Montgomery County Community College
BIO 121H
General Biology I: Honors
4-3-3

COURSE DESCRIPTION:
A study of the unifying principles which govern the operation of all living things; including biological chemistry, energy, metabolism, cell biology and genetics. This course is designed for allied health science majors, biotechnology, A.A.S. majors and other students desiring or requiring this course, a BIO 121/122 sequence or progression to BIO 151. This course is subject to a course fee. Refer to http://mc3.edu/adm-finaid/paying/tuition/course-fees for current rates.

This Honors course fosters high-achieving students' growth towards learning outcomes such as: problem solving, often with creative approaches; critical reading or original data analysis; forming judgments based on evidence, often from integrative learning; oral presentation; and articulate reflection on personal growth. Honors courses are more likely to utilize student-driven active learning, emphasizing exploration and discovery, rather than the acquisition of specific knowledge; faculty might provide projects with no pre-determined conclusion, but with real-world application.

Students taking this course anticipate going on to: BIO 122, 131, 140 and/or 151. Please see the MCCC catalogue for descriptions of the above continuing courses.

REQUISITES:
Previous Course Requirements
- ENG 011 Basic Writing II
- REA 011 Fundamentals of College Reading

Concurrent Course Requirements
- MAT 090 - Fundamentals of Algebra, or MAT 011 - Beginning Algebra, or MAT 011B - Beginning Algebra with Review of Arithmetic with a minimum grade of C within 5 years. May be taken prior or during course.
- Approval of Honors Coordinator required.

LEARNING OUTCOMES Upon successful completion of this course, the student will be able to:	LEARNING ACTIVITIES	EVALUATION METHODS
1. Evaluate role of science in western and world society.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays

LEARNING OUTCOMES	LEARNING ACTIVITIES	EVALUATION METHODS
2. Analyze the concept of evolution by natural selection and the degree of its acceptance by the scientific community.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
3. Discuss the impact of scientific and biological discoveries on society.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
4. Explain the relationship of atoms, ions, molecules within the living and nonliving universe.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
5. Discuss the scope, breadth, and interrelatedness of life on earth.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
6. Explain the crucial role of water in biological and nonbiological systems.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
7. Analyze the role of cells in organisms and what is unique about the cellular level of biological organization.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
8. Analyze the basic processes of all cells and living organisms.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
9. Analyze the distinctiveness of prokaryotic cells and their incredible importance to the biosphere.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays

LEARNING OUTCOMES	LEARNING ACTIVITIES	EVALUATION METHODS
10. Apply the scientific method and critical thinking skills to biological and scientific problems.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
LEARNING OUTCOMES	LEARNING ACTIVITIES	EVALUATION METHODS
11. Analyze a complex process to determine the main idea and make connections across concepts in biology.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
12. Demonstrate the ability to set up and utilize basic laboratory apparatuses to perform microscopy, chromatography and carry out basic experiments.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays
13. Support opinions concerning contemporary biological issues utilizing relevant resources.	Lectures Class Discussions Field Trips Class Presentations	Laboratory Exercises and Reports Quizzes and Exams Essays

At the conclusion of each semester/session, assessment of the learning outcomes will be completed by course faculty using the listed evaluation method(s). Aggregated results will be submitted to the Associate Vice President of Academic Affairs. The benchmark for each learning outcome is that *70% of students will meet or exceed outcome criteria*.

SEQUENCE OF TOPICS:

1. THE NATURE OF SCIENCE

I. Introduction to Science

- A. Discuss the idea of science as a process of gaining information: include the strengths and limitations of this process.
- B. Briefly describe Science in the 20th century and in historical context including Greeks and Romans.
- C. Compare science and the scientific method with other ways of gaining information such as intuition, authority and experience. Include hypotheses, experiments, theories, principles and facts.
- D. Discuss how science differs from political science, history, art, religion.
- E. Describe the relationships between science and technology.

II. Characteristics of Biology as a Science

A. Define the breadth and scope of biology; i.e., biochemistry, botany, bioinformatics.
B. Explain what is meant by “the unity of life” in the context to the levels of organization from atomic, cellular and ecological. Introduce the ecological terms: autotroph, heterotroph, consumer, decomposer, herbivore, carnivore, omnivore and their interdependence.
C. Explain what is meant by the diversity of life. Introduce the hierarchical classification system and the use of binomial nomenclature.
D. List, define and give examples for the characteristics of living things. Define homeostasis, metabolism, catabolism, anabolism, responsiveness, mutation, adaptation, reproduction, growth.

