

<b>COURSE: Biology</b>	<b>GRADE(S): 9</b>
<b>UNIT 1: BASIC BIOLOGICAL PRINCIPLES</b>	<b>TIMEFRAME: ~10 days</b>

**PA ACADEMIC SECONDARY STANDARDS FOR BIOLOGY**

**Organisms and Cells Content Standards:**

- **3.1.B.A1.** Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts).
- **3.1.B.A2.** Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.
- **3.1.B.A3.** Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.
- **3.1.B.A4.** Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.
- **3.1.B.A5.** Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.
- **3.1.B.A6.** Explain how cells differentiate in multicellular organisms.
- **3.1.B.A7.** Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.
- **3.1.B.A8.** *CHANGE AND CONSTANCY* Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. *PATTERNS* Demonstrate the repeating patterns that occur in biological polymers. *SYSTEMS* Describe how the unique properties of water support life.

**Genetics Content Standards:**

- **3.1.B.B1.** Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.
- **3.1.B.B2.** Describe how the process of meiosis results in the information of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.
- **3.1.B.B3.** Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic

code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

- **3.1.B.B4.** Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.
- **3.1.B.B5. PATTERNS** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, codominant, sex-linked, polygenic, incomplete dominance, multiple alleles) **CONSTANCY AND CHANGE** Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.

#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO.A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

**Module B CONTINUITY and UNITY of LIFE**

**BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

**BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

**BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

**BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

**KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

**OBJECTIVES / ESSENTIAL KNOWLEDGE**

**Explain the characteristics common to all organisms.**

1. Identify the steps of the Scientific Method and describe how it is applied in order to gain new knowledge.

- The steps of the Scientific Method include asking a question or recognizing a problem, forming a hypothesis, testing the hypothesis with an experiment, recording and analyzing data, and drawing a conclusion.
    - A hypothesis is a tentative answer to a question. In order to be useful, it must be testable with an experiment.
    - An experiment must contain a control, which is a known or standard, and a variable, the changing part of the experiment which is being tested.
    - A good experiment tests only one variable at a time. An independent variable is that which is being manipulated by the researcher. The dependent variable is what changes as a consequence.
    - A theory is developed if repeated experimentation supports the result. A theory is a well-tested, well-supported result or the best possible explanation based on the data available.
2. Describe the characteristics of life shared by all prokaryotic and eukaryotic organisms.
- Living things are distinguished from nonliving things on the basis of eight characteristics: response to the environment, growth and development, reproduction, homeostasis, complex chemistry, contain cells, obtain and use energy, and, as a species, change over time.
  - Four underlying principles form the basis of biology. They are cell theory, gene theory, homeostasis, and evolution.
  - Many living things interact with one another in some way. The interactions are often necessary for their survival.
  - The great diversity of life on Earth today is the result of 4 billion years of evolution. During that time, living things evolved from simple, single-celled organisms to complex, multicellular life forms.

**ACTIVITIES:**

1. List and describe the common characteristics exhibited by all living and once living things – both prokaryotic and eukaryotic.
2. Compare cellular structures and their functions in prokaryotic and eukaryotic cells.
3. Describe and interpret relationships between structure and function at the organelle, cell, tissue, organ, organ system and multicellular organism level of organization.

**RESOURCES:**

Dragonfly Chapter 1  
Flexbook Chapter 1

**ASSESSMENTS:**

Observation checklists  
Interviews and dialogue  
Group projects  
Individual projects  
Worksheets  
Model creation  
Writing responses  
Lab participation  
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**REMEDICATION:**

Small group instruction  
Individualized teacher support  
Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction

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<b>UNIT 2: The Chemical Basis For Life</b>	<b>TIMEFRAME: ~20 days</b>

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12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

**OBJECTIVES / ESSENTIAL KNOWLEDGE**

Describe how the unique properties of water support life on Earth.

1. Describe the unique properties of water and how these properties support life on Earth (e.g., freezing point, high specific heat, cohesion, adhesion, surface tension).

- Most of Earth's water is salt water in the oceans. Less than 3% is fresh water.
- Water molecules are polar and they form hydrogen bonds. This gives water unique properties such as a relatively high boiling point and ability to dissolve other substances.
- Pure water has a neutral pH of 7. Acids have a pH lower than 7, are corrosive, and are sour. Bases have a pH higher than 7, feel slippery, and are bitter.
- Solutions can be formed when one substance (solute) is dissolved in another (solvent). When a substance does not completely dissolve in another, it can form a suspension.
- Water is involved in most biochemical reactions. Therefore, water is essential to life.

Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).

1. Explain how atoms, elements, compounds, and isotopes are related.
  - Atoms are the basic unit of matter and contain protons, neutrons, and electrons.
  - Elements contain one specific type of atom with a set number of protons and electrons. The number of electrons in an element gives it certain chemical properties.
  - Isotopes are elements with different numbers of neutrons. Some isotopes can be radioactive.
  - Compounds form from two or more elements.
  - Elements form compounds through chemical bonds such as covalent or ionic bonds.
2. Explain how carbon is uniquely suited to form biological macromolecules.
  - Carbon's unique ability to form chemical bonds allows it to form millions of different large, organic compounds. These compounds make up living things and carry out life processes.
  - Organic compounds are distinguished from inorganic compounds by the presence of carbon.
  - Carbon, atomic number six, has six electrons.
    - a. Two are in the first electron shell and four are in the second electron shell.
  - Carbon must share four electrons with other atoms to fill its outermost electron shell and attain a stable configuration.
  - Carbon atoms can share electrons with a wide variety of elements also commonly found in organic compounds, the most notable being other carbon atoms, hydrogen atoms and oxygen atoms
3. Describe how biological macromolecules form from monomers.
  - Four Biological Macromolecules
    - a. Carbohydrates: Monosaccharides (Monomer) →Disaccharides →Polysaccharides (Polymer/Macromolecule)
    - b. Proteins: Amino Acid (Monomer) →Polypeptide Chains →Protein (Polymer/Macromolecule)
    - c. Lipids: Tend to have a wide range of monomers depending on the type of lipid; they generally contain glycerol and fatty acid chains.
    - d. Nucleic Acid: Nucleotide (Monomer) →Nucleic acid (Polymer/Macromolecule- either DNA or RNA)
4. Compare the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms.
  - Carbohydrates – organic compounds made of carbon, hydrogen and oxygen with a ratio of 1:2:1
    - a. Key source of energy (typically short term)
    - b. Carbohydrates include sugars and starches. They are found in most foods especially fruits, vegetables and grains
    - c. A complex carbohydrate known as cellulose provides structural support for plants.
  - Lipids are organic compounds such as fats and oils. They store energy (longer term) and help form cell membranes in addition to having other functions in organisms.
    - a. Nonpolar molecules that are not soluble in water
    - b. Fatty acids tend to be the monomer of the larger, more complex lipids.
  - Proteins are organic compounds made up of amino acids. They form muscles, and bones, speed up chemical reactions, and perform many other cellular functions.



- a. Building block for many structures in the body.
- b. 20 different biological amino acids are used to form a wide variety of different proteins.
- c. The arrangement of amino acids dictates the protein's function.
- d. Proteins fold into complex structures and their folding patterns are important in their function.
- Nucleic acids are organic compounds that include DNA and RNA. DNA contains genetic instructions for making proteins, and RNA helps assemble the proteins
  - a. Used for protein production and hereditary information storage.
  - b. DNA( Deoxyribonucleic Acid) stores hereditary information and consists of two strands of nucleotides twisted around each other.
  - c. RNA (Ribonucleic Acids) is used in the manufacturing of proteins and consists of a single strand of nucleotides that code for a specific protein to be made by the cell.

**Explain how enzymes regulate biochemical reactions within a cell.**

1. Describe the role of an enzyme as a catalyst in regulating a specific biochemical reaction.
  - A chemical reaction is a process that changes one set of chemical substances into another set. It involves breaking and forming chemical bonds.
  - Some chemical reactions release energy, whereas other chemical reactions absorb energy.
  - Enzymes increase the speed of a chemical reaction by lowering the activation energy required. Without enzymes chemical reactions would not occur quick enough to sustain life.
  - The molecule that an enzyme acts on is called the substrate. Substrate molecules are changed, and a product is formed. The enzyme molecule is unchanged after the reaction, and it can continue to catalyze the same type of reaction over and over.
2. Explain how factors such as pH, temperature, and concentration levels can affect enzyme function.
  - pH effects on enzymes:
    - a. Each enzyme functions best in a specific pH range.
    - b. When the pH changes, the active sites progressively distort and affect enzyme function. A distorted shape makes it so an enzyme-substrate complex cannot form and impedes the reaction.
  - Temperature effects on enzymes:
    - a. Chemical reactions speed up as temperature is increased, so, in general, catalysis will increase at higher temperatures.
    - b. However, each enzyme has a temperature optimum, and beyond this point the enzyme's functional shape is lost.
    - c. Temperatures above an enzyme's optimum will denature the enzyme.
  - Concentration effects:
    - a. Increasing substrate and/or enzyme concentration increases the rate of reaction.
    - b. Reactions cannot increase indefinitely, though; there will be a maximum speed of reaction based on the enzyme and substrate available.

