynthesis first evolved in prokaryotic organisms; scientific evidence supports prokaryotic (bacterial) photosynthesis was responsible for the production of an oxygenated atmosphere.

3. During photosynthesis, chlorophyll molecules absorb free energy from light, boosting electrons to a higher energy level. The part of the spectrum we can see – visible light – drives photosynthesis.

4. Two stages of Photosynthesis:

   a. Light-dependent Reactions involves a series of coordinated reaction pathways that capture free energy present in light to produce ATP and NADPH (electron carrier).

      1. L.R. occurs in the __________________________. Draw a picture (P.185)

2. Light Reactions has two parts: Photosystems I and Photosystems II that are embedded in the internal membranes of the chloroplasts (thylakoids).

   a. Photosystems II (P680) light gathering unit at the _________ wavelength. Light strikes and splits water which releases excited electrons. Each excited electron passes from PSI to PSII on an electron carrier down the electron transport chain. Oxygen is given off.

   b. Photosystems I (P700) light gathering unit at the _________ wavelength. The 2nd set of Pigments absorbs best at this wavelength. Electrons are excited to another level.

   c. The formation of the proton gradient is a separate process, but it is linked to the synthesis of ATP from ADP in the membrane of the Chloroplast. Photophosphorylation is the creation of ATP from light.

   d. Highly energized molecules, ATP and NADPH (final electron acceptor), move into the Calvin Cycle with energy to power the cycle.

3. Calvin Cycle (light independent cycle) uses ATP and NADPH to convert CO₂ into sugar.

   a. Calvin Cycle occurs in the ________________.
b. To make one molecule of glucose, the cycle turns six times.

E. Alternate forms of Photosynthesis have evolved in hot, arid climates.
   
   1. C₄ plants are so named because they use an alternate mode of carbon fixation that forms a four-carbon compound as its first product instead of a three carbon compound. Traditional photosynthesis would be C₃ plants. C₄ plants use spatial separation by utilizing two different cells for the process instead of one. (P.197)

   2. CAM plants utilize temporal separation which allows the stomata to be closed during the day and open at night.

http://www.sciencedaily.com/releases/2012/04/120412105430.htm

Discuss the latest breakthrough with photosynthesis as stated in the article above.
In Eukaryotes, heritable information is passed to the next generation via processes that include the cell cycle and mitosis or meiosis plus fertilization.

I. Cell Cycle: It is a complex set of stages that is highly regulated with checkpoints, which determine the ultimate fate of the cell. (Page 219) IPMAT-C

Chromosomes

Somatic Cells

Chromatin

Sister Chromatid

Centromere

Mitosis

Cytokinesis

Meiosis
A. Interphase consist of three phases:

1. ________________________________

2. ________________________________

3. ________________________________

B. Mitosis (PMAT) – It plays a role in growth, repair, and asexual reproduction

1. Prophase: The chromatin become visible chromosomes, the nucleoli disappear, duplicated chromosomes become sister chromatids joined together; mitotic spindles begin to form; ______________ appear.

   Centrosome

   Aster

2. Metaphase: the Kinetochore microtubules of the spindle fibers attach to the Centromere and move the chromosomes to the middle on the ___________ plate.
3. Anaphase: the two sister chromatids of each pair pull apart and become full-fledged ___________________; the chromosomes move the opposite poles.

4. Telophase: two daughter nuclei begin to form in the cell; ______________ envelope reappears; the chromosomes become less visible.

5. Cytokinesis is the division of the cytoplasm; in animal cells – cleavage furrow causes the cell to pinch apart; in plant cells – the cell slices apart.

6. Result of Mitosis: the production of two genetically identical daughter cells.
   
   a. Asexual reproduction
   
   b. Binary fission
7. Control of the cell cycle: The regulatory molecules are proteins of two main types – kinases and cyclins. Protein kinases are enzymes that activate or inactivate proteins that give the go-ahead signals at checkpoints such as; the G1 and G2 checkpoints. G0 is the nondividing phase of the cell. Cyclin is a protein that deals with cyclically fluctuations of the cell. Some Kinases must be attached to a cyclin to become active – cyclin dependant kinases (Cdks).