III. Evolution by Natural Selection
A. Explain the historical context, include fixity of species.
B. Discuss Darwin’s contributions: Theory of Evolution by Natural Selection.
1. His proposed mechanism for evolution: “Natural Selection” and his published body of evidence for evolution in Origin of Species. Use the definitions: Darwinian: “descent with modification” and the modern synthesis with genetics: “change in allele frequency in a population over time.” Reminder: populations evolve, not individuals
2. Contrast with earlier Lamarckian “inheritance of acquired characteristics”
C. Identify the Requirements of Natural Selection:
1. Phenotypic variation: importance of environmental vs. genetic determination of phenotype
2. Variation with genetic basis, “heritable”
3. Differential fitness of the variants
Define fitness: proportional genetic contribution to the next generation
4. Identify that differences in individual reproductive success leads to greater “adaptation” of a population to its environment D. List the Origins of genetic variation in a population:
1. Ultimately, all originates from mutations (random, not arising in response to “need”)
2. Sexual recombination
a. independent assortment in gamete formation
b. crossing over
c. new allele combinations resulting from sexual fertilization
d. larger-scale mutations, e.g., chromosome duplications, polyploidy
E. Discuss the major lines of evidence which support the principle/theory of evolution.
Include: comparative anatomy (homologous vs. analogous characters), biogeography, fossil record, molecular biology (e.g., amino acid and nucleotide sequencing, ubiquity of genetic code and fundamental biochemical

pathways) embryology and development. F. Discuss the controversies surrounding evolution.

2. CHEMISTRY

I. Atomic and Molecular Structure

A. Describe the nature of the atom with regard to size and arrangement of subatomic particles comparing and contrasting the Bohr model and the contemporary/quantum model.

B. Define, give example and uses for isotopes.

C. Discuss the nature of chemical reactions, include the collision theory. Explain the physical factors affecting reactions such as temperature, pressure, concentration.

D. Explain the importance of and formation of ions and ionic bonds. Include definitions of oxidation and reduction, anion and cation. Give examples. E. Explain the formation of molecules.

F. Compare and contrast ionic, covalent (polar covalent, non-polar covalent) and hydrogen bonds. Explain the biological significance of each.

II. Water Molecules

A. Describe the molecular interactions of water as a gas, liquid, solid.

B. Describe the properties of water as a small, polar molecule with regard to its solvent, adhesive, cohesive and latent heat properties. Define specific heat, thermoconductivity, and heat of vaporization.

C. Explain the properties of water at its boiling and freezing points and the biological significance.

D. Describe the dissociation of water molecules.

E. Define acids, bases and neutralization.

F. Explain the importance of hydrogen and hydroxyl ion concentrations in biological systems.

G. Understand the pH scale in terms of simple mathematical relationships.

H. Define buffers, their biological importance and give some examples.

3. BIOLOGICAL MACROMOLECULES

I. Carbon and Hydrocarbons

A. Describe the structure of the Carbon atom, its bonding capabilities and hydrocarbon molecular arrangements.

B. Distinguish between organic and inorganic molecules.

C. Recognize common functional groups such as: hydrogen, hydroxyl, carboxyl, amine, phosphate.

D. Describe possible origins of biological molecules on a primitive earth briefly discussing the significance of Stanley Miller’s work.

E. Describe the structure and function of the major biological molecular groups including: carbohydrates, lipids, nucleic acids, proteins. Recognize basic structure and characteristics for each. Apply the terms monomer and polymer.

F. Describe the formation and degradation of biological polymers from monomers by condensation (dehydration synthesis) and degradation (hydrolysis). Understand the universal nature of these processes.

II. Major Biological Molecules
- A. Protein
  1. Describe amino acid structure and the formation of peptide bonds
  2. Define primary, secondary, tertiary and quaternary protein structures
  3. Discuss the specificity of proteins due to infinite possibilities of amino acid arrangements, illustrate mathematically, 20^1, 20^2, 20^3, etc.
  4. Explain the structure and function of proteins in biological systems. Include enzymes, carrier molecules, antibodies, neurotransmitters, cytoskeleton components
- B. Carbohydrates
  1. Describe the structure and function of a monosaccharide and a disaccharide
  2. Describe polysaccharide formation and structure
  3. Discuss the function of polysaccharides and the relationships of the structure to the function for cell walls, energy storage, exoskeletons, etc.
- C. Lipids
  1. Describe the structure and biological importance:
     a. fatty acids
     b. triglycerides
     c. phospholipids
     d. sterols
  2. Describe the function of lipids in membranes, energy storage, communication, etc.
- D. Nucleic Acids
  1. Describe the structure of nucleotides and their polymers
  2. Describe the function of RNA, DNA, ATP, NAD+, NADP+, FAD
- E. Be able to distinguish between the major biological macromolecules utilizing hands-on, standard laboratory assays.
  1. Understand the role of a control in assessing the results of a chemical test.