<p><b>ACTIVITIES:</b></p> <ol style="list-style-type: none"> <li>1. Describe the unique properties of water.</li> <li>2. Explain how the unique properties of water support life on earth.</li> <li>3. Describe the structure of a carbon atom.</li> <li>4. Explain how carbon atoms bond to form biological macromolecules.</li> <li>5. Describe how biological macromolecules form from monomers.</li> </ol>	<p><b>ASSESSMENTS:</b></p> <p>Observation checklists          Interviews and dialogue          Group projects          Individual projects          Worksheets          Model creation          Writing responses          Lab participation          Lab reports</p>
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6. Compare the structure and function of carbohydrates, lipids, proteins, and nucleic acids in organisms.
7. Explain how enzymes act as catalysts to regulate biochemical reactions.
8. Explain how environmental factors affect the function and reaction rate of the enzyme.
9. Interpret graphs to analyze enzyme catalyzed reactions.

**RESOURCES:**

Dragonfly Chapter 2  
Flexbook Chapter 2

Journal entries  
Presentations  
Quizzes  
Tests

**REMEDIATION:**

Small group instruction  
Individualized teacher support  
Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction

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#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO. A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

**Module B CONTINUITY and UNITY of LIFE**

**BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

**BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

**BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

**BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

**KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

**OBJECTIVES / ESSENTIAL KNOWLEDGE**

**Identify and describe the cell structures involved in processing energy.**

1. Describe the fundamental roles of plastids (e.g., chloroplasts) and mitochondria in energy transformations.
  - Chloroplasts: only found in plants.

- a. Is composed of stacks of thylakoid sacks.
- b. Chlorophyll is found in thylakoids.
- c. With a combination of water and carbon dioxide, light is converted into glucose. This chemical process of producing glucose is called *photosynthesis*.
- Mitochondria: found in all eukaryotic cells.
  - a. ATP molecules are produced and stored; ATP is a result of cellular respiration and requires a food source
  - b. Mitochondria contain cristae created by multiple folds of the membrane to maximize surface area. The mitochondrion uses the vast surface of the inner membrane to perform chemical reactions. The chemical reactions include filtering out certain molecules and attaching other molecules to transport proteins. The transport proteins will carry select molecule types into the matrix, where oxygen combines with food molecules to create energy.
- Living things need energy to carry out all life processes.
- Autotrophs make their own food. Heterotrophs get food by eating other living things.
- Glucose and ATP are used for energy by nearly all living things. Glucose is used to store energy, and ATP is used to power life processes inside cells.
- Many autotrophs make food through the process of photosynthesis, in which light energy from the sun is changed to chemical energy that is stored in glucose. All organisms use cellular respiration to break down glucose, release its energy, and make ATP.
- Both stages of photosynthesis take place in chloroplasts. The light dependent reactions take place on the thylakoid membranes, and the Calvin cycle takes place in the stroma.

**Identify and describe how organisms obtain and transform energy for their life processes.**

1. Compare the basic transformation of energy during photosynthesis and cellular respiration.
  - Photosynthesis: the process by which plants use solar energy to convert the raw materials carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O) into glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>) for use as an energy source.
    - a. Oxygen gas is produced as the byproduct
    - b. The general chemical equation for photosynthesis is:  $6 \text{H}_2\text{O} + 6 \text{CO}_2 + \text{solar energy} \text{ -----} \text{-----} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2$
    - c. Occurs in the chloroplasts of plants.
  - Most autotrophs make food using photosynthesis. This process occurs in two stages: the light reactions and the Calvin cycle.
  - Both stages of photosynthesis take place in chloroplasts. The light reactions take place on the thylakoid membranes, and the Calvin cycle takes place in the stroma.
  - The light reactions capture energy from sunlight, which they change to chemical energy that is stored in molecules of NADPH and ATP. The light reactions also release oxygen gas as a waste product.
  - The reactions of the Calvin cycle add carbon (from carbon dioxide in the atmosphere) to a simple five-carbon molecule called RuBP. These reactions use chemical energy from NADPH and ATP that were produced in the light reactions. The final product of the Calvin cycle is glucose.
  - Some bacterial autotrophs make food using chemosynthesis. This process uses chemical energy instead of light energy to produce food.
  
2. Cellular respiration: is the release of energy from energy-storing compounds (i.e. glucose, fructose, starch).
  - a. The cells of all organisms require a continuous supply of energy for the performance of their daily, vital activities.
  - b. Respiration is represented by the chemical equation:  $\text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \text{ -----} \text{-----} \rightarrow 6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{energy (ATP)}$
  - c. The process of cellular respiration is essentially the reverse of photosynthesis; the reactants of one reaction are the products of the other
  - d. The catabolic breakdown (burning) of glucose requires the presence of oxygen and yields energy and carbon dioxide
  - e. Releases carbon dioxide as a byproduct, which may then be used by plants in the

photosynthetic process.

f. Occurs in the mitochondria.

- Cellular respiration uses energy in glucose to make ATP. Aerobic ("oxygen-using") respiration occurs in three stages: glycolysis, the Krebs cycle, and electron transport.
  - a. In glycolysis, glucose is split into two molecules of pyruvate. This results in a net gain of two ATP molecules. This step is anaerobic, not requiring oxygen.
  - b. The Krebs cycle and electron transport occur in the mitochondria. The Krebs cycle takes place in the matrix, and electron transport takes place on the inner membrane.
  - c. During the Krebs cycle, pyruvate undergoes a series of reactions to produce two more molecules of ATP and also several molecules of NADH and FADH<sub>2</sub>.
- During electron transport, energy from NADH and FADH<sub>2</sub> is used to make many more molecules of ATP.
- In all three stages of aerobic respiration 38 molecules of ATP may be produced from a single molecule of glucose.
- Fermentation is a way of making ATP from glucose without oxygen. There are two types of fermentation: lactic acid fermentation and alcoholic fermentation.
  - a. Lactic acid fermentation changes pyruvic acid to lactic acid and forms NAD<sup>+</sup>. The NAD<sup>+</sup> allows glycolysis to continue so it can make ATP.
  - b. Alcohol fermentation changes pyruvic acid to ethanol and carbon dioxide and forms NAD<sup>+</sup>. Again, the NAD<sup>+</sup> allows glycolysis to keep making ATP.
  - c. Aerobic respiration produces much more ATP than anaerobic respiration. However, anaerobic respiration occurs more quickly.

3. Describe the role of ATP in biochemical reactions.

- ATP (Adenosine Triphosphate) is used for energy storage
- Composed of: Adenine ring and Ribose sugar and three Phosphate groups
- Number of phosphate groups determines the power of the nucleotide:
  - a. AMP: Adenosine monophosphate – 1 phosphate group – acts like a very weak battery
  - b. ADP: Adenosine diphosphate – 2 phosphate groups – acts like a dollar store battery (has power but not the best)
  - c. ATP: Adenosine triphosphate – 3 phosphate groups – acts like a Duracell lithium battery
- ATP is fuel for cells – it is consumed by a variety of different processes.
  - a. Once it is spent, it reverts back to adenosine diphosphate and adenosine monophosphate.
- ATP transports chemical energy within cells for metabolism.
- ATP is produced in Photophosphorylation, Cellular respiration, and Fermentation
- ATP is used in Enzyme function, and by structural proteins in many cellular processes including metabolism, motility, and cell division.

**ACTIVITIES:**

1. Describe the structure of mitochondria and chloroplasts in eukaryotic cells.
2. Describe the fundamental roles of plastids (e.g., chloroplasts) and mitochondria in energy transformations.
3. Compare the basic transformations of energy during photosynthesis and cellular respiration.
4. Describe the structure of ATP.
5. Describe the role of ATP in biochemical reactions.

**ASSESSMENTS:**

Observation checklists  
Interviews and dialogue  
Group projects  
Individual projects  
Worksheets  
Model creation  
Writing responses  
Lab participation  
Lab reports  
Journal entries  
Presentations  
Quizzes  
Tests

**RESOURCES:**

Dragonfly Chapters 7-9  
Flexbook Chapters 3-4

**REMEDIATION:**

Small group instruction  
Individualized teacher support  
Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction



<b>COURSE: Biology</b>	<b>GRADE(S): 9</b>
<b>UNIT 4: Homeostasis and Transport</b>	<b>TIMEFRAME: ~10 days</b>

**PA ACADEMIC SECONDARY STANDARDS FOR BIOLOGY**

**Organisms and Cells Content Standards:**

- **3.1.B.A1.** Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts).
- **3.1.B.A2.** Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.
- **3.1.B.A3.** Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.
- **3.1.B.A4.** Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.
- **3.1.B.A5.** Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.
- **3.1.B.A6.** Explain how cells differentiate in multicellular organisms.
- **3.1.B.A7.** Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.
- **3.1.B.A8.** *CHANGE AND CONSTANCY* Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. *PATTERNS* Demonstrate the repeating patterns that occur in biological polymers. *SYSTEMS* Describe how the unique properties of water support life.

**Genetics Content Standards:**

- **3.1.B.B1.** Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.
- **3.1.B.B2.** Describe how the process of meiosis results in the information of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.
- **3.1.B.B3.** Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic

code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

- **3.1.B.B4.** Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.
- **3.1.B.B5. PATTERNS** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, co-dominant, sex-linked, polygenic, incomplete dominance, multiple alleles) **CONSTANCY AND CHANGE** Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.

#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO.A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

**Module B CONTINUITY and UNITY of LIFE**

**BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

**BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

**BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

**BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

**KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

**OBJECTIVES / ESSENTIAL KNOWLEDGE**

**Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.**

1. Describe how the structure of the plasma membrane allows it to function as a regulatory structure and/or protective barrier for a cell.