8. Loss of Cell Cycle control results in cancer cells,
   a. Cancer cells do not heed the normal signals that regulate the cell cycle.
   b. Cancer cells either fail to stop dividing or do so at irregular check points.
   c. The cancer cell may form a lump known as tumor; if it is easily dealt with it is a benign tumor; if it is invasive and affects the functions of organs it is known as a malignant tumor.

C. Meiosis, a reduction division, followed by fertilization ensures genetic diversity in sexually reproducing organisms.

Genes

Gametes

Locus

Homologous Chromosomes

Sex Chromosomes

Autosomes

Diploid cell
Haploid cell

1. Meiosis reduces the number of chromosome sets from diploid to haploid
   
a. Meiosis I

b. Meiosis II

2. Fertilization is the fusion of gametes that results in a zygote. (Sexual Reproduction)
   
a. Genetic variation produced in sexual life cycles contributes to evolution.

b. Independent Assortment of Chromosomes occurs during metaphase of Meiosis I; the homologous pairs consisting of one maternal and one paternal chromosome are on the metaphase plate; a “random” chance of receiving either is possible.

c. Crossing Over
II. Differences between Mitosis and Meiosis

<table>
<thead>
<tr>
<th>Property</th>
<th>Mitosis</th>
<th>Meiosis</th>
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<tbody>
<tr>
<td>DNA Replication</td>
<td></td>
<td></td>
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<tr>
<td>Number of Divisions</td>
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<tr>
<td>Synapsis of Homologous Chromosomes</td>
<td></td>
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<td>Number of daughter Cells</td>
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<tr>
<td>Role in the animal body</td>
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</table>
A. Mendelian Genetics

1. Rules of __________________ can be applied to analyze passage of single gene traits from parent to offspring.

2. Each variant for a character, such as purple or white color for flowers is called a ________________.

3. Mendel started his experiments with varieties that were true-breeding. When true-breeding plants self-pollinate, all their offspring are of the same variety.

4. The wild type is the organism that is found in nature. The opposite would be the mutant type.

5. Mendel crossbred two different phenotypes. He crossed (mated) two true-breeding varieties of an organism. Mendel crossed pea plants that varied in flower color. Purple vs. White.
   a. Phenotype
   b. Genotype

6. F1 Generation results

7. F2 Generation results

B. Mendel’s Experiment

1. Genes control traits in pairs.
   a. Alleles
   b. Genes on a chromosome (drawing) Page 255
   a. Dominant
   
   b. Recessive
   
   c. Homozygous
   
   d. Heterozygous

3. Law of Segregation states that the two alleles for a gene separate during gamete formation. This law deals with one trait such as flower color. (Page 255) Include the punnett square.

   a. Punnett Square is a device for predicting the allele composition of offspring from a cross between individuals of known genetic makeup.
   
   b. Monohybrid Cross is a punnett square involving only one trait.
   
   c. Test Cross is the breeding of a recessive homozygote with an organism of dominant phenotype but unknown genotype. Example:

4. Law of Independent Assortment follows two traits at the same time. For example seed color and seed shape. These traits assort out independent of each other. They do not travel on the same chromosome.
a. Dihybrid Cross is a punnett square that crosses two traits.

b. Typical results (Page 257)

C. Inheritance Patterns can often be predicted from data that gives the parent genotype/phenotype and/or the offspring genotype/phenotype.

1. Codominance states that the two alleles both affect the phenotype equally. Example from online:

2. Incomplete dominance states that neither allele is completely dominant and falls in the middle of the spectrum of dominance. Example from textbook page 260

3. Multiple Alleles, such as the ABO blood type, demonstrate more than two alleles for a given trait. See page 262, do punnett square example

4. Epistasis, a gene at one locus alters the phenotypic expression of gene at a second locus. Example in mice page 262.

Does Michael Phelps have Marfan’s syndrome? Could this genetic disorder have had an impact on his swimming success?

6. Polygenetic Inheritance (converse of Pleiotropy) many genes are needed to express one trait. Example human skin color in which many genes are needed to determine.