4. CELLS

I. History and General Characteristics
- A. Unity of life: Biological systems obey physical, chemical and mathematical laws.
- B. Discuss the Cell Theory and its historical perspective.
- C. Understand surface area/volume relationships (use simple mathematical calculations).
  1. Discuss its affect on cell size and function
  2. Discuss its affect on organs
  3. Describe how organism design copes with SA/V. Indicate the importance of the relationship of size to function
- D. Briefly introduce the range of cell types from the various kingdoms.

II. Discuss the Nature of Prokaryotic Cells
  A. Describe the size range and internal and external structure.
  B. Describe the biological importance of prokaryotic cells to ecosystems, health. Identify their distribution into all environments. C. Briefly describe the evolutionary history.

III. Discuss the Nature of Eukaryotic Cells
  A. Briefly introduce the evolutionary history including an overview of endosymbiosis.
  B. Describe the microscopic techniques for viewing cells.
  C. Explain the importance of structure related to function.
  D. Explain an overview of the cell membrane.
  E. Compare and contrast plant and animal overall cell structure.
  F. Describe organelle structure and function. Compare and contrast plant and animal organelles.
    1. chloroplast
    2. central vacuole
    3. cell wall
    4. mitochondria
    5. nucleus
    6. reticular (endomembrane) system include rER, sER, Golgi, lysosomes, peroxisomes
    7. ribosomes
    8. cytoskeleton/nucleo skeleton
    9. cilia, flagella
    10. nucleolus

IV. Demonstrate Appropriate Use of the Compound Microscope
  A. Wet mounts
  B. Prepared slides
  C. Be able to scan a slide to locate specific structures or cell types.
  D. Oil immersion

V. Visually Distinguish and Identify Different Cell Types Using a Light Microscope
  A. Prepare and mount samples of onion, potato, cheek, and *elodea*.
  B. Apply appropriate stains to biological specimens and visualize under a light microscope.
  C. Identify appropriate cellular components.
  D. Compare and contrast different cell types.

5. MEMBRANE STRUCTURE & FUNCTION

I. Cell Membranes: Plasma Membrane and Internal Membranes
  A. Describe the Biological importance of membranes:
    1. structure: separation of two aqueous compartments
    2. transport functions: regulation of passage of materials between two compartments
    3. functions: service as site to carry out specific functions

II. Membrane Structure: The Fluid-Mosaic Model

A. The phospholipid bilayer
   1. Identify the structure and function of phospholipids
      a. hydrophobic fatty acid tails vs. polar heads
      b. length of fatty acid tails and saturated vs. unsaturated fatty acids
   2. Identify the structure and function of sterols
   3. Identify the structure and function of glycolipids
   4. Describe the fluid behavior and asymmetrical structure B. The Membrane proteins
   1. List the types and describe the functions of membrane proteins. Include: transport proteins, receptor proteins, recognition proteins, adhesive proteins
   2. Discuss the protein variation in different cell types

III. Membrane Functions: Passive Transport A.
Define.
B. Explain the role of concentration gradients and the role of kinetic energy.
C. Describe types of passive transport:
   1. Diffusion. Use the terms direct and simple diffusion
      a. Definition
      b. Discuss the random movement of particles (Brownian motion)
      c. Describe the net movement of particles and dynamic equilibrium
      d. List factors affecting the rate of diffusion
      e. Explain the importance of diffusion of oxygen and carbon dioxide across the cell membrane
      f. Hypothesize and test via hands-on experimentation which substances may pass through a semipermeable membrane.
   2. Osmosis
      a. Definition
      b. Explain: isotonic, hypotonic and hypertonic solutions
      c. Give examples of osmotic regulation in some aquatic and terrestrial organisms
      d. Hypothesize and test via hands-on experimentation the outcome of exposing cells to hypertonic, hypotonic, and isotonic solutions
   3. Facilitated diffusion
      a. Explain the use of channel proteins: regular vs. gated
      b. Explain the use of carrier proteins

IV. Membrane Functions: Active Transport A.
Define.
B. Explain the carrier protein basic operation and the importance of the Na^+/K^+ pump. Identify Na^+/K^+ pump as Primary Active Transport (specific details of the mechanism are not important).