- The plasma membrane is a phospholipid bilayer that supports and protects a cell and controls what enters and what leaves the cell.
  - Phospholipids contain hydrophobic tails that face inward and hydrophilic heads that face outward.
  - Plasma membranes are sheet-like structures composed mainly of lipids and proteins.
    - a. Membrane lipids are organized in a bilayer (two sheets of lipids making up a single membrane).
    - b. The proteins, on the other hand, are scattered throughout the bilayer and perform most membrane functions.
    - c. Both lipids and proteins are constantly moving within the membrane.
  - The cell membrane is selectively permeable to ions and organic molecules and controls the movement of substances in and out of cells.
    - a. Controls what enters and leaves the cell
  - The basic function of the cell membrane is to protect the cell from its surroundings.
  - Other functions of the cell membrane:
    - a. cell adhesion
    - b. ion conductivity
    - c. cell signaling
    - d. serve as the attachment surface for several extracellular structures
2. Compare the mechanisms that transport materials across the plasma membrane (i.e., passive transport—diffusion, osmosis, facilitated diffusion; and active transport—pumps, endocytosis, exocytosis).
- The cell employs a number of transport mechanisms that involve biological membranes:
  - Passive Transport: substances move from an area of high concentration to an area of low concentration.
    - a. No energy is required to move from high to low concentrations. Types of passive transport: Diffusion: Some substances (small molecules, ions) such as carbon dioxide ( $\text{CO}_2$ ), oxygen ( $\text{O}_2$ ), and water, can move across the plasma membrane. Osmosis: is the diffusion of water from areas of high concentration to areas of low concentration. Facilitated diffusion: is the spontaneous passage of molecules or ions across a biological membrane passing through specific trans-membrane integral proteins. The facilitated diffusion may occur either across biological membranes or through aqueous compartments of an organism.
  - Polar molecules and charged ions are dissolved in water but they cannot diffuse freely across the plasma membrane due to the hydrophobic (water fearing) nature of the fatty acid tails of phospholipids that make up the lipid bilayers.
  - Only small nonpolar molecules, such as oxygen can diffuse easily across the membrane.
  - This process does NOT use energy – molecules travel from areas of high to low concentration.
  - Active transport requires energy from the cell. It occurs when substances move from areas of lower to higher concentration or when very large molecules are transported.
  - Types of active transport include ion pumps, such as the sodium-potassium pump, and vesicle transport, which includes endocytosis and exocytosis
  - Sodium-potassium pumps: is responsible for cells containing relatively high concentrations of potassium ions but low concentrations of sodium ions.
    - a. The pump, while binding ATP, binds 3 intracellular  $\text{Na}^+$  ions.
    - b. A change in the pump exposes the  $\text{Na}^+$  ions to the outside, so they are released.
    - c. The pump binds 2 extracellular  $\text{K}^+$  ions - transporting the  $\text{K}^+$  ions into the cell.
    - d. The pump has a higher affinity for  $\text{Na}^+$  ions than  $\text{K}^+$  ions, so the two bound  $\text{K}^+$  ions are released.
    - e. ATP binds, and the process starts again.
  - Endocytosis: is the process in which cells absorb molecules by engulfing them.
    - a. The plasma membrane creates a small deformation inward, called an invagination, in which the substance to be transported is captured.
    - b. The deformation then pinches off from the membrane on the inside of the cell,

- creating a vesicle containing the captured substance.
    - c. Two types of endocytosis: Phagocytosis - cell eating -small molecules and ions / Pinocytosis - cell drinking
  - Exocytosis: occurs in various cells to remove undigested residues of substances brought in by endocytosis.
    - a. Secrete substances such as hormones and enzymes, and to transport a substance completely across a cellular barrier.
  - Cell transport helps cells maintain homeostasis by keeping conditions within the normal ranges inside all of an organism's cells.
- 3. Describe how membrane bound cellular organelles (e.g., endoplasmic reticulum, Golgi apparatus) facilitate the transport of materials within a cell.
  - Endoplasmic reticulum: the transportation system of the eukaryotic cell.
    - a. Secretory proteins are moved across the endoplasmic reticulum membrane.
    - b. Proteins that are destined for places outside the endoplasmic reticulum are packed into transport vesicles and moved along the cytoskeleton toward their destination.
  - Golgi apparatus: The vesicles that leave the rough endoplasmic reticulum are transported to the Golgi apparatus, where they fuse with the Golgi membrane and empty their contents into the lumen.
    - a. The Golgi complex modifies many products from the ER including proteins and phospholipids.
    - b. The complex also manufactures certain biological polymers of its own.
    - c. Once modifications have been made and molecules have been sorted, they are secreted from the Golgi via transport vesicles to their intended destinations.
    - d. Some of the molecules are destined for the cell membrane where they aid in membrane repair and intercellular signaling. Other molecules are secreted to areas outside of the cell. Still other vesicles contain enzymes that digest cellular components; these are called lysosomes.
  - Vesicles transport molecules throughout the cell.
  - Vacuoles store extra materials in the cell.

**Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.**

1. Explain how organisms maintain homeostasis (e.g., thermoregulation, water regulation, oxygen regulation).
  - Cell transport helps cells maintain homeostasis by keeping conditions within normal ranges inside an organism's cells.
  - The human body is regulated by mechanisms that involve organs, glands, tissues and cells.
  - Internal body temperature of humans should be around 98.6 F. Humans maintain body temperature by:
    - a. Behavior - where we consciously change our behavior
    - b. Physiology - our body automatically alters its functioning without conscious control (such as shivering and sweating).
  - The body relies upon a constant fluid level to ensure metabolic reactions within cells can proceed.
    - a. Gases, nutrients, ions, hormones and wastes are carried in body fluids.
    - b. Water is continually being lost from the body in a variety of ways, for example through sweat and urine.
    - c. When water is lost from any of the body fluids, dissolved solutes (typically waste products) become more concentrated and water is less concentrated.
  - Single-celled organisms rely upon their cell membrane to regulate diffusion of essential molecules.

<p><b>ACTIVITIES:</b></p> <ol style="list-style-type: none"> <li>1. Describe how the structure of the plasma membrane allows it to function as a regulatory structure and/or protective barrier for a cell.</li> <li>2. Compare and contrast active vs. passive transport mechanisms.</li> <li>3. Describe how membrane-bound cellular organelles facilitate intracellular transport of materials.</li> <li>4. Identify and explain mechanisms organism use to maintain homeostasis.</li> </ol> <p><b>RESOURCES:</b> Dragonfly Chapters 1, 7 Flexbook Chapter 3 Section 3</p>	<p><b>ASSESSMENTS:</b> Observation checklists Interviews and dialogue Group projects Individual projects Worksheets Model creation Writing responses Lab participation Lab reports Journal entries Presentations Quizzes Tests</p> <p><b>REMEDIATION:</b> Small group instruction Individualized teacher support Web-based reinforcement activities Peer tutoring Chunking of information</p> <p><b>ENRICHMENT:</b> Research Opportunities Independent Investigations Case Study Individualized teacher support Small group enrichment instruction</p>
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<b>COURSE: Biology</b>	<b>GRADE(S): 9</b>
<b>UNIT 5: Cell Growth and Reproduction</b>	<b>TIMEFRAME: ~15 days</b>

**PA ACADEMIC SECONDARY STANDARDS FOR BIOLOGY**

**Organisms and Cells Content Standards:**

- **3.1.B.A1.** Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts).
- **3.1.B.A2.** Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.
- **3.1.B.A3.** Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.
- **3.1.B.A4.** Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.
- **3.1.B.A5.** Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.
- **3.1.B.A6.** Explain how cells differentiate in multicellular organisms.
- **3.1.B.A7.** Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.
- **3.1.B.A8.** *CHANGE AND CONSTANCY* Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. *PATTERNS* Demonstrate the repeating patterns that occur in biological polymers. *SYSTEMS* Describe how the unique properties of water support life.

**Genetics Content Standards:**

- **3.1.B.B1.** Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.
- **3.1.B.B2.** Describe how the process of meiosis results in the information of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.
- **3.1.B.B3.** Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic

code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

- **3.1.B.B4.** Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.
- **3.1.B.B5. PATTERNS** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, co-dominant, sex-linked, polygenic, incomplete dominance, multiple alleles) **CONSTANCY AND CHANGE** Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.

#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO. A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.



- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

### **Module B CONTINUITY and UNITY of LIFE**

#### **BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

#### **BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

#### **BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

#### **BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

### **KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

### **OBJECTIVES / ESSENTIAL KNOWLEDGE**

#### **Describe relationships between structure and function at biological levels of organization.**

1. Compare cellular structures and their functions in prokaryotic and eukaryotic cells.
  - Discoveries about cells using the microscope led to the development of the cell theory. This

theory states that all organisms are made of one or more cells, cells form the basic units of structure and function for living things, and all cells come from pre-existing cells.

- Cells have a maximum size limit. Their small size gives them a relatively large ratio of surface area to volume, facilitating the transfer of substances. The shapes of cells may vary, and a cell's shape generally suits its function.
  - Cells are diverse, but all cells contain a plasma membrane, cytoplasm, and DNA.
  - Prokaryotic cells are cells without a nucleus. In general, this includes bacteria, which are unicellular organisms.
  - Eukaryotic cells are cells with a nucleus. Examples of eukaryotic cells include multicellular organisms such as plants, animals, and fungi as well as unicellular organisms such as protists.
2. Describe and interpret relationships between structure and function at various levels of biological organization (i.e., organelles, cells tissues, organs, organ systems, and multicellular organisms).
- The plasma membrane is a phospholipid bilayer that supports and protects a cell and controls what enters and leaves it.
  - The cytoplasm consists of everything inside the plasma membrane, including watery cytosol and organelles. The cytoplasm suspends the organelles and acts as the site for various chemical reactions. The cytoskeleton crisscrosses the cytoplasm and gives the cell an internal framework.
  - The nucleus is the largest organelle in a eukaryotic cell and contains most of the cell's DNA. Other organelles in eukaryotic cells include the mitochondria, endoplasmic reticulum, ribosomes, Golgi apparatus, vesicles, vacuoles, and centrioles (in animal cells only). Each type of organelle has important functions in the cell.
  - Plant cells have special structures that are not found in animal cells, including a cell wall, a large central vacuole, and organelles called plastids.
  - Cells can exist independently as single-celled organisms or with other cells as multicellular organisms. Cells of a multicellular organism can be organized at the level of cells, tissues, organs, and organ systems.

**Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.**

1. Describe the events that occur during the cell cycle: interphase, nuclear division (i.e., mitosis or meiosis), cytokinesis.
- Cell division is part of the life cycle of virtually all cells. It is a more complicated process in eukaryotic than prokaryotic cells because eukaryotic cells have multiple chromosomes and a nucleus.
  - The cell cycle is a repeating series of events that cells go through. It includes growth (G1), DNA synthesis (S), preparation for division (G2) and cell division (M). In eukaryotic cells, there are two growth phases, and cell division includes mitosis
  - The cell cycle is controlled by regulatory proteins at three key checkpoints in the cycle. The proteins signal the cell to either start or delay the next phase of the cycle.
  - Cell division in eukaryotic cells includes mitosis, in which the nucleus divides, and cytokinesis, in which the cytoplasm divides and daughter cells form.
  - Mitosis occurs in four phases, called prophase, metaphase, anaphase, and telophase.
  - Interphase- This is the longest phase of the cell cycle which includes the periods between divisions. The stages of interphase include G1, S, and G2 phase.
    - a. G1 Phase: Cell grows
    - b. S Phase: DNA is copied
    - c. G2 Phase: Cell continues to grow, organelles are copied
  - Mitosis:
    - a. Prophase: Spindle fibers form, nuclear envelope dissolves, chromosomes become visible
    - b. Metaphase: Chromosomes align at the cell's equator, spindle fibers attach to chromosomes
    - c. Anaphase: Spindle fibers pull chromatids apart at centromere, chromatids move to opposite poles
    - d. Telophase: The nuclear envelope reforms and chromosomes unwind.
  - Meiosis

- a. Prophase I: Chromosomes become visible, Nuclear envelope disappears, Crossing over occurs. Crossing over is essential to creating variability in sexually reproducing organisms; chromatid cross over on homologous chromosomes to exchange genetic information.
  - b. Metaphase I: Homologous chromosomes move to equator
  - c. Anaphase I: Homologous chromosomes move to opposite poles
  - d. Telophase I: Cytoplasm divides
  - e. Prophase II: New spindle fibers form around the chromosomes
  - f. Metaphase II: Chromosomes align at the equator
  - g. Anaphase II: Centromeres divide, Chromatids move to opposite poles
  - h. Telophase II: Nuclear envelope reforms around each set of chromosomes,
  - Cytokinesis: Splitting of the cell membrane into two separate cells; divides cytoplasm.
2. Compare and contrast the processes and outcomes of mitotic and meiotic nuclear divisions.
    - Mitosis- One division into two identical diploid cells.
    - Meiosis- Reduction division (Two divisions) 4 haploid cells result.
    - Mitosis is associated with asexual reproduction, as well as growth and repair in sexually reproducing organisms. Asexual reproduction involves one parent and produces offspring that are genetically identical to each other and to the parent.
    - Meiosis is a special type of cell division that produces gametes with half as many chromosomes.
    - Sexual reproduction involves two parents and produces offspring that are genetically unique.
    - During sexual reproduction, two haploid gametes join in the process of fertilization to produce a diploid zygote. Sexual reproduction has the potential to produce tremendous genetic variation in offspring. This variation is due to independent assortment and crossing-over during meiosis and random union of gametes during fertilization.
    - A life cycle is the sequence of stages an organism goes through from one generation to the next. Organisms that reproduce sexually can have different types of life cycles, such as haploid or diploid life cycles.

**Explain how genetic information is inherited.**

1. Describe how the process of DNA replication results in the transmission and/or conservation of genetic information.
  - DNA replication: Process of making an exact copy of DNA which occurs in the S phase of the cell cycle.
  - Chromosomes are coiled structures made of DNA and proteins. They form after DNA replicates and are the form in which the genetic material goes through cell division. Chromosomes contain genes, which code for proteins.
  - The central dogma of molecular biology states that DNA contains instructions for making a protein, which are copied by RNA. RNA then uses the instructions to make a protein. In short: DNA → RNA → Protein.
  - The work of several researchers led to the discovery that DNA is the genetic material. Other researchers discovered that DNA has a double helix shape, consisting of two polynucleotide chains held together by bonds between complementary bases.
  - DNA is replicated in a semi-conservative fashion, with the original parent strands serving as the template for the newly replicated strands. The DNA copies are then "checked" by various enzymes, including DNA polymerase, to ensure accuracy.
2. Explain the functional relationships between DNA, genes, alleles, and chromosomes and their roles in inheritance.
  - Chromosomes are coiled structures made of DNA and proteins. They form after DNA replicates and are the form in which the genetic material goes through cell division. Chromosomes contain genes, which code for proteins. Alleles are different forms of the same gene.
  - Chromosomes are long strands of DNA
  - DNA is the genetic material that codes for the hereditary traits of organisms.
  - Genes are segments of DNA that are located on a chromosome and code for a specific

hereditary trait.

- Alleles are alternative forms of a gene that govern a characteristic, such as hair color.

**ACTIVITIES:**

1. Describe the structure of mitochondria and chloroplasts in eukaryotic cells.
2. Describe the fundamental roles of plastids (e.g., chloroplasts) and mitochondria in energy transformations.
3. Compare the basic transformations of energy during photosynthesis and cellular respiration.
4. Describe the structure of ATP.
5. Describe the role of ATP in biochemical reactions.
6. Identify and explain mechanisms organism use to maintain homeostasis.
7. Describe the events that occur during the cell cycle.
8. Compare and contrast the processes and outcomes of mitotic and meiotic nuclear divisions.
9. Describe processes that can alter composition or number of chromosomes (chromosomal mutations).

**RESOURCES:**

Dragonfly Chapters 10, 11-4  
Flexbook Chapter 5

**ASSESSMENTS:**

Observation checklists  
Interviews and dialogue  
Group projects  
Individual projects  
Worksheets  
Model creation  
Writing responses  
Lab participation  
Lab reports  
Journal entries  
Presentations  
Quizzes  
Tests

**REMEDIATION:**

Small group instruction  
Individualized teacher support  
Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction

<b>COURSE: Biology</b>	<b>GRADE(S): 9</b>
<b>UNIT 6: Genetics</b>	<b>TIMEFRAME: ~40 days</b>

**PA ACADEMIC SECONDARY STANDARDS FOR BIOLOGY**

**Organisms and Cells Content Standards:**

- **3.1.B.A1.** Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts).
- **3.1.B.A2.** Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.
- **3.1.B.A3.** Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.
- **3.1.B.A4.** Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.
- **3.1.B.A5.** Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.
- **3.1.B.A6.** Explain how cells differentiate in multicellular organisms.
- **3.1.B.A7.** Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.
- **3.1.B.A8.** *CHANGE AND CONSTANCY* Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. *PATTERNS* Demonstrate the repeating patterns that occur in biological polymers. *SYSTEMS* Describe how the unique properties of water support life.

**Genetics Content Standards:**

- **3.1.B.B1.** Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.
- **3.1.B.B2.** Describe how the process of meiosis results in the information of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.
- **3.1.B.B3.** Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic

code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

- **3.1.B.B4.** Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.
- **3.1.B.B5. PATTERNS** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, co-dominant, sex-linked, polygenic, incomplete dominance, multiple alleles) **CONSTANCY AND CHANGE** Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.

#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO. A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

### **Module B CONTINUITY and UNITY of LIFE**

#### **BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

#### **BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

#### **BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

#### **BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

### **KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

### **OBJECTIVES / ESSENTIAL KNOWLEDGE**

#### **Compare Mendelian and non-Mendelian patterns of inheritance.**

1. Describe and/or predict observed patterns of inheritance (i.e., dominant, recessive, co-dominance, incomplete dominance, sex-linked, polygenic, and multiple alleles).

- Gregor Mendel experimented with pea plants to learn how characteristics are passed from parents to offspring.
- Probability is the chance that a certain event will occur. For example, the probability of a head turning up on any given coin toss is 50 percent.
- Probability can be used to predict the chance of gametes and offspring having certain alleles.
- Punnett squares are used to predict the appearance of the offspring produced from two known parents.
- Dominant genes are those that are always expressed if they are present in an organism's genotype. Recessive genes are those that are only expressed if dominant genes aren't present.
- The genotype is the pair of alleles that an organism receives from its parents. (Example: AA, Aa, aa)
- Homozygous genotype: a genotype in which the alleles are the same (Ex: AA – Homozygous dominant, aa – Homozygous recessive)
- Heterozygous genotype: a genotype in which the alleles are different (Ex: Aa)
- The phenotype is the physical expression of the pair of alleles for a specific trait. (Example: Purple flowers or white flowers)
- Exceptions to simple inheritance:
  - a. Polygenic traits: traits that are determined by the combined effect of more than one pair of genes. The genes may be scattered along the same chromosome or located on different chromosomes. All polygenic traits tend to have varying degrees of intermediate conditions. Examples: Human hair color, eye color, height, weight
  - b. Incomplete dominance results in an intermediate expression of a trait in heterozygous individuals. For instance, in primroses, snapdragons, and four-o'clocks, red or white flowers are homozygous while pink ones are heterozygous. The pink flowers result because the single "red" allele is unable to code for the production of enough red pigment to make the petals dark red.
  - c. Co-dominance: Two dominant alleles are expressed at the same time. Both dominant phenotypes are expressed at the same time. Example: Human Blood Type – Parent one with AA blood type has a baby with parent two who has BB. They will have a child with AB blood type, because the A and B alleles are both dominant.
  - d. Multiple alleles: Genes with three or more alleles; an individual can have only two of the possible alleles for that gene. Example: Human blood type – A, B, or O alleles
  - e. Sex-linked traits: A gene that is found only on the X chromosome and not the Y chromosome. Though the sex chromosomes code for gender, they also contain genes coding for other traits. Because males only have one X chromosome, they are more likely to show a sex-linked recessive trait since they will only inherit one gene for that trait.