D. Pedigree Analysis is a collection of family history for a particular trait that is assembled on a family tree. (page 265)

1. Dominant disorder
   a. Achondroplasia, form of dwarfism, is caused by a dominant allele.

   b. Huntington’s disorder (268)

2. Recessive disorder
   a. Cystic fibrosis strikes one in every 2,500 people of European descent. Children that receive two recessive alleles for cystic fibrosis experience excessive mucus build up in the lungs. If untreated, most children die before the age of five.

   b. Sickle- cell disease (267) - the most common inherited disorder among African-Americans.
c. Consanguineous (page 267) - close relatives mating increases the chance of a recessive disorder.

E. Gene Linkage: linked genes tend to be inherited together because they are located near each other on the same chromosome. Example: Freckles and Red hair

1. Morgan’s fruit flies - (page 279) - Are the genes for body color and wing size in fruit flies located on the same chromosome?

2. Linkage Mapping (page 281) – a linkage map shows the relative ________________ of genes along a chromosome.

F. Sex Linkage: Sex-linked genes exhibit unique patterns of inheritance. Sex-linked genes reside on sex chromosome (X in humans). Very few traits reside on the Y chromosome.

1. In fruit flies, white-eye color tends to be a male trait. Female fruit flies have red-eyes. Morgan observed this pattern of inheritance for eye-color locus in Drosophila. Fathers pass sex-linked traits to their daughters. Mothers pass to both sons and daughters.

2. Colorblindness (283)

3. Duchenne Muscular Dystrophy

4. Hemophilia
5. X Inactivation in Female Mammals (284)

G. Alterations of Chromosome can cause genetic disorders

1. Nondisjunction in which the members of a pair of homologous chromosomes do not move apart properly during meiosis II.

   a. Aneuploidy, an organism will have an abnormal number of chromosomes.

      Example: Trisomic, when a chromosome is present in triplicate

      1. Down syndrome (287)

2. Klinefelter syndrome (sex chromosomes) – These people have male sex organs, but the testes are abnormally small and the man is sterile. This is a result of an extra X chromosome in males. (XXY)

   Example: Monosomic

   1. Turner syndrome (sex chromosomes) – females with only one X chromosome (XO). These females are sterile. Most have normal intelligence.

   b. Polyploidy are organisms with more than two complete chromosome sets. This is common in plants and produces healthy plants.

2. Duplication (Page 286)

3. Deletion (*cri du chat*)

4. Inversion
5. Translocation

Unit Six – Molecular Genetics: Outline pages 37 - 41; Textbook Chapter 16 & 17

A. DNA is the genetic material. Genetic information is transmitted from one generation to the next through DNA or RNA.

1. Morgan’s group showed that genes are located on chromosomes; the two chemical components of chromosomes – DNA and protein – became the candidates for genetic material.

2. Frederick Griffith, 1928, introduced the idea of transformation with bacteria. Transformation would support DNA as the genetic material.

3. Oswald Avery, 1944, his group was the first to announce that the transforming agent is DNA. Many scientists were still skeptical about “DNA”.

4. Hershey and Chase, 1952, used radioactive _____________ and _____________ to trace the fates of protein and DNA – with T2 phages infected bacteria cells. They concluded the DNA of the virus is injected into the host cell during infection, leaving the protein outside.

   a. Bacteriophage (bacteria-eaters) or just phages are the combination of viruses that infect bacteria and are used as tools by researchers in molecular genetics.
B. DNA structure – a **double helix**

1. Rosalind Franklin’s X-ray diffraction photo was used by _____________ and _____________ to identify and name the double helical structure. Franklin worked with Wilkins who received the Nobel Prize in 1962. Franklin died of cancer in 1958 due to the X-ray process.

2. The building blocks of DNA are _________________. The monomer consist of a nitrogenous base (T, A, C, G), the sugar deoxyribose, and a ________________ group. (Page 296)

3. The backbone of DNA (sides)

   a. Deoxyribose sugar

   b. Phosphate

4. The rungs of the DNA ladder (middle steps)

   a. Purines (double ring)

      Adenine (A)

      Guanine (G)

   b. Pyrimidines (single ring)
Thymine (T)

Cytosine (C)

c. Hydrogen bonding between bases. Base pairing rules according to Chargaff.

d. AGGTTAC pairs with ________________.