V. Membrane Functions: Endocytosis and Exocytosis A.
Define endocytosis. Identify the energy source.
1. Define phagocytosis and include examples of macrophages, free-living protists
2. Define pinocytosis
3. Describe receptor-mediated endocytosis and specifically identify the example of cholesterol uptake

B. Define exocytosis. Identify the energy source.
1. Use examples: release of indigestible food particles and secretion of hormones and proteins

VI. Cell-to-Cell Junctions
A. Describe the basic structure, function and cell types for:
1. tight junctions
2. desmosomes
3. gap junctions
4. cell walls
5. plasmodesmata

B. Briefly identify the importance to tissue formation in plants and animals.

6. ENERGY AND METABOLISM I.

Energy
A. Define Kinetic and potential energy with examples.
B. Explain the role of energy in metabolism using terms catabolism and anabolism.
C. Explain the biological relevance of the First and Second Laws of Thermodynamics.
D. Explain why organisms like plants allow all organisms to overcome entropy.
E. Describe exergonic and endergonic reactions in terms of substrates, unstable intermediates and products.

II. Enzymes
A. Describe the characteristics of an enzyme as it applies to enzyme specificity, activation energy, increase in reaction rate and their reusability.
B. Describe the effects of temperature and pH on enzyme activity and relate to the catalase lab.
C. Explain the role of cofactors like dinucleotides (e.g. $NADP^+$, NAD^+, FAD) and metallic ions (e.g. Fe).
D. Perform hands-on assays to measure the activity of an enzyme.
1. Propose and experimentally test hypotheses relating to the impact of changes in pH, temperature, and substrate concentration on enzymatic activity

III. Metabolic Pathways
A. Explain redox reactions.
B. Discuss metabolic activity (photosynthesis and respiration) in terms of oxidation and reduction.
C. Explain the role of electron transport systems.

D. Define Feedback inhibition (negative feedbacks mechanisms) and allosteric proteins.

IV. ATP
- A. Describe the general structure.
- B. Describe the Phosphorylation cycle (ADP-ATP).
  1. Relate to endergonic and exergonic reactions
  2. Relate to photosynthesis and cellular respiration.

7. PHOTOSYNTHESIS I. Overview
- A. Write the General equation.
- B. Identify the role of light and water. Define transpiration.
- C. Identify the end products formed (PGAL and Oxygen) and their importance to life on Earth.
- D. Relate the structure of the leaf to the acquisition of raw materials and the process of photosynthesis.

II. Light Dependent Reactions of Photosynthesis
- A. Identify the location in the chloroplast for these reactions.
- B. Pigments:
  1. Identify the role of pigments: primary and accessory pigments
  2. Identify the locations of the photosystems and their role in trapping light energy
  3. Identify the roles of chlorophyll a (P680 and P700) as they relate to PS II and PS I
  4. Conduct a paper chromatography assay to biochemically separate the various pigment molecules within a sample of plant material
- C. Photolysis
  1. Define
  2. Describe the importance to the ETS chemiosmosis
  3. Identify the importance of and movement of hydrogen ions, electrons and oxygen
  4. Conduct hands-on assays to observe the generation of $O_2(g)$ by a sample of *elodea*, and the ability of the plant to alter the pH of a solution via carbon dioxide uptake and fixation using a pH indictor
- D. $NADP^+$
  1. Identify the role as the final electron (hydrogen) acceptor of light dependent reaction. Discuss the location of formation in preparation for light independent reaction
  2. Identify the role in the Calvin Cycle
- E. ATP production (photophosporylation)
  1. Explain the role of chemiosmotic gradient to ATP production. Include the role of photolysis and cytochromes
  2. Identify the role of ATP synthetase in the light reactions

III. Light Independent Reactions (Calvin Cycle) of Photosynthesis
- A. Provide an overview of the "general" process as a cyclical metabolic pathway.

B. Discuss the concept of carbon fixation bringing inorganic carbon into organic molecules.
C. Explain the roles of reduced NADP, ATP, CO_2, rubisco.
D. Chart the fate of the product, PGAL, include regeneration of RuP and synthesis of other carbohydrates.

IV. Coupling of Light Dependent and Independent Reactions A. Explain what coupling means.
B. Explain specifically the coupling between:
1. ADP and ATP
2. Reduced and oxidized NADP
C. Using a hands-on approach, conduct the Hill Reaction to validate the biochemical separation of the light-dependent and light-independent reactions.

V. C4 and CAM Metabolism
A. Compare and contrast the structure of a C3 and C4 plant. Identify C4 plant examples. List the environmental advantage.
B. Compare the time and location of carbon fixation in CAM plants. Give examples.
C. Correctly identify and distinguish between prepared specimens of C3, and C4 plants under a light microscope.