**Explain how genetic information is expressed.**

1. Describe how genetic mutations alter the DNA sequence and may or may not affect phenotype (e.g., silent, nonsense, frame shift).
  - Point mutations often caused by chemicals or malfunction of DNA replication, exchange a single nucleotide for another.
    - a. Insertion: add one or more extra nucleotides into the DNA. Alters the reading frame of the gene. They are usually caused by errors during replication of repeating elements. Example: Original strand ATCGAT; New strand ATCTGAT
    - b. Deletion: removal of one or more nucleotides from the DNA. Like insertions, these mutations can alter the reading frame of the gene. Example: Original strand ATCGAT; New strand ATAT
    - c. Substitution: one nucleotide is replaced with another. Example: Original strand ATCGAT; New strand ATCTAT
  - Effects of point mutations:
    - a. Silent mutations are DNA mutations that do not result in a change to the amino acid sequence of a protein, or that do result in amino acid change but do not



result in radically different properties of the changed amino acids. Because silent mutations do not alter protein function they are often treated as though they are evolutionarily neutral.

- b. Nonsense mutations are a point mutation in a sequence of DNA that results in a premature stop codon.
  - c. Missense mutations are a point mutation in which a single nucleotide is changed, resulting in a codon that codes for a different amino acid and tends to make the resulting protein nonfunctional.
  - d. Frameshift mutations will in general cause the reading of the codons after the mutation to code for different amino acids.
    - The frameshift mutation will also alter the first stop codon ("UAA", "UGA" or "UAG") encountered in the sequence.
- The polypeptide being created could be abnormally short or abnormally long, and will most likely not be functional.
  - Mutations are caused by environmental factors known as mutagens. Types of mutagens include radiation, chemicals, and infectious agents.
  - Germline mutations occur in gametes. Somatic mutations occur in other body cells. Chromosomal alterations are mutations that change chromosome structure.
  - Mutations are essential for evolution to occur because they increase genetic variation and the potential for individuals to differ. The majority of mutations are neutral in their effects on the organisms in which they occur.
  - Beneficial mutations may become more common through natural selection. Harmful mutations may cause genetic disorders or cancer.
2. Describe processes that can alter composition or number of chromosomes (i.e., crossing over, nondisjunction, duplication, translocation, deletion, insertion, and inversion).
- Crossing Over: the exchange of genetic material between homologous chromosomes that results in recombinant chromosomes.
  - Occurs during Prophase I of meiosis.
  - Crossing over usually occurs when matching regions on matching chromosomes break and then reconnect to the other chromosome.
  - This process shuffles the allele content between homologous chromosomes and creates more possible combinations of offspring outcomes.
  - Nondisjunction: is the failure of chromosome pairs to separate properly during meiosis, specifically in anaphase.
  - The result of this error is a gamete with an imbalance of chromosomes.
  - Loss of a single chromosome, in which the gamete with the defect will have one chromosome missing from one of its pairs, is referred to as a monosomy.
  - Other than Turner Syndrome (women who are missing one of a pair of X chromosomes), all other cases of full monosomy are lethal and the individual will not survive fetal development.
  - Gaining a single chromosome, in which the gamete with the defect will have one chromosome in addition to its 23 pairs is referred to as a trisomy. Example-Trisomy 21 (Down Syndrome)
  - Common chromosomal mutations:
    - Chromosomal deletion: Part or a whole chromosome is lost.
    - Duplication: leading to multiple copies of all chromosomal regions, increasing the dosage of the genes located within them. Example: Original strand ATCGAT New strand ATCATCGAT
    - Inversion: a segment of a chromosome is reversed end to end. An inversion occurs when a single chromosome undergoes breakage and rearrangement within itself. Example: Original strand ATCGAT New strand CTAGAT
    - Translocation: is a chromosome abnormality by rearrangement of parts between non-homologous chromosomes. A gene fusion may be created when the translocation joins two otherwise separated genes. The occurrence of which is common in cancer.
  - The human genome consists of about 3 billion base pairs of DNA. In 2003, the Human

Genome Project finished sequencing all 3 billion base pairs.

- Humans have 23 pairs of chromosomes. Of these, 22 pairs are autosomes. The X and Y chromosomes are the sex chromosomes. Females have two X chromosomes, and males have one X and one Y. Human chromosomes contain a total of 20,000 to 22,000 genes, the majority of which have two or more alleles.
- Linked genes are located on the same chromosome. Sex-linked genes are located on a sex chromosome, and X-linked genes are located on the X chromosome. The frequency of crossing-over between genes is used to construct linkage maps that show the locations of genes on chromosomes.
- A minority of human traits are controlled by single genes with two alleles. They have different inheritance patterns depending on whether they are controlled by autosomal or X-linked genes.
- Most human traits have complex modes of inheritance. They may be controlled by one gene with multiple alleles or by multiple genes. More complexity may be introduced by pleiotropy (one gene, multiple effect) and epistasis (gene-gene interactions).
- Many genetic disorders are caused by mutations in one or a few genes. Other genetic disorders are caused by abnormal numbers of chromosomes.

**Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).**

1. Describe how the processes of transcription and translation are similar in all organisms.

The process of transcription and translation occurs in all organisms.

- Transcription is the DNA → RNA part of the central dogma of molecular biology. It occurs in the nucleus. During transcription, a copy of mRNA is made that is complementary to a strand of DNA. In eukaryotes, mRNA may be modified before it leaves the nucleus.
- The genetic code consists of the sequence of bases in DNA or RNA. Groups of three bases form codons, and each codon stands for one amino acid (or start or stop). The codons are read in sequence following the start codon until a stop codon is reached. The genetic code is universal, unambiguous, and redundant.
- Translation is the RNA→protein part of the central dogma. It occurs at a ribosome. During translation, a protein is synthesized using the codons in mRNA as a guide. All three types of RNA play a role in translation.
- Describe the role of ribosomes, endoplasmic reticulum, Golgi apparatus, and the nucleus in the production of specific types of proteins.
  - a. Ribosomes: are found in both prokaryotes and eukaryotes.
    - i. The ribosome is a large complex composed of many molecules, including ribosomal RNAs and proteins.
    - ii. The ribosome molecules translate the mRNA genetic code to a specific sequence of amino acids that make up a protein is called translation.
    - iii. It is the "factory" where amino acids are assembled into proteins.
    - iv. tRNAs (small noncoding RNA chains) that transport amino acids to the ribosome.
    - v. tRNAs have a site for amino acid attachment, and a site called an anticodon.
    - vi. The anticodon is an RNA triplet complementary to the mRNA triplet that codes for their cargo amino acid.
  - b. Endoplasmic reticulum: only found in eukaryotic cells.
    - i. The ribosome binds to the outer membrane of the rough endoplasmic reticulum
    - ii. The polypeptide chain that is produced by the ribosome is then released into the endoplasmic reticulum.
    - iii. The ER then transports the polypeptide chain to the area of the cell where it will be used.
  - c. Golgi Apparatus: is composed of flattened fluid-filled sacs that controls the flow of molecules in a cell.
    - i. Produces a product called glycoprotein.
    - ii. Carbohydrates are added to freshly translated proteins to complete its production.
    - iii. These newly formed glycoproteins (proteins with added carbohydrates) are

used in a variety of ways, and in light of this, there is a wide variety of proteins in relation to their function.

- d. This finished product, glycoprotein, is 'pinched off' the Golgi apparatus, and is transported by a vesicle of the cell membrane.
- e. When this vesicle reaches the cell membrane, it binds to a receptor on the surface and excretes the protein, where it can then undergo its function.
- d. Nucleus: directs protein synthesis by synthesizing messenger RNA (mRNA) according to instructions provided by the DNA.

**Apply scientific thinking, processes, tools, and technologies in the study of genetics.**

1. Explain how genetic engineering has impacted the fields of medicine, forensics, and agriculture (e.g., selective breeding, gene splicing, cloning, genetically modified organisms, gene therapy).
  - Selective Breeding: is the process of breeding plants and animals for particular traits.
    - Benefits: high crop yields; resistance to disease; high growth rate; improved medicinal production
    - Negative impacts: The other animals or plants become redundant and unnecessary; Possible genetic problems; animals may become sick easier; disrupts the food chain and the natural order of life.
  - Gene splicing: cutting the DNA from one organism and attaching it to the DNA of another organism causing the host organism to demonstrate a new phenotype. Example: attaching the insulin gene to bacteria to mass produce the drug.
  - Cloning: is the process of producing similar populations of genetically identical individuals that occurs in nature when organisms reproduce asexually. Gene cloning is the process of isolating and making copies of a DNA segment such as a gene. The polymerase chain reaction makes many copies of a gene or other DNA segment.
  - Gene therapy: DNA can be used to supplement or alter genes within an individual's cells as a therapy to treat disease.
  - Stem cell therapy: an intervention strategy that introduces new adult stem cells into damaged tissue in order to treat disease or injury.
  - Biotechnology can be used to transform bacteria so they are able to make human proteins, such as insulin. It can also be used to create transgenic crops, such as crops that yield more food or resist insect pests.
  - Biotechnology has raised a number of ethical, legal, and social issues. For example, are genetically modified foods safe to eat, and who controls a person's genetic information?