5. Backbone is Anti-parallel (297) & (88,89)

a. 5’ end is phosphate end

b. 3’ end is sugar end

*Draw and label a DNA example
C. DNA replication ensures continuity of hereditary information. Replication occurs during

Replication is needed so that the new cell gets a copy of the DNA from the old cell.

1. **Replication** is a semi-conservative process; one strand serves as the template for a new, complementary strand.
   a. Leading strand (302)
   b. Lagging strand (302)

   Okazaki fragments -

2. Replication requires enzymes to complete the process.
   a. DNA polymerase promotes the ________________ of new DNA. Polymerase adds new nucleotides to the growing strand.
   
   b. Ligase is the enzyme that joins the 3’ end of the DNA that replaces the primer to the rest of the leading strand.
   
   c. Helicase _____________ the double helix at the replication forks.
   
   d. Topoisomerase corrects _________________ ahead of replication forks by breaking, swiveling, and rejoining DNA strands.

Summary:
D. **Transcription** is the DNA directed synthesis of RNA. Genetic information is copied from DNA onto RNA; so that the gene can actually be expressed. Transcription occurs in the __________________________. DNA --> RNA

1. RNA Characteristic
   
a. Sugar is ribose
   
b. Base is ________________ instead of Thymine
   
c. RNA is ________________-stranded.

2. Types of RNA
   
a. mRNA carries ________________ from the DNA to the ribosome in the nucleus.
   
b. rRNA are functional building blocks of ________________.
   
c. tRNA bind specific amino acids and allow information in the mRNA to be translated to a peptide sequence.
3. Steps of Transcription

a. Initiation

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.

b. Elongation

The RNA strand develops (elongates) until the entire gene is copied onto the mRNA. RNA splicing (snRNPs) – the splitting of the RNA into segments to exclude introns – noncoding segments. Only exons remain which are the coding sections.

c. Termination

The strand terminates when the selected gene has been successfully copied.

d. Eukaryotic cells modify RNA after transcription. Enzymes modify the two ends of a eukaryotic mRNA molecule. The modified ends may promote the export of mRNA from the nucleus and help protect it. Addition of a __________ cap and a __________________ ________ (317)

4. Genetic code exists in a triplet code. A set of three letters that are transcribed from DNA and then translated into an actual trait.

a. Codon is the mRNA triplet code that corresponds with a particular amino acid on the genetic code chart page 314. AUG – start codon. The mRNA interacts with rRNA of the ribosome to initiate translation at the (start) codon.

b. Anticodon is the tRNA triplet code that corresponds with codon. AUG would pair with what ________________.
c. The genetic code is nearly universal. The RNA codon CCC is translated as the amino acid _________________ in all organisms.

d. Genetic code practice -

E. Translation is the RNA-directed synthesis of a polypeptide. As a molecule of mRNA moves through a ribosome, codons are translated into amino acids. Translation occurs in the _________________ . RNA --> Protein

a. The mRNA interacts with the rRNA of the ribosome to initiate translation at the (start) codon. (initiation)

b. tRNA brings the correct amino acid to the correct place on the mRNA. The amino acid is transferred to the growing peptide chain (elongation)

c. The process continues along the mRNA until a ____________codon is reached. (termination) The process terminates by release of the newly synthesized peptide/protein.

d. Phenotypes (what you look like) are determined through protein activities. Example: protein synthesis

Article on DNA mutations:

http://evolution.berkeley.edu/evolibrary/article/0_0_0/mutations_06
I. The Genetics of Viruses and Bacteria (334)

A. Virus has a genome but can reproduce only within a host cell

What is a virus?

1. Structure of Viruses

   a. Capsid

   b. Envelopes

2. Reproductive Cycles; viruses replicate via a component assembly model allowing one virus to produce many replicas rapidly. Virus replication allows for mutations to occur.
DNA virus

RNA virus

a. Lytic cycle

b. Lysogenic cycle

3. Examples

a. HIV – retroviruses

4. Emerging Viruses
5. Viroids and Prions:

B. Bacteria (346)

What is a bacterium?