8. CELLULAR RESPIRATION

I. Role of Cellular Respiration
A. Identify the importance of the major B vitamins in energy metabolism; e.g. niacin, riboflavin, pantothenic acid.
B. Explain the overall goal of catabolic metabolism with emphasis on oxidation of substrates and reduction of energy carriers.

II. Anaerobic Glycolysis
A. Discuss the process as an ancient pathway. Recognize many organisms are obligate anaerobes.
B. Understand the overall concept and reasons for the pathway.
C. Know glucose as the starting compound, PGAL as the first 3-C intermediate and pyruvate as the end product.
D. Know the energy requirements and energy yields: ATP by substrate level phosphorylation *and* NADH and compare with other pathways.
E. List the possible fates of pyruvate: aerobic cellular respiration and fermentation.

III. Aerobic Respiration
A. Draw and identify the structure of a mitochondrion. Explain the function of each region.
1. inner and outer membranes, significance of cristae
2. intermembranous space
3. matrix
B. Discuss the role of acetyl coenzyme A and the “transition reaction” in metabolism.
1. Link glycolysis and Krebs cycle

2. Link between fatty acid metabolism and metabolism of some amino acids

C. The citric acid (Krebs) cycle
   1. Know the starting compounds and end products
   2. Discuss the significance of cyclical pathway
   3. Explain the major types of reactions (exact places of reactions and names of intermediates are *not* important)
      a. oxidation/reduction (dehydrogenation): generation of NADH & $FADH_2$
      b. generation of CO_2
      c. substrate level phosphorylation

D. Electron transport system (ETS) /oxidative phosphorylation (oxphos)
   1. Explain the relationship between mitochondrial structure and oxphos
   2. Discuss the role of the ETS (carrier names are not important)
   3. Show the source and outcome for electrons and hydrogens
   4. Explain the concept of the proton pump
   5. Explain the hydrogen ion gradient as potential energy
   6. Explain chemiosmotic theory
   7. Relate the need for oxygen to complete electron transport and regenerate oxidized NAD^+
   8. Compare and contrast with oxphos in chloroplasts with regard to location, process, products

IV. Anaerobic Fermentation
   A. Define fermentation.
   B. Know Lactate and ethanol fermentation with reactants, products, purpose.
   C. Understand the concept of limiting electron carriers and metabolic reason fermentation occurs.
   D. Relate hypoxic/anoxic conditions to pathological states in animal, i.e. stroke, heart attacks.
   E. Using a hands-on approach, experimentally compare the relative efficiency of aerobic and anaerobic respiration under varying conditions of oxygenation and type of carbohydrate food source.

V. Lipid Metabolism
   A. Show Triglyceride catabolism with the Fatty acid catabolism via acetyl coenzyme A and Glycerol catabolism entry at PGAL in glycolysis.
   B. Show Triglyceride anabolism via “reversal” of steps above (but different pathways).
   C. Relate allosteric control of metabolic pathways to fat anabolism.

VI. Protein Metabolism
   A. Understand that dietary amino acids are used for protein synthesis but that excess amino acids are oxidized.
   B. Explain catabolism of amino acids involving deamination and formation of ammonia and then urea. Relate to diet in kidney disease.

C. Show the “carbon skeletons” have variable structure and enter into metabolic pathways at several points, i.e. Krebs cycle, pyruvate, or acetyl CoA.

D. Non-essential amino acids may be synthesized via “reversal” of the above steps (but by different pathways).

9. CELL DIVISION

I. Describe Prokaryotic Division by Binary Fission

II. Eukaryotic Division

A. Introduction

1. Distinguish between cellular and organismal reproduction
2. Distinguish between somatic and germ cells
3. Distinguish between mitosis and meiosis as nuclear divisions
4. Distinguish among chromatin, chromatids and chromosomes
5. Distinguish between haploid and diploid nuclei and cells
6. Describe the importance of chromosome condensation in terms of equal distribution and separation of genetic material

B. Eukaryotic Cell Cycle

1. Draw and describe the basic activities and the reasons for each stage of the cell cycle: interphase (G_1, S, G_2) and mitosis (M stage) and cytokinesis
2. Describe G_0 stage, its importance and cell examples
3. Briefly describe specialized cells that "return" to a mode of cell division

C. Mitosis

1. Describe the basic activities in prophase, metaphase, anaphase and telophase. Include the roles of the cytoskeleton and various organelles
2. Compare and contrast mitosis in plants and animals
3. Discuss problems in cell division

D. Cytokinesis

1. Define cytokinesis
2. Explain why this process is equivalent and not exact
3. Distinguish between cytokinesis in plants vs. animals
4. Observe and correctly identify the various stages of mitosis within a prepared plant and animal specimen under the light microscope 5. Observe the differences plant and animal cytokinesis

10. MEIOSIS

I. Introduction

A. Compare and contrast sexual and asexual reproduction as it applies to a single parent (asexual) and as it applies to two parents (asexual and sexual).