<p><b>ACTIVITIES:</b></p> <ol style="list-style-type: none"> <li>1. Describe how DNA replication results in the transmission and/or conservation of the genetic information.</li> <li>2. Explain the structural relationships between DNA, genes, and chromosomes.</li> <li>3. Explain the unified process of protein synthesis.</li> <li>4. Describe the role of nucleus ribosomes, ER, and Golgi apparatus in the production and processing of proteins.</li> <li>5. Describe how genetic mutations alter DNA sequence and may or may not affect phenotype.</li> <li>6. Describe and/or predict observed</li> </ol>	<p><b>ASSESSMENTS:</b></p> <p>Observation checklists            Group and individual projects            Worksheets            Model creation            Writing responses            Lab participation            Lab reports            Journal entries            Presentations            Quizzes            Tests</p> <p><b>REMEDIATION:</b></p> <p>Small group instruction            Individualized teacher support</p>
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- patterns of inheritance.
7. Explain how genetic engineering has impacted the fields of medicine, forensics, and agriculture.

**RESOURCES:**

Dragonfly Chapters 9, 11-14  
Flexbook Chapters 6-8

Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction

<b>COURSE: Biology</b>	<b>GRADE(S): 9</b>
<b>UNIT 7: Theory of Evolution</b>	<b>TIMEFRAME: ~25 days</b>

**PA ACADEMIC SECONDARY STANDARDS FOR BIOLOGY**

**Organisms and Cells Content Standards:**

- **3.1.B.A1.** Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts).
- **3.1.B.A2.** Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.
- **3.1.B.A3.** Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.
- **3.1.B.A4.** Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.
- **3.1.B.A5.** Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.
- **3.1.B.A6.** Explain how cells differentiate in multicellular organisms.
- **3.1.B.A7.** Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.
- **3.1.B.A8.** *CHANGE AND CONSTANCY* Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. *PATTERNS* Demonstrate the repeating patterns that occur in biological polymers. *SYSTEMS* Describe how the unique properties of water support life.

**Genetics Content Standards:**

- **3.1.B.B1.** Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.
- **3.1.B.B2.** Describe how the process of meiosis results in the information of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.
- **3.1.B.B3.** Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic

code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

- **3.1.B.B4.** Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.
- **3.1.B.B5. PATTERNS** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, co-dominant, sex-linked, polygenic, incomplete dominance, multiple alleles) **CONSTANCY AND CHANGE** Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.

#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO. A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

**Module B CONTINUITY and UNITY of LIFE**

**BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

**BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

**BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

**BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

**KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

**OBJECTIVES / ESSENTIAL KNOWLEDGE**

**Explain the mechanisms of evolution.**

1. Explain how natural selection can impact allele frequencies of a population.
  - Natural selection can increase the frequencies of alleles if they are advantageous to a species' survival and reproductive abilities.

- If they somehow produce a phenotype that is not a selective advantage, their frequency will decrease.
  - The change in allelic frequencies is one way of defining evolution.
  - A population evolves as "better" alleles increase in frequency in the gene pool.
2. Describe the factors that can contribute to the development of new species (e.g., isolating mechanisms, genetic drift, founder effect, migration).
- Reproductive isolation: Factors which prevent individuals from mating.
    - a. Geographic isolation: Species occur in different areas, and are often separated by terrestrial and aquatic barriers.
    - b. Temporal isolation: Individuals do not mate because they are reproductively active at different times.
    - c. Ecological isolation: Individuals only mate in their preferred habitat. They do not encounter individuals of other species with different ecological preferences.
    - d. Behavioral isolation: Individuals of different species may meet, but one does not recognize any sexual cues that may be given.
  - Genetic Drift: In each generation, some individuals may, just by chance, leave behind a few more descendants (and genes, of course!) than other individuals. The genes of the next generation will be the genes of the "lucky" individuals, not necessarily the healthier or "better" individuals.
    - a. Effects of genetic drift: Drift reduces genetic variation in populations, potentially reducing a population's ability to evolve in response to new selective pressures.
    - b. Genetic drift acts faster and has more drastic results in smaller populations. This effect is particularly important in rare and endangered species.
    - c. Genetic drift can contribute to speciation. For example, a small isolated population may diverge from the larger population through genetic drift.
    - d. Reduced genetic variation means that the population may not be able to adapt to new selection pressures, such as climatic change or a shift in available resources, because the genetic variation that selection would act on may have already drifted out of the population.
  - The Founder Effect: The founder effect occurs when a pioneer group of organisms leaves its original population and colonizes a new area.
    - a. Factors affecting this group are often more significant because the group has a smaller population, less genetic variation, and different environmental conditions to which they adapt.
3. Explain how genetic mutations may result in genotypic and phenotypic variations within a population.
- Mutations are a change in genetic material that results from an error in replication of DNA. Mutations can be beneficial, harmful, or neutral.
  - Mutations are caused by environmental factors known as mutagens. Types of mutagens include radiation, chemicals, and infectious agents.
  - Mutations are essential for evolution to occur because they increase genetic variation and the potential for individuals to differ. The majority of mutations are neutral in their effects on the organisms in which they occur.
  - Beneficial mutations may become more common through natural selection. Harmful mutations may cause genetic disorders or cancer.
  - Most human traits have complex modes of inheritance. They may be controlled by one gene with multiple alleles or by multiple genes. More complexity may be introduced by pleiotropy (one gene, multiple effect) and epistasis (gene-gene interactions).
  - Many genetic disorders are caused by mutations in one or a few genes. Other genetic disorders are caused by abnormal numbers of chromosomes.

**Analyze the sources of evidence for biological evolution.**

1. Interpret evidence supporting the theory of evolution (i.e., fossil, anatomical, physiological, embryological, biochemical, and universal genetic code).



- Scientists compare the anatomy, embryos, and DNA of living things to understand how they evolved.
  - a. Evidence for evolution is provided by homologous structures. These are structures shared by related organisms that were inherited from a common ancestor.
  - b. Other evidence is provided by analogous structures. These are structures that unrelated organisms share because they evolved to do the same job.
- Fossils show a pattern of development from early ancestors to modern descendants. Fossils provide a window into the past. They are evidence for evolution. Scientists who find and study fossils are called paleontologists.
  - a. Most direct evidence that evolution takes place.
  - b. Provides an actual record of Earth's past life-forms.
  - c. Change over time can be seen in the fossil record.
- Anatomical: comparisons of the different types of organisms often reveal basic similarities in body structures even though the structure's function may differ between organisms.
  - a. Vestigial structures: remnant structures present in organisms, but are reduced in size and either have no or little function than in other related species. Examples: Human appendix, whale hip bone
  - b. Homologous structures: structures derived from a common ancestor or same evolutionary or developmental origin.
- Embryological:
  - a. At some time in development, all vertebrates have a tail, buds that become limbs, and pharyngeal pouches.
- Biochemical:
  - a. With the increase of anatomical differences, protein and DNA differences also increase; however, many organisms share a high percentage of their DNA, indicating a common origin for life.
- Molecular clocks are used to estimate how long it has been since two species diverged from a common ancestor. These are based on known mutations rates that cause slight differences in DNA.
- Much of what we know about the history of life on Earth is based on the fossil record.
- The geologic time scale is another important tool for understanding the history of life on Earth. It divides Earth's history into evolutionary time which marks major events such as extinctions and the rise of new life forms. The geologic time scale is broken into eons, eras, periods, and epochs based on major events that have occurred in Earth's history.
- Origins of Life
  - The first organic molecules formed about 4 billion years ago. This may have happened when lightning sparked chemical reactions in Earth's early atmosphere. RNA may have been the first organic molecule to form as well as the basis of early life. (See Miller and Urey)
  - The first cells consisted of little more than an organic molecule such as RNA inside a lipid membrane or proteinoid sphere (varied hypotheses). The last universal common ancestor (LUCA), gave rise to all subsequent life on Earth.
  - Photosynthesis evolved by 3 billion years ago and released oxygen into the atmosphere. Cellular respiration evolved after that to make use of the oxygen.
  - Eukaryotic cells probably evolved about 2 billion years ago. Their evolution is explained by endosymbiotic theory. Eukaryotic cells would go on to evolve into the diversity of eukaryotes we know today.
  - Biogeography is the study of how and why plants and animals live where they do. It also provides evidence for evolution. On island chains, such as the Galápagos, one species may evolve into many new species to fill available niches. This is called adaptive radiation.

**ACTIVITIES:**

1. Explain how natural selection can impact allele frequencies of a population.
2. Describe the factors that can contribute to the development of a new species.
3. Explain how genetic mutations may result in genotypic and phenotypic variations with in a population.
4. Interpret evidence supporting the theory of evolution.
5. Use scientific terms properly in written and oral form.