C. Structure

1. Plasmids

2. Nucleoid

D. Reproduction

1. Binary fission
2. Conjugation

E. Genetic variation

1. Transduction

2. Transformation

3. Transposable elements

4. Mutations
II. Regulation of gene expression (353)

A. Operons – 4 components

What is an operon?

1. Repressor protein

2. Promoter region

3. Operator region

4. Structural region
Two types of Negative Gene Regulation: Repressible and Inducible Operon

B. The lac operon in E. coli (Inducible operon)
Example:

C. The \textit{trp} operon (Repressible Operon)

Example:

III. DNA technology

A. Recombinant DNA and Gene Cloning

1. Genetic engineering
Example:

2. Biotechnology

Example:

3. DNA cloning

Example:

4. Restriction enzyme

Example:

5. Sticky ends
6. Blunt ends

7. Ligase

PCR

Gel Electrophoresis

Recombining DNA
IV. Mutations (328)

A. Point Mutations

Example: Substitution

1. Missense substitutions

2. Nonsense substitutions

B. Insertions
C. Deletions

Example: Frameshift mutation

V. Ethical issues

A. Human Genome Project
B. Medical Applications

1. Diagnosis of disease
   
a. Stem cell research

2. Human Gene Therapy

3. Forensic Evidence
Example: DNA fingerprint

4. Genetically modified organisms

Case studies used as example of ethical dilemmas
Unit eight – Evolution: Outline pages 52 - 59; Textbook Chapters 22-25

I. Early Concepts of Evolution

A. Fossils

1. Paleontology is the study of fossils.

2. Cuvier (1769-1832) developed the idea of paleontology.

3. Catastrophism states that each boundary between strata represents a

______________________

B. Gradualism – slow changes over time.

Example: Uniformitarianism - Lyell and Hutton’s idea that geologic processes
are operating today as in the past, and at the same _________________. These
processes occur at a slow rate.

C. Lamarck’s theory of Evolution (1744-1829)

1. Use and disuse principle which is the idea that parts of the body that are used
extensively become larger and stronger, while those not used
________________________.

2. Inheritance of acquired characteristics principle states that an organism could
pass these modifications to its offspring. Example: giraffe stretching his neck
II. Darwin’s view of life: Descent with Modification (1809-1882)

A. Voyage of the Beagle (1831)

B. The Origin of Species – Darwin’s book that stresses two main points.

1. Descent with Modification – a phrase that summarized Darwin’s view of life.

Darwin perceived **unity in life**, with all organisms related through descent from an ancestor that lived in the remote past.

   a. The history of life is like a tree; a common trunk, multiple branches, young twigs represent ______________. 

   b. Evolutionary tree of the elephants is based on fossils. (444)

2. Natural Selection states that competition for limited resources results in ______________ survival. Individual with more favorable traits are more likely to survive and produce offspring. Evolutionary ______________ is measured by reproductive success.

C. Evidence for Evolution
1. Comparative Anatomy – **homology** which is similarities in organisms resulting from a common ancestor.

   a. Homologous structures such as arms, forelegs, flippers, and wings of different mammals have similar bone structures that are adapted for different ________________.

   b. Vestigial structures are remnants of structures that served important functions in the organism’s ancestors. Example: skeletons of some snakes retain “leftover” pelvis and leg bones from walking ancestors.