B. Define the terms haploid and diploid and explain what is meant by sets of chromosomes.

C. Describe homologous chromosomes, maternal chromosomes and paternal chromosomes.

D. Generally compare and contrast mitosis and meiosis.

II. Meiosis I
- A. Describe the basic activities in prophase I, metaphase I, anaphase I and telophase I.
- B. Compare and contrast meiosis I to mitotic division.
- C. Describe the importance of recombination and crossing over to genetic variability and evolution. Include terms such as bivalents, tetrads, chiasmata, synapsis.
- D. Describe the importance of independent assortment to genetic variability and evolution.

III. Meiosis II
- A. Describe the basic activities in prophase II, metaphase II, anaphase II and telophase II.
- B. Compare and contrast meiosis II to mitotic division.

IV. Gametogenesis
- A. Define gametogenesis.
- B. List the importance of oogenesis and spermatogenesis.
- C. Starting with a primary oogonium or spermatogonium, show the unequal cytoplasm and organelle distribution in oogenesis and explain the reason for one ovum vs. four spermatids. (Details of cell types are not important.)
- D. Briefly describe spermatozoa differentiation and the organelles which remain. Explain why all mitochondria are from maternal descent.

V. Summarize the Aspects of Meiosis and Sexual Reproduction As They Relate to Evolution

11. OBSERVABLE PATTERNS OF INHERITANCE

I. Concepts of Heredity Before Mendel's Time
- A. Discuss spontaneous generation and Louis Pasteur.
- B. Introduce the blending inheritance theory.

II. Mendelian Genetics A. History of Mendel
- 1. Introduce his background in physics and mathematics
- 2. Discuss the choice of garden pea plant's four characteristics
- 3. Explain his experiments as thoroughly scientific. Define reciprocal crosses

- B. Define basic terms in genetics: dominant, recessive, homologous, homozygous, heterozygous, genotype, phenotype, dominant, recessive, allele.
- C. Be able to solve genetics problems involving:
  - 1. monohybrid cross using Punnett squares
  - 2. monohybrid testcross or back cross. Identify the purpose for a testcross
  - 3. dihybrid cross
- D. Explain Mendel's Principle of Dominance, Principle of Segregation and Principle of Independent Assortment and the importance to evolution.

III. Variations on the Mendelian Theme
- A. Emphasize the predictability and unpredictability of inheritance.

B. Differentiate the different patterns of inheritance. Be able to solve problems in Dominance relations patterns of inheritance for both a monohybrid and dihybrid cross.
   1. Define and give examples for complete dominance
   2. Define and give examples for incomplete dominance
   3. Define and give examples for codominance. Include human ABO blood types

C. Define and give examples for Multiple allele system. Include human ABO blood types.

D. Define and give examples for Pleiotropy.

E. Define and give examples for Polygenic inheritance.

F. Define Epistasis, and be able to solve problems involving Labrador coat color.

G. Explain Environmental effects and why an organism is a product of genetics and the environment. Include external factors such as temperature, light, diet and internal factors such as hormones.

12. CHROMOSOMES AND HUMAN GENETICS I. Chromosomes

A. Define Sex chromosomes and autosomes.

B. Show a Karyotype analysis and identify sex.

II. Genetics of Sex

A. Identify the genetics of sex determination in humans and other organisms.

B. Define and give examples of X-linked and Y-linked traits.

C. Be able to solve X-linked pattern of inheritance problems with fruit fly eye color, colorblindness, hemophilia.

III. Linkage

A. Define linkage.

B. Discuss the importance of recombination frequencies to the localization of genes on chromosomes. (Students do not need to solve mapping problems.) Briefly identify why linked genes do not follow the Law of Independent Assortment.

IV. Chromosome Mutations

A. Define and provide examples for changes in chromosome number.
   1. Aneuploidy: monosomy, trisomy
   2. Polyploidy. Include its importance to plants and detriment to animals

B. Define and provide examples for changes in chromosome structure. Include: deletion, inversion, duplication, translocation.