**RESOURCES:**

Dragonfly Chapters 15-17  
Flexbook Chapters 9-10

**ASSESSMENTS:**

Observation checklists  
Group and individual projects  
Worksheets  
Model creation  
Writing responses  
Lab participation  
Lab reports  
Journal entries  
Presentations  
Quizzes  
Tests

**REMEDIATION:**

Small group instruction  
Individualized teacher support  
Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction

<b>COURSE: Biology</b>	<b>GRADE(S): 9</b>
<b>UNIT 8: Ecology</b>	<b>TIMEFRAME: ~25 days</b>

**PA ACADEMIC SECONDARY STANDARDS FOR BIOLOGY**

**Organisms and Cells Content Standards:**

- **3.1.B.A1.** Describe the common characteristics of life. Compare and contrast the cellular structures and degrees of complexity of prokaryotic and eukaryotic organisms. Explain that some structures in eukaryotic cells developed from early prokaryotic cells (e.g., mitochondria, chloroplasts).
- **3.1.B.A2.** Identify the initial reactants, final products, and general purposes of photosynthesis and cellular respiration. Explain the important role of ATP in cell metabolism. Describe the relationship between photosynthesis and cellular respiration in photosynthetic organisms. Explain why many biological macromolecules such as ATP and lipids contain high energy bonds. Explain the importance of enzymes as catalysts in cell reactions. Identify how factors such as pH and temperature may affect enzyme function.
- **3.1.B.A3.** Explain how all organisms begin their life cycles as a single cell and that in multicellular organisms, successive generations of embryonic cells form by cell division.
- **3.1.B.A4.** Summarize the stages of the cell cycle. Examine how interactions among the different molecules in the cell cause the distinct stages of the cell cycle which can also be influenced by other signaling molecules. Explain the role of mitosis in the formation of new cells and its importance in maintaining chromosome number during asexual reproduction. Compare and contrast a virus and a cell. Relate the stages of viral cycles to the cell cycle.
- **3.1.B.A5.** Relate the structure of cell organelles to their function (energy capture and release, transport, waste removal, protein synthesis, movement, etc). Explain the role of water in cell metabolism. Explain how the cell membrane functions as a regulatory structure and protective barrier for the cell. Describe transport mechanisms across the plasma membrane.
- **3.1.B.A6.** Explain how cells differentiate in multicellular organisms.
- **3.1.B.A7.** Analyze the importance of carbon to the structure of biological macromolecules. Compare and contrast the functions and structures of proteins, lipids, carbohydrates, and nucleic acids. Explain the consequences of extreme changes in pH and temperature on cell proteins.
- **3.1.B.A8.** *CHANGE AND CONSTANCY* Recognize that systems within cells and multicellular organisms interact to maintain homeostasis. *PATTERNS* Demonstrate the repeating patterns that occur in biological polymers. *SYSTEMS* Describe how the unique properties of water support life.

**Genetics Content Standards:**

- **3.1.B.B1.** Explain that the information passed from parents to offspring is transmitted by means of genes which are coded in **DNA** molecules. Explain the basic process of **DNA** replication. Describe the basic processes of transcription and translation. Explain how crossing over, jumping genes, and deletion and duplication of genes results in genetic variation. Explain how **mutations** can alter genetic information and the possible consequences on resultant cells.
- **3.1.B.B2.** Describe how the process of meiosis results in the information of haploid gametes and analyze the importance of meiosis in sexual reproduction. Compare and contrast the function of mitosis and meiosis. Illustrate that the sorting and recombining of genes in sexual reproduction results in a great variety of possible gene combinations in offspring.
- **3.1.B.B3.** Describe the basic structure of DNA, including the role of hydrogen bonding. Explain how the process of DNA replication results in the transmission and conservation of the genetic

code. Describe how transcription and translation result in gene expression. Differentiate among the end products of replication, transcription, and translation. Cite evidence to support that the genetic code is universal.

- **3.1.B.B4.** Explain how genetic technologies have impacted the fields of medicine, forensics, and agriculture.
- **3.1.B.B5. PATTERNS** Describe how Mendel's laws of segregation and independent assortment can be observed through patterns of inheritance. Distinguish among observed inheritance patterns caused by several types of genetic traits (dominant, recessive, co-dominant, sex-linked, polygenic, incomplete dominance, multiple alleles) **CONSTANCY AND CHANGE** Explain how the processes of replication, transcription, and translation are similar in all organisms. Explain how gene actions, patterns of heredity, and reproduction of cells and organisms account for the continuity of life. **SCALE** Demonstrate how inherited characteristics can be observed at the molecular, cellular, and organism levels.

#### **Evolution Content Standards:**

- **3.1.B.C1.** Describe species as reproductively distinct groups of organisms. Analyze the role that geographic isolation can play in speciation. Explain how evolution through natural selection can result in changes in biodiversity through the increase or decrease of genetic diversity within a population. Describe how the degree of kinship between species can be inferred from the similarity in their DNA sequences.
- **3.1.B.C2.** Describe the theory suggesting that life on Earth arose as a single, primitive prokaryote about 4 billion years ago and that for the next 2 billion years, a huge diversity of single celled organisms evolved. Analyze how increasingly complex, multicellular organisms evolved once cells with nuclei developed. Describe how mutations in sex cells may be passed on to successive generations and that the resulting phenotype may help, harm, or have little or no effect on the offspring's success in its environment. Describe the relationship between environmental changes and changes in the gene pool of a population.
- **3.1.B.C3. CONSTANCY AND CHANGE** Compare and contrast various theories of evolution. Interpret data from fossil records, anatomy and physiology, and DNA studies relevant to the theory of evolution. **PATTERNS** Discuss the implications of a universal genetic code for evolution.

#### **KEYSTONE ASSESSMENT ANCHORS**

##### **Module A CELLS and CELL PROCESSES**

##### **BIO.A.1 - Basic Biological Principles**

- A.1.1. Explain the characteristics common to all organisms.
- A.1.2. Describe relationships between structure and function at biological levels of organization.

##### **BIO.A.2 - The Chemical Basis for Life**

- A.2.1. Describe how the unique properties of water support life on Earth.
- A.2.2. Describe and interpret relationships between structure and function at various levels of biochemical organization (i.e., atoms, molecules, and macromolecules).
- A.2.3. Explain how enzymes regulate biochemical reactions within a cell.

##### **BIO. A.3 - Cells and Cell Processes**

- A.3.1. Identify and describe the cell structures involved in processing energy.
- A.3.2. Identify and describe how organisms obtain and transform energy for their life processes.

##### **BIO.A.4 - Homeostasis and Transport**

- A.4.1. Identify and describe the cell structures involved in transport of materials into, out of, and throughout a cell.

- A.4. 2. Explain mechanisms that permit organisms to maintain biological balance between their internal and external environments.

**Module B CONTINUITY and UNITY of LIFE**

**BIO.B.1 - Cell Growth and Reproduction**

- B.1. 1. Describe the three stages of the cell cycle: interphase, nuclear division, cytokinesis.
- B.1. 2. Explain how genetic information is inherited.

**BIO.B.2 - Genetics**

- B.2.1. Compare Mendelian and non-Mendelian patterns of inheritance.
- B.2.2. Explain the process of protein synthesis (i.e., transcription, translation, and protein modification).
- B.2.3. Explain how genetic information is expressed.
- B.2.4. Apply scientific thinking, processes, tools, and technologies in the study of genetics.

**BIO.B.3 - Theory of Evolution**

- B.3. 1. Explain the mechanisms of evolution.
- B.3. 2. Analyze the sources of evidence for biological evolution.
- B.3. 3. Apply scientific thinking, processes, tools, and technologies in the study of the theory of evolution.

**BIO.B.4 - Ecology**

- B.4. 1. Describe ecological levels of organization in the biosphere.
- B.4. 2. Describe interactions and relationships in an ecosystem.

**KEY CONCEPTS**

1. Organisms share common characteristics of life.
2. New cells arise from the division of pre-existing cells.
3. Hereditary information in genes is inherited and expressed.
4. Evolution is the result of many random processes selecting for the survival and reproduction of a population.
5. Life emerges due to the chemical organization of matter into cells.
6. Cells have organized structures and systems necessary to support chemical reactions needed to maintain the living condition.
7. Structure is related to function at all biological levels of organization.
8. Through a variety of mechanisms organisms seek to maintain a biological balance between their internal and external environments.
9. Eukaryotic cells can differentiate and organize making it possible for multicellularity.
10. Organisms obtain and use energy to carry out their life processes.
11. Organisms on Earth interact and depend in a variety of ways on other living and nonliving things in their environments.
12. DNA segments contain information for the production of proteins necessary for growth and function of cells.

**OBJECTIVES / ESSENTIAL KNOWLEDGE**

**Describe ecological levels of organization in the biosphere.**

1. Describe the levels of ecological organization (i.e., organism, population, community, ecosystem, biome, and biosphere).

- Organism: individual living creature.
- Population: A group of organisms of one species that interbreed and live in the same place at the same time (e.g. muted swan population).
- Community: A group of organisms or a population of different species occupying a particular area. A community is the biotic part of an ecosystem. It consists of all the populations of all the species that live in the same area. It also includes their interactions.
- Ecosystem: A system that includes all living organisms (biotic factors) in an area as well as its physical environment (abiotic factors) functioning together as a unit. A niche refers to the role of a species in its ecosystem. A habitat is the physical environment in which a species lives and to which it is adapted. Two different species cannot occupy the same niche in the same place for very long.
- Biome: A major ecological community of organisms adapted to a particular climatic or environmental condition on a large geographic area in which they occur.
  - a. Terrestrial biomes are determined mainly by climate. Climate influences plant growth, biodiversity, and adaptations of land organisms. Terrestrial biomes include tundras, temperate forests and grasslands, chaparral, temperate and tropical deserts, and tropical forests and grasslands.
  - b. Aquatic biomes are determined mainly by sunlight and concentrations of dissolved oxygen and nutrients in the water. Aquatic organisms are plankton, nekton, or benthos. Marine biomes are found in the salt water of the ocean. Freshwater biomes include standing and running water biomes. Wetlands are extremely important biomes. They may have freshwater or salt water.
- Biosphere: The part of the earth where living things exist.