2. Biogeography states that closely related species tend to be found in the same ________________ region.

3. The Fossil Record – the oldest known fossils are prokaryotes which are consistent with other data.

4. Comparative Embryology – Scientists compare embryos of organisms and can detect a common ancestor.

5. Molecular Biology – Biologists observe similarities among organisms at the molecular level and compare it to other organisms to establish common descent.
III. Population genetics provides a foundation for studying evolution. It is the study of how populations change genetically over time. Population is a group of individuals that are capable interbreeding and producing ________________ offspring. (454)

Example: Microevolution

Macroevolution

A. Gene pool consists of all the ________________ in a population at any one time.

B. The Hardy-Weinberg Theorem named for the two scientists who independently derived the principle in 1908. (456)

1. Hardy-Weinberg equilibrium principle states

2. Equation for Hardy-Weinberg equilibrium

3. Conditions for Hardy-Weinberg Equilibrium
a. Large ________________ size

b. No_______________________

c. No_______________________

d. Random ________________

e. No ______________________

4. Practice Problems for Hardy – Weinberg

a. Mader practice problems


C. Causes for Changes in Genetic Equilibrium

1. Natural Selection
a. Production of more individuals than the environment can support leads to a struggle for existence among individual of a population.

b. Survival depends on inherited traits which allow the organism to reproduce. These organisms have a higher fitness rate and are likely to leave more offspring than less fit individuals.

c. This unequal ability to survive and reproduce will lead to gradual change in a population.

2. Mutations are the cause of new _____________ and alleles originating in an organism. Mutations are the source of all heritable variation. They can alter gene numbers or sequence.

3. Gene Flow is the loss or gain of alleles in a population. This results from the movement of fertile individuals or gametes.

4. Genetic Drift is fluctuations or deviations of alleles within the population.

a. Founder effect is when a few individuals become isolated from a larger population. Example –

b. Bottleneck effect is a sudden change in the environment, such as ___________ or ___________ that may drastically reduce the size of a population.

D. Modes of Selection: Natural selection can alter the frequency distribution of heritable traits in three ways.
1. Directional selection is most common when a population’s environment changes; it shifts the overall makeup of the population by favoring variants at one extreme of the distribution. See book example (465)

2. Disruptive Selection will favor variants at both ends of the distribution. See book example (465)

3. Stabilizing Selection removes the extreme variants from population and preserves intermediate types. See book example (465)

4. Sexual Selection is natural selection for _____________ success. (468)
   
   a. Sexual dimorphism is marked differences between the sexes in secondary sexual characteristics which are directly associated with reproduction; such as: size, color, and ornamentation.

   b. Intrasexual selection is selection “within the same sex”.

   c. Intersexual selection is usually most obvious in males.

5. Artificial selection (445) – “selective breeding” Darwin derived part of his theory on human modification of organisms. Scientist pass desirable traits down to the next generation.
IV. Reproductive Barriers (473)

A. **Reproductive isolation** is the existence of biological factors (barriers) that impede members of two species from producing fertile.

1. Prezygotic barriers
   a. Habitat isolation - textbook ex.
   b. Temporal isolation - textbook ex.

2. Postzygotic barriers
   a. Gametic isolation textbook ex.
   b. Reduced Hybrid viability textbook ex.
   c. Reduced Hybrid fertility textbook ex.
B. Patterns of Speciation – the two main modes in which new species form.

1. Allopatric (“other country”) Speciation

   Online example –

2. Sympatric (“same country”) speciation

   Online example –

C. Phylogeny is the evolutionary _____________ of a species or group of species. It is based on common ancestries inferred from fossils, morphological (body structure), and molecular evidence (DNA and RNA). (495)

   1. Phylogenetic systematic connects classification with evolutionary history. (497)

   a. Taxonomy is an ordered division of organisms into categories based on a set of characteristics used to assess similarities and differences.

   b. Binomial Nomenclature is a two-name naming system.
Hierarchical Classification uses K, P, C, F, G, and S to set up the categories.

Phylogenetic trees are based on Phylogenetic systematic that include shared characteristics.

Cladistics is the analysis of how species and all its descendants.

Monophyletic “single tribe”; it consist of the ancestral species and all its descendants.

Paraphyletic groupings consist of an ancestral species and some of its descendants.

Polyphyletic groupings consist of several species that lack a common ancestor.

Cladogram is a pattern of shared characteristics depicted in a diagram.

Example: Simple vertical cladogram with the common ancestor at the bottom.
Example: Simple horizontal cladogram with common ancestor to the left.

-beetles-
-wasps, bees, ants-
-butterflies, moths-
-flies-

Appendix
AP Biology Activities & Handouts