V. Human Genetic Analysis

A. Utilize pedigree analysis to illustrate family geneology.

B. Be able to follow a pedigree in single gene inheritance.
   1. Autosomal recessive: albinism, sickle-cell anemia (include the advantages in heterozygotes), Tay-sach's disease, cystic fibrosis, phenylketonuria (PKU), etc.

2. Autosomal dominant: Huntington's, polydactyly, familial hypercholesterolemia
3. X-linked recessive: colorblindness, hemophilia
4. X-linked dominant: faulty dental enamel
5. Y-linked: SRY gene, sperm production, hair in the ears

C. Abnormal chromosome inheritance
1. Define nondisjunction of autosomes with example Trisomy 21/ Down syndrome
2. Define nondisjunction of sex chromosomes with examples: Turner syndrome, Klinefelter syndrome, XYY condition, Metafemale
3. Show changes in chromosome structure: cri-du-chat, fragile X syndrome

13. DNA STRUCTURE

I. Integrate with a Review of the Scientific Method the Evidence that DNA is the Genetic Material
A. Griffith's experiments with transformation.
B. Avery's experiments with DNAse, protease and purified DNA. Link DNAase to the transformation lab.
C. Hershey and Chase's experiments. Integrate with bacteriophage life cycle.

II. The DNA Structure as Elucidated by Watson and Crick, et al.
A. Discuss the nature of the science in a historical context. Discuss Chargoff's rules, Franklin's x-rays.
B. Diagram and discuss nucleotide structure.
C. Nucleotide polymer structure
1. sugar phosphate backbone
2. nucleotide base sequence which contains the genetic information
D. Diagram and discuss the Double stranded structure of DNA
1. Show hydrogen bonding between A and T and G and C
2. Show the double helix design with anti-parallel nucleotide polymers
3. Define complementary base pairing. Include its importance to form a foundation for discussions on DNA replication, transcription, translation, mutation repair

III. Process of DNA Replication
A. Define and show the origins, unwinding, unzipping process. Define the function of helicase.
B. Draw the template strands and explain the replication forks.
C. Define the function of DNA polymerase.
D. Explain the process as semiconservative replication. Include a discussion of the experiments of Meselson and Stahl.
E. Discuss the accuracy of DNA replication:
1. Identify mutation rates and the role of DNA polymerases in proofreading
2. Discuss the importance to evolution and cell aging

IV. Organization of DNA in Eukaryotic Chromosomes A. Identify the need to package DNA.
B. Discuss the function of histones and the formation of nucleosomes.
C. Define euchromatin, heterochromatin and mitotic chromosomes.

14. GENE EXPRESSION

I. Gene Structure and Transcription
A. Discuss the present day “Central dogma.” Define transcription and translation.
B. Basic gene organization
1. Define and identify the coding region (structural genes) Define and identify the noncoding region
2. Define the function of regulation regions: promoters and terminators
C. Process of Transcription in the Nucleus
1. Identify the role of RNA polymerase
2. Explain the promoter recognition and the role of transcription factors
3. Show DNA unwinding and RNA production and termination
D. RNA
1. Show the basic structure of RNA nucleotide: ribose, phosphate, adenine
2. List the types of RNA, the functions of each type, the location for their production and location where they function
a. messenger RNA
b. transfer RNA
c. ribosomal RNA

II. The Genetic Code
A. Provide the experimental evidence for the three base code.
B. List the properties of the code.
1. Redundant (degenerate). Include the advantages of degeneracy
2. Lacks ambiguity
3. Universal (nearly)
4. Function and importance of start codons and stop codons
C. Students should be able to use the table of the genetic code to determine the amino acid sequence produced by any particular mRNA.

III. The Process of Translation A. Components of translation 1. Ribosomes:
a. Structure: small and large subunits
b. Basic functions of ribosomal RNA.
c. Basic function(s) ribosomal proteins
2. Transfer RNA
a. Define anticodon
b. Define the amino acid attachment site-the aminoacyl site
c. Explain the function as an adapter molecule between mRNA and protein
3. Messenger RNA
a. Explain the basic structure

b. Discuss the importance of the nucleotide sequence in determining the amino acid sequence
c. Define codon. Show the relationship of complementary pairing and importance to the tRNA anticodon

B. Explain the overall basic concepts behind the events of the stages of translation.
1. Initiation
2. Elongation and translocation
3. Termination

IV. Antibiotics
A. Define and list some sources for antibiotics.
B. List some reasons for specificity for prokaryotes.
C. Briefly describe the effects on translation and on other processes including the interruption of the cell cycle.