2. Describe characteristic biotic and abiotic components of aquatic and terrestrial ecosystems.

- Biotic components are the living things in an ecosystem as well as their products (e.g. secretions, wastes, and remains).
- Abiotic components are the nonliving (NEVER has lived) physical and chemical attributes of a system, for example light, temperature, wind patterns, rocks, soil, pH, pressure, etc. in an environment.
- Aquatic environments include saltwater ecosystems (oceans, intertidal zones...), freshwater ecosystems (lakes, rivers...), and brackish ecosystems (combination of salt and freshwater; mangrove swamps, estuaries)
- Terrestrial biomes differ based on their average climates and dominant communities. Examples include tropical rainforests, tropical dry forests, savannas, deserts, temperate forests, temperate grasslands, taiga, tundra...
- Succession refers to the growth of an ecosystem
- Primary succession occurs when a disturbance, such as a volcanic eruption, occurs that removes or covers the soil. Growth then starts with organisms such as lichens and mosses that can grow on the bare rock and break it down to create soil.
- Secondary succession occurs when a disturbance, such as a wildfire, occurs but does not remove the soil.

**Describe interactions and relationships in an ecosystem.**

1. Describe how energy flows through an ecosystem (e.g., food chains, food webs, energy pyramids).
  - Food Chains: A feeding hierarchy in which organisms in an ecosystem are grouped into trophic (nutritional) levels and are shown in a succession to represent the flow of food energy and the feeding relationships between them.
  - Food Webs: A food web is many food chains linked together to show a more accurate model of all possible feeding relationships of organisms in an ecosystem.
  - Energy Pyramids: A graphical model that is shaped like a pyramid to show how the energy flows through a food chain, how the amount of energy is decreasing and becoming less available for organisms as it enters each trophic level, and how much of the energy in the ecosystem is lost to the atmosphere as heat. As a general rule, ten

- percent of the available energy is transferred to the next trophic level.
2. Describe biotic interactions in an ecosystem (e.g., competition, predation, symbiosis).
    - a. Predation: A relationship between two organisms of unlike species in which one of them acts as predator that captures and feeds on the other organism that serves as the prey. A predator-prey relationship keeps the populations of both species in balance.
    - b. Competition: A relationship between or among living things for resources, such as food, space, shelter, mate, ecological status, etc. Intraspecific competition occurs between members of the same species. It improves the species' adaptations. Interspecific competition occurs between members of different species. It may lead to one species going extinct or both becoming more specialized.
    - c. Symbiosis: a long-term, close relationship between two different species. Examples of symbiosis:
      - i. Mutualism: in this type of symbiosis, both organisms of different species rely on one another for nutrients, protection and other life functions, hence, they are usually found living in close proximity. Mutualism is a symbiotic relationship in which both species benefit.
      - ii. Commensalism: A form of symbiosis between two organisms of different species in which one of them benefits from the association whereas the other is largely unaffected. For example, a bird benefits from building a nest in a tree, but the tree is neither harmed nor helped.
      - iii. Parasitism: A form of symbiosis in which one organism is harmed and the other organism is helped. An example is a flea on a dog. The flea acts as a parasite, gaining a food source, while the dog is a host that is harmed in the interaction.
  3. Describe how matter recycles through an ecosystem (i.e., water cycle, carbon cycle, oxygen cycle, and nitrogen cycle).
    - Water cycle:
      - a. Within this cycle, energy is supplied by the sun, which drives evaporation whether it is from the ocean surfaces or from treetops and leaves (transpiration).
      - b. The sun, with the help of wind, also supplies the energy, which drives the weather systems, which moves water vapor in the form of clouds, from one place to another, or else it would only rain over oceans. Precipitation occurs when water condenses from a gaseous state in the atmosphere and then falls to earth. Gravity pulls the water underground (seepage) or groundwater across the surface of the terrain (also called runoff), either way gravity goes on to pull water lower and lower until it reaches the oceans. Water returns to the atmosphere by:
        - c. Evaporation is the reverse process where liquid water becomes gaseous. Once water condenses, gravity takes over and the water is pulled to the ground.
        - d. In plants, water is drawn in at the roots and moves to the gas exchange organs, the leaves, where it evaporates quickly. This special case is called transpiration.
        - e. As the water vapor moves higher in altitude, the water cools and forms clouds in a process known as condensation.
    - Carbon Cycle: the key events of this cycle are the complementary reactions of respiration and photosynthesis.
      - a. Respiration takes carbohydrates and oxygen and combines them to produce carbon dioxide, water, and energy.
      - b. Photosynthesis takes carbon dioxide and water and produces carbohydrates and oxygen. The outputs of respiration are the inputs of photosynthesis, and the outputs of photosynthesis are the inputs of respiration. The reactions are also complementary in the way they deal with energy.
      - c. The chief reservoirs for carbon dioxide are in the oceans and in rock. Carbon dioxide dissolves readily in water (also known as erosion).
      - d. Animals acquire all their carbon in their food, and, because of this, all carbon in biological systems ultimately comes from plants (autotrophs). Through combustion of

- organic material, which oxidizes the carbon, it contains, producing carbon dioxide (as well as other things, like smoke).
- e. Burning fossil fuels such as coal, petroleum products, and natural gas releases carbon that has been stored in the geosphere for millions of years.
- Nitrogen Cycle:
    - a. Nitrogen is critically important in forming the amino portions of the amino acids, which form the proteins of your body.
    - b. The principal reservoir of nitrogen is the atmosphere, which is about 78% nitrogen.
    - c. Nitrogen is a non-reactive gas meaning it takes a lot of energy to get nitrogen gas to break up and combine with other things, such as carbon or oxygen. Nitrogen gas can be taken from the atmosphere (fixed) in two basic ways: Lightning provides enough energy to "burn" the nitrogen and fix it in the form of nitrate, which is  $\text{NO}_3$ . The other form of nitrogen fixation is by nitrogen fixing bacteria. They use special enzymes instead of the massive amount of energy found in lightning to fix nitrogen.
    - d. Most plants can take up nitrate and convert it to amino acids.
    - e. Animals acquire all of their amino acids when they eat plants (or other animals).
    - f. When plants or animals die (or release waste), the nitrogen is returned to the soil.
    - g. The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia.
    - h. Ammonia is toxic but there are nitrite bacteria in the soil and in the water, which take up ammonia and convert it to nitrite.
    - i. Nitrite is also somewhat toxic, but another type of bacteria, nitrate bacteria, will take nitrite and convert it to nitrate,
4. Describe how ecosystems change in response to natural and human disturbances (e.g., climate changes, introduction of nonnative species, pollution, fires).
    - Disturbances are events that change communities, remove or destroy organisms from communities, or alter resource availability.
    - Abiotic disturbances – droughts, fires, floods, volcanic eruptions, earthquakes, storms
    - Biotic disturbances – bulldozing, clear-cutting, paving, plowing, and mowing land (human influences).
    - Some organisms may depend on disturbances to survive
    - Disturbances may create the opportunities for new species to occupy a new habitat
    - Ecological succession is the process in which a community gradually changes through time.
    - Primary succession occurs in an area that has never before been colonized.
    - Secondary succession occurs in a formerly inhabited area that was disturbed.
    - Air pollution consists of chemical substances and particles released into the air, mainly by human actions. The major cause of outdoor air pollution is the burning of fossil fuels. Indoor air can also be polluted. Air pollution, in turn, causes acid rain, ozone depletion, and global warming.
  5. Describe the effects of limiting factors on population dynamics and potential species extinction.
    - Population density is the average number of individuals per unit of area or volume. The pattern of spacing of individuals in a population may be affected by characteristics of a species or its environment.
    - Population growth rate is how fast a population changes in size over time. It is determined by rates of birth, death, immigration, and emigration.
    - Under ideal conditions, populations can grow exponentially. The growth rate increases as the population gets larger. Most populations do not live under ideal conditions and grow logistically instead. Density-dependent factors slow population growth as population size nears the carrying capacity.
    - When the carrying capacity is reached, the number of individuals the environment can support is reached and population growth becomes stable.
    - Any factor that restrains the growth of a population is a limiting factor. (Space, sunlight,



food, water, availability of mates).

- As the population grows, competition for resources increases. Thus reproduction shrinks over time. This may lead to species extinction.

**ACTIVITIES:**

1. Describe and differentiate between the levels of ecological organization.
2. Describe characteristic biotic and abiotic components of terrestrial and aquatic ecosystems.
3. Describe how energy flows through an ecosystem.
4. Describe biotic interactions within an ecosystem.
5. Describe the niche of an organism.
6. Describe how matter recycles through an ecosystem.
7. Describe how ecosystems change in response to natural and human disturbances.
8. Describe the effects of limiting factors on population dynamics and potential species extinction.

**RESOURCES:**

Dragonfly Chapters 3-6  
Flexbook Chapters 11-12

**ASSESSMENTS:**

Observation checklists  
Group and individual projects  
Worksheets  
Model creation  
Writing responses  
Lab participation  
Lab reports  
Journal entries  
Presentations  
Quizzes  
Tests

**REMEDIATION:**

Small group instruction  
Individualized teacher support  
Web-based reinforcement activities  
Peer tutoring  
Chunking of information

**ENRICHMENT:**

Research Opportunities  
Independent Investigations  
Case Study  
Individualized teacher support  
Small group enrichment instruction