V. Mutations
A. List and define the types
1. Point mutations: silent, missence (radical and conservative), nonsense
2. Frameshift
3. Students should be able to solve gene mutation problems when given hypothetical mRNA, the genetic code table and any of the above mutations

B. Show the effects of mutations
1. alteration of protein function
2. alteration of gene regulation
3. consequences of mutations to germ cells and the importance to evolution
4. consequences of mutations to somatic cells
5. possible relevance to aging

C. List some causes of mutations
1. DNA replication errors
2. radiation
3. chemicals, free radicals

D. Show mutation repair
1. Role of DNA polymerase
2. Concepts of repair enzymes

E. Relate gene mutations to gross chromosomal mutations.

15. REGULATION OF GENE EXPRESSION

I. Lactose Operon: A Simple Model of Transcription Regulation in Prokaryotes
A. Understand the concept of why the operon evolved.
B. Draw and know the basic function of
1. the repressor
2. the operator
3. the structural genes

C. Briefly understand the process of Negative control.

1. repression
2. induction

D. Briefly understand the process of Positive control.

II. Eukaryotic Genomes A. Define Repetitive DNA.

B. Define Transposons.

III. Gene Regulation in Multicellular Eukaryotes

A. Discuss gene regulation in the context of development and cell differentiation.

B. Identify transcriptional control promoters and enhancers.

C. Briefly describe an overview of chromatin structure and gene regulation

1. heterochromatin vs. euchromatin
2. variation in nucleosome structure

D. Identify Post transcriptional control introns and exons

1. Explain the basic concept of RNA splicing and its importance
2. Discuss possible explanation of why split genes exist E. Identify the concept of translational and post-translational control.

F. Know about modification with poly(A) tails and 5' caps. IV. Cancer

A. Define cancer. List some types of cancer.

B. List characteristics of cancer cells including: lack of contact inhibition, vascularity, plasma membrane, cytoskeleton and cytoplasm changes, abnormal disorganized growth.

C. List some mechanisms and causes of cancer.

D. Identify and define the genes involved

1. proto-oncogenes, oncogenes
2. tumor suppresser genes
3. DNA repair genes. Define apoptosis

E. Briefly discuss the multistep theory and genetic predisposition.

F. Identify treatment

1. historical perspectives such as drug discovery
2. screening and early detection
3. surgery
4. concept of how chemotherapy works using fluorouracil, taxol
5. radiation
6. side effects

16. GENETIC ENGINEERING

 Note: It is important to stress the uses and implications of genetic engineering and not to overwhelm students with the techniques.

I. Define and Discuss the Concept and Importance of Gene Cloning

A. Tools needed

1. DNA, chromosomal or copy DNA (cDNA) (very brief with cDNA)
2. Define Vectors. Examples: plasmids or viruses
3. Enzymes: restriction enzymes (endonucleases): natural and exploited function DNA ligase

4. Host: special strains of *Escherichia coli*
5. Transformation

B. Define and explain Polymerase chain reaction (PCR).

C. Define and discuss the concept and importance of cloning of organisms.

II. Uses of Cloned Genes

A. Understand the importance of biotechnology as a major industry in modern society.

B. Define Probes and hybridization

1. Explain the basics of the technique and the importance DNA fingerprints/ restriction fragment length polymorphism (RFLP)
2. Explain genetic screening with emphasis as a way to identify persons at risk for disease
3. Identify usage to determine gene location, structure and expression

C. Define transgenic organisms. For each of the following, briefly describe the technique and discuss the uses and positive and negative societal or environmental impact. Include current news items

1. genetically engineered microorganisms (GEMS)
2. transgenic plants
3. transgenic animals

D. Gene therapy

1. Discuss the concept and importance
2. List technical approach(es) such as viral vectors
3. Provide examples of the therapy such as cystic fibrosis, adenosine deaminase deficiency
4. Define somatic cell and germ cell gene therapy
5. List positive and negative aspects with a discussion of eugenics

E. Hands-on Experimental Manipulation of DNA

1. solate a sample of DNA from a biological specimen
2. Transform bacterial cells with plasmid DNA

LEARNING MATERIALS:

Textbook:

Reece, J., Taylor, M., Simon, E., Dickey J., and Hogan, K. (2014). Campbell Biology: Concepts and Connections (8th Edition). Pearson Publishing Company.

Lab Manual:

All Lab protocols provided on Blackboard as pdf files.

Other learning materials may be required and made available directly to the student and/or via the College's Libraries and/or course management system.

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This course is consistent with Montgomery County Community College's mission. It was developed, approved and will be delivered in full compliance with the policies and procedures established by the College.